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Economic Analysis of Forest Landscape Restoration Options in Kenya

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On behalf of
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We hope the information in this report will be useful in making a contribution towards the development and implementation of the National Forest Restoration Strategy to enable Kenya realize its commitment to the AFR100 and by extension the Bonn Challenge of restoring 5.1 million ha of its degraded landscape.

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Abbreviations and Acronyms

ASALs	Arid and Semi-Arid Lands
ASDS	Agricultural Sector Development Strategy
BAU	Business as Usual Approach
BCR	Benefit Cost Ratio
CBA	Cost Benefit Analysis
CBD	Convention on Biological Diversity
EAA	Equivalent Annual Annuity
EMCA	Environmental Management and Co-ordination
FAO	Food and Agriculture Organisation
FLR	Forest Landscape Restoration
FLR	Forest and Landscape Restoration
HA	Hectare
GBM	Green Belt Movement
GHG	Green House Gas
GoK	Government of Kenya
InVEST	Integrated Valuation of Ecosystem Services and Trade-Offs
IPCC	Intergovernmental Panel on Climate Change
IRR	Internal Rate of Return
ISRIC	International Soil Reference and Information Centre
IUCN	International Union for Conservation of Nature
KALRO	Kenya Agricultural and Livestock Research Institute
KEFRI	Kenya Forestry Research Institute
KES	Kenya Shillings
KFS	Kenya Forest Service
LADA	Land Degradation Assessment
LRTWG	Landscape Restoration Technical Working Group
LUCC	Land Use/Land Cover Changes
MEA	Multilateral Environmental Agreements
MENR	Ministry of Environment and Natural Resources
NGO's	Non-Governmental Organizations
NLP	National Land Policy
NPV	Net Present Value
REDD+	Reducing Emissions from Deforestation and Forest Degradation
ROAM	Restoration Opportunities Assessment Methodology
SDG	Sustainable Development Goals
SLM	Sustainable Land Management
ToR	Terms of Reference
UN	United Nations
UNCCD	United Nations Convention to Combat Desertification
UNEP	United Nations Environmental Programme
UNFCC	United Nations Framework Convention on Climate Change
WRI	World Resources Institute
WWF	World Wildlife Fund

Foreword

Kenya's forests and landscapes are facing severe challenges of degradation caused by among others; increasing population, and unsustainable utilization of land for products and services. Increasing demand for food has resulted in expansion of cropland into marginal and unsuitable areas, competition for pastures and increased encroachment of forest lands. land degradation in the country has manifested in increased sedimentation of water bodies; flash floods, reduced water quality and reduced capacity of catchment areas to support flow of rivers especially in the dry seasons. Forest and Landscape degradation in the rangelands have also exacerbated human-wildlife conflicts due to scarcity of rangeland resources. Communities in arid and semi-arid are dependent on pastoralism and therefore are severely impacted by recurrence of droughts. Degradation is also linked to country's declining natural assets in forms of plant and animal biodiversity thus jeopardizing the vibrancy of the country's tourism sector. In short, forest and landscape degradation has been very costly to the country.

There is concern that continued landscape degradation will have long term impacts on the overall human wellbeing and some initiatives have been mooted to address and minimize impacts of degradation. Kenya is actively involved in many initiatives meant to alleviate the effects of forest and landscape degradation and climate change. As a party to the Paris Agreement the country has committed to decrease its "Green-houses gases (GHG) emissions by 30% by 2030 relative to a baseline scenario. Kenyan government has also pledged to restoration and reforestation of 5.1 million hectares by 2030 as part of its commitment to global forest and landscape restoration.

Availability of information on likely costs and benefits of restoration efforts is crucial to inform all stakeholders on the best bet for achieving restoration goals. To address the data and information gaps, it has been found necessary to quantify the likely costs and benefits of various restoration interventions in varied landscapes.

The economic and financial analysis of various restoration interventions over different landscapes will support the county's efforts to mobilize and justify resources from various partners and stakeholder for national forest landscape restoration targets. The report is in tandem with many governments of Kenya initiatives outlined in various policies, legal instruments, and multilateral environmental agreements. The Constitution of Kenya, vision 2030, National Land Reclamation Policy (GoK 2013c), National Environment Change Action Plan 2013–2017 (GoK 2013d), the National Land Commission Act in 2012 (GoK 2012a), National Climate Change Action Plan 2018-2022, National Adaptation Plan 2015-2030, National forest Programme 2016 (2016-2030) . The report provides information on a basket of restoration options to enable public agencies, planners and landowners to prioritize projects that will deliver most with limited budgets and resources. From the reports it is clear that the country needs enormous financial resources for restoration of the various degraded landscapes that have to be mobilized from citizens, exchequer, development partners' and the private sector. We hope, the enormous cost of doing nothing in our degraded landscapes will inspire a paradigm shift that reverses the current trend and restores our ecosystems for a health and prosperous future.

Executive Summary

Forest and land degradation is a serious global problem worldwide, particularly in developing countries experiencing high population growth and unemployment rates. It is estimated that at global level between 1 billion to over 6 billion ha of the forest landscapes are degraded. The main cause of degradation is through conversions of forests to alternative land uses that has impacted negatively on productivity and diminished the flow of products and services for human well-being. Forest landscape restoration received global endorsement for collective actions to restore health and vitality of degraded landscapes. The decision was informed by the fact that continued environmental degradation will have long term impacts on the overall human wellbeing hence the need to undertake some initiatives to address and minimize the impacts. Through the Bonn Challenge the global community has pledged to restore 150 million hectares of the world's deforested and degraded land by 2020, and 350 million hectares by 2030 (www.bonnchallenge.org/content/challenge). Underlying the Bonn Challenge is the Forest and Landscape Restoration (FLR) approach, which aims to restore ecological integrity and improve human well-being through multifunctional landscapes. The Bonn Challenge is a practical method of realizing many existing international commitments, including the CBD Aichi Target 15, the UNFCCC REDD+ goal, and the Rio+20 land degradation neutrality goal. As part of its contribution to the global effort to mitigate climate change, the Africa Continent through AFRA A100 pledged 100 million hectares. Kenyan government has pledged to restoration and reforestation of 5.1 million hectares by 2030 as part of its commitment to global Forest Landscape restoration. However, forest restoration involves investments whereas the costs and benefits of undertaking such massive project are yet to be defined in monetary terms. However, forest restoration involves investments and the costs and benefits of massive planned landscape restorations are yet to be defined in monetary terms. Therefore, access on likely costs and benefits of restoration efforts is crucial to inform all stakeholders on the best bet for achieving restoration goals. To address the data and information gaps, it is critical to quantify the likely benefits and costs of various interventions over wide range of landscapes. Economic analysis will help justify and support resource mobilization for the national forest landscape restoration targets. In addition, the analysