ASARECA

Transforming Agriculture
for Improved Livelihoods

Payment for environmental services
Laying the ground work

Case studies from Eastern and Central Africa

Editors: Hezron Mogaka, J. B. Okeyo-Owuor, Anderson Kipkoech

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DEDICATION

This book is dedicated to Assan Ng'ombe and Alice Ruhweza for their financial support in the International Conference on Payment for Environmental Services.

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LIST OF ACRONYMS

ASAL	Arid and Semi-arid Lands
ASARECA	Association for Strengthening Agricultural Research in Eastern and Central Africa
CBD	Convention on Biological Diversity
CBNRM	Community Based Natural Resource Management
CBO	Community Based Organization
CCD	Convention to Combat Desertification
CIDA	Canadian International Development Agency
COP	Conference of Parties
CSWCT	Chimpanzee Sanctuary and Wildlife Conservation Trust
CVM	Contingent Valuation Method
DBH	Diameter at Breast Height
DFID	Department for International Development of the UK
DNA	Designated National Authority
EAC	East African Community
ECOTRUST	Environmental Conservation Trust of Uganda
EPWS	Equitable Payment of Water Services
ES	Ecosystem Services
EU/EC	European Union/Commission
FACE	Forests Absorbing Carbon Emissions
FAO	Food and Agricultural Organization of the Unite d Nations
GDP	Gross Domestic Product
GHG	Green House Gases
GIS	Geographical Information System
GPS	Global Positioning System
IPCC	Intergovernmental Panel on Climate Change
IUCN	International Union for the Conservation of Nature and Natural Resources
KARI	Kenya Agricultural Research Institute
KFS	Kenya Forest Service
KWS	Kenya Wildlife Service
LVBC	Lake Victoria Basin Commission
MDG	Miillenium Development Goal
MDTF	Multi-Donor Trust Fund
MEA	Millenium Ecosystem Assessment
MENP	Mt Elgon National Park
MRERECEP	Mt Elgon Regional Ecosystem Conservation Programme
MUIENR	Makerere University Institute of Environment and Natural Resources
NEMA	National Environmental Management Authority
NEMC	National Environmental Management Council, Tanzania

NFA	National Forest Authority
NGO	Non Governmental Organization
NMK	National Museums of Kenya
NPV	Net Present Value
NTFP	Non-Timber Forest Products
ODA	Overseas Development Assistance
PA	Protected Areas
PES	Payment for Ecosystem (Environmental) Services
PWS	Payment for Watershed Services
REDD	Reducing Emissions from Forest Deforestation and Degradation
REMA	Rwanda Environmental Management Authority
SD	Sudanese Dinar
SOC	Soil Organic Carbon
SPSS	Statistical Package for Social Scientists
SSA	Sub-Saharan Africa
UNCED	United Nations Conference on Environment and Development
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	UN Framework Convention on Climate Change
UNSO	United Nations Sahalan Office
USAID	United States Agency for International Development
UWA	Uganda Wildlife Authority
VCO	Voluntary Carbon Offset
WTP/A	Willingness to Pay/Accept
WWF	World Wildlife Fund

PREFACE

Ecosystem services broadly refer to the benefits that people derive from ecosystems. The services are categorised as provisioning, supporting, regulating, and cultural. For a long time, these services have been considered as nature's free gift to humanity and have systematically been undervalued. In many cases, these services are hardly captured by the National Accounting Systems. This is so because they are not ordinarily traded in conventional markets, nor are they captured by the existing price signals and regimes. The outcome from this market mechanism is the negligency of such services.

Payment for Environmental Services (PES) is a noble attempt to address this challenge, which has contributed to environmental degradation experienced in the Eastern and Central Africa sub-region in general and more specifically within critical watershed ecoystems. It is anticipated that through PES Schemes, landowners and land managers will be compensated for the ecosystem services that their landscapes provide by factoring environmental services in household production functions and decision making processes at all the critical levels (local/watershed, national and regional). The need for schemes that compensate providers of ecosystem services also stems from the fact that the beneficiaries of the ecosystem services are often located some distance away from where the ecosystems services are generated. PES has been defined for carbon, water and biodiversity that include the landscape services. PES for carbon services normally relates to land use, land-use change, and forestry initiatives. This may involve activities to increase carbon sinks by activities such as improved forest management (e.g. conversion from conventional logging to reduced impact logging), afforestation (foresting land), agroforestry and avoided deforestation. Carbon markets are either the compliance market created by the Kyoto Protocol or the voluntary market that emerged out of the compliance framework. Some provisions emerging from international agreements on Payments for Environmental Services (PES) accords an opportunity for the potential to use payments for soil C sequestration, either through a policy such as Clean Development Mechanism (CDM) or through a C emissions credit market, as a mechanism to provide farmers in developing countries with economic incentives needed to adopt more sustainable natural resources management practices.

Payments for Environmental Services for watershed services (water quantity and water quality) typically pay, or compensate upstream land owners to adopt good land management practices to mitigate siltation and ensure water flow. This results from the fact that without management by the upstream landlords and managers, vegetation cover and soil management can influence the interception, infiltration, storage, runoff, and evapor-transpiration of water which in turn influence water quantity and quality enjoyed by downstream populations. Payment for Environmental Services for watershed services thus, typically pay, or compensate upstream land owners to adopt good land management practices to mitigate siltation and ensure water flow. Still, ecosystems can provide non-material services to humans for tourism, recreation and for spiritual or religious values. Payments for Environmental

Services PES for biodiversity and landscape conservation focus on payments to conserve landscape beauty, often linked to the provision and marketing of services for tourism and recreation.

If countries want to engage in PES, they need to tackle the governance and policy failures which perpetuate anti-poor outcomes. While, effective governance and secure tenure are more important drivers of sustainability than PES, strengthening intermediary institutions will be required particularly where PES schemes seek to involve multiple buyers/ funders and multiple land-users. There may also be need to establishing legal and political background conditions relevant to PES schemes. It is thought that communities' participation in PES is limited by lack of institutional capacities to exploit such opportunities, market inequity, lack of local and international legal and institutional frameworks and the lack of information on suitable methods for Valuation, Attribution and Compensation that would support the process and provide policy guidelines in this direction.

During 2009-2011, the Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA) supported a consortium of five institutions in three countries, namely, the School of Environmental Studies (Moi University), Kenya Agricultural Research Institute (KARI), and VIRED International – all of Kenya; University of Kinshasa & INERA of D. R. Congo; Nature Harness Initiatives and the Environmental Conservation Trust both of Uganda, to conduct research to develop methods for Valuation, Attribution and Compensation for Payments for Environmental Services (VAC-PES) in Eastern and Central Africa. The target research landscapes were the Mt. Elgon Region (Cross boundary between Uganda and Kenya) and the Albertine Rift (between Uganda and DRC). Many other institutions have carried out studies and undertaken PES related activities in other landscapes in Eastern and Central Africa, but the information on these activities occurs in a disjointed manner.

The papers presented in this book are an attempt to pool some of this information into one volume. The papers cut across different aspects of Environmental Services (watershed management, carbon sequestration, and biodiversity management), as well as policy and institutional issues related to PES. It is envisaged that this publication will provide information necessary to spur PES programmess in the region.

Theme 1

POLICY CONSIDERATIONS IN PAYMENT FOR ENVIRONMENTAL SERVICES

POLICYAND INSTITUTIONAL FRAMEWORK FOR TRANSBOUNDARY PAYMENT FOR ENVIRONMENT SERVICES

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ABSTRACT

This paper seeks to examine and assess existing and planned policy, legal and institutional arrangements of the East Africa Community (EAC) for implementation of Payment for Environmental Services (PES) schemes. It reviews the various instruments of the EAC and reveals that there are adequate provisions for initiation and implementation of PES in East Africa's ecosystems. There are examples of PES being implemented in Mt Elgon on both the Kenya and Uganda side of the border, and the Mara River Basin on both the Kenya and Tanzania sides. In the latter, the PES framework is being developed and coordinated by the EAC and Lake Victoria Basin Commission (LVBC). Payment for Environmental Services schemes are a potential approach to of sustainable management of the environment and natural resources, while ensuring sustainable ecosystem services to meet appropriate human and ecological needs in trans-boundary ecosystems of East Africa.

Introduction

Trans-boundary ecosystems are ecosystems that span across an international boundary of two or more countries (Harris *et al,* 2003). Within the EAC Partner States, such systems are many and occur as transboundary terrestrial and aquatic ecosystems. They consist of very high diversity of flora and fauna of immenent value to governments, communities and conservationists (BAP, 2010) and not forgetiing the future generation. Typical examples of key transboundary ecosystems in the EAC region include the terrestrial systems of the eastern Arc Mountain Forests of the Taita and Pare Hills (Kenya- Tanzania); Mount Elgon ecosystem (Kenya and Uganda); the Volcano-Mganhinga-Virunga (Rwanda-Uganda- DR Congo); Minziro-Sango Bay Swamp Forest (Uganda and Tanzania) and Nyungwe National Forest Park (Rwanda and Burundi) (Twongo, Sikoyo & Wakhungu, 2003). The main aquatic transboundary ecosystem in the region is Lake Victoria with its constituent systems such as the Masai Mara-Serengeti ecosystem (Kenya and Tanzania); Minziro- Sango Bay Kagera ecosystem and the Sio River system (Okonga *et al*, 2005). The other notable transboundary aquatic system is the Lakes-Jipe and Chale ecosystem (Tanzania and Kenya) which is a system that is very sensitive to perturbations in the upstream sources (EAC- Lake Jipe, 2005).

Currently, all these transboundary resources, just like the national natural resources are experiencing pressures of different kinds and magnitude, the main driver to this being the increasing population directly and indirectly dependent on these resources. The bulging population have unmatched alternative economic opportunities for engagement, and this, coupled with lack of appropriate technologies to practice environmentally sound economic activities, have contributed to the current degradation of shared ecosystems. Recent studies undertaken in Mt Elgon, Masai Mara and Lake Victoria showed that the attitude of communities riparian to transboundary resources was only nationally informed in terms of the legal and policy environments, but have little regard of their responsibility to beneficiaries of the same resource from a neighboring country (LVBC, 2007; MERECP, 2009; TWBHH-MRB Project, 2010). This perspective is not very surprising since only very few National Statutes that apply to transboundary systems make reference to their shared nature, and hence the shared responsibility implications thereof. Transboundary natural resources management requires collective efforts, cooperation, collaboration, participation and involvement of all stakeholders, including the local communities and private sector. It also requires innovative approaches that enjoin both upstream and downstream resource users to share both benefits and the responsibilities of managing transboundary ecosystems sustainably. The downstream users would provide or support the incentives to facilitate the upstream users to conserve the resources to the benefit of all. In this way, the upstream users would appreciate that it is for their own good too that the resources are protected.

In view of the foregoing, the new paradigm of Payment for Environmental Services (PES) is an appropriate framework since it is premised on provision of incentives to sustainably manage natural resources and ensure sustainable ecosystem services to stakeholders at all levels in a manner commonly applied to business enterprises. Payment for Environmental Services links service providers, service beneficiaries, the public and the private sector under an agreed contractual arrangement. However, PES application in transboundary resources management requires definitive policy, legal and institutional frameworks within the regional organization, in this case the East African Community and its institutions. This paper examines and assesses the existing and planned policy, legal and institutional arrangements of the EAC with a view to identifying those with relevance for application of PES. Examples are given where PES has already been applied within these frameworks.

Relevance of Payment for Environmental Services in a Transboundary Context

The Treaty for the Establishment of the East African Community is the principle policy and legislative framework for guiding the implementation of all the activities, programmes and projects of the Community (EAC, 2000). A review of the various chapters and articles of this Treaty reveals relevant provisions for the implementation of Payment of Environmental Services (PES) in transboundary natural resources. Some of these are as highlighted below, as follows:

- Article 5, Objectives of the Community, and specifically 5 (3):
  (c)- ...... the Community shall ensure promotion of sustainable utilization of natural resources of Partner States, taking measures that would efficiently protect the natural environment of Partner States.
  (g) ….. the Community shall ensure enhancement and strengthening of partnerships with private sector and civil society in order to achieve sustainable socio-economic and political development.
- Article 6, Fundamental Principles of the Community, specifically 6(b) ... peaceful co-existence and good neighborliness" and 6(f) ...cooperation for mutual benefit.
- Article 7, Operating Principles of the Community 7(1)... the principle of subsidiarity with emphasis on multi-level participation and involvement of a wide range of stakeholders in the process of integration.
- Article 8, General undertaking as to implementation: 8 (1) ... Partner States shall (a) plan and direct their policies and resources with a view to creating conditions favorable for the development and achievement of the objectives of the Community and the implementation of the Treaty; (b) coordinate, through the institutions of the Community, their economic and other policies to the extent necessary to achieve objectives of the Community and (c) abstain from measures likely to jeopardize the achievement of the provisions of the Treaty". Further, the provision in Article 8(4) ...Community organs, institutions and laws shall take precedence over similar national ones on matters pertaining to the implementation of this Treaty further provides the direction on the PES implementation.

In addition, under specific Articles 111, Environmental Issues and Natural Resources; 112, Management of Environment; and 114, Management of Natural Resources; 116 Wildlife Management provide specific arrangement to foster cooperation in the joint and efficient management and sustainable utilization of natural resources within the EAC Partner States. The Partner States have further negotiated, signed and ratified specific Protocols for implementation of some aspects of these Treaty Articles namely; the EAC Protocol on Environment and Natural Resources (2010); the Protocol for Sustainable Development of the Lake Victoria Basin (2004), the Protocol for Wildlife Development (2008.) and the Protocol on the Common Market (2009) which provides a new opportunity for underscoring the importance of PES in the transboundary context (EAC 2004, EAC 2010; EAC 2009 and EAC, 2010) .

National Implications of PES in Transboundary Resources

In the absence of a specific Community law or policy, the Treaty provisions shall be implemented using national policy and legislative arrangements as guided by the operating principle of subsidiarity. So in effect, the existing plethora of national policies, legislations and institutions governing the management of the environment and natural resources may be applied in implementing PES (Sikoyo *et al.*2004*).* The existing environment laws and institutions in each of the five Partner States, namely; NEMA- Uganda, NEMA- Kenya; NEMC- Tanzania; REMA- Rwanda and INECN- Burundi are the principle legal frameworks that can be used effectively for the establishment of PES in transboundary ecosystems (NEMA, 1995; EMCA, 1999; NEMC, 2004; REMA, 2005 and INECN, 2007). In addition to these, Partner States have other sectoral policies and laws which include water, forestry, wildlife, and fisheries, among others, all of which seek to promote sustainable natural resource use. In particular, these sectoral policies have provisions for involvement of stakeholders other than the usual state actors in the management of natural resources; participatory management and user rights for local communities in the management of all catchment areas with linkages to the agriculture and water; formation of user groups as the basis for constructive engagement in management; and promotion of environmental management and natural resources conservation programs at basin/sub-basin levels.

Payments for Environmental Services Related Initiatives in EAC- Shared Ecosystems

There are many examples globally of water-related PES schemes, which are being implemented in national jurisdictions and are greatly contributing to the conservation of environmental resources. A few examples are briefly considered below; one from the USA and the other two from Kenya and Tanzania (Okurut, 2009). The city of New York recently purchased 685 acres of land for $3.1 million as part of more than 105,000 acres of land acquired for protection. This acquisition builds on the City's efforts to protect the upstate watershed and maintain the outstanding quality of drinking water for New York. This Land acquisition program has been an important part of resource protection undertaken by the City since watershed protection is considered the best way of maintaining drinking water quality over the long term. The City has invested more than $1.5 billion in watershed protection programs, and their success is the main reason why New York City remains one of only five large cities in the USA that is not required to filter most of its drinking water. This example demonstrates that investment in land protection is vital to efforts in promoting environmental protection, as well ensuring quality services from ecosyetms – notably clean water.

Dodoma, the capital of the United Republic of Tanzania under the Dodoma Urban Water Supply and Sewerage Authority (DUWASA) has a total of 20 boreholes in *Mzakwe area* with average production capacity of 37 million litres of water per day, but currently only 12 boreholes are used to produce 29 million litres per day. However, the water demand for Dodoma, with a population of over 250,000, is 45 million litres per day. In order to protect the borehole field at Mzakwe (the only viable water source), DUWASA through the government, had to compensate and move the villagers out of the area at a cost of USD 600,000, but with a handsome reward of a guaranteed water source. In its effort to protect and enhance the watershed recharge capacity, DUWASA has planted about 6,100 trees in this area, but targets to plant 300,000 trees within three years.

The case of Eldoret Water and Sanitation Company (ELDOWAS) is an illustration of participatory community approaches to guarantee and secure water supply for a town. Here, the source of raw water is approximately 80 km away from the town and a dam was built in complete disregard of bordering community interest for water. This caused discontent within the community and they threatened to farm and cut all vegetation surrounding the dam. The potential revenue loss prompted the intervention of the water company. Recognizing the omission, the company immediately initiated measures that incorporated the participation of the bordering communities including: inclusion of one of the representatives of the community as a director in the company's Board of Directors – to take care of the interests of the community; erection of a water distribution system to supply the community with water; and establishment of a tree nursery within the community. The management bestowed responsibilities delegated to the community, including planting of the seedlings in catchment areas. In return they are paid for services rendered – hence creating jobs. The initiatives have created a working relationship between the two parties, such that the communities now embrace the project as their own as they have a sense of ownership, inclusivity and participation, while the company has been able to satisfy its customers with a wholesome service/product and sustain its operations.

Transboundary PES Implementation in the EAC

In the transboundary EAC's shared ecosystems, there are some efforts towards PES related schemes that are being implemented, although to varying degrees of sophistication. Two cases for discussion are the Mount Elgon Regional Ecosystem Conservation Programme (MERECP) being implemented in Mt Elgon at the Kenya and Uganda border and the Mara River Basin at the Kenya and Tanzania border. The Mount Elgon Regional Ecosystem Conservation Programme under implementation by LVBC supports the governments of Kenya and Uganda to strengthen management of Protected Areas in the Mt. Elgon Ecosystem; namely: Mount Elgon National Park, Mount Elgon Forest Reserves, Chepkitale National Reserve in Kenya; and Mt. Elgon National Park, and Namatale Central Forest Reserve in Uganda. In addition, the programme is supporting sustainable development and livelihood improvement activities in the six (6) Districts of Uganda and three (3) districts in Kenya. Under this programme the basic forms of PES scheme are currently in trial, implemented under cash payment for avoidance of deforestation in Kapchorwa District in Uganda and Kapchebut and Chepkwirot in Kenya. This is where intact natural forest still stands adjacent to the selected communities and settlements in the Mt Elgon area, and cash payments of $50 per ha per year was offered to households through the CBOs for protection of these intact forest patches. Payments have been made based on performance: 100% protection deserves 100% payment; in addition, if CBOs engage in additional voluntary plantation outside the PA, they are entitled to receive an additional bonus of $20 per ha; these payments are limited to a five year period, after which the CBO and the settlement adjacent to this intact forest are expected to protect it voluntarily on the assumption that the community revolving fund (CRF) should have brought about appreciable additional livelihood benefits (MERECP Strategy, 2009).

The process for PES implementation in the Masai Mara-Serengeti Ecosystem has been extensively developed through several consultative processes involving stakeholders from both Kenya and Tanzania (Mahadev *et al.*, 2009). The stakeholders range from state to non-state actors, including the private sector and local communities. The model for PES linkage between various services and service providers in the Mara River Basin is shown in Figure I. From the Figure it is clear that there are goods and services provided by the Mara River Basin in whole parts of its forests, water and land compartments (LVBC, 2010; LVBC, 2009). The service providers and players who should be involved in the design, creation and implementation of PES in the MRB are also identified. The proposed institutional mechanism for PES scheme in the Mara is the market for environmental services (MES) or Market-financed PES: This mechanism is strictly a market-based arrangement that involves direct financial transfers between service providers and beneficiaries of watershed services. The legally enforceable contracts may be drawn between individuals and/or groups representing the above market players. The contract must specify rules of transactions, including products and services delivered, quantity, quality, timing, pricing structure and consequences of breach of agreement.

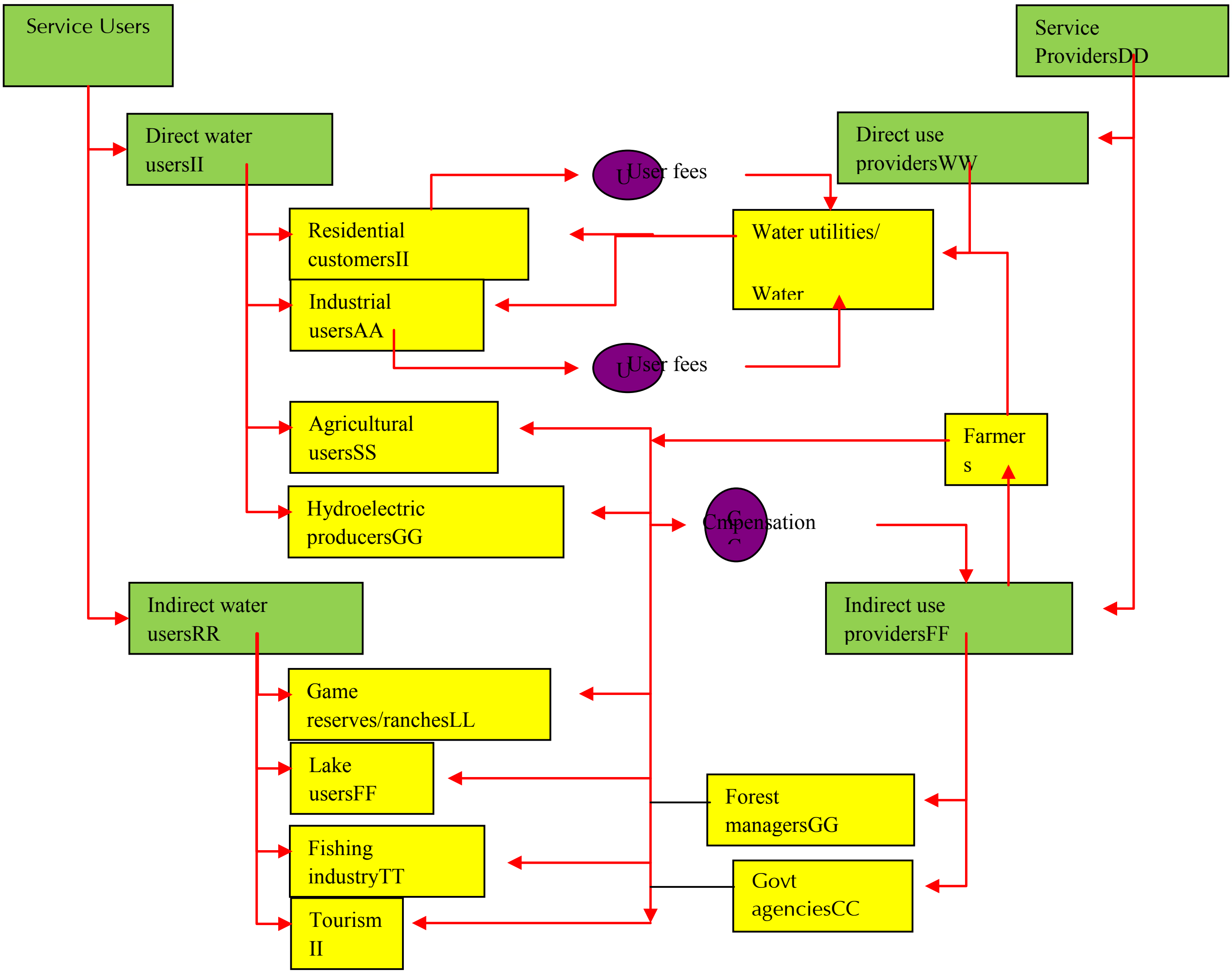

Figure I: Linkages between Service Providers and Service Users

Currently, the PES implementation is being modeled around 14 Water Resources User Associations (WRUAs) in Tanzania and 32 water user groups under the Mara River Water Users Association (MRWUA) Board in Kenya. These WRUA and MRWUA which are community based organisations are charged with the responsibility of deciding how water is apportioned and used, and in conjunction with the Lake Victoria Basin Water Office (LVBWO) at Mwanza and Lake Victoria South Water Resources Management (WRMA) at Kisumu, deciding on user rights. The proposed multi-institutional collaboration framework for each country in the basin is given in Figure II below.

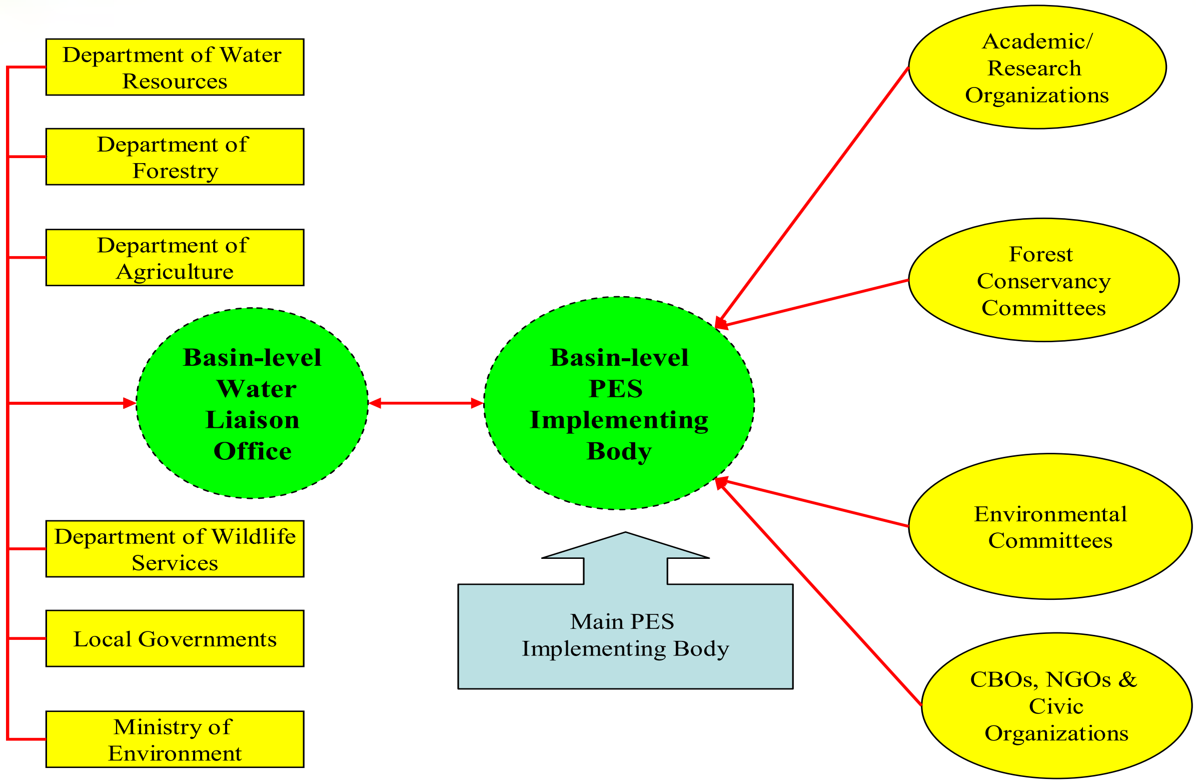

Figure II: Proposed Multi-Institutional Collaboration Framework
Source: Payment for Water Services in the Mara River Basin (Mahadev, Dhat *et al*., 2009)

The PES framework for Mara River Basin as a transboundary resource is being developed. The development is coordinated by the EAC/LVBC and the envisaged implementation and structure is given in Figure III. To-date MCC Tanzania and MRWUA Kenya have been facilitated to form Transboundary Water Resources Users Forum, whose aim is to promote dialogue between stakeholders and service providers from both countries. It is envisaged that the Mara River Basin Corporative framework once completed and approved would provide the platform for establishing the Transboundary legal framework for a PES scheme.

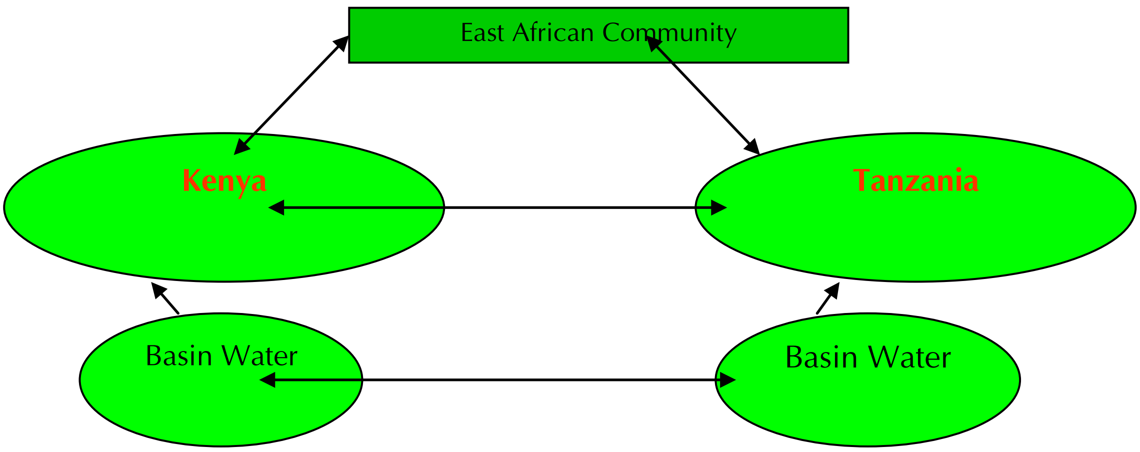

Figure III: Institutional Framework for Mara River Basin PES Scheme

Source: Payment for Water Services in the Mara River Basin (Mahadev, Dhat *et al*., 2009)

Conclusion

This paper has examined and assessed existing and planned policy, legal and institutional arrangements of the EAC for application of PES. A review of various instruments of the EAC including the Treaty for the establishment of the EAC shows that there are adequate provisions for the implementation of PES in the transboundary natural resources in the region. Further, there are existing environment and natural resources policies, laws and institutions in each of the five Partner States that can be used effectively for the establishment of PES in transboundary ecosystems. Already, there are examples of PES being implemented in Mt Elgon at the Kenya and Uganda border and the Mara River Basin at the Kenya and Tanzania border. Once it is concluded, it would provide the potential platform for establishing the Transboundary legal framework for a PES scheme. This makes PES a potential source of sustainable management of environment and natural resources while ensuring sustainable ecosystem services to meet appropriate human and ecological needs in transboundary ecosystems of East Africa.

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PAYMENT FOR ENVIRONMENTAL SERVICES: FOREST POLICY ISSUES IN MOZAMBIQUE

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ABSTRACT

Mozambique has a significant vegetation cover with over 40 million ha. of forests. Many people in the rural areas depend on these resources, besides the high demand for land for various competing development initiatives which result in deforestation and forest degradation. The country has been slow to develop Payment for Environmental Services (PES) to promote sustainable forest management. Climate change, land use change, increased emissions bring a new impetus to the possible relevance of the tool.

The objective of this paper, therefore, is to analyze the current policies, identify opportunities and make recommendations for implementing the PES in Mozambique, with lessons that other countries in the region may learn from. The analysis shows that the land and forest rights for the communities embedded in the current policy framework provide a strong platform for making Payments for Environmental Services work. However, the recommendation is to spell out the rights: '*the rights to environmental services, in particular carbon, belong to the communities*'. This is necessary to direct payments to the rightful beneficiaries. In addition, the paper stresses that PES can significantly impact livelihoods and secure sustainable management of resources only if the full set of services are acknowledged, evaluated and land users compensated for them. The total payment, therefore, should comprise of 'biodiversity' *plus* 'watershed services' *plus* 'carbon sequestration' *plus* 'other services' in order to account for the real opportunity costs of providing the services. Furthermore, disaggregation of land users in different resource contexts will allow the design of relevant payment mechanisms. Further research should be carried out to quantify the tradeoffs between the various land uses and related services.

Introduction

Mozambique's economy relies on exploitation of renewable natural resources. The land used for agriculture, fisheries, water, forestry and energy resources are of particular importance in sustaining both the formal and the informal sectors of the economy. Non-renewable resources in the country such as coal, gas, heavy sands and other minerals are emerging as potential key drivers of economic growth in the coming years. Overall, the agriculture sector contributes about 29% to the GDP[1] and the forestry resources less than 5%, despite the fact that it sustains livelihoods of almost all the rural population, as well as the urban poor. The official statistics do not yet capture the full value of the formal forest activities, let alone the informal ones. Therefore, forest services are either not acknowledged, under-valued or they are embedded in other sector statistics, such as tourism, agriculture or water.

Mozambique is a signatory to several international conventions like the Convention on Biological Diversity, Convention to Combating Droughts and Desertification, and the United Nations Framework Convention on Climate Change. The government has developed policies, particularly in the mid 90's aiming at delivering sustainable management of forests and land. After more than 10 years of implementation of these policies, the question is whether the policies have delivered sustainable management and provision of environmental services, or there is a need to develop innovative mechanisms to value and compensate for the opportunity cost of providing such services. While Latin America and Asia have advanced experiences in payments for ecosystems services, similar examples in Africa are scanty.

Payment for Environmental Services (PES) is a voluntary transaction or a mechanism to compensate the providers (sellers, landholders) by the beneficiaries (buyers) to ensure sustainable supply of clearly defined services. The payments are conditional on the delivery of the services (Pagiola, 2006; UN, 2009; Richards 2007). Generally, local landholders are paid by companies or individuals or through public funding to offset their emissions or for conservation of biodiversity and watersheds. In this context, this paper has two objectives. The first objective is to review some of the incentives for conservation of environmental services in the forestry and wildlife sector in Mozambique, which aim primarily at improving livelihoods of those that strive to conserve the resources on one hand, and on the other hand, discourage those that destroy the resources. The second objective is to suggest the policy and legal frameworks to enhance sustainable management of natural resources and benefit they confer, particularly the conservation of forests, watersheds, carbon sequestration and biodiversity through Payment for Environmental Services (PES).

[1] Mozambique at a glance, World Bank site, Mozambique

Background: Broader Context and Resources Base

A French Development Agency (FDA) study conducted recently indicated that the natural capital represents 49% of the wealth in Mozambique, while the intangible and physical capitals represent 32% and 19%, respectively, (Ollivier,*et al*., 2009). Subsequent breakdown of the natural capital indicates that 22% is constituted by forest resources, 36% agriculture land resources, including cropland and pastureland, and 41% minerals. According to these authors, environmental degradation is estimated to cost US$ 370 million a year, equivalent to 6% of the GDP and 20% of the Overseas Development Assistance (ODA) (ibid). Although water pollution related health problems are responsible for more than 50% of the environmental cost, soil degradation and deforestation, as well as climate change do have a significant contribution to the lost national income due to unsustainable use of the resources.

This paper focuses on the 58% of the natural capital (constituted by forests, cropland and pasture land). The rural and the urban poor populations are dependent on these resources for wood biomass energy which meets 85% (about 24 million m^3 per year) of the consumption in the country. Shifting cultivation with use of fire, the short fallows and increasing agriculture land due to growing population are responsible for degradation and deforestation. As a result, 219 000 ha of forests are lost annually. Miombo woodlands cover two thirds (2/3) of the forest area. The second most extensive forest type is Mopane woodlands. The centre and most of the north of the country have high forest cover of commercial value. Overall, Maputo, Inhambane and Nampula have low forest cover. The forest cover and potential for forest plantations resources are presented in Box 1.

Box 1 Forest Resources
Source: National Inventory – Marzoli 2007
Natural forests
40.1 million ha of forests of which,

- 26.9 million ha are productive forests
- 14.7 million ha are multipurpose areas (including forests, thicket and woodlands),
- 13 million ha (16% of the country's surface) are protected areas
    - Six national parks
    - Six game reserves
    - Fourteen forest reserves
    - Three *integral* reserves and
    - Twelve hunting areas

400 000 ha of mangrove vegetation
Potential for reforestation
Source: Reforestation strategy (MINAG, 2009;(Nhantumbo, 2009)

Plantation objective	South (ha)	Centre (ha)	North (ha)
Conservation	3 469	3 818	2 713
Community	17 343	19 092	13 566
Energy	103 858	54 140	63 465
Commercial	-	337 000	663 000

NB: Calculation based on data from reforestation strategy

The estimate of land for community forests and even for conservation is somewhat understated. It is clear that large-scale plantations are given high priority. The forests also provide habitat for large and diverse populations of wildlife inside and outside the protected areas. There are human inhabitants inside some of the forests, and in the surrounding areas. These directly bear the cost associated with protection of biodiversity – limited access to and use of resources and attacks by the wildlife or damage to crops and property. There are also about 36 million ha of agriculture land, of which only 12% is cultivated at any one time by both subsistence and commercial farmers. Smallholder farmers cultivate about 80% of the land. All types of forests are under pressure from competing uses such as agriculture, biomass energy, infrastructure development, including human settlements, legal and illegal logging, hunting and bushfires. After the large fires of 2008 in the central provinces of Sofala and Manica, the government declared this as one of the national disasters that the country has to deal with. Of late there has been a growing pressure on land for production of biofuels and forest plantations of exotic species. This defines the context in which payments for environmental services should be designed and implemented.

The Current Incentives for Conserving Environmental Services

The Policy Environment

There are two main policy and legislation developed in the 1990's that have a significant bearing on the tenure and management of forestry resources. First, the Land Policy was approved in 1995, and subsequently the legal and operational instruments including the 1997 Land Law and the 1999 Regulation and the Technical Appendix. The principal provisions include:

- (i) The land belongs to the State and it cannot be sold nor alienated;
- (ii) The State reserves the right of allocation of the land to the users and acknowledges the customary rights of the communities;
- (iii) Rights of occupation for over 10 years being equivalent to formal rights to the land;
- (iv) Men and women have equal rights to land;
- (v) Communities can (voluntarily) delimit their land (negotiated boundaries with the neighboring communities) to acquire formal rights to land through a certificate of Land Use and Improvement Rights (DUAT);
- (vi) Allocation of land to third parties such as the private sector should be preceded by a community consultation process.

The consultation provision entails the presentation of the potential investment to the community and subsequent *acceptance*. Signed minutes of such consultation form part of the land application documentation. The communities use this opportunity to voice their expected benefits. Employment opportunities, social infrastructure such as roads, schools, and clinics are generally the predominant demands. This has been perceived as an opportunity for negotiation between the communities and private investors, as well as motivating the latter to assume its corporate social responsibility (CSR).

Second, the other set of instruments include the Policy for the Development of the Forestry and Wildlife Sector (1997), the 1999 Forestry and Wildlife Law, the 2002 Regulation of the Forestry and Wildlife Law, and the 2005 Mechanism for Benefit Sharing (between the State and local community – generally known as the '20% provision'. The following are the main features of the forestry policy and legal frameworks:

(i) Communities have free access to forest products for their subsistence (direct consumption of for example food, fiber, fuelwood and construction materials) in all forest management regimes (productive, multipurpose and protected);

(ii) Both communities and private sector can secure user rights to productive forests provided they define the boundaries of the forest, conduct a forest inventory, develop a management plan (simplified for the annual licenses and detailed for concessions) and establish a processing industry in case of long term uses (forest concessions);

(iii) 40% of the royalties on forest harvesting is waved for timber processed inside Mozambique and this benefit accrues to the concessionaires;

(iv) Communities can acquire collective rights to forests, including the productive forests, forming a basis for implementing participatory natural resources management. This provision is defined in the social objective of the policy and acknowledges the fact that the forest-dependent people should benefit from sustainable management of forests. The motivation for this provision was the assumption that clear property rights will contribute to addressing the issues of intensive forest harvesting for fuel wood to meet the energy demand in urban areas, and curb the use of bushfire for agriculture expansion and hunting.

(v) The government shares 20% of its revenues of the royalties, from forest and wildlife products and services (tourism) with the local communities within the area in which those taxes were collected.

There are three instruments used by the government to promote sustainable use of forestry resources by the communities:

a) Stronger and more secure (collective) rights to land and forests in productive and multipurpose areas;
b) Opportunity for community to negotiate benefits with private investors and,
c) Sharing of benefits between communities and the State.

The first direct result of these provisions is that more than 5 million ha of land have been formally registered as community land. Civil society organizations facilitated this process aiming empower communities concerned to negotiate from a stronger position with the potential investors on their land. Secondly, since the first pilot of CBNRM in the mid 90's was based on a borrowed concept from Zimbabwe's CAMPFIRE, 70 initiatives were established (including the initial five pilots implemented by the government with a budget of US $5 million) (Foloma, 2006). While these experiences proved to be beneficial for maintenance of forest resources with positive impact on biodiversity (flora and fauna) conservation, the small enterprises (*interest groups*) based mostly on non-timber forest products could not earn sufficient income to compensate the communities for the foregone benefits of unsustainable use of the forest resources (Nhantumbo *et al.*, 2006). The gains made from illegal charcoal production, for example, far exceeded the benefits from production of honey, wood carving, community ecotourism and other alternative income generating activities combined. The sustainability of these interventions that aimed at integrating conservation and development purposes could not be secured. The trade offs were significant. The short term nature of the initiatives (average of 3 years, hence projects rather than long term programs) further exacerbated the situation. The end of the 'project' was subsequently followed by resumption of old unsustainable practices. Thirdly, 1,100 communities mostly in the productive forest areas were identified as eligible to receive the 20% revenue from royalties. The assumption was that this payment would motivate the communities to contribute to sustainable management of the forests such as reduced use of fire and illegal logging. The organization of the communities and their registration as associations with a bank account (with community members as signatories) were prerequisites for making the payments. Though apparently simple, these requisites have high transaction costs, especially for the potential beneficiaries living in remote areas. Since 2005 to mid 2009, only 542 communities received the equivalent of US$ 3.5 million (Nhantumbo, 2010). Fourthly, there are also requirements to promote sustainable logging in commercial forests under long term contracts of about 30 years. There are more than 126 forest concessions in operation out of 148 approved, but only 85 have approved management plans. Three concessions are FSC certified. On the other hand, there are a huge number of forest operators who have annual licenses to harvest a maximum of 500 m^3 of timber. The legislation permits movement of the latter from one area to another (*shifting forest harvesting or creaming of the forest*) contributing to forest degradation and loss of biodiversity. The law enforcement and monitoring capacity continues to be a challenge to the delivery of the policies. Therefore, the extent to which the management plans and sustainable harvesting are implemented is uncertain.

Finally, the country has an estimated potential for reforestation of 7 million ha. There is a growing interest in forestry plantations, particularly by the Nordic countries, mainly for production of pulp and paper. However, companies are also looking at opportunities to capitalize on by-products such as carbon sequestration and associated financial benefits. In the absence of land use and zoning plans, there is risk of compromising conservation and social objectives. Conversely, plantations can also play an important role in the restoration of degraded lands or with high risk of erosion. In such cases, carbon sequestration would be a by-product. What are the main lessons from these policy provisions that can be extrapolated to inform PES?

1. Resource tenure contributes to addressing the challenges of sustainable use of forests with participation of stakeholders, in particular the local communities.

2. Generation of alternative sources of income (from sustainable forest management) for the local communities need to be long term. Subsequently, a combination with payment for the different services resulting from such endeavors should bring incremental benefit from the forest. Therefore, the PES could help to create incentives for less immediate profitable ventures.
3. Clear, unambiguous and fairly enforced policy provisions for sustainable investment and management of the forest resources by the private sector are equally important. Fair and efficient law enforcement and monitoring of practices are fundamental to foster compliance. However, self regulation with independent monitoring and market driven compliance can reduce the government-borne costs of enforcement.
4. The Mozambique legislation has financial incentives to compensate communities and private sector for investing in good forest management practices. However enforcement needs to be strengthened to tie the payments to observable provision of the services, i.e., sustainable forest management practices.

Climate change and the role of forests in its mitigation have suddenly increased its value in a way that was never before (Angelsen, 2009). The potential for curbing the contribution of the 20% of the world's emissions resulting from land use and land use change in the developing countries is the main reason why protecting and even increasing the forest coverage is seen as an option to be pursued. Mozambique is one of the countries vulnerable to climate change and the sustainable management of forests is considered as one of the options that can mitigate its impact. The country is one of the potential beneficiaries of the Forest Carbon Partnership Facility. Mozambique has just been through a process of designing the National Strategy for REDD+ (MICOA and MINAG, 2010) which outlines critical areas of intervention to address the multisectoral nature of land use and land use change. In addition, the 1995 Agriculture Policy emphasizes that food production should be done taking into account the sustainable management of the natural resources.

Payment for Environmental Services: Policy Challenges for Mozambique

The Meaning of PES for Mozambique

Payments for Environmental Services are different from corporate social responsibility payments in the sense that the first are paid when certain conditions are met (e.g. permanence and additionality) while the second is used to foster good relations between companies and local communities (UN, 2009). Both are important and complementary. The growing interest on these payments results from the rising scarcity of environmental services due to unsustainable use practices. Furthermore, PES can generate sustainable financing to complement government funding for conservation and mitigation of climate change impacts (UN, 2009).The Millennium Ecosystems Assessment defines different types of ecosystems services which are discussed below (Table 1) in the context of Mozambique.

Table 1: Ecosystems Services and their Importance (Examples) For Mozambique

Service	Forests	Cultivated land	Oceans
Provisioning	***Food, Fresh Water, Fuel,Fiber***	***Food,Fuel,Fiber***	***Food***
Regulating services	**Climate regulation** **Flood regulation** **Water purification**	**Climate regulation** **Water purification**	**Climate regulation** **Disease regulation**
The role of these services and threat to them	Increase in temperature in Mozambique is indicated to have been about 1.6 to over 2 in the past 3-4 decades (INGC, 2009). Long spells of drought and frequent and intensive floods and cyclones are increasing vulnerability. Most rivers are shared with upstream countries. Floods and droughts are 'exported' to Mozambique. Deforestation is contributing to devastating effects (environmental, economic and social) of these phenomena The removal of mangroves for biomass energy and construction materials exacerbates the impact of these disasters.	The sustainable use of agriculture land, cultivation of perennial crops and agroforestry systems are important for recovery of soils and for reducing frequent land use change and the consequent carbon emissions. However, unsustainable practices such as use of fire for conversion of forests into agriculture land prevail contributing to emissions.	The climate models indicate that Mozambique's coast, particularly in the central region with cities below the sea level, is likely to suffer the effect of increased temperature and consequent rise in the sea level (INGC, 2009). The coral reefs are also important depositories of carbon. Protected areas such as the Inhaca Biological Reserve, the Bazaruto National Park, the Quirimbas National Park, the Primeiras e Segundas Islands are some of the key depositories of these creatures.
Support services	**Nutrient cycling** **Soil formation**	**Nutrient cycling** **Soil formation**	**Nutrient cycling** **Primary production**
The role of these services and threat to them	The vegetation cover plays an important role in preventing soil degradation. Removal of vegetation especially in drylands increases the propensity for erosion. Mining and non enforced implementation of the environmental mitigation measures in the environmental impact assessments are particularly responsible for affecting these functions.	Poor soil management in agriculture land prevails. Inter-cropping and rotation of crops, agroforestry systems, and conservation agriculture are some of the technologies that can contribute to continuous renewal of soil nutrients and increase productivity and production. The multiplier effect of this is the possible reduction of land for farming expansion as sole form of increasing production.	
Cultural Services	***Aesthetic*** ***Spiritual*** ***Educational*** ***Recreation***	***Aesthetic*** ***Spiritual***	***Aesthetic*** ***Spiritual*** ***Educational*** ***Recreational***
The role of these services and threat to them	The local communities use traditional norms and taboos to establish sacred forests. These are places of worship as well as of transmission of spiritual values from generation to generation. The land policy and legislation recognize this type of protected area as fundamental for conservation of biodiversity and encourages establishment of new areas.	Lands with aesthetics and spiritual values are not converted for agriculture; instead they can be used as places of worship *asking* for precipitation and high crop production.	The coast of Mozambique has many attractive features for recreational purposes. The coral reefs, the beaches, the coastal vegetation among the National Parks of Archipelagos of Quirimbas and Bazaruto, the Inhaca Reserve and Ponta do Ouro important tourist destinations. Tourism is a growing industry in the country but community benefits are still negligible (low paid jobs, 20% of the revenue from royalties)

*These descriptions illustrate the environmental services relevant for the country and therefore identify areas that PES can potentially target.

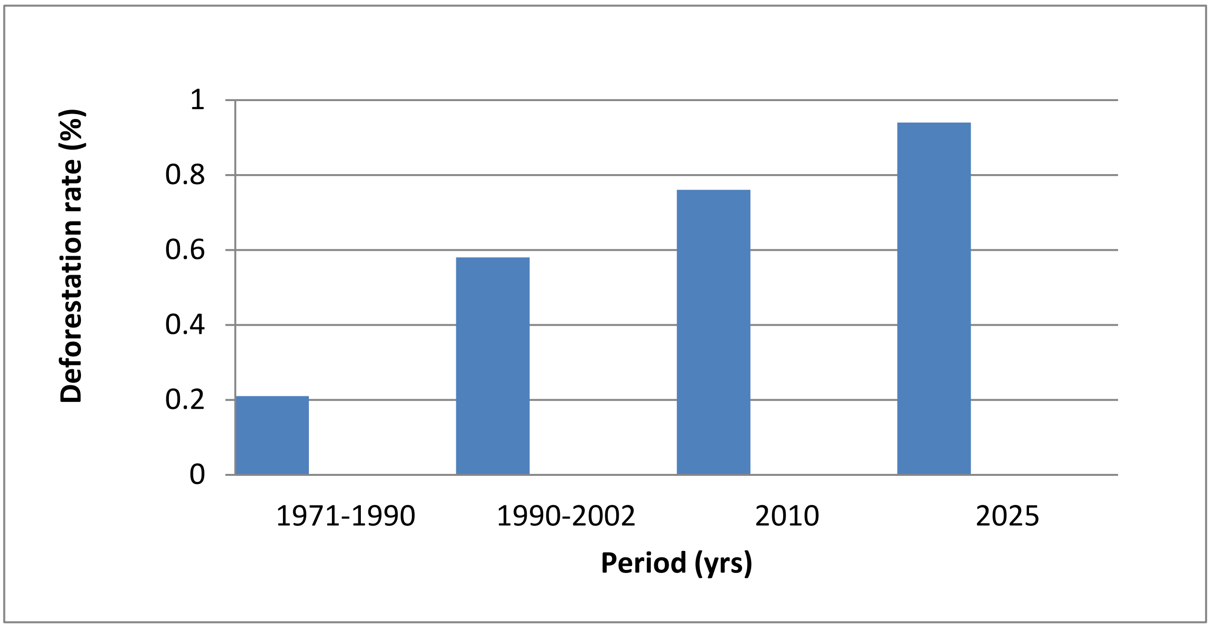
Gaps in the Policy and Legal Framework to Conserving Environmental Services

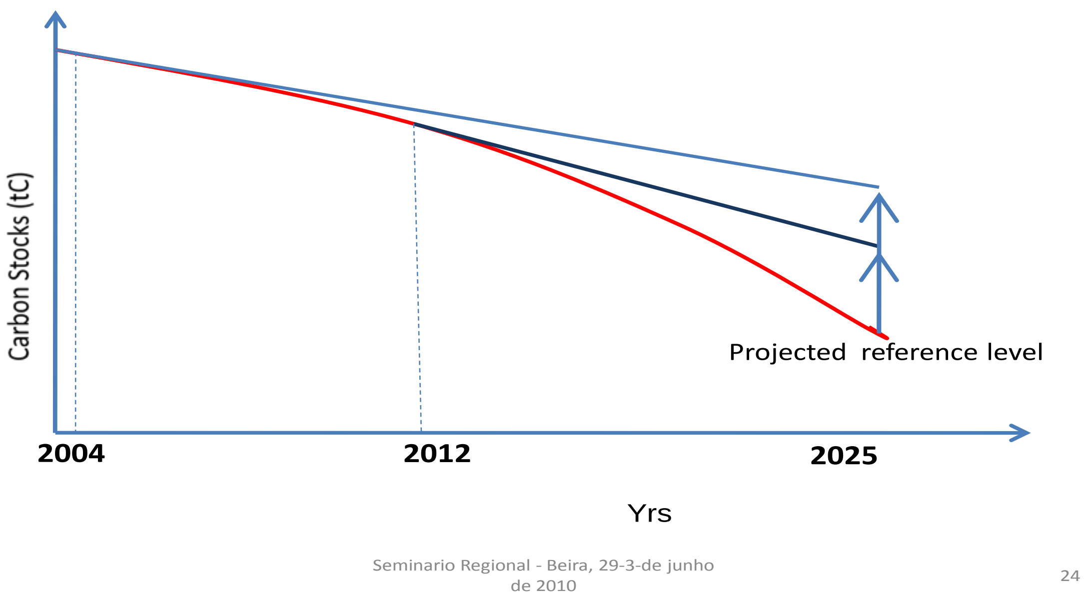
As Wunder (2005) highlights, PES bring to the policy debate the flexibility and adaptability as it embraces different environmental services managed for different objectives with different modes of payment and different markets. In addition, PES can contribute to promoting more effective land use planning and zoning, and monitoring of the compliance, promoting smart infrastructural investment, besides diversifying sources of income with potential impact on overarching goals such as poverty alleviation. Stemming from that, the second objective of the paper is to analyze the gaps in the policy and legal framework for enhancing sustainable management of natural resources through PES, to benefit the conservation of forests for water supply, carbon sequestration and biodiversity. Using the carbon sequestration as a central (but by no means the only one) function of forests in the context of mitigation of climate change, one of the important provisions is that PES should build from the existing recognition of the land and forest tenure by the community. IFAD and Bond, *et al.* (2009) stress that this is an important pre-requisite for PES.

The rights to carbon as a key component of climate regulation and other forest related services should be embedded in the rights to land and to forests. At the higher level, this means that the right of occupation and community rights to land based on customary norms acknowledged in the Constitution, and subsequently in the land legislation, embeds these services. In practice, this means that the payment for environmental services from the forest ecosystems (carbon credits) for all the native forests should go to the communities, the objective being to meet part of the opportunity cost of conservation and mitigation of climate change. This provision is important for the implementation of the National REDD+ strategy. Initial estimates of the baseline were based on deforestation levels observed in the period 1990-2002 (Sitoe, 2010). However, to increase the gains (increase carbon sequestration), the deforestation rate ought to be reduced to the 1972 level (Box 2). Further gains can also be made when the avoided emissions from forest degradation are included. This requires more detailed research for the different land uses.

Assuming that public finance will pay the land users to reduce deforestation at a corresponding value of US$ 10/tCO2, the potential funds of US$ 33.5 million should be allocated to farmers and charcoal producers to address the supply side, as well as investing resources to support the adoption, of for example, biomass energy saving stoves, use of gas and solar energy among other alternatives. Further Payment for Environmental Services need to combine the strengths of conditionality.

Box 2. Historical and projected deforestation rate and reference level

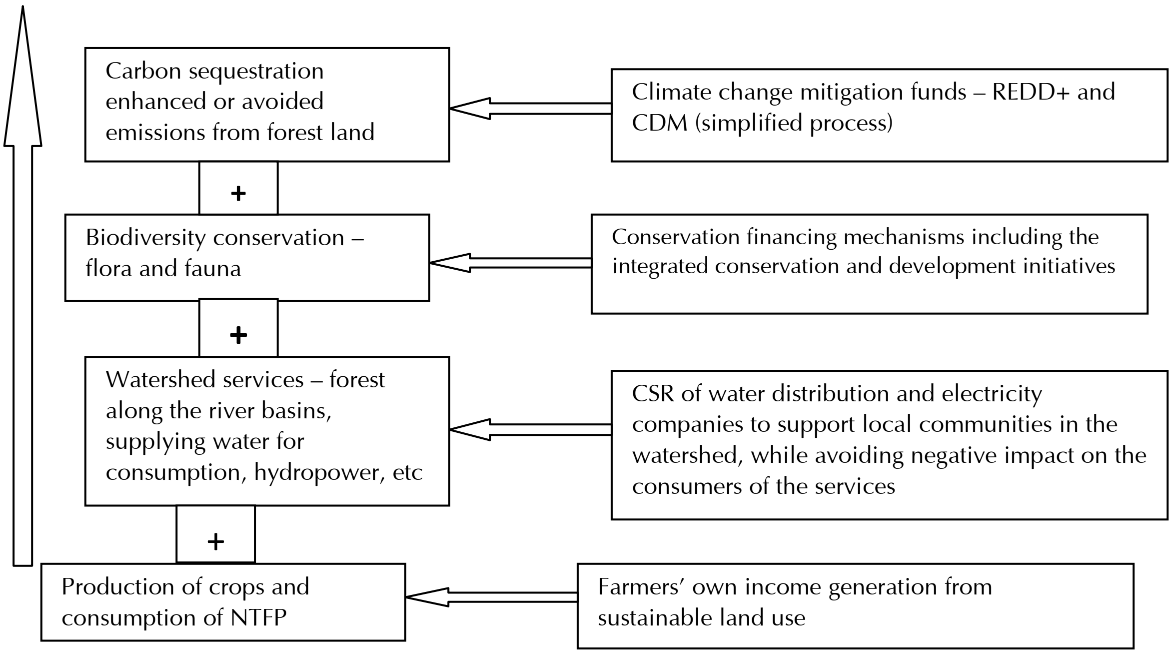




Current carbon stocks estimation indicate that by maintaining the current deforestation rate of 0.58% in the coming 20 years, the avoided carbon emissions would be 67 million tCO2, or 3.25 per year (Sitoe, 2010). This would be equivalent to US$ 16.75 – 33.5 million a year assuming prices per tCO2 of 5 and 10. Therefore, this would be the minimum financing (ideally from public funds to avoid the effects of fluctuation of carbon prices) that would have to be made in order to ensure that further increase in deforestation is avoided. However, the projects baseline is that Mozambique should commit to reducing deforestation in the next 15 years to the 1972 level of 0.21%, and then the avoided emission would increase the monetary value.

Box 2 Suggested policy provisions

- Environmental services from native forests are owned by local people, particularly the forest dependent communities. Therefore, direct payments (cash and/or in kind) should be made to them.
- Foreign and national investors entitled to environmental services from planted forests financed under CDM or similar mechanism.
- Payments to reduce deforestation should go where they are most effective. The balance of benefits between the forest dependent people and the biomass energy dependent urban dwellers should be defined.
- Urban dwellers should benefit from in kind payments to ensure adoption of alternative and energy saving technologies.
- Payments for carbon sequestration should be part of a series of environmental benefits. Avoided deforestation has a spillover effect of biodiversity conservation and maintenance of watershed services and vice-versa. Therefore, there should be mechanisms to finance the *total value* of services as illustrated below.



Addressing the challenges of the supply is crucial, and so is the demand which brings commitment and accountability as a basis for monitoring the land use practices, stimulate reporting and enable external verification. Additionally, they need to support sustainable livelihoods as well as development efforts at the local level. Carbon related payments alone will not be sufficient to effect the expected changes in land use practices and value attached to forest resources in general. Although Mozambique is the case study in this paper, this will certainly resonate beyond its borders. For example, the CBNRM in Southern Africa or other participatory resources management processes offer useful lessons on combining conservation and development, as well as on the governance structures particularly on income distributions.

In Mozambique, it is clear that failure to take into account the full value of resources (products and services) limited the potential economic benefits for the communities, hence their sustainability. The economic gains are clearly different in the wildlife and forest products based initiatives. The wildlife and associated tourism services in Botswana, Kenya, Namibia and Zimbabwe yields significant revenues, but the private sectors have a crucial role in running the businesses. On the contrary, areas focusing on non-timber forest products like in Ghana, Malawi, Mozambique, Tanzania and Zambia yields relatively lower benefits. CBNRM offer lessons on governance such as on payments at household and community levels and impacts (Bond *et al.,* 2009). The authors observe that while both CBNRM and PES have a small although positive contribution to income, they also bring other non-economic benefits such as strong rights. Failure to recognize the contribution of CBNRM to different services is the fundamental cause for their undervaluation in the context of these initiatives. The payment of full values should follow the observation of the following conditions:

- Clearly identified and the real threats to the services;
- Accurately quantified;
- Ascribe them to particular beneficiaries;
- Someone (private companies or individuals and/or public funding) is willing to pay;
- Through an adequate financial mechanism;
- Overseen by credible institutions;
- Credible management options to avoid that threat have been identified.

Another aspect of fundamental importance on the PES is the players, in particular the potential local beneficiaries. Communities are not homogenous, and they will not equally contribute to maintaining or enhancing environmental services. While payments to communities are important in ensuring share and collective responsibility, the identification of the different groups is relevant in determining the types of incentives that can be packaged to promote environmental services. Household economic status is useful disaggregation index (Figure 1).

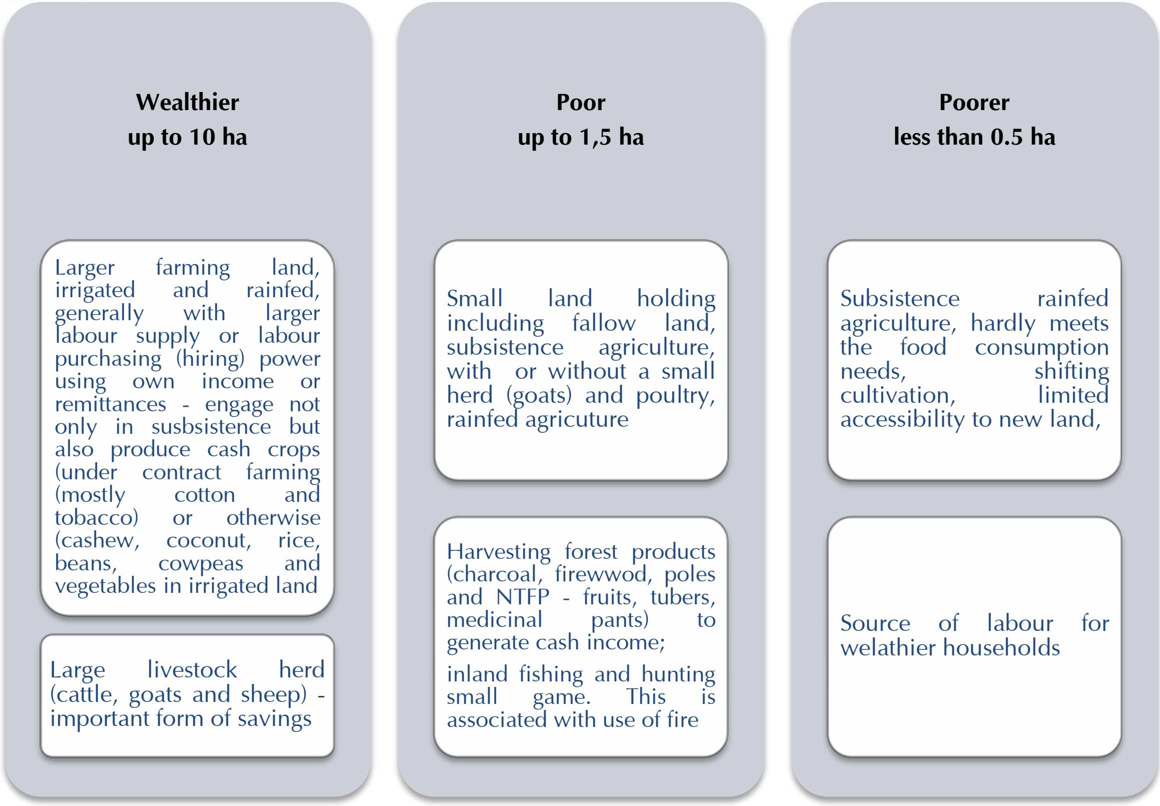


Figure 1: Understanding the Communities in General – What Poverty Means at Local Level

The 'wealthier' category can be targeted with interventions on sustainable agriculture land management to increase productivity and prevent area expansion and encroachment to the forests. Payments for environmental Services for the 'poor' category of land users could focus on promoting implementation of alternative income generation activities (for example, beekeeping which is not compatible with the use of bushfires, efficient technologies of charcoal production) and introduction of agroforestry and other conservation agriculture technologies. The third category of land users comprises the households with less access to land. These may not be significant beneficiaries of the PES as such, unless this is combined with rural development interventions. Identifying the different categories of actors and the extent to which they are associated with a particular product and service is key for targeting the payments where they will have most impact. In that sense, the forest categories (Figure 2) defined in the forestry and wildlife policy are equally useful in identifying the land users that can potentially participate in PES schemes.

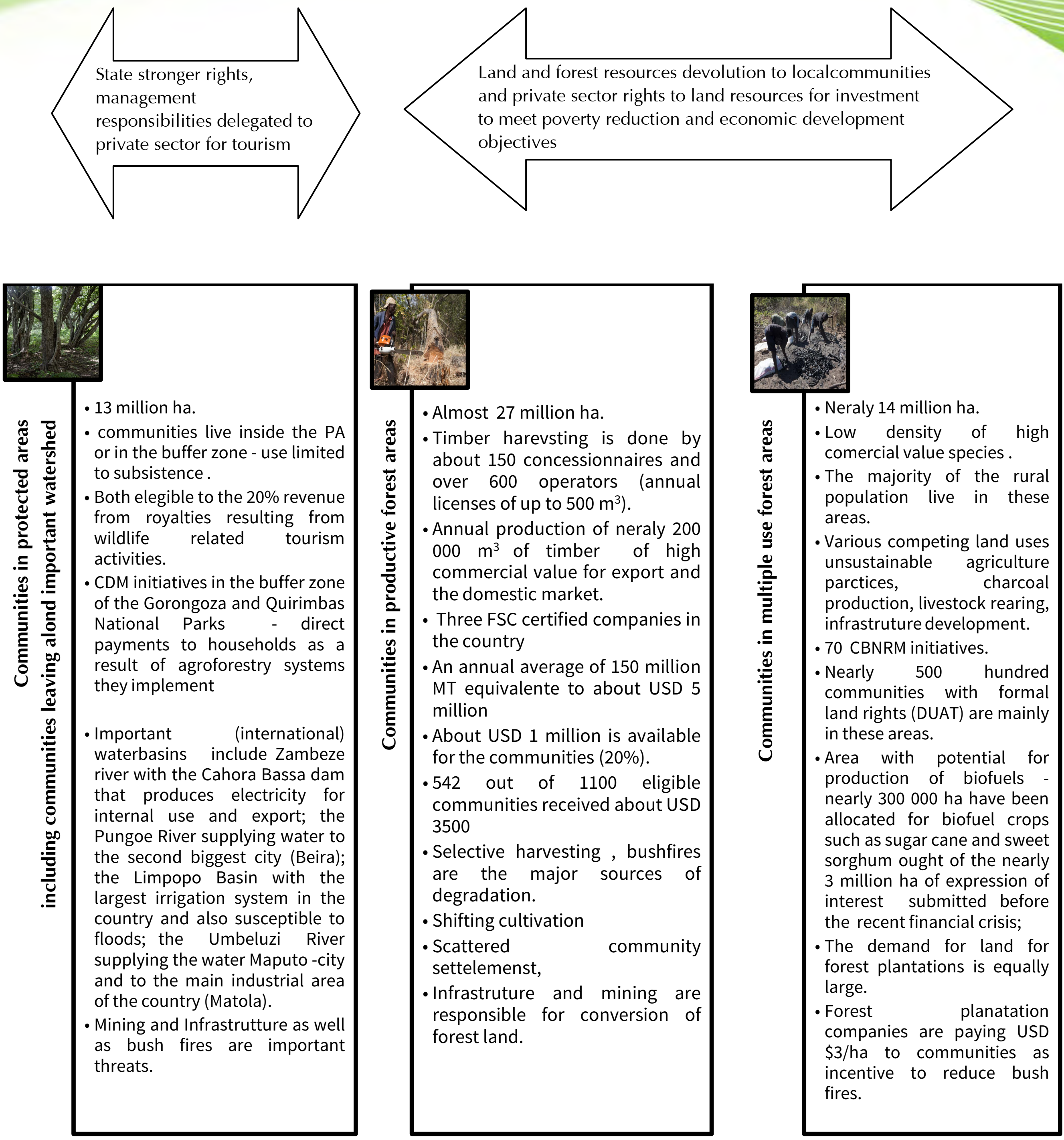


Figure 2: Understanding the Communities in Different Contexts of Forest Management regime

It is possible to continue the disaggregation of the communities and other resources users. However, the differentiation so far does serve to illustrate the fact that payment for environmental services needs to take into account these different contexts and identify the potential suppliers to subsequently monitor the impact. For example, the population in the protected areas should be provided with cash incentives to encourage development of economic activities outside or to provide some level of purchasing power. The population in the productive forest areas should target farmers and forest harvesting groups, including timber operators, to encourage formation of associations/societies in order to upgrade their operations to concessionaires, hence becoming bound to comply with the requisites for harvesting high value commercial timber.

These new and existing concessionaires should also strive to acquire FSC certification to provide an additional assurance of implementation of the management of the forest resources. The last category represents an area of different interests and competing land uses. Most of the deforestation takes place in this category. Therefore, further development of CBNRM and other integrated conservation and development initiatives is essential. Payments for a number of services (biodiversity, watershed protection and carbon) should be considered as complementing rural development interventions. This will address the needs of the poorest members of the community. CBNRM provides a platform for institutional set up on which to build the payment schemes. The Box 2 (continued) highlights additional provisions to take into account for different forest resources that the communities may may rely upon. These too should be considered in determining the amount and the payment mechanism.

Box 2 Policy statements or provisions (continued)

- The communities in protected areas bear the cost of conservation of biodiversity – e.g. human-wildlife conflicts. They should be compensated for their contribution to achieve that objective. The access and benefit sharing mechanism of the CBD should provide a platform for that. The area (surface) of population settlements determine the proportionof benefits that should accrue to each community.
- The threat to land conversion is significant, therefore the payment for reduction of emissions from land use change.
- The state already contributes 20% of the revenue from royalties to promote sustainable use and management of natural resources; the private sector exploring the protected areas should also make a contribution in order to compensate more fully the opportunity cost incurred by the communities.
- The protected areas in particular forest reserves were established to protect watersheds. Upstream and downstream communities should be compensated for their role in the maintenance of watershed or for encouraging them to do so. Hydropower, electricity distribution and water companies should be the main buyers of the service. Negative impact of transferring such costs to the consumers should be assessed in order to protect those in lower income extreme.
- The conditionality should be observed to ensure compliance.
- Land use planning and zoning should guide the payments to address specific environmental challenges and services, particularly in the productive and multiple use forest areas
- The support to integrated conservation and development initiatives, sustainable land management should continue as well as being complemented by innovative compensation mechanisms. Sacred forests should also be eligible to payments.
- The buyers of environmental services, the suppliers and government should ensure periodic monitoring of the impact that the payments are bringing to the environment and their spill over effect reducing poverty and in the development of the country as a whole. This information should be reflected in the national accounts.

In Mozambique, like elsewhere there is a declining trend in resource availability in the coming years in terms of value of the products, biodiversity richness and carbon stocks. The impact of climate change at local level may be mitigated through conservation. The REDD+ debate and the recently developed national strategy present a renewed opportunity to develop additional and innovative approaches to financing conservation in the country. REDD+ only addresses 20% of the global emission, but it has occupied the international debates on climate change mitigation. Calls are made to provide funding for developing countries to manage forest resources in a sustainable manner. However, discussion on the use of a market mechanism brings concerns of a potential drop of carbon prices as the supply increases. Experience over the years is that markets have led to the problems we are facing today. This creates serious doubts over their ability to address the impact of that failure in future. In addition, there is need for ealism while rewarding communities for the opportunity costs of conserving ecosystem services. In Mozambique, the experience of Nhambita project has shown that on account of the substantial awareness that this CDM project has had on the local farmers, their expectations of benefits could be very high. Yet, communities are receiving benefits for 7 years only out of the 100 years of contract. Against the high expectations, it is hard to foresee sustainability of the system. A public fund with robust systems to ensure fairness and transparency in decision making, ensure payments to the right land users and monitor the application of equitable mechanisms is the way forward.

Conclusions

This paper has explored the possible introduction of payment for ecosystems services in Mozambique to complement the efforts on integration of conservation and development and sustainable rural development interventions. The National REDD+ Strategy provides a momentum in assessing the policy gaps and opportunities to implement payment for environmental services schemes in the country. The basic requirement of resources tenure, particularly land and forests rights for the communities are already embedded in the legislation. However, given the growing interest on implementing climate change mitigation measures, it is essential to spell out particularly the rights to environmental services (particularly carbon due to its role in climate regulation). As such, the paper suggests that the ownership rights should be ascribed to the local communities. It is further suggested that PES should be considered in a context of overlaid benefits starting with supporting efficient productions systems through to carbon sequestration. Avoided deforestation and conservation of resources inside and outside protected areas has a spillover effect on biodiversity conservation and maintenance of watershed services and vice-versa. Therefore, there should be mechanisms to finance for the total value of services (watershed *plus* biodiversity *plus* carbon). Only these payments can address the opportunity costs of different land uses, hence being potentially more attractive and just for the land users. This also will enable the leverage on the different UN conventions which have financing mechanism such as the CBD, CCD and the FCC. Markets have failed to address the problems of sustainable use of resources in the past and will not fix the climate change challenges in future. Therefore, the PES while capitalizing on the payments that companies and individuals are likely to make, there is need to have a public fund to address the problem. Identification of different land users in different contexts will allow the design of payment mechanisms that respond to particular challenges. Building on this, further qualitative and quantitative analysis should be carried out to provide insights on the tradeoffs of policy provisions and payment schemes. Given the yet limited application of PES in many countries in Africa and the lessons on the implementation of participatory natural resources management and CDM initiatives, a comparative analysis with countries like Ghana, Tanzania and Uganda is likely to be pursued.

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POLICY, LEGISLATION AND INSTITUTIONAL FRAMEWORKS GOVERNING PAYMENT FOR ECOSYSTM SERVICES IN UGANDA

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ABSTRACT

The policy, legal and institutional framework for payments for ecosystem services in Uganda shows a system that can be adapted to accommodate development of markets or compensation for ecosystem services. Principally, the policy structure was not designed for payments for ecosystem services (PES). Even newer policies such as the National Forestry Policy (2001) and the National Fisheries Policy (2004) policies did not explicitly integrate PES for ecosystem services. Nonetheless, whereas the laws and policies are not entirely conducive for PES, the set up appreciates the need for compensation for ecosystem services. Thus, it provides a rudimentary framework for PES, which can be improved over time. Indeed, many actors in ecosystem services schemes appreciate that even with some limitations; there is room for operationalising PES.

Introduction

Payment for ecosystem services (PES) has been defined as a voluntary transaction where a well defined ecosystem service, or land-use likely to secure that service is being bought by a buyer from an ecosystem service provider; and if the ecosystem service provider secures the service provision (Wunder, 2007). Generally, payments for ecosystem services refer to restitutions made to ecosystem service stewards to offset foregone ecosystem stewardship benefits (Van Noordwijk *et al.,* 2007). They include self-organised contracts, negotiated agreements and remit systems. Globally, payments for Ecosystem Services (PES) deals have emerged wherever businesses, public-sector agencies, and non-profit organizations have taken an active interest in addressing particular environmental issues. These schemes provide a new source of income for land management, restoration, conservation and sustainable use activities, and by this have significant potential to promote sustainable ecosystem management. However, for the schemes to operate effectively there should be conducive laws, policies and institutional frameworks in place.

In the midst of the growing interest in payments for ecosystem services in Eastern and Central Africa, there are several obstacles to their development (Ruhweza, 2008; Yatich, 2008). These obstacles include limited awareness of the monetary value of ecosystem services, limited awareness among beneficiaries, or limited awareness of potential buyers of the need to compensate providers, ambiguous statutory and policy framework for PES, and the limited institutional capacity for designing and implementating PES programmes (Ruhweza, 2008). This paper presents a review of existing policy, legal and institutional framework for PES in Uganda. Data was generated through focused group discussions with resource owners (stewards) and resource users (beneficiaries); and through interviews with key informants in the management of natural resources and those engaged in PES related activities at sub-national and national levels.

Overview of Payment for Ecosystem Services in Uganda

Over the last decade, payments for different types of ecosystem services emerged as one of the innovative responses for management of ecosystems. This trend reflects the conventional wisdom that alleviating poverty is the appropriate way to conserve and protect the environment. The majority of PES and PES-related activities undertaken in Uganda fall in three categories of payments for carbon sequestration, payments for biodiversity conservation and payments for watershed services (PWS). Inventories of PES and PES-related activities carried out by Ruhweza and Masiga (2005) identified at least eight groups of carbon finance schemes, namely; hydropower projects, small community level and large reforestation projects, biodiversity conservation projects especially with Uganda Wildlife Authority (UWA) and National forestry Authority (NFA), and other agencies, and proposed watershed payments projects. Since 2008, the number of carbon projects has increased in the country, including the first CDM bi-carbon project at Rwoho Central Forest Reserve. Examples of active carbon finance schemes include small bio-carbon forest projects (the

Plan Vivo-Trees for Global Benefits Program and the International Small Group and Tree Planting Programme-TIST); Large-scale Forests Rehabilitation in Mt Elgon and Kibale National Parks (UWA-FACE project); and the Nile Basin Reforestation project Under Global woods Uganda in Kikonda Forest Reserve (Ruhweza *et al*., 2008; Baldus, 2010) as described in Table 1. PWS schemes are the least patronised in the country.

Table 1: Forest Payments for Carbon Sequestration Projects in Uganda

Project	**Investor**	**Fund invested**	**Carbon offsets**	**Benefit sharing**
International Small Group and Tree Planting Programme (TIST)	World Bank Bicarbonate Fund, USAID, Dow Chemical Company	Dow US$ 1.2 million; WB share unknown	2.3 mtCo$_2$ by 2017	Carbon rights transferred to Clean Air Action (CAAC)
Forests Rehabilitation in Mt Elgon and Kibaale National Parks	FACE Foundation	Not available	7.1 mtCO_2 over 99 years	Carbon offsets with FACE Foundation. All other rights with UWA
Plan Vivo-Trees for Global Benefits Program	DFID, USAID, START, Tetra Pak (UK)	€ 1 million (expected)	0.9 tm CO_2 by 2012	Timber, biomass for farmers. Tetra Pak and others buyers of carbon credits
Commercial plantation Projects	Tree farms, AS, Norway (local subsidiaries)	At least US$ 0.6 million in Uganda	2.3 mtCO_2 expected in Uganda	Commercial plantation, all rights with the company
Private sector CDM or voluntary market	The New Forest Co.	US$ 4.5 million	Not available	Trees and products belong to NFC,
Nile Basin Reforestation	World Bank Bicarbonate Fund	Expected income by (2012) is US$ 435,000	0.25 mtCo$_2$ by 2017	Timber benefits shared with locals, carbon credits with World Bank

Source: Rohit *et al.,* (2007).

Biodiversity conservation projects in wildlife conservation, including tourism and ecotourism constitute the largest concentration of compensation and rewards schemes (Table 2). Biodiversity compensation schemes are operated by NGOs together with communities such as the Chimpanzee sanctuary on Ngamba Islands operated by the Chimpanzee Sanctuary and Wildlife Conservation Trust (CSWCT). There are several certified organic agriculture projects that can be considered as payments for biodiversity conservation. These activities are mostly organized under National Organic Agriculture Movement of Uganda (Tumushabe, *et al.,* 2008). The largest segment of biodiversity compensation schemes are managed by semi-autonomous government bodies in charge of forestry and wildlife conservation and management. These schemes include revenue sharing schemes and collaborative forestry management schemes under the UWA and NFA. These schemes are larger because the government agencies are responsible for a larger size of natural resource than is available for NGOs or private sector.

Table 2: Payments for Biodiversity Services

Project title	Buyer	Seller	Project location/ area	Description of deal	Flow of payments
Mgahinga Bwindi Impenetrable Forest Conservation Trust (MBIFCT)	Government of Uganda	The communities in and around Mgahinga Bwindi National Park	Located in southwestern Uganda. Bwindi Impenetrable N.P. covers 331 km^2 and Mgahinga Gorilla N.P	A government deal and World Bank GEF grants to assist local community groups to develop activities of positive impact on the parks.	Community development activities 60% 20% goes to ecological & socio-economic research 20% for park management
Chimpanzee Sanctuary and Wildlife Conservation Trust	CSWCT; UWA; UWS; ECOTRUST; Born Free Foundation; International Fund for Animal Welfare; Jane Goodall Institute	Land lords and local communities which own Ngamba island	Ngamba Island 40 ha of rain forest on L. Victoria. Habitat for chimpanzees confiscated from the wild.	CSWCT runs the sanctuary with the help of local communities and government support	CSWCT pays the land owners directly for their land
Co-management in Kibaale and Mt. Elgon N.P.	UWA and NFA on behalf of the GoU	Communities around Mt. Kibaale and Mt. Elgon N.P.	Kyabirizi, Nyakarongo parishes and Nyabweya parish in Mt. Kibaale and Mt. Elgon N.P. respectively	A GoU deal. Communities have signed formal agreements with UWA and NFA.	Rights arrangement between communities and N.P. Communities can minimally exploit park resources
Uganda organic products	Buyers of organic products from Uganda in North America, Europe, Japan.	More than 45,000 certified organic producer	Organic production throughout the country but concentrated in western, north and central Uganda. Area of over 250,000ha.	Organic export companies and farmer groups are certified and sell directly to traders in foreign markets at a premium.	Farmers receive a premium of 25% to 50% over the conventional products

Source: Ruhweza *et al.* (2008)

By all indications, PWS schemes are the least patronised in Uganda. Ruhweza *et al*. (2008) documented only two PWS projects (Table 3). Moreover, the documented PWS schemes cannot be completely separated from the objective of biodiversity conservation. Yet it has been shown by NEMA/UNPEI (2008) that PWS offers tremendous potential for revenue generation for the poor in rural areas and the soil and water conservation in watershed areas such as the Mt. Elgon areas of Uganda.

Table 3: Payment for Watershed Services

Project title	Buyer	Seller	Project location and area	Description of the deal	Flow of payments (structure)	Institutions engaged
Uganda Breweries Ltd – WID, NFA On-going activities	Uganda Breweries Ltd (UBL)	National wetlands programme and NFA	Management of wetland in Luzira, along the shores of Lake Victoria and the forest watershed in the L. Victoria Catchment	Contribution towards sustainable management of L. Victoria watershed management activities of WID & NFA	A partnership with the National Wetlands Programme (NWP) worth US$25,000	Makerere University Chemistry Dept, UBL, and MWE monitor quality of the water in the lake.
Kitanga Wetlands Conservation Grant on-going project	GoU	Kitanga Wetlands Fish Farmers Association (KWFFA)	Kitanga wetlands K.N.P. The wetlands are under threat from reclamation activities, seasonal fires and wildlife hunting, building	GoU deal Promotes regeneration of wetlands, which have shrunk from 859 ha to 496 ha and alternative livelihoods to farming communities	Activities include: environmental awareness, wetland conservation and management activities and promotion of alternative livelihoods	Kitanga Wetlands Fish Farmers Association (KFFA) is the community based organisation that manages the project

Source: Ruhweza *et al.* (2008)

Policy and Legislative Framework for Management of PES

On 9 May 1992, the world's governments, including Uganda, adopted the UN Framework Convention on Climate Change (UNFCCC) which provides the foundation for intergovernmental efforts to address the problem of anthropogenic global climate change (Pfaff *et al.,* 2000; UNFCCC, 2002). The Convention sets an ultimate objective of stabilizing atmospheric concentrations of greenhouse gases at levels that would prevent "dangerous" human interference with the climate system. According to the Kyoto Protocol, the interim implementation framework for the UNFCCC, developed countries agreed to limit their emissions to 5% (on average) below 1990 levels by the period 2008–2012. Meeting these commitments required significant costs and changes in energy use. In response to this challenge, it has been suggested that initiatives to slow deforestation and to promote natural forest regeneration and forestation could offset 12–15% of global fossil fuel carbon emissions from 1995 to 2050. The creation of certified emissions reductions (CERs) under the Clean Development Mechanism (CDM) established in Kyoto incorporated tropical sequestration within the effort to meet Kyoto emissions targets. That was envisaged to lower the cost of implementing these limits, thereby yielding economic and sequestration benefits (Pfaff *et al.,* 2000).

At the national level, the National Forestry Policy (2001) mentions the need to consider markets for carbon sequestration. In addition, both the National Forestry Policy (2001) and the National Forestry Business Plan (2003) describe other activities within the Community Forestry Management (CFM) arrangements and revenue generation in the latter that would be used as a basis for developing payments or compensation for carbon sequestration and biodiversity conservation.

However, it does not mention the roles or types of participants in such markets. The Wildlife Act, Cap 200 mentions several wildlife use rights such as access to medicinal plants and/or bio-prospecting, and wildlife trade. The same Wildlife Act also establishes mechanisms for benefit sharing schemes between communities and the Uganda Wildlife Authority (UWA). However, it still falls short of description of PES. Even though, the legislation did not clearly describe ecosystem payments, it makes significant mention of the possibilities for carbon and biodiversity ecosystem service trade. For UWA, benefit sharing consists of a 40% of the gate collections going to communities in the parishes neighbouring the park. Other benefits include access to the National Parks to extract Non-timber forest products such as firewood, honey, fruits, and medicinal plants. The communities can also perform cultural rites in the National Parks and Wildlife Reserves, through local arrangements with the Park authorities.

Regulation and Management of Sale of Ecosystem Services

Under the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto protocol, the Designated National Authority (DNA) is the Minister of Water and Environment, and the Department of Meteorology coordinates government's engagement in actions regulating emissions of green house gases. In 2009, a Climate Change Unit (CCU) was established in the Department of Meteorology to deal with carbon sequestration and provision of advice, supervision and registration for all projects dealing in carbon emission reductions. These activities are however not restricted to government agencies. There are other non-governmental institutions that are independently initiating PES activities in the country in sectors of energy, forestry, water and agriculture.

Property Rights, Land and Legal Rights to Sell Ecosystem Services

The management of natural resources is legislated under the Constitution of the Republic of Uganda that guarantees access of Ugandans to natural resources either in form of those managed on their behalf by the government and those they govern on their own. The Local Governments Act (1997) stipulates that the natural resources that are under the stewardship of local governments such as local forest reserves and other natural resources such as sand and stones are defined. The National Forestry and Tree Planting Act (2003) established forest governance under the National Forestry Authority (NFA), and the District Forest Services (DFS) under the District Forest Officer (DFO). NFA manages the central forest reserves and DFS manages both local forest reserves as well as forests on private land. Under the Act, private forest owners have the right to make decisions on how the forests will be managed and utilized. These decisions include whether or not to sell goods and services from their forests. Whereas several NGO-supported carbon sequestration projects are running in the country, the thrust of the carbon trade, especially under the Clean Development Mechanism is restricted to the national agencies of NFA and NEMA, apart from a few private deals such as Kikonda Forest Project and FACE Foundation. Others such as ecotourism, non-wood forest products, and bio-prospecting are carried out by government agencies such as UWA and NFA, and therefore have the rights to sell the ecosystem services.

Community Based Organizations' Legal Rights to Sell, Approve or Reject Deals

A number of communities and community groups have been organized by institutions such as ECOTRUST and NFA to participate in voluntary carbon trade arrangements with private buyers from Europe and the United States. The groups have been educated on the trade arrangements and are recruited on the basis of their willingness and ability to participate based on whether or not they own land and can plant trees. Some of these deals are built on introducing principles of sustainable forest management using indigenous trees and also as part of collaborative forest management arrangements. Other considerations include ensuring that the projects do not interfere with the food security of locations. The arrangement, which is contracted over a number of years, includes offering farmers a purchase plan for the emission credits they generate over an agreed number of years; usually over 10 years.

Management of Risks Associated with Payments for Ecosystem Services

Management of risks associated with PES is largely being provided by the project-specific funding agencies. For many of the organized PES schemes such as the Municipal Waste project and the Rwoho CFR-CDM project under NEMA and NFA, respectively, the World Bank is providing the risk assurance for the projects. There have been efforts by NEMA and UNDP to create awareness within the financial services industry on the possibilities of conservation financing and banks such as NEDBANK, Standard Chartered, Barclays Banks as well as Development Finance Company of Uganda (DFCU) are willing to participate in PES activities, particularly carbon trade arrangements. The banks' involvement is still limited by poor regulatory arrangements, including risk management.

Standards / Guidelines Related to Ecosystem Services Sales

For the three categories of ecosystem services - carbon, watershed and biodiversity services, there are international standards that apply for a mature PES market. The only standardized PES market in Uganda is that for carbon where emission reduction credits are sold in line with international arrangements. Biodiversity services sold as organic agriculture produce are certified and sold in the market in tones. A premium is earned above the conventional market price, which serves as the compensation. Whereas valuation is market determined, attribution is based on a well-structured value chain (Tumushabe *et al*., 2008). Payments for watershed services standards consider water quantity and quality. Quantitative measurements such as cubic metres could be used for such trade. In Uganda, the water act empowers the Directorate of Water Development (DWD) and Directorate of Water Resources Management (DWRM) in the Ministry of water and Environment

(MWE) to impose charges and fees and regulate easements for sustainable use of water resource. The Uganda Water Act Cap 152 makes provisions for Charges and Fees, which are fixed by the minister. They include charges and fees for taking or using water permit, discharge of waste under a waste discharge permit, charges and fees fixed in accordance with pricing policies established by water action plan or other policies as prescribed by government. Also, the director may levy and demand charges of fees fixed by minister.

The Water Act (Cap 152) also makes provisions for compensation from the Ministry of Water and Environment and the Director (Directorate of Water Development - DWD) for damage caused to land through exercise of powers. The damages include deprivation of possession of surface land, damage of surface land and any improvements (trees or crops), damage to stock, and all consequential damage. Compensation may be in the form of money or provision of alternative supply of water, exchange of land for another piece of public land or any type of compensation which minister may consider appropriate. The Water Act Cap 152 also makes provisions for easements. The holder of a water permit who wishes to bring water to, or drain water from his/her land over land owned or occupied by another person may apply to the Director of water development for the creation of an easement over that land if he/she has been unable to obtain an easement by agreement with the owner or occupier of that land. Also, the holder of a water discharge permit who wishes to drain waste from his/her land over land owned or occupied by another person may apply to the Director for the creation of an easement over that land if he/she has had unable to obtain an easement by agreement with the owner or occupier of that land.Whereas the modalities for compensation are not oriented to ecosystems services, mechanisms for valuation and attribution are clear and can be adapted for PWS.

Monitoring, Reporting and Verification for PES Schemes

Section (b) of the Bali Action Plan calls for enhanced national/international action on mitigation of climate change, including, inter alia, consideration of: (i) Measurable, reportable and verifiable nationally appropriate mitigation commitments or actions, including quantified emission limitation and reduction objectives, by all developed country Parties, while ensuring the comparability of efforts among them, taking into account differences in their national circumstances; (ii) Nationally appropriate mitigation actions by developing country Parties in the context of sustainable development, supported and enabled by technology, financing and capacity-building, in a measurable, reportable and verifiable manner; (iii) Policy approaches and positive incentives on issues relating to reducing emissions from deforestation and forest degradation in developing countries; and the role of conservation, sustainable management of forests and enhancement of forest carbon stocks in developing countries. There are limited efforts towards MRV at the sub-national level where a number of players are initiating PES demonstration projects.

As market arrangements for ecosystems services emerge, carbon payment schemes have measurement, verification and monitoring plans. Voluntary market and CDM market credits are measured verified and certified in compliance to the start under which the credits are being sold. In Uganda voluntary Market standards for Plan Vivo, Carbon Fix and Rain Forest Alliance are being operated in the voluntary market. Enforcement for the voluntary market is often undertaken within the associations or groups that are linked to the supporting or service provider organization. For the CDM market, the monitoring, compliance and enforcement roles have been left to the agencies that are part of the agreement such as the NFA and NEMA.

Biodiversity payments for organic agricultural produce are also managed through certification and continued monitoring and annual renewal of certification. This too is largely undertaken through international agencies. There have been efforts to raise the standards of national certification to meet international standards with UgoCert, which is affiliated to the National Organic Movement of Uganda (NOGAMU). With regard to ecotourism and tourism payments for biodiversity services, certification is being done by international ISO standards such as ISO 14001 or ISO 22000. There is growing interest for many industries dealing in agricultural products such as tea, sugar manufacturing companies to develop comparative standards, which is a positive development in relation PES.

Institutions and Institutional Arrangements for PES

Swallow *et al.* (2007) identified three generic types of functional groups in compensation and rewards for environmental services: ecosystem stewards, environmental services beneficiaries, and intermediaries. Ecosystem service stewards are entities whose actions modify the quantity or quality of ecosystem services available to environmental beneficiaries. Ecosystem service beneficiaries are entities who benefit from environmental services generated by an ecosystem. Ecosystem service intermediaries are entities that directly or indirectly shape interactions among ecosystem stewards, environmental service beneficiaries, and the ecosystem. The institutions engaged in PES or PES-related activities include Government agencies; Non-Governmental Organisations (NGOs), private companies, international agencies and communities/community groups. In Uganda, the government agencies include the NFA, NEMA, and UWA, Trade and investment promotion agencies of the Uganda Investment Authority (UIA) and the Uganda Export Promotions Board (UEPB), the Climate Change Unit of the Meteorology Department, and Non-Governmental Organisations (NGOs), principally ECOTRUST, Nature Harness Initiatives, Katoomba Group and Forest Trends. Eco-agriculture Partners and the Uganda Carbon Bureau are engaged as intermediaries, while the private sector consists of investors such as Global Woods Ltd.
The current organization of ecosystem service compensation is divided into market-based deals with payments of money, such as in the ECOTRUST's Plan Vivo scheme, the Kikonda Forest Reserve Project, and the Nile Basin Reforestation Project of Rwoho Central Forest Reserve. Many of the monetary payments are for carbon payments. For biodiversity conservation, it is a mixture of

monetary payments and incentives. The clearest deals are those managed by the NFA, UWA, the Chimpanzee Sanctuary and Wildlife Conservation Trust (CSWCT). Both NFA and UWA have collaborative resource management arrangements, where communities living next to the protected areas are allowed limited access to natural resources such as firewood, grass and water from the protected area in exchange for participation in keeping out encroachers. In specific cases, they have been allowed to even plant some of their trees in the protected areas as part of a reforestation program. The trees planted belong to the communities and they earn either carbon credits or sell the poles or timber harvested. Direct revenue is also earned from Revenue Sharing agreements over gate fees attained from tourists to the protected area. However, the revenue usually about 20% of the gate fees is often channeled to projects such as schools and medical centres nominated by the communities. The arrangement is strong on compensation and attribution, but weak on valuation. Indeed, there is a contention that some of the social enterprises supported may not be adequately recognizing the support.

Organization of watershed payments is in nascent stages. The current arrangements consist of community associations participating in soil and water conservation (SWC) activities that contribute to given ecosystem services. It is these ecosystem services that will be compensated by the beneficiary communities or entities. Appropriately designed PWS schemes are based on proper appraisal of ecosystem service beneficiaries and their willingness to participate in the schemes (Swallow *et al.,* 2007), and commitment of the stewards has to be obtained through contracts. Attribution for ecosystem services is often based on recognition of need between the buyers and sellers (van Noordwijk *et al*., 2007). Non-Governmental organisations active in PES activities in Uganda include Katoomba Group, ECOTRUST, Jane Goodall Institute (JGI), World Wide Fund for Nature (WWF) and the National Organic Movement of Uganda (NOGAMU). They also provide information about PES, training and capacity building. Katoomba provides information on the process individuals, companies, and other organizations have to go through to access certain PES markets. Through its incubator project, Katoomba Group provides technical support to promising PES projects.

ECOTRUST, JGI and WWF have performed as intermediaries for international agencies in the ecosystem services market, ***or*** as project implementers. ECOTRUST runs several community-based carbon finance forest projects, while JGI, CSWCT, WWF and NAHI engage in similar projects in biodiversity conservation. WWF, IUCN and NAHI have also been developing watershed payments activities in the Mt. Elgon region of Uganda. NOGAMU, the umbrella organization for organic agriculture firms, farmers associations and non-governmental organization supports market development, as well as policy advocacy for organic agriculture in the country. The institutional framework for PES and PES-related activities is still largely inefficient as acknowledged by many national level stakeholders. This is because there is a limited appreciation of PES among potential buyers and sellers of ecosystem services. In addition, there are few buyers and sellers, which increases transaction costs and further reduce the incentives intended for participation in PES activities.

Policy and Institutional Gaps in PES in Uganda

- There is no government agency in Uganda that exclusively regulates compensation or restitution for ecosystem services at the moment. However, a new Bill is before the Ugandan parliament that seeks to convert the meteorology department into a semi-autonomous agency that will, among other things, register, monitor and support the activities of carbon projects.
- Regulation of payments for biodiversity services is rather ambiguous because different agencies have mandates limited to their governing legislation to manage the resources within their areas of jurisdiction; e.g. National Parks and Wildlife reserves for Uganda Wildlife Authority (UWA) and Central Forest Reserves for the National Forestry Authority (NFA).
- There is no mechanism or strategy in place for risk management for PES or natural resources related projects in the country. For many of the organized PES schemes, there is no risk insurence, and for a few, such as the two CDM projects - the Municipal Waste project and the Rwoho Central Forest Reserve's CDM project under National Environment Management Authority (NEMA) and NFA, respectively, the World Bank itself is providing the risk assurance for the projects.
- Relevant Government standards/guidelines related to ecosystem service sales are limited to carbon sales where emission reduction credits are sold in line with international arrangements. The watershed services and biodiversity markets are not as clearly defined. However, in each case, there are international standards that would apply for a mature PES market.
- There is inadequate commoditization (valuation, attribution and market identification) of ecosystem services from Uganda's ecosystems. This has been mentioned as the major constraint for the NFA with regard to coming up with a position for payments for watershed services provided by central forest reserves in the country. Beyond commoditizing watershed and biodiversity services, there is also a need to build scientific evidence on the contribution of forests and other ecosystems to watershed and biodiversity services. This evidence is still inadequate and therefore, commoditization and establishing the financial value of environmental services remains a hard sale.
- The institutional framework for PES and PES related activities is still largely inefficient. This is because there is limited appreciation of PES among potential buyers and sellers of ecosystem services. Also, because there are a few potential buyers of ecosystem services, the transaction costs are quite high which further reduces the incentives intended for the sellers of the ecosystem services.
- Unlike non-governmental organizations, there are limited efforts by government agencies like NFA, UWA or NEMA to invest in technical capacity building in PES; yet, these government agencies are the ones mandated to manage most of the natural ecosystems.
- Enforcement of existing policies is lacking both at national and sub-national levels. This largely explains rampant degradation of Uganda's ecosystems.

Recommended Policy and Legal Options for PES in Uganda

Carbon Markets in Uganda

Broadly, there are two types of markets for carbon, namely, compliance and voluntary markets. Tradable carbon markets are derived from, among others, land use and forest projects, whereas the only national-level compliance market is in the European Union, which does not allow forest carbon to be traded under its system (WWF, 2010). Compliance markets are derived from a fixed regulatory system, such as cap and trade system designed to reduce carbon emissions (UNFCCC, 2010). There two main revenue streams that can be used for forestry conservation: new public funding from sale of carbon pollution permits and new private–sector funding. Voluntary carbon markets function outside compliance markets and enable companies and individuals to purchase and sell carbon offsets on a voluntary basis. Nonetheless, all carbon projects must be able to prove their integrity and sustainability. Viable and marketable projects must be independently validated against an accepted set of standards, certified by a known registry, and independently monitored and verified over time.

Payments for Watershed Services

Payments for watershed agreements are usually agreed either between private water users and environmental agencies and NGOs, or between government and landowners. The approach considers the impacts of industry operators and activities on a watershed. In general, payments for water use come from four major sources - hydroelectric power suppliers, large industrial users, municipal water suppliers and irrigation water users, and are applied toward achieving improved water quality and quantity, through habitat restoration in the watershed. For water payment markets to develop, certain elements must be in place - recognition of the goods and services provided within a watershed; agreement on the value and price of those goods and services; the presence of buyers and sellers; and established property, access and usage rights related to land tenure and water use (Smith *et al.,* 2006).

Watershed markets in Africa are limited due to the lack of technical and market information, inadequate legal framework, institutional inexperience, and few business models. In addition, the lack of monitoring and accounting makes it challenging to appropriately charge for water consumption. Willingness to pay for water services is also difficult due to the high levels of poverty and high transaction costs in overcoming the various obstacles in developing payment schemes (WWF, 2010). In Uganda it has been determined that PWS is feasible in some areas such as Kapchorwa district. The difficult next step is to design a PWS methodology and implement a pilot phase that is then integrated and adopted into the land-use system of the area. Additionally scientific research to monitor the ecosystem service will be necessary.

Compensation Payments

Compensation payments are an effective way to hold companies accountable for the impact they have on ecosystems and biodiversity. They finance conservation by collecting revenue from fines for pollution, royalty fees for natural resource use, compensation for environmental impacts, or even voluntary contributions. Although compensation payments don't necessarily reflect the actual environmental impact or provide one-for-one compensation, they pay for the extraction or use of one natural resource by investing in the conservation of another. Compensation payments are also often referred to as biodiversity offsets. However, biodiversity offset payments rendered by private sector companies are designed to account for direct environmental impacts from a development project. In contrast, compensation payments are typically calculated as a percentage of project development costs. An increasing number of natural resource companies are voluntarily addressing the environmental impact of their activities and enhancing their contribution to biodiversity conservation and sustainable development. Typically, donated financing is managed by an independent conservation trust fund or NGO dedicated to conserving the environment in the area where the resource extraction is taking place. Compensation payments can vary widely in amount and may be voluntary or required by law.

Property Rights, Land and the Legal Rights to Sell or to Approve or Reject Deals

In Uganda, the two fundamental approaches to sequestering carbon in terrestrial systems are protection of ecosystems that store carbon e.g. through actions of reduced emissions from deforestation and forest degradation (REDD); and manipulation of the ecosystem to increase the quantity of carbon dioxide sequestered (Ruhweza *et al* upcoming). The potential for REDD largely lies in protected areas under the management of UWA and NFA while potential for carbon storage increase exists in both protected areas and on private land. In many areas, tenure systems still have dominant customary land systems which, although feasible for small projects, are not attractive for large investments where considerable credit is required or sales of the land to an investor may be hampered by adequate papers. Land management practices seem to be strong for upstream communities but the downstream communities do not have the same level of discipline in managing the land. Upstream communities sometimes ask for some form of compensation for the good behaviour towards managing land compared to their counterparts downstream. There is lack of a clear understanding of how the practices of the communities along the riverbanks and landscape will affect the river and the other users of the water downstream. Learning by example from land management contours has shown that where they exist, the water quality improves in certain respects, e.g. It carries less silt or mud and is therefore cleaner to use.

Community Organisations

The design adopted under ECOTRUST for carbon financing is that the trust facilitates and oversees transactions which belongs to a community association or group, even though the revenue is paid out to individuals. The advantage of such an arrangement is in the shared responsibility of the group in assessing verified emissions rather than the individual alone. Additionally, group/community associations can be used to rally for enhanced impact in the development and conservation activities related to the trade. Community organizations are also a prerequisite for other projects either under CDM, such as the Uganda Nile Basin Reforestation Project in Rwoho CFR, or private deals such as the Kikonda Forest Project. The design of forest carbon projects under CDM rules show strong need to include livelihoods components. Thus future carbon finance policy in Uganda would have to consider socio-economic aspects of type (size, livelihood status, gender balance) of ecosystem service and expected livelihoods impacts. Similarly, community organizations are fundamental to success of PWS and biodiversity payments as on-going work in Kapchorwa district has shown.

Government Agencies that Regulate and Manage PES

In principal, only the Climate Change Unit (CCU) and Designated National authority (DNA) for CDM and UNFCCC in the Ministry of Water and Environment are engaged in regulating and managing the sale of carbon credits in Uganda. Moreover their role is limited to checking compliance of projects to set standards. There are no enabling agencies engaged in ecosystem service trade. Even though the Directorate for Water Development (DWD) issues licenses for water abstraction, for instance, its involvement in the ecosystem service trade is not definitive. In principal, however, adoption of PWS in the Ministry of Water and Environment ought to be a viable approach even though the concept may interfere with some of the current mandates of the Ministry's Directorate. A gap exists in central government participation in PES governance. Even the NFA and UWA who may be engaged are only limited to projects where they are act as investor, although they also regulate other investors undertaking PES projects in protected areas under their jurisdiction, including issuing, extending and cancelling leases. There is, therefore, the option of having an agency to register, monitor, and provide technical support on ecosystem service payments at national level, which would leave both NFA and UWA to act strictly as regulators.

Government's Role in Decreasing Risks associated with PES

Payments for ecosystem services are not a high priority investment area or livelihoods source in the country. For instance, opportunities for carbon finance are limited to three categories: private projects such as Kikonda Forest Project and FACE-Foundation in Kibale National Park, government agency led projects such as the Nile Basin Reforestation Project under the NFA and the non-governmental/non-profit organization intermediated deals such as Plan Vivo. Private deals are undertaken with the expectation of double revenue from timber and some revenue from the carbon finance. However, all these categories face shortcomings. Donor funding for the NFA, subsidies for commercial tree planting under the Sawlog Production Grant Scheme (SPGS) and support to district forests all tend to be small and short-term, and therefore unsustainable.

The private sector has already shown that they are willing and capable of developing commercial plantations with incentives such as Central Forest Reserve (CFR) land, technical support and credit subsidies during the expensive early phase of plantation establishment. The motivation for private projects is also production of timber as part of the major commercial output of forest plantations. However, the Forestry Tax Anomaly means that the main income when the trees are harvested is taxed as if it were an annual income with no recognition of the gestation of the forestry investment. The anomaly is dealt with in different ways in various countries, mainly through exemptions from, or lower rates of income taxes. In Uganda this could be rectified by either allowing the costs of replanting to be set against the proceeds from felling of the first crop or exempting plantation forestry from income taxes or a reform of the VAT system (SPGS, 2008).

Relevant Government Standards / Guidelines Related to Ecosystem Services Sales

International markets largely dictate the standards for ecosystem services in Uganda. This makes clear sense because carbon the most easily traded ecosystem service is sold to international buyers. For biodiversity conservation, however, there have been efforts to enhance the standard of practice based on hospitality industry such as tourism. On the other hand, there are no standards for watershed services because the markets for watershed services do not exist. Also, at the outset, the quality of watershed services must be negotiated in contracts between upstream and downstream communities. Such agreements are expected to provide a starting position for further improving the commitments and eventually lead to standards for watershed services, at least at national level.

Technical Assistance in Identifying and Establishing PES Markets

From a national government perspective the Uganda Investment Authority (UIA) and Climate Change Unit (CCU) in the Department of Meteorology promote carbon finance to investors. For instance, UIA added carbon finance opportunities onto the list of potential opportunities in forestry sector. The CCU provides information support to investors interested in carbon finance. Also, with a bill recently passed to turn it into an authority, the Meteorology Department is evolving from just a department into an institution that can better focus on climate change and meteorological issues. The new authority is expected to provide technical support. However, it is clear that the greater technical capacity to support the start up of carbon finance projects exists outside of government. Most investors in Uganda have used international agencies such as Carbon Fix Foundation and international consultants. In Uganda, there has been an effort by UWA, NFA, Uganda Carbon

Bureau, Katoomba Group, NAHI and others to develop capacity within the professionals in the country. However, none of these is a registered consultant with the UNFCCC or CDM secretariat a common requirement to be able to develop projects that are registered by CDM. Moreover consultancy and registration costs for carbon projects are usually quite high.

Monitoring, Compliance and Enforcement

The current state of monitoring, compliance and enforcement for carbon projects is dictated by the project design. However, for the most part, international verification agencies are used to monitor compliance. In the case of Plan Vivo projects, modalities have been developed where local communities together with the implementing organization, e.g. ECOTRUST can undertake monitoring. However, international experts are often needed for verification of the carbon sequestered in compliance with CDM or other standard regulations. Monitoring and compliance for biodiversity conservation are stated within the wildlife use rights regulations, as well as the Wildlife Act Cap 200. Similarly, the National Forestry and Tree Planting Act 2003 provide regulations on how biodiversity within the forest estate can be managed. The lack of nationally compatible standards as discussed above and lack of monitoring and compliance regulations or performance standards is a limitation on the technical capacity available generally for monitoring such compliance. It also limits the scope for local experts to undertake valuation for compensation and contribution for ecosystem services. In the medium and long term, therefore, there will be need to develop domestic capacity to fully participate in these performance and compliance activities, as well as measurability, reportability and verifiability of carbon emissions. Also, the compliance and monitoring standards for biodiversity conservation and watershed ecosystem services may need to be developed up to a level compatible with what can support market developers and investors to differentiate their product (ecosystem service) and sustain the market.

Recommended Options for Institutions/Institutional Arrangements for PES in Uganda

In characterizing a value chain for payments for ecosystem services in Uganda Ruhweza, Byamukama-Biryahwaho and Masiga (2008) proposed formation of a national PES bureau to act as a national authority or entity to coordinate the activities of government agencies, NGOs and private investors engaged in PES. In the current legislative framework, such an institutional set up could be within the National Environment Management Authority (NEMA) or in the Meteorological Authority. However, there is no short to medium term capacity in either institution to undertake this. Moreover, the mandates of the different government agencies may often clash; for instance whereas NEMA is responsible for domestication of some Rio Multilateral Environmental Agreements such as the Convention on Biological Diversity (CBD), it is not responsible for others such as the UN framework Convention on Climate Change (UNFCCC) which are under Meteorology. Hence, an umbrella national institutional arrangement may be the way forward.

Generally, it would probably be more feasible to use a national umbrella framework with equitable representation of all stakeholders to deal with PES matters. The new institutional framework would then develop rules, standards and also enhance definition of the value chain for PES in Uganda. If an agreement can be reached on the institutional framework, then other concerns can be dealt with - such as its funding modalities and building the technical capacities to support the development of PES opportunities in the country. At the national level, there has been considerable focus on carbon payments projects as delineated in the report on potential investment areas by the Uganda Investment Authority (UIA, 2007). The establishment of the Climate Change Unit (CCU) in the Department of Meteorology of the Ministry of Water and Environment and the novel CDM projects run by the NEMA and NFA provide considerable evidence of this focus. At community level, however, the effort of capacity building has been limited to the effort of non-governmental organizations such as ECOTRUST, NAHI, the Katoomba Group and many others. Whereas, for instance, some of the collaborative Forestry Management (CFM) arrangements between the NFA and communities have also resulted into carbon projects, these results have been mostly due to the efforts of the NGOs engaged to develop the CFMs. There is little evidence that the NFA, UWA or NEMA and other government departments are investing in technical capacity building beyond the efforts taking place within these organizations themselves. Outside of carbon trade, the markets in biodiversity and watershed services have been limited. There are exceptions. These include the Mgahinga-Bwindi Impenetrable Forest Conservation Trust where the country's most significant tourism and ecotourism takes place. However, community participation is largely limited to benefit sharing arrangements that are allowed in the act. Ecotourism sites exist in many conservations areas under the management of UWA and NFA and they involve communities running ecotourism sites or activities under concessions or through memorandums of understanding (MOUs). In these arrangements the communities obtain revenue, which they are able to use for salaries and also maintaining the conservation areas. The capacity of these direct participants has grown largely based on the strength of their own initiative. There are efforts to initiate PWS schemes in the Mt. Elgon regions that are largely NGO led.

As market arrangements for ecosystems services, carbon payments schemes often have measurement, verification and monitoring plans. Voluntary market and CDM market credits are measured verified and certified in compliance to the start under which the credits are being sold. In Uganda voluntary Market standards for Plan Vivo, Carbon Fix and Rain Forest Alliance are being operated in the voluntary market. Enforcement for the voluntary market is often undertaken within the associations or groups that are linked to the supporting or service provider organization. For the CDM market, the monitoring, compliance and enforcement roles have been left to the agencies that are part of the agreement such as the NFA and NEMA. The monitoring of compliance and enforcement is non-existent for watersheds markets. However, this reflects more on the scale and stage of development of these markets rather than the absence of the will to regulate, the watershed services markets are largely still in their infant stages. Many of the rules of the market are likely to emerge later after the initial pilot stages.

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STATUS, CHALLENGES AND NEW APPROACHES FOR MANAGEMENT OF THE TRANS-BOUNDARY MT. ELGON ECOSYSTEM: A REVIEW

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ABSTRACT

The Mt Elgon ecosystem straddles the frontier between Kenya and Uganda and is a major catchment for Lake Victoria, the Nile River system and Lake Turkana. It supplies a range of ecosystem goods and services to over 2 million people in Kenya and Uganda. Most of the people are poor, and place tremendous pressure on the integrity of the ecosystem. This has seen conflicts arising from competition for dwindling natural resources in a landscape that is fast degrading.. Government agencies in both countries have heightened conservation efforts through the command-and-control system that include evictions in Kenya and restrictions on use of Mt Elgon National Park's forest resources in Uganda. This paper reviews the status of Mt. Elgon Ecosystem with a view to developing better understanding of PES mechanisms suitable for rewarding the beneficiaries. There is concern that the communities are abandoning sustainable traditional forest use practices for more destructive activities. For sustainable management of Mt Elgon ecosystem and its multiple functions and services, a regional trans-boundary ecosystem management approach is envisioned. It is necessary to develop institutional collaboration between managing agencies, empower communities and guarantee ecosystem services to all. Incentives through PES could enhance participation in sustainable management, ecosystem rehabilitation and biodiversity conservation.

Introduction

In Africa, distribution of natural resources and biodiversity does not respect international boundaries. This makes it necessary to develop and promote trans-national conservation efforts through regional policies and international agreements, to ensure sustainable economic security and development, as well as ensuring global and local environmental protection. The challenges to trans-boundary conservation in developing countries are numerous. Apart from the well-understood challenges of planning, intervention and monitoring associated with single-nation protected areas, there are also conflicting regional or internatinal disparities in policy and priorities which work against conservation and sharing of natural resource benefits. Additionally, unfavorable macro-economic climate and, resulting financial disincentives encourage deforestation, settlement and land degradation through poor farming methods, all motivated by increased population and high poverty levels.

Mt Elgon ecosystem is endowed with exceptionally high biodiversity of renowned global importance (Howard *et al.,* 2000). This makes it among Africa's most important landscapes for the conservation of biodiversity as demonstrated by the many protected areas (National Parks and Forest Reserves) on both Kenyan and Ugandan sides. The landscape is also important because of the many ecosystem goods and services local communities get from it. These resources include the fertile volcanic soils, favourable climatic conditions, rare wildlife species, arable agricultural land, the huge source of firewood, medicines and building materials from the thick and expansive forests, the ubiquitous rivers and streams with clean fresh water flowing from the mountainous forested landscape; all these constituting the spectacular land formations and rich biodiversity. The ecosystem and its associated resources confer huge benefits to communities neighbouring the ecosystem, as well as others living far away, but dependent on the same ecosystem services; and to local and national governments, both in Kenya and Uganda as a source of job opportunities and foreign exchange earnings through tourism, among others. The Mt. Elgon landscape is a major water catchment and one of the five water towers in Kenya. Further, it is of regional significance as a source of water to Lakes Victoria, Kyoga and Albert, which are also sources of water for the River Nile. The fisheries in these water bodies provide a major source of livelihood for many people.

Because of the many ecosystem services derived from the Mt Elgon landscape, the areas surrounding the mountain forests have very high population densities, reaching 600 people/ km^2 in some areas.. Majority of the residents are poor subsistence farmers who depend on small-scale agriculture, various forest products and environmental services for their survival. Consequently, resource-use conflicts, poaching and encroachment have heightened environmental degradation in the area. These phenomena present a management challenge for the area. According to Scott (1998), there is need to concurrently address environmental management concerns, while at the same time also tackling deficiencies in people's livelihoods and well-being. However, achieving the right balance between conservation and development goals in Mt. Elgon area poses a major challenge because of the trans-boundary nature of the problem, which requires to be addressed before any other measures are undertaken in the area.

A veritable amount of information in various reports, publications and grey literature have been used to examine the various aspects (e.g. biodiversity, conservation and management, ecosystem threats and challenges and values and valuation of ecosystem goods and services) of the Mt Elgon ecosystem. However, much of the information is scattered and often times examines the situation in one country without regard to what is happening on the other side. This review analyzes the current status of the system, as well as conservation and management scenarios from a trans-boundary perspective for Mt. Elgon ecosystem. It identifies common threats, challenges, gaps and potential approaches that can enhance sustainable management of the ecosystem as a single and integrated unit. The documentation will help to integrate lessons learned in a way that can inform policy to advance management efforts to other areas in East and Central Africa with similar ecological, demographic and socio-economic characteristics.

Situation Analysis

Mt. Elgon is an extinct volcano, which is the fourth highest mountain in East Africa. It lies between the longitudes 30°20′49′′ E, 35°3′55′′ E and latitudes 0°43′31′′ N, 01°02′02′′ N with an estimated total area of 2,504 Km . The mountain extends 80 km North-South and 50km East-West with the 20 Km long Nkokonjeru arm to the west. The highest point is the Wagagai Peak at 4321 m a.s.l. The Mt Elgon ecosystem is a landscape that straddles the border between Kenya and Uganda. A report by the Forest Department of Uganda (1996) describes the prevailing natural vegetation as not particularly diverse but containing many species of extreme conservation importance by virtue of their rarity and/or limited distributions. The same situation was recently captured for the Kenyan side (Hitimana *et al.,* 2004). The protected area covers approximately 2045 Km with 1145 km^2 on the Ugandan side and 900 km on the Kenyan side. On the Ugandan side, the Bagisu and Sabiny are the two ethnic tribes around the mountain while the Sabaot and Dorobo, who for ages have been hunters and gatherers, occupy the Kenyan side. The indigenous people regarded the mountain as a sacred place where traditional ceremonies and rituals were performed. The caves have served as shelters for both animals and people. They were used strategically during conflicts as hideouts from adversaries. Some of them are rich in minerals such as salt, and are frequented by wildlife. Administratively, the landscape falls within six districts in Uganda (Mbale, Sironko, Kapchorwa. Bukwa, Bududa and Manafwa), and two districts (Trans-Nzoia and Mt. Elgon) in Kenya. The key resources (forests, wildlife, water catchments and tourism) in the landscape are separately managed at various levels by the wildlife and forestry authorities in both Kenya and Uganda, with additional contributions from Non-Governmental organizations and Community-Based Organizations. The major socio-economic activities in and around the lower and mid-level slopes of the mountain ecosystem are subsistence farming and livestock keeping by the numerous local communities (IUCN, 2006). Most of the montane forest on the Kenyan side is gazetted as

Forest Reserve (74,000 hectares) and currently managed by the Kenya Forest Service of the Ministry of Forestry and Wildlife Services. The transect of forest on the north-east slopes falls within Mount Elgon National Park (established in 1968 and comprised of 16900 ha, and extended in 1978, to 34,000 ha) is under the jurisdiction of Kenya Wildlife Service (KWS). In Uganda, a large chunk of the area is managed by Uganda Wildlife Authority (UWA) as part of Mt Elgon National Park.

The Mt. Elgon Ecosystems Function, Goods and Services

Ecosystem functions are defined as "the capacity of natural processes and components of natural or semi-natural systems to provide goods and services that satisfy human needs" (De Groot, 1992). Some important forest functions include water storage, groundwater recharge, storm protection, flood mitigation, erosion control, and retention of carbon, nutrients, sediments and pollutants (Dugan, 1990). All these functions are performed by the Mt. Elgon Ecosystem, the landscape also generates and avail products such as forage, wild foods and agricultural resources and water. In its pristine state, Mt. Elgon ecosystem provides for soil stabilization, biological diversity, natural heritage, cultural uniqueness and maintains many complex biological processes which are necessary for sustaining the ecosystem services.

(i) Biodiversity in Mt Elgon Ecosystems

Mt. Elgon ecosystem has habitats with unique and diverse flora and fauna, as reported in research reports of MEICDP (1999) and KFWG (2000). The ecosystem contains a number of plant species that are endemic to Mount Elgon region e.g. the Elgon Teak (*Olea capensis*), which is a hard wood highly valued by carpenters for its distinctively coloured and beautiful texture. Mount Elgon is also a designated as an Important Bird Area (IBA) according to the international wildlife classification system. The combined Kenyan and Ugandan protected areas are sufficiently large to maintain viable populations of many of the larger and rarer species of mammals such as elephants, buffaloes, leopards, giant forest hog, waterbuck, bushbuck, duiker and various monkeys, which are vulnerable to extinction in smaller National Parks. However, data on small mammals, arthropods and microorganisms are limited. Mount Elgon has higher levels of biological diversity compared to similar areas in many countries of East and Central Africa. The caves on the slopes of the mountain are home to large colonies of various types of bats and also provide salt licks for large and small mammals. According to a recent report by MUIENR/NMK (2005), even though the ecosystem has relatively low biodiversity compared to other mountainous ecosystems, it has a high number of rare and endangered species. . The report also highlights the importance of the ecosystem for the surrounding communities, and its importance as a regional source of water, while at the same time having a sufficiently large protected area to make it a prime area for the conservation of larger mammals.

(ii) Mt. Elgon Forest Cover Resources

Reports by IUCN (2004), MUIENR/NMK (2005) and Vedeld (2005) reveal that the natural and man-made forests in the region cover over 180,000 ha and constitute an essential element of rural livelihood systems. On the Ugandan side of the mountain, utilization of natural forests formally ceased with the proclamation of the forest as a National Park, apart from minor exceptions. Most forests, including plantations, are managed by the UWA as part of the National Park, although recent plantation forests based on a *taungya* approach (*shamba system*), are managed by both the UWA and NFA. A carbon sequestration project by a Dutch-based NGO, *FACE Foundation,* has reforested substantial areas of degraded forest with native species. On the Kenyan side of the mountain, commercial forestry has largely concentrated on three species: *Pinus patula, Cupressus lusitanica* and different *Eucalyptus spp* planted and managed by resident foresters from as far back as the 1930s. However, over the last two decades the forest coverage has drastically reduced, largely because of encroachment, poor management of the replanted areas, neglect of planted seedlings, and delays in replanting cleared areas. More recent replanting programme is supported by private firms e.g. Pan Paper Mills Company and that seems to be headed in the right direction.

(iii) Mt Elgon Water Resources

Mt. Elgon is an important watershed in the region and one of Kenya's five main 'water towers whose ecosystem services are substantially declining with the increasing land degradation. Mt Elgon and its forests play a key role as a water catchment area for two major rivers in Kenya, the Nzoia and the Turkwel Rivers. In particular, the River Nzoia supplies water to the entire high population region of Western Province as it flows into Lake Victoria. Major urban centres in western Kenya such as Kitale, Sirisia, Bungoma, Kapsokwony, Busia, Cheptais and Chwele obtain their water supplies from River Nzoia, further highlighting the importance of the Mt Elgon ecosystem. Furthermore, the Turkwel River is a major source of water, and one of three major rivers that feed Lake Turkana and serve the entire semi-arid Turkana district. In Uganda, towns such as Tororo and Mbale in eastern part of the country obtain their water supply from the Mt Elgon catchment, and the ecosystem also provides water to the Malakasi River that waters Lake Kyoga and eventually drains into the Nile.

(iv) Agricultural practices

In Kenya, land use on the lower slopes of Mt. Elgon is intensive with cultivation, with maize as the dominant crop (IUCN, 2006). Adjacent to the Mt Elgon forest are smallholder farmers who largely practice mixed farming, but also depend on the forest for their livelihood. But there are a few large-scale farms, such as those owned by the Agricultural Development Corporation (ADC), Kenya Seed Company, East African Seed Company and several individual large-scale farmers, including large-scale irrigated flower farms, especially in the recently created Kwanza district. Other crops grown include beans, Irish potatoes and vegetables. Some parts of the forest have been opened up to the local community for cultivation under the Plantation Establishment Livelihood Improvement Scheme (PELIS). Nevertheless, encroachment on the forest continues even as the Kenya Forest

Service and Kenya Wildlife Service continue to act against such actions, and hence, land use conflicts occasionally occur within and along the boundaries of the forest. On the Ugandan part of the mountain, efforts are in progress to enhance community-based afforestation programmes in the several hilly areas. However, several commercial crops such as coffee, barley and bananas, as well as food crops especially maize, beans, and sweet potatoes are grown. On both the Kenya and Uganda sides of Mt. Elgon livestock keeping is widespread, with pastoralists such as the Dorobo and Sabaot communities grazing their cattle in the grasslands and parts of the forest fringes high up the mountain slopes.

(v) Mt. Elgon Ecosystem and the Climate Issues

The natural forest resource endowment of the Mt Elgon landscape continue to contribute greatly in mitigating adverse effects of global warming through carbon sequestration, contribution to the regional water cycle, and maintenance of high diversity of both migratory and endemic species. However, this landscape has also presented major challenges in terms of land-use changes. Harding, (1992); Lean *et al.,* (1996);Kramer *et al.,* (1997) and Pattanayak and Kramer, (2000), note that protection of forests, especially in the tropics such as those of the Mt. Elgon landscape can have drought mitigation benefits. Positive anthropogenic interventions such as afforestation and reforestation may improve ecosystem conditions and thus increase humidity, lower temperatures and increase rainfall in the regions affected (Harding, 1992; Blythe *et al.,*, 1994). Conversely, acts that favour deforestation as currently being observed on both Kenya and Ugandan sides can instead lead to decreased local rainfall and increased temperatures and result in new and unsuitable climatic conditions that are unfavourable for regeneration of rainforest species (Gash and Shuttleworth, 1991; Meher-Homji, 1992). The current human activities on both sides of Mt. Elgon, if not well managed, will enhance degradation and lead to unfavourable climate conditions.

(vi) Regional Importance of the Ecosystem

Mount Elgon's water catchment capacity and bio-diversity functions are of regional significance in Eastern and Central Africa. It is the major water source for Lake Victoria and Turkana, a recognised trans-border ecosystem and, at global level, one of the 136 trans-frontier ecosystems consisting of Internationally Adjoining Protected Areas (Zbicz, 1999).

Threats to Ecosystem Integrity and Quality

Our survey on both sides of the Mt Elgon Ecosystem reveals that the landscapes are undergoing a widespread degradation, but especially on Kenyan's side. The main problems identified include encroachment for settlements and for agriculture, arbitrary and politically motivated excisions, illegal logging, charcoal burning and poaching, overgrazing and deliberate fires (Petursson *et al.,* 2006). These activities have been broadly grouped in three categories, and each discussed in detail below.

(a) Land Use and Land Use Changes

Our survey found that the ecosystems are threatened by the increasing population pressure which has continued to stretch forest products and services to their limits; hence, they are now in short supply. According to Petursson *et al.,* (2006), some areas such as Mbale in Uganda, have population densities of up to 600 persons $km^{-2.}$, and in Trans-Nzoia in Kenya the number is 300 persons km^{-2} (NEMA, 2007). The high population, coupled with encroachment and governments' engineered forest excisions, have transformed the land use from forest domination to the current agricultural and settlement uses. It is worth noting that as forest exercising has been implemented, no clear boundaries are demarcated between such areas and remaining forests, especially on the Kenyan side. Remnants of the indigenous vegetation on-farms indicate that the conversion has been going on in the past 10-15 years. For instance, an excision that was intended for only 3,686 ha at Chebyuk Settlement Scheme was later extended to 8,700 ha (Laman *et al.,* 2001).

(b) Excessive Cultivation

The continued quest to convert forests into farmland to provide subsistence food and increased income for the rapidly increasing human population has led to depletion of indigenous forest areas. Our survey observed that the lower slopes of Mt Elgon are intensively farmed up to the park boundary on a slope of more the 15 , which, according to the Agriculture Act is unsuitable for farming (Plate 1). This process has enhanced the rate of soil erosion, especially in instances where poor farming methods do not pay due regard to appropriate soil conservation practices. The bi-modal rainfall patterns in most of the Mt Elgon region provides opportunities for crop cultivation in two seasons per year which heightens the rate of soil erosion, leading to formation of deep gullies along most footpaths and unpaved roads that crisscross the landscape. We observed during our survey that during heavy rains, runoffs from farm lands and road sides are laden with silt, a situation which, if left unchecked will have long term implications on soil fertility and crop yields.

Plate 1: Evidence of settlement and farmland in the Kenyan part of Mt Elgon Ecosystem (Sept, 2009)

(c) Deforestation

During the survey the local administration and communities visited on the Kenyan side reported that selective logging of tree species, mostly Elgon Teak by saw millers such as the Pan Paper and Raiply companies and other unauthorized groups and individuals, has in the past had negative impacts on the forest cover, especially affecting the regeneration potential of certain tree species as well as age, distribution and the growing stock. This situation has been exacerbated by a lack of clear felling plans and unmatched planting programmes. Furthermore, until recently, the Kenya Forestry Service (KFS) had no comprehensive inventories of tree species to help determine and advice on the actual harvestable volumes of wood from existing forest stock on a long-term basis.

Ecosystem Management Challenges

The management of the Mt. Elgon ecosystem offers a daunting challenge not only because of its trans-boundary nature, but also because of its economic potential as source of finite goods and services that are critical in the livelihoods of the local communities and national economies. As a result, in both the Kenya and Uganda, a number of challenges have hampered sustainable resource use and conservation efforts in the area. The challenges include: lack of proper conservation and wise use methods, lack of alternative means of livelihoods and income, high level of poverty amongst the local communities and over dependence on farming and forest resources, lack of awareness and education on the ecological importance and long term role of Mt. Elgon Ecosystem, insufficient financial and technical resources, frequent political and administrative boundary changes, incoherence and uncoordinated policies and regulations by various conservation organizations, absence of methodologies for valuation, attribution and compensation for ecosystem services that could spur stakeholder interest and participation in conservation, as well as inadequate policies and institutional arrangements among others. These challenges need to be addressed to help reconcile conservation and development goals at the national and trans-boundary levels for the area. These challenges have often resulted into resource use conflicts over land ownerships mediated by internal drivers such as the ever increasing population pressure and inadequate distribution of natural resources.

(a) Internal Challenges

The team observed that on the Kenyan side of the ecosystem, tension exists between the forest departments in the two districts and the forest dwellers which have increased since the creation of National Reserves. Although many people have encroached on the forest in search of agricultural land, there is a clear distinction between the original land dwellers and those who encroached (Wass, 1995). The main argument has been that the original forest dwellers have coexisted with the forest since time immemorial and therefore their activities have largely been sustainable in nature. However, their concerns have been ignored and their presence in the forest is thought to be destructive. In fact, many of the forest dwellers have been flushed out by the government to pave the way for rehabilitation and conservation without being provided with alternative suitable settlements. This situation has escalated into conflicts such as the recent Sabaot Land Defence Force fighting for what they perceive to be their land rights. On the other hand, squatters who were brought into excised portions of the forest through "*shamba system*" also claim land ownership since they no longer consider themselves squatters. All in all, an increase in human population has led to further encroachment into the Forest Reserve. Furthermore, on both sides of the boundary, residents bordering the forests have complained of incessant wildlife attacks that destroy both property and crops. In some instances human injuries and deaths have been reported without any compensation from conservation agencies concerned. The situation has emboldened negative attitudes among the people who feel that the government considers the wildlife to be more important than them or their property (farms and domestic animals) and consider it a form of economic and livelihood deprivation when they are evicted from the protected areas to pave the way for wildlife conservation. Further, the forested areas are fertile ground for cattle rustlers and for hiding stolen livestock from across the borders. Therefore, the existing forest is perceived negatively by local residents. All these events boil down to insecurity which is a major concern in this trans-boundary ecosystem and a threat to conservation and sustainable utilization of natural resources therein, while at the same time it is likely to hamper planned afforestation and reforestation programs in the area. There also exist potential for conflicts between Kenya and Uganda authorities, over use of trans-boundary resources.

It is also worth noting that there is a perception that revenue collected by government departments and conservation authorities (or parastatals) from tourism activities in the protected areas has not been trickling down to benefit local communities. This sentiment is attested by the poor state of social infrastructure, both on the Kenyan and Ugandan sides. This is a fair cry considering the millions of shillings the ecosystem is able to generate through park revenue and other service charges like water and forest products (MERCEP, 2009). To date there appear to be insufficient budgetary provision, as well as inadequate capacity brought about by lack of investment on skilled training of stakeholders in forestry issues and best land use management practices. This challenge is manifested by the lack of appropriate incentives to support commercial production of wood and other forms of forestry. Currently, there is lack of skills in valuation of the environmental services that have resulted into low prices of many important plant/trees in the area. Our survey also found that there is inadequate information on appropriate seedlings to be planted in the area, evidenced by the generally high incidence of pests and diseases in tree nurseries, plantations and indigenous forest vegetation. The communities living next to the forest often ignite fires with intent to burn the grass and enable soft sooths for grazing during the onset of rains, which cause increased biodiversity loss and destroys some important tree species.

(b) Climate Variability and Change

Varying and changing Climatic conditions are external drivers with potentially negative impact on the integrity of the Mt Elgon ecosystem if mitigation measures are not put in place. Recent studies have shown the disproportionate risk of extinctions in mountain ecosystems and in particular, among endemic species (Pounds and Puschendorf, 2004; Andreone *et al.,* 2005; Pounds *et al.,* 2006). On Mt Elgon, the forest ecosystems, and associated biodiversity may be particularly at risk due to a combination of socio-economic pressures, and land-use and climate-change factors. Many species of amphibians, small mammals, fish, birds and plants are highly vulnerable to the ongoing and projected changes in climate that may alter their highly specialized mountain niches (IPCC, 2008). Climate change is known to alter the likelihood of increased wildfire size and frequency, while also inducing stress in trees. This indirectly exacerbates the effects of these disturbances. Many forest ecosystems in the tropics and high altitudes such as the Mt Elgon Ecosystem are becoming increasingly susceptible to drought and associated changes in fire, pests and diseases.

(c) Policy Gaps and Inadequate Implementation

There are policy discrepancies over access and use of ecosystem resources and services in the Mt. Elgon trans-boundary ecosystem. In Uganda farmers are allowed to harvest minor forest products while in Kenya they are not. The burning of forests during land preparation on the Ugandan side has also been reported to destroy forests on the Kenyan side when the fire gets out of control. Other forms of discrepancies in policy and implementation include;

- No compensation provided for wildlife damage in Uganda
- In Kenya, there is some level of inefficiency in policy implementation and practices - good policy versus lack of good will to support implementation.

- Lack of coherence in planning and management between institutions with jurisdiction over the resources (e.g., UWA vslocal government inUganda; KFS, KWS vs local government in Kenya)
- Differences in coordination of activities of NGOs and CBOs.
- Government economic policies being inclined to differing levels towards development rather than conservation of biological resources.
- Differing, albeit insufficient government budgetary support for conservation

Past and Current Management Practices

The Kenyan Side of Mt. Elgon

This section provides opportunities to use lessons learnt from the past and on-going ecosystem management practices that could spur future plans for effective conservation of Mt. Elgon ecosystem resources. In Kenya, the history of control of forests by the government for conservation purposes started in the colonial era. Mt Elgon forest was gazetted as a government forest in 1932. The colonial administration's emphasis was conservation of public goods through protection of forests and water resources, even if it meant displacing the local community. The gazettement brought along changes in management and exploitation of the resources. Communities that lived within the forest relocated into settlement schemes, where they felt alienated from forest resource use and management. Currently, the National Forest Policy guides the management of forest resources, supported by the forest Act (KFS, 2008). The newly created Kenya Forest Service (KFS), a parastatal under the Ministry of Forestry and Wildlife, is responsible for all gazetted forests. The main activities of KFS include active management of plantations, reforestation and afforestation, law enforcement to control illegal extraction, licensing of forest products and fire protection. Other government departments engaged in protecting the Mt Elgon ecosystem inlcude Kenya Wildlife Services (KWS) that manages Mt Elgon National Park in collaboration with Kenya Forest Service. Their goal is to conserve Mt Elgon natural environment (flora and fauna) for future generations. The KWS protects people and their property against damage caused by wildlife. One of the objectives of KWS is to share revenue collected from tourism with the local community. Water Resource Management Authority- Lake Victoria North Water Services Board has a mandate to ensure sustainable management of water resources. Their mandate includes enhancement and protection of natural flow regimes and maintenance of water quality. Other institutions taking part in conservation and management of various aspects of the ecosystem as a secondary activity are presented in Table 1.

Table 1: Kenyan Government and other institutions playing various secondary roles in conservation and management of the Mt Elgon Ecosystem

Government Department/ Parastatal	Roles/ Impacts
NEMA	-Coordination, supervision and regulation of environmental policy -Capacity building
KENGEN	-catchment conservation through funding of aforestation and reforestation
Ministry of Agriculture	-Capacity building, soil and water conservation
Ministry of National Heritage	-Conservation of heritage sites -Capacity building -Funding
Ministry of Lands	Land policy enforcement
Ministry of Water and Irrigation	Conservation of water resources
Town Councils and Municipalities	-Approve land use activities -Regulatory

Source: Okwuosa, *et al*., (2010); Recoinasence survey of Endebess Division, Kwanza district, unpublished report.

A number of intermediary organizations, including private institutions, NGOs, CBOs and CFOs/ CFAs, are also facilitating adoption of sustainable land use practices while at the same time participating in conservation initiatives. However, the adoption of sustainable land use practices in the area has been hampered by insecurity of tenure and low resource base for the farmers to invest meaningfully in conservation issues. A number of NGOs/CBOs such as UNDP, LVBC-MERECP, and VI-Agroforestry support communities to engage in tree nursery production, forest and riverbank rehabilitation and protection, advocacy, capacity building and funding of conservation initiatives. Our survey found that several youth and women groups have tree nurseries, but lack market for seedlings. Generally the community has limited strength in collective action to enable them pool resources for conservation.

The Ugandan Side of Mt. Elgon

The Mount Elgon National Park (MENP) has its roots in the colonial policies of the early 20th Century seeking to reserve the land for 'the general interests of the country' (Anon, 1912) and prevent local people from extending cultivation up the slopes. The area was gazetted as a Crown Forest in 1938 and technical changes to its status occurred in the 1940s and 1950s (UWA, 2000; Norgrove, 2003). At one time the Forestry Department adopted a populist strategy that permitted access for subsistence purposes to local residents. During the 'chaos' of the Amin and Obote II regimes, law and order broke down and people in the Mount Elgon area took advantage of this and expanded their agriculture and grazing into the forest and up the slopes. Some senior forestry officers issued licenses for residence, grazing and cultivation within the reserve in return for bribes. By the time peace returned to the country in the late 1980s, some 24,000 hectares of protected area had been degraded as many people believed they had acquired 'rights' to the forest reserves (van Heist, 1994). However, the protection status of Mount Elgon was raised to Forest Park in 1991 and National Park in1993, thus restricting use rights within the Park to "biodiversity conservation, recreation, scenic viewing, scientific research and any other [approved] economic activity" (GoU,1996). Uganda National Parks (UNP) adopted a preservationist approach to conservation and sought to evict cultivators and grazers from the Park and stop local residents from entering. UNP merged with the Game Department to become the Uganda Wildlife Authority (UWA) in the mid 1990s and around that time, changes in its approach began to occur with the introduction of 'community conservation' (Hulme and Infield, 2001).

Today, the primary management objective for MENP is, 'To conserve and manage the physical, ecological and cultural resources of Mt Elgon National Park for the benefit of present and future generations' through law enforcement and community conservation (UWA, 1999b). Law enforcement involves park rangers in military style operations (patrols, arrests and/or seizures). On the other hand, community conservation includes education and sensitization, and out-of-park sustainable development activities, revenue sharing and collaborative management agreements. These agreements signify a major move away from the traditional legal framework (e.g. decrees) that have not provided for user rights. Rehabilitative efforts being implemented in the Mt.Elgon region, especially in Uganda, are;

(a) Mount Elgon Regional Ecosystem Conservation Program (MERECP)

The Mt Elgon Regional Ecosystem Conservation Programme (MERECP) is a project under the Lake Victoria Basin Commission (LVBC) which aims at securing the multi-functionality of the Mt Elgon ecosystem and at the same time enhance sustainable development in the long term in order to secure livelihoods and alleviate poverty, both of which are priorities of the governments of Uganda and Kenya. The main objectives of the program include Conservation and management of natural resources and biodiversity in and outside protected areas promoted, Sustainable development in Mt. Elgon Ecosystem enhanced, Conservation and management needs of Mt. Elgon Ecosystem integrated into national, regional and international development frameworks, and, a regional trans-boundary programme is effectively implemented. This project covers all the three target districts in Kenya, plus the six surrounding Mt. Elgon in Uganda. With assistance from MERECP, tree planting is supported through participation of communities adjacent the degraded forests. It has targeted 600ha for Mbale region; 450 ha under UWA, and 150ha under NFA with about US$ 50,000 budgeted. Communities are going to get US$ 20 per hectare of forest per year for the trees planted. In addition, the project funds livelihood plantation sub-projects to support communities' plant trees on their land on an 8 year rotation. A revolving fund (US$ 10,000) for CBOs to support identified enterprises for improved livelihoods has been initiated as one of the major activities.

(b) FACE Foundation - Uganda Wildlife Authority

Forests Absorbing Carbon-dioxide Emissions (FACE) is a Dutch foundation set up in 1990 by the Dutch Electricity Generating Board N.V. Sep, to plant some150, 000 hectares of trees to absorb and store carbon to offset emissions from a 600 MW coal-fired power station built in the Netherlands. The foundation has been supporting the regeneration of 27,000 ha of natural forests in Kibale and

Mount Elgon National Parks since 1995 in conjunction with the Uganda Wildlife Authority (UWA). These forests are expected to sequester 7.1 million tC with a current market value of $85 million. The FACE Foundation works with the Uganda Wildlife Authority (UWA), the agency responsible for managing Uganda's national parks. In 1994, FACE Foundation signed an agreement with the Ugandan authorities to plant trees on 25,000 hectares inside Mount Elgon National Park in Uganda. The UWA-FACE project involves planting a 2 to 3km-wide strip of trees just inside the 211km boundary of the National Park. The project has so far rehabilitated/planted 25,000ha. In the areas planted with trees, forest regeneration has improved especially where the land had been used for agriculture. The project is certified under the Forest Stewardship Council (FSC) scheme as well managed. Each year, SGS (Sociйtй Gйnйrale de Surveillance) the world's leading inspection, verification, testing and certification company monitors the project to check that it complies with FSC's standards. The project has been selling carbon credits; however, in the past year, no sales were made because the verification noted that credits from Mt. Elgon project area were not 'clean' given the conflicts over the park boundaries and encroachment. The Major areas of conflicts are in Bumbo sub-county, Manafwa district. Project management attributed these conflicts mainly to political 'interventions' that derail the proper implementation of the project. However, because the situation of "no sale" of carbon credits had been anticipated, UWA is currently renegotiating the 99 years lease agreement so that the local community can benefit from the dividends FACE foundation is currently receiving.

(c) Mbale Coalition against Poverty (CAP)

The WELSH Assembly/UNDP consortium is working on supporting the Mbale Coalition Against Poverty in activities related to integrated climate plans and investment profiles, among others. This is still in planning phase; however, amongst activities being proposed are climate change mitigation measures - tree planting and energy conservation strategies, and water harvesting. Looking at the past and current scenarios on both the Kenyan and Ugandan sides, a clear picture that emerges is one that environmental degradation has been taking place for years despite the spirited efforts by government authorities to contain it. In a detailed analysis of the situation on the Ugandan side titled "Parking Resistance and Resisting the Park: 'Weapons of the Weak' and Conservation at Mount Elgon, Uganda", Norgrove and Hulme (2006) give a detailed account of how communities use both overt and covert strategies to carry out illegal activities in protected areas. The increasing human population has placed considerable pressure and drain on Mt Elgon Ecosystem, especially escalated by the high poverty index in the areas surrounding the parks. In order to improve the living standards of the people while at the same time promoting sustainable use of the ecosystem's natural resources, a number of initiatives by governments of the two countries, NGOs, international organizations and development partners have been promoted in the adjacent areas, but the efforts need to be better coordinated and scaled up.

Payment for Ecosystems Services as a New Management Approach

Daily (1997), and Daily and Ellison (2002) established that natural ecosystems provide services which benefit humanity, thus possessing both intrinsic and potential economic value. In other parts of the world, like the Amazonia, arguments have long been put forward for the more rational use of economic instruments to promote sustainable ecosystem management to attend to the basic needs of local populations and wider interests of society (Fearnside, 1989, 1997). In this respect, providing financial compensation to natural resource-users for their contribution to the long-term preservation of the physical and biological environment through 'payments for environmental services' (PES) has climbed high on the international policy agenda (UNDP, 2005; Stern, 2006; Hall, 2008). Payment for Environmental Services is based on the principle that the external beneficiaries of such services may make direct, contractual payments to local landholders and resource-users in return for adopting practices to restore and sustain ecosystems. On the Mt. Elgon landscape, providing incentives to both suppliers (landowners adjacent to the parks and forests) and consumers of environmental services (water users, forest users etc), PES will encourage ecosystem preservation especially considering that traditional government command-and-control methods on their own have failed to work properly. In working towards this end, there is a need to enhance utilization of PES approaches by establishing robust tools for valuation, attribution and compensation for carbon sequestration and watershed management in the trans-boundary landscapes. Currently our team is conducting a joint project "Methods for Valuation, Attribution and Compensation for Environmental Services in Eastern and Central Africa" funded by ASARECA. The guiding results/outputs of this initiative are;

- Appropriate frameworks for valuation, attribution and compensation of environmental services developed, validated and promoted,
- Policy briefs and institutional frameworks for payments of environmental services developed and shared,
- Training of stakeholders on design and management of payments for environmental services schemes conducted and
- The availability of information on approaches for valuation, attribution and compensation for environmental services enhanced.
- By the time the project ends, it is hoped that the outputs will enhance effective participation in PES initiatives, which will greatly enhance effective conservation and management of the resources in the area.

Lessons Learnt

This review on the Mt Elgon ecosystem has yielded a number of lessons necessary for enhancing harmony among conservationists, managers and communities living adjacent to protected areas. The following are the key lessons that have been identified;

1. Development of participatory park management strategies which seek to give local communities a role in park management and to create a linkage between conservation and development has the potential to enhance conservation, rehabilitation and sustainable development in the Mt. Elgon ecosystem. This is supported by the ideas put forward by Abbot and Thomas (2001), Western, *et al*. (1994), Adams and Hulme (2001), Norgrove and Hulme (2006) and Barrow and Murphree (2001).
2. In most cases the local community is not involved in decision making on forest and park management. This negates popular believe that participatory management has the potential to create a link between the different needs and values of park and forest authorities and neighbouring communities. However, research conducted on Mount Elgon, Uganda notes the difficulties of achieving this in practice and suggests ways and means that can enhance expected achievements (Norgrove and Hulme, 2006).
3. For communities living in areas adjoining the parks, the close proximity to wildlife have led to considerable economic burden and personal risk. These costs include crop loss and property damage, opportunity costs of protecting against wildlife damage, physical threats to people by wildlife and loss of livestock and disease transmission as well as predation by larger carnivores leading to numerous socio-economic costs and contribute to tensions and confrontations between communities and conservation actors (Musaasizi, 2004). Therefore, a form of compensation in case of wildlife damage to property, crops or even death will also help reduce tensions.
4. In an effort to offset the costs of conservation, some interventions involve provisions whereby a portion of conservation-related revenues (park fees, tourism permits) need to be reallocated to surrounding communities for small-scale development projects such as health clinics and schools.
5. The role of intermediary organizations (NGOs, CBOs etc) to facilitate capacity building on sustainable land use practices is key in natural resource management in the area. These institutions need to be supported and well coordinated to ensure success and minimize competition.
6. A regional approach towards conservation and development of the Mount Elgon ecosystem offers a number of advantages based on adopting an ecosystem approach to bio-diversity conservation instead of separate country specific approaches. This provides opportunities for joint action to be taken on ecosystem management problems which cross international borders.

Conclusions

Environmental degradation on both the Kenya and Uganda sides of the Mt Elgon landscape has intensified over the recent past mediated by both internal and external drivers. Internal drivers are mainly high population growth and high poverty levels among residents both within and outside the protected areas; this makes them over-reliant on the goods and services deriving from the landscape. External drivers include high demand for forest products by companies and saw millers, demand for agricultural land, overstocking and the resultant overgrazing. These challenges are rapidly eroding the capacity of the expansive ecosystem to sustainably supply ecosystems services to communities living both near and beyond. Realizing this challenge, environmental conservation and management agencies on both sides of the frontier have heightened measures aimed at controlling degradation. However, the command and control approach used has changed the views of the local communities from ownership of the natural resource to aliens. This has further led to continued encroachment on the forest causing conflicts between government agencies and communities. The future viability of conserving Mt. Elgon Ecosystem appears to hinge on the cooperation and support of local people and adequate technological and financial resource allocation, as well as better engagement of local communities and providing them with benefits and real opportunities. Mechanisms for providing compensation to natural resource-users for their contribution to the long-term preservation of the physical environment through 'Payments for Environmental Services' (PES), provides great opportunities provided methods for valuation, attribution and compensation for the services are developed, tested and properly implemented. This way communities living on the landscape will benefit as suppliers of ecosystems services, like watershed services and carbon sequestration. This is the main thesis and output for our current project being supported by ASARECA.

Recommendations

To effectively manage the Mt. Elgon landscape, this review recommends the following;

i) It is recognized that community participation in forest management contributes to reduce over exploitation of the natural resources. Conservation of natural resources should then be geared towards empowering local communities to take part in decision making process to have sense of ownership of the natural resource.

ii) The communities should also be allowed to have conditional access to natural resources. This view is supported by a recent study in Mt Elgon, Uganda in which communities were found to prefer forest reserve over wildlife reserves because their use of resources in wildlife reserves is more limited (Mwayafu, 2007).

iii) There is a need for a systematic and structured approach to management, something which is lacking. Successful conservation of Mt. Elgon ecosystem will also require strongly improved cross-border and inter-institutional cooperation.

iv) There is also a need of long-term monitoring of developments in the ecosystem and the impacts they are likely to generate.
v) Mt. Elgon is recognised as potential tourist destination and there is a need to ensure security in order to boost tourism in the region.

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PAYMENTS FOR ENVIRONMENTAL SERVICES IN SUB-SAHARAN AFRICA: TAKING STOCK AND GENERATING EVIDENCE FOR INCREASED INVESTMENT AND DEVELOPMENT OF PES

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ABSTRACT

The Millennium Ecosystem Assessment (MA) process showed evidence of a decline in the flow of ecosystem services in Sub-Saharan Africa (SSA). A major reason for this is that ecosystem services are not priced or assigned value by current systems of product exchange and regulation. The MA framework provides an elaborate framework that links changes in ecosystem services flow to direct and indirect drivers of change, and response options for policy-makers. From the policy responses emerge three sets of instruments for guiding environmental management. The instruments include stricter enforcement of regulations through restrictions and standards, increased information and awareness and/or the use of economic instruments. Of recent, payments for environmental/ecosystem services (PES) have become an attractive lever for economic instruments. This is due to their presumed attractiveness since a voluntary negotiated agreement that leads to a payment from ecosystem users to ecosystem service providers or stewards is conditional on the continued provision of the ecosystem service. This study by the United Nations Development Programme (UNDP) has taken stock and generated evidence of economic cases for increased investment in ecosystem services and development of PES. The paper concentrates on the definitions of PES and PES types, effectiveness of PES, PES poverty linkages and environmental sustainability, and PES and land use systems. PES has varying definitions, some focusing on market-orientation, while others focus on the compensation and rewards aspects. Whereas many PES initiatives have been effective in overcoming the threats to ecosystems and ecosystem services, many others have stalled at project development due to inability to secure funding and questionable tenure, among others. Although some few PES projects in SSA have achieved both environmental sustainability and poverty reduction, most of them seem to be more oriented towards achieving environmental sustainability than poverty eradication. In general PES projects have not been oriented at achieving sustainable land use; rather they have been focused on slowing down degradation.

Rationale for Studying PES in Sub-Saharan Africa

The Millennium Ecosystem Assessment and the Southern African Sub-global Millennium Ecosystem Assessment (SAFMA) noted that the quantity and quality of ecosystem services provided by the ecosystems in Sub-Saharan Africa are in decline (MA, 2005). As stated earlier, a major reason for the systemic decline of ecosystems is that ecosystem services are not priced or assigned value by the prevailing systems of product exchange and regulation, although markets exist for many of the provisioning ecosystem services. There tends to be incomplete or missing markets for regulating and supporting ecosystem services, and market failures tend to have public good characteristics while regulatory services are highly influenced by production externalities (Swallow *et al.,* 2009). Continually, several instruments are used to regulate human use of natural resources, and thus the flow of ecosystem services (Ravnborg *et al.,* 2007). The instruments include (i) regulations and restrictions sanctioned either culturally or through formal laws e.g. through the establishment of protected areas; (ii) increasing the level of information and awareness by informing people on ecosystem interactions which assumes that the flow of ecosystem services and the potential impact of peoples' own activities upon these services are dependent upon awareness and influence on behaviour; and (iii) economic instruments in the form of sanctions, such as fines to discourage pollution or deforestation, resource use fees, such as licenses to be paid for the right to cut timber or use water, incentives, such as tax reductions, or direct payments to encourage specific human activities such as maintaining forest cover and implementing technological change.

Purpose and Objectives of the Study

The consultancy to study Payments for Environmental Services (PES) in Sub-Saharan Africa (SSA) is being undertaken with the overall objective of developing evidence-based economic cases for increasing investment in ecosystem management and the development of PES markets in SSA. In addition, the study aims at providing recommendations on how to promote PES in SSA. This Consultancy assignment, will answer the following questions.

1. How PES schemes are defined (how does this differ from other conservation approaches)?
2. How PES schemes are evaluated for their effectiveness?
3. Whether or not PES schemes alleviate poverty?
4. What barriers exist to PES in Sub-Saharan Africa?
5. What is the status of institutional, regulatory and legislative capacities at national level; in terms of adequacy to introduce and manage PES, as well as the status of public and private sector participation in PES?
6. What is the suitability of PES in Sub-Saharan Africa in view of existing land use scenarios?
7. Also, that the PES assessment is undertaken based on sector review, of: Agriculture; Energy; Tourism; and Natural Resources (Water supply, forests, wildlife etc).

The overall objective of the Consultancy is to take stock and generate evidence based on economic cases for increased investment in ecosystem services and development of PES. The specific objectives for this paper are therefore to show (1) the definitions for PES used in Sub-Saharan Africa (2) the effectiveness of PES projects in Sub-Saharan Africa (3) the contribution of PES to the achievement of the MDGs and, (4) the suitability of PES to land use scenarios in Africa.

Methods and Tools for the Study

The study relied on knowledge of existing PES networks. These include knowledge or research networks such as Katoomba Group, Ecoagriculture Partners and the World Agro-forestry Centre (ICRAF) initiatives, Centre for International Forestry Research (CIFOR), and universities which have documented the practice of PES through inventories and other similar reports. Additional information was from reports available on websites, phone discussions, email exchanges, Skype and other Internet based discussions.

Definition for PES used in Sub-Saharan Africa

Four variations to defining incentive mechanisms or payments for ecosystem services have been provided.The four are payment, markets, rewards and compensation. The most commonly used definition for PES, developed by Wunder (2005), is that PES is a voluntary transaction whereby a well-defined ecosystem service or land use likely to secure that service is being bought by at least one buyer from at least one provider, if, and only if, the provider secures the provision of the service. One of the most widespread and easily understood forms of PES is a transaction between downstream water users and upstream landowners to secure the water-related benefits of a sustainably managed watershed, for example water flow regulation, filtration, and soil erosion control (Huberman 2008). Swallow *et al.,* (2007) and van Noordwijk *et al.,* (2007), felt that Wunder's definition was rather narrow. They argued that Wunder's definition does not adequately consider public payment schemes, open trading between buyers and sellers, for example under a regulatory cap or floor, self-organised private deals and eco-labelling of products. Even though, Wunder (2005) argued that rewards carried an overtone of entitlement or justice and run the risk of ignoring the quality or quantity of ecosystem service being provided, compensation seems to restrict the scope to those who bear the cost for providing the ecosystem service. Moreover, compensation seemed to imply that providers' surplus was not included in the payment for ecosystem service, which minimizes its poverty alleviation impact. Notwithstanding, Swallow *et al.* (2007) and van Noordwijk *et al.* (2007) went ahead to define a new term - Compensation and Rewards for Ecosystem Services (CRES) as contractual arrangements and negotiated agreements between ecosystem stewards, environmental service beneficiaries and/or intermediaries, for the purpose of enhancing, maintaining, re-allocating and offsetting damage to environmental services.

An alternative way of looking at incentives for ecosystem services is from the markets perspective. Durraiappah (2006) defined markets for ecosystem services as a mechanism that creates a market in order to improve the efficiency in the way the service is used. Examples include establishment of carbon sequestration offsets, tradable development rights, tradable quota systems, eco-labelling and environment certification and bio-prospecting, among others. It seems from the broad definitions that only PES standing alone has a non-functional element. Markets, rewards and compensation have a functional element. In the true sense then, PES remains the most easily recognizable definition for these types of incentive mechanisms. However, the functional differences are important for the different actors, as we shall continue to explore throughout this report.

Distinguishing Payment for Environmental Services by Type

Operationally, PES experts characterize the contracts and agreements by two criteria; the type of ecosystem or environmental services, usually carbon sequestration, biodiversity conservation, watershed protection and landscape beauty. The type of contractual agreement include self-organised deals, open trading schemes, payments made to ecosystem stewards by public agencies or philanthropic organizations, and eco-labelling or certification of products in ways consistent with good ecosystem stewardship (Jenkins, 2006; Swallow *et al*., 2007). This approach is particularly convenient for establishing the PES inventories and interpreting the relationships with the PES value chains. On the other hand, to understand the overall framework for organizing PES in terms of conservation and economic policy, Wunder (2005) suggested three basic distinctions for PES, (1) area versus product-based schemes, (2) public versus private schemes, and (3) use restricting versus asset building. Area based schemes include contracts stipulated land and/or resource use caps or pre-agreed number of land units, conservation concessions, easements, protected catchments or forest-carbon plantations. Under production based schemes, consumers pay a green-premium on top of the market price for a production scheme that is certified to be environmentally friendly especially to biodiversity e.g. ecotourism, premiums on shade-grown coffee, organic farming, certified timber, certified soy and cattle products. Public schemes occur where the state acts on behalf of ecosystem service buyers by collecting taxes and paying ecosystem service providers. Private schemes are more locally focused e.g. watershed schemes and basically all carbon schemes, and buyers pay directly. Use-restricting PES schemes reward providers for conservation (including natural regeneration) for capping resource extraction and land development; or for fully setting aside areas such as protected habitats. Here landowners are paid for their conservation-opportunity costs, plus the possibility for active production efforts against external threat. In contrast, in asset-building schemes PES aim to restore an area's ecosystem service for example (re) planting trees in a tree less degraded landscape. Conservation opportunity and protection costs aside, PES may also compensate the direct costs of establishing Ecosystem Services, often through investments within agricultural systems. Therefore, in describing individual PES projects, the distinction used by Swallow *et al*. (2007) will be invaluable. However, in understanding the contribution of the different PES projects to the area conserved or protected, and the economic contribution at a national or regional level, including poverty alleviation, the categories created by Wunder (2005) are more informative.

Effectiveness of PES Schemes in SSA:
Threats to Ecosystem Services and How They are Reduced or Avoided

Payment for Environmental Services projects (initiatives) in Sub-Saharan Africa have been in existence for at least 20 years. From the older carbon forest projects such as the rehabilitation of Mt. Elgon and Kibale National Parks in Uganda (16 years), the International Small Group and Tree Planting Program (TIST) in East Africa (11 years), the working for water and wetlands project in South Africa (12 and 10 years, respectively), and the Nkolifoulu Waste Management carbon sequestration project in the 1990s. Since 2000, a lot more PES projects have been initiated, piloted and are currently running. For purposes of evaluating their effectiveness, only projects with at least a life of three years were considered. The projects are listed in Table 1

Table 1: PES Projects in SSA with at least 3 Years Life Time of Activity

Country	Age (Years)	Projects
Benin	18	Village-based management of woody savannah and establishment of woodlots for carbon sequestration (1992-97)
Cameroon	12	Waste management carbon sequestration project at Nkolifoulu near Younde
Mali	4	Acacia community carbon plantation, Degnesse Mali
Senegal	10	Soil organic matter project
Niger	4	Acacia Senegal Plantation Project
Kenya	10	TIST
	8	Arabuko Sokoke Forest Management and Conservation Project
	6	Kitengela Wildlife Lease Programme
Madagascar	6	Makira Conservation Carbon Project
	6	Matandia Andasite Conservation Project
	5	JIRAMA Water Project
Ethiopia	4	Huambo Assisted Regeneration Forest Project
Mozambique	7	Nhambita Community Carbon Project
	9	Quirimbas Carbon Livelihoods Project
South Africa	12	Working for Water Project
	10	Working for Wetlands Project
	6	Eastern Cape sub-tropical thicket biome carbon project
	5	Klein-Letuba Valley Mpumalanga (ARISE) Carbon Project
Tanzania	11	TIST
	20	Joint Forestry Management
	20	Community based Forestry Management
	4	Idete Reforestration Project
Uganda	11	TIST
	16	Rehabilitation of Mt. Elgon and Kibale National Parks
	7	Trees for Global benefits (Plan vivo) projects
	13	AS Tree farms

Sources: Ecosystem Market Places; Jindal; World Bank Bi-carbon Fund; UNEP CASCADE

In general, there are still too few running PES projects in sub-Saharan Africa, estimated to be slightly more than 50. The majority of these are carbon, biodiversity and watersheds payment projects. The analysis was aimed at understanding the effectiveness of these projects on the basis of whether or not there was a cause and effect relationship with regard to threats to ecosystem service that are overcome, reduced or avoided by the project. Table 2 shows an assessment of the effectiveness of 26 listed projects, most of which have had an operating existence of about three years or more.

Table 2: Status of Transactions versus Threats and PES Project Goals in SSA

Project	**Problem/threat**	**Goals**	**Status**
Village based management of woody savannah and establishment of woodlots for carbon sequestration implementing agency UNDP Benin	Projected rapid increase in Green House Gas emissions from deforestation of woody Savannahs and slash and burn agriculture.	1. Reduce carbon dioxide emissions from several semi-arid areas by better management of forests and village lands 2. Eventual sequestration of about 5, 338, 167 tCo_2e 3. Containment of desertification 4. Increased diversity and yield of products due to improved soil and agriculture practices 5. Dramatically improved social and economic conditions -Project cost US$ 2,500,000	1. 842,000 tons of carbon were absorbed as a result of the project 2. The cost of the carbon absorbed at US$ 3.50/ton based on US$ 2.9 M cost of project 3. 30 % decline in damage related to fires equivalent to 73,000 tons of carbon 4. Improvement in organisational and institutional structures of communities
Cameroon Land fill Project - Yaounde	Excessive waste and emission of GHGs from the water	Capture and disposal of landfill gas from waste equivalent to 350,000 tons/year	Reduced accumulation of 73,000 tons of methane gas in the air, bad odours, nuisance and leachate
Acacia Community Carbon Plantation, Deguese, Mali -carbon Fund	Rehabilitation of deforested and degraded lands	1. Reforestation of 6,000 ha, total area 14,000 ha 2. Expected sequestration of 300,000 tons of CO_2 by 2017 & 800,000 tons of CO_2 by 2035	Still a proposed project
Sequestration of Carbon in Soil Organic Matter (SOCSOM) Senegal	Potential and importance of semi-arid and arid regions and soil organic matter to climate change, mitigation and adaptation	Quantify the carbon status and sequestration potential across agro-ecological zones in Senegal, to define the biophysical potential, evaluate possible management inputs, approach a full assessment in three extrapolatable areas	Research project
Acacia senegal Plantation Project Senegal Developers-Achats Services International (ASI)	Communal degraded land throughout Niger	*1.* Reforestation of over 17,000ha of *Acacia senegalensis,* 2. Sequestration of around 0.24 MtCOZe by 2017 3. Produce 1,200 tons of gum, ground nuts, cowpeas.	PDD in evaluation stage
TIST-Kenya	Carbon sequestration as contribution to mitigation demands of Western companies. Conversion of forests for agriculture	1. Smallholder farmer focus carbon sequestration 2. Low cost carbon sequestration 3. To reverse deforestation, drought and famine 4. East Africa aims to sequester 2.3 $MtCO_2e$ by 2017	Operations in Embu, Meru and Nyanyuki, total trees planted 4,799,897. Working with 6,968 groups & 51,442 members
Arabuko Sokoke Forest Management and Conservation Project, Kenya	Threats to biodiversity, soil, water protection and present levels of unsustainable resource exploitation	Develop mitigation measures to threats of forest degradation through sustainable collaborative and participatory management system which improve the quality of life communities	Development period 1993 to 1996. A strategic Forest Management Plan 2002-2027 developed.
Reto-o-Reto Kitengela Wildlife	Conflict between cattle keeping	Minimize land-use conflicts through zoning. The programme aims to	The programme now leases 8,500 acres from 117 families;

Lease Programme	communities and Wildlife authorities over land use	lease and conserve 60,000 acres - enough to allow the seasonal migration of wildlife to and from Nairobi National Park.	with more than 17,000 acres, are waiting to join.
Makira Conservation Carbon Project. Operator- Madagascar Ministry of Environment, Water and Forests (MEEF) & Wildlife Conservation Society	Safeguard one of Madagascar's most pristine remaining rain forest systems: using carbon financing from avoided deforestation across the	1. Protect over 350,000 ha in Madagascar's North eastern forest region 2. Total 9.5 $mtCO_2e$ over a 30 year accounting period.	500,000 ha forest. Protected one of the largest remaining rain forests in Madagascar, conserve rare and threatened biodiversity and create sustainable livelihoods for local communities.
Andaside-Matandia National Park Conservation Project -Conservation International		1. Holistic approach to mitigation and adaptation to climate change 2. Reforestation of 3,000ha	10 agreements of protecting 2,500ha of threatened forest endemic species around protected areas. Implementing cost US$100,000/year
Huambo Assisted Regeneration Forest Project, Ethiopia		1. Restoration of 15,000ha of biodiverse forest in Rift Valley 2. Improve livelihoods of about 3,000 local households 3. Expected to sequester 880,000 $mtCO_2e$ over 30 years	1. Under implementation since 2007 2. Has employed farmer managed natural regeneration (FMNR) technique.
Nhambita Community Carbon Project; Mizambique	1. Extremely poor country 2. Extreme weather patterns with droughts and floods.	1. Aims to help rebuild the local economy by establishing environmentally responsible farming and food security 2. Reforestation and agro-forestry	1. Started in 2003 Plan Vivo for implementing projects 2. Forest management started working on 8,000ha and fire management 3. Promoting interest groups
Quirimbas Carbon Livelihoods Project, Mizambique	Some 95,000 people reside in the park and 30,000 in the buffer zone. The large population in the park poses significant challenges to management	1. Generate verifiable carbon emission reductions using the Plan Vivo methodology 2. Forest Management and conservation of soils and river catchment areas including coral reefs in the National Park (7506 km^2, 1,522 km^2 in ocean)	Located in Quirimbas National Park. Project was still under development in 2009.
Working for Water Project -Department of Water Affairs and Forestry, South Africa	1. Water scarcity due to spread of alien invasive plants 2. 10 million ha (6.8%) of RSA and Lesotho had already become invaded in varying degrees of density 3. Invasives reduced national mean annual run-off by about 3300 million m^3 i.e. 6.7% of national run-off	1. To provide incentives to overcome environmental externatilities while directly tackling poverty issues. 2. Alleviate poverty through the provision of temporary work skills development on water shed enhancement projects involving mainly the removal of invasive alien plants.	1. Programme launched in 1995 I million ha of invasive species were cleared between 1999 and 2006, which yielded an estimated 48-56 million cubic metres of additional water per annum 2. Funds involved about US$66 million from government's Poverty Relief Programme and water users (R.58m) per year 3. Programme costs 10% management fees, 30% materials and 60% salaries.
Working for Wetlands Project, South Africa	65% of SA receives less than 500 mm of average annual rainfall, meaning that drought is an ever present rise.	1. To rehabilitate wetlands all over South Africa 2. Create employment and develop skills in wetlands management 3. Poverty reduction and capacity building 4. Water resource protection 5. Conservation of biodiversity	A public-private partnership annual budget of US$3.9million involves government departments, private contractors, corporate partners and WWF Plus$170,000 per year from WWF-South Africa to fund the operation of the Mondi Wetlands Project
Port St. Johns, Eastern Cape, South Africa	Degradation of Klein Letaba River with its tributaries (Nsami,	Rehabilitation of riparian vegetation	1. SCB-R.250,000 DWAF-R.7 million 2. Government payment

	Middle Letaba and Molototsi)		
Klein-Letaba Valley Mpumalanga (ARISE) Carbon Project, South Africa	Degradation of Klein Letaba River with its tributaries		DWAF-R.12 million DEAT-R.8 million over 3 years
TIST-Tanzania	Same as TIST-Kenya	Increase incomes of small holder farmers project members whose incomes generally are less than US$1 a day.	Between 2000 and 2005, two sales occurred in August 2004 and June 2005. The total amount paid was US$45,000 and at $4 per ton CO2e.
Idete Reforestation Project, Tanzania	Poverty alleviation & High demand for high quality wood products	To contribute to demand for quality wood products from well managed plantation forests while contributing to sustainable environment management, community development and poverty alleviation in Tanzania	Afforestation/reforestation project by Green Resources Company Ltd; and still at proposal state.
Uganda - Trees for Global Benefits Program	Threat of deforestation due to the high population density and alternate demands for forestry products	Enhancing forestry conservation practices, agro-forestry, forestry enterprises for communities including carbon finance	A total of 110 producers have been allocated buyers in 2009 bringing the total number of producers with sales agreements to 514. A total of 235 farmers are still waiting to be allocated sales covering 380 ha
TIST Uganda	Increasing carbon emissions in the west Poor farming practices lead to deforestation and low incomes	Mitigation efforts of western firms. Enhancing farmers income and forest conservation practices	Under this system, farmers get paid 35 USH per tree every year, in two installments of 17.5 USH per year.
UWA/FACE project , Uganda	Excessive degradation of sections of the Mt. Elgon and Kibale National Parks	Reforestation of degraded parts of Mt. Elgon and KIbale National Park Mitigate carbon emissions for European companies	25,000 hectare restoration part and the restoration area and the rest of the national park are managed as one management unit by UWA.

Sources: Forest Trends *et al.*, (2010)

For carbon payments projects which are the majority, the major driver for the project areas (source of problem or threat) was the increased deforestation of forestlands and woodlands. This was the case for the village based management of woody savannah in Benin, Acacia Community plantations in Mali, Cameroon and Niger, Huambo assisted regeneration in Ethiopia, and the Nhambita and Quirimbas projects in Mozambique among others. Several other forest carbon projects were developed with a biodiversity conservation objective, but also with carbon payments components. This was the case for Makira conservation projects, and the Andaside-Mantadia National Park conservation projects. For these projects, a holistic approach to mitigation and adaptation to climate change was pursued, although some projects were designed outright for biodiversity conservation, e.g. the Arabuko Sokoke Forest management and conservation project (Kenya) and Uganda's Mgahinga-Bwindi Impenetrable Forest Conservation Trust, and Ngamba Island Chimpanzee Conservation Sanctuary. Whereas, Payments for watershed conservation projects (PWS) have been designed in various countries, including Kenya and Uganda, only South Africa has successfully implemented PWS projects.

In East Africa, the PWS initiatives are envisaged through the concept of upstream users receiving payments from their downstream counterparts largely in the productive (processing, commercial farming and electricity generating) sectors, although most of these projects are still in development stages. In South Africa, payments are based on working for water and working for wetlands projects designed to deal with the issues of the spread of alien invasive species and rehabilitation of wetlands, respectively. The projects also, fulfill a government policy role of creating employment. The biodiversity conservation projects have generally focused on revenue sharing from the gate collections received from tourist sites and allowing communities through organizing tourism and ecotourism to contribute to increased livelihoods. Successes include the Arabuko Sokoke and bird viewing experiences in Kenya, and Budongo Forest conservation project in Uganda. The greater contribution of biodiversity conservation projects, however, throughout Sub-Saharan Africa has been to slow down the rate of encroachment on important biodiversity conservation zones in Kenya, Uganda and Madagascar. The status of mountain gorillas in Uganda, the bird biodiversity in Arabuko Sokoke, and the species biodiversity in Matandia-Andasibe National Park and Makira conservation area owe it largely to contributions of the existing biodiversity payment schemes. In South Africa, the public-private partnerships have led to the mobilisation of US$ 66 million and US$ 4 million for Working for Water and the Working for Wetlands, respectively. The Kitengela Wildlife Lease Programme consists of an agreed arrangement between livestock keeping communities in the south of Nairobi National Park and the Kenya Wildlife Services to lease land i.e. leave it unfenced and available for season movements of wildlife. In this case PES has been developed to overcome conflict over land and also compensate communities for the leases.

Payments for Environmental Services and the MDGs

Thirty three out the 49 Least Developed Countries in the world are found in Sub-Saharan Africa. Out of 45 countries in SSA, 37 have developed Poverty Reduction Strategy Papers (PRSPs) (World Bank, 2010). This information represents two common issues. First, 33 out of the 49 poorest countries in the world are in SSA. Secondly, development partners require many SSA countries to show their commitment to poverty reduction and the Millennium Development Goals (MDGs). The three pro-poor PES objectives considered in assessment of the poverty focus of PES in SSA were (Greg-Gram *et al.,* 2005), (a) access to and 'market share' in PES schemes that, poor potential ecosystem services providers compete for, (b) the extent to which poor providers get access and how PES participation affects their livelihood, and, (c) effects of PES on poor people not selling ecoystem services such as non-participating farmers, poor ecosystem service users, product consumers, and landless labourers. The environmental sustainability for PES in SSA was an assessment based on the three MDG global targets and their indicators (UNDP, 2005). (1) Integration of the principles of sustainable development into country policies and programs and reverse the loss of environmental resources: that is, (a) proportion of land area covered by forests; (b) ratio of area protected to maintain biological diversity to surface area; (c) energy use or conservation; (d) carbon dioxide emissions (per capita); and (e) proportion of population using solid fuels. (2) Halve, by 2015, the proportion of people without sustainable access to safe drinking water and sanitation: (a) proportion of population with sustainable access to an improved water source, urban and rural; and (b) proportion of population with access to improved sanitation. (3) Have achieved, by 2020, a significant improvement in the lives of at least 100 million slum dwellers: proportion of households with access to secure tenure.

Payment for Environmental Services and Poverty Reduction

Access to and 'market share' in Payment for Environmental Services Schemes that the Poor Potential Ecosystem Service Providers Compete For

Trees for Global benefits (Plan vivo) project: Trees for Global Benefits Program in Uganda is on a 600ha in the areas of Ruhinda Kiyanga Bitereko) and Bunyaruguru (Ryeru & Kichwamba) counties of Bushenyi District Western Uganda. This is a voluntary private deal from industry in Europe where the contract to the first was signed in 2004. The second deal was signed in 2005 and 2008 was the most recent deal where farmers receive carbon payments directly. In Tanzania, The International Small-group Tree-planting program (TIST) started in 1999 in villages in Morogoro, Tanga, Kigoma and Dodoma regions. Farmers were paid 20Tsh or $0.02 per tree per year. TIST contract states this fee is to be payable for the first 20 years, after which will 70% of the market price for every tree. Additional (non monetary) benefits to the farmers include small loans, HIV/AIDS awareness and training on improved soil management techniques. Some projects such as the *Acacia senegal* plantation project Niger have considerable promise, but the implementation status has stalled during project design. The project aims to build on a pilot project developed in the same type of environment in Niger, which also developed adapted technology. Out of the 6,000 ha, 3,000 ha will be developed on private land owned by Dǧguessi Groupe, a Malian private producer and importer/exporter of agricultural products and local communities on communal land will develop another 3,000 ha under a partnership agreement with Dǧguessi Groupe. Dǧguessi Groupe is the project developer and "carbon aggregator", having signed sub-project agreements with local communities for the commercialization of the Emission Reductions produced on their lands. Acacia Community Plantations in Mali (2007) are in a region of sparse savannah in northwestern Mali, near the Mauritania border. Hundreds of farming families are expected to receive social benefits from the project through additional revenues generated by Arabic gum, grains and forage, combined with Credit Emission Reductions (CERs). Their sale will be coordinated by Dǧguessi Groupe and will provide the necessary additional income to realize the project. Dǧguessi Groupe will purchase gum arabic from participating farmers and redistribute the proceeds of CERs sale to them.

Extent to Which Poor Providers to PES or PES Markets Access Affects Livelihoods

The Kitengela Wildlife Lease Programme, Kenya - Reto-o-Reto (Help me, I help you project) started in November 2000. The Wildlife Foundation pays pastoral families to lease their land voluntarily. The income from the Kenya wildlife Service supplements livestock income, helping families pay fees for modern necessities, including secondary school and college. Tree Planting for Carbon Sequestration and Other Ecosystem Services Programme, Malawi Government pays an initial Kwacha 100,000 to a farmer for establishment (for seedling production/purchase, tree planting, and managing for survival). The programme, implemented in all the 28 districts of Malawi, with 2 farmers per district growing at least 1 hectare of trees, is supported directly by Government of Malawi. Since its inception in 2007, two additional farmers per district have been added to the programme each year.

Effects of PES on Poor People who do not sell Ecosystem Services

Under the forest carbon projects as well as collaborative forestry management, there has been creation of employment and income has been generated for community members engaged in running tree nurseries as businesses. In many cases these people are not members of the carbon projects or the joint/collaborative forestry management arrangements. For instance, the Trees for Global Benefits Project in southwestern and western Uganda, many more people would like to be part of the PES project but cannot benefit. In the Zambezi Delta in Mozambique, the Carbon Livelihoods Project is establishing local nurseries for the propagation of indigenous trees for reforestation and forest rehabilitation, fruit and other agro-forestry activities, and deploying extension staff to transform agricultural practices amongst communities practising slash and burn agriculture. The delta of the Zambezi River in Mozambique is an extensive wetland area that forms a triangle of around 1,200,000 hectares. To the southeast, the delta includes two forest reserves, Nhampakuй and Inhamitanga, and is mostly made of the 'Marromeu Complex' - a 688 000 hectares Ramsar site that includes the special buffalo reserve of Marromeu. The project signed an MOU with local communities in 2006 to establish local nurseries and undertake reforestation, agro-forestry, and wise land use activities. The project had a target of 123,633 hactares for the first year, projected to 520,000 ha by year 5 and 1,150,000 ha by year 10. For the Joint Forest Management Agreements (JFM) in Tanzania, about 20,000 small farmer groups were protecting 5,033,570 trees, apart from raising another 4,022,859 seedlings in their nurseries. Direct benefits to members include increased access to fruits, timber, firewood and other NTFPs produced, and approximately 1,890,613 million hectares under joint forest management (JFM) between the state and 830 villages (13% of reserved forests).

Payment for Environmental Services and Environmental Sustainability

Payment for Environmental Services Projects Contributing to Forest Land Cover, Biological Diversity, Conservation of Energy, Reduction in Carbon Ddioxide Emissions

Mgahinga Bwindi Impenetrable Forest Conservation Trust (MBIFCT) became effective on July 12, 1995. The thriving gorilla tourism in the Bwindi and Mgahinga Gorilla National Parks in southwestern Uganda has increased, as it contributed 488 billion Ugandan shillings (about 225 million U.S. dollars) in 2008 to the Uganda Wildlife Authority (UWA) from zero in 1990. Gorilla tourism alone employs about 5,000 people in tours and travel, while national tourism accounts for 17 per cent of available jobs. Mantadia Biodiversity Conservation Corridor and Restoration Project, Madagascar (2006 - 2036) is located in Madagascar Island's eastern half in three national reserves: Mantadia, Ankeneny, and Zahamena. The conservation steps have helped protect threatened species of amphibians, birds and mammals, including lemurs found only on Madagascar, while also improving agriculture productivity, developing ecotourism, and increasing the sustainable production and sale of fuel-wood, fruits and high-value timber, hence improving livelihoods among the local community. Rehabilitation of degraded lands of Djidja Benin - project activities started in December 2009. Apart from selling products at the local markets, the project region is almost completely lacking income generation opportunities. Therefore, the re-vitalization of the forestry sector creates employment opportunities. In Uganda, the UWA/FACE Uganda project started in 1994 and in the first phase (1994 - 1997), a total of 3,320 hectares were restored in MENP. A second phase 1997-2000 2000 was approved for continuation of project activities. According to an SGS assessment report done in 2001, the project is expected to result in an increase in the average storage capacity of 3.73 million tons of C02 over its 99-year lifespan. The project was initiated to offset emissions from a planned 600 MW coal- fired power station in the Netherlands by planting thousands of hectares of trees to absorb carbon dioxide. These credits were then to be sold to GreenSeat, a Dutch carbon-offset business with Western clients, mainly airline companies, at US dollars 28 for 66 trees.

Reforestation at the Idete Forest Project in the Southern Highlands of Tanzania

Establishing 650 ha of community 'carbon' woodlots in the Idete Ward on village owned land, with the objective of generating VERs and achieving certification against the Climate, Community and Biodiversity Alliance. Mkuwazi Forest Reserve and Nyika National Park Forest Conservation Project Malawi, Nyika National Park covers a total area of 3,134km^2. Land cover consists of mainly Miombo woodland, grasslands and evergreen forest. Mkuwazi Forest Reserve covers 17.7 km^2 and is dominated by Miombo species on the lower dry slopes and evergreen forest along rivers. Smallholder farmers primarily exploit customary land surrounding Nyika National Park and Mkuwazi Forest Reserve. Between 1990 and 2005 approximately 38,000 hectares of forestland was lost per year in Malawi, equivalent to an annual loss of 0.9% of forest. The project started in March 09, covering the areas of Nyika National Park; 3,134 km^2; Miombo woodland, grasslands and evergreen forest on 37,677 ha. Aberdare Range/ Mt. Kenya Small Scale Reforestation Initiative - Kibaranyeki Small Scale A/R Project Kenya Mount Kenya Forest is one of the largest, most ecologically significant and commercially important natural forest areas in Kenya and is considered to be among the highest priority, forests for national conservation (Wass 1995), Mount Kenya Forest Reserve covers an area of just over 2 000 km^2 of dry montane and montane rain forest, making it one of Kenya's largest contiguous blocks of indigenous, forest. In 2007 and 2008 the Aberdare Range / Mt. Kenya Small Scale Reforestation Initiative reforested 1763 hectares of degraded forest lands in the Aberdare Range and Mt. Kenya Regions. Humbo Assisted Regeneration Ethopia, the

Humbo Assisted Natural Regeneration Project was developed by World Vision in partnership with the World Bank to restore 2,728 hectares of natural forest in the vicinity of the town of Humbo in southwestern Ethiopia. It is not only Ethiopia's first Clean Development Mechanism (CDM) project, but also Africa's first large-scale afforestation/reforestation project registered under the UNFCCC. It is expected to sequester over 880,000 metric tons of CO2e over 30 years. With financing provided by World Vision Australia the project is jointly implemented by World Vision Ethiopia and Australia, the Ethiopian Agriculture, Rural Development & Forestry Coordination Office, and several forest cooperatives. Community Based Forest Management (CBFM) Tanzania Predominantly in Tanga, Morogoro, Kilimanjaro, and Arusha Regions, and in coastal mangrove forests. The total area covered under CBFM is currently estimated at 1.3 million ha, or 1,280 villages (approx. 12% of total unreserved forest area in the country).

Contribution of PES to Proportion of People with Sustainable Access to Safe Drinking Water and Sanitation

Payment for Environmental Services working for wetlands in South Africa focuses on water resource management, to persuade stakeholders about the importance of wetlands. This case demonstrates how projects aimed at restoring wetlands as a source of water can have the added benefits of providing poverty reduction for the the local community, as well as conserving centers of biodiversity. Working for Water currently runs over 300 projects in all 9 South African provinces. Workers use a variety of techniques to clear invasive species, including mechanical and chemical methods, as well as biological and integrated control (Working for Water, 2007). The "service" being provided is increased water flow, which results from the reduction in invasives. The government uses poverty relief funds to pay the majority of the people participating in the project, and private entities are becoming more frequent purchasers of this ecosystem service as well. In Walker Bay, local landowners pay for half the clearing and all of the maintenance, whereas the farmers pay 60% of the cost of removing invesives (WRI, 2000-2001).

Contribution of PES to Household's Access to Secure Tenure

One of the principle requirements of Payment for Environmental Services is that the ecosystem service providers or stewards have secure access to the ecosystem services they are providing. In places where tenure rights have been unclear, PES projects have worked with several local communities to put in place demarcations especially with regard to customary land tenure eg, Plan Vivo and Kitengela Wildlife Lease Programme.

Suitability of PES for Land Use Scenarios in Sub-Saharan Africa

Wunder (2005) made the argument that a basic assessment of opportunity costs can help set PES rates competitively, and possibly target limited PES resources to those areas where they can really make a difference. Conservation's opportunity cost i.e. the returns to alternative land uses, are one discriminating factor determining where PES is applicable and it would be significant to observe whether the opportunity cost for employing PES make it viable or feasible, based on the land use context. As an instrument for increasing environmental (or ecosystem services) flows, PES can be used either to reduce the threat to ecosystems and ecosystem services, or to avoid such threat.

Land Cover Dynamics in Sub-Saharan Africa

A monitoring report on the land cover dynamics for Sub-Saharan Africa found that the sub-continent had lost 16% of its forests and 5% of its woodlands and grasslands over the 1975 to 2000 period. This was equivalent to over 50,000 Km^2 per year of natural vegetation, mostly converted to agricultural lands (Eva *et al.,* 2006). Despite the expansion, the agriculture domain became more concentrated as average rural population in SSA increased by 2.7% per annum, while the area covered by agriculture only increased by an annual rate of 2.3%. This resulted into a 20% increase in crowding on agricultural land between 1975 and 2000. Similarly, the reduction in natural pastures, combined with increase in livestock levels, meant that there was on average 40% less available pasture land per head of cattle in 2000. SSA's land cover in 2000 showed that 17.3% of the region was under agriculture, 18.8% forests, 60.8% non-forest vegetation, 2.5% barren and under 1% water. On the other hand, distribution of land cover by region (Table 3) shows that the Sudanian region contained the most agriculture while the majority of the forests lie within the Guineo-congolian region.

Table 3: Distribution of Land Cover by Eco-Region for the Year 2000

Land cover	**Agriculture**	**Forests**	**Non-Forest vegetation**	**Barren**
Afromontane	7.9	0.2	4.6	1.0
Guinea-congolia/Sudania	8.5	7.2	5.5	0.1
Guinea-congolia/Zambezia	0.3	4.8	5.1	--
Guineo-congolian	10.9	66.2	1.2	0.1
Kalahari-Highveld	2.3	--	10.1	4.9
Karoo-Namib	0.1	--	3.1	23.9
Madagascar	4.3	2.4	2.9	4.0
Sahel	11.7	0.2	7.8	1.0
Somalia-Masai	5.5	1.4	10.5	53.4
Sudaman	28.9	5.0	21.1	5.3
Zambezian	14.7	11.9	25.3	6.3
Zanzibar-Tongo Coast	4.8	0.6	2.9	--
% Totals	100.0	100.0	100.0	100.0

As a consequence of the dynamics of the land cover, the importance of protected areas as "refuges" for vegetation increased, even though, the protected areas are becoming "island refuges" and their viability is increasingly less certain, both functionally and politically. With dwindling regional natural resources available, they become targets for poaching, illegal grazing, invasion by farmers, and as a source of scarce fuel wood. Under future scenarios, local and regional politicians may find it difficult to justify their existence (Eva, *et al.,* 2006).

The Development Policy Cycle Potential for Carbon Finance Investment in SSA

Sub-Saharan Africa remains marginalized in global carbon markets, with Africa's market share constituting less than 1 percent (excluding South Africa and North African countries). The potential for mitigation through agriculture in the African region is estimated at 17 percent of the global total, and the economic potential (i.e. considering carbon prices) is estimated at 10 percent of the total global mitigation potential. Similarly, Africa's forestry potential per year is 14 percent of the global total, and the avoided-deforestation potential accounts for 29 percent of the global total (Elizabeth *et al.,* 2008). Many different strategies have been shown, under controlled conditions, to successfully rehabilitate degraded land and enhance the productivity. However, not all have been tested in real-world situations and not all are economically feasible.Three of the most promising land capability restoration project types include Conversion of degraded cultivated land into grassland or rangeland (Millennium Ecosystem Assessment, 2005), Conversion of degraded croplands and pastures to forests and conversion of degraded farmland into agro-forestry systems.

Conclusions

Due to significant reduction of available land for agriculture, a priority of rural development policy should be oriented to increased yields through intensification of agriculture and integration with animal husbandry. However, agricultural intensification should be carefully conducted in order to avoid soil degradation, excessive use of mineral fertilizers and pesticides, and to limit over exploitation. A close integration of agriculture and cattle ranching is highly recommended for increasing the overall productivity of agro-systems and degraded lands.Activities related to adaptation to climate change should be concentrated in the most sensitive areas. The Sahelian belt and the Afromontane domain are the ecoregions with the biggest land availability problems. They are also the eco-regions that will suffer from climate change with more frequent droughts for the Sahel and a lack of resilience in the mountain regions. Adaptation to climate change should therefore be focused on these regions where there is a high potential impact and the current situation is already unfavourable.

Management of protected areas should be considered at the regional scale through the development of integrated landscape policies and increased attention to ecological corridors. A careful assessment of the natural resources benefits by all stakeholders is necessary before engaging any protected area mechanisms. Development policy needs to address the drivers of conflict amongst which available and access to natural resources figure strongly. Particular attention must be paid to potential transhumance related conflicts: negotiated definitions of paths, stocking areas and periods should be encouraged. The continued erosion of fuel energy sources points to a necessity to develop and implement medium and long-term local, regional and national energy plans. In the most affected areas such as West Africa, the north of Central Africa and the Horn of Africa, there should be a drive to increase the use of renewable energy. There is also a need to support plantation and regeneration schemes, as well as maintaining and developing environmental education programmes. Environmental and natural resources issues must be fully integrated into development policies and processes, in a systematic manner. This includes when development is channeled through the general budget and sector budgets.

Acknowledgement

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RESOURCE IDENTIFICATION AND QUANTIFICATION FOR VALUATION FOR PAYMENT FOR ECOSYSTEM SERVICES: THE CASE OF EASTERN MT. ELGON ECOSYSTEM

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ABSTRACT

Mt Elgon catchments serve a large population with different socio-economic activities, derived from ecosystem services. Consequently, there is competition and conflict over resource use, inadvertently leading to degradation. Specifically, there is a growing concern on how the resources should be shared between the upstream and downstream beneficiaries. Ideally, on the basis of the "beneficiary pays", both upstream and downstream users should pay towards protection and conservation of the catchment, depending on the benefits they derive. To make the payments for ecosystem services the objective and less contestable, it is necessary to demonstrate to the users the sources, amounts and impacts of the services. This paper attempts to link the upstream ecosystem service providers to the downstream services by delineating the specific sub-catchments associated with different services areas. Geographic information systems technology is used to link different service points and service areas to specific ecosystems. The paper intends to quantify and cost the different service uses for purposes of determining an equitable payment scheme.

Introduction

Ecosystem services represent the multiple benefits that human beings can obtain either directly or indirectly from ecosystem functions (Constanza *et al.*, 1997, Li *et al.*, 2007, Vandewalle *et al.,* 2009). Most people readily pay for the direct services offered by ecosystems, but the indirect services, which are mostly treated as common or free goods are largely used without any direct payments. The concept of "payment for ecosystem or environmental services (PES)" is a relatively new conceptwhich is rapidly gaining popularity. This concept largely refers to the practice of offering financial incentives to resource "custodians", such as landowners, forest dwellers or communities living in or adjacent to forests, in exchange for maintaining these resources, more or less pristine, to enable to them provide the "intangible" ecological services to a third party. There are many of ecosystem goods and services. The Millennium Ecosystem Assessment, a 2005 UN-sponsored project that assessed the state of the world's ecosystems identifies twenty-four specific ecosystem services (MA, 2005). Among these, wild foods, timber, genetic resources, fresh water and air, and soil erosion regulation, pollination, recreation and cultural services are almost ubiquitous. However, most services are ecosystem specific and the quantities and quality vary from one area to another. For any meaningful implementation of PES programme, it is necessary to map availabilty (Troy *et al.,* 2006), as well as changes in quality and quantities over time and across space, and how the changes impact on ecosystem services (Li, *et al.,* 2007). This paper attempts to link the upstream service providers, for the Mt. Elgon ecosystem to the downstream service users (different stakeholders) by delineating the specific sub-catchments associated with different services, for purposes of determining an equitable payment scheme.

Mount Elgon straddles the Kenya-Uganda border and is the fourth highest mountain in Africa with a peak of 4320m above sea level. Geomorphologically, the mountain is a large extinct volcano of tertiary origin with an altitudinal range of between 2030 and 4320m a.s.l. The vegetation covering the mountain can be classified into four distinct zones, namely, open woodland at the lower levels, tropical moist forest, bamboo, and afro-alpine forest that is above the bamboo zone. *Juniperus procera, Hagenia abyssinica, Olea welwitschii, O.hotstetteri, Prunus africana, Podocarpus falcatus* and *P. latifolia* dominate the moist tropical forest. Moorlands, swamps and rocks form a major part of the afro-alpine zone. A wide variety of fauna inhabit the mountain, including large mammals, reptiles, birds and insects. Each of these is a potential provider of a variety of services. Although the density of the vegetation and the species diversity of Mt. Elgon forest are about normal for this ecological zone, the commercial and existance values of the forest are currently regarded as below normal. The density of trees has decreased significantly due to clearing and over-exploitation of some species such as Elgon teak. Forest fires, caused by charcoal makers and honey gatherers, have also destroyed some trees, and there seem to be some invasions of low utility species. The destruction of trees by large mammals has also contributed to decrease in tree species and density. For the mountains' integrity to be restored and maintained there is need for a more proactive conservation programme to be undertaken in the area.

Conservation and protection of ecosystems require finances. The current government's budget allocation for environmental programmes is not sufficient. Hence, the strategy of those who benefit from the goods and services arising from different ecosystem resources to pay for conservation on the basis of the "beneficiary pays" principle is a prudent alternative source of funding for conservation programmes. The beneficiary pays principle also implies that beneficiaries pay proportionately to the benefit they derive. To make the payments for ecosystem services the objective and less contestable, it is necessary to demonstrate to the users the sources, amounts and impacts of environmental services. Although relatively new, the process of identifying and quantifying ecosystem services is increasingly being recognized as a valuable tool for the efficient management of environmental resources (Heal *et al*., 2005; MA, 2005; de Groot, 2006; Troy *et al.,* 2006; Burkhad *et al*., 2009).

However, most reported studies focus on global aggregations (Constanza *et al.,* 1997, Naidoo *et al.,* 2008) which provide valuable information, but are not directly applicable for regional or local decision making, and hence inadequate for developing PES schemes. Implementation of functional PES programmes require, among other things, a detailed analysis of available services, their sources, potential users of these services and appropriate mechanisms through which they can pay for these services. The ecosystems services concept is strongly associated with a landscape ecology approach, as advanced in de Groot's "Functions of Nature" (de Groot, 1992). In this approach, the measurement of service is based on defining and identifying ecosystem functions. Unfortunately, not all functions are directly visible (Burkhad *et al.,* 2009), making it difficult to assess their services. Further, some of these functions, for example, the so called"cultural" functions, are highly subjective and intangible. This makes it hard to assess and put a value on them.

Finally, and perhaps most important, some critical services, such as carbon sequestration and climate regulation are enjoyed far beyond the spatial boundaries of the ecosytem providing them. In such cases, the custodian of the function-providing ecosystem may not even be aware of such services and hence the importance of the ecosystem. Worse still, the remote beneficiary is mostly seen as an"outsider" with no legitimate claim on the resource. All the same, any objective decision making on resource conservation rely on ability by the custodians or their agents to delineate, assess and associate services with specific ecosystems.

Such delineations must reflect structural and functional aspects of the landscapes in question and be amenable to some form of change assessment. This paper adopts the watershed approach, consisting of water and soils as well as the flora and fauna. A watershed, also referred to as catchment or a drainage basin, represents an area of land that drains down-slope to a common outlet (Chang, 2009). Since water affects and controls soils and vegetation characteristics, together with the animals found in an area, the watershed provides us with a unit that can be used to manage basic resources that provide goods and services to mankind, collectively and simultaneously. Trained geomorphologists can, to a large extent, accurately delineate watersheds from topographic maps. However, such delineations lack objectivity and replicability. Today, with wide access to geoinformatics, catchment delineation can be done automatically using Geographic Information Systems (GIS) technology. The accuracy and objectivity of automatic delineation rely on availability of high quality digital stream and elevation data.

Materials and Methods

The UNEP (2008) outlines four key steps for developing PES schemes. This paper focuses on the first step, namely, identification of ecosystem service prospects and potential buyers. Specifically the paper defines, delineates and apportions potential ecosystem service centres to the likely buyers of the services. To achieve this, a four step procedure is followed consisting of (i) definition of the study area, (ii) identification of prospective ecosystem services and the potential users, (iii) delineation of the catchments of each of these users, and iv) apportioning user to each of these. Each of these steps is described below.

Definition of Study Area

This paper considers the Kenyan side of Mt. Elgon. Although the mountain covers only two administrative districts in Kenya, i.e. Mt. Elgon district in the Western province and Trans Nzoia district in Rift Valley province, it is an important catchment for a number of rivers that drain beyond these districts. For the purpose of this paper, therefore, seven service areas namely; i) Cheptais and Mt. Elgon National Park (Mt Elgon District, ii) Bungoma, and iii) Webuye (both in Bungoma District), iv) Kitale and v) Endebbes (Trans Nzoia District) and Turkwel Hydroelectricity Power Station (Turkana District) are considered.

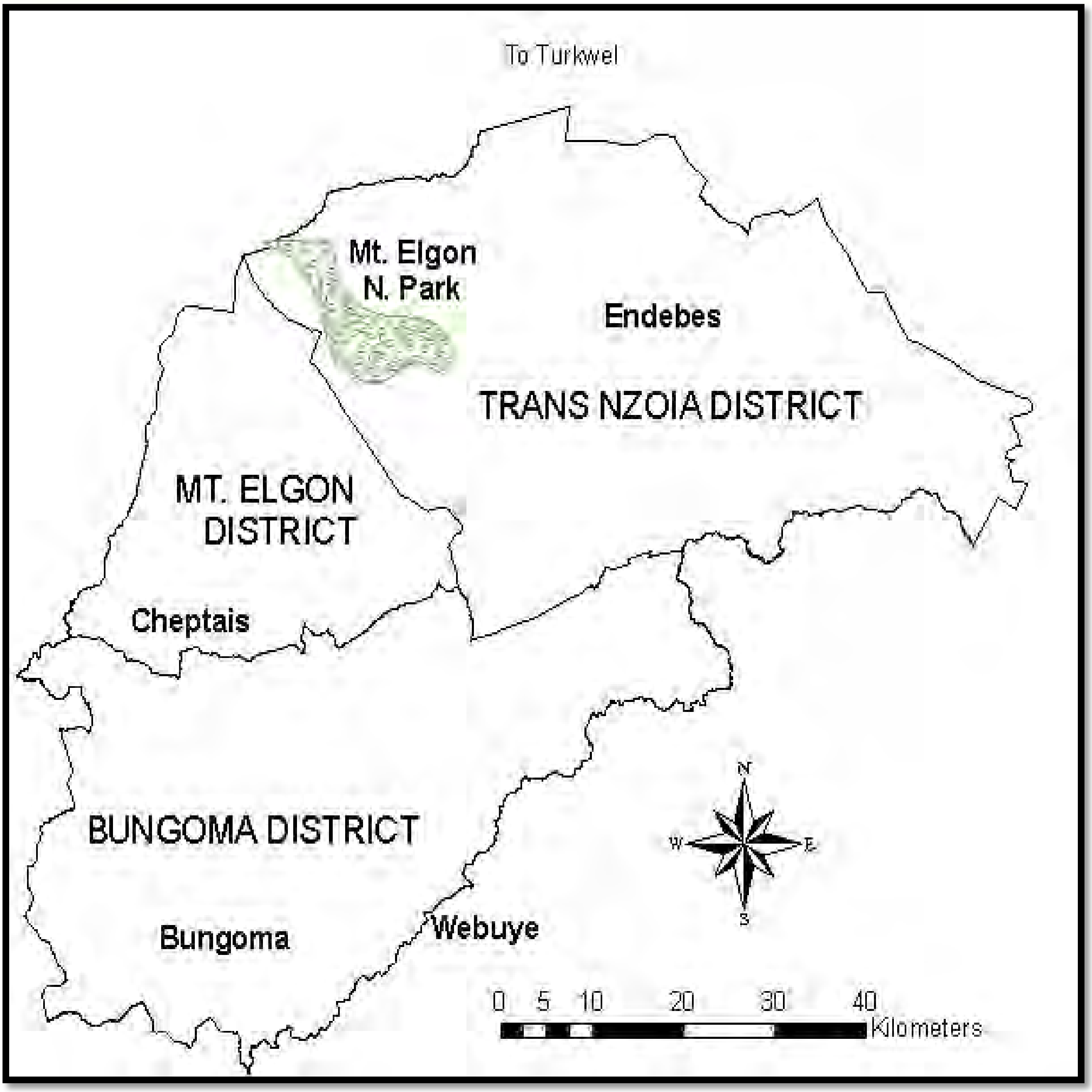

Figure 1: General Map of the Study Area

Identification of Services and Prospective Users

Ecosystem goods and services are derived from landscape functions which arise from the bio-physical landscape characteristics, i.e. landscape structure. One of the most widely used surrogates for landscape structure is land cover. This is because land cover, which refers to land use types, vegetation and surface soil properties, is most readily visible and measurable landscape character. Secondly, some of the land cover attributes, such as vegetation, are reliable indicators of the other landscape characteristics such as underlying soils and climate. Finally, land cover is the most easily modified landscape characteristic; hence its analysis can be used to infer changes in ecosystem service provision potential. In terms of ecosystem functions, land cover of the study area can be categorized into ten major classes, namely, 1) Moorland 2) Swamps, 3) Bamboo, 4) Natural forests, 5) Plantation forests, 6) Scattered trees and grasslands, 7) Large scale farms, 8) Subsistence agricultural settlements, 9) Urban settlements and 10) Surface water bodies. Landsat images covering the study area, namely, (P170/R059 and P170/R060) for 2003 were acquired. These were geo-referenced and *mosaicked,* from which a sub-image covering the study area was derived. Spectrally, each of the ten classes identified above is likely to have several subclasses. To take care of this variability, a total of fifty spectral classes were considered adequate in the analysis. The *K-means* algorithm of unsupervised classification was used to classify the image into 50 classes. Four Landsat TM spectral bands (bands 2, 3, 4 and 5) were used, with a maximum of 5 iterations. The resultant classes were manually merged to the 10 broad land cover classes with the aid of a 1960 land cover map of the area.

Delineation of Catchments

Automatic catchment delineation requires a minimum of two data sets, namely, a digital elevation and stream data. In addition a point data for the service centers and a land cover map are also required for purposes of assessing service values. The stream data should represent a network of interconnected streams. For purposes of this study, both data sets were extracted and automated from six 1:50,000 topographic maps, namely, sheets 74/3, 74/4, 88/1, 88/2, 88/3 and 88/4 obtained from Survey of Kenya. Both data sets were digitized and merged into a seamless data set of connected vectors. Geographic Information Systems (GIS) software was used to develop a TIN-based digital terrain model with elevation data provided by the contours and the rivers acting as break-lines to smoothen the network of triangles. This elevation model was then converted to a raster dataset for subsequent catchment delineation. The point-based automatic catchment delineation approach was used to delineate the catchments for the seven identified service centers namely: 1) Turkwel, 2) Endebes Farms, 3) Mt. Elgon National Park, 4) Kitale town, 5) Webuye, 6) Bungoma town and, 7) Cheptais area. These service centers were represented by a vector point data set which was converted to a raster of the same characteristics as the digital elevation grid.

Apportioning Ecosystems Services

After the catchement for each service center was derived, it was converted from the raster format to a vector format. Since these catchment boundaries cover the entire watershed (mountain region as well as the settlement areas), it was necessary to separate the major ecosystems. The vector watershed boundary was superimposed on the classified image and the appropriate ecosystem boundaries for moorlands, bamboo, afro-alpine montane, woodlands and settlements were added. The areas of each of these ecosystems in each watershed were extracted and tabulated.

Development of a Payment Scheme

There are several ways of paying for environmental services, including habitat purchases, payments for access, easements, trading rights and support for conservation (UNEP, 2008). This paper considers two modes, namely, support for conservation efforts and payments for access. The government, through KFS and KWS, who manage the mountain ecosytem, can use this data to obtain payments through carbon trading, an example of the trading rights payment system. Since the areas under different ecosystems within each watershed are known, as well as the potential beneficiaries, an appropriate cost function could be applied to determine how much each of the beneficiaries should pay. However, this was not within the scope of this paper.

Results and Discussion

Figure 2a presents the results for the land cover classification. From this figure it can be seen that Endebess and Kitale areas are dominated by large scale farms. In the Cheptais area, the prevalent land cover is small scale farms. Field studies confirm that subsistence farming (both crop and livestock production), domestic water and firewood abstraction are the main land use activities in this area.

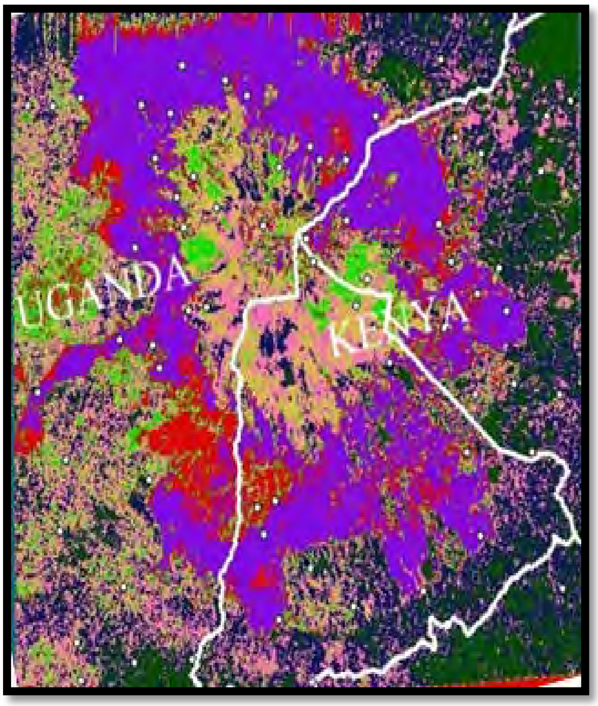

Figure 2a: Land cover classes

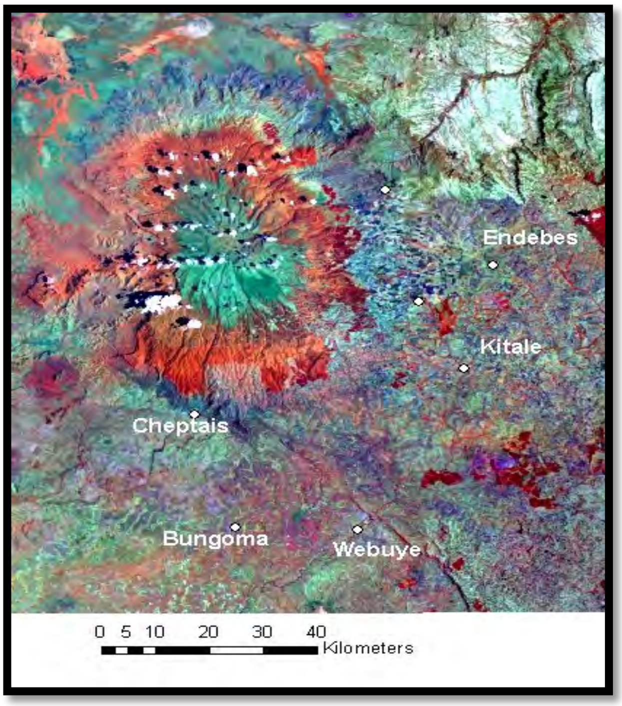

Figure 2b: False colour composite

Although the classification system did not pick the urban and sub-urban settlements, the false color composite (R, G, B = TM4, TM5, TM3) show these areas as bluish-grey (Figure 2b). From this figure, Kitale, Webuye and Bungoma towns can be identified. These towns get their water from the Nzoia River whose major tributaries originate from Mt. Elgon. Webuye and Nzoia towns next to Bungoma town have paper and sugar industries, respectively. The hydro-electricity generating plant in Turkwel Gorge (not shown in the figure), gets its water from the Turkwel river which is fed by streams from the Mt Elgon catchment, including the Suam river at the northern part of the Kenya-Uganda border.

Finally, the Mt. Elgon National Park, found on the upper reaches of the mountain (Figure 1) contains wildlife resources, which contribute to the National economy through tourism. The forests, both natural and plantation support the national economy with timber products. Furthermore, the forests, bamboo, the moorland and the swamps help to sequester carbon, purify air and water, conserve biodiversity and help in aquifer recharge to provide domestic water. The Nzoia Water Services Board's intake in Kitale is an example. Table 1 summarizes the major ecosystem services and their users.

Table 1: Potential Ecosystem Services

Service Type	**Ecosystem Service Consumer**					
Environmental Goods	**S.Scale Farmers**	**L.Scale Farmers**	**Urban**	**KWS**	**KenGen**	**Int'l Com**
- Fiber	X	X				
- Food	X	X	X			
- Fuel	X	X				
- Portable water	X	X	X	X		
- Irrigation water	X	X				
- HEP						
- Farming land	X				X	
Regulatory Services						
- Climate regulation	X	X	X	X	X	X
- Flood regulation	X	X	X			
- Water purification	X	X	X			
Supporting Services						
- Nutrient recycling	X	X		X		
- Soil formation	X	X		X		
- Pollination	X	X		X		
- Erosion control	X	X		X	X	
- Biodiversity preservation	X	X		X		
Cultural Services						
- Aesthetic				X		X
- Spirtual	X	X		X		X
- Educational			X	X		X
- Recreational			X	X		

From Table 1, it is apparent that the farmers are the greatest beneficiaries in terms of direct benefits from services provided by the ecosystem. However, it can be argued that most of their benefits, especially the small-scale subsistence farmers, are just livelihoods. Most of the derived benefits have no economic or profitable implications. On the other hand, the large scale farmers, Kengen, KWS and even the urban water supply company are profit generating entities. Furthermore, it is difficult to make the small-holder land-owners pay for ecosystem services, because most of them see the land as their ancestral right.

As a starting point, the payment system proposed targets large-scale farmers, urban water users, power-generating plants and the tourism industry. Figure 3a shows three delineated watersheds for the Turkwel power station, Endebes area and Mt. Elgon National Park. A false color image of the area is used as a backdrop to link the mountain ecosystem with the service areas. While, Figure 3b shows the three watersheds after being subdivided into different functional land cover types for assessment and apportioning of ecosystem service costs.

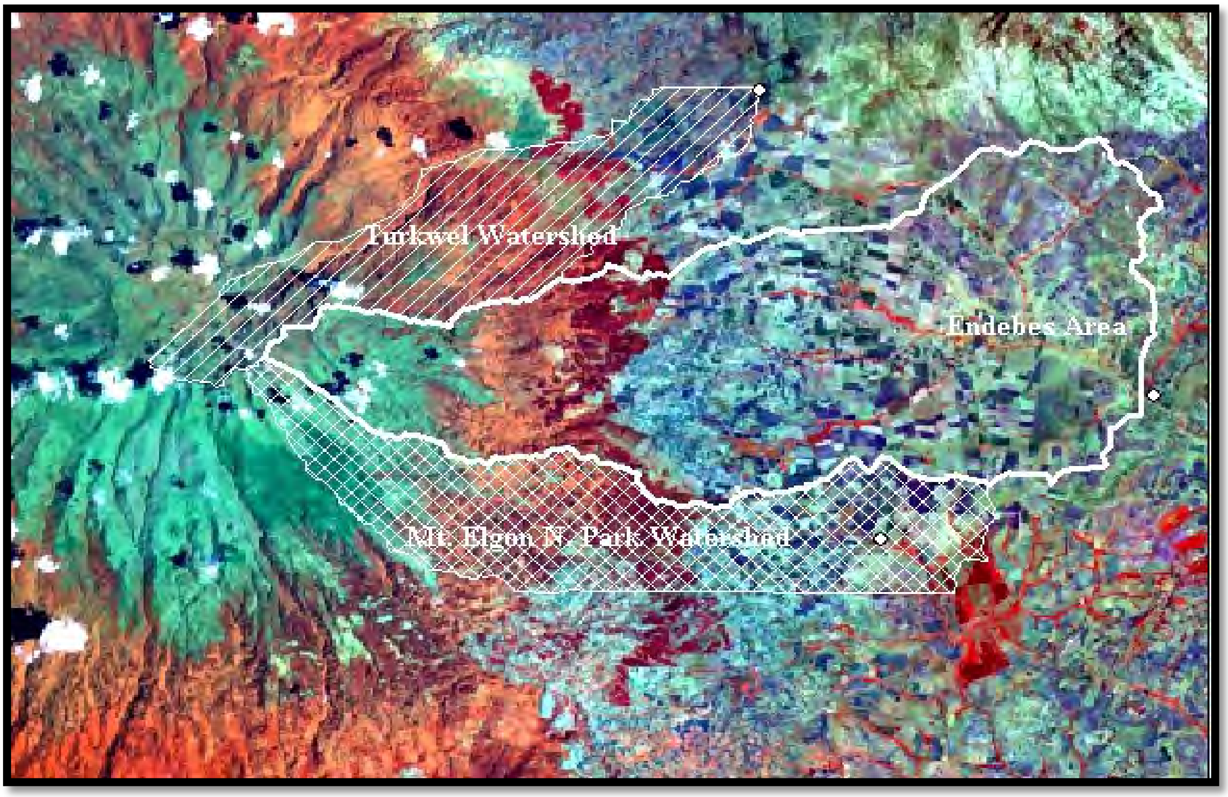

Figure 3a: Watersheds for Different Service Areas

Figure 3a shows three delineated watersheds for the Turkwel power station, Endebes area and Mt. Elgon National Park.

Figure 3a Three delineated watersheds for the Turkwel power station, Endebes area and Mt. Elgon National Park.

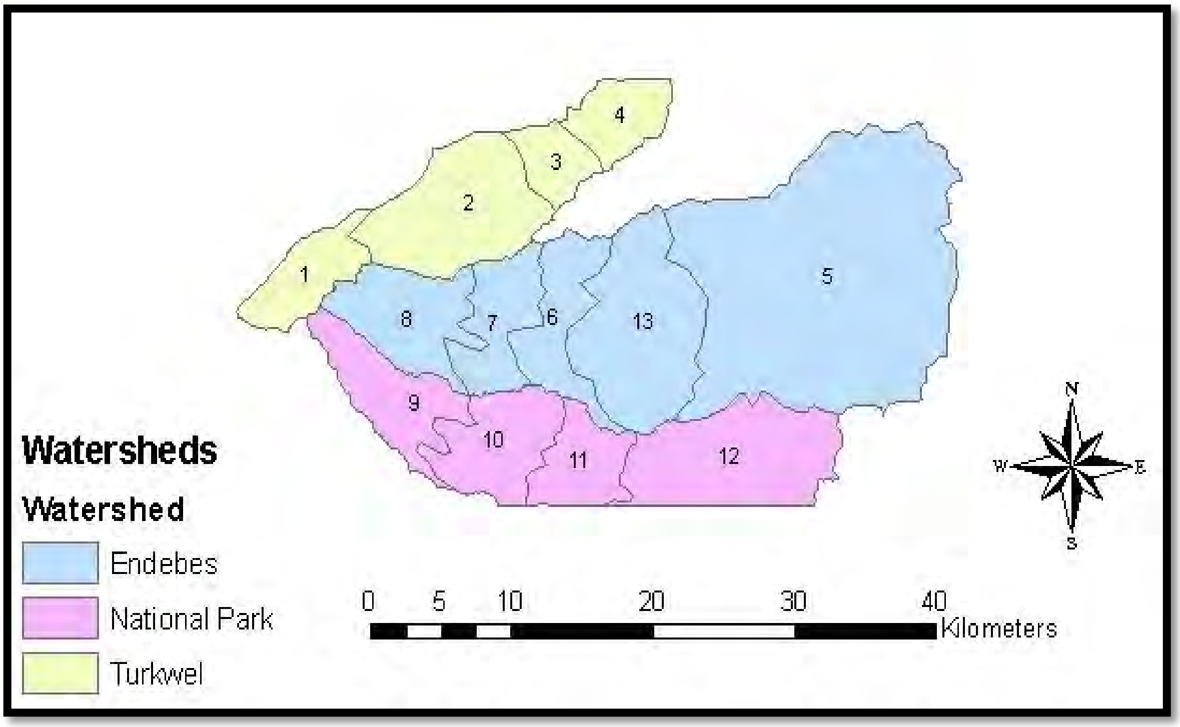

Figure 3b: Landscape Distribution in Different Watershed

Figure 3b. The three watersheds after being subdivided into different functional land cover types for assessment and apportioning of ecosystem service costs.

Table 2: Areas Occupied by Different Landscape Types within Different Watersheds

Id	**Type**	**Watershed**	**Area (km^2)**
1	Moorland	Turkwel	34.3
2	Natural Forest	Turkwel	82.7
3	Plantation Forest	Turkwel	21.8
4	Scaterred Trees	Turkwel	29.4
5	Large Scale Farms	Endebes	288.4
6	Plantation Forest	Endebes	42.6
7	Natural Forest	Endebes	40.1
8	Moorland	Endebes	53.7
9	Moorland	National Park	48.8
10	Natural Forest	National Park	49.7
11	Plantation Forest	National Park	34.1
12	Large Scale Farms	National Park	87.7
13	Subsistence Farms	Endebes	95.2

The economic activities within the Endebes watershed, consisting of both large- and small-scale farming and the Turkwel power station are each serviced by over 130km^2 of moor land, natural forest, and plantation forest. The National Park and the large scale farming activities around Kitale town also depend on the same forests and moorland. Apportioning of service payments on the basis of the "beneficiary pays" principle can be done on either the basis of the proportion quantity of service provided, e.g. amount of water, proportion of the service area or as a proportion of the serviced population. Using this formula, since the Turkwel watershed is only serving one service provider with potential to pay, it should be responsible for conserving the 130km^2 of forest and moorland. All that is required is to develop a value function for conserving one square kilometer and multiply this with the area. Large scale farmers around Endebes occupy 288km^2 and their farming activities are supported by 130km^2 of forest and moor land. Each farmer should pay a conservation fund, an amount equivalent to ((130÷288)*Farm Size*Value Function). Similarly for urban domestic water services, conservation fee could be calculated on the basis of either water intake or population served in different urban settlements.

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FINANCING PROVISION OF ENVIRONMENTAL SERVICES IN MOUNT ELGON REGION FOR THE PROTECTION OF WATERSHEDS

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ABSTRACT

This study examined direct Payments for Environmental Services (PES) as a program for supporting the conservation of forest resources and services where environmental conservation is financed on the basis of beneficiaries pay for the environmental services (ES) they enjoy, while custodians of these services are compensated for their provision. The objective of the study was to determine the distribution of forest resource benefits among different interest groups, and to assess the likely impacts of PES on conservation efforts and total value of forest utilisation in terms of improved environmental service provision. Data was obtained through administration of a questionnaire to 376 households in two districts adjacent to Mt. Elgon forest. Data was analyzed using SPSS. Results show that conservation impacts are indirect and realized with considerable efforts only in the long term. In order to implement PES schemes, there is need to build a strong legal and institutional frameworks that consider land use decisions affecting both forest and non-forest land cover. Payments for restoration and conservation would help landowners have long term obligation to accelerate forest re-growth and gains in water services. The other benefit of PES includes lessening competition between conservation efforts and improving local community welfare.

Introduction

The value of forest goods and services has, for many years, been neglected or underestimated and have not been factored in land use decisions. Yet, the forest services of biodiversity conservation, carbon sequestration, hydrological services, cultural services, provision of scenic beauty and improved human welfare play a critical role in supporting other production systems. Forest resources have spill-overs beyond the forest adjacent communities that benefit local communities, private sector, regional or international communities but the benefits or costs do not enter into gain calculations in the sub-sectors. The forest benefits are mostly left unpriced and hence the beneficiaries normally do not bear the cost of their consumption in the private market environment. Forest services are supplied to the economic units for free or at the point where the marginal costs of provision of environmental services are less than the marginal benefits since little effort or expenditure is required on the part of the consumer. On the other hand, the owners incur opportunity costs in providing the benefits. The retention of forested areas for watershed services can have a number of positive externalities through regulating hydrological flows that improves the quantity and quality of water flows downstream, reduction in sedimentation and flooding downstream, and the improvement of water quality to households and commercial water users. There are indirect benefits to other key sectors like the pharmaceutical industry and biodiversity conservation (Tegart et al., 1990). There are also other benefits of forest conservation that relates to carbon sequestration and mitigating the deleterious impacts of climate change.

The economic benefits of watershed environmental services are shared among economic units and cannot easily be marketed and priced. For this reason, these services have a distorted market mechanism, and hence cannot be adequately provided. The owners or managers of the forests do not enjoy the full benefits of these ecosystem services. Hence, they are not motivated to conserve them. Environmental resources are often not seen by communities as important unless economic benefits are appropriated by those who control or own the ecosystem. In welfare economics a rational man aims at maximizing his utility and thus, will respond to economic signals released by the environment in a manner that maximizes own utility. When economic units do not enjoy the benefits from the environment, it creates a perverse incentive structure that leads to forest degradation. In order to achieve optimum forest cover, the producers of the positive externalities must be compensated by the consumers of these services. Forest preservation benefits national and international consumers by carbon sequestration and biodiversity conservation, while the local and regional economy benefits through hydrological services and ecotourism benefits. For the forest cover to be maintained, a mechanism in which all the beneficiaries compensate the producers of these services must be instituted (Chomitz *et al.*, 1998). It is a direct payments system to landowners to plant or protect forests. This concept of payments for environmental services is meant to provide sustainable financing for forest areas and improve livelihoods. It is estimated that the global value of environmental services is US $ 33 trillion which is higher than the entire world gross national product (WWF, 2006). The payments for environmental services (PES) mechanism is a market-based approach to alter incentives for forest ecosystem management that improves continued provision of environmental services (ES) and alleviates poverty and social conflict which are the main drivers of forest degradation. The payment may be monetary or in kind; it could be a private sector or government financing.

Successful PES schemes in Costa Rica show how the scheme can be used to finance environmental conservation by allowing landholders to be compensated for the ES they provide (Chomitz *et al.*, 1998). The approach is that of delinking environmental services from the financing of these services. It actively sells the services of carbon sequestration and watershed protection to domestic and international buyers. The proceeds from these sales are ploughed back to finance the provision of these services. The government acts as an intermediary in the sale of services, while the private sector initiates a payment mechanism for forestry environmental services program (FESP) which reimburses money for reforestation, sustainable management of forests, forest preservation and forest regeneration (Chomitz *et al.*, 1998).

In Kenya there is a conscious move by many communities to ensure that ES providers are compensated for conservation. Although this concept of PES is much unknown, many community leaders in different parts of Kenya have increasingly demanded to be rewarded even in kind for protecting environmental goods and services from those who derive economic or consumptive benefits of such services. This demand for environmental services compensation is still rudimentary but real. This study attempts to determine a sustainable mechanism for financing provision of ES. Payment for Ecosystems Services has the potential to help conserve forest biodiversity and inject sustainable funding for protected areas and improve rural livelihoods, especially because the poor are the main beneficiaries of the scheme, obtaining on average of 30-50 percent of their total income (World Bank, 2004). Forests services have the potential to become a forum of social conflict resolution, especially between communities that provide and those that consume these services, and between local communities and extractive industries. In economic theory, it is expected that mutual interest of service providers and users is the driving force behind negotiations and hence the program is likely to be sustainable even without government or donor funding support. These negotiations will encourage efficiency for watershed services due to its market based mechanism.

World Wide Fund for Nature (WWF) introduced a new approach to PES, which is called equitable PES (WWF, 2006). In this concept a balance between poverty reduction and conservation is introduced. The traditional PES emphasises on forest conservation and little of poverty alleviation. But the new approach links environmental resource conservation to poverty eradication, which is in line with the global targets of the Millennium Development Goals (MDGs). The contribution of this approach is significant because the rural poor are not only negatively impacted by forest degradation, but they are also the main drivers of forest degradation. By addressing the underlying causes of forests invasion and unsustainable resource use, the perceptions to these resources are changed to encourage conservation. This approach has the advantage of incorporating sustainable management practices, like community participation, into payment for environmental service schemes and hence, improving efficiency of PES projects. The objective of the study was to determine distribution of forest resource benefits among different interest groups, and, assess impacts of PES on conservation efforts and total value of forest utilisation in terms of improved environmental service provision.

Materials and Methods

Empirical Model

The concept of PES is based on the market-based principles in which environmental conservation is financed on the basis that those who benefit from services provided by the watershed (like flood control, reduced siltation to hydro-electric projects) should pay those who facilitate the provision of these services that they enjoy (The World Bank, 2008). The approach seeks to internalise externalities by creating mechanisms in which transactions fora for negotiations are arranged for equilibrium price attainment between the environmental service providers and service consumers. Due to increased population pressures on available arable land, the opportunity costs of forests ecosystem conservation are high, posing a great threat to the remaining forest. In order to continue providing forest environmental services, the net benefits for conserving the forest ecosystem should exceed the opportunity cost of conservation, i.e. what has to be given up for conservation to take place (Turner *et al.*, 1994). This is also the propensity value to degrade the forest. It can be said to be the optimal amount of compensation that the providers of the environmental services are willing to accept (WTA) to continually protect the forest. For this service to be effective the amount of reward or compensation to the providers of ES should be above the landowners forgone land use. Lindahl financing mechanism was used in this study for valuing the provision of watershed environmental services among households in Mount Elgon forest region. The share price household -C^h, where C is consumption of watershed services and h denotes household, would be the willingness to be paid for providing the service. This can be expressed as,

$$X^h = (X_1^h, \ldots\ldots X_2^h = X_n^h)$$

To maximize utility on watershed services, $u^h(X_G^h)$, Subject to the constraint, $\sum P_i E_i^h - C_h^G = \sum_i P_i X_i^h$, Where, $\sum P_i E_i^h$ is the market of h,s endowment in income, C_h^G is the consumption of watershed services and $\sum_i P_i X_i^h$ is consumer price of private goods.

In the mathematical expression above, the market price of watershed services through compensation of ES by appropriating property rights brings into effect efficiency in price mechanism as in private goods. Lindahl financing mechanism compensating agents, which are the beneficiaries of watershed services, provide a price of the social marginal product cost (SMPC) proportional to the marginal willingness to pay (MWTP) for the consumption of the environmental service. The MWTP is the amount the ES providers are paid for them to continue generating watershed services to the consumers.

Study Area

The study was based in Mt. Elgon forest ecosystem. Mount Elgon is located north of Lake Victoria on the border between Kenya and Uganda. It has an altitude of 4320 metres above sea level. The Mt. Elgon ecosystem covers an area of 220,000 hectares both in Kenya and Uganda, out of which 108,300 hectares is in Kenya. It lies between latitude $0^0 48'$ and $1^0 30'$ North and longitudes $34^0 22'$ and $35^0 10'$ East. Mt. Elgon forest occupies 645.05 sq. km and its ecosystem lies within Mt. Elgon and Trans-nzoia districts (currently counties) in the same ecological zone. Most of the mountain forest is gazetted as a Forest Reserve (73,705 hectares) and is managed by Kenya Forest Service. The forest consists of indigenous and plantation trees. Divisions of study were Kapsokwony, Kaptama, Kopsiro and Cheptais in Mt. Elgon District and Kwanza in Trans-nzoia District, with total area of 936.75 sq Km and the main area being forested as shown in Table 1.

Kwanza district is on the foot of Mount Elgon with rich volcanic soils. Mt Elgon waters are drained by the main rivers in Kwanza, namely, Ewaso, Rongai, Koitobos, Noigamet, and Suam which flow to Lake Victoria and Lake Turkana for the latter. On the slopes of Mt. Elgon there are strong red and brown clays which are fertile with high content of clay minerals. It is because of these rich soils and the favourable climatic conditions that agriculture and livestock are the mainstay of the economy in this district.

Table 1: Area of Mt. Elgon District by Divisions

Division	**Total area (Sq.km)**	**Forested area (Sq.km)**	**Arable land (Sq. km)**
Kapsokwany	255.66	198.99	56.67
Kaptama	209.95	142.81	67.14
Kopsiro	248.78	160.90	87.88
Cheptais	222.36	143.34	79.02
Total	936.75	646.04	290.71

Source: Republic of Kenya, 2001

Data Collection

The study required both secondary and primary data. Various methods were used to collect the required data. Primary data was gathered through interviews, key informants and focus group discussions of the studied population(s) in household survey. Secondary data was extracted from various published materials. In analysing environmental services in Mount Elgon, Kenya, a questionnaire was administered to 376 households. Individual household heads were interviewed on local watershed management.

Data Analysis

All the completed questionnaires were collected before being subjected to analysis. Responses to questions were coded and entered into SPSS (Statistical Package for Social Scientists) spreadsheet to facilitate creation of statistics. Descriptive statistical analysis techniques were used to analyse the data. Qualitative and quantitative data was analysed by use of frequencies, tables, percentages and cross tabulations. The analysed data is presented in form of tables, graphs, pie-charts and other appropriate presentation techniques.

Results and Discussions

Results of the study show that 54.7 percent of the respondents had primary education (eight or less years in school) and below, while only 9.4 percent of the respondents had tertiary education. Microeconomic theory suggests that the education of the household members is positively related with the willingness to pay for environmental service improvements. Hence, the education of the household was expected to influence awareness about impacts of forest resource use in watershed management. The people interviewed have stayed in their farms on average for 32 years. Since environmental changes impact the poor most, it means that changes in natural resource use in this region would heavily impact on the local communities (World Bank, 2008).

Most of the households (88.4%) of the respondents said that the household economic activities have been affected by the diminishing status of natural and tree cover within their localities. The community said that climate effects have been manifested in erratic rainfall patterns and sometimes prolonged drought/rains, making it difficult to plan farming activities. The changes in the environment have led the community to change (91.7% of the respondents) their cropping patterns. New crops have been introduced in the area that cope better with changing climatic conditions, and irrigation of crops has also been introduced to supplement rain water, especially during dry seasons. This has affected household income as the costs of food production have increasingly gone up. Figure 1 below shows percentage respondents of various factors influencing engagement in long term environmental services project.

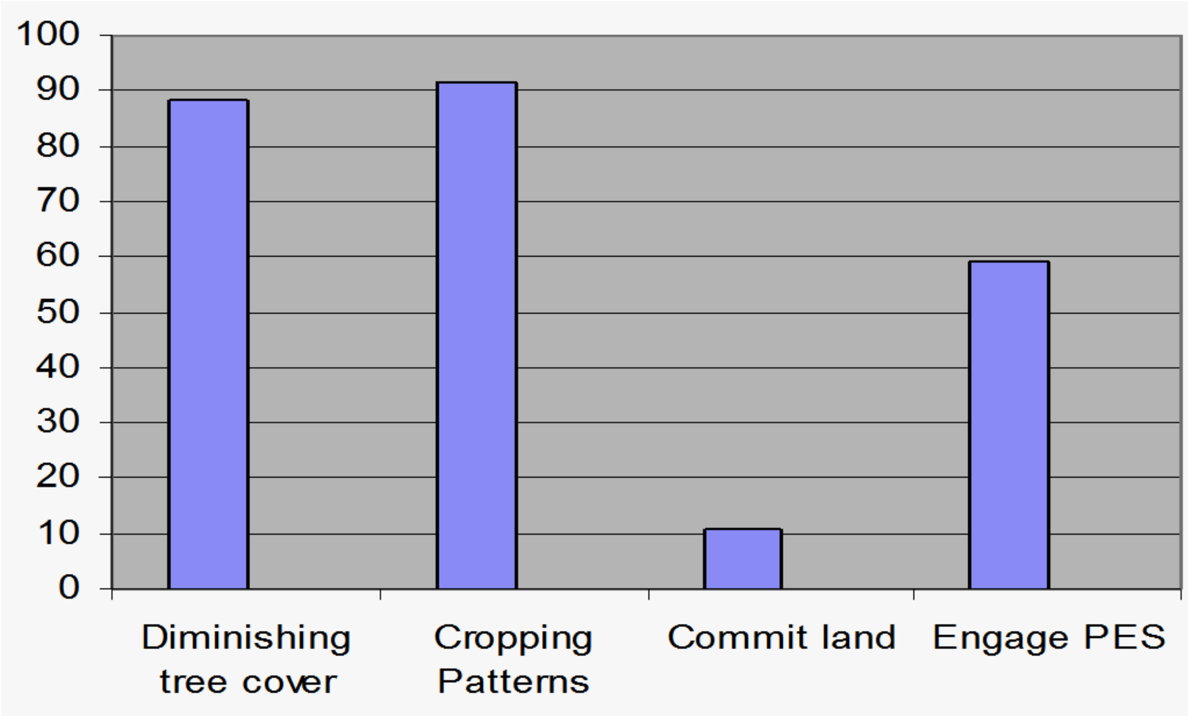

Figure 1: Effects of Change in Environment on Household Characteristics

The average monthly income from farming activities is KSh 4948.9. With an average of 7 household members, it means that most of the people live below poverty line. With an average household land ownership of 4.4 acres, the average acreage of land the respondents were willing to commit to tree growing per household was 0.48 acres.This means that respondents were willing to commit 10.9 percent of their land to tree growing, which is just above the national allowed limit for household land under tree cover. About 59% of the respondents were willing to engage in long term contracts under environmental service projects. The fact that these people were willing to make such long-term commitments, which may extend for as long as 20 years, shows that it is possible to engage the community in long term payments for environmental services in their farms. The willingness to engage in environmental service project reveals the landowner's willingness to accept compensation offers to plant trees on their farms. With the average land size of 4.4 acres and remaining average land of 3.9 acres for food production, the farmers feel confident that they have enough remaining land for agricultural productivity. Hence, the willingness of landowners in Mount Elgon region to engage in environmental service compensation scheme means that direct payments to landowners to plant or protect forests can be promoted as an effective mechanism for providing watershed services. These results show that conservation impacts are indirect and realized with considerable efforts only in the long term.

Mount Elgon Region Watershed Services Payments

The community respondents identified water provision as the most important role played by the Mount Elgon forest ecosystem. When the watershed services were defined the effects on the different land uses were directly identifiable by the community. Hence, quantification of benefits can easily be done. Because of its ability to generate payment streams, water services have strong PES potential (The World Bank, 2008). Community leaders said sometimes provision of water services and use of land resources have caused inter and intra community conflicts. A well-defined services user and provider transactions framework can benefit substantially both parties. These parties were easily identifiable and their nature of interest operations is specific. Transactions in hydrological services are site specific and depend on the local physical, social and environmental characteristics.

In the recent years there has been increased interest in quantifying and marketing watershed services provided by forests. Some of the Mount Elgon watershed services include sediment prevention especially in nearby urban towns of Kitale, Bungoma, Kapenguria, and Kapsokwony. Other benefits are regulation of run-offs and stream flows. Local water service providers also benefit from the continued provision of forest's watershed services for clean water. Kenya Electricity Generation Company (KENGEN) depends on reliable supply of water for Turkwell hydropower plant. The company depends mainly on hydropower plants with sediment-sensitive reservoirs. The water supplies of the above towns are managed by water services boards that depend on the continued provision of these watershed services for clean water. These companies' willingness to invest in the maintenance of Mt. Elgon watershed is premised on the fact that good forest cover regulates stream flows. Forested catchments become temporary water reservoirs that release it gradually. Places like Kwanza sometimes experiences serious floods which is currently a major problem in the area. Protection of forested catchment regulates the rainfall patterns, as well as regulating surface runoffs and stream flows. Regular rainfall flows also assists town councils manage better their drainage systems, and prevent sedimentation.

A recent World Bank (2008) report goes contrary to the common belief thst many water users are willing to pay for environmental services. For example in Costa Rica, many water consumers like bottlers, hotels, agribusinesses, hydrological producers and municipal water companies do pay to conserve the source watersheds with annual payments of US $500,000. In Kenya, Nairobi Water Company is willing to pay for watershed protection (The World Bank: 2008). Many water service companies have on many occasions been forced to solve controversies of water services payments with the custodians of the source of water supply. The principle of this payment is that the water users would pay for upstream conservation from savings resulting from cost cuts to the local water services producers. It is the responsibility of those who bear the costs of forest degradation – such as affected local governments, downstream water utilities, household consumers – to seek opportunities to reduce these costs by financing upstream forest conservation. To date, there are increasing number of private companies, non-governmental organisations (NGOs), individuals, intergovernmental organisations and local communities participating in the PES initiatives. Examples of these organisations include AES, an international power company in Paraguay, which paid US $2 million for the protection of undisturbed dense tropical forest (Powel *et al.*, 2002). The purpose of the payment was to reduce sedimentation downstream and offset carbon emissions. Another example is in Colombia where, by law, hydroelectric and water utilities are required to allocate certain percentage of their revenues to an ecosystem fund. The purpose of the fund is to pay private landowners for watershed management. In Brazil fiscal measures have been applied where a percentage of state tax is allocated to municipalities involved in active protection of watersheds (Powell, *et al*., 2002). All these examples illustrate the diversity of payments for the environmental services across the globe.

Potential for PES Markets in Mt. Elgon Region

Since majority (59%) of the respondents were willing to engage in long term contracts under an environmental service project, it follows that PES markets in the region can be created. Also, the fact that these people were willing to make such long-term commitments, which may extend for as long as 20 years, shows the potential stability of engagements in payments of environmental services. However, in order to develop the market for such services in Mt. Elgon, the forest services needs to be packaged into tradable commodities and properties. When the respondents were asked about the reason why they would engage in watershed PES, most of them could not connect with continued provision of watershed services and financial benefits of service. Hence, there is a low conceptualization of PES in Mt. Elgon. Although 96% of the people interviewed consider water provision as a nature service, nonetheless, most of the community recognize that water is a scarce commodity and that it is valuable. The potential for establishing market structures are varied, depending on socio-economic, environmental factors and levels of market development (Powel *et al.*). One of the options for financing the maintenance of ecosystem services in the region is the Private Sector Financing where the principle source of finance in watershed conservation is the private sector, because of the forests' significant commercial value (World Bank, 2008). Most of the forest products consumed by the local community and payment for carbon sequestration could provide an additional use of the forest resources. Economic valuation is necessary to assess the viability of the market mechanism to support the latter use. There are many valuation methods (e.g. contingent valuation method, travel cost method, hedonic pricing method and conjoint valuation) which can be applied. The creation of the markets requires strong leadership, creativity and knowledge as most markets are unique in their regulatory frameworks, and associated fiscal and legal systems.

Open trading schemes provide another opportunity for financing of ecosystem services in the region. This is a monetary policy scheme where economic instruments are traded in open markets. A good example is environmental performance bonds, which are economic instruments that aim to shift responsibility of controlling forest loss and enforcement to individual environmental service consumers. The consumers of environmental services are charged in advance for the potential damage. This scheme avails adequate funds for the maintenance and restoration of damaged forests ecosystem. Environmental bonds need not be a constraint in economic activity, as they can be invested in interest-bearing accounts or replaced by bank guarantees. The potential of this scheme will be confined mostly to the lumbering industry which is destructive. The Public sector can contribute to the payment of environmental conservation by providing institutional framework for PES. Some of these public institutions include KENGEN, local water service boards, and other government agencies that depend on Mount Elgon watershed services. This scheme has been successful in the U.S. where forest conservation and wetland reserve programs are financedby government (Powell *et al*., 2002). The payment is made to farmers for managing lands in order to reduce erosion and runoff. A similar scheme was started by the Chinese government in partnership with the private sector where there are direct payments to forest landowners. Although there is an increased private sector engagement in forest production that supports corporate social responsibility in the area (Republic of Kenya, 1996), most of these investments are in forest conservation. In spite of the potential of environmental markets in the region, there is none available currently.

Conclusions

Although microeconomic theory suggests that the education of the household members is positively related with the willingness to engage in environmental service improvements, our study revealed that even with low levels of education, most residents of Mount Elgon region were willing to participate in long term environmental service project. As the education of the household often influence awareness about impacts on forest resource use in watershed management the forest-derived watershed environmental services are often regarded as public goods that are freely-accessed. It is therefore important that the providers of the watershed services must appreciate the economic value of the services they generate to the consumers of these services. Hence, payments for restoration and conservation would help landowners have long term obligation to accelerate forest re-growth and gains in water services. Due to the fact that the income generating activities have changed as a result of changes in forest ecosystem cover it is important to protect the Mt Elgon watershed. When the residents benefit from the provision of environmental services then PES market can be used as a tool for environmental restoration and improvement of local community welfare. Because there was no market structure in the region there is need to develop appropriate institutions within the existing framework and/or develop new institutions.

Existence of sufficient funds to finance regular delivery of service is very important for the success of PES mechanism. To implement PES schemes, there is need to build a strong legal and institutional frameworks that consider land use decisions affecting both forest and non-forest land cover. Since communities were willing to avail over 10 percent of their land for watershed service provision with the remaining average (3.9 acres) for food production, it can be concluded that direct payments to landowners to plant or protect forests as an environmental service mechanism can be promoted as an effective tool for not only providing watershed services but also improving community welfare. The 3.9 acres remaining for household food production does not affect local food security situation. This means PES benefits landowners by lessening competition between conservation efforts and improving local community welfare. To effect PES strategies in the region, voluntary certification and eco-labelling schemes, and direct payment schemes for forest watershed provision services are recommended. Partnerships can be made with those who are engaged in private market mechanism like non-governmental organisations, corporate sector social responsibility support and individuals initiative for better watershed service delivery in the region.

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PAYMENT FOR ECOSYSTEM SERVICES FOR SOCIAL WELFARE ENHANCEMENT AT COMMUNITY LEVEL, THE CASE OF RWANDA

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ABSTRACT

Two of the biggest challenges facing Rwanda today are reducing poverty, especially among rural households, and protecting ecosystems which provide essential services that support activities such as agriculture, availability of safe drinking water and the harvesting of forest products. Combining these two objectives is challenging and there are numerous pitfalls to effective policy design. This paper explores the possibilities of linking the growing interest in Payments for Ecosystem Services (PES) mechanisms with alleviating poverty of smallholder farmers of Rwanda. Specifically, the potential of PES programs for carbon offsets, water quality enhancement and biodiversity conservation are analyzed to indentify key challenges and opportunities for successful implementation. To have a positive impact on rural farmers, the main recommendation emphasises the need for integration of PES programs with other rural development initiatives in order to avoid contradictory policies and actions in rural development and land use planning. PES programs also need to be tailored to the specific economic challenges faced by smallholder farmers.

Introduction

Two of the biggest challenges facing Rwanda today are reducing poverty, especially among rural households, and protecting ecosystems which provide essential services for a growing population whose survival is dependent on subsistence agriculture, collection of safe drinking water and the harvesting of forest products. Connecting payment for ecosystem services (PES) with the rural poor could make a significant contribution to both of these challenges. Most of the population in Rwanda consists of smallholder subsistence farmers who produce most of their own food on one hectare of land or less. These farmers critically depend upon local ecosystems for survival and are directly affected by changes in availability of ecosystem goods and services such water, medicinal plants, firewood and raw materials for constructiom.. Thus, the loss of ecosystem services important for food, fiber, fuel and water can be devastating for the rural poor in Rwanda. Already, deforestation has contributed to soil erosion, loss of agricultural productivity and fuelwood scarcity. The loss of wetlands has threatened the availability of clean water. Subsistence farmers participate in the formal cash economy only in limited ways and therefore cannot readily substitute imported food, fuel or water for declining local resources.

In addition, one of the most important needs for smallholder farmers in Rwanda, as elsewhere, is the need to generate cash income and participate more fully in local markets, and ideally even in regional or global markets. Opportunities for extra income not only directly improve material standards of living, but also allow for important investments to increase the productivity of the major asset of the rural poor – land. Increased income can allow farmers to invest more in fertilizers, improved seeds, small-scale irrigation projects and be a cushion during more meager times such as droughts (Polak, 2008). Payments for ecosystem services could provide such extra income. By using their land, smallholder farmers can provide valuable services such as carbon sequestration, water flow, or biodiversity protection. Buyers of such services can include international actors such as countries or utilities seeking to offset carbon emissions, local entities such as hydropower facilities dependent on reliable water flows, tour operators dependent on availability of biodiversity and nongovernmental organizations. Thus PES policies can be used as tools to help protect ecosystems and alleviate rural poverty by allowing smallholder farmers to generate income through providing valuable public goods.

The Importance of the Ecosystem Services

The Millennium Ecosystem Assessment (2003) defines ecosystem services as “the benefits people obtain from ecosystems”. The word “services” in ecosystem services refer to both what economists would call goods (e.g. food and fiber) and services (e.g. waste assimilation and climate regulation). The Millennium Ecosystem Assessment categorizes ecosystem services into four different categories – provisioning, regulating, supporting and cultural. Provisioning services are those physical entities provided by ecosystems. Examples include food, fiber, fuel, water and some pharmaceutical products. Regulating services include climate control, prevention of erosion and water purification. Support services include ecosystem functions that are necessary for other ecosystem services and soil formation and nutrient cycling. Finally, cultural services include recreation, the spiritual significance of some ecosystems and aesthetic values (Millennium Ecosystem Assessment, 2003). There are other ways of classifying ecosystem services but it is indisputable that ecosystems provide valuable services that are necessary for human well being and would be either very expensive or impossible to replace. In their seminal paper, Costanza *et al.,* (1997) estimated that the value of the world's ecosystems is conservatively about $33 trillion.

Man has always been dependent on the services that ecosystems provide. However, for most of human history, the impact of human activity on the provision of these ecosystem benefits was relatively small and localized. Recently, however, as the scale of human activity has increased and the human population has grown, we are altering ecosystems in ways that have never been done before. These changes have begun to threaten many of the crucial services that ecosystems provide. For example, forests are important, among other things, for filtering and retaining terrestrial freshwater supplies. Approximately 4.6 billion people depend on forests for at least part of their water supply; yet over the last 300 years, the world's forest cover has been reduced by 50% through human activity (Millennium Ecosystem Assessment, 2005). Somewhere between 10 and 30 percent of mammal, bird and amphibian species are threatened with extinction (Millennium Ecosystem Assessment, 2005). This reduction can impair ecosystem function and therefore other ecosystem services and reduce the genetic diversity of the world's biota which is an important resource for, among other things, pharmaceutical development. Through burning of fossil fuels and land-use change the atmospheric concentration of CO_2 and other greenhouse gases have significantly increased - CO_2 by approximately 34% (IPCC,, 2007). This change in atmospheric composition has and will continue to increase global temperatures, thereby causing negative impacts on agricultural production in the tropics, flooding of coastal areas and potentially much more devastating and frequent extreme weather events such as hurricanes. Overall over 60% of the ecosystem services examined by the Millennium Ecosystem Assessment were found to have been degraded or are currently managed unsustainably (Millennium Ecosystem Assessment, 2005).

Rwanda specifically has experienced a decline in multiple ecosystem services that impact human well-being. For example, deforestation in mountainous areas and the destruction of wetlands in low-lying areas have reduced the capacity of these ecosystems to filter, regulate and clean water. Over the past 40 years Rwanda has suffered very serious losses to its natural areas. Since Independence in 1962, the total area within protected areas (PAs) has been halved: from 4115 km^2 to 2073 km^2. The Volcanoes National Park (NP) has lost nearly half of its habitat from 310 km^2 since the end of the colonial period to the present 160 km^2, while Nyungwe NP has lost more than 13% (from 1175 km^2 to 1013 km^2) in the same period. Troubling as this situation is for Rwanda's parks, the losses are even greater in forest areas outside the PA network and in wetlands. For example, of the 280 km^2 of natural habitat available within the Gishwati Forest Reserve in 1980, only 7 km^2 remain; of the 50 km^2 present within the Mukura Forest Reserve in 1980, no more than 8 km^2 of degraded habitat remain (Weber, Masozera, & Masozera, 2005). And according to Kanyarukiga and Ngarambe (1998) at least 93,754 ha of a total 164,947 ha of wetland surface area have been destroyed for cultivation. Degradation of wetlands and deforestation of natural forests has resulted in soil erosion, landslides and flooding, thereby inducing the relocation of people and sedimentation of hydropower plants, leading to power shortages and water scarcity in much of the country.

The cost of energy per kWh has increased from 7.5 cents USD in 1997 to 20 cents USD in 2005 (Nile Equatorial Lakes Subsidiary Action Program, 2006). The decrease in energy generation and water scarcity will likely become very significant in the near future as the demand for clean water and energy in Rwanda increases due to economic and population growth. Almost 50% of the agricultural land in Rwanda shows signs of soil erosion, indicating a reduction in the capacity of the land to produce food and fiber. A study by Stoorvogel and Smaling (1990) revealed that Rwanda has one of the most severe nutrient depletion rates in Africa, with on average -54 kg N, -20 kg P^2O^5, and -56 kg K^2O per ha per year. As a result the documented yields of legumes and beans have been declining over recent years (International Institute for Sustainable Development, 2005). The majority of Rwandans use wood or charcoal as their main energy source. Yet deforestation threatens this important ecosystem service. In addition, rapid deforestation and loss of some protected areas threatens biodiversity which is important for tourism and potential for pharmaceutical developments. Finally climate change is projected to impact all the ecosystem services mentioned above by changing local climatic conditions such as increasing the frequency and severity of droughts (Working Group on Climate Change and Development, 2006). Impairment of these and other ecosystem services in Rwanda can significantly reduce human well-being and threaten future development prospects for the country. Hence, natural resource management for the protection of ecosystem services must be a high priority for the Rwandan government and its development partners, including civil society and private industry. Hitherto, resource management decisions are generally made on the margins of other supposedly more important development decisions. However, for ecosystem services to be realized, the disincentives facing resource management, including those by smallholder farmers, need to be addressed, as well as putting in place positive incentives for natural resource managers.s. PES programs are designed to provide such incentives. For example, the Clean Development Mechanism (CDM) under the Kyoto Protocol allows developed countries to meet some of their reduction requirements by sponsoring afforestation and reforestation projects that sequester carbon in developing countries. Other PES programs are aimed at inducing resource users to protect biodiversity, provide clean water and enhance other valuable ecosystem services.

Linking Payment for Environmental Services and Rural Poverty Alleviation in Rwanda

Payment for Environmental Services (PES) is increasingly identified as potential avenues to the synergetic objectives of conservation and development, particularly for landowners in the low-income tropics (Tschakert, 2007). Most of the experience with PES has been in Latin America with some limited cases studies in Africa. Pagiola *et al*. (2005) review a range of experiences with Latin American PES programs, and highlight key factors that contribute to local participation, which include the profitability of PES practices, secure land tenure, investment costs, level of technical capacity required to adopt PES-promoted practices and transaction costs. In addition, these experiences have suggested that wealthier farmers with larger asset bases, more diversified incomes, non-farm income, and better access to information and social networks tend to gain disproportionately from signing up for ecosystem service provision while poorer, less flexible, and less connected households can be left out (Brown & Corbera, 2003; Grieg-Gran, Porras, & Wunder, 2005). These insights illustrate the challenge of creating a synergy between ecosystem services and poverty alleviation in Rwanda. Despite these challenges, however, there is potential to produce ecosystem services on smallholder land in Rwanda. Much of the land in Rwanda is mountainous, which means that soil erosion and the resulting loss of soil fertility is a significant problem. Planting suitable land in forests or agro forestry systems can be an effective way to mitigate this problem, while also providing a source of income for the farmer. Forests and agroforestry can also improve water quality, sequester carbon and enhance biodiversity. Planting bamboo can sequester carbon and provide building and craft material. To understand how such practices can be applied to smallholder farmers in Rwanda, in light of the challenges in doing so, it is necessary to understand the specific challenges faced by smallholder farmers in this part of Africa.

In Rwanda most farmers employ manual labor with very few inputs such as fertilizer, pesticides or improved seeds. According to Drechsel and Reck (1997), the use of fertilizers is very low (0.4-0.5 kg/ha) due to their high price. Many areas in sub-Saharan Africa, including Rwanda, are prone to regular droughts with soils less fertile than other parts of the world. In addition, Sub-Saharan Africa has less irrigated agriculture than other parts of the world. For example over 35% of Asia's farmland is irrigated, whereas only 4% of sub-Saharan Africa's farmland is irrigated (Sachs, 2005). In 2000, cereal yields in Sub-Saharan Africa were a little over one metric ton per hectare. By comparison, in Asia cereal yields were over 3.6 metric tons per hectare; in Latin America about 2.8; and in North Africa and the Middle East a little over 2.6 (Sachs *et al*., 2004). In addition, Rwanda is landlocked with no easy road or railway linkages to the coast. This geography can play an important role in economic growth by depriving a country of access to international markets.

With low yields, susceptibility to droughts and limited access to markets, smallholder farmers in Rwanda often do not invest in agricultural technologies even if credit markets are available. Farmers in such a situation need two things to climb out of their poverty. First they need low risk strategies to generate surplus income from cash crops. Growing such crops must require relatively few inputs besides labor in order to avoid the loss of significant financial investments during periodic climatic events such as droughts or floods. These cash crops also need to be able to be integrated into the subsistence farming that is a necessity for smallholder farmers in Africa. Second markets need to be made available for these cash crops. Providing ecosystem services could meet such requirements under certain conditions. Agroforestry, for example, could provide a means to diversify food and fiber production and allow smallholder farmers to generate income through selling carbon credits or water quality benefits. The income generated from ecosystem services could allow these farmers to invest in improved seeds or small scale irrigation. In addition selling ecosystem services such as carbon sequestration has the advantage that the output does not need to be transported. Hence it can benefit smallholder farmers in remote areas. Carbon sequestration is also a service without scope for quality differences. Hence, the relatively high production costs often faced by smallholders in meeting national or international standards do not arise in this arena (Cacho, Marshall, & Milne, 2003). This situation makes it critically important in Rwanda that agricultural policies including those involving the production of ecosystem services focus on smallholder farmers, particularly those with one hectare or less.

Potential PES Programs for Rwandan Smallholder Farmers

In the following section we discuss three ecosystem services, carbon sequestration, biodiversity and water enhancement, that Rwandan smallholder farmers can potentially supply. We highlight the challenges in designing PES programs aimed at smallholder farmers for each ecosystem service. It is hoped that designing policy and institutional arrangements around such challenges will produce more effective PES programs. The ecosystem services discussed here are not exhaustive of the potential services that could be provided by Rwandan smallholder farmers. However there is some experience in developing PES programs around these ecosystem services in developing countries and they each pose their own obstacles and opportunities to implementation. It is important to note that different ecosystem services are not exclusive. Often specific management techniques can yield multiple ecosystem services. For example, protecting riparian habitats by leaving a vegetative buffer strip along water courses can provide a multitude of ecosystem services. The vegetation can sequester carbon helping to mitigate climate change. The buffer strip can also protect biodiversity, both terrestrial and aquatic, and improve water quality downstream. Thus it is conceivable that a particular farmer can be compensated for several ecosystem services, further diversifying his or her income stream.

Carbon Sequestration

Anthropogenic climate change resulting from the build-up of carbon dioxide and other greenhouse gases is causing increasing global concern. Terrestrial vegetation plays a significant role in the global carbon cycle by sequestering carbon dioxide from the atmosphere during photosynthesis and storing it in biomass. Land-use change can either increase or decrease atmospheric carbon dioxide levels by increasing or decreasing the amount of biomass. Currently, agriculture and forestry account for approximately 30% of anthropogenic greenhouse gas emissions (Intergovernmental Panel on Climate Change, 2007). As a result various incentives, including PES programs, have been set up for the sequestration of carbon dioxide or the prevention of carbon dioxide emissions from land management. Adopting agroforestry and planting bamboo are two promising means of sequestering carbon on smallholder land in Rwanda. Agroforestry involves planting trees along with traditional agricultural crops. The trees increase the biomass on a plot of land through the sequestration and storage of carbon from the atmosphere. In the tropics, it is estimated that for smallholder agroforestry systems, potential C sequestration rates ranges between 1.5 to 3.5 Mg C/ha/year and also have an indirect effect on C sequestration by helping decrease pressure to convert natural forests, which are large sinks of terrestrial C (Montagnini & Nair, 2004).

In Rwanda, Agroforestry is a traditional practice that could be expanded fairly easily. Currently, smallholder farmers in the country plant fruit trees or trees to use as firewood, building material or other wood products. In addition to sequestering carbon, agroforestry can provide many other benefits such as provision of firewood which is a critical need in Rwanda, prevent soil erosion on sensitive hilly land and in some cases replenish soil minerals such as nitrogen, phosphorus, calcium and magnesium, and protect water quality (Roose & Ndayizigiye, 1997). Bamboo is a fast growing species that can rapidly sequester carbon, prevent soil erosion, help restore degraded land, serve as a source of energy and can be the raw material for various marketable products. Embaye *et al*. (2005) reported a biomass content of 66 mg above, plus below ground carbon per ha per year in a mature Bamboo stand in Ethiop. Due to its fast growth, the species can be harvested on yearly basis. However, while there are documented social, economic and environmental benefits of agroforestry and bamboo, it is important to understand the challenges for carbon sequestration in leading to poverty alleviation for smallholder farmers in Rwanda. Programs that promote the alleviation of poverty through the adoption of land use change are not new and have formed a major aspect of rural development efforts over the past four decades (Lipper & Cavatassi, 2004). However despite the positive effects of these programs, the adoption of low-cost technology such as agroforestry has remained low. The agricultural and economic development literature has frequently stressed that disparities in access to labor, land, asset, and money, as well as farmer's knowledge, institutional linkages, and social networks define how vulnerable resource users are to uncertainties and risks intrinsic in technology adoption and market participation (Desgupta, 1993; Lipper & Cavatassi, 2004; Perez, Roncoli, Neely, & Steiner, 2007; Shiferaw, Okello, & Reddy, 2009).

Elsewhere, there is social differentiation and spatial variation in resource availability among smallholder farmers in Rwanda meaning that practices that seem feasible and eligible for carbon payments in one location or social group may not necessarily be so in another location. For instance a study by Bidogeza *et al*. (2009) found that female-headed households in Rwanda were adopting relatively cheap inputs such as compost and green manure because they are constrained by a low level of education and small farm size which prevent them from adopting other more costly technologies. To successfully engage smallholder farmers in a carbon sequestration program, it will be important to understand these social and spatial variations in order to design a carbon credit scheme that contributes to poverty reduction. For instance, an appraisal of the profitability of carbon enhancing technologies (relative to existing practices) across different agro-ecological zones of Rwanda can determine the spatial variability in smallholder farmer willingness to adopt and to commit to implementing them over time, and hence, can assess whether carbon sequestration revenues can increase rural farmer's incomes. Agricultural extension services can also tailor assistance to the specific needs in a region.

The adoption of appropriate institutional arrangements is also important. Economic incentives to sequester carbon may not necessarily translate into carbon sequestration programs without suitable institutional arrangements to facilitate the processes of aggregation, monitoring and verification (Perez, *et al*., 2007). As Rwanda's landscape is a mosaic of small agriculture plots averaging less than a hectare, it would be difficult to develop carbon credits by reforesting individual fields or parts of fields, given the extremely small parcel size. One way to address this issue would be to aggregate small amounts of carbon sequestered in a large number of small plots to scales large enough to be tradable on carbon markets. For instance a certain number of families could be aggregated and organized under carbon cooperatives in which local communities agree to reforest and protect a portion of their land that could be used collectively for sustainable wood harvesting and generation of carbon credits. The cooperative would be in charge not only of selling carbon credits but also providing support to farmers. As Eaton and Shepherd (2001) note, it is not enough to identify activities with high income generation potential for rural people; rather it is critical to provide a reliable and cost-effective package of support and services ranging from extension advice, good seed, fertilizers and credit, to facilitate smallholder farmer participation. Institutional arrangements that can facilitate the provision of support for smallholder participation in carbon markets are therefore essential.

In addition, facilitating cooperation among various administrative agencies that impact the management of smallholder land is crucial. The government of Rwanda has embraced decentralization as a form of local governance to enable people to participate more directly in the governance processes and empower marginalized communities. This policy has created a conducive environment for creating cooperatives and associations and opened opportunities for institutional capacity building at the local level. However at the national level, given the current institutional arrangement, it is unclear which government agencies will in practice control forest-based carbon credits. For instance the National Forest Authority (NAFA) has the responsibility of managing and monitoring forest cover, deforestation and overall land use changes and centralizes carbon credit transactions from forest-based projects. The Rwandan Environment Management Authority (REMA) has the overall responsibility of management of the bio-physical environment throughout the country and contains the Designated National Authority (DNA) for Clean Development Mechanisms (CDM) projects. The DNA has the responsibility of approving carbon projects proposed within the scope of the CDM. To encourage inter-institutional and intersectoral collaboration and ensure transparency in measuring and accounting procedures and equitable access to information by rural communities, a cross-administration forest-carbon group could be established. This group should have clear authority to evaluate and support forest-carbon projects, as well as to develop a set of guidelines on revenue-sharing, ecological values, and community benefits with which every potential project has to adhere.

In Rwanda, credibility in a carbon market system will hinge on the existence of sufficient technical capacity within the country, to apply rigorous methodologies and standardized protocols for carbon measurement, monitoring and verification; and for estimating costs and benefits of carbon sequestration. Experience in some other countries (e.g. Mexico) suggests that substantial funding can be lost in preparation of unsuccessful project proposals because of lack of necessary knowledge and capacity (Corbera, Soberanis, & Brown, 2009). In addition, often project developers do not explain in plain language the requirements to developing a successful carbon project in terms of design, implementation, monitoring, verification, certification and interactions with intermediaries. Unfortunately this has helped create an impression that PES programs are a foreign owned process creating skepticism in many countries, including Rwanda. Technical capacities are present in Rwanda (e.g. GIS analysis and remote sensing), but they are scattered in different government agencies, universities and nongovernmental organizations. It is critical that efforts be made to assess the capacity needs and design a capacity building program to adapt to the evolving opportunities in carbon sequestration.

Finally, in addition to carbon sequestration activities on smallholder land, there is an opportunity to generate the revenue for conservation of Rwanda's protected tropical mountain forests by valuing standing forests for the carbon they contain. For instance, a preliminary feasibility study on the opportunities for carbon asset development from forest conservation in Nyungwe National Park (NFNP) demonstrated that assisted natural regeneration of burned forest areas could generate a total 30-year net revenue of $ 11.8 million (De Gryze *et al*., 2009). Potential markets for developing countries to store carbon in protected areas are being discussed as part of post-Kyoto climate change negotiations. Ways of ensuring that at least some of the revenue from such projects benefits smallholder farmers living around protected areas should be pursued. This would be critically important in Rwanda as some of the poorest communities in Rwanda are located near the borders of protected areas.

Watershed conservation

The ability of healthy watersheds to moderate water flows and purify drinking water supplies is one of their most tangible and valuable (social and economic) services (Postel & Thompson, 2005).

Land management can have a significant impact on both water quantity and quality. Forested areas and intact wetlands filter water before it enters streams, rivers and lakes, and retain water, thus regulating the amount and timing of water delivery in watersheds. Watersheds without adequate protection deliver less clean, less reliable water to downstream users. Deforestation, clear cutting, and poor farming practices can send large influxes of eroded sediments into rivers and streams, thereby degrading the quality of water (Calder, 2000). As suspended sediment levels increase, so is the time and effort required in treating water, leading to increasing expenditures on treatment, maintenance, and operations, as well as additional costs of capital equipment.

Unlike carbon sequestration and biodiversity, most of the ecosystem services related to water accrues to local or regional beneficiaries. Rwanda's cities depend on small forested watersheds and wetlands for their water supplies and electricity generation. Of the total installed electric power generation capacity of 41.25 MW, hydropower accounts for 65% while thermal power accounts for 35% (Safari, 2010). Many of the existing hydroelectric power plants are run-of-the river schemes, with minimal storage which make them very dependent on stream-flow for their operation, a constraint that becomes particularly significant during the dry season. In addition, they are more vulnerable to sedimentation because of their limited storage capacity, and damage to their tubing and turbines from sediments. High peak-flows are also harmful because much of the water cannot be used for power generation and transported debris can clog intakes and damage turbines. Owing to pressure for agricultural land, combined with failure national planners to formally recognize, protect and manage the water purification and sediment control services provided by the watersheds have led to the incremental deterioration in these services over the last two decade. As a result, Rwanda has experienced energy and water shortages, especially in cities. For example, due to reduced water flows the generation of electricity from two hydropower stations, Ntaruka and Mukungwa, has declined in the last two decades from 11.25 MW to 2.5 MW and from 12.45 to 5 MW, respectively (Safari, 2010). In addition, increased sedimentation resulting from high rates of hillside erosion due to the cultivation of the Gishwati forest led to rising treatment costs of urban water and higher maintenance costs of water and hydropower plants. For instance, the average amount of aluminum sulfate needed to remove sediments from water plants located in an intact watershed, such as Nyungwe forest, varies between 0 and 40 g/m^3 while for a plant located in the Gishwati watershed it is around 143 g/m^3 (Masozera, 2008).

Rwanda government's strategy to deal with the problem of water scarcity and its consequences has mainly focused on law enforcement and expanding the physical infrastructure through engineering projects. Environmental management instruments are almost completely absent from the government's strategy. The growing cost of infrastructure services has induced the government to subsidize production and consumption of water and electricity as many households have difficulties affording the services. Due to the increasing costs associated with supply-side measures and the failure of past policies to inspire appropriate and sustainable management of natural resources, it is important to create economic incentives for improved environmental management to ensure regular flow of water resources.

A rich variety of institutional mechanisms exists to encourage higher levels of protection of hydrological functions, including payment for watershed services. The rationale of such PES schemes is to provide economic incentives to avoid environmental degradation in areas where severe water problems are linked to environmental degradation such as deforestation. However, despite the global experimentation with payment for watershed services (PWS) schemes for almost a decade, only a few programs exist in Africa. Two of them that are operational are located in South Africa and six others are being initiated or are in planning phases in Kenya, South Africa, and Tanzania (Ferraro, 2007). Payment for watershed services proponents frequently cite a common list of obstacles to the development of payment schemes, including lack of technical and market information, limited institutional experience, inadequate legal frameworks, limited successful business models, suspicion of markets for public goods and equity concerns. Ferraro (2007) notes two other fundamental barriers to establishing PWS in Africa, namely, the financial health of institutions benefiting from watershed services and consumers with the ability to pay. These two barriers are relevant to the Rwanda context as well. Two potential consumers of water ecosystem services in Rwanda are the Rwanda Electricity Company and the various tea factories around the country.

Despite the fact the Rwanda's current energy pricing policy does not take into account the real economic costs of environmental damage, the average supply cost estimated at 22 US cents per Kwh remains above the current price level of 20 US cents (Nile Equatorial Lakes Subsidiary Action Program, 2006). This situation has made the Rwanda Electricity Company inefficient in operating and undermined its capacity to improve and expand services. One of the potential solutions to improve efficiency of Rwanda utility companies would be to charge consumers the full economic costs of water and electricity by reviewing the pricing policy and subsidize connection to facilitate access to low income groups. The current consumption subsidies for electricity in Rwanda are regressive in large part due to access factors that prevent the poor from using the services (Angel-Urdinola & Wodon, 2007). As poor households tend to live in areas without electricity service, or far from electric lines where service exists, it is difficult for them to benefit from electricity subsidies simply because they are not connected to the network. Angel-Urdinola and Wodon (2007) suggest shifting from a single rate for all consumers to a Volume Differentiated Tariff (VDT) structure whereby only those consuming a total volume of water or electricity below a certain threshold would benefit from lower prices. VDTs are composed of two or more different tariffs, the first highly subsidized and the second much less or not at all, to which consumers are assigned based on their total volume of consumption. This system could lower the price and improve access to services for low income groups while increasing the price to more affluent households. Under this regime the money collected by electric and water utilities could pay smallholder farmers located in critical/sentitive watersheds to implement conservation practices, such as planting vegetation buffer strips or utilizing agroforestry, on their land that would improve water quality and quantity.

Industrial water users such as tea estates are self-supplied industries not connected to a distribution network. Tea production necessitates a considerable amount of water for growing and processing. For instance, the global average virtual water content of 1 kg of black tea is 10.4 m^3 (Chapagain & Hoekstra, 2008). This makes water a strategic commodity for tea estates as it is a main factor of production. But it is still considered as an open access resource or a free gift from nature as the economic cost of water is never included in the market price of the tea produced. Based on avoided costs estimates tea estates dependent on clean water from Nyungwe Forest National Park could pay the Office of Tourism and National Parks for the conservation of the forest and smallholder farmers around the park to engage in best agricultural management practices. The extra income from such payments could increase the income of smallholder farmers in the region and reduce pressure to convert land in the park or the buffer zone around the park to agricultural uses.

Biodiversity conservation

Rwanda possesses an extraordinary level of biodiversity given its small geographical size. Most of this biodiversity is located in three protected areas within the country. Virunga National Park in the northwest of the country and Nyungwe National Park in the southwest consists of high Mountanous tropical forests. Akagera National Park in the east consists of tropical savannah. Significant threats facing these protected areas and the biodiversity contained within them include land conversion to agriculture of buffer zones and even the parks themselves, and illegal use of park resources (i.e. collecting plants, mining, etc.) by the local population surrounding the parks (Hatfield, 2005; Masozera & Alavalapati, 2004). If local smallholder farmers surrounding these protected areas could directly benefit from the biodiversity protected in these parks then some of the pressure to convert these areas to agriculture and illegal poaching of the resources would be lessened. The value of the biodiversity in these areas is large and mostly accrues to the international community. Therefore there could be potential for payments to help protect these natural areas and increase the income of smallholder farmers surrounding themFor example, one recent study clearly indicates that the forest in Virunga National Park provides significant positive value to the international community through tourism (i.e. gorilla tracking expeditions), existence values and other ecosystem services. However, local communities, particularly smallholder farmers receive little of the benefits produced by the Park and disproportionately bear the costs of the Park. Specifically, over 20 million USD of the benefits derived from the Park accrue to the national and international community. The local communities actually lose approximately 11.7 million USD mainly in the form of the opportunity cost of land occupied by the Park (Hatfield, 2005). This creates a system where there is little incentive for local smallholder farmers around the Park to support its protection and refrain from land conversion in and around the Park.

Payments made to local farmers to refrain from converting more land to agriculture through intensification on existing agricultural land could help alleviate this situation. For example, Hatfield (2005) in the study mentioned above found that as little as 68.10 USD could be paid to smallholder farmers around the Park to mitigate the desire to convert additional forestland to farmland. This payment could be used to invest in agricultural inputs to increase the productivity of these farmers or as credit to be invested in land use practices that could sequester carbon and increase soil fertility. This increased productivity could relieve poverty in the area; while at the same time increasing the ecosystem services that the global community receives from the Park by reducing the pressure to convert forestland. Along these lines the Rwanda National Parks Services (ORTPN) has initiated a revenue sharing scheme that aims at increasing the effectiveness of national parks in attaining conservation objectives and contributing to the improvement of communities' livelihoods around the parks. The revenue sharing policy earmarks 5% of the total gross revenue earned in each park to be combined into a national pool where at least some of the money is used for poverty alleviation. However this program is small relative to the population density of poor smallholder farmers around the Parks. Such programs should be substantially scaled up and linked to other rural development initiatives.

Conclusions and Recommendations

While PES programs are not designed to be a poverty alleviation strategy, they can result in more sustainable livelihoods through the provision of cash or in-kind benefits to participants, especially when targeted specifically at rural communities (Pagiola, *et al*., 2005). For over 30 years research has focused on the development and promotion of low-cost technologiessuch as agroforestry, fast growing nitrogen-fixing legumes and the inter-or relay-cropping of green manure (Drechsel & Reck, 1997; Roose & Ndayizigiye, 1997). However, despite the positive effects of these technologies on nutrient supply, reduction in soil loss, increased crop yields and fodder and firewood production, their adoption has remained low (Drechsel & Reck, 1997). The adoption has failed because the new technologies have not matched with the socioeconomic circumstances of farm households. The literature on adoption of natural resource management technologies and innovations has frequently stressed the role of different factors, such as farm size, capital and labor availability, education, risk perception and risk attitude, and land ownership (Bidogeza, *et al*., 2009). It has also been demonstrated that improved market access that raises the return to land and labor, access to credit and availability of pro-poor options for beneficial conservation are critical factors in stimulating livelihood and sustainability-enhancing investments (Lipper & Cavatassi, 2004; Shiferaw, *et al*., 2009). These are barriers that can prevent smallholder farmers from participating in PES programs. There is also tendency to assume homogeneity within the faming population, particularly with respect to socioeconomic variables (Nkonya, Schroeder, & Norman, 1997). PES programs and extension activities aimed at smallholder farmers need to focus on the specific needs of smallholder farmers and adapt programs to the variability of smallholder farmers needs in different regions and social groups.

Ecosystem services cut across all economic sectors and are supplied at different institutional and geographic scales. As Brown and Corbera (2003) note, a critical challenge in the new carbon economy is establishing robust cross-scale institutional frameworks to enable an equitable interaction among stakeholders and, more importantly to deliver sustainable development to local communities. To successfully design and implement a PES program, efforts should be made to ensure institutional coordination to avoid contradictory policies and actions in rural development and land use planning. Studies that explore the roles, interests and perspectives of different actors involved will help decision makers to identify areas of synergies and conflicts across institutional arrangements. In addition, transaction costs are a major issue in determining the viability PES programs associated with smallholder farmers. Future research needs to focus on which type of institutional arrangements for smallholder farmers reduce transaction costs. For example the effectiveness of different cooperative arrangements of smallholder farmers in facilitating the participation in PES programs should be explored. The role that indigenous institutions could possibly play in this regard should also be considered.

Finally PES programs are very information intense. Both suppliers and beneficiaries need information on the ecosystem services provided by various ecosystems and how they are impacted by management. For instance, downstream water users such as a tea factory need to know the quality of the water they are receiving from upstream and how it is influenced by specific land use practices. They also need information on the value, to them specifically, of improvements to water quality due to land management practices. Only then could they put a value on the management practices of upstream farmers and facilitate payments. One vehicle for gathering such information is through traditional research funded by the government and international donors. Thus there is a need for the international environmental community and development agencies to collaborate in funding research to gather information on ecosystem services in Rwanda. In addition, however, Environmental Impact Statements (EIS) could be used to gather needed information. As elsewhere in the World EIS's are already used in Rwanda to gather information on how various projects in the private sector influence the environment. Numerous consulting agencies offer their expertise to entities needing to conduct an EIS. Environmental Impact Statements could be required to include information on the ecosystem services impacted by the projects, the value of these impacts on specific impacted groups and the level of dependency of a particular project or economic activity on ecosystem services. This type of information could range from rough qualitative estimates to detailed quantitative estimates depending on the cost and availability of information. Over time this could help build a substantial base of information that can be used to develop PES programs.

Payment for Environmental Services programs alone cannot reduce poverty of rural farmers in Rwanda. Therefore, PES programs should be integrated with other rural development initiatives as a means to increase incomes with particular emphasis on restoring or preserving ecosystems and raising the awareness of the importance of ecosystem services. It is becoming increasingly clear to both development advocates and conservationist/environmentalist that the goals of economic development and conservation must be linked and that ultimately one depends on the other. Without protecting the flow of ecosystem services development will ultimately be hindered. Without alleviating poverty and providing a means for social and economic development of the poor the challenge of conservation will be substantially more difficult in developing countries such as Rwanda. While not a panacea, PES programs provide a potential tool to address both economic development and ecological sustainability in Rwanda. In order for such an endeavor to make a significant contribution it is essential that such efforts focus on smallholder farmers.

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CAN PAYMENT FOR ENVIRONMENTAL SERVICES ENHANCE THE RURAL ECONOMIC DEVELOPMENT AND FOREST CONSERVATION IN KORDOFAN REGION, SUDAN?

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ABSTRACT

Non-wood forest products have economic, social, cultural and ecological importance in Sudan. The objective of this paper is, to reflect the importance of implementing the Payment for Environmental Services (PES) in sustaining the role of gum Arabic from *Acacia senegal* L. (Wild) and fruits from Boabab (*Adonosonia digitata* L.) in economic development and environmental conservation in rural areas. Primary and secondary data were collected in 2007 and 2008 using a pre-constructed questionnaire and direct observations. The results show that human activity, market variables, lack of microfinance and lack of capacity in extension, and climatic factors were the main constraints in the region to achieve the twin objectives of economic development and conservation of the region's tree cover. The study concluded that PES incentives could assist the rural people to sustain their economic benefits while at the same time conserving their natural resources.

Introduction

Forest ecosystems provide a wide variety of environmental services such as water regulation, biodiversity conservation or carbon storage for climate mitigation (de Groot *et al.*, 2002). Market mechanisms for forest environmental services are used increasingly for fostering environmental conservation and their impact on development (Grieg-Gran *et al.*, 2005). Adopting Payment for Environmental Services (PES) mechanisms can be a way to achieve both development goals and natural resource conservation, especially in poor regions (Tschakert, 2007). However, PES for reforestation has been widely criticized for possible negative impacts on rural livelihood and resource conservation (Bull *et al.*, 2006). This debate has been currently reactivated by the inclusion of afforestation and reforestation projects under the Clean Development Mechanisms (CDM) of the Kyoto Protocol (Totten *et al.*, 2003). The essence of these mechanisms is to provide financial benefits to developing countries to minimize deforestation and degradation activities, so that the forests can continue to reduce CO2 emissions below those that occurred during a certain reference period.

The provision of financial incentives to developing countries for forest conservation has received support from many quarters. Nevertheless, it has also raised concerns about the potential impact on the rights and livelihood improvement of the rural people who could see themselves deprived of their traditional lands or their rights of access to forest resource (Griffiths, 2007). To address these concerns, various options have been investigated to foster the participation of rural inhabitants (Angelsen *et al.*, 2009), and paying them for forest conservation, reforestation and afforestation through the PES mechanism seems to hold the most promise. Whilst PES schemes were not developed as an instrument to improve livelihoods, there has been an increasing interest on the livelihood impacts on participants, particularly in relation to poverty alleviation (Grieg-Gran *et a,* 2005; Pagiola *et al.*, 2005; Porras *et al.*, 2008; Wunder 2008), which therefore makes the schemes a very interesting subjet of study.

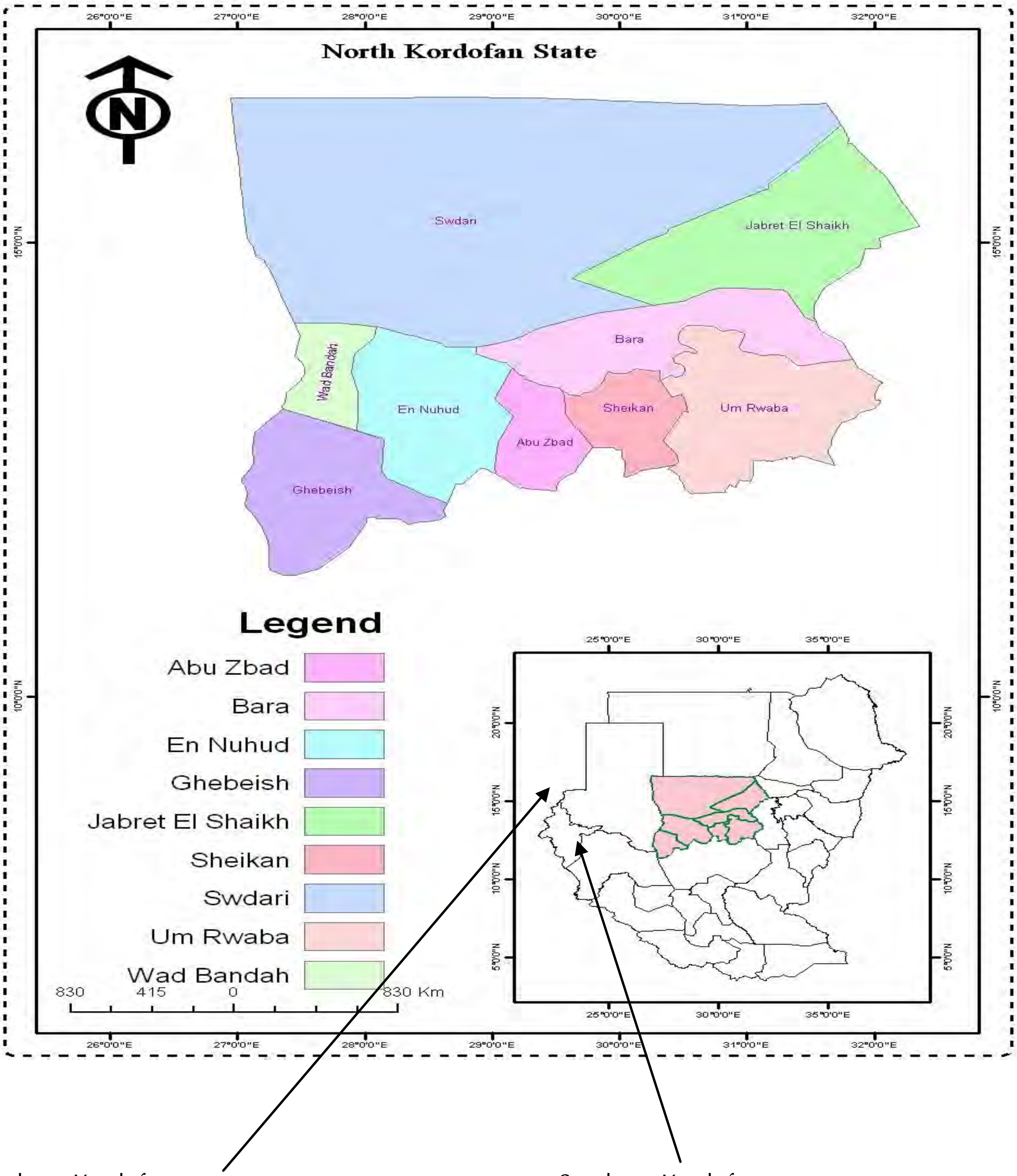
In developing countries, PES remains poorly tested except for a couple of pioneer experiences in Latin America. Until now, mainly four types of environmental services have been sold: (1) carbon sequestration and storage (e.g., northern electricity companies paying tropical farmers to plant or maintain additional trees), (2) biodiversity protection (e.g., conservation donors paying landholders for creating or seting aside areas for biological corridors), (3) watershed protection (e.g., downstream water users paying upstream farmers for adopting land uses that limit soil erosion or flooding risks (4) protection of landscape beauty (e.g., tourism operators paying a local community not to hunt in a zone used for wildlife viewing). Reactions to PES in conservation and rural development circles are mixed. Advocates of PES stress that innovation in conservation is urgently needed, because current approaches provide too little value for money. PES can provide new private conservation funding and improve livelihoods for poor service selling communities.

In Sudan the contribution of the forestry sector to the national economy and livelihoods is significant. Besides direct benefits, forestry products include non-wood forest products (NWFPs) and environmental services (Gasana et al., 2009). Communities in Sudan receive income from collection, processing and marketing of the products like gum arabica (Republic of Sudan, 2009). Gum Arabic from *Acacia senegal* and other acacias is a resource for farmers' income generation and contributes significantly to Sudan exports (Gorashi, 2001). On the other hand, the Baobab tree (*Adansoniadigitata* L.) in Sudan is mostly found on sandy soils and near seasonal streams in low grassland savannas in Kordofan, Darfur, Blue Nile and Bahr el Gazal. The tree provides foods, shelter and medicine, as well as environmental services. The fruits sold in local markets are an important source of cash income for certain tribes living in Central and South Sudan. In addition, the fruit pulp has very high vitamin content; almost ten times that of oranges (Becker, 1983). This paper highlights the importance of implementing PES incentives in sustaining the role of forest resources in rural economic development and environmental conservation, taking an example of these two non-timber producing trees, namely, gum Arabic from *Acacia sengal* L. and baobab fruits from *Adansonia digitata* L.

Methodology

The study was conducted in North Kordofan State in the dry semi-arid region between latitudes 11,15°-16,45N° and longitudes 27,5°-32,15°E and South Kordofan State which is located in the southern half of the Sudan between latitudes 9° to 13° N and longitudes 27° to 32° (Fig 1). The data was collected from 65 respondents for gum arabic and 76 for *Adansonia digitata* respondents using a constructed questionnaire selected purposively. The survey data was encoded, entered and analyzed with the SPSS statistical package (Version15). Data was summarized in descriptive statistics. The questionnaire delved into the main problems that hinder the role of NTFPs in the rural economy and tree species conservation, and the opportunities that currently exist for development.

Fig1: Map showing the Study Area



Socioeconomic Characteristics of Sample Household and Gum Arabic Landowners

The sociological characteristics of respondents towards *Adansonia digitata* L. indicate that the majority of sample household heads (80.1%) were male, whereas only 19.9% were female. 35.9%, 20%, 40% and 4.1% of the sample household have age-range of 18-28, 29-38, 39-48 and 49-58 years, respectively. A larger percentage of the sample were illiterate (48%), while only 22% have some *Khalwa*[2] education, 15% have some primary education, 10% have some intermediate education and 5% have some secondary education. It is also found that the surveyed sample members were married (70%) and unmarried (30%). On the other hand the sociological characteristics of respondents towards *Acacia Senegal* tree show that of the 65 farmers surveyed 64 (98.5 %) were men and 1 (1.5 %) women. The study revealed that 19 respondents (29.2%) had an age range between 55 to 64 years, 18 (27.7%) an age range between 35 to 44 years, while 10 (15.4%) of the respondents indicated an age range between 25 to 34 years or more than 65 years, respectively. 6 (9.2%) respondents had an age range between 45 to 54 years. The lowest percentage (3.1%) was for the age range from 20 to 24 years. 23 (35.4%) of respondents were illiterate, 13 (20%) of respondents attained Khalwa and 29 (44.6%) attained basic school.

The Contribution of Non Timber Forest Products to Local Economy

Table 1 reveals that the household earnings from selling of NTFPs are US$ 350.66 annually. The table also shows that household's total return from all its economic activities is US$ 600.498. The contribution of NTFPs activities, agriculture production, livestock production, wage labor, and remittance is 58.4%, 20%, 10%, 6.6% and 5%, respectively, on the average basis to household total income.

Table 1: Averages of Household Annual Income Share by Different Economic Activities and Percentage of Share to Total Annual Income in US$, (n = 65)

Economic Activity	Average Share (US$)	% of Share
NTFPs	350.66	58.4
Agriculture production	120.1	20
Animal production	60.05	10
Wage labor	39.633	6.6
Remittance	30.025	5
Total income	***600.498***	***100***

Source: Field Survey (2008/09)

Constraints to Non-Timber Forest Products Activities

Respondents illustrated constraints associated with *Adansonia digitata* fruits and gum Arabic collections and trade (Table 2). The main constraints mentioned are related to the low product prices (100%), high transportation cost (90%), high taxes (98%), lack of capacity building (80%), lack of microfinance (90%), low value added at local level (90%), lack of extension message and lack of organization.

[2] Religious school in which Muslims study Holy Koran and its studies

Table 2: Constraints to Non Timber Forest Products Activities

Constraint	% of households (*n = 65*)*
low products prices	100
transportation cost	90
high taxes	90
lack of capacity building	80
lack of microfinance	90
Low value added	90
Lack of extension message	75
Lack of organization	90

**Note: These categories are not mutually exclusive, percentages add up to more than 100%*).

Problems Facing the Resource Base

The changes that occur in the trees species of the NTFPs over time are due to animal grazing, the consequence of intensive browsing, and excessive lopping and cutting. Moreover, as excessive lopping and cutting more frequently occur in forests for basic needs, an opportunity exists to introduce controls and systems for sustainable management of the resource base by involving local people in resource management. Results of our study show that (55%) of *Acacia senegal* landowners mentioned that human activities cause 91.7% damage of *Acacia* trees while (60.0%) of the non-landowners of *Acacia senegal* mentioned human activities as a major cause to damage of Acacia trees by 8.3%. 33.3% of the *Acacia Senegal* landowners mentioned climate as one of the major causes by 90.9%, while (40%) of the non landowners of *Acacia senegal* mentioned climate as one of the major causes by 9.1%.

Discussions

The study results show that the NTFPs activities face many constraints that hinder financial returns. These factors include the characteristics of households, products market factors and climatic factors. Such constraints seem universal as most NTFPs case studies reveal more or less similar conditions (Marshal *et al*., 2003, 2006; Te Velde *et al*., 2006). Increasing the product prices will enhance proportionally the financial returns of NTFPs activities and thus, rural development. The households listed transportation costs as major constraint and access to microcredit would be extremely beneficial (Adam and Pretzsch 2009). Additionally, organizations' and institutions' capacity building by assisting rural people to organize themselves would give them an identity and improve negotiation power with different stakeholders, concerning their needs, taking group activities like sharing transportation costs to distant markets, and cooperate in terms of price fixing (Adam and Pretzsch, 2010). Dry land forest resources may contribute greatly to alleviating poverty and sustaining communities by responding to many of their subsistence needs. Demonstrating ways through which forestry contributes to increasing income and reduction of poverty, particularly in the dry land areas of sub-Saharan Africa, would lend additional weight and relevance to forest management initiatives. During the implementation of PES, surveys should monitor changes in the well-being and living standards of beneficiary communities (FAO, 2010). As our results imply, the destruction of forest through human activities to satisfy needs will be reduced or managed by PES to enhance their satisfaction taking into account the community-based management of the resources.

The production of gum Arabic is governed by factors such as drought and desertification (Elhadi, 2009), as well as biological factors such as the cerambycid beetles which cause a dieback disease killing the Acacia trees (Jamal, 1994; Eisa *et al*., 2008 and 2010). As our results imply, human activity and climatic effect on *Hashab* trees was also agreed by Elhadi (2009) who demonstrated that the average area of *Hashab* gardens has declined drastically from 1960's to the 1990's as a result of drought and human misuse. PES can be used through encouraging farmers to preserve the gum tree as a component of the household farming system, disseminating the extension services as a channel for technical assistance and that would help and increase farmers awareness and recognize the problem of pests as well as the environmental degradation.

Conclusions and Policy Implications

In Sudan the over-use of multipurpose fruit trees, such as baobab, has become a crucial problem. There is high year-round demand for fruits. With fruit being collected from wild stands of trees, stocks are decreasing and no provision is made for planting these trees. Moreover, there is often a lack of awareness by the local people on the need to plant, protect and manage under-utilized fruit species, a proposed solution for solving such problems will be encouraged by applying PES. Sudan's dry region faces the challenge to PES incentives that could enable achievement of food security while ensuring environmental quality and conservation of natural resources base. In food deficit regions like the study area, there is therefore the need to respond to climate change from an integrated land-use management perspective taking cognizance of livelihood and food security. Economic development policies related to land use practices are well-designed, but not directed to livelihoods enhancement and promotion of environment conservation. In addition to economic development and environmental conservation oriented policy, the conditional incentives and reward mechanisms provide an additional approach for solving the problem of low income and forest cover deterioration. The options will help to align the incentives and encourage the local people to pay attention to environmental quality.

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PAYMENT FOR WATER SERVICES AS BASIS FOR NATURAL RESOURCE MANAGEMENT: EXPERIENCE FROM PANGANI BASIN, TANZANIA

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ABSTRACT

Payments for ecosystem services are increasingly being promoted as a means of providing incentives in natural resources management. However, this has not been documented in detail for the case of Pangani Basin Tanzania. The study explored the link between payment for water services and natural resource management. Field surveys were the main method for data collection. A Global Positioning System (GPS) was used to record coordinates, whereas structured questionnaires were used in socio-economic data collection. The SPSS analytical package was employed in socio-economic data analysis. Power production, domestic uses and irrigation were identified as the main ecosystem goods and services provided by the Pangani Ecosystem. Flower companies were the main water users. . It can be concluded that because of the importance of water, the entire Pangani ecosystem needs to be conserved for posterity, especially through implementation of Payment for Water Services schemes.For that reason, thorough economic assessment of water values should be undertaken in Pangani Basin.

Introduction

In the past few decades, the field of ecological economics has witnessed a spectacular rise of interest in the areas of the valuation of ecosystem functions, goods and services (De Groot *et al.,* 2002). Early references to the concept of ecosystem functions, services and their economic value date back to the mid-1960s and early 1970s (King, 1966; Helliwell, 1969; Hueting, 1970; Odum and Odum, 1972). More recently, there has been an almost exponential growth in publications on the benefits of natural ecosystems to human society (De Groot, 1994; Bingham *et al.,* 1995; Costanza *et al.,* 1997; Pimentel and Wilson, 1997; Limburg and Folke, 1999; Wilson and Carpenter, 1999; Daily *et al.,* 2000). The haphazard increase of utilization of the benefits from natural ecosystems and the impact of human society on the natural environment is threatening the basic foundation upon which human being depend for food, shelter and well-being (Kashaigili *et al.,* 2005; Lalika, *et al.,* 2008). Of all natural resources that are important to human beings, arguably the one which is under most pressure is fresh water. Traditionally, the focus has been on the provision of water for human needs, with little or no attention on the conservation of the ecosystems that comprise the sources of water (Echavarria *et al.,* 2004; Pagiola, 2008). It is extensively acknowledged that well-functioning ecosystems provide reliable and clean flows of water, productive soils, healthy and balanced biota, and many other ecosystem services for human well-being (Schusler and Riddington, 2006). It is also broadly documented that today's water generating ecosystems are under threat due to a number of drivers such as land use/cover changes and the global climate change patterns (MEA, 2005).

The Millennium Ecosystem Assessment estimated that 60 per cent of ecosystem services (ES) that have been degraded globally over the past 50 years are those associated with watersheds (MEA, 2005). A similar scenario has been documented in the Pangani Basin (PB) where water is perilous and collectively in a worse condition than ever before (IUCN, 2003; 2007; Kulindwa, 2005; Mbonile, 2005; Turpie *et al.,*. 2005; Sotthewes, 2008). Many factors and drivers have contributed to the degradation of natural resources and watersheds in Pangani Basin. Land use and land cover changes caused by anthropogenic activities, global climate changes, lack of appropriate and adequate incentive mechanism for watershed conservation, inadequate sustainable land use and management; and poor allocation of water resources among many competing water demands between different sectors are among the attributing factors (Schusler and Riddington, 2006) that have led to the present situation.

Payment for Environmental Services (PES) are being developed largely as a response to the challenges and constraints that are facing regulatory mechanisms for the management of natural resources and watersheds (Costanza *et al.,* 1997; De Groot *et al.,* 2002; Abel *et al.,* 2003; Chee, 2004; Groffman *et al.,* 2004; Eamus *et al.,* 2005; Kremen, 2005; MEA, 2005; Farber *et al.,* 2006). PES are incentives geared towards the conservation of ecosystem goods and services, and are also increasingly promoted as a means for documenting the values humans place on ecosystems and evaluating benefits derived from natural resources. Payments for watershed services (PWS) are a sub-set of PES and specifically seek to establish new relationships between water users and upstream ecosystem managers (Echavarria *et al.,* 2004; Landell-Mills and Porras, 2002; Pagiola, 2008; Turpie *et al.,* 2003; 2005; 2008). Payment for Water Services (PWS) is an important trend, and particularly important in the case of water conservation where values delivered by watershed are often difficult to describe in economic terms and rarely well-explained in natural resource decisions. Despite the potential impact of PWS on poverty alleviation and nature conservation (Pagiola *et al.,* 2002; Schusler and Riddington, 2006b), little has been done to document the contribution of the Pangani Ecosystem. The available information in the form of hard scientific documents contains little information on relationship between ecosystem goods and services, PWS, and natural resource management. The objectives of this study were to identify and map goods and services delivered by the Pangani Ecosystem,; to identify types of water user stakeholders in the study area, and to quantify the economic value of water resources generated by the Pangani Ecosystem.

Materials and MethodsThe Study Area

The main Pangani River Basin (PRB), the largest of the sub-basins within Panga Ecosystem overs an area of about 43,650 km^2 (IUCN, 2007). The Pangani River system drains the southern and eastern sides of Mt Kilimanjaro (5,985 m) as well as Mt. Meru (4,566 m); then passes through the arid Maasai Steppe in the west, draining some of the Eastern Arc Mountains (Pare and Usambara Mountains), which are the World biodiversity hotspots, before discharging to the Indian Ocean at Pangani town. The basin hosts an estimated 3.8 million people, 80% of whom rely directly or indirectly on irrigation agriculture for their livelihoods (IUCN, 2007; Kamugisha, 2008). This study was conducted in all three regions of the Basin, namely Arusha, Kilimanjaro and Tanga Regions. Figure 1 is a map showing the location of the Pangani Basin within Tanzania.

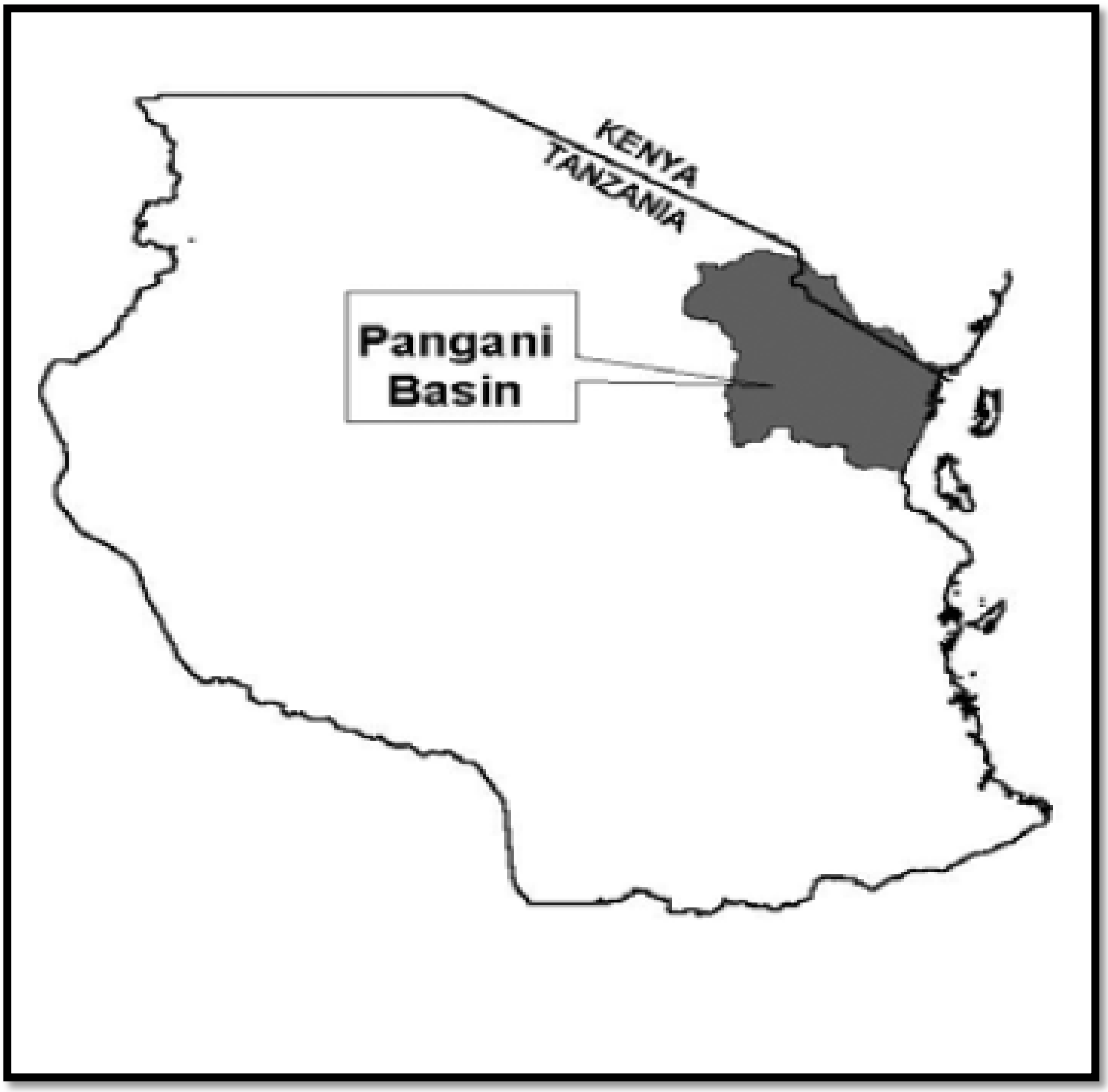

Figure 1: Location of Pangani Basin and Alignment of Pangani Main River Basin and its Tributaries, Tanzania

Data Collection and Analysis

Field visits were conducted to identify ecosystem goods and services in the study area. A Global Positioning System (GPS) was used to record coordinates for mapping ecosystem goods. This was integrated with compiled layers of maps using digital top sheets, digitized from the scanned topographical map sheets of a scale 1:50,000 covering the PB. The final compiled layout was done in ArcMap. A digital camera was used to capture photos of ecosystem goods and natural resources. Structured questionnaires, interviews with key informants and documentary reviews were also used during data collection. Relevant document on PWS were reviewed in order to supplement information collection in the field. While ArcGIS soft was used for mapping ecosystem goods, Statistical Package for Social Sciences (SPSS) was the main software for analyzing socio-economic data. Microsoft excel was finally applied to produce figures and tables.

Results and Discussions

Goods and Services Delivered by Pangani Basin

Water related ecosystem goods and services in Pangani Basin are associated with natural resources. These natural resources include Kilimanjaro, Meru, North and South Pare, and West and East Usambara Mountain forests (Figure 2). The Pangani Main River, for instance collects water from Kikuletwa (Meru Mountain), Ruvu (Kilimanjaro Mountain), Mkomazi (South Pare Mountains), Luengera (West Usambara Mountains) tributaries.

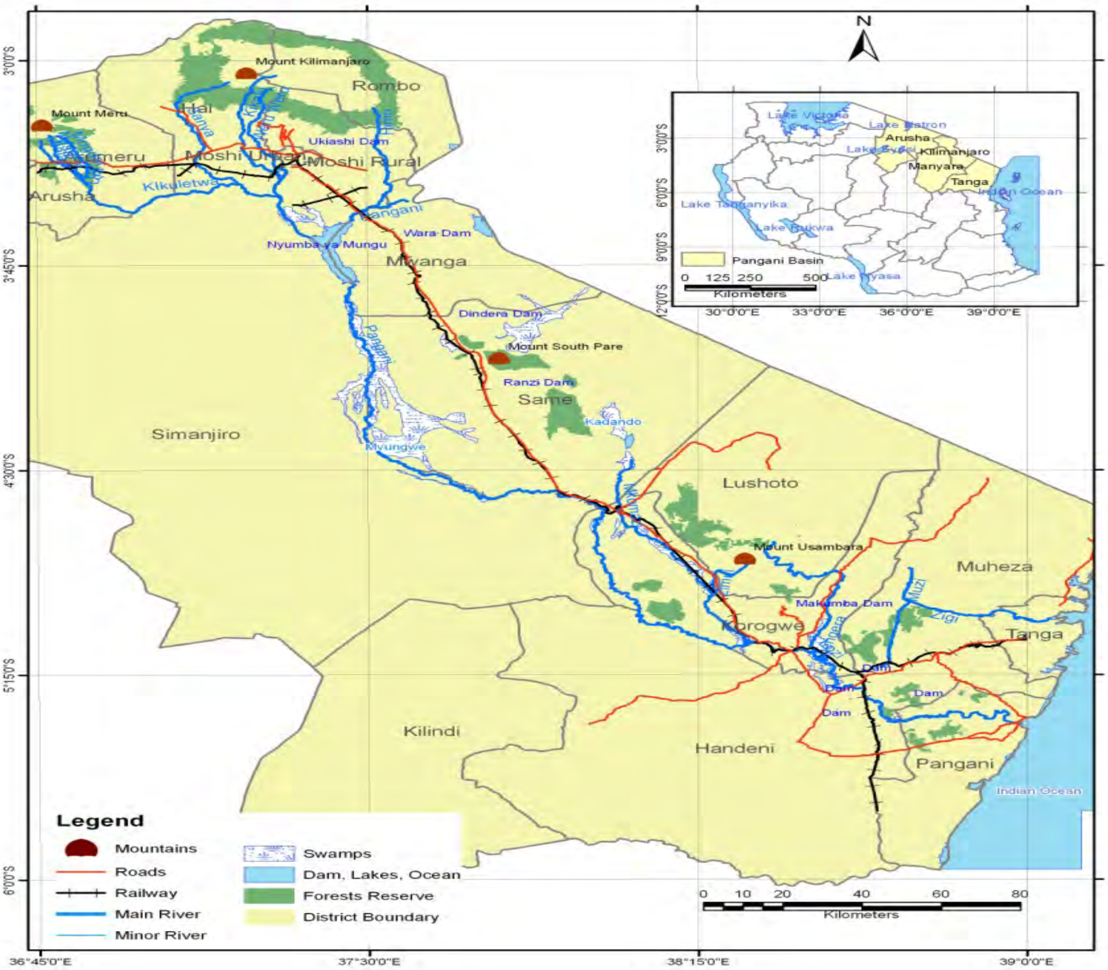

Figure 2: Natural Resources that Generate Goods and Services in Pangani Basin, Tanzania

Tourist Attraction in Kilimanjaro Mountain National Park

Being the highest peak in the African continent, the scenic beauty of Kilimanjaro Mountain ice caps attracts many tourists to visit Pangani Basin. Kilimanjaro Mountain National Park (KMNP) and its Forest Reserve is a habitat to wild animals and a catchment area for many rivers and streams. Ecologically, the national park and the forest reserve play an important role in conserving the watershed areas upstream. Furthermore, the forest reserve modifies climate condition for the adjacent local communities. Therefore, if the income generated from the goods and services delivered by KMNP could trickle down to local communities, then this would justify the conservation role of PWS.

Watershed Conservation at Mount Meru Catchment Forest Reserve

The catchment forest is the main source of water for domestic and other economic undertakings in Arusha City (Plate 1). Apart from playing an important role in modifying the weather conditions of Arusha city and the neighbouring towns, the catchment serves the role of releasing water gradually throughout the year. Furthermore, the catchment forest performs crucial ecological functions by providing asylum to animal and plant biodiversity, purifying the air, controlling soil erosion, absorbing carbons from emissions, just to name a few.

Tourism and Eco-tourism in Usambara Mountains

Amani Nature Reserve (ANR) provides picturesque areas for attracting foreign exchange through tourism in East Usambara Mountains. Records at the reserve show that from 1997 to August 2007, a total of 10 544 tourists visited East Usambara Mountains. The number of tourists has been increasing from 295 in 1997 to 1082 in 2007. Eco-tourism is another alternative ecosystem service and a way of making use of the valuable biodiversity and catchment forests, while supporting local livelihoods in West Usambara Mountains.

A total of 49 million Tanzania shillings were generated from eco-tourism activities of which 20% was accrued by village governments for social service development. Local communities sell cultural items and merchandize to tourists, and some of the local people are employed as tour guides. All these contribute substantially to individual and household incomes (Mwembe, 2008). The eco-tourism sub-sector is considered as a way forward to sustainable natural resource management as it creates job opportunities and additional means of revenue generation for local communities.

Plate 1: Mount Meru Catchment Forest Reserve, theSource of Nduruma River in Pangani Basin, Arusha Tanzania

Nutrient Regulation by Kirua and Manka Swamps

Kirua and Manka Swamps (Figure 2) stabilize water levels around the average level in water rerservoirs along Pangani River Basin. The swamps eliminate rapid changes in the water level due to rapidly varying releases from water reservoirs upstream. Findings from key informants revealed that since 1994, large portions of the largest wetland (Kirua Swamp) have dried as a result of the regulation of water flows from Nyumba ya Mungu water reservoir and channelisation of the river through the swamp. A once vibrant fishery ground, Kirua Swamp is now much reduced and restricted to the river channel and water and nutrients that were used to grow crops are no longer brought onto the floodplain by the annual floods. The fluctuation of annual flooding of the swamp ceased due to the construction of Nyumba ya Mungu dam upstream, thereby causing lop-sided environmental flows downstream. Nevertheless, majority of households still have a strong relationship with the aquatic ecosystem for water supply and the supply of water related natural resources, goods and services. Rural households in Pangani Basin rely heavily on water abstraction from dams for small scale irrigation and domestic purposes (Table 1).

Population increases, coupled with poor maintenance of the dams, plus lack of foresight in their overall management have culminated in low capacity of the dams to provide goods and services they were meant to. For instance the Kalimawe and Chunguli water reservoirs are no longer in use due to environmental degradation that took place upstream. Poor farming practices, land use changes, water abstractions, and land degradation are among the attributing factors. Poor management of donor funded development interventions also contribute to the degradation of water bodies in Pangani Basin. Even those water reservoirs that are still in use for domestic purposes (such as Sholo, Mwororo, Chanika and Kwenkambala) are facing environmental degradation (poor quality water and eutrophication) due to anthropogenic activities taking place upstream. However, water supply remains a crucial issue to households' income and improved livelihoods. Livestock production is also an extremely important economic undertaking throughout the basin. Water is a limiting resource for this activity and maintaining stream water supplies or alternative sources is clearly also a high priority for rural households.

Table 1: Water Resevoirs and Dams in Pangani River Basin, Tanzania

District	Name of Dam/reservoir	Location	Year of construction	Capacity (in m^3)	Water uses / Remarks
Mwanga , Simanjiro na Moshi Rural	Nyumba ya Mungu	Nyumba ya Mungu	1965	1.1 bil	The dam was constructed mainly for HEP production. However, water is sometimes used for domestic and irrigation. Agricultural crops irrigated include sugarcane, coffee, paddy flowers, bananas and vegetables.
Same	Kalimawe	Kalimawe Ndungu	1959	24,700m	Has undergone degradation caused by siltation and eutrophication. Dykes have been broken and fishing is no longer carried out due to water reduction and pollution.
Mwanga	Chunguli	Ugweno	1965	246,600m	Anthropogenic activities at the upper part have resulted into mud deposition, water quantity reduction and eutrophication.
Moshi	Sholo	Kirua Vunjo	1965	2,100m	Still in use mainly for domestic water supply
Moshi	Ukyashi	Kirua Vunjo	1962	181,000m	Still in use mainly for domestic water supply
Moshi	Mworoworo	Kirua Vunjo	1961	159,000m	Still in use mainly for domestic water supply
Muheza	Mabayani	Pande	1978	5.0m	Still in use for domestic and other miscellaneous uses in Tanga City
Handeni	Chanika	Handeni	1957	17,190m	Still in use for domestic use in Handeni Town
Handeni	Kwenkambala	Chanika	2003	460,320m	Still in use for domestic use in Handeni Town

Water Supply for Hydropower Production

Hydropowerr generation is by far the major contributor to Tanzania electric power supply. Currently, hydroelectric plants in place in the Basin are Nyumba ya Mungu, Hale and New Pangani falls (Table 2 & Figure 2).

Table 2: Discharges for Hydropower Generation in Pangani Basin Tanzania

Hydro Electric Power Plant	Minimum Flow (in m^3/s) (Average per month)	Maximum Flow (in m^3/s) (Average per month)
Nyumba ya Mungu	9.8	35
Hale	8.5	45
New Pangani falls	9	45

(Adapted from IUCN and PBWO, 2008)

The reduction of river discharge has contributed to low capacity of power generation and intrusion of salt water in Pangani River upstream (Figure 2).

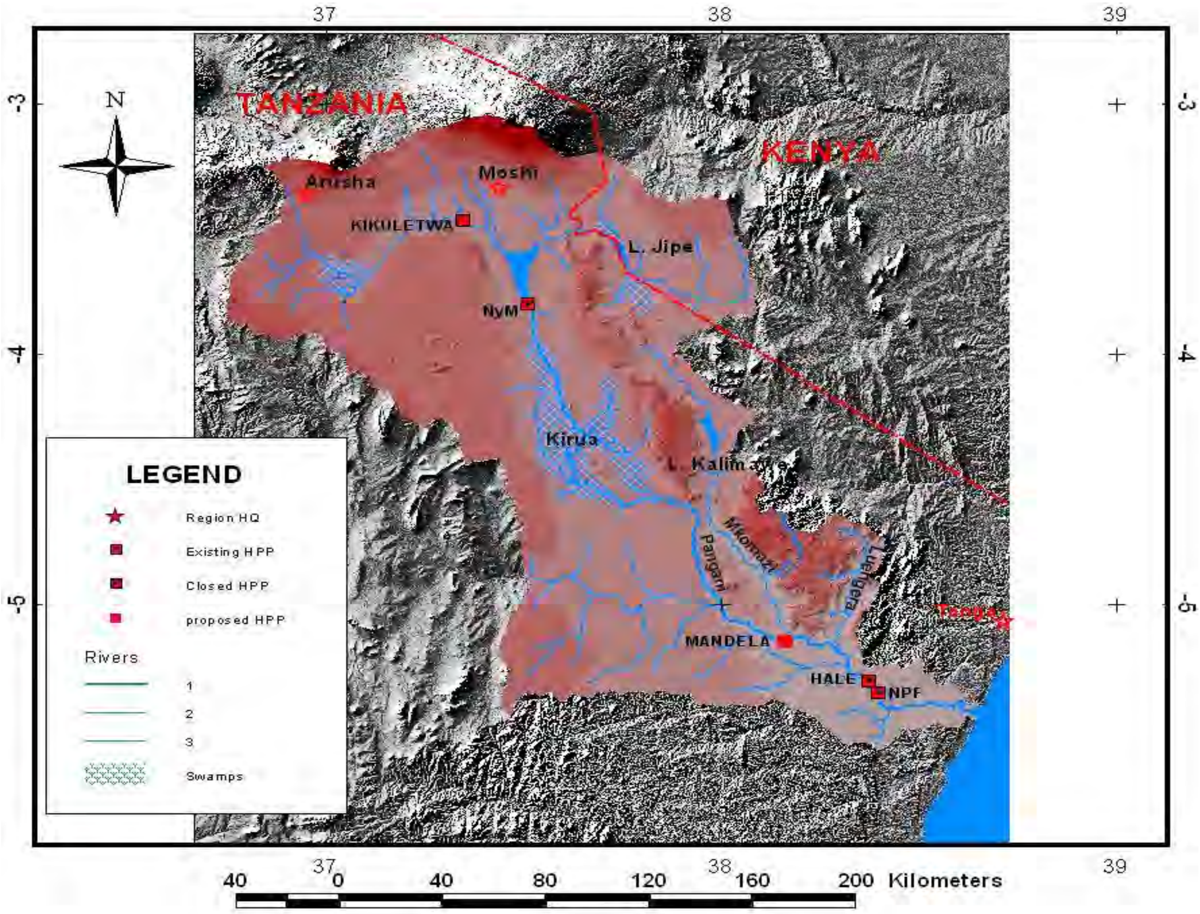

Figure 2: Location of Hydro Power Plants in the Pangani River Basin, Tanzania (Adapted from Luteganya and Kizzy, 2009)

Tanzania Electricity Company Limited (TANESCO) is the sole supplier of electricity in the country and relies mainly on two sources, namely, hydro generation and thermal generation using fuel-oil/diesel, and to a little extent coal. Information from TANESCO indicated that hydropower contributed 97.4% of total power produced in Tanzania while thermal electricity generation accounted for only 2.6% shared amongst diesel and coal. Pangani Basin contribution to the hydropower was 17% (IUCN and PBWO, 2008) of the nation's total hydropower generation. This high reliance on hydropower implies that Tanzania has to place due emphasis on maintaining the integrity of the catchment forest areas so as to ensure the continued supply of this vital ecosystem service for the country's economy and social wellbeing. Therefore, PWS is vital for sustainable generation of hydropower and natural resource management in PB.

Water from Sigi River Catchment (East Usambara Mountains)

Sigi River (that collect water from Muzi and Kihuhwi tributaries) drains the eastern slopes of the East Usambara Mountains, and into the Indian Ocean via the Mabayani Dam, the main source of water for Tanga City (Figure 2). The East Usambara Mountains catchment, the source of Sigi River, serves as a habitat for endemic, endangered, threatened, and/or rare animal and plant species, including the Saint Pulia vegetation. Establishment and implementation of PWS initiatives will not only improve water conservation and sustainable flow, but also contribute to the ecological status of Amani Nature Reserve, sustain continued flow of Sigi River and lead to sustainable management of the Basin's ecosystem as a whole.

Water Supply for Irrigation

Pangani Main River, with its tributaries - Kikuletwa, Ruvu, Luengera and Mkomazi (Fig. 2) are the main source of water for small-scale irrigation. The use of underground water is very limited due to poor technology and limited finances for water extraction. As a result, the majority of small scale irrigators depend on water abstraction from rivers, increasingly leading into water use conflicts and degradation of natural resources. Major irrigated crops that consume large amounts of water include flowers, sugarcane and coffee, (Table 3). Although some of these crops are grown under modern methods of irrigation, including drop irrigation (flowers) and other improved canal irrigation sysems, they nevertheless disperse a lot of water from the natural water courses, thereby contributing to resource use issues.

Table 3: Type of crops that consume large quantity of water in Pangani Basin, Tanzania

Crop Type	**Water Quantity(in m^3/ha)**
Flowers	18 250
Sugarcane	12 000 – 17 000
Coffee	1 000

Furthermore, small scale irrigation that consume little amount of water is carried out under traditional furrow (3 000 m^3/ha) and improved schemes (850 – 1 195 m^3/ha) in the highland's upper basin and lowland areas. A large proportion of smallholder irrigators in the highlands do not have access to enough water. The plausible explanation is that they are not allowed to access water in the name of maintaining sustainable environmental flow in the lowlands. Thus, it is high time to institute PWS mechanism for sustainable conservation of water sources and natural resources.

Water User by Stakeholders in Pangani Basin

Large scale irrigators, small scale irrigators, domestic abstractors, industries and livestock use are the main categories of water user stakeholders identified in PB (Figure 3).

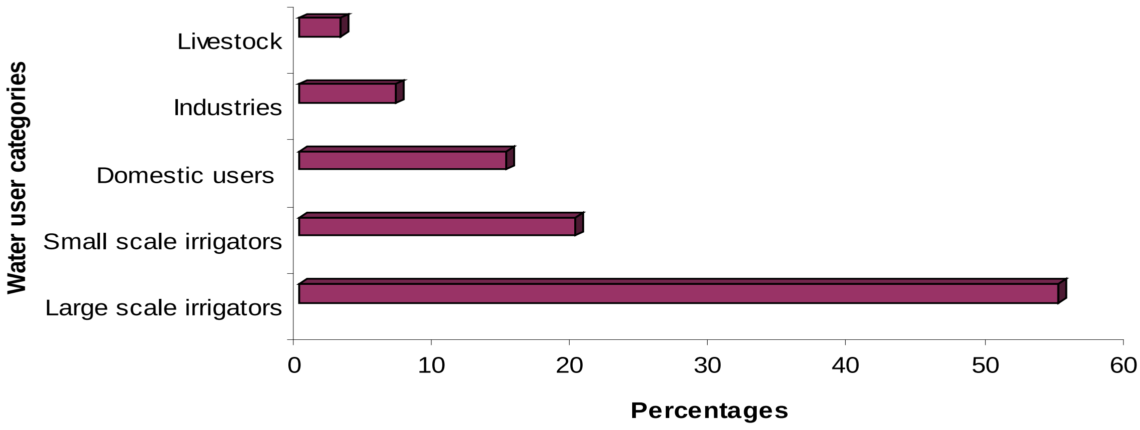

Figure 3: Categories of water user stakeholders in Pangani Basin, Tanzania

Large Scale Irrigation

Flower growing is the main economic undertaking that uses a large quantity of water in the Basin. Private firms that engage in flower irrigation include Diligent Tanzania Ltd, Fides Tanzania Ltd, MultiFlowers Tanzania Ltd, Kiliflora Flowers Tanzania Ltd, Dekker Bruins Kilimanjaro Ltd. Most of these export flower cuttings to European countries (especially The Netherlands) and to USA. Flower companies employ large number of causal labourers, thereby improving household incomes in the Basin. However, pesticides which are used in killing flower pathogens are an environmental challenge whose impact is yet to be quantified.

Small Scale Irrigation

The small-scale irrigators identified were mainly linked to water user associations or groups (such as Lekitatu, Tegemeo, Chawampu, Chawampyo, Shamima, Ambureni/Moivaro, etc), usually for production of paddy rice, maize, vegetables and fruits. Under this category, water is mainly used for growing subsistence crops which are used locally within Pangani Basin.

Domestic and Iindustrial Water Uses

Domestic abstractors include water user authorities (e.g. Arusha Urban Water and Sewerage Authority, Moshi Urban Water and Sewerage Authority, Tanga Urban Water and Sewerage Authority, Mwanga Water Supply and Sewerage Authority, Same Water Supply and Sewerage Authority, Korogwe Water Supply and Sewerage Authority, etc); water user associations (including

Uroki- Bomang'ombe, Losaa-Kia, Lawate-Fuka, and several others); and some of the industrial users of water at the time of the study included Tanzania Breweries, Bonite Bottlers and Pepsicola Company Ltd.

Livestock and Wildlife Water Uses

Although livestock and wildlife numbers that depend on water are not well established in the basin, they too place demands on water resources. This makes water availability in the basin even more crucial in the near future. As advocated by Kulindwa (2005) and Notter (2010), water uses are mounting geometrically; increasing water demand exacerbates the situation of water availability to different water user stakeholders in Pangani Basin. Therefore, conservation of natural resources (catchment forest in particular) would ultimately contribute to water and balanced environmental flow in PB.

Economic Value of Water Resources in Pangani Basin

At the time of the study, the average prices of water in the Basin were Tsh 0.256/lt and Tsh. 1.543/lt in villages of Kilimanjaro and Arusha Regions, respectively, and Tsh 0.25/lt in villages in Tanga Region, respectively. Average prices of water in highland villages were Tsh 1.50/lt, Tsh 1.25/lt in the Kirua Swamps area, and Tsh 1.20/lt at the coast. These prices are equivalent to Tsh 1500, Tsh 1250 and Tsh 1200 per m^{3}, respectively, (Figure 4).

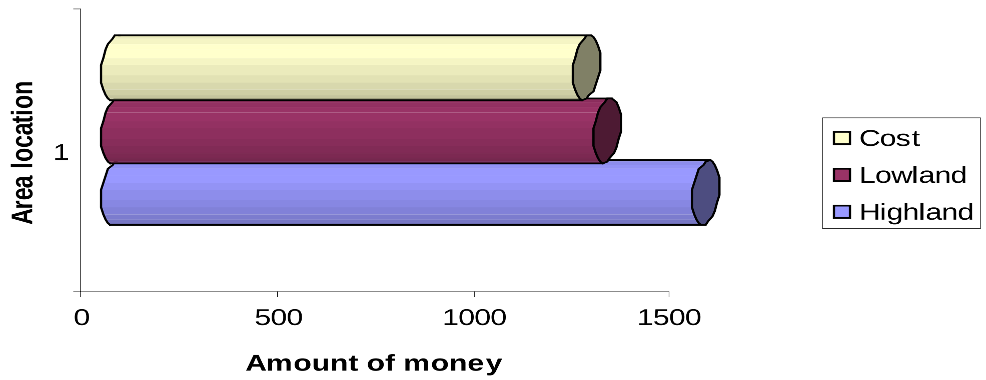

Figure 4: Water Prices in Three Agroecological Zones in Pangani Basin, Tanzania

Generally, the study has indicated that the cost of supplying water in Pangani Basin is often much lower than the true market value of water. Further results have shown that water supplies to urban areas are often priced to recover supply costs, but these prices do not necessarily reflect the market value of water. The value of water for domestic use is better reflected in the willingness to pay demonstrated through trade of water in rural areas. Total willingness to pay for the true value of domestic water supplies in Pangani River Basin is estimated to be in the order of Tsh 37 – 46 billion (Turpie *et al.,* 2005). The value is higher if the total population of the Pangani Basin is considered.

These values may not have any bearing on water allocation decisions, since all inhabitants should have access to basic water supplies, but are of interest in terms of the potential for revenue generation and water demand management. Table 4 gives the estimated value of water for domestic use in Pangani River Basin and Pangani Basin as TSh 1350 per m^3 and, the lower bound of total value of the estimated water for domestic use in Pangani River Basin and Pangani Basin was Tanzania shilling 36, 769 and 52, 960 million, respectively, whereas the upper bound was 45, 962 and 66, 200 million, respectively. However, these estimated values need to be revisited as it changes over time.

Table 4: Estimated Economic Value of Water in Domestic Use in Pangani River Basin and Pangani Basin, Tanzania

Variable	Value in Pangani River Basin (in Tshs)	Value in Pangani Basin (in Tshs)
Water value (m^3)	1,350 m	1,350 m
Total value (lower bound)	36,769 m	52, 960 m
Total value (upper bound)	45,962 m	66, 200 m

Conclusions

The study was carried out to identify and map ecosystem goods and services delivered by Pangani Basin. It was revealed that the future flow of water depends on implementation of PWS activities, integrated water management and sustainable utilisation of natural resources. Large and small-scale irrigators, domestic users, industrial and livestock use are the categories of water user stakeholders identified in Pangani Basin. However, the total number of water users in the basin has not fully been recorded. Although the values presented in this paper are preliminary findings, they nevertheless give an idea of how important water conservation is in Pangani River Basin. Furthermore, the study indicated that majority of households in the basin have a strong relationship with aquatic ecosystems, both for water supply and the supply of natural resources. Rural households in the basin rely heavily on small-scale agriculture for subsistence and income.

Recommendations and Way Forward

- Integrated water management is key for efficient utilisation and management of ecosystem goods and services, all stakeholders in the basin need be involved.
- Management of water resources in a holistic approach is key towards optimization of ecosystem goods and services.Therefore, thiscalls for integrated water management and involvement of all actors in the Pangani Basin and, a thorough assessment/economic analysis of economic goods and services in the study area.

- There is need for an in-depth assessment and designing for payment mechanism for ecosystem goods and services in Pangani Basin.
- Practical application of integrated water management should be incorporated into sector policies.
- Ecological and social impacts of water allocation need to be considered. It is through this approach that natural resources will be sustainably conserved.
- Water which is allocated for extractive uses such as agriculture and industry generates substantial returns in terms of value added to the regional and national economy. However, these allocations take water from the ecosystem which has an effect on its functioning and quality,and hence its ability to supply such ecosystem services in future. Therefore, PES mechanism should be designed so as to encourage local communities to conserve watersheds in PB.

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PAYMENT FOR ENVIRONMENTAL SERVICES: A MECHANISM FOR ADOPTING THE AGRO-FORESTRY FARMING SYSTEM AMONG GUM ARABIC PRODUCERS IN SUDAN

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ABSTRACT

The traditional agroforestry system is recognized as one of the successful forms of the natural resources management in the dry lands of Sudan. However, field level adoption of indigenous agroforestry technology by gum Arabic producers has generally been limited due to emphasis on crop production at the expense of trees, mainly as a result of less supportive policy and institutional frameworks, to encourage the adoption of the traditional tree production system, interventions other than regulations are needed. This paper argues for institutionalization of Payment for Environmental Services (PES) as a significant additional option for adopting the agroforestry system among gum Arabic producers. Specifically, the paper discusses how incentive mechanisms could help address the problem of low adoption of the sustainable land management practices, and enhance the possibility for encouraging gum Arabic producers to adopt the agri-environmental farming systems that offer them direct benefits, while at the same time contributing to reduction of green house gas emissions. Policy interventions, including targeted incentives for agri-environmental farming systems, while mitigating financial vulnerabilities are highly recommended.

Introduction

Acacia trees which yield the gum Arabic occur over a large belt of Africa.. It extends through the southern frontier of the Sub-Sahara Africa, from Mauritania to Sudan Ethiopia and Somalia, and extends southwards to Mozambique along the southern coast of Africa (Nas, 1979; Ross, 1968). In the Sudan, the term gum belt applies to that part of the country in which various types of gum are produced, the most important of these being gum Arabic. Acacia trees that produce gum Arabic are a key component of the production systems within the region. However, previous drought incidences in the region affected the ecological balance and the regenerative capacity of the land (UNSO, 1986), leading to the disintegration of these production systems and increased desertification. According to IIED & IES (1990), environmental degradation in the gum belt has been in existence since 1935. Environmental degradation in the gum belt area is attributed to the process of desertification, either due to climatic aridization of the environment or due to anthropogenic causes. This is compounded by erratic rainfall which is poorly distributed within the gum belt. As a consequence of desertification, large areas have become completely bare and subject to wind erosion. These include cultivated fields, settlements, roads and livestock trails. Moreover, in some areas, active dunes have already formed and surround villages and agricultural land. North Kordofan in Western Sudan is most affected by successive droughts and desertification, leading to large areas of *Acacia senegal* and other tree species and food crops dying as a result of moisture stress (UNSO, 1994) and thus a decline in productivity per unit area.

Agroforestry Farming System

Shifting cultivation is a common farming system in the study area, adopted as a mechanism for maintenance of soil fertility. Land is left fallow after some years of continuous cultivation and the fallow periods are influenced by population density and soil type of an area. Areas with high populations have shorter fallow periods, while poor soils are associated with longer fallow periods. The period of years under continuous cultivation in areas with high population density generally varies from 4 to 8 years. During land preparation for crop growing, old gum trees are cut close to the ground and only allowed to produce coppice shoots 4-6 year later after the cropping period. The soil will then be left fallow to give the old stumps and seedlings the opportunity to grow vigorously and uniformly to form a stand of *Acacia senegal* on the abandoned plots. During crop direct sowing, farmers sow *hashab* seeds with their crops and keep cultivating the same plots until the soil is exhausted. By the time, the *hashab* trees are 4 or 5 years old and have formed a gum garden, the plot is abandoned to remain as a gum orchard. Traditionally, each farmer has some gum orchards for cash crop, and some cultivated fields for his subsistence crops. However, this elaborate system is now under serious disturbance due to occurrences of periodic droughts, coupled with harmful human activities. The *Hashab* trees play a key role in balancing the agricultural fallow systems through nitrogen fixation, stabilizing dunes, acting as windbreaks and minimizing soil erosion. After crop harvests, the *hashab* plots provide supplementary employment and income to the farmers, who tap the hashab for gum and can be used as animal feed and provide wood for building poles, hand tools and firewood.

Statement of the Problem

North Kordofan state has over the years suffered successive droughts, leading to desertification and deterioration of natural resources. Soil erosion and the creeping desert are hindering successful crop production and natural regeneration, Gum producing trees have suffered from land degradation. The reported reduction in the area of *Hashab* gardens is 63% from 1960s to 1970s and a further 62% reduction from the 1970s to the late 1980s and early 1990s (Chikamai 1996). The area of *hashab* gardens per household has also reduced, from 32 hectares of gum garden per household during the 1960's, to 12 hectares during 1970's and to 9 hectares during the 1980's and 1990's for the same number of correspondent households (El Dukheri 1997;Taha 2000); and a low average of only 7 hectares in 2005 (Elhadi 2009). The reduction of *hashab* stock is caused on the one hand by cutting and selling the trees as wood or charcoal, and on the other hand by the expansion of area of field crops on the expense of gum forest areas.

Gum production in Sudan also dropped due to the drought of the early 1970's to half of what it used to be in 1960's and droped even further in the 1984 drought (IIED & IES 1990). Desertification and drought have contributed to the shift in the gum belt to the south. Now you can hardly find any *hashab* left north of latitude 14° 45´ in Kordofan or Darfur, and even the areas south of latitude 13° 45´ have already lost about 80% of their hashab (Figure 1). The situation in Northern Kordofan where gum Arabic is produced by a system of shifting cultivation used to be most ecologically sound. The system is however no longer sustainable owing to population pressure and the resulting increased demand for land for both cultivation and human settlement. This has led to the shortening of fallow period and increased continuous cultivation of fields for several years. A study survey in 2005 shows that only 20% of the respondents practiced shifting cultivation whereas 80% of the respondents could not (Elhadi, 2009). All these problems call for an urgent need to retain the capacity of the land to produce food crops, combat desertification and rapid deterioration of natural resources. A readily available solution is in the use of *Acacia senegal* for reforestation which has proved to be effective in this respect in an improved farming system for the area - minimizing wind and water erosion, while keeping the basic features of the traditional agroforestry system. The study aimed, firstly, at determining how farmers could be effectively encouraged to return to *hashab* trees as a component of the farm household cropping system, and secondly, to assessed how PES could be used as an instrument to re-integrate the *hashab* tree in the households' cropping system for environmental conservation.

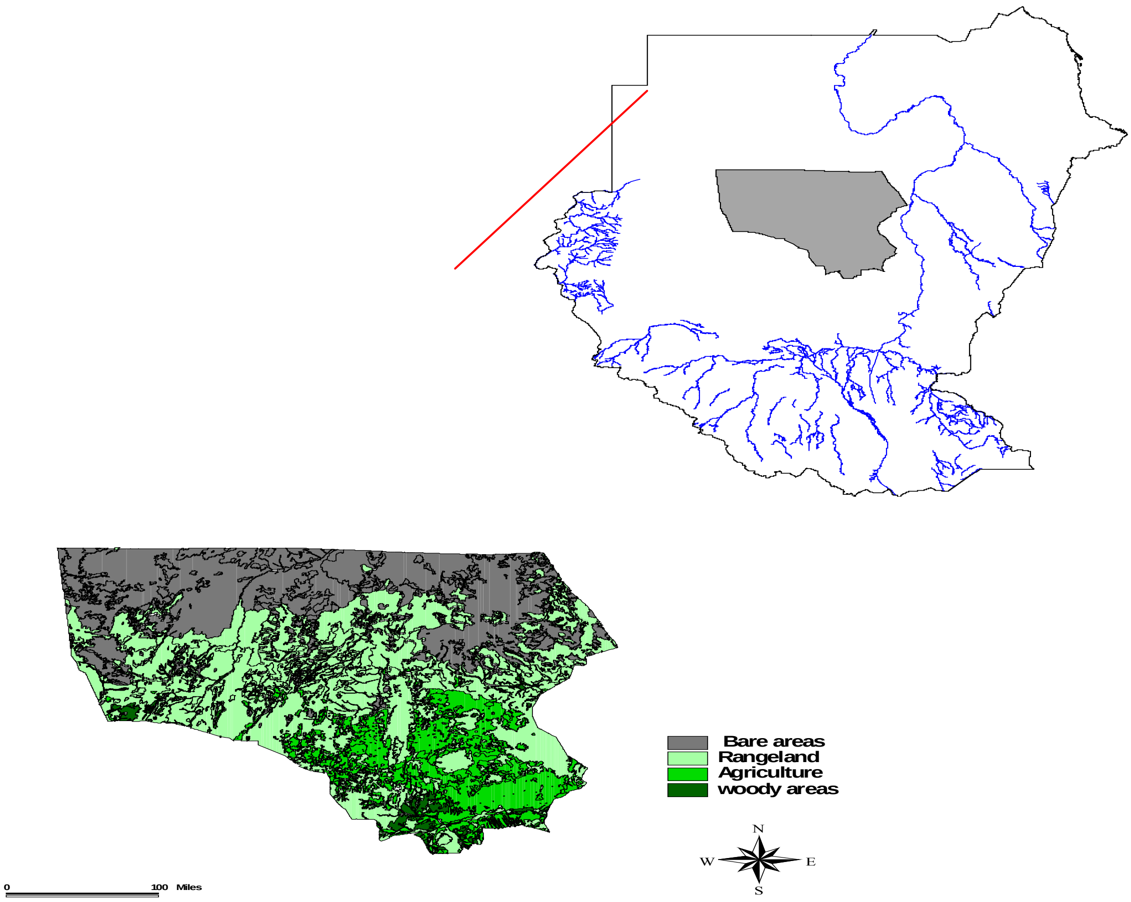

Figure 1: Location and Ecological Zones of North Kordofan State, Sudan
Source: Community-Based Rangeland Rehabilitation (CBRR) Project, 2002

Methodology of Study

Sources of Data

The study was carried out in the North Kordofan State, Western Sudan. The main economic activities of the households include crop farming, livestock grazing and gum production. Data was collected through administration of questionnaires to a sample of 173 households distributed in 20 villages. Other sources of data included informal discussions with farmers and other key informants, as well as visits to relevant markets.

Tools of Analysis

The cost benefit analysis techniques were used to assess the financial profitability of gum Arabic reforestation practices. The term financial analysis is used in this study to mean the actual monetary flows from **cost** to **return** for specific individuals or groups of individuals within a particular farming community. Financial analysis deals only with those goods and services for which people pay or are paid. The criteria used in this study is Net Present Value (NPV), which determines the present value of net benefits by discounting the streams of benefits (B) and costs (C) back to the beginning of the base year (t =1). A project or a policy is accepted if NPV is positive (John, *et al*. 1997):

$$NPV = \sum_{t=1}^{n} \frac{B_t - C_t}{(1+r)^t}$$

The analyses were undertaken for gum Arabic reforestation in an area of one hectare. The average rotation period of the gum tree was found to be sixteen years. The rate of stocking was 175 trees per hectare and the average gum production per tree estimated at 250 grams, starting from the 5^{th} year.

Results and Discussion

Due to the importance of the farmer as producer and consumer of gum Arabica, CBA from the farmer's point of view (farmer's level) were carried out. Taxes are considered as a cost. The gross benefit is the farmer's income from sales of his/her crops at the local market and gross costs are those incurred by the farmer only. The monetary values of outputs depended on the prices of units of outputs prevailing in their markets.

Farmers' Output

The farmers usually grow trees alongside agricultural crops. The main crops are sesame and groundnuts as cash crops, while millet and sorghum are partly cash crops, but constitute the main food consumed by the farmer's household. Minor areas were cultivated under hibiscus. The type of farming is the traditional rain-fed farming system which is marked by low yields and enjoys relatively lower costs of production. This is due to the absence of the use of modern inputs such as tractors, fertilizers and herbicides. As mentioned before, the ideal rotational system that ensures sustained yields of gum and agricultural crops is under serious disturbance because of the desertification. During the survey the average farm size was found to be about 21 hectare divided as shown in Table 1 below.

Table 1: Major Crops Cultivated in the Bush-Fallow System and their Areas in North Kordofan State, Sudan

Crop	Area (hectare)	% of total area
Gum Arabic	7.476	35.77
Millet	3.884	18.58
Sorghum	3.047	14.58
Groundnuts	0.560	02.68
Sesame	4.188	20.04
Hibiscus	1.745	08.35
Total	**20.9**	**100**

Source: Field survey 2005

Gum Arabic Production

Basing on the field survey data 2005, production of gum starts in the 5th year and continues up to the sixteenth year, the year of felling. The rate of stocking is 175 trees per *Mukhamas*[3] (233.3 trees per hectare).The average gum production per tree is estimated at 250 grams and the average gum Arabic producer price is 3000 SD[4]/kantar. Assuming no yield decline, yield of gum Arabic per hectare can be obtained by simple calculation as; Gum production per kilogram in one hectare = 58.33 kg/ hectare, Gum production per kantar[5] in one hectare = 1.313 kontar/hectare. Gum Arabic producer price (year 2002/2003) = 3000 SD/kantar and, Gross revenue /hectare = 1.313 X 3000 = 3939 SD/hectare.

Firewood Production at Year of Felling

The direct products of *hashab* are gum arabic and wood. The stocked stand of *hashab*, 233 trees per hectare is expected to produce after sixteen years 7.0 m firewood (All wood is assumed to be used as firewood). The price of one m in the local market was averaged at 2500 SD. The firewood revenue in year sixteen per hectare = 23333.33 SD/hectare.

Farm Costs

In the present traditional system, the cost of cultivating *hashab* is low because land preparation and weeding impose no separate costs since this is done for agricultural crops anyway. The farm costs include: labor cost, costs of gum Arabic transportation from farm to market, costs of tools used for gum production, trees felling (*sunki* and axes) and gum collecting, cost of seeds and seedlings, land costs, as well as taxes.The labour cost which include the cost of tapping and collection, in addition to the cost of tree felling after a 16 year are given Table 2, below.

Table 2: Labor Costs in Different Operation in North Kordofan State, Sudan

Operation	**Man-day/*mokh*.**	**Wage/SD**	**Labor cost SD/hectare**
Tapping	2.5	400	1333.3
Collection	2.0	400	1066.6
Tree felling	3.5	200	0933.3

Source: Based on information given by farmers (2005)

[3]*Mukhamas*: a local unit for area measurement, equivalent to 0.75 hectare.
[4]1 Sudanese Dinar(SD) = $264.17
[5]Kantar: a local unit of weight measurement, equivalent to 44.44 kilograms.

Costs of gum Arabic transportation from farm to the market =150 SD/kantar. Cost/hectare[6] = 1.313 X 150 = 196.95 SD/hectare. Cost of tools used for gum production (*sunki* and axes) was stated by the farmers to be 228.12 SD per hectare. The tools would, roughly, be replaced every five years. The cost of tools used for firewood production (axes) in year 16th was stated by the farmers to be 200 SD per hectare. In the study area, only jute sacks are used for gum collecting. Each sack is used on average three times before a new one is purchased. One sack can take 2 kantar of gum Arabic. The local price of jute sacks used for the gum product is 300 SD. i.e. one kantar requires 150 SD. The cost of sacks per hectare = 1.313 X 150 = 196.95 SD. The cost of seeds and seedlings was also calculated. The cost of seeds or/and seedlings required / hectare = 228.12 SD (this cost include seedlings establishment and planting). In the study area, land is mostly free of charge as declared by most of the respondents (gum producers), although some other land tenure arrangement (share cropping, *tugundi*, hiring or renting) are also applied. According to Monke and Pearson 1989, the market value of land is the annual cost, or rent of land itself. Therefore, the rental value of the land in 2002 is used as land price in the financial analysis. The average rental value is 731.57 SD/hectare. Taxes include direct taxes, indirect taxes, religious taxes (*Zakat*) and regional fees all of which were estimated at about 512 SD.

Financial Profitability of Gum Arabic Production

The financial analysis assumes that gum production as part of a bush-fallow rotation system has to be established by re-planting in the area, and the hashab trees are beginning production at the age of 5 years and they are cut down for firewood after their 16th year (Table 3).

Table 3: Calculation of Financial NPV/ha of Gum Arabic in North Kordofan

Years	**Total revenue**	**Total cost**	**Net income**
1st	-	959.7	-959.7
2nd	-	731.6	-731.6
3rd	-	731.6	-731.6
4th	-	731.6	-731.6
5th	3939	4465.6	-526.6
6th	3939	4040.5	-101.6
7th	3939	4040.6	-101.6
8th	3939	4237.5	-298.5
9th	3939	4040.6	-101.6
10th	3939	4268.7	-329.7
11th	3939	4237.5	-298.5
12th	3939	4040.6	-101.6
13th	3939	4040.6	-101.6
14th	3939	4237.5	-298.5
15th	3939	4268.7	-329.7
16th	27272.33	5202.0	+22070.3
NPV (12% d. r.)*			**+258.4**
IRR			**12.7**

* d. r. (discount rate) = Interest rate of the Central Bank of Sudan.

[6] 1 hectare produced 1.313 kantar of gum Arabic

The calculation of financial NPV of gum production assumes constant yield throughout the 16 years of rotation period (production per tree 250 grams) at 12 % discount rate, shows a positive financial net present value (NPV = SD 258.37). The internal rate of return (IRR) which is the discounting rate at which the net present value (NPV) is equal to zero = 12.7% (Table 3). In spite of the positive NPV, the discounted net income is negative from the 1st to the 15th year of the *hashab* rotation period (Figure 3).

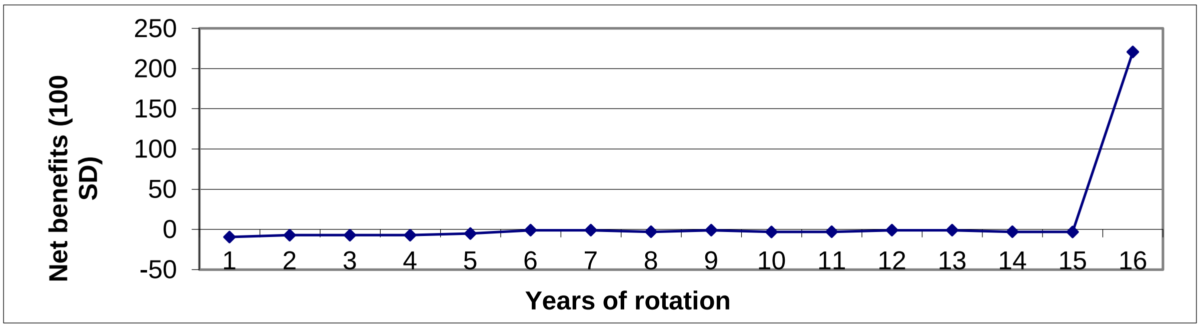

Figure 3: Financial Net Benefits (SD) of Gum Arabic Reforestation per Hectare.

The output prices were low and could not meet the cost of producing the crop. The net benefit turns positive in the 16th year when the value of firewood was included (net income = SD 22070.31) as shown in Figure 3. Farmers could earn up to three times more per hectare from firewood and charcoal production than from gum Arabic which causes farmers to shift from reforestation of *hashab* for gum Arabic production, to *hashab* tree cutting for charcoal production. However, these financial returns from gum Arabic offer no guarantee that the farmer will in fact undertake gum Arabic reforestation. This decision will also depend on what returns farmers obtained from other crops and the time profile of these returns. Most of the gum Arabic producer in the study area are relatively poor and may prefer the immediate financial returns offer by annual crops.

Financial Profitability of Other Major Crops in the System

Other than gum Arabic production, farmers in the study area practice crop farming under the traditional fallow rotation system. Millet and sorghum acquired priority to meet household food needs as the main staple food crops while groundnuts for the domestic oil market and export, and sesame and hibiscus are produced as cash crops. No yield decline is assumed for all crops, as the bush-fallow rotation is expected to maintain soil fertility.The financial profitability per hectare of field crops using 12% interest rate, is displayed in Table 4.

Table 4: Financial Profitability per Hectare of Major Crops in the Study Area

Crops	Total costs	Total revenue	Net income	NPV at 12% I.R*
Millet	10555.2	8745.90	- 1809.4	- 12618.5
Sorghum	10667.9	10760.0	+92.0	+ 641.8
Sesame	10273.1	10560.6	+ 287.5	+ 2005.2
Groundnuts	16005.3	22920.0	+ 6914.7	+ 48223.2
Hibiscus	32981.0	34224.65	+ 1243.6	+ 8673.1
Total NPV				+ 46924.9

*I.R. = Interest rate of the Central Bank of Sudan

Table 4 shows the financial profitability analysis of major alternative crops that compete for land with gum Arabica. The analysis indicates that Groundnuts production was most profitable (SD 48223.23) followed by hibiscus (SD 8673.13), sesame (SD 2005.23) and sorghum (SD 641.82), while millet production acquired losses (NPV = SD -12618.52). The farmers in this area grow millet and sorghum crops despite the low financial returns compared to other field crops to meet subsistence needs, and as food for hired labour. Hence, they are willing to subsidize the losses from their more profitable cash crops. In fact the millet crop is frequently subjected to ravages of pests, especially locusts and birds, as well as stressful climatic conditions, but for the stated reasons, it is still grown.

In conclusion, the financial analysis of crops in bush-fallow rotation systems shows that the financial returns from growing crops such as groundnuts, sesame, hibiscus and sorghum are substantially higher on a per hectare basis than for gum Arabic. However, this does not necessarily imply that land under the gum Arabic trees should be shifted to cultivate the field crops, because this profitability can not be sustainable without fallow rotation periods with gum trees, because rotation with gum trees helps to maintain soil fertility and water retention. Moreover hashab trees provide cash income to farmers outside the growing season of the other crops.

Sensitivity Analysis

To argue for the establishment of a *hashab* reforestation programme as an important agri-environmental system, the sensitivity analysis is performed by changing the values of important variables at specific levels and observing the impact of the changes on farmer's profitability. Profitability is examined under difference scenarios;

a) Primarily the gum Arabic farmer price is assumed to increase by 5% and 10%.
b) All inputs required for gum trees replanting is subsidized at 5% and 10%.
c) Different interest rates such as 8, 10, 12, 15 and 17 percent are applied.

Table 5 shows the NPV and IRR of gum Arabic production in case of increased gum producer prices or when all production inputs are subsidized at 5% and 10%.

Table 5: Influence of 5% and 10% Increase of Producer's Prices and Inputs Subsidized on NPV And IRR Of Gum Tree Replanting in the Study Area

	% Increase in Gum Price		**% Subsidy of Production Inputs**	
	5%	10%	5%	10%
NPV	1631.9	2973.2	1210.2	2163.9
IRR	17.1	23.3	15.4	18.3

Results in Table 5 show that profitability of gum Arabica is sensitive to changes in input and product prices. Increase in the gum arabic producer price (5% and 10 %), caused a significant increase in the financial profitability of gum arabic production by 6.3 and 11.5 respectively.When the inputs are subsidized at the same percentages, the NPVs of gum Arabic increased by 4.7 and 8.4 times, respectively, compared to the actual NPV. This profitability exceeded the profitability of cash crops in the bush-fallow system (i.e. sesame and hibiscus). The results indicate that if the determined floor price of gum Arabic was raised to SD 3150 or SD 3300 per kantar (5% or 10% respectively) instead of SD 3000, the gum producers would find it remunerative and sufficient incentive to re-establish gum production in the study areas. On the other hand the discount rates at zero NPV increased to 17.07 and 23.32 when gum prices increased, while it increased to 15.38 and 18.31 when input subsidizes at 5% and 10% respectively. The gum Arabic profitability is also calculated at different discount rates (8, 10, 12, 15 and 17 percent), which display in Figure 4.

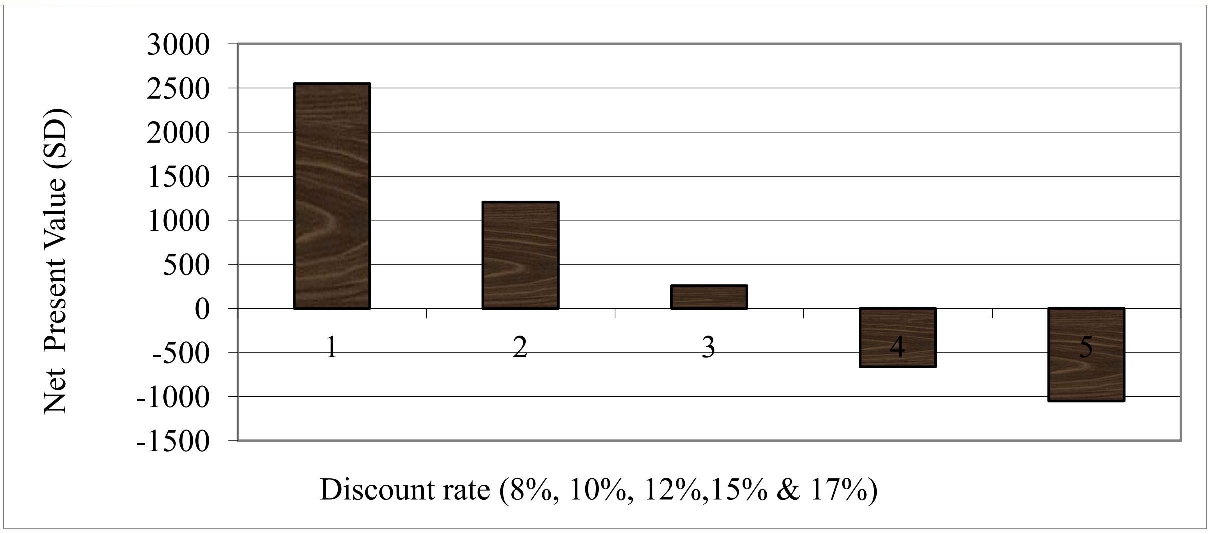

Figure 4: Financial Net Present Values at Different Discount Rates

It can be seen from the figure that the NPVs of gum Arabic replanting show positively high returns at interest rates of 8 and 10% with 16 years rotation. When 15% and 17% interest rates are applied, NPVs show negative sign. The results indicate that if farmers borrow money from the formal sector (central bank, agricultural bank and others) that normally offer interest rates of 10% or less annually, gum belt replanting as a measure for combating desertification and environmental conservation acquires high profits (SD 1150 and 2600).

Valuing of Nitrogen Fixation by Hashab Trees

The value of nitrogen fixation as one of environmental effects of *hashab* trees on land quality in the gum belt of the Sudan was calculated based on the following: Firstly *hashab* trees provide an amount of nitrogen estimated as 770 part per million (Hussein 1983), that is, every million measuring units of area contain 770 nitrogen units by weight. This amount of nitrogen is equivalent to 7.7 kilograms per hectare. It can be concluded that *hashab* trees provide the soil annually with 7.7 kilograms of nitrogen element. Secondly; the amounts of nitrogen provided by *hashab* trees were valued using current market prices of the fertiliser used in the irrigated areas to compensate for the loss in nitrogen. There are many types of fertilisers used in the irrigated sector in Sudan. The most important is the Urea (ammonia nitrate).The ammonia nitrate fertiliser contains, in addition to other elements 46% nitrogen (IIES & IES 1990 &Taha 2000). Therefore, the amount of nitrogen provided by *hashab* trees (7.7 Kg/hectare) could be available if 16.74 Kilograms of ammonia nitrate were supplied (7.7 x 46/100).

Using the replacement cost approach advanced by Saastamoinen (1992) and, Markandya (1992) to value the environmental benefits of *hashab* trees.The total cost of ammonia nitrate equivalent to nitrogen provided by *hashab* trees per hectare can be computed by multiplying the cost of one kilogram ammonia nitrate (768.50 SD) by the equivalent amount of ammonia nitrate necessary to supply 7.7 kilograms of nitrogen. The total cost of nitrogen provided by *hashab* trees/hectare = 16.74 Kg x 768.50 SD = 12,864 SD. In other words, the presence of *hashab* trees can save the cost of supplying fertiliser which is equal to 12,864.0 Sudanese diners per hectare. The total economic net present value (NPV) after including the nitrogen fixation as an environmental benefits = 46,499.51 SD.It is valuable to note that nitrogen fixed by this leguminous tree could encourage grassy growth for grazing of livestock. This is of value to silvo-pastoral sedentary farming systems as well as to some nomadic systems in the area as reported byPearce, (1990).

Conclusion

The financial analysis of *hashab* replanted shows a positive return at 12% discount rate. In spite of the positive NPV, the discounted net income was negative from the 1st to the 15th year of *hashab* rotation period. These results are explained by the poor producers' price, which is reflected in low producers' revenue. In addition to benefits from firewood in the 16th year of rotation, the net income turns positive. The low producers' prices and low production fees on firewood and charcoal production resulted in development of firewood and charcoal markets which contributed to more deforestation in the area. However this positive financial return offers no guarantee that the farmer will undertake gum arabic production within the availability of other alternative land uses, such as growing groundnuts, sesame, hibiscus and sorghum. A possible incentive for the farmers to continue with gum Arabic production is the introduction of PES schemes. Payment for Environmental Services schemes would supplement farmers' incomes, thereby encouraging them to continue with the traditional system of planting trees as part of the rotation for land management. The benefit of this is that the trees would benefit the global community through carbon sequestration and holting of desertifying influenes, while at the same time benefiting the communities through extra income and more sustainable land management.

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THEME 2

SUPPORTING BIODIVERSITY CONSERVATION THROUGH PAYMENT FOR ENVIRONMENTAL SERVICES SCHEMES

VALUATION OF PROTECTED AREAS IN UGANDA: A CASE STUDY OF MURCHISON FALLS CONSERVATION COMPLEX

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ABSTRACT

Protected areas (PAs) play important roles through provision of ecosystem services for the local, national, regional and global benefits; yet their economic values have not been established. Establishing the economic values will facilitate the incorporation of these roles into national accounting systems and facilitate natural resources management initiatives, especially Payments for Ecosystem Services (PES). Murchison Falls Conservation Complex (Murchison Falls Conservation Area and Budongo Central Forest Reserve) were selected as a case study. A total economic valuation approach was used whereby financial, ecological, cultural and non-use values of the PA were estimated. A Socio-economic survey, consultative meetings and existing information were used to collect the relevant data required for the study. The PAs were found to provide important ecosystem services as habitats for wild flora and fauna, as well as other ecosystem services and products that included non-timber products (fuelwood and construction materials), non-wood products - food, medicines, soil erosion control, recreational values, carbon sequestration, catchment services, educational and bequest/existence value. The academic role of PAs was estimated at US$2474 per annum and existence value contributed the highest value of the PAs of US$16 billions per annum. The carbon sequestration value was estimated at US $2 million per annum. There was no compensation mechanism in place for the local communities participating in conservation of the PA, and for the foregone utilisation, yet this would guarantee sustainable conservation and mitigate prevailing levels of poverty. It is recommended that PES should be considered as a tool for involving local communities in the conservation of Protected Areas (PAs), thereby affording them opportunities for improving livelihoods ahile at the same time securing the conservation status of the PAs.

Introduction

Lack of information on economic value from environmental goods and services and their roles in poverty reduction has been identified as a threat for existing protected areas (PAs) to achieve targets of the Convention of Biological Diversity[1]. Although protected areas in Uganda are recognized as key to countering loss of the country's biodiversity and contributing to sustainable development, most of them are under weak management, inadequate institutional collaboration, as well as inadequate funding (NEMA 2009a), compared to other national sectors such as the social (educational, health), production (agriculture, trade and energy) and infrastructure (public works, roads). While some of the sectors have been prioritized based on financial contribution, rate of growth and prospects (MoFPED 2010), services derived from the natural resources have not been valued in financial terms to allow their clear understanding and comparison. The forestry and fisheries sectors for example are considered as part of agriculture in national accounts and only their direct financial values are credited (UBOS, 2009). There are currently three major categories of protected areas (PA) in Uganda, namely, national parks, wildlife reserves and forest reserves. Uganda's forest estate is currently estimated at 24% of the country's total land area. The majority of this estate comprises of woodland (80%), tropical high forest (19%) and the rest is plantations. High rates of degradation have been reported in all natural biomes (NFA, 2003), which has been associated with encroachment for conversion of land to agriculture, unsustainable harvesting of timber and other forest products, urbanization, industrialization and institutional failures (NEMA 2004). The protected wildlife estate comprises of 10 national parks (11,180 sq. km), 10 wildlife reserves (8,764 sq. km), 7 wildlife sanctuaries (850 sq. km) and 13 community wildlife areas (27,604 sq. km). These protected wildlife areas combine with a magnificent scenic beauty of extensive forests and woodlands, mountain peaks and other aesthetic resources to provide a back bone for the tourism industry (GoU, 2010).

Uganda recognizes the importance of the natural resources for the country's well being. Efforts to ensure their conservation and sustainability have been put in place through entrenchment of environmental issues in the national constitution and national development strategies (GoU 2010). Establishment of various key government institutions dealing with management of the environment and natural resources, and formulation of various policy interventions are some of the other efforts put in place. In spite of all these efforts, natural resources degradation, depletion and overexploitation are still going on (NEMA, 2009a, NEMA, 2009b), thus compromising the ability of the environment to sustainably provide ecosystem services important for livelihoods (NEMA, 2009b). Other global shocks like the threat of climate change require robust ecosystems that will not only aid in mitigation and adaptation, but also reduce the extent of change (UNEP, 2009). Queries have been raised about the best approaches to address the sustainability of natural resources; (Scherl, *et al.,* 2004) believes that it is by inculcating an understanding of the roles these resources play in human welfare.

Valuation of the natural resources has been recommended to estimate the value in monetary terms and thereby validate sustainable utilization of the resources (Costanza, *et al*., 1997). Valuation is also recognized and has recently become popular as an important and strong tool in natural resources for policy formulation, comparing management options (i.e. either for conservation or conversion to non-restrictive uses); ensuring proper planning and management interventions (De Groot, 2006); monitoring changes in quality and quantity (Loomis, *et al*., 2000); stock taking for decision making (e.g. harvesting) and integration of environmental products and services in national statistical accounts (UN *et al*., 2003). The concept of national accounting provides a common framework for economic and environmental information, permitting a consistent analysis of the contribution of the environment to the economy and of the impact of the economy on the environment. The goal of national accounting is to meet the needs of policy makers by providing indicators and descriptive statistics to monitor the interaction between the economy and the environment, as well as serving as a tool for strategic planning and policy analysis to identify more sustainable development paths (UN *et al*., 2003). As an effort to advance ecosystem valuation methods in the United States, the Environment Protection Agency convened an expert group of ecologists, economists and other social scientists to an ecosystem valuation forum (Bingham *et al*., 1995). The forum was a dialogue platform for stakeholders to agree on information requirement for ecosystem services, approaches, demand for ecosystem valuation and make decisions on handling the controversies associated with valuation studies. The forum recommended the need for more linkages between ecologists and economists in improving the ecosystem valuation methods with a research agenda of identifying and exploring the real challenges of ecosystem valuation through practical case studies. The experts further observed that through the crucible of real experience, methods will be developed that will make useful and realistic contribution to public decision making. Nunes and van den Bergh (2001) evaluated the notion and application of economic monetary valuation of biological diversity by a thorough review of the economic valuation studies and established that the assessment of biodiversity value does not lead to a univocal, unambiguous monetary indicator. The range of monetary estimates of biodiversity values was dependent on the level of life diversity under consideration, the biodiversity value type under assessment, and selection of the valuation method. Valuation for biodiversity was considered at genes, species, ecosystem and function levels. Many of economic valuation estimates were regarded as incomplete for failure to consider the entire range of benefits.

To respond to the incompleteness of past valuations, a global valuation of ecosystem services has been undertaken. The services of ecological systems and the natural capital stocks that produce them are critical to the functioning of the Earth's life-support system. They contribute to human welfare, both directly and indirectly, and therefore represent part of the total economic value of the planet. Costanza *et al*., (1997) gathered scattered information on valuation of 17 ecosystem services for 16 biomes and estimated values for ecosystem services per unit area by biome, and then multiplied by the total area of each biome and summed over all services and biomes. For the entire biosphere, the value (most of which is outside the market) is estimated to be in the range of US$16–

54 trillion per year, with an average of US$33trillion per year. The value was comparable to the global gross national product total estimated at US$18 trillion per year (Costanza *et al*. 1997). The study concluded that since ecosystem services are not fully 'captured' in commercial markets or adequately quantified in terms comparable with economic services and manufactured capital, they are often given too little weight in policy decisions. The concept of total economic value (TEV) emerged in the mid-1980s and is now widely used to identify the economic benefits associated with PAs (Phillips, 1998). Total economic valuation attempts to incorporate all services, whether positive or negative (Hitchcock, 2000). It encompasses the marketable values, non-market values, ecological functions and non-use benefits associated with PAs. When considering PA economic values, it is important to include economic costs, as well as economic benefits. The total economic cost of PAs is now seen as being greater than just direct management expenditures, encompassing both opportunity costs and losses to other economic activities incurred by the presence of PAs (Scherl *et al*., 2004).

A number of valuation studies have been undertaken in Uganda to meet different objectives (Moyini *et. al*. 2002; Emerton and Muramira 1999; Yaron *et al*., 2004; Muramira, 2007). Moyini and Uwimbabazi (2000) estimated the value of the gorilla tourist attraction at full capacity at US $ 7-33 million per annum using the travel and contingent value method. The study focused on the economic significance of tourism based on the mountain gorilla (*Gorilla gorilla berengei*) in Mgahinga Gorilla National Park and Bwindi Impenetrable National Park. Buyinza *et al.,* (2007) undertook an economic valuation of Bujagali Falls Recreational Park using zonal travel-cost and hypothetical valuation approaches. Bush *et al.,* (2001) estimated the value of forests in Uganda to contribute to livelihoods, watershed, carbon sequestration, biodiversity and soil erosion services using total economic method. While these studies have been monumental for valuation philosophy, they all considered one ecosystem service in their approaches and hence failed to articulate other services, and therefore could not arrive at the total economic cost and the entire importance of ecosystems to human survival (Costanza *et al*., 1997). This study builds on existing information of valuation in Uganda, to establish the ecosystem services provided by the protected areas and their values, in an effort to improve the appreciation of the importance of PAs and to facilitate natural resources management initiatives, especially payment for ecosystem services, poverty reduction, and national growth. A total economic valuation approach was adopted where a number of valuation techniques were used (Birol, *et al*., 2006; Costanza, el al. 1997) to estimate the various ecosystem services accruable and already utilized from the PAs.

Methodology

Study Area

This study was carried out in the Murchison Falls Conservation complex, that is, the Marchison Falls Conservation Area (MFCA) and Budongo Central Forest Reserve (BCFR)), both very important PAs for conservation of biodiversity in Uganda. Due to the interface between the two protected areas, associated management and the homogeneity of the community characteristics, the PAs were considered as one entity - Murchison Falls Conservation Area and Budongo Central Forest reserve Complex (MFBFC). The areas have attracted many studies, one of which is governance issues affecting PAs that is on-going. The MFCA consists of Murchison Falls national park, Bugungu wildlife reserve and Karuma Wildlife Reserve with a total area of 5,072km^2, while Budongo Central Forest Reserve has an area of about 825km^2 with 72% of it being a forest estate, while 16% is an overlap with Bugungu Wildlife Reserve and the rest with Karuma (UWA 2001). Figure 1 shows the location of Murchison Falls Conservation Complex (MFBFC).

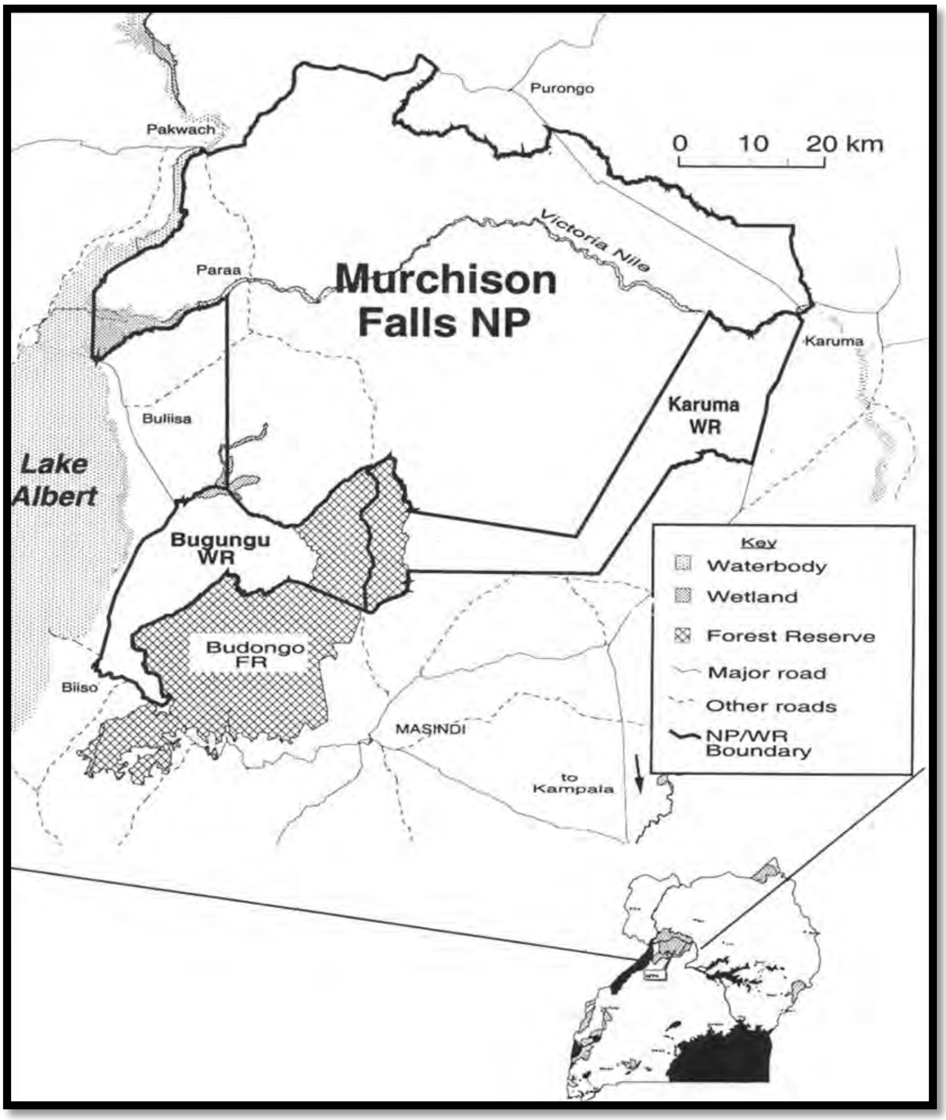

Figure 1: Location of Murchison Falls Conservation Complex (Source: UWA 2001**)**

Data Collection

Both primary and secondary data collection methods were used. Primary data was collected through administration of a questionnaire during a socio-economic survey of households and tourists. Observations and consultation meetings were also carried out. Secondary data was collected through review of existing literature.

Study Approach

To value the protected areas, a total economic valuation method was adopted to establish all benefits (financial, ecological, cultural and non-use) from the PAs. The direct values, indirect values, option values and existence values were used as the benefits derived by either use or non-use. Other aspects considered were the costs either direct or indirect in terms of management, those associated with the management option adopted, and opportunity costs.

The valuation techniques adopted were those commonly used in valuation (Birol *et al.,* 2006) and included the following:

Market Prices Analysis

This method was adopted for goods and services obtained from the PAs that were sold in markets. Market price analysis complimented information from an inventory on the timber stock in Budongo forest for various tree species and also the value of carbon sequestration.

Replacement Costs

The replacement and avoidance cost were used to estimate the soil erosion control service derived from the PAs. Another value estimated using this method was the costs of replacement of the current biome types, under the assumption that without conservation efforts, they could be lost.

Travel Costs

Travel costs reflect the value that people place on leisure, recreational or tourism aspects of PAs. Travel method approach was used in estimating the recreational value of the PAs. A survey was conducted for the tourists of the PAs upon which the travel cost functions were established. Secondary information of the total visitation in the PA complemented the survey to estimate the value of recreational services.

Financial Returns

In some cases accounting for returns and expenditure derived from a specified protected area may provide the value associated with it. Most of the intrinsic values become clear when people pay to visit and enjoy the services derived from the resource. The net return of the PAs' financial transactions is considered as its business or financial value. This value was derived by using the annual accounts of PAs and establishing the profit made in the year under consideration.

Contingent Valuation

Theoretically, the contingent valuation technique is recommended in assessing the option and existence values; however, it needed modification and use of indirect inquiry or proxy. Conventionally the contingent valuation approach attempts to value through inquiring on the "willingness to pay or accept"; and while this method has been used widely (Birol, *et al*., 2006), it may raise issues when a resource in consideration is surrounded by controversy at the time of study. Land ownership and the fear of displacement to allow oil exploitation were rife during the survey and questions addressing payment and accepting any pay would have caused confusion and anxiety. Hence, respondents were queried only about their perception on the total value accrued from the PAs.

Hedonic Methods

Hedonic methods measure the differentials in property prices and wages between locations, and isolate the proportion of this difference that can be ascribed to the quality and provision of environmental goods and services. The methods were used to measure the value of land in the community owned areas and how much they could pay for land in the protected areas in its current condition or if the vegetation cover was to be removed. The PA is in remote areas with the neigbouring community majorly involved in subsistence agriculture.

Benefit Transfer

Application of environmental valuation techniques may be expensive, particularly for local decision-making where research budgets are limited. Benefit transfer offers a lower cost alternative to performing a full-scale study for any particular issue. Benefit transfer is an application of a data set or results developed for addressing one particular environmental or natural resource valuation question to another context. Given the expense and time associated with estimating values of non-market natural resources and services, benefit transfer can be a reasonable method for determining such values. A number of valuation of ecosystem studies have been undertaken in tropical areas akin to the country's ecosystems with the values being transferable to other areas (McComb *et al.,* 2006). This approach was built on by literature review with the value derived from various services simulated to the PA under consideration.

Results and Discussions

Table 1 shows the values for various ecosystem goods and services attributable to MFBFC, the valuation technique adopted in estimation; and the value derived for the various goods and services in either stock or flow.

Table 1: Potential and Extractable Value of Ecosystem goods and services from MFBFC

Potential and Extracted Ecosystem Goods/Services from the PA	Valuation Technique for the Service/Goods	Value of the Service/Good (US$)
Value of timber stock	Market price	76.8 million period
Non-timber products (mainly wood)	Market price/benefit transfer	2.5 million per year
Non-wood Forest products (food)	Market price/benefit transfer	2.9 million per year.
Medicinal and pharmaceutical values	Market price/benefit transfer	1.1 million per year
Soil erosion control	Avoidance/replacement cost	7.2 million per year
Aesthetic value	Travel cost method	58.1 million in 2008
Carbon sequestration and storage value	Mitigation impacts/ market price	2.0 million per year
Option, bequest and existence value	modified contingent valuation	15.8 billion
Relocation and rehabilitation value	Modified hedonistic/replacement cost	60 billion
Watershed protection and catchment services	Benefit transfer	13.9 million
Research and education	market price (service changes)	24,740 units
Costs to the community	Summation	1.3 million per year
Opportunity costs for MFCA (livestock husbandry)	Scenario building/market price	2.5 million per year
Opportunity costs for BCFR (sugarcane option)	Scenario building/market price	10.5 million
Income of the MFCA	Financial accounting	1.2 million (2008)
NB: exchange rate 1US$=Uganda shillings 1900		

Source (Field data)

The protected areas provided a number of stock and flow services. The stock services included the timber stock that was estimated at US$76.8 million and the services associated with opportunity costs such as livestock pastures and sugarcane growing zones. Flow services included provision of non-timber wood products (fuelwood, rafters etc), non-wood forest products (food, herbals), soil erosion control measures, watershed protection, carbon sequestration, aesthetic values and academic values. Other services included the pride associated with the existence of the PAs which was considered as option, bequest and existence value. Protected areas have been in existence for about three quarter of a century, as such, they have had a value ebbed in the land they occupy, which has been transformed to various biomes that act as biodiversity habitats for both flora and fauna. The availability of the PAs predisposes the decision of having to displace people to give way for a protected area in future. If the area had been settled and the need for displacement was to arise, it would have costed the authority substantial amount of money to compensate those who were to be resettled. If the resettlement was to be undertaken in 2009 and allowing the area time for rehabilitation and undergoing the necessary ecological succession, it would have required about US$ 60 billion. This amount would include the cost of the entire land parcel and an allowance of about 80 years for the ecosystem to recovery and its associated net present worth. The protected area is, therefore, an investment to conservation works and its existence generates satisfaction to the citizens. Both the value held by the investment of the protected area and existence values were the highest at US$60 billion and 15.8 billion, respectively. It was realized that the protected areas play an important role in providing households with necessities like firewood which was estimated at US$2.5 million annually. The households were assured of a secure source of energy for warmth provision and cooking derived from harvesting the dead branches, trunks and twigs, and was considered to be sustainable. The value presented was only for artisanal exploitations.

Communities around protected areas gather food products including honey, mushrooms, fish and food additives from the protected areas. Game meat is a significant source of protein and household income, although its acquisition was more often than not illegal. The potential value of the PAs provision of this service was estimated at US$2.9 million per annum. The annual pharmaceutical or medicinal values potential the PAs provided to the communities was estimated at US$1.1 million per year. The utilization potential value was restricted to the neigbourhood utilization based on indigenous traditional knowledge. Value addition would arise from improved research which would quantify the specific organ of the plant with medicinal value, its concentration at a given age and the necessary environmental (soil and weather factors) conditions that would guarantee the highest active ingredients. With relevant information on medicinal potential and potential for industrial processing, the pharmaceutical value would be improved. The value associated with ecological services included watershed protection and catchment services that were estimated at US$ 14 million. By protecting forests and other biomes such as bushlands, grasslands and shrublands, and only allowing non-exhaustive utilization of these resources, the biomes restrain destruction to the watershed. Healthy watersheds ensure quality water (void of suspension of dirt) and well controlled flow. While higher levels of soil eroision have been reported in agricultural farmlands in Uganda and entire East Africa (Stoorvogel and Smaling, 1990), the protected areas have their vegetation cover intact, thereby restricting erosion. Water percolates to the water table or flows slowly to fill springs that act as river sources. Vegetation restricts runoff that would result into flooding, which in turn would cause human catastrophes downstream. The PA contribution to controlling soil erosion was estimated at US$7.2 million per annum.

Vegetation provides an important sink for carbon storage and sequestration, thereby contributing significantly to reductions of greenhouse gases that are contributing to climate change. Plants convert carbon dioxide to carbohydrates ensuring the carbon molecules are stored in a more benign form in plant matter. The undisturbed soils in the protected areas also improve the potential of soil to retain more carbon in benign form. The PAs provided the carbon sequestration value estimated at US$2 million per annum. Protected areas have remained important sites for recreation services (GoU, 2010; Scherl, *et al*., 2004). Protection of biodiversity or any other rare or threatened features ensures that those who would derive pleasure in the utility get a chance to enjoy it today and in the future. The MFBFC has a wide range of sites that attract tourists, including the waterfalls, sport fishing, game-drives, sites for birdwatching, chimpanzee tracking, etc. The PA recreational value potential was estimated at US$58 million in 2008. Being a PA, MFCA alone is largely used for tourism which is compatible with its focus on biodiversity conservation. The financial return from the PA financial generating activities in 2008 was US$ 1.2 million. In the course of providing all the ecosystem services, the PA is a cost to the local community. The wild animals in the PA always get out of their boundary and damage farmers' crops and /or attack them and their livestock. This externality of the PA was estimated at US$ 1.3 million per year.

Conclusions

The value of the MFBFC has been determined using various valuation techniques based on the ecosystem goods and services the PA provide. The benefits accruing from the PA go to the neighbouring community and the country, as well as to global stakeholders. While all services provided were important, conservation investment provided the highest value. The PA could accrue more benefits if the value of the rich biodiversity of flora and fauna were included. Such values could not be established due to information dearth on species' populations and value to allocate every species, such as the value of crocodile against that of a monitor lizard, or of insects against that of birds. Other values that could not be estimated included the value of oil and gas reserves, climate moderation values, gene bank values, pollinations and other agricultural production services, and cultural and historical values.

While the goal of PAs establishment was to ensure conservation of the biodiversity, it is clear that more utilities could be enjoyed without compromising the goal. Hence, efforts should be made to ensure increased financial returns from the PAs to meet their operational and externality costs. Opportunities for improved returns existing by determining which ecosystem services could be turned into direct financial gains, e.g. through the Reducing Emission from Deforestation and Degradation (REDD) project. The country could still get financial benefits from the carbon sequestration services. The REDD's reward could go in improving the welfare of the communities or investing in projects that will sequester more carbon, thereby earning both non-financial services and direct financial returns. Improving tourism returns through promotion and improvement of tourism infrastructure will increase the financial returns from the PA. Already the Uganda Wildlife Authority is working on a management plan that will ensure increased tourism revenue from the PA (UWA, 2001). More studies need to be continuously undertaken, especially on the inventory of the natural resources base to provide more information that could aid in detailed valuation in future. The population structure of resident organisms, their distribution and the role they play in the ecosystem either in energy or chemical cycles need to be established. More valuation studies need to be undertaken at smaller units within the PAs to aid in resources management and for long-term planning purposes. All in all, it can be said that there is great potential for deriving additional monetary benefits from the MFBFC by engaging in PES initiatives.

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VALUATION OF YALA SWAMP: A MICROCOSOME OF LAKE VICTORIA BIODIVERSITY RICHNESS

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ABSTRACT

Although the ecological importance of Yala swamp has been recognized, management options that could ensure the conservation of the resident biodiversity and sustainable development for the locals who live around the swamp are lacking. A survey that involved interviewing locals living within a 20 km radius from the wetland was undertaken in 2007 – 2008. Information sought by the survey was on the resource inventory and regeneration, and on the nature and scope of utilization of the resources.. Based on ecological, economic and cultural significance, the wetland resource base was categorized into: open water, wetland vegetation and lacustrine. Valuation of the resources from the wetland utilized by locals featured as follows: as water source (53%), source of food (60%), grazing (58%), source of construction materials (68%), raw materials for households' equipments (98%), fish (61%), cultural significance (23%), medicines (45%) and fuel (45%). The ecological importance of the wetland included habitats for flora and fauna (birds, fish and animals), as well as hydrological functions. Conservation and local community desires were compatible, and a management option that could ensure biodiversity conservation and at the same time allow artisanal utilization by locals had the best short and long-term value of US $ 12 billion per annum. That was 590% and 230 % higher than if the resources were respectively utilized either for agricultural or grazing.

Introduction

Although the government has the mandate of ensuring that the natural resources are managed for sustainable development, it has had conflicts with the conservationist on management options for the Yala swamp. A battery of conservation agencies has advocated for the wetland protection as it represents a unique habitat with rare species. Yala swamp is categorized as an Important Bird Area (Site Code 41) in Kenya due to its unique biodiversity, including globally threatened and biome restricted species (Bennun and Njoroge, 1999). Ole Nkako (1992) recommended its conservation and conversion to either a National Park or Reserve on account of its rich birdlife, high biodiversity and endemism, water catchment control functions , presence of riverine forests and high tourism potential. The swamp has a very important hydrological function as it acts as a natural filter of agricultural pollutants and silt from the surrounding catchment, before its waters enter Lake Victoria (Crafter *et al.,* 1992). The wetland is significant as a living museum of the fish fauna of L. Victoria. It contains haplochromine fish, some of which are no longer found in Lake Victoria, as well as two cichlid species that are almost extinct (Mavuti, 1992). The wetland has not escaped the attention of international wetland conservationists, who would like more information to confirm its potential as a Ramsar Convention Site. To some locals, the wetland is a source of religious inspiration (sacred sites), and a source of livelihood (Abila, 1998). Others see it as a "useless wilderness" associated with breeding of disease vectors like mosquitoes and tsetse flies (Okondo, 1989). The Lake Basin Development Authority (LBDA), the custodian of the wetland for the local community considers the wetland as well endowed with agricultural potential, that it could be managed to provide food to feed the region's over 5 million persons. Considering the resource endowment of the swamp, the high levels of poverty of the local community and the lack of consensus of its utilization, it is important to undertake a valuation of the resources and then to recommend an approach that embodies both optimal utilization of the resourcs for poverty reduction and biodiversity conservation.

Methodology

Various approaches were undertaken to value the services that the wetland could be providing for the local community and as a habitat for the biodiversity. The approaches adopted included: Resource Inventory, an inventory of utilizable resources in the wetland and accruable economic services was undertaken. Survey of the Locals, a survey was administered to 225 inhabitants of the area surrounding the wetland (0.5 to 12 km) to establish the benefits derived from the wetland and also the challenges faced by locals living around the wetland. The survey queried the locals on the benefits accrued from the wetland resources. The means of resource exploitation, extent of utilization, level of reliance on the wetland and potential utilization were evaluated. Consultative Meetings, the consultative meetings were held with local groups involved in papyrus business. The choice of a group was based on its relationship with the wetland, its potential for providing useful information and its willingness to share unbiased information. Experimental Sites, six experimental sites were established randomly within the swamp in a manner that is representative for the various habitats (dense, disturbed and area under extreme pressure) to establish papyrus vegetation growth rates. An inventory was also undertaken around the wetland to observe the influence of the wetland on its margin (riverine), the size of the riverine and its utilization. Hydrological Role, to investigate the hydrological importance of the wetland, samples were collected for laboratory analysis of the chemical gradient across the wetland.

Results and Discussion

Discription of the Wetland

Yala Wetland provides a resource base in three aspects, depending on the dominant composition, viz, water body, papyrus vegetation or the riverine area. The water body comprising of three lakes (Lake Kanyaboli, L. Namboyo and L. Sare) provides fishery resources, water for domestic and livestock consumption, and a potential site for tourists who may visit for boating, sport fishing and swimming. The water bodies are habitats for micro- and macro-organisms. The papyrus vegetation provides another resource harvested for making of handcrafts, construction, animal feeding and human food additives. This zone also provides habitats for wild fauna and flora. The lacustrine zone provides an arable land that supports year long food for the local community and a reliable grazing zone for the livestock.

After the vegetation and the lakes, River Yala drains into L. Victoria through a number of tributaries, including Thogoi, Nyahairani, Obaro, Buruani, Nandehe, Sindoho and Ndekwe. River Ndekwe drains water from both the River Yala and Nzoia during the rain seasons. All these rivers carry clear water devoid of soil suspension, unlike the mother River Yala which has dirty water due to loads of impurities of mostly soil particles. A transect across the vegetation at around Jusa in Bondo district observed a dense papyrus vegetation covering the first 50 m, followed by about 150 m margin of a mixture of grasses, (two species), low dense papyrus and some patches of reeds and a dense papyrus vegetation that extends to the a lake. The inner thicket of papyrus was estimated to be about 250 m wide. In areas with narrow wetland vegetation sandwiched between the dry land and water body, the entire vegetation was composed largely of papyrus.

Socioeconomics Survey

The survey covered inhabitants of Busonga, Alego and Usigu divisions of Busia, Siaya and Bondo districts, respectively. The respondents had lived in the area for an average of 40 years, with ages ranging between 89 years and one year. They were members of families with an average of six individuals, with a large proportion (95%) employed directly in natural resource exploitation through agriculture, fishing, animal husbandry and handcraftship. Most locals were subsistence farmers growing maize, beans, sorghum and millet, as influenced by agro-climatic conditions. The reliability of harvest for annual household food needs was about 50%. About 97% of respondents didn't farm sufficient food. On average 2.6 acres were cultivated by every household using the rainfed system. The swamp was important to the local community as it had a wide range of services. The uses of the wetland were as follows:

Agriculture

A small margin around the wetland provided a year-long arable land where the locals cultivated high value crops. Six in every ten households had small parcels of land along the wetland that was irrigated. On average, every household had 664 m^2, which were planted with kale, tomatoes, sweet potatoes, arrow roots, sugar cane, cowpeas and banana. The production level of each of these crops could not be established, as the locals could not state their value. Intercropping was so intense that one could find about 5 crops in a 100m^2 plot. The composition of farmers cultivating various crops are shown in Fig. 1.

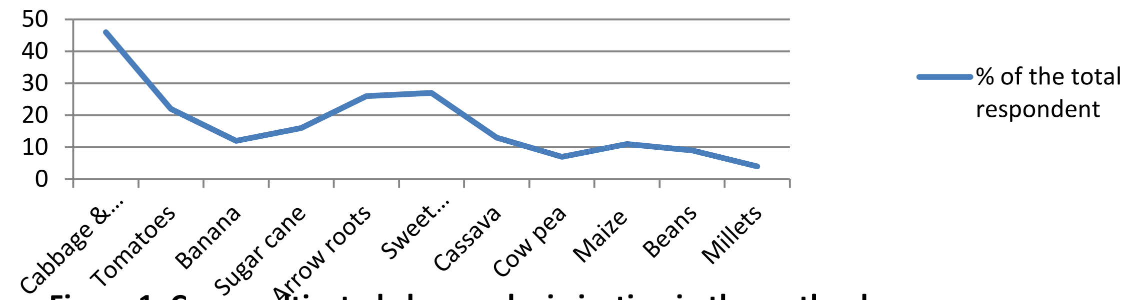

Figure 1. Crops cultivated along or by irrigation in the wetland

Farms from which these crops were cultivated were found to form a 100m margin along the wetland on the east and an area about 2300 ha previously reclaimed by LBDA. And of the 135 farmers who irrigate the land, 18% could not estimate the income or the production level of their farms. The estimated income from the total area irrigated by respondent (115,612m^2) was KShs. 521732, averaging KShs. 2596 per respondent per year on a plot of 504 m^2.

Grazing Area

Grazing around the wetland is an important socio-economic activity among the locals. Table 1 shows grazing returns from the wetland. All those respondents with cattle (58%) depended entirely on the wetland for foliage and water. On average every household interviewed had four cows grazing in the wetland on daily basis. The total annual value of the cattle owned by the respondent was KShs. 6.98 millions, with KShs. 30,452 to every household. A total of about 795 liters of milk was being produced daily during the study. With the average cost of milk per litre being KShs. 22.80, the overall value of milk harvested daily was KShs. 18134, giving an average of KShs. 79.20 per household. Some of the cattle were oxen that aided the locals in ploughing. A total of 154 oxen were reared by 23% of respondents. On average, ploughing an acre by oxen was valued at KShs 1280, with a total of about 122 acres ploughed during the year of study by 24% of respondents. The increased value by oxen to cattle was KShs 156,160 with an average of KShs 682 per household. Goat and sheep were grazed in the wetland too. Only a 10% of the 43% of households that reared goats didn't depend on the wetland. About a fifth of households reared sheep with 82% depending on the wetland for forage. Sheep were valued at KShs. 321,400, livestock were used as a symbol of wealth and for dowery payment, sale to get cash, and for slaughter during households' ceremonies.

Table 1: Contribution of the Wetland to Livestock Industry among Locals

Product	% of Respondents	Total Number	Cost per Unit	Monetary Value (Kshs)	% Feeding on Wetland	Average Return per Household
Cattle	58	863	8091	6982500	100%	24273
Milk (liters/day)	58	795	22.80	18134	100	79.20
Oxen services	23	154	1014	156160	100	682
Goat	43	545	1341	730950		3248
Sheep	17	-	-	321400	82	-

Construction and Handcrafts

The wetland vegetation especially papyrus and reeds found a lot of use in construction and handcrafts. The use of papyrus was so intense among the locals, to the extent that papyrus products were visible in 98% of homestead visited for the survey. The papyrus products visible included thatched huts, papyrus mats used as ceiling boards, papyrus tables, chairs, stools, fishing baskets and papyrus by-products that littered the compound after being used as animal foliage. Construction relied on wetland resources with 68 % of houses thatched with vegetation harvested from the wetland and 6% entirely built with papyrus. Table 2 shows contribution of the wetland to construction and handcrafts.

Table 2: Contribution of the Wetland in Construction and Handcrafts among the Local Community

	Number	Proportion (%)
Total number of houses in respondents' households	1071	-
Iron sheet thatched	341	32
Grass thatched	730	68
Mud walled	941	88
Wood/bricks or blocks walled	100	9
Papyrus walled	30	3
Papyrus interior subdivisions in wood and mud walled	31	3
Total numbers of seats	1573	-
Capacity of seats	1701	-
Papyrus seats	110	7
Papyrus made tables	80	14
Timber made tables	498	86
Table capacity	1541	-
Mattress	534	-
Sleeping Mats (Papyrus mattresses)	220	-
Mats and mattress capacity	1396	-

Recreational Services

The wetland provided recreational services, with 30% of respondents confirming enjoying the services. Table 3 shows the recreational services available to the locals. Fifteen percent of the total household respondents surveyed (1215) had visited the wetland for recreation. They made about 2738 outings with each outing lasting less than two hours (101 minutes). The largest proportion of visitors (46%) enjoyed relaxing around the wetland. They claimed the environment of the wetland was cool, silent, refreshing and admirable, hence they could walk around or choose a place to either sleep or sit as they meditated. Some who toured the wetland were attracted to boating and fishing, swimming, and watching birds, animals and the vegetation. A part from respondents' family members, neighbours also enjoyed the wetland recreational service; about 328 other individuals were seen enjoying the service (Table 3). About 60% of the respondents believed Yala wetland could attract foreign tourists particularly for game viewing (41%) and others like sport fishing, boating and swimming.

Table 3: Recreation Potential of the Yala Swamp

Activity	**Number**	**% of Respondents**
Visit the wetland for recreation	68	30
Number of individuals involved	182	15
Number of outing made per year	2738	-
Duration of stay in minutes per outing	101	-
Specific recreational activity	**Number of Respondents**	**% of those Visiting**
Recreational fishing and boating	21	31
Recreational swimming	7	10
Observing Fauna, Flora and nature	12	18
Walks, resting under trees, etc.	31	46
Watch farming activities	8	12

Fishery Resources

Fishing within the wetland was an important endeavour that provides food and employment to locals. Ninety-seven percent of the respondents used fish as an important component of their food. The fishery resources were harvested from both the wetland lakes and Lake Victoria. Six in every ten respondents relied on the wetland lakes for fish while the rest 39% depended on L. Victoria. Prices of fish depended on location, size and type of fish. Locals relying on catches from the wetland (both L. Kanyaboli and Sare) enjoyed a larger variety of fish species than those depending on nearby L. Victoria.

Table 4: Fisheries Utilisation and Fishing Efforts among the Community around Yala Swamp

	% of Local Fish consumers of various varieties of Fish				
Varieties of Fish	**Varieties**	**Victoria**	**Kanyaboli**	**Sare**	**Overall**
	2	17	14	22	18
	3	75	51	63	64
	4	8	27	13	15
	5	0	8	3	3
Cost of A fish Meal from Various Sites					
Average cost in Kshs		78.4	84.1	72.21	77.19
Per capita meal cost in Kshs.		17.0	21.1	15.17	17.9
Time to harvest a meal worth fish (hrs)		3.7	3.7	3.5	3.6

Medicinal Plants

Among the respondents interviewed, 45% had treated or had received treatment from plants collected from the wetland. A sizeable number (27%) were informed on some medicinal plants used and the diseases treated. Table 5 shows the 23 plant species that were associated with medicinal values and diseases they treated. The diseases treated using wetland vegetation include: skin infections, malaria, snake bites, measles, stomach-aches, intestinal worms, bilharzias, coughs, eye and ears problems, joints-aches, body swellings, weil and chira (bewitched) and mothers with delivery problems;and livestock diseases, including anthrax, foot and mouth and delivery problems have been treated with local herbs. Some plants' vernacular names could not be found in the available reference books (Beentji, 1994; Ruffo *et. al*. 2002; ICRAF, 2002).

Table 5: Wetland Associated Plants with Medicinal Values

Vernacular name	Botanical/ English Name	Diseases Treated
Hafifi	------------	Measles
Oyieko	*Cassia siamea*	birth problems/ worms/ joint
Nyayado	*Carisa mangium*	teeth-ach
Oluoro chieng	----------	stop bleeding
Olandra	*Flemingia grah*	curse (locally called chira)
Nyohanyoha	----------	curse (locally called chira)
Owino	*Senna didymobotrya*	swellings/skin/protozoan
Oyumbe	-----------	Joint pains
Morakado	*Rosa canina*	Skin diseases
Ombulu	*Abrus prec*	Cough and Chest problems
Amayo	*Salium elli*	Ear and Eye infection
Aringo	-----------	Ear and Eye infection
Ober	*Albizia coriaria*	Skin and tooth decay
Osiri	------------	Boils and Measles
Anyuongi	*Talinum triangulare*	Rashes and Measles
Onyodhi	-------------	Stop bleeding
Ogaka	*Aloe spp*	Skin Problems
Nyakisumo	*Centaurea cyanus*	stomach ache/ witches
Nyambudue	*Centaurea kirkii*	birharzia

Wildlife Resources

Some wildlife was reported to be living in the wetland. Resident animals included waterbucks, sitatunga, velvet monkey, hippos, mongoose, squirrels and wild pigs. Other species of animals mentioned included leopards, baboons, snakes, monitor lizards and crocodiles. Birds observed during the study included the yellow papyrus warbler, Great white egret, waterfowl, weaverbirds, malachite kingfisher, pied kingfisher, red-beaked kingfishers and crested crane.

Cultural and Religious

The swamp is bestowed with some myths, traditions and religious practices. A quarter of respondents were keen on some myths related to the wetland and observed or were ready to observe them strictly.

Diseases and Pathogens

A number of diseases have been associated with the wetland. Ninety-eight percent of respondents associate the wetland with diseases. Overall 37%, 34% and 23% of respondents considered the wetland to be associated with 1, 2 or 3 diseases, respectively. The diseases associated with the wetland include malaria (214), Typhoid and amoeba (86), Cholera and dysentery (41), sleeping sickness (37), Bilhazia (25), skin infection (11) and others (6).

Fuel wood

About a quarter of the respondents depended on the wetland as a source of fuel wood. The fuel wood is from the rhizomes of papyrus and other wetland plants. The papyrus rhizome as firewood was used to smoke a preferred type of fish that was mostly sold to distant markets.

Functional Resource Base Services and Potential

A lacustrine ecosystem was found around the wetland. The ecosystem extended to a margin of 50-120 metres around the non-rehabilitated area of the wetland except the southern side. The southern end had a rocky terrestrial ecosystem bordering the papyrus and the other made a papyrus mass that extended to L. Victoria. The lacustrine ecosystem was used by locals for cultivation and grazing. A representative area was evaluated for its grazing potential.

Grazing Potential

The main grass species recorded during the inventory were *Paspalum scrobiculatum*, *Cynodon dactylon*, *Leersia hexandra* and *Digitaria scalarum (Table 6), o*ther species observed include *Comelina spp, Cyperus radiata* and *Solanum incunum.*

Table 6: Foliage and Species Composition and Grazing Conditions in the Wetland

Species	**Species Composition and Density (%)**									
Species	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8	Site 9	Site 10
Comelina spp	0	0	0	0	0	0	0	5	0	0
Paspalum scrobiculatum	90	100	70	0	0	0	0	0	0	0
Cynodon dactylon	8	0	15	100	75	90	10	95	100	100
Leersia hexandra	1	0	5	0	0	0	90	0	0	0
Digitaria scalarum	1	0	5	0	25	10	0	0	0	0
Cyperus spp.	0	0	5	0	0	0	0	0	0	0
Ground cover	100	10	70	100	60	100	100	60	90	80
Succulence	80	80	80	80	75	80	70	80	80	70

The ground was well covered with herbage averaging 86% cover, which ranged between total ground cover to 60% cover. The herbage had higher level of digestible or succulent parts largely the leaves and tender stems, which averaged 78% of the whole vegetative plant. Although the area had species associated with a flooding plain, its grazing potential was high as water logging and over grazing was not observed. The negligible presence of *Cyperus radiata* was a good indicate of low water logging which could be associated with regular deposition of soil with good water retention levels (Jaetzold and Schmit, 1983). The low occurrence of invader species (*Solanum* *incunum* and *Comelina spp*) is an indicator that the land is not overgrazed and trampling is still at low levels (Platt and Gwynne, 1977).

Papyrus Regeneration Rate in Various Ecotones

Table 7: Papyrus Sprouting Rate and Height Increase in Different Sites

Site	Height at 14 days (Sprouts)	Height at 14 days (Average)	Height at 120 days (Average)	173 days (Sprouts)	Remants at 173 days (Sprouts)
Ratuoro	16	57.75	47	73	0
Ramogi	13	46.5	197	314	0
Ururi	5	19.2	42	74	0
Usenge Bea	14	53.1	191	218	2
Usenge Vill	2	26.1	91	161	0
Nyangena	10	43.7	46	114	3

It was observed that papyrus sprouting after slashing differed between ecotones with higher numbers of sprouts observed on the more disturbed sites. Higher average heights were also observed among the more disturbed plots on the 14th day after harvesting. The number of sprout increased with time. More disturbed plots produced more sprouts throughout the study.

Hydrological Functions of Yala Swamp

The wetland has an important hydrological function as it acts as a natural filter of agricultural pollutants and silt from the surrounding catchments before the water enters Lake Victoria. A chemical analysis that was taken to compare the concentration of anions and cation pollutants before the river drains into the wetland and after the wetland showed that indeed the wetland does ameliorate pollution in the River Yala. The anions laboratory analysis was done using the titrimetric techniques and spectrophotometric analysis. Results of the analyses showed taht samples from the Yala River (main inlet) had high concentrations of phosphates (2.20 mgl^{-1}), sulphates (608.06mgl^{-1}) and chlorides (305mgl^{-1}) anions, compared to wetland's outlets levels that showed reduced anions' concentration (Table 8).

Table 8: Comparison of anions levels between the inlets and outlets of Yala Swamp

Samples	**Phosphates in mg/l**	**Sulphates in mg/l**	**Chlorides in mg/l**
R. Yala (main inlet)	2.20	608.06	305
R. Ndekwe	1.90	432.27	270
R. Sidoho	2.00	86.45	265
R. Mgangu	1.70	266.08	265
R. Dhogoye	2.10	243.00	285
R. Ulwani	1.80	496.00	265

The swamp played an important function in reducing the salt levels in the water before getting to L. Victoria. Table 9 shows the results from atomic absorption spectroscopy for cations of water samples collected from the inlet and the outlets of the Yala Swamp. From the table, it is clear that higher levels of cation concentration were observed in the inlets than in the outlets. The reduced concentrations of cations in the outlets indicate that the wetland had damped the salts levels of the water. Only Mn+ levels were high in the outlets than in the inlet due to the fact that in some cases water absorbs ions from the wetland too. Presence of heavy metals (Zinc, Cupper, and Lead) cations was not identified in Yala's water, perhaps because its catchment is of agricultural nature with minimal industrial activities.

Table 9: Comparison of Cations Levels between the Inlets and Outlets of Yala Swamp

		R. Yala (Inlet)	**R. Ndekwe**	**R. Sidoho**	**R. Mgangu**	**R.Dhogoye**	**R. Ulwani**
Mg	Absorbance	0.305	0.254	0.260	0.151	0.719	0.135
	Conc. (ppm)	11.14	9.72	9.88	6.42	7.37	5.80
Ca	Absorbance	0.143	0.128	0.126	0.099	0.131	0.104
	Conc. (ppm)	5.857	5.175	5.094	3.936	5.366	4.124
Fe	Absorbance	0.127	0.003	0.003	0.004	0.004	0.004
	Conc. (ppm)	4.414	0.134	0.123	0.149	0.154	0.169
Mn	Absorbance	0.001	0.002	0.002	0.001	0.002	0.002
	Conc. (ppm)	0.013	0.023	0.021	0.012	0.028	0.023
K	Absorbance	0.240	0.183	0.193	0.185	0.221	0.101
	Conc. (ppm)	2.091	1.594	1.681	1.610	1.921	0.879

Options in Yala Wetland Management

The swamp covers an area of 17, 500 hectares. The area falls under ecological zones V and VI as described by Platt and Gwyennes, 1977 and agro ecological lower midland (Jaetzold & Schmidt, 1981). Already, 2300 hectares had been reclaimed by developers collaborating with the Kenyan Government for agriculture. The rehabilitated zone was used for grazing. Another zone of 2700 was on wetland grasses and other shallow water vegetation, mostly the sedges. The other mass of the wetland was composed of open water body masses of Lakes Sare, Kanyaboli and Namboyo, and wetland vegetation in varying levels of canopy cover and the depth of water. From the exterior the canopy appear to be homogenous but it is composed of vegetation that can be distinguished into the following: 50 metres occupied by papyrus, this area was adjacent to the dry land and experiences a lot of disturbances from the water level changes, fires and harvesting. 150 metres largely composed wetland grasses, sedges, shrubs and bushes, this area was observed to harbour a number of wildlife, which grazed here. During the dry seasons the locals could get to the part of wetland in search of thatching material (wetland grasses) and the reeds. 250 metres composed of the pure stand of papyrus and climbers: This zone was very rich in bird species which could be observed and heard singing either from the water bodies or from the other vegetation types. With the information on the structure of the wetland, its size and some uses of the wetland and recommended uses it would be possible to approximate the values of various uses option including,

- Preservation of the Wetland. In this case the ecosystem will continue with its ecological functions of filtering the water of rivers flowing to L. Victoria and serve as an interrupted home of all wildlife that abode in it. This managerial option will improve the efficiency of wetland in improving the quality of water flowing in the L. Victoria, hence denying it the nutrients that have sustained the growth of the water hyacinth. The non-fishing in the associated lakes will allow the diminishing fishery resources to blossom and hence enriched biodiversity. High levels of Carbon dioxide will be absorbed from the atmosphere hence reducing the greenhouses gases. The wetland may win a high premium for carbon sequestration, as high carbon levels will be held in the vegetation and humus.

- Agriculture Development. In this, rice farming has been practiced in various places in the country more so in the wetlands including, Bunyala, Ahero and Mwea. Yala flood plains have been receiving silt and nutrients from the Kenyan western highlands with the basic nutrients estimated to be 42 kg Nitrogen, 3 kg Phosphorus and 29 kg Potassium annually per hectare (Smaling, 1993). Mwea Rice Scheme is the most successful rice farming area in Kenya with an area estimated at 18,958 ha. The crop has two seasons annually and yields earn farmers an average of Kshs 225, 600 ha^{-1} yr^{-1}. If productivity and cost of operations are assumed to be that of Yala, then, the entire wetland if put under rice could annually be valued at Kshs 225,600 x

17500 = Kshs 3,948,000,000. This return from rice farming will compromise the existence of any other option use.

- Animal Husbandry. Livestock found here are mostly indigenous cattle that have adapted to the climatic conditions and tsetse flies. The cattle belong to the Small East African Zebu breed and the Nandi sub-breed. The animal's utility has been described by Pratt and Gwyenne, (1977) as for milk, draught, meat and ceremonial purposes. Other important attribute that would aid in economic analysis include the average weight that ranges between 200-415 kg, age at first calving is 43 months, calving interval ranges between 11-14 months, maximum milk production per lactation is 2265 kg. The grass community found here are the highly nutritious, preferred and palatable perennials unlike in the surrounding areas, which are dominated by bushes and ephemeral grasses occurring during the rainy seasons. Although the whole region around the wetland has been referred as an area of poor yielding potential (LM3 and LM4) with forage and pasture allowing stocking rate of a livestock unit (LU) per 2 hectares, grass species of high potential areas (LM 1) with a 0.13 ha/ LU. This improvement of potential is contributed by the wetland. The role of the wetland could be calculated in terms of improved livestock capacity as, in the neighbourhood an LU requires 2 ha, while on the wetland it requires 0.13 ha therefore improved grazing (forage) capacity = (2 - 0.13) ha/0.13ha % = 1438. Thus, the capacity of the wetland is1438% better than the surrounding. A LU of a Nandi sub-breed averages at (200 + 415) kg /2 = 307.5 hence, a unit ha of the surrounding carries 307.5 kg x 0.13 ha = 40 kg but the wetland carries 40 kg x 1438% = 575 kg. While this is the recommended capacity (Jaetzold and Schidts, 1982), a large number of livestock (1820 cattle's, 497 goats and 322 sheep) were found grazing on a wetland area approximated to be about 1400 hectares with conditions on the forage observed to be stable. The area assessed was part of the 2300 ha reclaimed by the LBDA, with the rest being under agriculture or reverting back to papyrus. The forage was of highly nutritious and palatable perennial grasses associated with highlands. The grasses, mainly star grass (59.3%) and Pasparum spp (26%) had high levels of succulence (77.5%) and good ground cover (87%). The forage indicated that the capacity of the wetland was not exceeded or pressured by the grazing. If the livestock counted were to be assumed to be the only grazer during the entire year, then the wetland capacity could be calculated as, LU grazed = (1820 LU + (497 x 30 +332 x 35)/307.5 = 1905 LU. LU per ha = 1905/1400 = 1.36 and, 1.36 x 307.5 = 418.2 kg. The animal capacity at the wetland was1.36 LU (418.2 kg) per ha which was less than its capacity subject to forage of 1.87 LU (575 kg). The value of the wetland if it was entirely left for grazing would be the Total area x 1.87. The survey indicated (Table 3) the value of a cow averaged at Ksh. 8091 Hence (17500 ha x 1.87 cattle ha^{-1}) x Kshs 8091 = Kshs 264,777,975. If we assume that 90 percent of a herd of cattle are cows, and that each cow calves once a year, then 17500 ha x 1.86 cattle x 90 cow/ 100 cattle = 29453 cows. The sub-breed milk production is estimated as 2265 kg per lactation (Pratt and Gwyenne, 1977) with a litre (kg) found selling at Kshs 22.80. Hence every cow's milk is valued at 2265 x 22.80 = 51642. In total milk production is estimated 51642 x 29453 =

1,521,011,826. In total livestock (cattle) grazing in the entire wetland will yield Kshs. 1,785,789,801 per annum.This amount only considers values for milk and returns if the livestock is sold and does not consider utility to cultural issues, self pride and use of animals for draught.

- Papyrus Utilization (Including Handcrafts). One of the strongest candidates for resource use in the wetland by the fact that it considers both the ecological and economic roles of the wetland, are industry-based uses of the available vegetation. Papyrus dominates the wetland vegetation and has a high resilience to harvesting and faster regenerations rate. In a year the papyrus could be harvested 4 times without interfering with their regeneration rate. Harvesting (disturbances) of papyrus vegetation resulted in more tillers and hence more stems per unit area (Table 7). A transect taken across the papyrus vegetation recorded a gradient on its density. From the fringe of the wetland, papyrus plants per square metre were 24 on the first 50 m, 0.3 per the next 150 m and 48 per the last 250 m boundaring the water body. Since the density and proportional areas of various vegetation structure have been established, the number of papyrus could be estimated and hence its value. The area already rehabilitated (2300 ha) can be removed from the calculation, as it was not considered to have papyrus during the survey. Also note that the area with open water will be assumed to be covered with vegetation, area covered with papyrus is 17500 ha – 2300 ha = 15,200 ha. Assuming the proportional area observed during transect is homogenous all round, then, proportional area with papyrus density 24 per m^{-2} (50m/450m) x 15200 ha = 1689 ha. Number of papyrus is 1689 ha x 24m^{-2} x1000x1000 = Papyrus plant = 4.05 x10^{10} . Area with density 0.3 papyrus per m^2 = 150m/450m x 15200 ha = 5067 ha. Number of papyrus = 5067 x 0.3 m^{-2} x (1000m x 1000m) = 1.52 x 10^{9}. Proportional area with papyrus density 48 per m^{-2} (250m/450m x 15200) = 8444 ha. Number of papyrus plant = 8444 ha x 48 m^{-2} x1000m x 1000m = 4.05 x10^{11} In total about 447,368,100,000 papyruses that are harvestable in 3 to 4 months. Then in a year if harvesting is done after 4 months, then the total number of stems harvestable is 1,342,104,300,000. The worth of this enterprise will depend on the returns of every stem of papyrus and from the study a number of uses were found to be associated with plant. The value of the papyrus will depend on its use whether used as an entire stem or made into twines. If used for mats, then from the market survey it was observed that a 9 by 6 feet (with 21-27 papyrus stems per feet) mat retailed at Kshs120. Then a 1 by 9 feet mat is valued at Kshs 20 and hence if an average of 24 stems is assumed to make a foot, then every papyrus will cost Kshs 0.83. Hence, the value of wetland under papyrus vegetation would be Kshs 1,113,946,565,000. If the papyrus is used in production of twines and later handcrafts, then the value of every stem can be derived as follows. Every stem yields between 1 to 3 twines, with a bunch of 150 twines selling at Kshs 40-60. If every stem is assumed to yield 2 twines, then a bunch of 150 twines will require 75 stems. This 75 stems can be assumed to have an average value of Kshs 40-60. Hence every stem is valued at between Kshs 0.53 and 0.8 or an average of Kshs 0.67. If then the entire wetland is under papyrus its value would be Kshs 899,209,881,000. Adoption of better technologies, increased product lines and improving the marketability will increase the worth of using the papyrus and the wetland. For example, in Nairobi a 1 by 1 feet piece of papyrus curtain (wide equal to about 20 papyrus sticks) was retailing at Kshs 70. Hence as papyrus mostly gets to heights above 6 feet, then a papyrus stem is worth Kshs 3.5. Note this will increase the worth of papyrus by at least 322%. It is important to note that the use of the renewable vegetation (papyrus) will assure that there is always habitat for the fauna as it is impossible to have the entire wetland harvested. The most interior vegetation, which provides the habitat for birds, will never be harvested, as it would be easier to utilize the exterior, which will renew itself regularly. This option will also provide grazing pasture on the already rehabilitated hence the livestock cultural significance will be fulfilled. At least 4301, (2300 x 1.87) herds of cattle will be having grazing pasture. The option will allow other cultural, religious and conservation of the wetland practical.

Conclusion

The wetland vegetation plays an important economic role including medicinal, handcraft making and construction. A strategy to improve the economic situation of the locals through strengthening the current utilization wetland resources will also result in conservation. By improving the marketability of the handcrafts, handcrafts product lines and the processing technologies, locals will be assured sustainable returns. The more the locals value the wetland as a sustainable resource the more they will be eager to engage on its conservation. Achieving the economic goal will confirm the conservation goal subject to the degradation and poverty paradigm" As the poor strive to exploit the environment for survivor, they result to more degradation hence reducing its capacity to serve them leading to severe poverty". Successful options in Yala Swamp conservation will entail management strategies that will increase the worth of the resources to the locals and make them proud of it.

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THEME 3

PAYMENT FOR ENVIRONMENTAL SERVICES FOR WATERSHED MANAGEMENT

EQUITABLE PAYMENTS FOR WATERSHED SERVICES (EPWS) PROGRAMME: A PRACTICAL EXPERIENCE OF AN INNOVATIVE APPROACH IN DELIVERING CONSERVATION AND POVERTY REDUCTION IN ULUGURUS, TANZANIA

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ABSTRACT

Payments for Environmental Services (PES) are market-based instruments that arose as a response to remedy market failures associated with environmental services. The basic principle of PES is that those who provide environmental services should be rewarded for doing so (Wunder, 2005). This means that mechanisms are put in place that transfer rewards from those who benefit from an environmental service to those who manage it. PES schemes have the potential to contribute to this long-term effort by motivating and supporting landowners to adopt best land use practices (Branca,*et al.*, 2009). They pool funds from public and private sources to help cover implementation costs and may also provide continuous payments to compensate opportunity costs, if best land use practices don't offset these by increasing productivity. This is possible due to the fact that PES can provide technical support during the adoption phase and help farmers overcome gaps in information and technical capacity. Payment for Environmental Services in the context of watershed protection considers services associated with natural resources and the benefits they provide to the people who manage them. For example, upstream watershed protection services typically benefit downstream stakeholders, including domestic users, bottling and hydro-electric companies (Branca, *et al.*, 2009). In most cases, however, these beneficiaries have not compensated upstream land managers for the provision of the services, and have been "free-riding" (i,.e deriving benefits at someone else's expense). Thus, PES for watershed protection aims at motivating and supporting land managers (who are mostly rural poor communities) to adopt best land use practices such as terraces, agroforestry and riparian restoration.

Tanzania Equitable Payment for Water Services (EPWS) Programme's Overview

Background of EPWS

Payment for Environmental Services was originally conceived as an innovative market-based solution to environmental problems. More recently, environmental and development agencies in the Developing World have started to look at the social impacts of PES – primarily the potential to support poverty reduction, and also the need to avoid negative social impacts that may occur where there are changes in land use (WWF/CARE, 2005, 2007). CARE International in Tanzania and WWF Tanzania Country Office has jointly established and are implementing the "Equitable Payment for Water Services (EPWS)" program in the country as part of broader PES concept. This is a global program being implemented in other countries namely; Kenya, Peru, Guatemala and Indonesia.

The EPWS implementation was designed to roll-out over a 5-year period, divided into two distinct phases. The first phase (2006-2007) consisted of a feasibility study, building a business case for investment through justification of certain "business criteria" and gathering knowledge to structure the new market appropriate to local conditions and equitable outcomes. Thus, a number of studies were conducted between July 2006 and September 2007 as follows: Hydrological Assessment, Preliminary Buyer Profiling, Seller Livelihood Analysis, including capacity assessment, Cost Benefit Analysis and Legal Analysis. Starting early 2008, phase II started supporting implementation on a pilot scale after the feasibility assessment. This second phase drew lessons from the feasibility studies to establish a trial market for watershed services so as to ascertain the viability of PWS as an effective natural resource management tool and its ability under the EPWS framework to deliver sell-side equitable outcomes. Phase III, which will be financed almost totally by the buyers, will then extend the scheme beyond a large pilot to the full scale needed to secure the improvement in water quantity and quality that the buyers are looking for. Figure 1 indicates the framework for the Feasibility Assesment of the EPWS project in Tanzania.

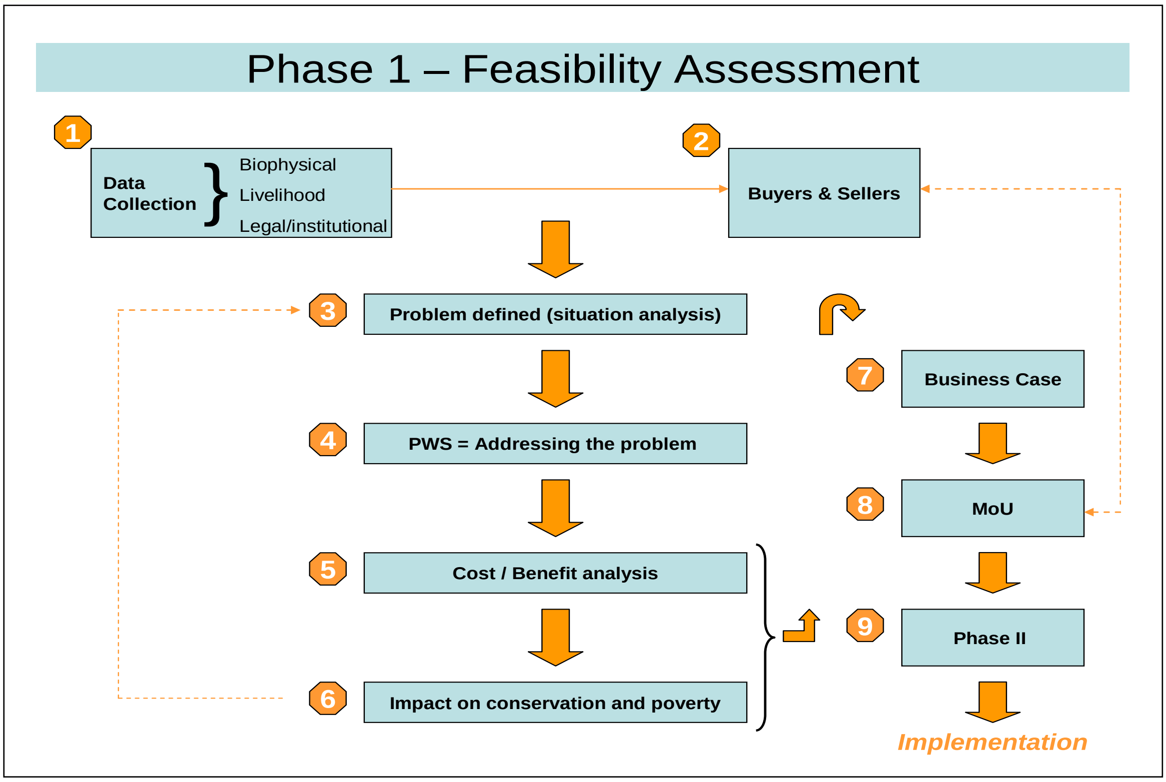

Figure 1: Framework forthe Feasibility Assesment of the EPWS Project in Tanzania

Goal of the EPWS project

The overall goal of EPWS project is to deliver sustainable natural resource management (modifying land use to conserve and improve "watersheds" for reliable flow and quality of water) and improved livelihoods of the rural poor with social justice and equity.

Objectives of the EPWS Project in Tanzania

1. To establish long term financial investment (FI) in modifying land use to conserve and improve "watersheds" for reliable flow and quality of water.
2. To establish a compensation mechanism that recognizes the needs and priorities of the marginalized and poor people to improve their quality of life, hence contributing to poverty reduction.

The Project Approach

- Works with the upstream and downstream stakeholders to create a win-win scenario where both the upland communities who are the stewards of the catchment areas and downstream water users benefit.
- Ensures that resources are applied to the priorities and needs of the poor and that local values, knowledge and practices are incorporated into natural resources management practices, as well

as ensure that women and marginalized groups directly participate in, and benefit from the payment for watershed services mechanism.

- Engages a wide range of national partners including local NGOs, private sector, government agencies and institutionsin implementation of the project.

Expected Outputs

- Land use changes are implemented in the project villages.
- Financial sustainability of the programme for long term provision and acquisition of watershed services.
- Institutional sustainability of the Programme (governance).
- Ownership of the Programme by local stakeholders to assure sustainability.
- Impact of intervention is measured downstream.
- Learning mechanisms are in place.

Geographical Location and Population of the Project Area

The programme site is in the Uluguru Mountains located at about 200km west of Dar es Salaam at an altitude range of 780 m. to 2,638 m above sea level. It is part of the Eastern Arc Mountain Forests Eco-region with a population of approximately 150,000 inhabitants, concentrated in 51 villages with agriculture as their main subsistence activity. The Uluguru Mountains are also part of the ten most important tropical forest sites for conservation in Africa. They are key elements of the Eastern Arc Range, whose natural forests are recognized as part of the 25 richest and most threatened reservoirs of plant and animal life on Earth. Within the Uluguru Mountains, the programme is being implemented in Kibungo sub-catchment within Kibungo Juu Ward which is located about 85km South-East of Morogoro town (the district administrative centre) in the villages of Lukenge, Kibungo, Lanzi, Dimilo and Nyingwa villages (Fig.2 &3).

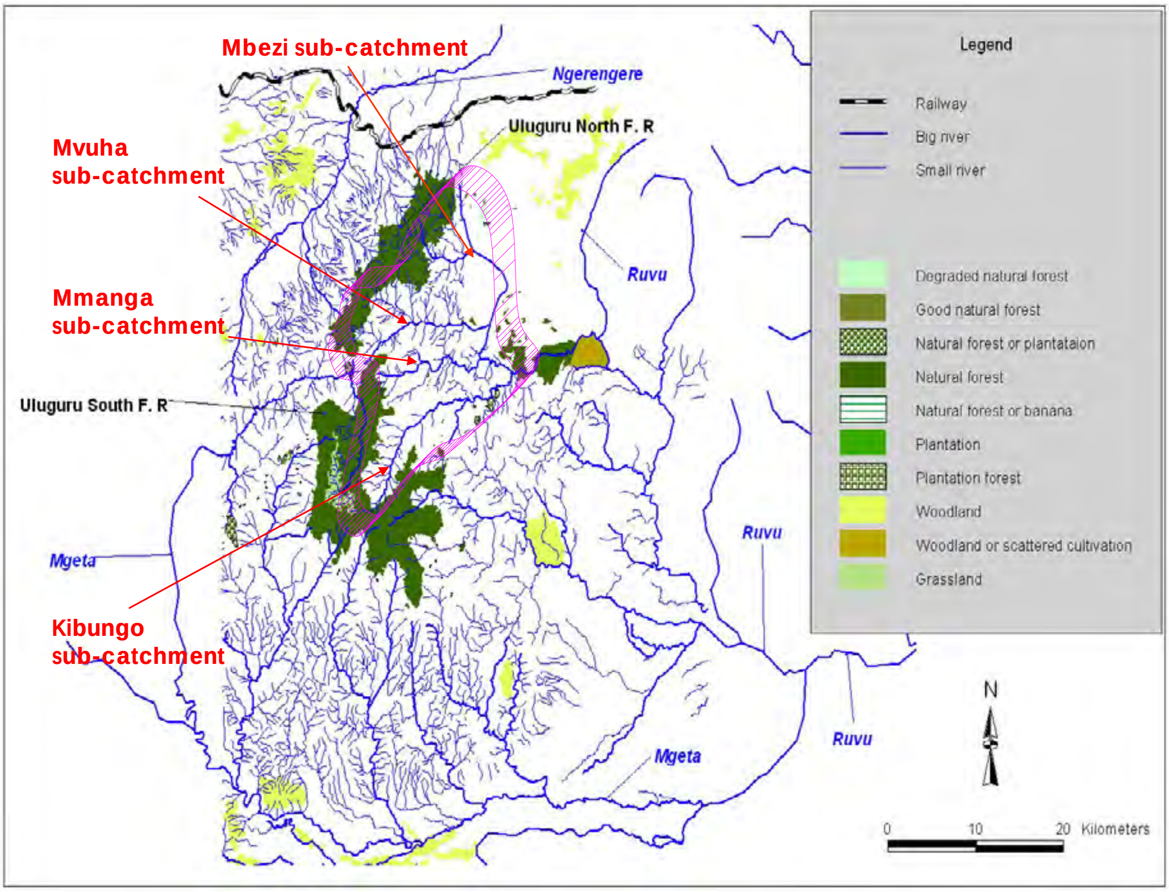

Figure 2: Location of Kibungo Catchment

The Uluguru mountain forests are specifically important because of having catchments which drain water downstream to the Indian Ocean. They receive an average rainfall of 2,000mm/year which is high enough to feed the many small rivers and streams that consequently join together to form the main Ruvu River that covers an area of 17,700km^2 and flows east into the Indian Ocean. The river is major source of water that supplies over 4 million people for domestic purposes, as well as to agricultural and industrial users in Dar es Salaam and other towns. The upland communities depend on the water for domestic and agricultural purposes. However, due to various human activities including subsistence farming (CARE/WWF, 2007), there is mismanagement and destruction of watersheds; hence, the uses of water from the upstream areas are not sustainable. This brought the necessity of implementing the EPWS program in Uluguru so that those incidences can be stopped, while at the same time improving livelihoods of the local poor communities living in the mountains.

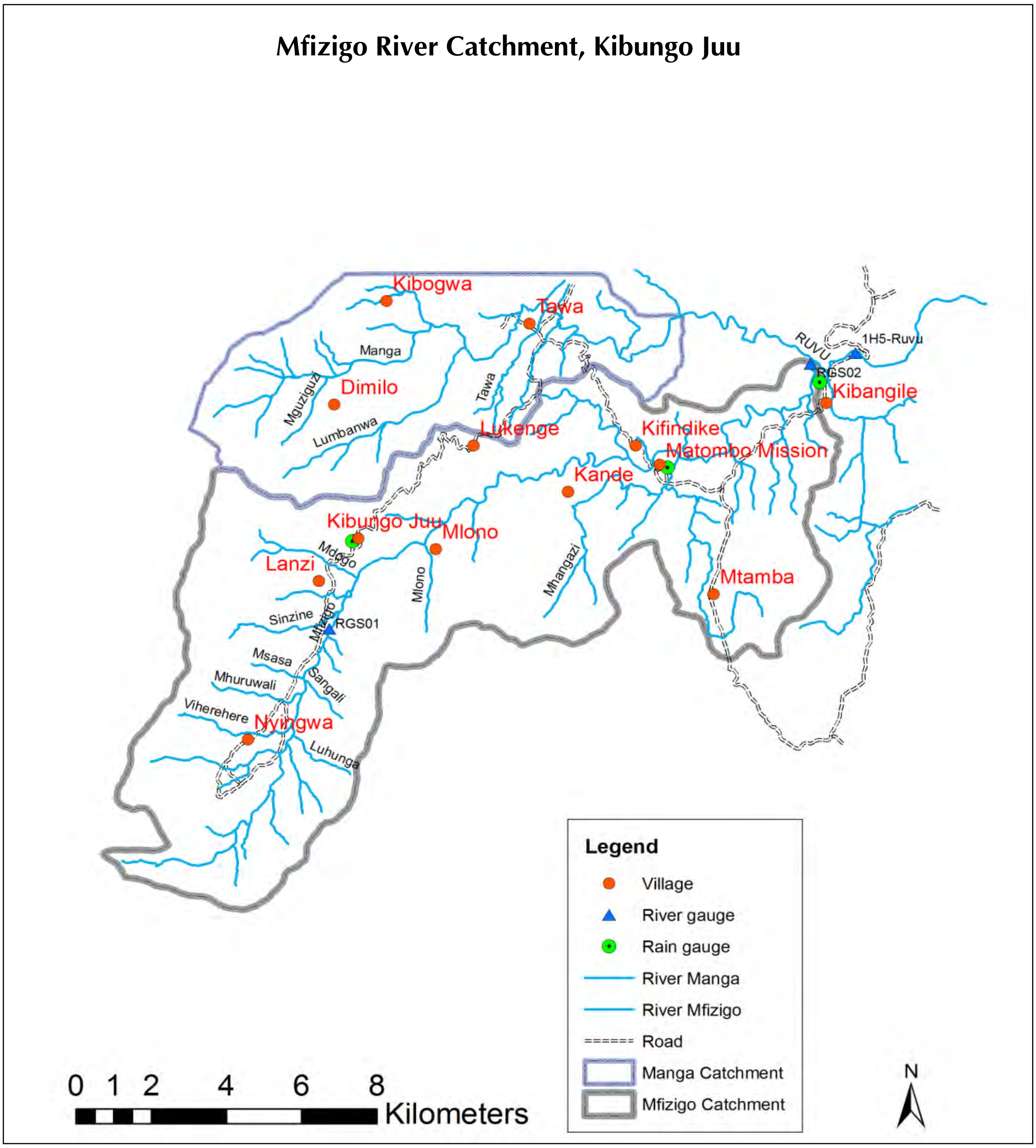

Figure 3: Location of Villages in Kibungo Juu ward, Kibungo Catchement

Programme Implementation Phase

Main Land Use Practices to Solve the Problems

As stated earlier, the EPWS programme is being implemented for improving water quality and livelihoods of communities living in the watershed. It was thought that this could be achieved through successful implementation of land use interventions that would ensure control of hydrological quality and improve productivity in Kibungo Juu, hence improving livelihoods. Poor agricultural producers in Kibungo Juu rural areas are the main suppliers of Uluguru watershed services. The farmers are engaged in improving the land use practices to improve water quality downstream, hence facilitating reduction in cost of treatments of water users. The main land use practices as key solutions and/or measures to restore watershed services were agro-forestry, reforestation, bench terraces, fanya Juu/chini, grass strip planting and contour planting of crops. Riparian zone management aimed at reducing run-off and soil erosion was also emphasized.

Capacity Building and Training Programmes

The project initiated and is running an ongoing capacity building and training programme aimed at extending practical skills of local farmers in application of appropriate soil and water conservation (land use) and agronomic practices. The areas of training include:

- Excavation and uses of fanya Juu and bench terraces technologies.
- Tree nursery establishment and management
- Tree planting methods and field management
- Grass strip farming techniques

Project Achievements Todate

Training in Land Use Practices

A total of 446 males and 244 females have been trained in proper landuse practices. Table 1 shows the technologies and number of farmers trained by gender**.**

Table 1: Farmers Who Received Training towards Improvement of their Land Use Practices between July 2009 and June 2010

Technology	Male	Female	Total
Grass strip, fanya juu and bench terraces	184	81	265
Tree nursery establishment and management	20	15	35
Tree planting methods and field management	242	148	390
Total	**446**	**244**	**690**

Source*:* Field data 2010.

Study Tours

To strengthen learning, various study tours are being organised and conducted to enable local farmers learn practically from other experienced farmers and areas within and outside the country. From 25th through 29th October 2010, Kibungo Juu farmers had an exchange visit to Kenya to learn from Naivasha catchment about EPWS implementation. The farmers also visited Machakos as the famous area for fanya Juu/chini in east Africa.

Establishment of Demonstration Plots

Demonstration plots for Fanya Juu and Bench terraces were established in every project operating village and were excavated by farmers themselves. In addition, each village was supported with all necessary equipments for accomplishing farm activities. These include: hand hoes, *sururu*, pangas, and spirit levels, calculators, grinding stones *(tupa)*, axes, animal manure and high value crops seeds.

Plate 1: Demonstration Site for Fanyajuu Distribution of Tree Seedlings for Nursery Establishment

About 170,000 seedlings of *Grevillea robusta* and *Khaya anthotheca* were planted between April 2009 and June 2010, and survival rate was established to be 85%. Currently, over 105,000 poly bags have been filled and sown with *Grevillea robusta* and *Faidherbia albida.*

Agronomic Practices

All farmers engaged in implementation of the programme are applying appropriate agronomic practices to ensure high yield. The farmers have been trained in farm ploughing, intercropping especially maize, beans and groundnuts, agro-forestry (intercropping bananas and trees), selection and application of improved crop seeds, application of manure and production of specilised high value crops such as beans, bananas, tomatoes and cabbages.

Livelihood Improvement

So far, the project has reached approximately 550 farmers, out of whom 32% are women farmers. Overall, 45% of the target for the project work has already been covered through activities established just a year back. Productivity has increased quite significantly for participating farmers for the first year of intervention.

Hydrological Monitoring

Fixing of hydro-meteorological equipments is already done. Data collection for rainfall, temperature, water level, and flow volume has started, while data analysis for water quality is underway at Sokoine University of Agriculture (SUA) laboratory.

Plate 2: Hydro-meteorological equipment fixed for hydrological monitoring

Payments to Participating Farmers and Institutions

In 2009, a total of 137 farmers from 4 villages and 3 institutions received payments for participating in the scheme (Table 3).

Table 3: Number of Farmers Motivated to Participate in Project Activities 2009

Village	Male	Female	Institution	Total
Kibungo	30	20	1	51
Dimilo	11	7	-	18
Nyingwa	15	6	1	22
Lanzi	25	20	1	46
Total	84	53	3	137

Source: CARE/WWF data base, May 2010.

Payment Arrangements and Modalities

Farmers/Sellers

The payments are provided to individual farmers based on the land size and the land use technologies applied. The prices for the technologies are determined by labour inputs and opportunity costs (for loss of production). Table 2 presents labour and opportunity costs based on to determine the compensation amounts.

Table 2: Labour and Opportunity Costs of Implementing Respective Improved Land Use Practices in the Kibungo Sub-Catchment

Technology	Land Removed from Productive Use in the First Year	First year Opportunity Cost (TSH/ha)	Labour Days/ha	First Year Labour cost (TSH/ha)	Total Cost (TSH/ha)	Total Cost (TSH/ acre)
Bench terraces	100%	160,000	140.0	210,000	370,000	149,798
Fanya Juu	20%	32,000	103.7	155,610	187,610	75,955
Reforestation	100%	160,000	50.0	75,000	235,000	95,142
Pineapple contour farming	14%	22,400	12.0	18,000	40,400	16,356
Agroforestry	17%	27,200	9.0	13,500	40,700	16,478
Grass stripping	17%	27,200	9.0	13,500	40,700	16,478
Riparian restoration	100%	160,000	8.0	12,000	172,000	69,636

Source: CARE/WWF, 2008

Fund Managers/Facilitators

For facilitation of the payments to farmers, CARE and WWF provide the linkages and transfer of money. The buyers (DAWASCO) disburse money to CARE Tanzania which then transfers the money to respective programme village councils to distribute to individual farmers who have registered to implement the improved land use practices. The Village Council is an autonomous local authority that consists of village chairpersons, village executive officers and village council members totalling to 25 leaders. The village councils are paid a certain amount of money for their role in facilitating and supervising the programme initiatives. The payment is based on the amount of land converted with the improved land use practices/interventions. CARE ensures fairness in payments to farmers by involving them in taking GPS measurements, GIS applications and designing the data collection tool for verifying land sizes and land use technologies applied.

Payments Provisioning by Buyers

The project has so far received payments totalling to USD $5,060 from the private sector (DAWASCO) that consolidates the principle of the EPWS. Figure 4 shows the flow of money from the buyer to the individual famers/sellers. First bunch of farmers received the first compensation through private sector engagement.

Project Sustainability and Replication

In implementing this programme, many actors and stakeholders are involved in various ways which ensures sustainablity of the programme. They include the communities in programme villages in Kibungo Juu Ward, the major users of water in Dar es Salaam notably DAWASCO and Coca Cola Kwanza Limited, and Uluguru Mountain Agricultural Development Project (UMADEP) under SUA. Other stakeholders are Uluguru Nature Reserve Office in Morogoro and Wami-Ruvu Basin Water Office in Morogoro. Formation of farmers' network to own and continue advocating for implementing the EPWS initiatives in Uluguru Mountains will also involve them in scaling up and replicating the EPWS scheme beyond the current programme villages. Also, linking farmers to profitable markets to ensure continuous investment and implementation of soil and water conservation measures through production of high value crops is a strategy towards the sustainability of the EPWS program.

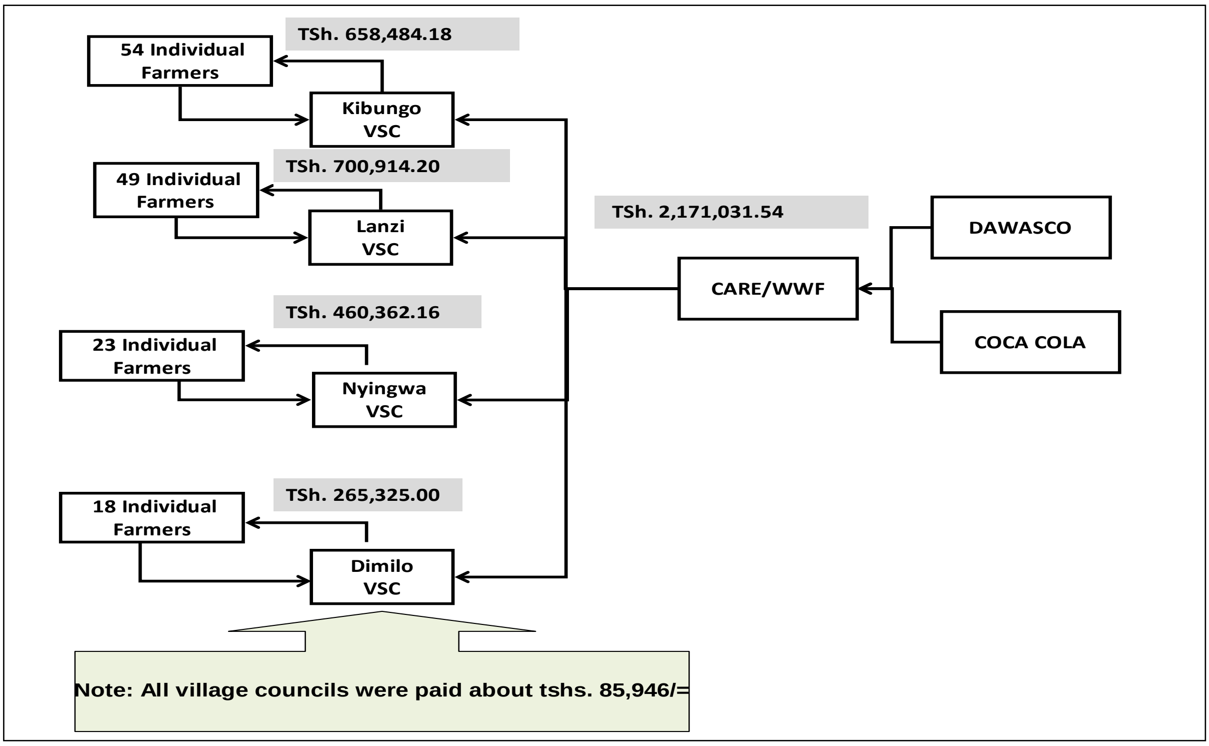

Figure 4: Payment Flow from the Buyer (DAWASCO) to Individual Farmers who Implemented the Land Use Interventions by December 2009 in May 2010 (Source: Drawn in May 2010).

Building capacities of local farmers on EPWS initiatives, especially soil and water conservation measures and establishment of para-proffessionals as trained local extension contact persons is key, so as to enhance extension services among farmers. Also key is the formation and operationalisation of an Intermediary Group (IG) which is composed of members from local communities (sellers), buyers, government agencies as well as CSOs to own the initiative The IG will take the lead where the role of CARE and WWF in facilitating the implementation of the project comes to an end and will also seek to scale-up the initiative across Uluguru Mountains. The effort to bring more buyers on board will ensure flow of resources to the upland farmers. So far contact to Tanzania Breweries Ltd has been established.

Lessons Learnt

In the course of implementing this EPWS programme, it appears that the programme has the potential to contribute to this long-term effort by motivating and supporting local farmers to adopt and use improved/best land use practices. This is through getting continuous payments to compensate opportunity costs and increasing farm productivity. Insofar as EPWS programme provides incentives for improved resource management by individuals and communities, there is emerging interest by various local farmers, local and/or central government authorities, groups of people, civil society organisations and research institutions to engage in the EPWS initiatives. This has indicated signs of sustainability of the initiatives being implemented at Kibungo Juu sub-catchment.

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ASSESSING THE ECONOMIC VALUE OF FOREST: IS IT A PREREQUISITE FOR PAYMENT FOR THE ENVIRONMENTAL FUNCTIONS IN MT. ELGON?

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ABSTRACT

Implementation of Payment for Eenvironmental Services (PES) in East and Central Africa has been slow because of lack of markets, proper pricing and market enforcement mechanisms for forest services. While the scarcity of forest products triggers a market response leading to increase in prices and development of substitutes, scarcity of forest services is less market responsive. The provision of the environmental services often falls within the domain of the poor, the vulnerable and the powerless at landscapes adjacent to the forests. This study assesses the factors that influence the value of forests for watershed management and adoption of PES. The Contingent Valuation Method (CVM) was used to assess the value of the forest for watershed management by asking respondents to vote to support the protection of the forest at the stated price or cost. The binary logit model was used to analyze the respondents 'yes' and 'no' responses. The significant factors influencing the value of forest for watershed management include education, income level and sex of the household head, household farm size, whether households practice irrigated and/or commercial agriculture, social status and training on environmental conservation. The aggregate value of willingness to pay ranged from Ksh 0 to 1500 (US$ 18.8).

Introduction

Natural forests perform many ecological and non-ecological functions. While timber values are well known and generally drive decisions concerning the use of forests, the other functions such as the watershed services, including hydrological regulation in the form of low-flow augmentation, flood control and groundwater recharge, water quality enhancement, and soil conservation are very important, though generally under-appreciated. There is a general concern that these forest services are becoming increasingly scarce (Panayotou & Ashton, 1992). The scarcity of the environmental service from forest is manifested in the climate change phenomenon, the increasing incidences of floods downstream, and the shrinking species diversity. While scarcity of marketed forest products triggers a market response leading to increase in prices and development of substitutes, forest services do not respond to levels of scarcity because most of these functions have no market, at least in the developing economies, and if the market exists, it is in the domain of the poor, the vulnerable and the economically powerless members of the local communities. In the recent years, however, tropical forests have received global attention because they are major repositories of biodiversity (Mertz *et al*., 2007), leading to interest in identifying win-win situations or trade-offs between biodiversity and watershed services (Wendland *et al.,* 2009). The consequences of the reduction in the forestservices are costly and sometimes irreversible.

Conserving forests for provision of watershed services requires that the economic value of such functions is demonstrated and a mechanism for attributing the values to the owners of the natural resource is provided. The extent to which studies on valuation of non-market services have been successful is subject to debate, the validity of such values depends on the methodology and how far these estimates represent the local values. This therefore means that non-market values depend on the geographical area in which the resource is found and the people's values that touch on ethical and moral values. The value of forest for watershed management must be captured, converted into a real resource flow which must accrue to those who forego using the forest in order to allow it perform the watershed function. Comparison of the economic values of forests for various uses in order to justify their conservation and that of the biological resources that thrive therein is not tenable when benefits of conservation have no marketable dimensions. Valuing ecosystem services is controversial because of the potential importance of such values in influencing public opinions and policy decisions (Costanza *et al*., 1998). Because most forest ecosystems such as Mt. Elgon are owned by government or government institutions, the services provided assume the public good nature and require a clear definition and enforcement of property rights. Lack of markets for externalities favours exploitative land use where timber purports to be the highest value for forest products. However, recently the national and international schemes involving payments for ecosystem services (PES) have taken off in several countries where the value of the watershed services of forests is given as the main rationale (Pagiola, 2008; Southgate & Wunderm, 2009) for forest conservation.

Conceptualizing Watershed Functions of the Forests

The forests' watershed function is particularly important for communities in sub-Saharan Africa because in these regions, rainfall is highly seasonal and locally limited; and agricultural production is dependent on the rainfall, and agrarian landscapes downstream are directly affected by soil-hydrological processes in the upstream forested areas (Bonell & Bruijnzeel, 2004; Krishnaswamy, 2006). The conventional wisdom, *viz.*, that more and denser forest of any kind at any location generates greater watershed services than any other land cover for all downstream communities presents an oversimplification of the importance of the forest structure in influencing watershed functions of the forest (Lelea, 2009). The forest structure is manifested in the different layers of the forest, namely, the intact natural forest of trees with huge canopies and dense undergrowth; the logged forest with scattered trees; the timber plantations planted with exotic tree varieties; slightly forested areas with pasture; and the household forest stands, thickets and agro-forestry arrangements. The structure provides synergism in the provision of watershed functions. The forest structural arrangements also influence erosion rates, sediment load, water chemistry, water flow levels, water temperatures and groundwater recharge. In economic sense, the forest function is directly linked to the cost of water purification associated with influence in the chemical and sediment composition of raw water, increased fertilization/erosion of floodplain lands, siltation of downstream water reservoirs and the resultant reduction in water quantity stored and flood control. Negative impacts of forest degradation can be decomposed to assess cost implications to different stakeholders in the forest flood plain. The value of the changes in forest structure should in this regard be aggregated to understand the distribution of impacts across space and time, and compute the net change in economic welfare (Dixon, 1997).

Changes in forest structure present different cost regimes and human impacts that provide important clues to valuation of the forest for watershed management. These impacts may be positive or negative; for example, the conversions of natural forest to pine plantations consistently shows reduced flows (Vincent *et al.*, 1995; Nunez *et al.*, 2006), whereas conversion of forest land into a pasture land could greatly reduce sedimentation impacts (Aylward, 1998). The impact of changes in forest structure also depends on the agricultural regimes downstream, as well as whether it is rain-fed or irrigation. For instance, deforestation is expected to cause reductions in agricultural incomes among rural farmers because of reduced base flow to their rain-fed agriculture (Barkmann, 2008). In some instances, however, afforestation may reduce agricultural incomes because agriculture depends on surface runoff filling downstream tanks (Lele *et al.*, 2008).

In performing each of the functions outlined above, the forest is influenced by factors such as presence of floodplain agriculture or dams and water purification plants downstream. Thus, the change in a process variable such as increase in soil erosion may have positive or negative human impacts. Using the utilitarian approach, the functions or processes generate services only if there are humans that benefit from them; if stream flow changes but communities downstream do not in any way use stream flow, there is no change in ecosystem service (Fisher *et al.*, 2009). The land-cover type is meaningful only in terms of their effect on the magnitude of watershed services provided by the forest while the *in situ* soil fertility in the forest should be ignored because it cannot be measured because forest soils do not generate agricultural produce (Chomitz & Kumari, 1998). The watershed functions in influencing water flow rates can also be considered if they are technically or potentially feasible among the communities in the area, for example, if the communities are able to draw the water from the streams.

Methods for Valuing Forests Watershed Functions

An appropriate methodology for valuation should take into consideration the structural changes, the impact on the ecosystem services and potential and actual impacts to the human population. Attempts to calculate the value of the hydrological service from a hectare of forest may be meaningless since the influence per ha of forest size in watershed management is largely compromised, while large trucks of forest land is more efficient. The methodology should demonstrate a clear link between forest cover-watershed processes and the socio-economic impact to the communities surrounding the forest. A serious methodological flaw is to equate process with service and to estimate absolute economic value rather than differences with respect to specific alternative land-use scenarios (Lelea, 2009).

Several watershed models have been used by economists to value watershed functions of forests. While several methods can be used to capture “use values” such as the market price of timber, a few can estimate the “non-use values” associated with an ecosystem. To place a value on ecosystem services, a stated preference or contingent valuation (CV) survey instrument was designed. Contingent valuation is a standardized and widely used survey method for estimating willingness to pay (WTP) or willingness to accept compensation (WTA) for use, existence, and bequest values for resources (Loomis, 1996). CVM produces estimates reliable enough to be the starting point for a judicial or administrative determination of natural resources values (Arrow *et al.*, 1993) and could, therefore, reveal what a person would accept to be paid to allow the forest perform the watershed management function. For example, destructive floods occur almost annually in many parts of the watershed areas of Mt. Elgon. We can make a rough calculation of the contribution of the catchment’s natural vegetation in limiting floods by calculating how much water is held by the forest sponge at times of flooding that could have been added to the flood water downstream. The volume of water held in the sponge can be translated to equivalent extra area of land that would have been flooded to a given mean depth and the associated economic or welfare loss; for instance, loss in agricultural output or habitats. Using the logistic model (Green, 1997), this paper statistically analyzes respondent’s response to the WTP or WTA specific amounts for the watershed functions.

By using a comprehensive value, rather than breaking the values among the various environmental services, the possibility of double counting and the summation problem common in CVM projects is avoided (Hoehn & Randall, 1989) . The current conditions of a watershed and the envisaged situation are explained to respondents in order to compare baseline conditions to improved or degraded conditions in the watershed. Willingness to pay questions regarding purchasing of increased ecosystem services such as volume of water in the river, dilution of waste water, natural purification of water, erosion control, habitat for fish and wildlife, flood control and recreation can be estimated through administration of questionnaires to participants. The management actions necessary to increase the level of watershed services can be developed that involve a form of buffer strips to eliminate interference with water catchment areas and to increase the volume of water flow that can be valued. The problem with the CVM, however, is that it is dependent on the identification of the forest function from which surrogate markets can be constructed. It also does not allow interactions because this would pose a complex scenario to the respondents.

Study Area and Data Sources

Mount Elgon District is situated in the Western Province of Kenya. It borders Uganda to the west, Bungoma to the south, and Trans Nzoia to the east. The district comprises of four divisions, namely Kopsiro, Kaptama, Kapsokwony and Cheptais. The district has four livelihood zones, notably, mixed farming-high potential, mixed farming, formal employment and forest. The district is an agriculturally high potential area and receives a well distributed reliable amount of rainfall of between 1200 mm and 1800 mm per annum. Opportunity for crop production is quite good due to the fertile soils. The district has potential to produce a food surplus in excess of 350,000 bags (31,500 TN) of maize annually, and typically large amounts of food are sold to the neighbouring districts, as well as the rest of Western and Nyanza Provinces. Unfortunately, the district has been affected by land clashes since November 2006. The worst effects of these clashes were experienced from July 2007 to March 2008 forcing farm families (about 35,000 persons), especially those from Kopsiro, to relocate to other areas of the district and into neighbouring districts and across borders. For instance, Emia location in Kopsiro was virtually deserted during the early months of 2008. The severity of the conflict made it impossible to carry out farming activities in the mixed farming high potential locations of Kopsiro Division. The mixed farming division of Cheptais was also adversely affected. As a result, the district had to uncharacteristically receive relief food supplies for the first time ever. The situation has, however, improved after intervention by the Kenya Army, and hence some people are resettling back in Kopsiro and Cheptais Divisions. The main challenge is lack of food, shelter, farm inputs and start up resources to rebuild their lives. This is because the majority of farmers lost their entire household items and farm implements, and livelihood assets during the clashes. The residents derive most of their basic income from subsistence farming. The major crops grown are maize and beans, mostly for home consumption, but the surplus is sold. The community depends highly on the neighbouring Mt Elgon Forest for fuelwood, timber, medicinal herbs, posts and poles for construction, and for grazing livestock. An area of the forest has also been set aside for dislocated people to cultivate, although they have to pay some duty to the Kenya Forest Service (former Forest Department) on yearly basis for this service. Since their land sizes are small, this service has improved yields of the rural farmers tremendously. The sampling for this study was done using multi-stage approach to select sample sites and a systematic sampling procedure to select sampling units, mainly rural households. A total of 97 households were selected (47 from Kwanza district and 50 from Mt. Elgon).

Results and Discussion

Socio-Economic Characteristics of the Sample Population

Most households (67%) are headed by women with an average family size of about 5 persons (Table 1). About 80% of the respondents have primary school education (less than 8 years in school). The households in Mt. Elgon are small-scale farmers, practicing mostly rain-fed agriculture. The dominant crop planted is maize, while beans, tomatoes and potatoes are grown during the off-season farming. The area receives a bi-modal rainfall pattern with the peaks in March-April and September-October. The main source of households' income is farming and sale of off-season farm produce of tomatoes and beans. The off-farm sources of income are limited to trading and sale of household labour, while the households' main source of income is more confined to the sale of agricultural produce. Because the production is done during the dry periods, the quantity of water supplies is critical to the survival of households in the area. The average farms under tomatoes are 0.3 acres. Water storage structures are limited at the household level and thus water is collected directly from the river and used in watering crops. The demand for water often exceeds the supply in the tributaries, and household and farming groups then have to agree on water use schedules.

Table 1: Summary Characteristics of the Households in the Area

Household characteristic	**Mean**
Age of the household head (years)	44.2
Percentage households headed by females	47.0
Educational level of household head	2.6
Average farm size (ha)	2.4
Percentage of land under crops	26.8
Percent of farmers with irrigation	27.1
Percent of farmers with horticultural crops	67.4
Percent of respondent concerned with water quantity	87.3

Households consider water to be adequate in terms of quality parameters of temperature and taste. However, the quality of water decreased as the distance from the catchment area increased. This shows that the household activities along the river channel influenced water quality. Survey data show that about 17% of the households cultivate on the edges of the river banks making the soil vulnerable to erosion and thus increasing the sediment load in the river. The most common water treatment in the area was settling of the sediments. There was a general concern about water quantity in the area. The water quantity was directly related to the water quality parameters of turbidity and taste. It is imperative that when flow rates are low, it may not be enough to dilute natural and treated anthropogenic waste products and to maintain levels of turbulence sufficient to promote water aeration. Because forest soils filter contaminants and reduce soil erosion and sedimentation in rivers, the role of forest in filtering contaminants was not significant because there were no upstream activities in the mountain. The most important function of the catchment areas was to ensure continuous water flows and flood mitigation. The GIS maps show that in the last two decades, agricultural land increased mainly through excision of forested areas by illegal settlers (Ben Mwasi, pers. comm, July 2010). Runoff from farms in headwater catchments discharges directly into streams, and occasionally farmers experience flooding. Often farmers experience increased run-offs through their farms, with others wondering why rivers left their course to flow in farms (Table 2), as water quality deteriorate with the distance from the ecosystem. The result was increased soil erosion and sedimentation in the rivers.

Table 2: The Influence of Distance from the Catchment Area on Water Quality

Distance of households from the catchment	**Perception about water quality**[a]
Within 5km	1.2
10-15km	2.4
Over 15km	2.7

[a]1=very good (Does not require treatment), 2=fair (usable without treatment), 3=bad (may require some treatment) 4=very bad (nearly unusable)

Conversion of large areas of headwater catchments to agriculture and erosion exacerbated by poor soil conservation practices are believed to explain the increase in sediment load observed in rivers downstream such as Lwakhaha, Kiptogot and Nzoia. These changes have also led to reduced dry-season base flows. When the community was asked to rank water flow over the years (4=more than adequate; 3=slightly adequate; 2=Just enough; 1=inadequate), their ranking showed sharp reduction in water flows from rivers originating from Mt. Elgon, a reduction estimated to be about 50% in the last 30 years (Figure 1).

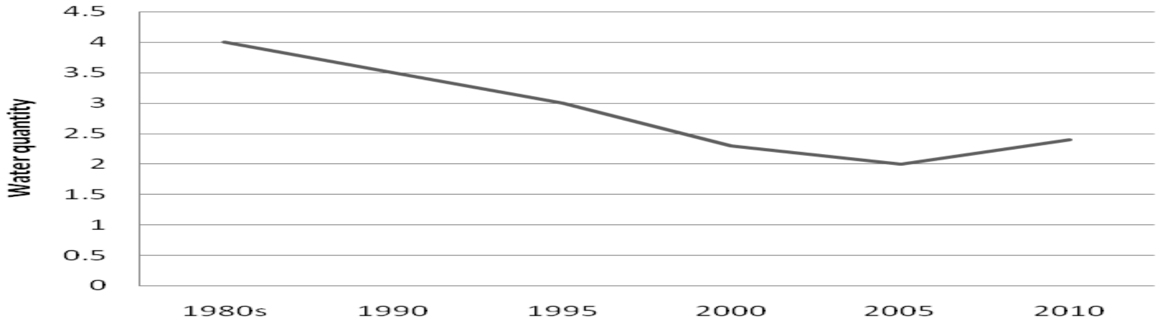

Figure 1: Perception of the Respondents on Changes in River Water Flows overtime

Factors Affecting Willingness to Pay for Watershed Protection

Results of the CV study show that the willingness to pay for watershed functions ranged from Ksh. 0 -500. Important water parameters that the households were concerned with were the water turbidity and quantity. The water shortages were estimated at 12% by the households for domestic use and 30% for agricultural producers. Water shortage was rated the most worrying trend of in the area. Expansion of water use was about 14% in the last three years, with agriculture being responsible for the increase in water demand. The WTP corresponded to the value of activities households carried out using the water, highest values of WTP were quoted by horticultural crop farmers. The purpose for using water influenced WTP amount quoted by households, those with agricultural interests and whose incomes solely depended on agriculture quoted higher values. Household characteristics such as education, income, labour, skills, and technical capacity were central to implementing PES schemes (Table 3). Availability of technical support from institutions was shown to be crucial, as households with minimum levels of education and fewer contacts with extension staff were experiencing difficulty adapting to a new land-use system.

Table 3: The Results of Logistic Regression Model

Variable	**Coefficient factors influencing WTP for watershed management**	**Coefficient factors influencing adoption of watershed management structures**
Intercept	36	-
Level of education household head	0.7*	0.6*
Household cash income	0.1	0.4*
Labour availability	0.3	0.7
Household land size	0.5	0.4*
Irrigates agriculture (yes =1, no=0)	0.03*	0.1*
Type of farmer (commercial=1, subsistence=0)	0.02*	-
Farm income	-	0.02*
Training on conservation	0.4	0.7
Distance from the river	-0.07*	-
Member of social group	0.01*	-
Sex (male =1, female =0)	0.01*	-

* Significant p<0.1- variable not included in estimation

Availability of family labour was a key factor in the participation of households in land-use modification and technology adoption decisions. Family labour and education level positively associated with willingness to adopt PES schemes however, the larger the farm lands under irrigation the greater the chance was of households participating in PES. Commercial agriculturalists were not likely to adopt watershed management activities, as, small landholders may not be able to allocate land for PES without jeopardizing their production. The absence of a strong community-based organization results in weak social networks and lack of community capacity to pool resources for conservation or providing pressure for watershed protection. This is due to the fact that the decision-making procedure is usually complex among farmer associations who seem to prefer that decisions are made by a third party, and they are led on how to access resources. Decision making is more complicated and costly with increasing group size since the required time and effort appear to be rapidly increasing functions of the size of the group. This is particularly the case of water access among the farmers in Cheptais area. Profitability of adoption or modification of existing land uses emerged as an important concern for the poor and smallholders. Acceptability of PES schemes could be low if payments were not sufficient to meet costs associated with socially and environmentally acceptable land-use practices (Pagiola, 2002). This could happen as a result of a mismatch between the net value of the current payment and net costs for adopting the new technology (*e.g.*, land-use practices) and forgone income from existing land uses. PES schemes must be able to meet the opportunity costs of land if sustainability conditions are to be satisfied. Adequate socio-economic incentives for local people help shift farmers' behaviour towards more environmentally friendly activities, even though this sort of land use provides little benefit in the short run. The work of institutions initiating PES schemes will be concerned with identifying and implementing necessary incentives for the adoption on PES.

There is need to consider the gender dimension in assessing the impacts of adoption of the PES schemes. Most women are concerned with the needs that are used on daily basis by the households. It is important to identify households' needs so as to determine what is acceptable in the short run and what is acceptable upon implementation of incentives. For example,a requirement for households to remove livestock from grazing in the forest may be received with a lot of resistance in the short run. Similarly, shifting farming from the catchment and river banks is likely to receive resistance, although in both cases, the measures could be beneficial in the long term. Support for PES should include credit service and technical advice for enhancing efforts for provisioning of environmental services. Most land-use modifications in PES require upfront investments which could be a barrier for participation. Moreover, it became clear that debt burdens may force households to harvest plantation forests, which could undermine the optimal level of watershed services. Micro-credit facilities for potential farmers may encourage the adoption of PES in such situations.

The Role of Intermediary Organizations

There is an important role for NGOs and community-based organizations in creating awareness about PES schemes in the region. Studies have shown that awareness of environmental services and even willingness to pay for environmental services rose through the concerted efforts of environmental NGOs (Leimona & Lee, 2008). Other than creating awareness, NGOs can assist communities in crafting rules and regulations at the local level. The community seems to lack the capacity or the willingness to be involved in starting PES schemes. This is attributed to the fact that water management has long been considered a natures' service. When the community was asked to state why the water was flowing, 86% responded as being provided by nature, 45% thought water could always flow from the mountain and the rest (55%) believed that water supply was strongly threatened. The survey data show that in the study area, the government (represented by Area Chief) held only one meeting in the past year on environmental education, while NGOs and community-based organizations (CBOs) held 67 meetings on environment related issues. The key messages by NGOs/CBOs were resource mobilization (18%), community mobilization (34.6%), environmental conservation (23.7%) and community welfare (23.7%). The community identified impediments to development of contracts included, concerns on whether the contracting entity would honour the contract arrangement (45.6%) and, only 4.1% of the households said they would accept contracts unconditionally (Table 4).

Table 4: Community Concerns about Formation of Contracts

Concern	Percentage of households
Contracts may not be honoured	45.6
Long period of time	12.6
Prefer non-contract arrangement	14.2
Difficulty in negotiation	8.6
May not be profitable	14.9
No concern	4.1

Availability of households who accept to adopt contracts provides an opportunity for an entry point for PES. Just like technology adoption in agricultural development, there are phases in adopting technology, starting with early adopters, then a phase where most of the community members will adopt, then the laggards (Feder, 1986) following a sigmoid adoption curve. It is imperative that NGOs will play an important role in community mobilization, organization build up, data collection, conflict resolution, and execution of environmental activities compatible with the PES scheme in the watershed. Mobilizing collective community strength, enhancing institutional access to information and credit, and addressing inefficiencies of government institutions are crucial if farmers are to adopt PES. Building local institutional capacity for implementing PES enhances their competence to influence decision-making policy, and rationalizing local responsibilities in resource conservation. These concerns have a cost dimension in that high transaction costs could be a barrier to participation in PES, because they create disincentives for market exchange.

Establishing the Price for PES

Determining the price to charge in a PES scheme is critical in ensuring acceptability of the scheme. The basic assumption is that households are economic players aiming at maximizing their income subject to the available resources. Thus, PES is factored in the household production function and considered as a production enterprise, much as food production is an enterprise. The farming households have an average farm size of 4.5 acres. About 40% of household farms are allocated to crop production while 10% is not arable and usually allocated to tree growing or bushes. These farms are usually located near river banks or in the steeper parts of the farms. The opportunity cost of turning prime crop farms into PES-compatible land use was estimated to be Ksh 15,000 (US$ 187.5) per annum net of costs. The opportunity cost of leaving forests for PES-compatible schemes was estimated at Ksh. 1260 (US$ 15.8) per household per annum as the values of firewood, grazing and timber products obtained by households each year. The opportunity cost is comparable to the WTP by households to allow forest to perform environmental functions. Households would need to be compensated to leave the forests and to allocate their farms to tree planting and other watershed management structures.

Benefits of Watershed Management

The benefits of watershed management around Mt. Elgon would benefit households living near the mountain and the water selling companies. The demand for water by households is roughly $0.1m^3$ for households without irrigation and $1m^3$ for households with small irrigation projects. All households acknowledged that there were periods with low water supply. The PES schemes leading to conservation would improve water supply. Although the conserved forest would be expected to increase the water supply, the amount of water supplied would depend on how much the conserved environment influences infiltration of rainwater and the retention on the ground for slow release into rivers. The important watershed management requirement for water treatment plants are those that decrease sedimentation and increase water supply. The cost of water treatment by water selling companies would significantly reduce with watershed management. The costs related to environmental degradation include increase in sedimentation in the water that leads to abrasion of components in a treatment plant. Settling of sediments was about 20% of the cost of water treatment. Managers of water treatment plants estimated up to 70% of the maintenance and repairs in water treatment plants related to damages caused by sediments. Increase in water volumes would increase plant capacity to meet increasing water demand.

Transaction Costs in Implementing PES

Transaction costs were interpreted to mean the costs associated with developing a PES scheme, negotiation and enforcement of the scheme. Households have different preferences and the WTP depended on their socio-economic characteristics. A payment scheme should, as much as possible, take into consideration the uniqueness of each of the households in demanding water. Often, total contractual costs should include costs of certification, monitoring of contractual obligations of buyers and sellers, and among groups of buyers and sellers (Adhikari & Lovett, 2006). Higher transaction costs involved in the implementation of PES schemes have implications on cost-efficiency, effectiveness, and equity involved in developing the schemes, as well as their sustainability in the long run (Mayrand & Paquin, 2004). A high cost has an implication in determining a viable minimal price for charging water users. Findings from this study confirm the earlier arguments that high transaction costs (*e.g.*, of information, of defining property rights, and of drawing up legal contracts) could create barriers for small holder's participation in environmental service markets. The cost of negotiation was estimated at Ksh. 810 per household for 5-year period. The administration cost of the institutions will require households to make contributions. By charging a minimum amount of Ksh. 46, institutions are more likely to meet the cost of enforcement and maintenance of water catchment and watersheds.

Conclusions

Capturing enough demand is critical for PES programs. For location-dependent services such as water quality protection, it might be easier to identify and engage beneficiaries for an undetermined period of time. The sequence of engagement will be to begin by identifying the beneficiaries who benefit most from the protection or enhanced environmental services, e.g. those that depend on water for crop production and the water companies. The local community is expected to be averse in the first few periods and adoption will follow the s-shaped adoption curve. The institutions implementing PES would need to train the community on its importance and to demonstrate returns on investment by the community. The water companies are likely to see the importance of PES straight away through the anticipated reduction in cost of chemicals and machine maintenance resulting from reduced solutions and sedimentation in water. The implementation of PES may take a political dimension and institutions will need to cautiously demonstrate efficiency and productivity. Collective action towards PES is envisaged as an efficient solution for the provisioning of environmental services. Community-based approaches help to minimize the costs of transaction. Community-based approaches also help reduce the costs of transactions, particularly those related to the monitoring and certification of PES schemes. Few local contextual factors appear to be relevant for the operation of PES and also their outcomes. Proximity of the watershed to beneficiaries is a real stimulator for the market for watershed services. There is a great opportunity to include a wider population through supplying of piped water and asking them to contribute towards environmental conservation. The sedimentation, infiltration and surface flow models are important in understanding how the changes in land use and conservation measures are likely to affect water parameters. These parameters determine the willingness to pay by the households.

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DIFFICULTIES AND LIMITATIONS IN IMPLEMENTING PAYMENT FOR ENVIRONMENTAL SERVICES (PES) SCHEMES IN WATERSHEDS: A CASE STUDY OF THE VALUATION OF MT. KENYA FOREST

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ABSTRACT

Water flows in a watershed, and hence the timing and availability of water downstream, depends on the vegetation cover in the catchment upstream. As ecosystems within a watershed are changed, lost or degraded, their capacity to deliver watershed services to satisfy human needs is adversely affected. Payment for Watershed Services is a recent important innovation in water management to address this problem. It uses an incentives-based approach for maintaining watershed services that are critical for water security. Different schemes have been developed to pilot the approach. They have been variously labeled as Payment for Ecosystem Services (PES), water banks, water trading schemes or water subsidies. These schemes operate on the premise that the community upstream ought to be compensated if they are conserving the watershed. To adequately compensate such a community, however, one must establish the perceived value of the forest. A wrong valuation of the ecosystem services would variously affect the compensation. Where they are overvalued the buyers (payers) will be reluctant to pay. Where they are undervalued the sellers (resource providers) will be unwilling to conserve the forest. Since ecosystem services (ES) are not marketed, they have to be valued using indirect methods. Such methods depend vastly on the respondents' attitudes and perceptions, leading to multiple problems and limitations. Valuation is undermined by generalizations, perceptions or "myths", which are often not based on sound empirical facts. In some situations, the real value of ES can be totally different from those expected on the basis of the social-cultural perceptions. Other difficulties and limitations include, for example, model specificities, protest bids and adjustments for certainty.

Introduction

The author carried out a study in 2007-2008 in Karatina, Kenya, to develop a framework for the valuation of forest watershed management, on which basis compensation for conservation activities of ES resource providers would be undertaken. The specific objectives of the study were to identify and document ecosystem services of Mt. Kenya; identify and characterize beneficiaries and cost bearers of its watershed protection services, and to estimate the economic value of watershed protection services provided by Mt. Kenya forest.

Study Area and Characteristics: Mt Kenya Forest

Mount Kenya is 5,199 metres, the highest in Kenya and second highest in Africa. The mountain has a thick forest that changes with altitude and for this reason; it is one of the five critical fresh water sources in Kenya. Its rivers make up almost 49% of the country's biggest river, the Tana. Its forests alone cover over 220,000 ha and are estimated to meet more than 40% of Kenya's water needs. The Mt. Kenya forest consists of two administrative units namely, the Mt. Kenya National Park (715km') managed by Kenya Wildlife Service (KWS) and, Mt. KenyaForest Reserve (1,420km') managed by Kenya Forestry Authority.

History and People of the Mount Kenya Area

Before about 1650, central Kenya was densely forested and inhabited only by the Gumba hunters (a 'dwarf like' hunter tribe) and by Athi and Digiri sections of the Ogiek/Ndorobos (Bussman 1994). The Maasai words "Ndorobo" or "Ol toroboni" means one who keeps bees or poor people since they regard cattle as a sign of wealth. Around 1650, the Kikuyu arrived in Murang'a and Kiambu area, occupying the land ridge by ridge by cutting the forest and trapping animals, reaching Nyeri region around 1730. The Meru occupied the east of Mt. Kenya in the 14^{th} century and together with the Kikuyu cleared large forest areas for farming. Only Naro Moru, which the British administration declared a forest corridor in 1902, remained as a wet forest (Muriuki 1974). By agreement with his majesty's commissioner of East African protectorate in 1904/1911, the Illpurko Maasai had to move southwards to Narok. Their land and large areas of Kikuyu territory became part of the *White highlands*. Since the early 1970s, the indigenous forests around Mt Kenya have been heavily exploited by selective logging of valuable timber trees such as the Cedar (*Juniperus procera*), olive (*Olea capensis and, O. europaea,* camphor (*Ocetea usambarensis*) and Meru oak (*Vitex keniensis*). In addition to logging, innumerable grazing licenses were issued and indigenous forest cleared and opened to allow for non-residential cultivation. The rapid recession of the glaciers from 1963 onwards indicates a change in climate involving higher temperature (Mt. Kenya Management Plan 2001). The objective of the study was to develop a framework for valuation of forest watershed management, on which basis compensation for conservation activities of ES resource providers would be undertaken.

Study Methodology

The study used a face-to-face, Contingent Valuation survey to determine households' willingness to support a Payment for Environmental Services (PES) program for protecting Mt. Kenya forest watershed. The hypothetical program's goal was to help change land uses in the study area to conserve the forest and protect water quality and quantity. The study collected data using a household survey. The survey respondents were provided with background information about the communities' water supply and land use issues within the forest watershed. The survey questionnaire also collected data on respondents' socio-economic characteristics, water use, sources and costs, and willingness to participate in PES programme so as to protect the watershed, and by extension current drinking water sources.

Sampling

The interviews were carried out between July 2007 and July 2008 in Kagochi and Karatina towns. These sites rely upon the Mt. Kenya forest watershed and specifically the Ragati River for drinking water. The research target population were male or female heads of household (18 years of age or older) that receive their water from Ragati and Karatina water projects. Satellite photographs were used to mark forest coverage over time across the target watershed. The highest populated locations were selected and households to be interviewed randomly selected. If a head of a household was not available during a first attempt to conduct interview, that house was revisited up to two additional times. The target sample size was estimated as N=350 and, stratified random sample drawn from the watershed population. To give room for non response a total of 389 completed interviews were obtained.

Data Analysis

The data was first analyzed without adjustment for certainty and without excluding protest bids. In later analyses, the responses were evaluated in view of the respondents' certainty and excluded the protest bids. The Logit regression analysis was used to determine the extent to which different factors affected the WTP.

Limitations of Valuing and Paying for Ecosystem Services

Lack of Standardized Methodology for Valuing Ecosystem Services

In the analysis of literature to determine the most suitable method to value the ecosystem, it was established that all the case studies used different variables and even when they were the same, their applications were varied. Although there are several ways of estimating the value of non-marketed environmental services, most studies used Contingent valuation methods. Very little information is available in the literature instructing on the methods to use. Criteria on selection of a valuation method for valuing forest ecosystem services are not available. Contingent Valuation method questionnaires for most of the studies had different questions, and in most studies it is not indicated how protest responses were treated.

Problem of Long and Short-Term Benefits

Welfare benefits from preservation of forests have long streams of benefits, and such benefits cannot be easily written off under current income or welfare streams hence, the need for separate estimation. This calls for discounting of future benefits. The value of the Mt. Kenya forest in terms of water management, however, is so uncertain that even among relatively homogeneous group, there was significant difference in perceptions of the forest future value.

Problem of Double Counting

After hervesting from the forest, timber has a price reflecting its use or utility value. It is assumed that the timber value is exclusive of environmental services. When framing the referendum question for the study, it was assumed that the approval or yes answer indicated the willingness to pay for the watershed programe to protect water supply. This however, did not exclude the benefits of the forest in biodiversity and carbon sequestration. How to exclude other values and only value trees for watershed management was a major difficulty.

Certainty Adjustment

The inclusion of respondent's uncertainty (or certainty) in Contingent Value model is one of the frontier issues in non-market valuation of environmental resources (Subade, 2005). Thus, this study tested the effect of qualifying the "yes" responses on WTP. Qualifying the "yes" responses means converting them into "no" responses depending on the respondent's answer to the follow up question about their level of certainty. Respondents were asked how certain they are about their WTP response. The respondents were asked to choose one of five levels of certainty: completely sure and willing to convince others, completely sure, sure, not sure and completely not sure. To adjust for uncertainty, this study converted the "yes" responses to "no" if the respondent was "not sure" or "completely not sure". Calibrating for certainty is expected to decrease the WTP percentage. Although the respondents gave answers to this question, it was not well received because it amounted to questioning their honesty. It was therefore not quite settled whether this contributed to the fact that there was no significant different between the findings before or after calibration for certainty.

Protest Bid Identification

Protest bids, as identified by Bateman *et al*., (2002) are non-responses of households wherein the genuine WTP are not provided and respondents either responded with a zero value or with an unrealistically high value i. Their responses do not represent their true value of the nonmarket good since they are protesting to an aspect of the hypothetical scenario, such as mistrust for the institution who will manage the funds or the belief that watershed protection is a government responsibility; thus, they could also be termed as scenario rejecters (Subade, 2005). To separate protest votes from "true" responses, respondents who are not willing to pay the bid price were asked a debriefing question (Collins, Rosenberger and Svetlik, 2005) , in which they are asked to state their reason for their unwillingness to pay anything for the non-market good. Because they were assumed not to be indicative of the true valuation of the respondents, such protest responses were removed from the CV sample. About 43 such respondents were removed from the sample. The responses cited were grouped as in Table 1 below.

Providers, Users and the Service itself are not well Identified

Many respondents had a problem with the definition of the service for which the payment system could be established. There was confusion as to whether they were paying for the water quality or the forest. This causes serious deficiencies in the system, since it reduces the users' willingness to pay. Relating theory to this study, price refers to that being paid for the improvement in water quality and quantity, and income is the individual's mothly income. All of these variables change. However, the improvement in water quality and quantity is offset by the change in income so that ones utility remains constant. This is the underlying theory of a CV. An individual WTP represents the amount of money he/she would be willing-to-forgo, given the public good improvement while remaining on the same utility curve.

Table 1: Classification of Reasons for Respondents' Non-Willingness to Pay

Protest Votes	**Valid NO Responses**
I think it should be the government that should finance the watershed management activities	I cannot afford to pay any additional amount to what I am currently paying
I do not trust the institution who will manage the funds for this conservation work in the Watershed	Not all water comes from Mt. Kenya Forest
Only the rich should pay	Poor people will be affected
The rich companies getting resources should pay	We are not benefiting from it
Present water service is not good	We do not have any water problem
The Water Service Board already charges a very high amount	Just recently got connected
Those who consume more must pay	The water supply may not be continuous
It is not our obligation as citizens	The price may increase again

*The protest votes were significant among the public sector employees and those over 55 years old. This invalidated the findings for this group.

Social-Cultural Perception and Valuation

Value of Charcoal and WTP

The aerial survey of Mount Kenya identified the issue of charcoal burning in and outside the forest as one of the key threats to the mountain's ecosystem. Charcoal burning has been popular especially among the unemployed youths who have been engaged in logging and setting up charcoal kilns in their homesteads. Previously, charcoal kilns were set up in the forest but with the ban on logging, unlicensed access to the forest for wood, and the internal monitoring by local conservation groups against these forest practices, these young people have resorted to setting up charcoal kilns in their homesteads after cutting trees and ferrying them into their homes. The value of charcoal influenced the responses from the sample so that most were indifferent to the watershed management programme, more so because of what would be the loss of charcoal revenue than because of water issue. This was difficult to establish given that charcoal burning was illegal and straight answers were unavailable.

Culture, Religion, Types of Trees and WTP

The presence of timber trees like cedar (*Juniperus procera*), olive (*Olea capensis ssp.hochstetteri, Olea europaea ssp.cuspidata/africana*), camphor (*Ocetea usambarensis*) and Meru oak (*Vitex keniensis*) complicated the WTP values. It was difficult to value the forest in terms of tree type since the trees were intermixed. The value of the forest to a number of the respondents was because of religious and cultural significance. They found a *Mugumo* tree priceless as it was sacred to the Kikuyu people. For some of them, the WTP to support a watershed conservation programme was not based on the value of the water but the sacredness of the tree. The value of the forest to these respondents is therefore not because of its contribution to water management, but to culture and religion. To isolate this 'sacred value' from the watershed value of the forest was difficult.

Model Specification

CVM was used in this study. CVM deals with indirect utility. From the standard economic theory standpoint, there is an indirect utility function given by $V(\cdot)$ which describes the maximum amount of utility a household can get from their income (Y) subject to the prices of the goods (P), and the level at which the non-market environmental goods or services (Q) will be provided. The item being valued, the Mt. Kenya forest, is denoted by q. Assuming the individual is a consumer of a marketed product, he is assumed to have a direct utility function defined over the quantities of various market commodities, denoted by the vector x, and q, $u(x, q)$.Corresponding to this direct utility function, the indirect utility function is, $v(p, q, y)$, where p is the vector of the prices of the commodities and y is the person's income. An assumption is usually made that $u(x, q)$ is increasing and quasi-concave in x, which implies that $v(p, q, y)$ satisfies the standard properties with respect to *p* and *y*. If the respondent regards ***q*** as a "good," *u(x, q)* and *v(p, q, y)* will both be increasing in ***q***; if he regards it as a "bad," *u(x, q)* and *v(p, q, y)* will both be decreasing in ***q***; and if he is indifferent to ***q****, u(x, q)* and *v(p, q, y)* will both be independent of ***q***. The possible effect of demographic and socio-economic factors *(d)* on this utility is also assumed. This is given by:

$$v\ (y, p, d, q) \quad (1)$$

The act of valuation implies a contrast between two situations – a situation with the item, and one without it. We interprete what is being valued as a change in *q.* Any change in one of the factors would impact the level of household utility. Specifically, suppose that *q (in our case, Forest cover)* changes from q^0 to q^1; the person's utility thus changes from $u^0 \equiv v(p, q^0, y)$ to $u^1 \equiv v(p, q^1, y)$. If he regards this change as an improvement, $u^1 > u^0$; if he regards it as a change for the worse, $u^1 < u^0$; and if he is indifferent, $u^1 = u^0$. Improving the water supply, say from q^0 to q^1, represents an improvement - in the case of this study, this is represented by the establishment of the watershed management program – and thus, household utility will be higher;

$$v\ (y, p, d, q^1) > v\ (y, p, d, q^0) \quad (2)$$

In a CV survey, respondents are assumed to compare utilities and make decisions based on these. The value of the change in monetary terms is represented by the two Hicksian measures, the compensating variation *C* which satisfies;

$$v\ (p, q^1, y - C) = v\ (p, q^0, y), \quad (3)$$

and the equivalent variation *E* which satisfies;

$$v\ (p, q^1, y) = v\ (p, q^0, y + E) \quad (4)$$

The resident of Karatina would accept the proposal if:

$$v(y- p, d, q^1) > v(y, d, q^0) \quad (5)$$

The household is willing to pay the bid amount provided his utility with the watershed management program and the required payment is higher than without the watershed management program at the zero bid price. The watershed program represents a conservation of the forest. It entails the increase in forest cover and quality. Willingness to pay for the program is an indirect value of the forest. A revealed preference for the programme implies the preference for the forest. However, there is also a random part of respondents' preferences which cannot be observed by the researcher and is therefore uncertain. For a community that is heterogeneous such as the Karatina one, this random part changing the WTP model into a stochastic model that can generate a probability distribution for the survey responses was very challenging. In the study a stochastic component was introduced into the deterministic utility model. Ie;

$$v(y-p, d, q^1) + \varepsilon_1 > v(y, d, q^0) + \varepsilon_0 \qquad (6)$$

The respondent was asked: "Would you vote to support the change from q^0 **to** q^1 if it would cost you Kshs. *A*?" Suppose the response is 'yes'. In terms of the underlying WTP distribution, the probability of obtaining a 'yes' response is given by;

$$\text{Prob (Response being 'yes')} = \text{Prob}(WTP \geq A) \qquad (7)$$

The probability that the respondent would accept the proposal is given by:

$$\text{Prob (Yes)} = \text{Prob}\,[v(y-p, d, q^1) + \varepsilon_1] > \text{Prob}\,[v(y, d, q^0) + \varepsilon_0] \qquad (8)$$

The willingness to pay for a change in Q can be expressed as:

$$log[\frac{Prob(Yes)}{1-Prob\,(Yes)}] = \alpha_0 + \beta_1 P + \beta_2 Q + \sum \beta_i D_i \qquad (9)$$

D_i in the equation represents the socio economic variables**.** The α and β in the equation was calculated parametrically using the logit regression. From the parameter estimates derived by the equation, the mean WTP was estimated using the formula:

$$\text{Mean WTP} = [1/Я_1]\,[\ln(1+\exp(\alpha_0 + Я_2 G +- Я_i D_i)] \qquad (10)$$

These variables, indicated as, ***D*** in the model, were chosen because of similar previous CV studies as well as economic theory.

Table 2: Summary of Variable Names, Description and Coding

Variable name	Variable description	Expected sign
WTPVAL	Willingness-to-pay Bid Amounts (Kshs. 50, 75, 100, 250)	(-)
KNOWLG	1=Familiar with the Mt. Kenya Watershed of, 0 otherwise.	(+)
EDULEV	1= Education level with at least a college degree, 0 otherwise.	(+)
GENDER	1= Female, 0 otherwise.	(?)
AGE	A respondents age (years).	(+/ -)
INCOME	Household's monthly income in Kshs.	(+)
MARI.STAT	Respondent's marital status 1= married, otherwise	(?)
ENVGRP	Membership in Environmental Organization 1= Yes, 0= No	(+)

Selecting the variables was done based on previous similar studies. The circumstances were, however, different. This posed a problem. For example, membership in Environmental organization was included in the model, but with different meaning. In Mt. Kenya membership in such an organization ignored membership in Societies and self help organizations that involved themselves directly in environmental management. Issues like proximity to watershed were not included in this study as it was found to be insignificant in an initial study, and, the same was length of stay in the watershed. Change in D_i significantly affected the mean WTP and therefore, perceived value of the watershed. However, decision on which variable to include and which not toinclude in the equation was a major challenge.

Conclusions

- There is need to domesticate a valuation method and to determine the variables to include in the equations. This will be difficult to achieve given that there are endemic factors in each landscape, but the effort is worthwhile for standardizing results of such valuations though, the values will be a reflection of both respondents and researcher's perception since the criteria for selecting variables is unique to the scientist.
- Hence, it is important to use other methods of valuation to compare the value arrived at. CVM is controversial and needs to be supported by other methods
- Since value changes with time, one would need to discount the future value of the watershed. An agreeable value must be a mean of the value across age groups, income groups and water use, but must have a temporal dimension.

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IMPACTS OF COMMUNITY ACTIVITIES ON ENVIRONMENTAL RESOURCES: THE POTENTIAL FOR DEVELOPING PAYMENT FOR ENVIRONMENTAL SERVICES

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ABSTRACT

Natural resources have continued to be degraded largely because of lack of well-defined property rights, population pressure, high levels of poverty and the lack of understanding of the deleterious impacts of depletion of forest and watershed resources. The social cost of exploiting the resources is higher than the private benefits, but individuals usually have incentives to excessively extract natural resources at the expense of conservation. This study considered the socio-economic aspects of farm size and activities, water availability, the distance of the agricultural activities to the edge of the forest and/or riverbank, and agricultural management practices employed by the population in Mt. Elgon District of Western Kenya. A proxy price was obtained using hypothetical structured questions on willingness to pay and willingness to accept. A sample of 236 households was used to obtain data. Field surveys, structured questionnaires, interviews with key informants, and review of secondary sources were the main tools used for data collection. The statistical package for social science (SPSS) and Microsoft Excel programme were the main software for data analysis.

The results reveal average households of eight persons, with most households living below the poverty threshold of one dollar per person per day, and on average farm size holdings of 3.105 acres per household. The results also show that most farms are within the edge of the forest and riverbank at a distance of between 8 km and 1 km, respectively. More than 50% of the sample population do not practice water and soil management, resulting in undesirable physical properties of the water, such turbidity, taste and smell. The exercise to determine the contingent value of ecosystem pricing from willingness to pay (WTP) and willingness to accept (WTA) yielded mean prices of Ksh. 728.82 and Ksh. 6,631.44, respectively.

In conclusion, household activities of the community in the Mt Elgon landscape encourage resource depletion. Therefore, adoption of sustainable agriculture and ecosystem management that consider conservation of natural resource in order to have desired qualities of the ecosystem services and to reduce the costs to the population living downstream are recommended. There is need to educate the local population living around the forest and watershed areas to practice sound farming practices.

Introduction

Human well-being is highly dependent on ecosystems and the benefits they provide such as food and drinkable water. Over the past 50 years, however, humans have had a tremendous impact on their environment (UNCED, 1994). The world community recognizes the importance of sustainable management of the soil, water and nutrient resources. Agenda 21 of the 1992 UN conference on Environment and Development (UNCED) identified several issues of environmental resources management that require global planning and coordinated effort (Lal & Stewart, 1995). An important strategy for sustainable management of environmental resources is to maintain an ecological balance between soils-climate-vegetation, and yet intensify agricultural production. Maintaining an ecological balance is especially critical in view of the necessity to mechanize farm operations, enhance soil fertility by using off-farm inputs, adopt monoculture or simplified systems and use pesticides to decrease production losses. The problem of environmental degradation is perceptual and subjective because ''lowering'' of value is relative to actual or possible land use, and relative managerial skills and off-farm input. In many cases, losses in productivity due to degradation can be offset by adding chemical amendments or organic manures, improving drainage of waterlogged soils and leaching of salt affected soil, decreasing bulk density of compacted soils and managing accelerated erosion through appropriate use of preventive or ameliorative measures. Land degradation, therefore, becomes a social or managerial problem if society has no resource to alleviate land related constraints to crop production and environmental stewardship.

Farming in communities that rely on traditional agricultural systems produces low yields and requires more and more land area to support an increasing population. This is because traditional production systems use little or no additional farm inputs. External inputs become a viable alternative to extensive cultivation and lengthy fallow periods for fertility restoration.. According to Oldeman *et al.* (1990), most soils of the tropics have low buffer capacity because of low organic matter content and predominance of low activity clays. Consequently, these soils are highly prone to physical degradation which is set in motion by crusting, compaction, low infiltration, high runoff and accelerated erosion. The result is lowering the quality of water in that soil particles affect the water turbidity, thus making the commodity not safe for domestic purposes. Physical degradation is accentuated by replacement of manual farm operation by mechanized operations. Application of inorganic fertilizers can lead to acidification (*i.e.* decline in soil pH) of these soils of low-activity clays. Since pesticides have drastic adverse effects on soil fauna (*e.g.* earthworms and termites), soil biodiversity and biomass carbon are drastically reduced as a result. Because of the strong effect of these anthropogenic activities, understanding processes that affect agronomic productivity and sustainability is crucial to sustainable use of environmental resources. An important strategy is to understand the effects of land use, farming/cropping systems and soil and crop management on cultivated steep lands and catchment areas that encourage soil erosion and loss of water quality. It is the management induced alteration in environmental soil properties and processes that affect factors such as yield, response to inputs, the severity and type of soil degradation, and environmental regulatory capacity of the soil. This study set out to undertake a valuation of various services provided by the Mt Elgon ecosystem.

Study Area

Mt Elgon District is situated in Rift Valley Province, Kenya. The district lies between latitude 0^0 48′ and 1^0 30′ North, and longitude 34^0 22′ and 35^0 10′ East (Figure 1). It is characterized by an undulating landscape with the altitude rising from 1800 m above sea level in the south to about 4300 m to the north, both in Kenya. The mean annual rainfall is 1800 mm, with a pattern showing a bimodal type of rainfall with the long rains between March and June, and short rains from September to November. Temperatures vary between 14^0C and 24^0C, with lower altitude experiencing higher temperatures. The climate is favourable for a wide range of agricultural and livestock activities which account for about 90% of the economic activities in the region. The main crops grown are maize and beans during the rainy seasons, and vegetables are usually planted during the off-season using irrigation water. The district has a total of 50,866 ha of gazetted forest which supports a timber industry, provides wood fuel and environmental services like influencing the climate which is favourable for agriculture and livestock activities, mitigating soil erosion and providing good habitats for wild animals. The soils in the district can be grouped as mountainous soils, developed on olivine basalts and ashes of volcanoes, mostly found in the forest zones. They are fairly well drained soils occupying 14% of the district. Soils on volcanic foot ridges developed on tertiary basic igneous rocks and are well drained, very fertile, with humic endosols occupying 45% and acidic humic topsoil occupying about 25% of the district. Lastly, soils on the foot of slopes are developed on colluviums from basic igneous rocks and are well drained and found on the lower regions of the district occupying about 6% of the district.

The population of the district stands at 159,632 persons with 19,954 households, and it is classified as one of the densely populated areas in Kenya, with a high poverty index according to the post-census of 2009; and the population has a substained annual growth rate of 2.3% (Kenya National Bureau of Statistics, 2010). Land tenure is private with most households acquiring land through inheritance; and communities on Mt Elgon region derive most of their livelihoods from agricultural activities. Traditionally, maize and beans are the major crops grown as staple food for most households in the district, even though there is increasing reliance on vegetables such as onions, tomatoes and green vegetables sold for cash. Most households also keep livestock for sale and own consumption of milk and meat, as well as small stocks of goats and sheep, pigs and chicken.

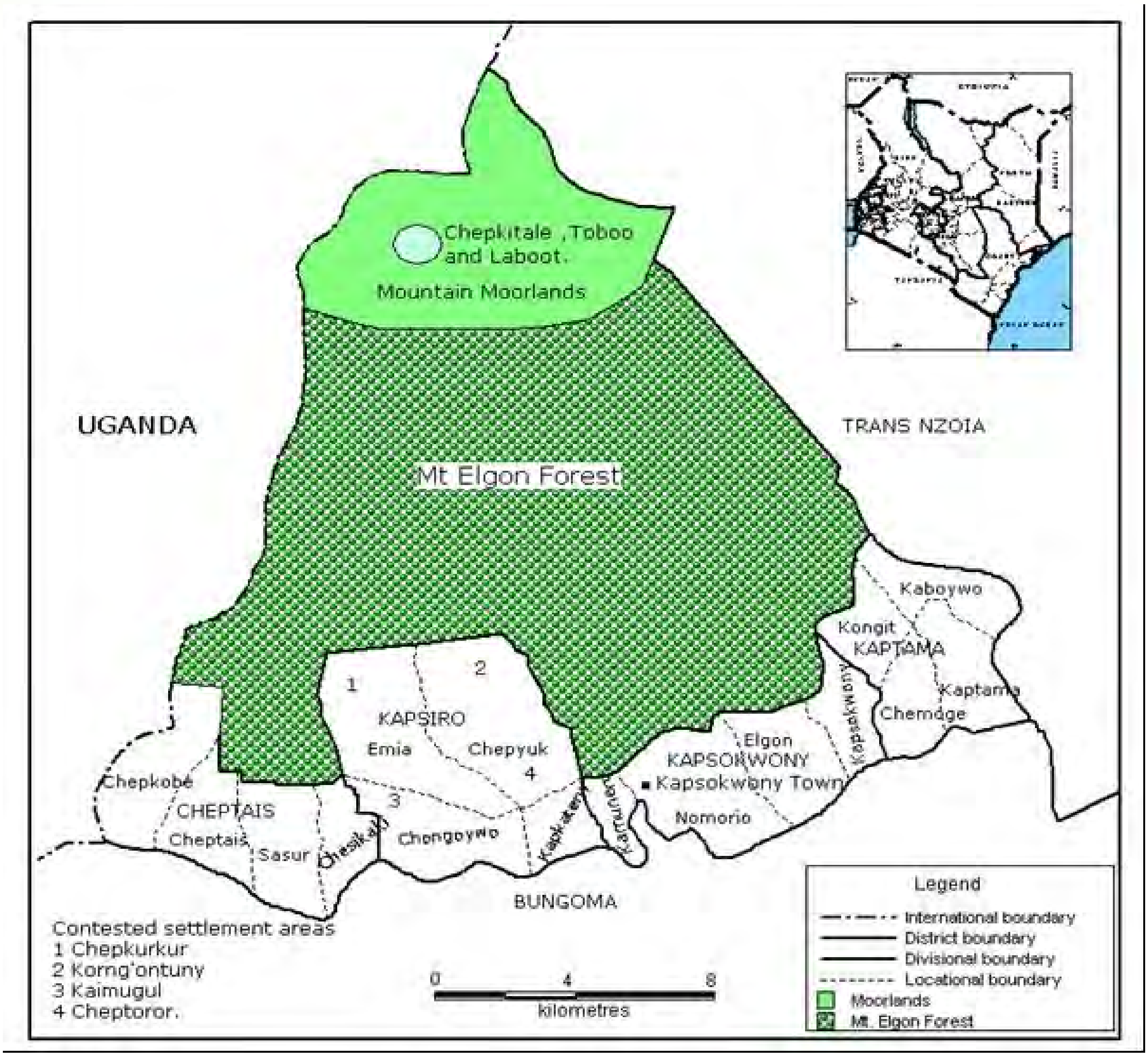

Figure 1: The Study Area of Mt Elgon Landscape of Kenya

Materials and Methods

The sampling was done using a multi-stage approach, and systematic sampling was employed in carrying out interviews at household level. To determine the sample size, recent post-census enumeration maps and list of household for sub-location in the selected divisions was used. Basing on the population of the village and other factors, the sample selection was obtained using the Morgan table of sample selection, which has been scientifically determined to draw a representative of the entire population. A sub-location was considered as the smallest sampling units in an administration boundary and the household viewed as the basic unit in a community. Two sets of questionnaires were used in the survey; one for household and the other for the key informants, NGOs, CBOs and other organizations dealing with environmental conservation and related issues in the region. In adition, focused group discussions were held. A focused group is an assemblage of purposely selected individuals who are representatives in the sampled units, such as opinion leaders, administrative leaders, representative of the youth and women, etc. The data that was collected and analysed included farm size, the distance of the agricultural activities to the edge of the forest and riverbank, and agricultural management practices employed by the population in Mt Elgon landscape (Table 1). A proxy price on valuation of ecosystem service was obtained using structured question on hypothetical willingness to pay and willingness to accept.

The Study Results

Table 1: Showing Parameters and Findings on the Study

Variable	Sample Size	Total	Mean	Percentages
Age of household head (yrs)	235	10373	44.14	-
Casual labour (%)	79		-	33.47
Permanent labour (%)	46		-	19.49
Household size	236	1949.5	8.26	-
Farm size (acres)	234	736.975	3.1495	-
Income on-farm	212	4358852/=	20,560.60/=	89.80
Income off-farm	81	570200/=	7,040/=	34.32
Distance from river bank (km)	154	251595	1.634	-
Distance from forest edge (km)	164	1343313	-	-
Water inadequacy	141	-	-	59.79
Water storage facility	56	7718.48L	100.24 L	32.62
Fertilizer application	177	-	-	74.58
During planting	44	-	-	48.00
Top dressing	56	-	-	34.33
Willingness to pay	118	867229/735/=	-	-
Willingness to accept	117	789,141/=	6744.79/=	-

The results show an average household size of 8 persons and annual income of Ksh. 20,560.60 earned from on-farm activities (Table 1). Over 85% of the households depend on on-farm while 34.32% get some income from off-farm activities, with mean of Ksh. 7,040. Each household has farm size averaging 3.105 acres, with most of the households practicing subsistence farming. About 33.47% obtained some of their labour by employing casual labourers. 19.49% of the households have permanent labourers while the majority depend on household members. The main crop grown is maize intercropped with beans, but tomatoes, onions and coffee are also grown by few household on a small scale. About 74.58% of the households plant crops by applying fertilizers either during planting or when they are top dressing. About 48% of the sample households apply fertilizers during planting, mostly using farmyard manure and Double Ammonium Phosphates (DAP), while 34.33% top dress their crops with Calcium Ammonium Nitrates (CAN). The proportion of respondents that was concerned about water inadequacy during the month of October to March was 59.79%, pointing out the problem as overuse through irrigation and reduction in water quality due to soil particles, making water unsafe for domestic use. Most households have to search for drinking water elsewhere from a distance. The concern about water storage facility shows that about 32.62% of the sample households had water storage facilities (plastic containers) with holding capacity of about 100 litres. The average distance of farms from the riverbank and the edge of the forest was 1.060 km and 8.404 km, respectively. In terms of conservation practices, such as soil conservation through farm management structures, the findings on the proportion of the households that have practiced such management are shown in Table 2: On the scheme of payment using proxy prices with contingent valuation of the ecosystem services, willingness to pay (WTP) and willingness to accept (WTA), the mean prices of the responses were Ksh. 728.82 and Ksh. 6,631.44, respectively.

Table 2: Showing Proportion on Farm Management Structures

Farm Management Structure	Frequencies	Percentage (%)
Contours	63	26.7
Strip Cropping	99	41.95
Mulching	66	28
Terracing	107	45.34
Others	13	5.51

Discussions

Agriculture is closely linked to many environmental concerns, including biodiversity loss, global warming and the loss of water quality and availability. Subsistence farming is the main economic activity in Mt Elgon district, considering the small farmland sizes and household own labour supply as the basic working units. On average, about 80% of the households had an annual on-farm income of Ksh. 20,560 compared with the off-farm average income of Ksh. 7,040, which shows that most households depend on on-farm production. If this income level is considered against Millennium Development Goals (MDGs) poverty threshold of USD 1.00 per day, and using current rate of Ksh. 80 = 1US dollar, this threshold translates to an income of Ksh. 25,200. According to these results, the majority of the respondents then live below the poverty line. In this context, it is therefore not surprising that the majority of the inhabitant of the Mt Elgon district practice low-input, (traditional) slash and burn agriculture, putting more pressure on natural resources, particularly the forest. Evidence from the results shows that the majority of the households depend on farm activities with low technological input such as application of fertilizers and pesticides, and the lack of water storage facilities hampers their efforts in trying to seek alternative livelihoods such as rainwater harvesting. Over reliance on soil fertility without nutrient supplement will put such vulnerable resources to degradation. From the results, 89.83% of the households depend on on-farm products which, in relation to the poverty threshold are insufficient. The low income can be attributed to constraints in their production activities, small farm sizes, limited diversification, poverty levels, culture and poor adoption of technologies. The farmers' production is also limited by factors such as low application of fertilizers and deterioration of water quality, which pose threats of diseases associated with water, as most of the households do not have enough water storage facilities to cater for the household. Evidence shows that large areas of land on steep slopes are already in arable use and proximity of farms to rivers are likely to remain so. Farming on steep slopes is rampant, which with the current low degree of soil management practices, leads to serious soil erosion. Such areas if left unprotected will become more vulnerable and unviable, leading to further expansion of farmland into the pristine environment, thereby worsening conditions of the already fragile environment, and hence lowering quality and quantity of water comming from the ecosystem.

Human disturbances of the forest and riverbanks generate considerable runoff, which in turn washes away large amount of fertile topsoil down the slopes, thereby threatening the agricultural production of most households who depend on on-farm income. The effect of such increased run off and sediment load on rivers will fall into two broad groups: on-site and offsite. On-site, the loss of top soil is critical in these low-input agriculture areas, as the top soil contains the bulk of the readily available nutrients essential for plant growth. In addition, the removal of the upper soil layers eventually exposes infertile underlying soil which then provides a poor environment for crop establishment and growth, leading to poor production triggering low crop yields for the household. Apart from that, degraded soil will bring an externality to most households on costs of purchasing fertilizers to compensate nutrient losses, thus causing an economic burden. Loss of water from the site is also critical in the rainfed agricultural system, particularly with the marked dry seasonal. Off-site consequences of high runoff and sediment load following cultivation on steep sloping are of major importance on the low-lying lands such as Lake Victoria where the increased sediment loading eventually end up. Besides, the increased sediment loading affects water quality and also increases the cost of treating water downstream for water utility companies. Degraded catchment areas would also have reduced water holding capacity which in turn leads to reduced quantity of water downstream, causing limited supply of water downstream, hence bringing additional economic cost. Contrary to the expectation on the availability of such commodity being abundant, water inadequacy is already experienced in the watershed. This is posted by the results which show that 59.79% of the respondents felt water was not sufficient for their needs. This means that if the mechanism of water depletion is not checked, the water shortages loom both on-site and downstream.

The application of fertilizers upstream will have cumulative effects downstream, such as lowering thequality of water to the users downstream due to presence of metals washed with soil sediments. It will also affect water bodies downstream such as Lake Victoria in which it will contribute to eutrophication levels. This brings ecological disturbance to the lake ecosystem, thereby endangering the lake resources and the livelihoods of communities that depend on them. In other words, the effect of a degraded ecosystem upstream brings in an externality downstream. Although environmental destruction upstream is associated with costs incurred by the people, downstream people cannot be reflected by contingency method of valuing the environment. Setting the value of forest services using willingness to pay and willingness to accept (Table 1) shows that people are willing to pay less compared to what they are willing to accept as compensation for forest conservtaiom. This value can be used as the minimum price for valuing ecosystem services, in the contingency valuation method.

Conclusions

Living below a dollar per day, the impacts of community activities, especially agricultural activities of cultivation in Mt Elgon District encourages resource depletion. The degradation of the environmental resources takes place on steep slopes and watershed region that acts as a water catchment for many rivers in the region. Based on the results of this study, there is a conspicuous paucity of farm management experience in the district. Although intensification of agricultural activities is economically and ecologically feasible, it requires careful appraisal through farm management. Therefore adoption of sustainable agricultural techniques should be done with the primary objective of enhancing per capita food production and improving on-farm income from existing arable land. Furthermore, degraded and marginal lands can be brought under cultivation provided that sound farm management practices are conducted on soil restoration to avoid loss of fertile soils through runoff and to improve water quality for domestic uses, both on-site and downstream. There is also need to focus on the needs of small farms in diverse ecosystems by improving rural livelihoods, empowering marginalized stakeholders and developing market structures for ecosystem services through PES schemes using proxy prices.

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ANALYSIS OF FACTORS AFFECTING THE IMPLEMENTATION OF PAYMENT FOR ENVIRONMENTAL SERVICES IN EASTERN AND CENTRAL AFRICAN REGION

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ABSTRACT

Implementation of the payment for environmental services (PES) in East and Central Africa has been slow because of lack of markets and proper pricing, as well as lack of market mechanisms for forest services. While scarcity of forest products triggers a market response leading to increase in prices and development of substitutes, scarcity of forest services is less market responsive. The provision of the ecosystem services is often in the domain of the poor, the vulnerable and the powerless who, live in landscapes adjacent to forests. This study assesses the factors that influence the value of forests for watershed management and adoption of PES. The contingent valuation method was used to assess the value of the forest for watershed management by asking respondents to vote to support the protection of the forest at the stated price or cost. The binary logit model was used to analyze the respondents' 'yes-no' responses.

The results show that the significant factors influencing the value of forest for watershed management include the reduction of risk of erosion, floods, and landslides, fishing in the lower parts of the watershed, water clarity, purity and taste, and the reduction in amount of suspended sediment in the water. Other factors such as water temperature from restoration of vegetation cover along the watershed areas and the allowable quantity of water for irrigation and watering of animals also influenced the watershed value that reached more than 60% of the total economic value of the forest when other forest uses are considered. There was a low score for recreation functions of the forest among the local community, although recreation is directly related to the support of watershed management programs.

There is a positive correlation between the bid price and the number of conservation structures supporting forests for watershed management attributed to the increasing quantity and quality of water with the increase in the investment to improve the watershed areas. There is an intrinsic value of forest for cultural and aesthetic use that ranks high among the motives for planting and conserving forests.

This paper concludes that monetary gains from PES alone cannot motivate communities to conserve forests. Training and education of the communities on the need to conserve forest ecosystemsm and, implementation of water management policies that promote forest conservation are necessary.

Introduction

Forests play a critical role in providing ecosystem and hydrological services, acting as a carbon sink and by providing basic needs to communities who live adjacent to them. Kenya's indigenous forests are home to many communities whose livelihoods depend on the natural resource. Wass (1995) estimated that the people living adjacent to forests in Kenya at that time to be approximately 2.9 million. With the population growth rate of 2.8%, the population of forest adjacent communities has been increasing over time, thereby increasing the demand for forest products and resources. Population growth is claimed to be a major driver behind environmental degradation as expansion of agriculture has been achieved at the expense of the natural resource base (Kamugisha *et al.*, 1997). Forests within the Mt Elgon ecosystem are protected areas and are managed through strict enforcement of rules to prevent degradation. This pits the local community who feel excluded from management against the forest administrators. In some cases, open conflicts have occurred which have resulted in losses of life and property (Wunder, 2005). Yet, agriculture would be the first casualty of forest degradation and could lead to decrease in food production even with expansion of land to the forested area. In addition, water quantity and quality are directly related to the intactness of the catchment area.

In recent years, the recognition of environmental services and their value has led to efforts to internalize the services through direct, contractual and conditional payments for environmental services (PES) to land owners (Wunder, 2005). From an economic perspective, loss of environmental services (ES) is explained by the fact that most of the services present externalities or public goods which, as long as they are provided for free, their owners will not give much attention when making land use decisions. Still the fact that forests belong to the government, requires that tenure arrangement be changed to include the community for any eventual benefits from Payment for Environmental Services (PES). Payment for Environmental Service provides opportunities for forest-adjacent communities to earn incomes while conserving their environment. With the current global focus on PES under changing climate and its effects, a number of organizations are using different approaches to facilitate implementation of PES schemes in Eastern and Central Africa. It is envisaged that there are prerequisite activities that need be fulfilled in order to fully benefit from opportunities presented by environmental conservation-cum-social welfare schemes such as PES. This study aimed to estimate the willingness to pay by local residents to conserve their forest and watershed areas in order to improve the quality of water supplies.

Methods of the Study

The Study Area

The study was carried out in Mt Elgon District. The district borders the Republic of Uganda to the north and west, Trans Nzoia District to the east and Bungoma District to the South. It is located on the North Western Kenya and Eastern Uganda international boundaries and between latitude 0^0 48' and 1^0 30′ North, and longitude 34^0 22′ and 35^0 10′ East. The region receives an annual precipitation of 1280 mm and minimum and maximum temperatures of 9°c and 22°c, respectively, (Jaetzold, 2008). The soils are poorly drained dark peaty loams, ranging in colour from reddish brown to black. They are shallow with rock outcrops above 3000 m. On the mountain footsteps most of which is covered in forest, soil is mostly well-drained humid friable clay, with dark red subsoil derived from volcanic rocks. The vegetation of Mt. Elgon ecosystem can be zoned into four; that is, open woodland, tropical moist forest, bamboo and afro-alpine zone that is above the bamboo zone. *Juniperus procera, Hagenia abyssinica, Olea welwitschii, O. hotstetteri, Prunus africana, Podocarpus falcatus* and *P. latifolia* dominate the moist tropical forest. Moorlands, swamps and rocks form a major part of the afro-alpine zone. Mt Elgon district is divided into 4 divisions, namely, Kapsokwany, Kaptama, Kopsiro and Cheptais, with a total population of 135,033 (GoK, 1999 Census). Although the size of the population in the district is small in absolute numbers, the rate of population growth is still high. The climate of Mt Elgon district is favourable for a wide range of agriculture and livestock activities which account for about 90% of the economic activities. This makes the district a potential area for agro-based industries whose resource base can be major crops like coffee, pyrethrum, wheat, maize, oil crops and horticulture crops. The cool temperature is also ideal for the development of dairy industry.

The Conceptual Framework

Contingent Valuation Method (CVM) is used where prices for environmental resources are not available because their markets either do not exist or they are not well developed, or where there are no alternative markets. According to Hutchinson *et al.* (1995), the CVM directly elicits people's views to determine how much they would be willing to accept or to pay in the event of a threat to deprive them of the resources in question. However, the use of CVM has some application problems where people are not used to purchasing a particular forest product or service, and so find it difficult to attribute a monetary value to it. According to Brown *et al.* (1995), CVM is more effective when the respondents are familiar with the environmental good or service and have adequate information on the resource or service being valued based their preferences, bearing in mind that 'preference' is not synonymous with willingness to pay. Thus, modifications are required in order to ask, for example, about relative preferences that can be easier to express than monetary valuations.

The contingent valuation method was used to estimate the local resident's willingness to pay to conserve forest and watershed in order to improve the quality of water. The contingent valuation was used in providing information for decision making about whether to keep the unprotected forest for lumber or to create it as the forest reserve, and to quantify the non-marketed benefits of the potential forest reserve. Household production functions provided through ecosystem services were analyzed as a function of estimated annual household income, education level of the household, sex of the household head, size of the land owned, the number of livestock per household, average distance of the households from domestic water intake point, among other factors; and from these, estimates of WTP determined.

Data Collection

Structured questionnaires and interviews with key informants were used to collect data. Questionnaires were systematically administered to randomly selected land owners in the district. To complement information from the household questionnaires, a purposive target sampling procedure was used to identify key persons in the divisions surrounding the forest. These key persons included area chiefs, church leaders and progressive members in the society. In addition, secondary data dealing with forest resources and forest conservation was collected using internet and library sources, government and research institutions, as well as official government documents. Secondary sources including journal articles were also used to supplement information collected from the primary sources. Records from selected land owners around Mt Elgon were also used to supplement the other secondary sources.

Data Analysis

The data collected for the study was analysed using SPSS to generate descriptive statistical outputs, cross tabulations, correlation results and multiple regression, Chi-square statistics and the Pearson's correlation coefficients (r) were used to determine associations between the independent and dependent variables used in the study. Frequencies were used for descriptive analysis. Multiple regression equation of the type, Y on X, which predicts values of Y given those of X values was used in the analysis. A regression equation used was of the form;

$$Y = a + bi\ Xi,$$

Where, Y = output of PES adopted by respondents (*i.e.* dependent variable); Xi = level of education, gender participation, income available, attitude towards forest conservation, land sizes and demand for land (*i.e.* independent variables); a = constant parameter estimate; bi = parameter estimates showing the slope of the regression line. The 'a' and 'b' values were obtained by use of ordinary least squares (OLS). The linear regression model used is specified as , WTP = f (level of education, training on environmental degradation, cultural values, gender participation, available income, attitude of owners towards forest conservation, demand for land, land sizes). And the WTP derived as follows;

$$WTP = a + b_1X_1 + b_2X_2 + b_3X_3 + \ldots\ldots.. + b_nX_n$$

Where, WTP = willingness to pay amount stated by the respondent; X_i = factors involved in forest conservation, a = intercept and b_i = parameter estimates of the OLS regression model.

The logit model was specified as, P (Adoption of PES) = $e^I / (1 + e^I)$ Where, P = probability of adoption of PES; I = threshold = $a + b_1X_1 + b_2X_2 + b_3X_3 + \ldots\ldots.. + b_nX_{n;}$ and, e = natural logarithms

Results and Discussions

Socio-Economic Background of the Study Community

Mt. Elgon district had a greater percentage of female headed households compared to Kwanza district. This could be because of land-related clashes in the region where a number of male heads had been killed during the clashes and others were single mothers. The average education of households beyond primary level was still low in both districts. The households' both on-farm and off-farm average income was Ksh. 2340 for Kwanza and Ksh 1870 for Mt. Elgon (Table 1). The average number of livestock owned was higher for Kwanza compared to Mt. Elgon. Soil management structures were practiced in both districts. Farming and livestock rearing are the most common occupations.

Table 1: Socio-Economic Characteristics of the Sample Households

Variable	Kwanza	Mt. Elgon
% of female headed households	12.6	14.0
Average education of households (> primary)	2.43	2.54
Average annual household income (Ksh. in 1000)	2.34	1.87
% of households with farm employees	0.96	0.89
Average size of household land (acres)	3.63	2.66
Average water usage direct from river (litres)	1.58	0.52
Average distance of households from domestic water intake point (Km)	1.91	1.34
Average size of crop area with fertilizers (acres)	1.02	0.67
Average number of livestock per household	8	4
% of household farm size under trees	1.08	1.54
Average household size with soil management conservation structures (number per household)	0.69	0.78

Source: Household survey, 2010

From Table 1, some apparent differences emerge between the sample households in Kwanza and Mt Elgon areas. For example, there are more female headed households in Mt Elgon compared with Kwanza, which show twice as high livestock holding per household as Mt Elgon. Besides higher cash income, the households in Kwanza also report higher average per household land holdings compared to those in Mt Elgon. The result is also clear that on average, more households in Kwanza directly draw their water from the river compared with the households in Mt Elgon area.

Concerns about Water Quality

Table 2 shows the concerns about water quality in Mt. Elgon were good for all attributes while in Kwanza turbidity and taste were good except smell and quality. These results suggest that there is need for water quality improvements through water treatment, although much more treatment is required in Kwanza.

Logistic Results

Table 3 results of the logistic regression model portray that; WTP = $49.717X_1-22.042X_2+347.687X_3-0.006X_4+342.243X_5-19.306X_6+79.675X_7+80.039X_8$ +E Where, WTP= is willingness to pay; X_1= is level of education of the respondent; X_2= is the number of livestock owned per household; X_3= is the sex of household head (a dummy variable male=1; female =0); X_4= is household income per annum (KSh.); X_5= is presence of soil management structures (dummy yes=1; no=0); X_6= is the size of land under irrigation (in acres); X_7= is the distance from the water source (in km); X_8= is the land sizes (in acres) and, E= is the error term. From Table 3, education, sex of household head and, soil management structures did not influence respondent's willingness to pay as the parameter value is not significant and their respective standard errors very high. Household income inversely influences the WTP amount in that households with high levels of income are willing to pay less compared to those with less income. This may be as a result of the fact that those with less income derive their utilities from the forest; hence they are willing to conserve the forest. On the contrary, those households with high income may obtain their income from elsewhere apart from the forest; hence they may be less inclined to engage in conserving forests and putting in place soil management structures. The number of livestock per household is also inversely related to the WTP, meaning that those with more livestock are less willing to pay towards environmental conservation because their animals obtain food from the forest. On the other hand, those sample households with fewer animals are willing to pay more to conserve the forest. The size of the land is directly proportional to the WTP in that those with large size are willing to pay more compared to those with small piece of land.

Table 2: Concerns about Water Quality

Water Attribute	Kwanza		Mt Elgon	
	Good	Bad	Good	Bad
Turbidity	54.5	45.5	87.7	12.3
Smell	45.5	54.5	67.1	32.9
Taste	50.4	49.6	69.3	30.7
Quality	47.9	52.1	66.7	33.3
Others	48.7	51.3	51.7	48.3

Source: Household survey, 2010

Table 3: Result of Logistic Regression Model

Variable	β (Coefficient)	Std. error
Level of education of household head	49.717	963.171
No. of livestock per household	-22.042	54.941
Sex of household head (Male=1; Female =0)	347.687	499.771
Household income per annum (Ksh.)	-.006	.007
With soil management structures (Yes=1; No=0)	342.243	497.937
Size of land under irrigation (acres)	-19.306	50.181
Distance from the water source (km)	79.675	98.435
Farm size (in acres)	80.039	91.318

Source: Household survey, 2010.

Influence of the Socio-Economic Characteristics on the WTP

Table 4 reports results of influence of the socio-economic characteristics of the sample households on the willingness to pay amount for Kwanza and Mt Elgon. Relatively speaking, females are more responsive to pay towards environmental conservation than males do, and farm sizes better indicate WTP amount in Kwanza than in the Mt Elgon landscape. What interestingly emerges from these results is that the level of formal education is not a prerequisite for the WTP amount to conserve forest ecosystem services, or environmental conservation in general. Thus, the forest adjacent communities, who often have low cash income and small farm size holdings, can continue to be custodians of environmental conservation and management. This result in particular is a good pointer in terms of developing markets for environmental services, and thus the likelihoods for the local communities to embrace emerging market mechanisms for payments for the environmental services in the study area, and by extension in the similar landscapes in the region.

Table 4: Influence of the Socio-Economic Characteristics on the WTP

Variable Category		Average WTP
Sex		
	Males	371.0[a]
	Females	425.2[a]
Farm sizes(acres)		
	Kwanza (0)	3.63[a]
	Mt. Elgon (1)	2.66[a]
Education level		
	No formal education (1)	750.4[a]
	Primary (2)	421.9[a]
	Secondary (3)	432.3[c]
	> tertiary level (4)	139.2[b]

Source: Household survey, 2010, * Values followed by the same letter are statistically equal

Discussions and Conclusions

From Table 1, level of education, sex of household head and those with soil management structures do not significantly influence the respondent's willingness to pay. These are reflected in the parameter values which are not significant and their respective standard errors are very high. Household income inversely affects the WTP, as those households with high levels of income are willing to pay less compared to those households with less income who are willing to pay more. This may be as a result of the fact that those households with less income derive their livelihood needs directly from the forest; hence they are more willing to conserve the forest. On the contrary, those households with high income may get their income from elsewhere, apart from the forest, and hence may not be particularly interested in conserving the forest. The number of livestock per household is also inversely related to the WTP. Those households with more livestock numbers are not willing to pay much because their animals get food from the forest. Those with fewer animals are willing to pay much to conserve the forest. The size of the land is directly proportional to the WTP amount in that those with size are willing to pay more, compared to those with small piece of land. Interestingly, the level of formal education seems not to be a prerequisite for the individual WTP amount, which particularly suggests the importance of entrusting forest adjacent, and often poor vulnerable households, with environmental conservation and management efforts. The result further suggests the important role conservation agencies can play in training and strengthening environmental awareness among the local communities in the region.

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THEME 4

PAYMENT FOR ENVIRONMENTAL SERVICES FOR CARBON SEQUESTRATION

POTENTIAL OF SMALLHOLDER TREE FARMERS IN AFRICA'S ARID AND SEMI ARID LANDS (ASALS) PARTICIPATING IN CARBON TRADE

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ABSTRACT

Tree planting by smallholder farmers in Africa can lead to sustainable development and at the same time contribute to the global effort of stabilizing levels of Green House Gases (GHGs) in the atmosphere. Planting the right tree species could provide important tree products and also act as sinks of atmospheric carbon dioxide. Such programs can be used to offset carbon dioxide emissions in industrialized countries whose emission levels have been capped. This could help the smallholder farmers to benefit from selling carbon credits. Many countries in Africa have met the requirements under the United Nations Framework Convention on Climate Change (UNFCCC) for hosting forestry projects under the Clean Development Mechanism (CDM). A study was carried out in Kenya's Arid and Semi Arid Lands (ASALs) to assess whether the smallholder tree farmers in this region are capable of participating in carbon-offset projects. The study established that opportunities exist for smallholder tree farmers to incorporate carbon offset as one of the tree products and therefore participate in carbon trade under the CDM or the Voluntary Carbon Offset (VCO) markets. On average, each farm is having 11.23 tons valued at 224US$. There exist in the study area community institutions in form of co-operatives and farmer groups which can be used to mobilize farmers to tap into the carbon market.

Introduction

Carbon dioxide, a major component of green house gases, is reported to be accumulating in the atmosphere at a rate of about 3.5 billion tons per annum as a result of fossil fuel combustion and tropical deforestation. In light of the potential negative socioeconomic and environmental consequences likely to be faced by the global community, the 1992 United Nations Conference on Environment and Development (UNCED) agreed to a convention on climate change to stabilize Green House Gases (GHG) levels in the atmosphere at a level that would not cause dangerous changes in the global climate (FAO, 2001). The United Nations Framework Convention on Climate Change (UNFCCC) was conceived to coordinate the programmes to stabilize GHG levels. At the third conference of the parties to the UNFCCC in 1997 in Kyoto Japan, a set of nationally differentiated emission targets of green house gases were agreed, subject to ratification, by industrialized economies for the first commitment period between 2008 and 2012. Developed countries agreed to reduce green house gas emissions to an overall average of 5.2 % below 1990 levels. No emission reduction targets were assigned to developing countries.

In Africa, on farm tree planting can be an important carbon sequestration strategy due to its huge carbon storage potential in plant materials and its applicability in agricultural lands. By planting trees on farm, farmers can raise the productivity of their land through the added sale of the tree crop. In other words, trade in carbon credits from carbon sequestered in the tree crop can provide an extra benefit to farmers. There are many parts of Africa that consist of fragile ecosystems and are generally inhabited by poor households. Some of these areas are currently characterized by poor and erratic rainfall that leads to poor crop productivity. Continuous cropping in these fragile ecosystems and extensive vegetation clearing has resulted in severe land degradation. Addressing the problem of the high poverty levels, declining crop yields and wanton environmental degradation in many parts of Africa requires exploitation of all opportunities to raise the productivity of the land and restore degraded ecosystems. Tree farming presents an appropriate opportunity to raise land productivity and arrest land degradation in these areas. Carbon sequestered by growing trees is a recognized tradable environmental service, in addition to tree products, and can be used to boost income levels from the tree component of farm forestry systems. However, information on the amount of carbon available for purposes of guiding both farmers and investors willing to participate in exploiting the opportunities presented by CDM is scanty. Requisite information on the abilities of farmers to participate in carbon trading is very crucial, not only to guide farmers and investors, but also to inform participating governments and policy makers. This information is important as the process is governed by rules that host governments, farmers and investors must conform to. The objective of the study was to assess whether the smallholder tree farmers in the ASAL region have the capacity to participate in carbon-offset projects, and if not, to determine the main constraints to their participation.

Materials and Methods

Study Area

The study was carried out in Siakago division in Mbeere district, Eastern Province of Kenya. The district falls mainly within the Lower Midland 5 (LM5) agro ecological zone (Jaetzold and Schmidt, 1983). The average annual rainfall is 700 mm and the mean temperature is 21^{0}C. Small scale crop farming and rearing of livestock are the main pre-occupation of the farmers (Ministry of Planning, 2002). The division has a population average density of 95 persons per km^2. High level poverty characterizes the division, with 60% of the population living below the poverty line (Ministry of Planning, 2002).

Data Sources

Both primary and secondary data were used. Secondary data was obtained from government offices, local NGOs and local leaders. Primary data was obtained through interviews of farmers and key informants. Observations were made through transect walks. Semi- structured interviews were used to collect data from household heads and key informants. For purposes of assessing the amount of carbon resources within the farm, actual measurements of trees on farm were carried out to determine biomass accumulation. A total of 250 farms were sampled for the administration of the questionnaire. This number formed the basis for which the attributes of the community and their land holdings as a whole were estimated. Twenty six farms were further randomly sampled to estimate the amount of above and below ground carbon sequestration under different on farm tree planting methods. Carbon Sequestration was determined by calculating the biomass of different tree species and ages within the farm holdings under different tree planting methods. Individual tree parameters that were collected in the field included tree species, diameter at breast height (DBH), tree height and root collar diameter for seedlings below 5cm DBH. The number of trees under each farm forestry technology was also collected. Tree biomass was calculated using established allometric equations that rely on the empirical relationship between the tree diameter and above ground biomass developed by Brown *et al*. (1989). The constants and coefficients used are those developed for areas with rainfall less than 1,500 mm per annum. The above ground biomass was calculated using the formula;

$$Y=34.4703-8.0671DBH+0.6589DBH^2$$

Where Y= biomass in kg per tree and, DBH= diameter at breast height. This method was applicable for trees of DBH of 5 cm or more. A recommended for tropical ecosystems, above ground tree carbon was estimated at 50% of the total above ground biomass (MacDicken, 1997) while, below ground biomass was estimated at 10% of above ground biomass (Hamburg, 2000). Once the total biomass and carbon amounts were calculated for individual farm holdings, the quantities were divided by the area of the farm holdings to get the production per acre. For purposes of valuation, a value of US $20 per ton of carbon that is normally used in World Bank calculations was employed.

Results and Discussions

Available Carbon Stocks within the Farms

All the farm holdings sampled can be classified as smallholder afforestation and reforestation project activities within the CDM definition. This makes them eligible for the simplified assessment and monitoring procedures awarded to low income smallholder carbon producers under CDM in view of their subsistence nature, low individual carbon stocks and the need to provide a mechanism to reduce transaction costs that go with the process. The combined accumulated carbon stock in the 26 sampled smallholder farms was 291.96 tons (Table 1). Using upper end market price of $20 per ton of sequestered carbon, the value of carbon sequestration resources from the sampled farm holdings is equivalent to US$ 5,825.2 with an average carbon sequestration level per farm of 11.23 tons (market value of US$ 224).

Table 1: Carbon Sequestration Levels in the Sampled Farm Holdings in Siakago Division

Number of farms.	Above ground Biomass (Kg)	Above ground carbon (Kg)	Below ground carbon (Kg)	Total carbon (Kg)	Total carbon (Tons)
26	530,840.48	265,421.24	26,542.12	291,963.37	291.96
Average	20,416.94	10,208.51	1,020.85	11,229.36	11.23

Smallholder tree planting project activities as defined within the CDM are expected to result in net anthropogenic GHG removal of less than 8 kilotonnes of carbon dioxide per year and implemented by low-income communities and individuals. This allows them to enjoy simplified assessment and monitoring procedures (IPCC, 2001). Average annual carbon sequestration per hectare within farm holdings studied is about 2.08 tons per hectare which compares well with the Watson *et al*. (2000) average carbon sequestration rates range of 1.5 to 3.5 tC per ha for smallholder farm forestry systems in the tropics. In an area where extreme poverty levels have been estimated at 60%, sales of carbon are likely to boost family incomes by providing an extra income from the trees. Further analysis revealed that a maximum of 712 smallholder farmers would be required to achieve the 8,000-ton threshold carbon. This provides an opportunity to farmers to jointly participate in the program and reduce transaction costs. To put the figures in perspective, between 10 and 15 small-scale farm forestry projects would be required to cover the whole of Siakago division. This may result in high transaction costs (Roshetco *et al*., 2002; Cacho, 2003). The challenge therefore is to develop bundling mechanisms to reduce costs. It may be necessary to identify intermediaries for carbon trading who can help decide how farmers share the costs and benefits.

Carbon Sequestration within Different Tree Planting Designs

Boundary planting was found to be the most preferred option for tree establishment in the study area (Table. 2). With a total of 175 tons of carbon sequestered under this system, and a total carbon value of US $ 3,500, boundary planting represents 61% of the total carbon resources sequestered within the farm holdings in Siakago division. Inter-planting of trees with food crops and establishing woodlots are also popular tree planting methods in the area where there is a combined total carbon stock of 78.54 tons valued at US$ 1570.8. Other tree planting methods practiced in the study area include windbreaks and homestead planting. The tree species that is most popular in the area is *Grevillea robusta* and has sequestered 52.25% of the total carbon stock. It is a fast growing species making it highly preferred by farmers.

Other tree species grown include *Senna siamea* and *Melia volkensii.* They are also fast growing and have superior wood quality for timber, poles, fuel wood. They are becoming popular with farmers althoough the main problem with *Melia volkensii* is seed germination.

Table 2: Trees and Estimated Carbon Value in Different Tree Planting Methods in Siakago Division

Planting method	No. of Trees	Total Carbon (Tons)	Price/Ton (US$)	Carbon value (US$/ Technology)
Boundary planting	3,793	175.00	20	3,500
Homestead planting	560	23.14	20	462.8
Inter-planting	819	43.93	20	878.6
Windbreak planting	318	14.37	20	287.4
Woodlots	949	34.61	20	692.2

Conclusions

Farmers in Siakago division are eligible to participate in small-scale CDM project. This would allow them to enjoy simplified baseline and monitoring methodologies and make their participation in the CDM process easy and cheap. This methodology also allows bundling of project activities, thereby enabling farmers within the area to participate as a group for further reduction in individual costs and easy access to education materials. Tree species selection as currently done by smallholder farmers for incorporation within the agricultural systems are suitable for raising overall land productivity and do not compromise food security. *Grevillea robusta, Senna siamea, Melia volkensii*, and other trees species that are promoted within the area are appropriate for incorporation into the farmlands as they are fast growing, easily coppice, enhance overall land productivity and promote positive ecological and economic interactions within the farming system. Within the framework of UNFCCC under which CDM activities would operate, the tree species satisfy the definition of a tree as contained in the Kenyan communication, promote biodiversity conservation and possess important attributes for sustainable development.

Tree planting as practiced in Siakago division fulfils the additional requirement of CDM projects by providing verifiable carbon credits beyond those achieved by original land use, while at the same time encouraging carbon credits that are secure over a long time. On farm tree planting is also unlikely to result in any significant project leakage as it puts emphasis on diversification and sustenance of household incomes. Significant carbon stocks exist within the small holder farms and have accumulated mainly after year 2000, with average carbon sequestration level per farm holding at 11.23 tons, with a market value of US$ 224.6. These stocks could be used as residue stock for purposes of initiating carbon offset projects for participation within the CDM. Under the current rules for small-scale carbon offset projects, tree based carbon stocks do not form part of the baseline scenario and would therefore qualify for issuance of CER's. These stocks can act as incentives for more investment in on farm tree planting.

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SOIL ORGANIC CARBON CONTENT UNDER DIFFERENT LAND USES IN THE MT. ELGON ECOSYSTEM, KENYA

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ABSTRACT

This study compared total soil organic carbon in soils from a mature primary undisturbed 30-year old forest with that from 5-year old secondary forest plantation and 20-year old coffee plantation in Cheptais forest of the Mt. Elgon ecosystem. Insights into its potential for soil carbon sequestration are essential in developing carbon offset products from the ecosystem. Data was collected from plot sizes of 50m by 50m (2500 m^2) set up at different landscapes depicting different land use types. Soil profiles were excavated to a depth of 40 cm at representative points within each plot. Three separate soil samples were taken from 0- 10 cm, 10-20 cm and 20-30 cm starting with the lower depth. Total organic carbon was estimated using chemical combustion method. The undisturbed forest had higer levels of SOC compared to the coffee cropped land. With the opportunities presented by Reducing Emission from Deforestation and Degradation (REDD) and Payment for Environmental Services (PES), the productive landscapes should indentify strategies that improve the SOC and package them for possible consideration in the carbon market and other carbon offset programs for ecosystem management in the region.

Introduction

Soils as a carbon sink are proposed in recent years as a strategy for mitigating the effects of elevated carbon dioxide (CO_2) concentration (Lal, *et al*., 1999; Lal. 2002, 2005). In order to determine the potential of soil to absorb carbon, estimation of soil organic carbon (SOC) content under different land use and management practices needs to be assessed through estimation of C stocks in exiting land uses (IPCC, 1997). Soil organic carbon (SOC) shows variability according to land use and soil depth which generally diminishes with depth. Land management practices regulate carbon sinks. Land use, erosion and reafforestration are significant in controlling the soil carbon cycle. Some of the common activities that affect soils are shifts in land use or shifts in cultivation. The shifts in land use are manifested through the influence in the amount of plant residue input and therefore soil organic matter.

Different tree species and the set up of the tree species (forest structure) have a different impact on soil carbon dynamics (Paul *et al*. 2002, Glenday 2006, Russell *et al*., 2007).

Studies conducted by Glenday, (2006) in the Kakamega forest, a tropical forest in Kenya, estimated C stocks in an undisturbed indigenous forest at 356 t C ha^{-1} compared to 94 and 108 t C ha^{-1} in a 10-year Eucalyptus saligna and 30-year *Cupressus lusitanica* plantations, respectively. Kamau, *et al*., (2008) reported that in Kenya biomass C in tea plantations ranged from 43 to 72 t C ha^{-1} which compared with C stored in tree plantations of 30 years of age. With conversion of land use from such forests, the estimated carbon stock will be released. Given its vast area, the Mt. Elgon ecosystem is a potential carbon sink capable of contributing to terrestrial carbon stock in the East African region. Insights into its potential for soil carbon sequestration are essential in developing carbon offset products from the ecosystem. This study aims at quantifying the amount of soil organic carbon under dominant land use types in the hilly Mt Elgon ecosystem. The results obtained will provide a valuable baseline for evaluating changes in SOC associated with conversion on productive landscapes; and the information will provide a basis for developing carbon offset programs for ecosystem management in the region.

Materials and Methods

Study Area

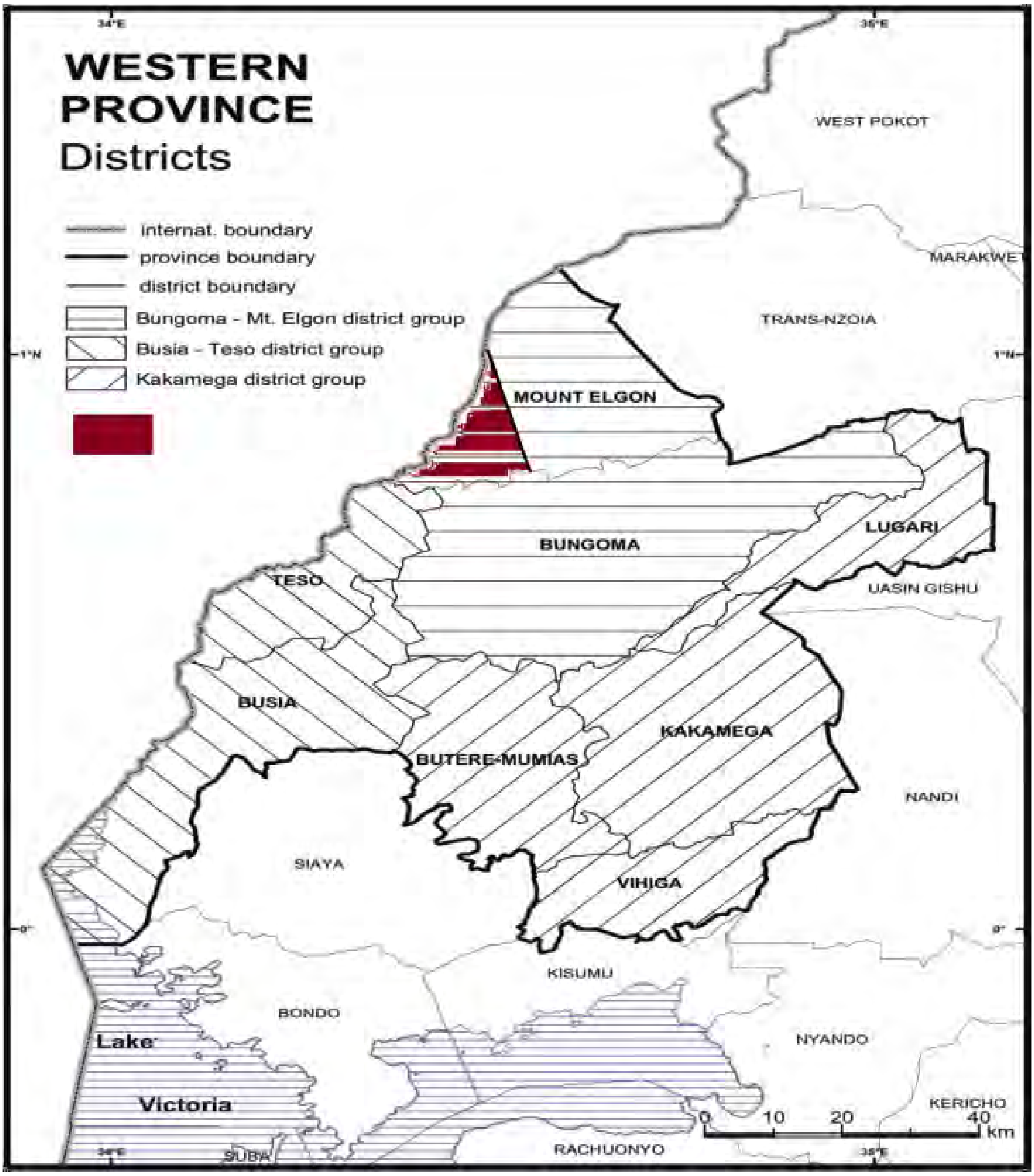

Figure 1: The Mt Elgon ecosystem

The Mt Elgon ecosystem (Figure 1) lies between latitude 2.50 S and 1.50 N, and longitude 320 and 350 E, and is bisected by the border between Kenya and Uganda. Figure 1 shows the location in Kenya where the ecosystem spans an area of 107,82 ha (Forest Department, 2000) and falls within the Trans Nzoia and Elgon districts; and has an altitude of up to 4250 m above sea level in the Kenya part of the mountain. The ecosystem is made up of protected areas which include indigenous and plantation forests, a national park and a national reserve which are under the jurisdiction of the Kenya forest service and the Kenya wildlife service, respectively. Settlements are located on the slopes of the mountain, with a small community of an indigenous tribe living within the forest reserves. The landscape consists of low hills with steep slopes (23% on average), and the most common soils are relatively young, poorly developed, sandy loams (Cotler *et al*., 2002). Using the FAO system, the soils found in the area can be grouped into Luvisol, Cambisol, Rigosols, and Fluvisols.

Soil Sampling and Data Analysis

Soil sampling sites were selected to represent each of the dominant land use types within the ecosystem. Plot sizes of 50m by 50m (2500m^2) were set up in each land use type. Soil profiles were excavated to a depth of 40 cm at representative points within each plot. Then three separate soil samples were taken from 0- 10 cm, 10-20 cm and 20-30 cm starting with the lower depth. Soil samples were air dried, sieved through a 0.5 mm sieve and then analysed for total organic carbon by the chemical combustion method as outlined in Okalebo et *al*., (2002). Soil reaction (pH) was determined with a pH electrode at soil /water ratio of 1:1 (Hesse, 1971); Soil bulk density (BD) determined by the core ring method which involves driving cores into the soil by hammering until sufficiently filled (Blacke and Hartge, 1986). The soil carbon stock was calculated using the following equation, C (t / ha) = [(soil bulk density, (g / cm3) Ч soil depth (cm) Ч OC g/kg)] Ч100. Data was analyzed using Genstat, the one way analysis of variance (ANOVA). Statistical significance was calculated using turkeys test at P< 0.05 level.

Result and Discussions

Soil Bulk Density

Figure 2 shows that the conversion from forest to coffee increased soil bulk density (BD). Undistrubed soils had a low bulk density that can be attributed to less disturbance through tillage or commercial harvesting. On the other hand, the coffee plantations had a high BD indicating compaction.

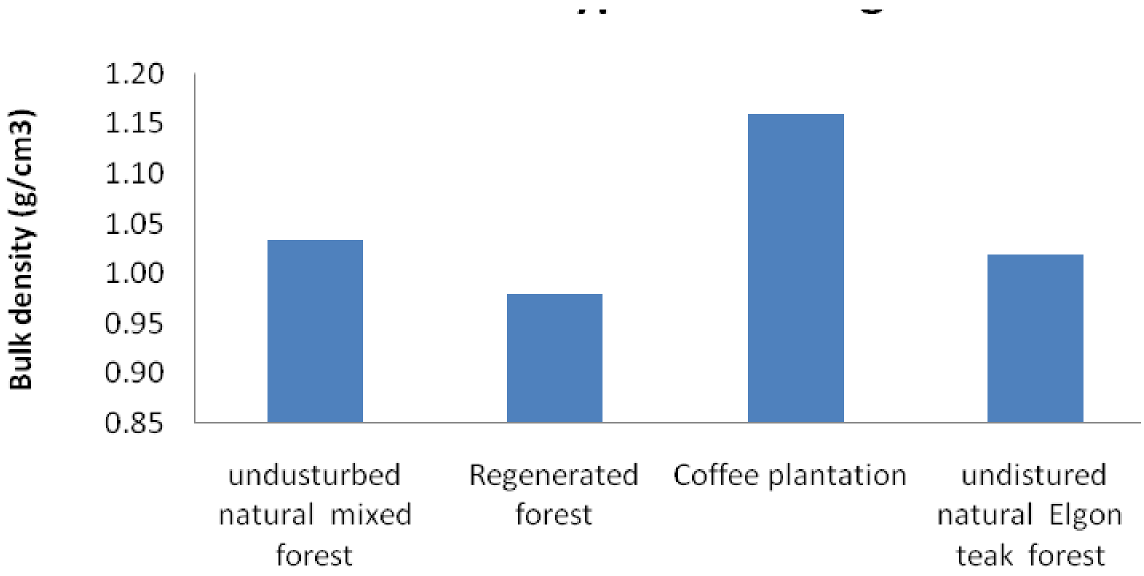

Figure 2: Soil Bulk Density at 0-15 Soil Depth for Four Land Use Types in Mt. Elgon

Soil Organic Carbon Content

The impact of cultivation was pronounced for the top 10 cm for coffee plantations and regenerating plantation. The undisturbed forest had higer levels of SOC compared to the coffee cropped land and regenerating forest which had been under cultivation for 10 years before regenarating in the last 5 years. The low SOC can be attributed to breakdown of soil aggregates and a high rate of C mineralization (Lal 1999). The amount of SOC in deeper profiles varies across land used with high C amounts in 20-30 cm depth for coffee plantation. There maybe redistribution due to tillage or deep rooting.

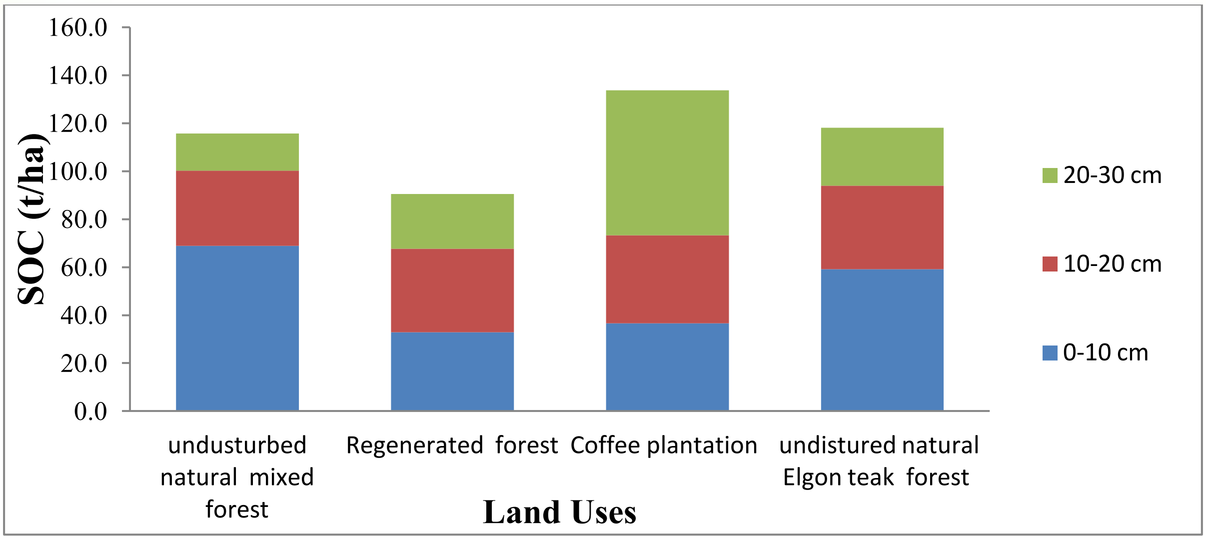

Figure 3: Soil Organic Carbon in different depths under various land uses in Cheptais forest, Mt. Elgon, Kenya.

Conversion to cropland reduce SOC in 0-10 cm and increased in 20-30 cm depth. Cultivation increased SOC due to increased translocation of SOC. Whole soil profiles need to be assesed in order to get accurate assesment of the correct SOC pool. Because of their natural regeneration and higher plant diversity, secondary and regenerated forests have higher carbon stocks similar to natural forests due to higher biomass returns.

Conclusions

This study has demonstrated that soil organic carbon varies with the different land uses.SOC acts as a good indicator of the effects of land use change from forest to intensively managed systems, such coffee plantation and other agricultural uses. With the opportunities presented by Reducing Emission from Deforestation and Degradation (REDD) and Payment for Environmental Services (PES) the productive landscapes should indentify strategies that improve the SOC and packaged for possible consideration in the carbon market. It is imperative that conversion of lands to different possible use causes alteration of the SOC stocks. In order to mitigate the impacts of climate change, there should be concerted efforts to assess the changes in SOC from all productive landscapes to identify any synergism or antagonism of land use arrangement in different productive landscapes.

Acknowledgements

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ASSESSING THE ABILITY OF COMMUNITIES AROUND MT ELGON TO PARTICIPATE IN CARBON SEQUESTRATION PROGRAMS THROUGH THEIR FARMING SYSTEMS

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ABSTRACT

Agroforestry is a dynamic, ecologically based natural resource management system which, through integration of trees on the farm and their agricultural landscapes, can contribute immensely towards carbon sequestration in the smallholder farming systems. This paper analyses the impact of changing land use practices on livelihoods of the smallholder rural people in Eastern Mt Elgon region; and presents information on the factors that influence adoption of agroforestry technologies by the region's households to sequester carbon. It was observed that the smallholder farmers' level of adoption of agroforestry technology is low. Farm size, formal ownership of land, involvement in farm-based transactions on contract and income from sale of timber and non-timber products all negatively contributed to the farmers' probability of adopting agroforestry technologies. Of the total number of farms visited, agroforestry adoption was found only in 68% while the rest had not intitated agroforestry on their farms. It was observed that most (75%) farmers may adopt agroforestry if it is promoted in the form of PES for Carbon Sequestration payment programs in a manner that leads to poverty alleviation. Institutional support, recognition of indigenous knowledge and property rights while engaging collective management structures that enhance smallholder participation would also be important stimuli for PES.

Introduction

The Intergovernmental Panel on Climate Change (IPCC) predicted that global temperature could rise by as much as 5.8°C above 1990 levels due to increases in greenhouse gases (Nakicenovic *et al*., 2000). Deforestation, agricultural activities and combustion of fossil fuel and other industrial activities have contributed to increased carbon dioxide and other Green House Gases (GHGs) (Maryland *et al.*, 2003; IPCC, 2000). This phenomenon has weighty implications on the climate at local, regional and global scales, particularly impacting negatively on on agriculture and food production systems (Brown *et al.*, 2008). The IPCC predicts that Climate change will affect developing countries more severely because of their low capacity for adaptation (IPCC 2001) and therefore will interfere with most African countries' ability to meet urgent rural development demands, including the improvement of food security, poverty reduction, and provision of an adequate standard of living for growing populations. This is because the agricultural sector is highly climate-dependent and thus vulnerable, putting especially the rural population at risk.

Both the IPCC and the Kyoto protocol recognize that positive land use activities such as reducing deforestation, expansion of forest plantations, agroforestry, reducing soil degradation and rehabilitating degraded forests (IPCC, 2000; Tipper, 1997; Niles *et al.*, 2002) and good soil management practices such as use of cover crops provide great potentials for terrestrial carbon sinks. Agroforestry is a dynamic, ecologically based natural resource management system that integrates trees on farm, diversifies and sustains agricultural landscapes and production for increased social, economic and environmental benefits. It can also contribute immensely towards carbon sequestration in the smallholder farming system (Boye *et al.*, 2005; Tolentino *et al.*, 2009). In other words, investments in carbon sequestration could represent valuable financial inflows for developing countries (Jindal *et al.*, 2008). If undertaken with small land holders, carbon sequestration projects can help alleviate rural poverty and improve local livelihoods in developing countries (Tipper, 2002).

The objective of this study was to evaluate the socio-economic factors that influence the probability and level of adoption of agroforestry technologies that can sequester carbon. This study analysed effects on land use on livelihoods of smallholder rural people in Eastern Mt Elgon region. It further examined whether growing trees on the farm leads to carbon sequestration that could enable rural farmers benefit from carbon offsets.

Materials and Methods

The Study Area

This study was conducted in Cheptais and Kwanza districts which form part of the Eastern Mt Elgon Ecosystem, in Kenya.

Household Interviews

Smallholder farmers' ability to participate in carbon sequestration was assessed using semi-structured questionnaires and focused group discussions. A total of 240 randomly sampled household heads were consulted during the interviews. Two focused group discussions were held to cross check the answers from individual interviews. Questions aimed at capturing issues relating to willingness, opportunities and constraints for effective and sustainable participation in carbon sequestration activities among the target communities were asked and answers recorded.

Theoretical Analytical Framework

Tobit model was used to evaluate the socio-economic factors that jointly influence the probability and level of adoption of agroforestry. The model is based on the assumptions that household decision on allocating resources among activities depends on the relative returns each provides. For example, farmers will shift to agroforestry if the incentives are higher than those of alternative land use activity (de Jong *et al.*, 2000). The farmer's decision to participate in carbon sequestration and thus provide carbon offsets is determined by the incentives for and capabilities of the farmer (Feder *et. al*, 1985). The adoption decision is a behavioural response arising from a set of alternatives and constraints facing the decision maker, in this case the farmer. These alternatives and constraints are weighed against each other in the mind of the adopter to bring about the observed choice, which is either to grow trees on farm or not. Conceptually the decision can be related to the set of alternatives and constraints facing the decision maker, thus providing theoretical underpinnings during analysis. Given two discrete choices, 'i' and 'j', the probability of choosing 'i' over 'j' occurs when the utility of 'i' is greater than that of 'j', that is; $U_{in} \geq U_{jn.}$ Therefore the probability of an individual'n' choosing 'i' is Pr (i) = Pr $\{U_{in} \geq U_{jn}\}$, while that of choosing 'j' is Pr (j) = 1 – Pr (i). The utility function, although unobserved, is a function of observed characteristics (Adesina and Zinnah, 1993);

$U_{in} = V_{in} + e_{in}$, and $U_{jn} = V_{jn} + e_{jn}$,

Where 'e's are the random components, V's are the deterministic components, and can be written as $\beta_1 X_1, + \beta_2 X_{2\ldots} + \beta_n X_n$, Where, the estimated parameters (β's) are marginal utilities and the X's are the observed characteristics. Replacing U with V and e in the above equation gives Pr (i) = Pr$\{ U_{in} \geq U_{jn} \}$, and re-arranging the components gives Pr(i) = Pr$\{e_{jn} - e_{in} \leq V_{in} - V_{jn}\}$. Thus the differences in the error terms ($e_{jn} - e_{in}$), are the same differences in the observed characteristic.

Data Analysis

Data from pre-coded questionnaires was entered in the statistical package for social scientists (SPSS) version 12, cleaned and analyzed to obtain descriptive statistics and cross tabulations which provided a general description of the characteristics and performance of smallholder agriculture in the study area. Analysis for socio-economic variables was desegregated into age and gender. Analysis was done for impacts of labour on participation in carbon sequestration activities; household income generating opportunities on incentive to participate in the activities; existing land use systems and tree growing activities and inherent potential for carbon sequestration in the ecosystem; contribution of tree and tree products to household needs and marketed products as an incentive to keep such tree and tree crops in the production system; land tenure system and its impact on willingness to invest in long duration tree-based, agro-enterprises as opposed to short duration crops; and farmer willingness to participate in tree and tree crop growing as part of the general land use system.

Results and Discussions

Household Characteristics

Study results showed that the average household size was 5 persons per household, with majority percentage of household heads having at least a primary level formal education. It was found that all respondents had access to land, which suggests that land as an important resource in Mt Elgon landscape was not a limiting factor for the resident households. From the study findings three types of land tenure were discernable i.e. customary, freehold and leasehold. The study revealed that some 37% of the households have formal ownership of land and possess title deeds, while some 10% of the sampled households had subdivided their land parcels. The most common form of land acquisition was through purchase (36%) and inheritance (37%) but some 20% of the respondents also said that they leased additional land to increase their production at an average land rent of US$62.5 per acre per year (in 2010).

Land Use, Farming Systems and Livelihood Dynamics

Eighty seven per cent (87%) of the interviewed households depended on agriculture and agricultural related activities for their livelihood, of which mixed farming was prevalent. The average farm size was 2.5 acres and 4 acres in Cheptais and Kwanza districts, respectively. The common cash crops grown in the area are maize, beans, Irish potatoes, onions and tomatoes. All maize farmers sold part of their harvest to the Kenya's Cereal and Produce Board and local business people. The proportion of maize sold varied with the quantity harvested as those with big harvest sold a greater portion of the harvest. The average income from crops in Cheptais was $1,250 per year with 30% of the income generated from sale of onions. In Kwanza farmers' average annual income was $1,500; of which 70% was from maize. Only 20% of the households grew coffee. According to the respondents many coffee growers have shifted to maize growing after sustained periods of depressed coffee prices, mismanagement of co-operative societies, high cost of inputs and low productivity. Nevertheless, all the respondents observed that there is a general decline in crop production resulting into low farm income in the two districts.

The study found that residents of Mt. Elgon region source fuel wood and medicinal herbs from the neighbouring forest and sold this to supplement their income. It was found that some 15% of the respondents sold fuel wood to supplement their income, but only 3% of the respondents/households acknowledged that they earned $37.5 from the sale of medicinal herbs that were sourced from the forest. The household livestock enterprise comprised of 4 cross-bred cattle on the avarage, some goats, sheep, poultry and pigs. Livestock had a dual importance for livelihoods; to improve diet and generate income. According to local extension officers, since the KWS and KFS banned wildlife hunting, many forest adjuscent communities have taken to increased livestock keeping to enable them maintain their animal protein consumption levels and for sale(Situma Per com.). This phenomenon has seen increased dependency on pastures from the forest so that the KFS now charge grazing fees at the rate of $ 0.625 per mature animal per month since zero grazing units or tethering of the animals is rare in the area. It was found that income from livestock and livestock products generated an average of US$ 437.5 per year per household, even though both the respondents and extension officers observed a general decline in the livestock enterprise in the area. During focused group discussions farmers attributed this decline to increased cattle rustling among communities and across the Kenya/Uganda border. They observed that the nearby forest acts as hiding place for the stolen livestock. This view could hinder community partcicipation in forest conservation and rehabilitation activities desired by both KWS and KFS and even lead to further forest degradation unless alternative mechanisms such as PES initiatives are put in place to better engage and compensate the residents on their efforts.

Table 1 show that 82% of the households reported changes (decline) in their income generating activities over the past 10 years. A majority of the farmers attributed the change to poor functioning of the market which made farming enterprises unprofitable as the ratio of benefit to cost was always less than one. But in addition, farmers appreciated the fact that continuous farming on slopping land has led to a decline in soil fertility, leading to low yields and hence food insecurity and a drop in farm income. Focused group discussions and respondents interviewed revealed that agricultural activities were affected by the fluctuating seasonal calendar which had induced more vulnerability to the smallholder agricultural production system. They also remarked that changing status of the natural resources rendered previously sustainable land management practice unsustainable.

Table 1: Causes of Changes in Smallholders' Income Generating Activities (2000 -2010)

Cause of Change in Income	% Respondents
Subdivision of land	56
Reduced soil fertility	72
Post harvest losses	48
Animal diseases	54
Cattle rustling	36
Strong wind	61
High input prices	80
Low output prices	82

Source: Authors survey, 2010

Land Use Activities that Sequester Carbon

Soil and water conservation technologies adopted by farmers that can lead to carbon sequestration are summarized in Table 2. Land management practices that can restore degraded soils varied between landscapes and between districts. Kwanza district is situated on the leeward side of Mt Elgon and receives low rainfall. Most farmers in this area use plant residues and grow other plants to protect soil from degradation and minimize soil moisture losses. Use of compost manure using crop residues and planting agroforestry trees are the prefered technologies for soil and water conservation. It is worth noting that adopting these practices, especially agroforestry will have the potential to sequester carbon and deserves to be promoted and supported. It was found that 70% of the respondents had some trees on their farms. The urge for tree planting resulted from restrictions imposed on accessing the natural forest. Trees were also grown on farms for purposes of soil conservation. Agroforestry systems were used to make more effective use of scarce land, labour and nutrients. Those measures increased the carbon density of existing agricultural systems while at the same time they improved economic productivity. Some 35% of the respondents had woodlots for fuel wood and construction materials. Trees on the woodlots were mainly *Eucalyptus* and *Pinus* species. Others were *Grevillea robusta*, *Codia abysinica* and*Codia Africana to provide* shade.Trees planted along the boundaries as wind breaks included *Croton, Grevillea robusta and Markhamia lutea*. Coffee was also observed in several farms during the study. *Prunus africana* was grown for medicinal purpose by 10% of the respondents, while 7% grew fodder trees in home gardens to provide high quality nutritious livestock feed. Only 8% of the respondents had fruit trees on their farms-avocado, loquats, quavas, castor apple and mangoes were some of the fruit trees grown in the homesteads. The fruits were grown for both subsistence and commercial purposes. Indigenous trees were grown in riparian buffer zones by14% of the farmers. They were important for providing the ancillary environmental benefits to water quality and for providing wildlife habitats, especially in these riparian areas.

Table 2: Soil and Water Conservation Technologies adopted in Mt Elgon Landscape

Technology	% of respondents
Agroforestry	68
Cover cropping	28
Terracing	36
Retention ditches	25
Compositing/green manure	74
Contour planting	45
Crop rotation	52

Source: Authors survey, 2010

Farmers' Willingness to Plant More Trees

The study recorded that 85% of the respondents were willing to plant more trees in woodlots even as their preferences and reasons varied with species and benefits derived from such plants. *Grevillea* species was desired by 62% of the respondents for its contribution to soil fertility, as a source of fuel wood and timber; *Eucalyptus* species was preferred by 38% of the households for their fast growth, use as building material and ability to regenerate after harvest; and indigenous tree species were preferred by 27% of the respondents for their medicinal value, production of hard wood and preventing soil erosion. Fruit trees were favoured by 25% of the farmers for their multi-purpose attributes - food, shade, income generation and source of fuel wood. Some farmers desired to increase acreage of *Pinus* species on their farms to meet their demand for timber. The results further showed that 37% of the respondents had access to agricultural extension services which they perceived to have improved their knowledge on land use technologies that leads to carbon sequestration. However, lack of funds to invest in agroforestry, poorly defined property rights and risks associated with food insecurity were some of the challenges faced by the smallholder farmers in their attempt to grow more trees on farm. It was further found that only 13% of the respondents had experience of farm-based contracts having been contracted by British American Tobacco Company (BAT) to grow tobacco. However, 75% of the farmers involved in the contract stated that the products were of low prices and were unfavourable to them. The farmers indicated lack of information on contractual obligations required in carbon sequestration and carbon trading.

Farmers' Ability to Participate in Carbon Sequestration through Agroforestry

Table 3 shows that households with high income had 0.18% increase in probability of adopting agroforestry and increased their land under agroforestry by some 0.19%. It was observed that households with non-farm income invested in agroforestry, thus depicting interdependence between farming and the non-farm sector. Male-headed households increased the probability of agroforestry adoption by 0.11%. However, educated men showed a negative association with agroforestry and would rather engage in other activities, probably off-farm. Data analyzed from this study depicts that a one-acre increase in land size was associated with 0.27% increase in the probability for agroforestry adoption, suggesting that the size of land holding is a key determinant of whether or not farmers will adopt the technology. The study showed that the farmers with over 10 years adoption of other soil conservation technologies had 0.08% probability of adopting agroforestry and 0.3% increase in the portion of land under Agroforestry. This implies that there is a possibility of increasing tree-based carbon sinks in the smallholder farming systems. The farmers with formal land ownership (possessing land title deeds) had 0.28% probability of adopting agroforestry technology, and 0.41% increase in portion of land under agroforestry.

Farmers who had been involved in farm-based contracts had 0.27% probability in adopting agroforestry and 0.31% increase in the proportion of land under agroforestry. Signing a 20-year contract of having trees on the farm reduced the probability of adopting agroforestry by 0.22%. This reveals the farmers' inability to adopt and maintain the required land use and management practices due to uncertainty about long term productivity benefits of the practice, price uncertainty and political risk. It also means that the community would not accept restrictions on their current land use options for a nebulous social goal accrued to an outside investor. Farmers who belonged to farmer groups/ association had 0.34% probability of adopting agroforestry and 0.4% increase in portion of land under agroforestry. This is attributed to the effect of Common Interest Group (CIG) approach adopted by the ministry of agriculture in Kenya for technology dissemination. Most of the farmers were members of tree nursery self help groups where they raised trees in the nurseries and sold as a group. This means that there is a possibility of smallholder farmers providing carbon offsets through common property arrangements to reduce the transaction costs involved in carbon trading.

Table 3: Estimated Marginal Effects for Adoption of Agroforestry

Independent Variable	**Total Change in Adoption**	**Change in adoption Intensity**	**Change in Adoption Intensity Probability**
Monthly Income category of household	0.19(0.0105)*	0.005	0.18
Gender of household head	0.111(0.0145)*	0.0376	0.110
Age of household head (years)	0.193(0.0529)	0.005	0.0191
Education level of the household head	0.003(0.0248)*	0.0003	0.001
Education by gender	- 1(0.03)	-1	- 0.2
Present land size (in acres)	0.373(0.186) **	0.166	0.27
(Formal ownership of land	0.410(0.2609)**	0.075	0.28
Proportion of land willing to put to agroforestry %	0.122(0.0115)	0.034	0.078
Soil conservation practice (10 years ago)	0.300(0.1565)*	0.067	0.245
Amount of money got from sale of tree& tree products	0.04(0.0232)**	0.001	0.004
involvement in farm-based transaction on contract	0.310(0.134)**	0.074	0.272
willing to grow trees 20 for year contract	- 0.201(0.0327)*	-0.027	-0.220
Group membership or association	0.400(0.1492)*	0.095	0.349
Off-farm income as main source of income	0.503(0.0725)	0.224	0.036
Constant 0.142; Percent of correct prediction 60% Adopters 68% ; Non-adopters 32%			

* and **indicate coefficient of significance at 5% and 10% respectively

Conclusions and Recommendations

- In Cheptais and Kwanza districts of Mt. Elgon Landscape, Kenya, agroforestry was adopted by most smallholder farmers, even if at low intensity. The farmers' interest to participate in carbon sequestration was demonstrated by their willingness to plant trees on-farms. Probability and intensity of agro-forestry technologies adoption were influenced by households' land size, formal ownership of land, involvement in farm-based transactions on contract, and income from timber and non-timber products.
- To overcome constraints in investment in land use technologies that sequester carbon, a well thought out PES scheme is necessary and any payment schemes considered could be designed to meet investment needs, or offer credit packages to participants in the sequestration programs.
- Creation of incentive mechanisms for carbon sequestration in agricultural production systems could contribute to rural poverty alleviation. Thus, payment necessary to entice a land-user to fore-go the low income would be lower for poor producers than those capable of engaging in more commercial systems. The implications are that low income land users could potentially be least cost providers of sequestration services, especially if the program addresses food security and risk management issues.
- Adopting carbon sequestering land use technologies would change labour allocation to land use as more trees are established on agricultural land. The potential return to labour released from land use activities would be an important determinant of adoption. However, in Mt Elgon region, there were few non-land use opportunities for labour employment. Consequently, labour-intensive sequestration activities could make the most attractive alternative.
- In Mt Elgon region land, politics and transboundary cattle rustling, as well as the unclear property righs are intertwined, yielding a strong hindrance to implementing carbon sequeteration programs and climate change mitigation through agroforestry. Even as great potentials for PES programmes exist, these constraints will need to be addressed for successful implementation. Furthermore, carbon sequestration payment programs which include some institutional support for clarifying and establishing property rights and forms of collective management would be appropriate for increasing the level of participation of smallholder farmers.
- Local communities need information to enable them understand the fact that carbon payments are different from financial support of other development programs, so as to enlist their support and engagementlong term (say 20 years or more) envisaged in the more or less permanence of carbon sequestered carbon contracts. To enhance this, farmers can be offered relatively short term contracts with appropriate incentives and with the option for them to renew, and price appropriately adjusted to reflect implied non-permanence of the carbon.

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CONCEPTUAL AND METHODOLOGICAL ASPECTS OF QUANTIFICATION, SIMULATION AND VALUATION OF CARBON SINKS IN MANAGED AND NATURAL ECOSYSTEMS

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ABSTRACT

Lack of institutional arrangements, and appropriate tools and methods for valuation, attribution and compensation for environmental services have long been identified as major constraints to effective participation by environmental managers in Sub-Saharan Africa, despite the emerging markets on Payments for Environmental Services (PES), such as Certified Carbon Emission Reductions (CERs). The magnitude of this scenario is demonstrated in the fact that out of the total annual global market value for trade in CERs estimated at US$ 15 billion, Africa benefits a paltry 1.4% of the market value. Key to effective participation in market opportunities availed under the auspices of CERs is the demonstration of total quantities of carbon sinks and permanency of such sinks under a contract period. A robust and generic tree-based carbon sequestration projection utility model has been developed for purposes of quantification, simulation and valuation of carbon stocks in managed and natural forests over pre-determined temporal scale. The model has as its inputs measurable variables such as project start date; project area; tree density; tree attrition; area withdrawn; annual diameter at breast height gain; root to shoot ratio; leaf and root turnover; soil carbon sequestration and, soil organic matter turn-over. Experiments were set up in Mount Elgon Ecosystem and samples of variables for validation of the model are being collected and analyzed at regular intervals. The purpose of the experiments was to validate the model, taking into account required adjustments if any, so that the model can later be applied through use of simple measument equipment, thereby reducing high costs associated with current complicated process of monitoring PES programmes.

Introduction

Carbon in the form of carbon dioxide (CO_2) is currently accumulating in the atmosphere at rate of 3.5 billion metric tones per annum (Rosenberg *et al.,* 1998), as a result of fossil fuel combustion, tropical deforestation and other land-use changes. In Africa alone, International Energy Agency (IEA) (2001) estimates that the three main energy sources, namely coal, oil and gas emit 800 million tons of CO_2 equivalent per year. Carbon dioxide is the one causing the greatest concern on account of its abundance and long life-span (up to 100 years in the atmosphere before disintegration) and also has the highest rate of increase in concentration among the greenhouse gases (GHGs) – other major ones are methane (NH_4) and nitrous oxide (N_2O). The net effect of these gases in the atmosphere is that they let short wavelength solar radiation to heat the earth's surface while they trap the out-going long wavelength terrestrial radiation, thus raising the temperature of the atmosphere with potential for significant changes in the climate.

Due to the potential impacts of climate change on the environment as a result of increasing concentration of GHGs in the atmosphere, the world community established the Intergovernmental Panel on Climate Change (IPCC) in 1988 whose responsibility was to undertake an assessment of the science, impacts, adaptation, and mitigation options in relation to climate change, and the to advise the Conference of Parties (COP) of the United Nations Framework Convention on Climate Change (UNFCCC). The clearly articulated provisions and functions of this convention, as well as that of the Kyoto Protocol (1997), have set the pace for implementation and management the levels of CO_2 and other Green House Gases (GHG) in such a manner that adverse effects of climate change are mitigated at global, regional, and national and local levels. In this connection, all countries in Easern and Central Africa are signatories to both the UNFCCC and Kyoto Protocal, and are therefore committed to observing the main features of the protocols, namely, (i) the Clean Development Mechanism (CDM) which allows for creation CERs mainly in developing countries; (ii) Joint Implementation (JI) by creating emission reduction units; (iii) International Emission Trading (IET) system; (iv) placement of a provision binding agreement by industrialized countries to reduce greenhouse gas emissions to 1990 CO_2 or equivalent levels; (v) establishment of strict measures for carbon inventory, reporting, and registry of offsets; (vi) enacting a compliance regime with distinct branches for facilitation, enforcement and putting together punitive measures for non-compliance; (vii) controlled use of forests and agricultural sinks to meet commitments; and (viii) enhancing flows of finance and technology transfer to developing countries for capacity building on climate change mitigation and adaptation.

Various components of the provisions in the Kyoto Protocol are meant to work in favor of development interests of developing countries such as Kenya, while at the same time; through CDM they enable voluntary participation with new sources of financing sustainable development and poverty reduction. Although at the sixth Conference of the Parties (COP-6) in Marrakech, Morocco, limits were placed on the nature of activities that could be undertaken and the amount of carbon credits that could be generated through land use change and forestry activities, further negotiations have led to establishment of favourable rules and actions for the case of small scale reforestation and afforestation projects. Under the CDM, net anthropogenic greenhouse gas removals by sinks have been capped at 8000 tons of CO_2 per year, meaning that any excess removal will not be eligible for issuance of Certified Emissions Reductions (CERs). Furthermore, negotiations have resulted in an initiative on "Reducing Emissions from Deforestation and Forest Degradation" (REDD), which is a set of steps designed to use market/financial incentives in order to reduce the emissions of greenhouse gases from deforestation and forest degradation, but may also deliver "co-benefits" such as biodiversity conservation and poverty alleviation. REDD credits offer the opportunity to utilize funding from developed countries to reduce deforestation in developing countries, such as in ECA. "Reducing emissions from deforestation and forest degradation" implies a distinction between the two activities. The process of identifying the two is what raises questions about how to measure each within the REDD mechanism; their distinction is therefore vital. Deforestation is the permanent removal of forests and withdrawal of land from forest use. Forest degradation refers to negative changes in the forest area that limit its production capacity. Proposed incentives for reducing GHG emissions both under the Kyoto Protocol and REDD initiatives require quantification and ascertainment of the permanence of the carbon sinks in given natural or managed ecosystems. Therefore it has been found necessary to systematically analyze literature on methods used to measure and assess terrestrial carbon stocks, using an evidence-based approach and to develop methods tailored towards estimation, simulation and valuation of carbon sinks in both managed and natural tropical ecosystems.

Conceptual Aspects of Quantification of Carbon Stocks

Estimating Carbon Stock Changes in Forest Biomass

The IPCC Guidelines for National Greenhouse Gas Inventories (IPCC, 1997) provides methods used to estimate carbon stock changes and greenhouse gas emissions and removals associated with changes in biomass and soil organic carbon on forest lands. The annual change in biomass is calculated in terms of the difference between biomass growth and loss. Greenhouse gas inventory for the land-use category under "Forest Land" involves estimation of changes in carbon stock from five carbon pools (i.e. above ground biomass, below ground biomass, dead wood, litter, and soil organic matter). The summary equation, which estimates the annual emissions or removals from forest land with respect to changes in carbon pools, is given in equation 1 following. The Annual Emissions or Removals from Forest Land (F_L) ΔC_{FL} is given by;

$$\Delta C_{FL} = (\Delta C_{FLLB} + \Delta C_{FLDOM} + \Delta C_{FLSoils}) \qquad (1)$$

Where, ΔC_{FL} = annual change in carbon stocks from forest land, tonnes C yr^{-1}

ΔC_{FLLB} = annual change in carbon stocks in living biomass (includes above- and belowground biomass) in forest land given in tonnes C yr^{-1}

ΔC_{FLDOM} = annual change in carbon stocks in dead organic matter (includes dead wood and litter) in forest land given in tonnes C yr^{-1}

$\Delta C_{FLSoils}$ = annual change in carbon stocks in soils in forest land given in tonnes C yr^{-1}

Change in carbon stocks in living biomass is calculated by multiplying the difference in oven dry weight of biomass increments or losses with the appropriate carbon fraction. Methods for estimating biomass increments and the losses are presented below. Biomass increments include biomass growth. Losses include fellings, fuelwood gathering, and natural losses. Two methods can be used to estimate carbon stocks in the natural and plantation forests , the default method (Method 1) and the stock change method (Method 2) (IPCC, 1996). The default method is where the biomass carbon loss is subtracted from the biomass carbon increment for the reporting year and is illustrated in equation 2 following.

$\Delta C_{FLB} = (\Delta C_{FG} - \Delta C_{FL})$ (IPCC, 1996) **(2)**

Where, ΔC_{FLB} = annual change in carbon stocks in living biomass (includes above- and belowground biomass) in forest land, tonnes C yr^{-1}

ΔC_{FG} = annual increase in carbon stocks due to biomass growth, tonnes C yr^{-1}

ΔC_{FL} = annual decrease in carbon stocks due to biomass loss, tonnes C yr^{-1}

The stock change method requires biomass carbon stock inventories for a given forest area at two points in time. Biomass change is determined by the difference between the biomass at time time 2 and time1, divided by the number of years between the inventories (Equation 3).

$\Delta C_{FLB} = (C_{t2} - C_{t1}) / (t_2 - t_1)$ **(3)**

and $C = [V * D\ BEF_2] * (1 + R) * CF$

Where, ΔC_{FLB} = annual change in carbon stocks in living biomass (includes above- and belowground biomass) in forest land, tonnes C yr^{-1}

C_{t2} = total carbon in biomass calculated at time t2, tonnes C

C_{t1} = total carbon in biomass calculated at time t1, tonnes C

V = merchantable volume, $m^3\ ha^{-1}$

D = basic wood density, tonnes d.m. m^{-3} merchantable volume

BEF_2 = biomass expansion factor for conversion of merchantable volume to aboveground tree biomass, dimensionless.

R = root-to-shoot ratio, dimensionless

CF = carbon fraction of dry matter (default = 0.5), tonnes C (tonne d.m.)$^{-1}$

In general the stock change method provides good results for relatively large increases or decreases of biomass, or where very accurate forest inventories are carried out. However, for forest areas of mixed stands, and/or where biomass change is very low compared to the total amount of biomass, there is a risk with the stock change method of the inventory error being larger than the expected change. In such conditions incremental data may give better results.
The default method for estimating the changes in above ground and below ground biomass uses a series of equations. These require activity data on areas of different land-use categories, according to different forest types or management systems, corresponding emission and removal factors, and factors to estimate biomass loss. Several data sets are available globally and regionally (FAO 2006; IPCC 2006) that inform this initiative by providing parameter information.

The IPCC (2006) recognizes that trade offs exist when using secondary data and presents a multi tiered approach to estimate change in carbon stock with three levels with differing specification of methods and sources of activity data. The accuracy of the estimate depends on the tier chosen for biomass estimation. Tier 1 applies to countries in which either the subcategory (forest land or biomass carbon pool) is not a key category or little or no country-specific activity data and emission/removal factors neither exist nor can be obtained. Tier 2 utilizes forest land or biomass carbon as a key category. It uses country-specific estimates of activity data and emission/removal factors.Tier 3 uses highly detailed localised data, often with repeated measures of permanent forest sample plots. It utilizes detailed national forest inventory data supplemented by dynamic models or allometric equations calibrated to national circumstances that allow for direct calculation of biomass increment. Tier 3 approach for carbon stock change allows for a variety of methods, and implementation may differ from one country to another, due to differences in inventory methods and forest conditions. Proper documentation of the validity and completeness of the data, assumptions, equations and models used is therefore a critical issue at Tier 3. Various equations have been developed (IPCC 1997) for estimating change in carbon stocks in living biomass (ΔC_{FLB}) using the default method. For Annual Biomass Increase Estimation fro example, Annual increase in carbon stocks due to biomass increment in forest land (ΔC_{FG}) is given by as shown in equation 4 following.

$$\mathbf{\Delta C_{FG} = \Sigma_{ij}(A_{ij} * G_{TOTALij}) * CF} \qquad \textbf{(4)}$$

Where, ΔC_{FG} = annual increase in carbon stocks due to biomass increment in forest land by forest type and climatic zone, tonnes C yr^{-1}

A_{ij}= area of forest land, by forest type (*i* = 1 to *n*) and climatic zone (*j* = 1 to *m*),

$G_{TOTALij}$= average annual increment rate in total biomass in units of dry matter, by forest type (*i* = 1 to *n*) and climatic zone (*j* = 1 to *m*), tonnes d.m. ha^{-1} yr^{-1}

CF = carbon fraction of dry matter (default = 0.5), tonnes C (tonne d.m.)$^{-1}$

Average Annual Increment in Biomass (G_{TOTAL}) is the expansion of annual increment rate of aboveground biomass (G_W) to include its belowground part, involving multiplication by the ratio of belowground biomass to aboveground biomass (often called the root-to-shoot ratio (R)) that applies to increments. This may be achieved directly where G_W data are available as in the case of naturally regenerated forests or broad categories of plantation. In case G_W data are not available, the increment in volume (IV) can be used with biomass expansion factor for conversion of annual net increment to aboveground biomass increment, the relationship is as shown in the equations following. In case aboveground biomass increment (dry matter) data are used directly, the average annual increment in biomass G_{TOTAL} is given as,

$$\mathbf{G_{TOTAL} = G_W * (1 + R) \quad (A) \qquad (5)}$$

Otherwise, GW is estimated using equation B or it's Equivalent, in case net volume increment data are used to estimate G_W.

$$\mathbf{G_W = I_V * D * BEF_1 (B)}$$

Where, G_{TOTAL}=average annual biomass increment above and belowground, tonnes d.m. ha^{-1} yr^{-1} G_W = average annual aboveground biomass increment, tonnes d.m. ha^{-1} yr^{-1}; R = root-to-shoot ratio appropriate to increments, dimensionless, I_V=average annual net increment in volume suitable for industrial processing, m^3 ha^{-1} yr^{-1},D= basic wood density, tonnes d.m m^{-3}; BEF_1 = Biomass expansion factor for conversion of annual net increment to aboveground biomass increment, dimensionless.

Basic wood density (D) and biomass expansion factors (BEF) vary by forest type, age, growing conditions, stand density and climate. For countries using Tier 2 methods, it is good practice to use country as well as species specific (D) and BEF values if available nationally. These values should be estimated at species level in countries adopting Tier 3BEFs for biomass increment, growing stock and harvest differ for given species or a stand. For Tiers 2 and 3, inventory experts are encouraged to develop country-specific D and BEF values for growing stock, biomass increment and harvests separately. Due to country-specific conditions, BEF and D may be combined in one value and in such cases; guidance given should be applied to the combined values as appropriate.

Annual Biomass Decline Estimation

Annual Decrease in Carbon Stocks Due to Biomass Loss in forest land (ΔC_{FL}) is a sum of losses from commercial roundwood fellings, fuelwood gathering, and other losses and is given by

$$\Delta C_{FL} = L_{fellings} + L_{fuelwood} + L_{other\ losses} \quad (6)$$

Where, ΔC_{FL} = annual decrease in carbon stocks due to biomass loss in forest land, tonnes C yr^{-1}, $L_{fellings}$ = annual carbon loss due to commercial fellings, tonnes C yr^{-1} $L_{fuelwood}$ = annual carbon loss due to fuelwood gathering, tonnes C yr^{-1}, $L_{other\ losses}$ = annual other losses of carbon, tonnes C yr^{-1} . The equation for estimating the annual carbon loss due to commercial fellings given as $L_{fellings}$ is;

$$L_{fellings} = H * D * BEF_2 * (1 - f_{BL}) * CF \quad (7)$$

Where, $L_{fellings}$ = annual carbon loss due to commercial fellings, tonnes C yr^{-1}, H = annually extracted volume, roundwood, m3 yr^{-1}, D = basic wood density, tonnes d.m. m^{-3}, BEF_2 = biomass expansion factor for converting volumes of extracted roundwood to total aboveground biomass (including bark), dimensionless, f_{BL} = fraction of biomass left to decay in forest (transferred to dead organic matter) and CF = carbon fraction of dry matter (default = 0.5), tonnes C (tonne d.m.)$^{-1}$.

In applying the above equation, there are two choices;

(i) Total biomass associated with the volume of the extracted roundwood is considered as an immediate emission. This is the default assumption and implies that f_{BL} should be set to 0. This assumption should be made unless changes in dead organic matter are being explicitly accounted for, which implies use of higher tiers (REF).

(ii) A proportion of the biomass is transferred to the dead wood stock. In this case, f_{BL} should be obtained by expert judgment or based on empirical data (Tier 2 or 3).

Annual Carbon Loss due to Fuelwood Gathering $L_{fuelwood}$ is given by,

$$L_{fuelwood} = FG * D * BEF_2 * CF \quad (8)$$

Where, $L_{fuelwood}$ = annual carbon loss due to fuelwood gathering, tonnes C. yr^{-1} FG = annual volume of fuelwood gathering, m3 yr^{-1}, D = basic wood density, tonnes d.m. m-3, BEF_2 = biomass expansion factor for converting volumes of extracted roundwood to total aboveground biomass (including bark), dimensionless and CF = carbon fraction of dry matter (default = 0.5), tonnes C (tonne d.m.)$^{-1}$

Other carbon losses in managed forest land include losses from disturbances such as windstorms, pest outbreaks, or fires. A generic approach for estimating the amount of carbon lost from such disturbances is provided below. The proposed generic method illustrated below assumes complete destruction of forest biomass in the event of a disturbance – hence the default methodology addresses “stand-replacing” disturbances only. Countries reporting under Tier 3 should consider both stand-replacing and non-stand replacing disturbances**.** Annual other losses of carbon $L_{other\ losses}$ is given by;

$$L_{other\ losses} = A_{disturbance} * B_W * (1 - f_{BL}) *CF \qquad (9)$$

Where, $L_{other\ losses}$ = annual other losses of carbon, tonnes C yr^{-1}, $A_{disturbance}$ = forest areas affected by disturbances, ha yr^{-1}, B_W = average biomass stock of forest areas, tonnes d.m. ha^{-1}, f_{BL} = fraction of biomass left to decay in forest (transferred to dead organic matter) and, CF = carbon fraction of dry matter (default = 0.5), tonnes C (tonne d.m.)$^{-1}$.

The Impact of Other Losses Depends on the Tier Used in Estimation

Tier 1**,** under Tier 1, disturbances are assumed to affect the above ground biomass only; it is also assumed that all aboveground biomass carbon is lost upon disturbance. Hence, f_{BL} is equal to zero. Tier 2, under Tier 2, countries reporting at higher tiers, which account for emissions/removals from all forest pools, have to distinguish between the proportion of the pre-disturbance biomass that is destroyed and causes emissions of greenhouse gas, and that which is transferred into the dead organic matter pools and later decay. Tier 3, countries reporting under Tier 3 should consider all significant disturbances, both stand-replacing and non-stand replacing. When accounting for the impact of non-stand-replacing disturbances, countries may add a term to Equation (9) to adjust for the proportion of pre-disturbance biomass which is not affected by the disturbance.

Estimation of Tree Carbon Stocks

Above ground carbon in tree species in the study landscapes was estimated based on an empirical relationship between tree diameter at breast height (DBH) and aboveground biomass. The DBH was measured using either a diameter tape, where tree diameter (D) is calculated from tree circumference (C) using the formula D = C/pi where, pi = 3.14159. Allometric equations based upon power functions were employed to assign biomass to trees. The constants and coefficients in the power of equations vary with average precipitation in the zone where estimations of tree biomass are being made. Food and Agriculture Organization (FAO) of the United Nations (1997) estimated such constants and coefficients for four categories of precipitation. For Mt. Elgon and Albertine Rift ecosystems, two of the four categories were of interest based on rainfall amounts in the landscapes. (i) Zones with precipitation >900<1500mmyr^{-1}, where above ground tree biomass (kg $tree^{-1}$) is given by $Y = \exp^{(-1.996+2.32 \ln D)}$, and; (ii) Moist zones with precipitation in the range >1500<4000mmyr^{-1}, where above ground tree biomass is given by $Y = \exp^{(-2.134+2.53 \ln D)}$. Where, Y is aboveground tree biomass in kg, exp = 2.71828 and D is the measured DBH in cm. Aboveground tree carbon is estimated at 0.47 of the total aboveground biomass (AGB) for zones with annual precipitation in the range >900<1500mm yr^{-1}, AGB C = $0.47 \times \exp^{(-1.996 +2.32 (\ln DBH))}$.

Root biomass C = 0.35 AGB; Annual leaf drop and fine root turnover = 0.3 total tree biomass, and; Soil organic Carbon (SOC) formation = 0.08 tree input turnover. Woomer (2003) developed a simple table (Table1 a) that allows for estimation of tree carbon based on established bio-physical relationships. It provides total Carbon (in tons) contained in aboveground woody biomass of different sized trees based on an allometric relationship between DBH and total tree biomass. In the relationships (Table 1a), carbon sinks are independent of land area so tree numbers may be obtained from different size categories and carbon stocks estimated for any known land area. Carbon stocks may not be readily interpolated between categories because of the exponential nature of the allometric function. Carbon C for a tree 27.5 cm in diameter may not occur midway trees of 25 and 30cm diameters but rather is skewed toward higher diameter (Woomer, 2003). Extrapolation may however be made by extending values obtained within rows for 35 (ie 30 +/-5) trees of same diameter size category.

Table 1a: Estimates of total tree biomass for different tree numbers and DBH based on aboveground biomass (ABG) where, AGBC = 0.47 x $\exp.^{(-1.997+.32)\ (\ln DBH)}$ and root biomass =35 AGB. DBH (cm)

Tree No.	5	7.5	10	12.5	15	20	25	30	35	40	45	50	60	70	80	90	100
1	0.00	0.01	0.02	0.03	0.05	0.09	0.15	0.23	0.33	0.45	0.59	0.75	1.15	1.65	2.24	2.95	3.76
2	0.01	0.02	0.04	0.06	0.09	0.18	0.30	0.46	0.66	0.90	0.18	0.51	2.30	3.29	4.49	5.89	7.53
3	0.01	0.03	0.05	0.09	0.14	0.27	0.45	0.69	0.99	1.35	1.77	2.26	3.45	4.94	6.73	8.84	11.29
4	0.01	0.04	0.07	0.12	0.18	0.36	0.60	0.92	1.32	1.80	2.36	3.01	4.60	6.58	8.97	11.79	15.05
5	0.02	0.05	0.09	0.15	0.23	0.45	0.75	1.15	1.65	2.25	2.95	3.77	5.75	8.23	11.21	14.74	18.82
6	0.02	0.06	0.11	0.18	0.28	0.54	0.91	1.38	1.98	2.69	3.54	4.52	6.90	9.87	13.46	17.68	22.58
7	0.03	0.06	0.13	0.21	0.32	0.63	1.06	1.61	2.31	3.14	4.13	5.28	8.05	11.52	15.70	20.63	26.34
8	0.03	0.07	0.14	0.24	0.37	0.72	1.21	1.84	2.64	3.59	4.72	6.03	9.20	13.16	17.94	23.58	30.11
9	0.03	0.08	0.16	0.27	0.42	0.81	1.36	2.07	2.97	4.04	5.31	6.78	10.35	14.81	20.18	26.53	33.87
10	0.04	0.09	0.18	0.30	0.46	0.90	1.51	2.30	3.29	4.49	5.90	7.54	11.51	16.45	22.43	29.47	37.63
15	0.05	0.14	0.27	0.45	0.69	1.35	2.26	3.46	4.94	6.74	8.85	11.31	17.26	24.68	33.64	44.21	56.45
20	0.07	0.18	0.36	0.60	0.92	1.80	3.02	4.61	6.59	8.98	11.80	15.07	23.01	32.90	44.85	58.95	75.27
25	0.09	0.23	0.45	0.76	1.15	2.25	3.77	5.76	8.24	11.23	14.76	18.84	28.76	41.13	56.06	73.68	94.08
30	0.11	0.28	0.54	0.91	1.38	2.70	4.53	6.91	9.88	13.47	17.71	22.61	34.52	49.35	67.28	88.42	112.90
40	0.14	0.37	0.72	1.21	1.85	3.60	6.04	9.22	13.18	17.96	23.61	30.15	46.02	65.81	89.70	117.89	150.54
50	0.18	0.46	0.90	1.51	2.31	4.50	7.55	11.52	16.47	22.46	29.51	37.68	57.53	82.26	112.13	147.36	188.17
60	0.22	0.55	1.08	1.81	2.77	5.50	9.06	13.82	19.77	26.95	35.41	45.22	69.03	98.71	134.56	176.84	225.80
70	0.25	0.65	1.26	2.12	3.23	6.30	10.57	16.13	23.06	31.44	41.32	52.76	80.54	115.16	156.98	206.31	263.44
80	0.29	0.74	1.44	2.42	3.69	7.20	12.08	18.43	26.36	35.93	47.22	60.29	92.04	131.61	179.41	235.78	301.07
90	0.32	0.83	1.62	2.72	4.15	8.09	13.58	0.74	29.65	40.42	53.12	67.83	103.55	148.06	201.83	265.26	338.71
100	0.36	0.92	1.80	3.02	4.61	8.99	15.09	23.04	32.95	44.91	59.02	75.37	115.05	164.52	224.26	294.73	376.34

Methodology

Carbon stocks measurements were conducted on below ground carbon sinks in forests within Mt Elgon landscape. The below ground soil organic carbon was measured using randomly collected soil samples from stratified components of the landscapes. Actual amount of soil organic carbon was determined as described by Okalebo *et al.,* (2002); Soil C (t ha^{-1}) =C (kg ha^{-1}) x bulk density (kg l^{-1}) x soil depth (cm) x 100.

Results

Tree-Based Carbon Sequestration Projection Utility Model

In order to apply this model , tree density, tree attrition, area withdrawn, root to shoot ratio, leaf and root turnover rate, soil C sequestration and soil organic matter (SOM) turnover were determined. A tree-based carbon sequestration projection utility model that can quantify and simulate carbon sinks build-up over a temporal scale of up to 20 years, including the value of such sinks, was developed (Table 1b). The model will play an important role in solving the problem of accounting of permanence of carbon sinks in any contracting arrangement in carbon offset markets. Table 1b gives carbon sinks build-up and associated value for a period of three years measured in increments of one quarter (0.25) of a year. This spreadsheet model gives carbon projections from tree planting in the tropics based on eleven user-defined inputs. Options are provided for tree root and soil C gains. For no root C set root: shoot = 0. For no soil C set soil sequestration = 0. Carbon is priced as CO_2 Emission Reductions. The projections run on a quarterly timestep expressed as years (0.25 = 3 month intervals) and may be generated for individual field (> 0.1 ha) to project (thousands of ha) level. Suggested values for some inputs (root and soil) are provided (Maximum 20-year project lifetime).

Table 1b: Tree-Based Carbon Sequestration Projection Utility Model

beginning of project		2009.00				year (in increments of 0.25)							
project area		1000.0				Ha							
Tree density		400				trees per ha (400 = 5 m x 5 m spacing)							
Tree attrition		0.0				% per year (baseline = 0%, signifies death or poaching of trees)							
Area withdrawn		0.0				% per year (baseline = 0%, signifies land withdrawn from the project)							
annual DBH gain		2.20				cm per year (baseline = 2.2 cm per year)							
Root to shoot ratio		0.35				root biomass / shoot biomass (baseline = 0.35, 0 for no root C)							
leaf & root turnover		0.30				total biomass C per year (baseline = 0.3)							
soil C sequestration		0.08				t soil C per t organic C input (baseline = 0.08, 0 for no soil C)							
SOM turnover		0.80				soil C remaining after 1 year (baseline = 0.8)							
CO2ER price		3.00				US$ per t CO2 emission reduction where 1 t C = 3.67 t CO2 (baseline = $3)							
Project	**Project**	**tree**	**tree**	**area**	**area**	**Dbh**	**AGC**	**BGC**	**treeC**	**soilC**	**totalC**	**CO2 ER**	**value**
Date	Year	survival	survival	loss	loss	Cm	-------------------------- t ----------------------------						US$
2009.00	0.00	1.00	1.00	1.00	1.00	1.20	39	14	53	1	54	197.657	593
2009.25	0.25	1.00	1.00	1.00	1.00	1.75	94	33	126	4	130	478.013	1434
2009.50	0.50	1.00	1.00	1.00	1.00	2.30	176	62	238	9	247	906.027	2718
2009.75	0.75	1.00	1.00	1.00	1.00	2.85	290	102	392	17	408	1496.706	4490
2010.00	1.00	1.00	1.00	1.00	1.00	3.40	437	153	590	27	617	2262.903	6789
2010.25	1.25	1.00	1.00	1.00	1.00	3.95	619	217	835	42	877	3215.947	9648
2010.50	1.50	1.00	1.00	1.00	1.00	4.50	837	293	1130	61	1191	4366.008	13098
2010.75	1.75	1.00	1.00	1.00	1.00	5.05	1094	383	1477	84	1561	5722.336	17167
2011.00	2.00	1.00	1.00	1.00	1.00	5.60	1390	487	1877	112	1989	7293.431	21880
2011.25	2.25	1.00	1.00	1.00	1.00	6.15	1728	605	2333	146	2478	9087.166	27261
2011.50	2.50	1.00	1.00	1.00	1.00	6.70	2108	738	2845	185	3030	11110.883	33333
2011.75	2.75	1.00	1.00	1.00	1.00	7.25	2531	886	3417	230	3647	13371.468	40114

Soil Carbon Stocks in Mount Elgon Ecosystem

As part of the on-going sampling and measurement of soil samples from various sub-ecosystems in Mount Elgon landscape, the baseline position for soil organic carbon has been established. Table 2 (i, ii and ii) shows the simulated SOC per ha and % carbon for the sites where the soil samples were taken up to the depth of 30cm.

Table 2. Baseline Soil Organic Carbon in Selected Points-Mount Elgon Ecosystem

Table 2(i): Mt Elgon Bamboo Plantation

Lab. No.	Code Ref.	GPRS Coordinates	Elevation (MASL)	Organic C (T/ha)	%C
948	NP5	N:01.03731°, E:034.73759°	2562	71.556	8.04
949	NP5	N:01.03731°, E:034.73759°	2562	45.212	5.08
950	NP5	N:01.03731°, E:034.73759°	2562	29.192	3.28
952	NP6	N:01.032257°, E:034.74427°	2530	51.81	6.6
953	NP6	N:01.032257°, E:034.74427°	2530	22.294	2.84
954	NP6	N:01.032257°, E:034.74427°	2530	13.816	1.76
956	S3	N:01.21227°, E:034.73066°	2530	44.352	6.16

Table 2(ii); Cheptais Regenerated Forest

Lab. No.	Code Ref.	GPRS Coordinates	Elevation (MASL)	Organic C (T/ha)	%C
687	C002	N:00.83848°, E:034.47537°	1966	33.048	4.08
688	C002	N:00.83848°, E:034.47537°	1966	27.864	3.44
689	C002	N:00.83848°, E:034.47537°	1966	22.680	2.8
690	C003	N:00.83920°, E:034.47610°	1955	34.992	4.32
691	C003	N:00.83920°, E:034.47610°	1955	18.144	2.24
692	C003	N:00.83920°, E:034.47610°	1955	15.228	1.88
693	C004	N:00.83870°, E:034.47687°	1974	34.992	4.32
694	C004	N:00.83870°, E:034.47687°	1974	29.808	3.68
695	C004	N:00.83870°, E:034.47687°	1974	21.06	2.6
696	C005	N:00.83762°, E:034.47766°	1990	43.74	5.4
697	C005	N:00.83762°, E:034.47766°	1990	35.64	4.4
698	C005	N:00.83762°, E:034.47766°	1990	31.104	3.84
699	C006	N:00.83815°, E:034.47713°	1981	43.416	5.36
700	C006	N:00.83815°, E:034.47713°	1981	23.004	2.84
701	C006	N:00.83815°, E:034.47713°	1981	11.016	1.36

Table 2 (iii): Kapsokwony Eucalyptus Plantation

Lab. No.	Code Ref.	GPRS Coordinates	Elevation (MASL)	Organic C (T/ha)	%C
774	E1	N:00.83909°, E:034.47526°	1968	33.108	3.72
775	E1	N:00.83909°, E:034.47526°	1968	31.328	3.52
776	E1	N:00.83909°, E:034.47526°	1968	18.512	2.08
777	E2	N:00.87136°, E:034.68657°	2064	33.82	3.8
778	E2	N:00.87136°, E:034.68657°	2064	23.496	2.64
779	E2	N:00.87136°, E:034.68657°	2064	11.036	1.24
780	E3	N:00.87036°, E:034.68712°	2052	37.736	4.24
781	E3	N:00.87036°, E:034.68712°	2052	33.464	3.76
782	E3	N:00.87036°, E:034.68712°	2052	13.528	1.52
783	E4	N:00.86953°, E:034.68770°	2036	35.956	4.04
784	E4	N:00.86953°, E:034.68770°	2036	24.208	2.72
785	E4	N:00.86953°, E:034.68770°	2036	17.444	1.96

Conclusions

The analysis has been able to tease out various conceptual and methodological issues that touch on the subject of quantification, simulation and valuation of carbon sinks in both natural and managed ecosystems. Most of the conceptual issues addressed theoretical aspects of the underlying science in quantification of inherent carbon dynamics in the ecosystems. Methodological aspects of the analysis touched on the advantages, shortcomings and means of circumventing the identified constraints in use of each of the methodologies in quantification, simulation and valuation of carbon sinks. With such simplified conversion factors, it is possible to develop capacity of stakeholders in study landscapes to estimate the carbon sinks in conserved and managed ecosystem through use of simple measurement equipment, and thus reduce on the additional costs associated with monitoring and measurement processes that are a pre-requisite for certification to be given for linkage to markets for carbon offset credits. The preliminary results of soil carbon sinks show that there exists great potential in the Mount Elgon ecosystem in terms of soil carbon sinks in the top 30 cm of the soil. This will serve as a rallying point in negotiating for compensation for such sinks not only in Mount Elgon ecosystems but also in other ecosystems with similar ecological mix.

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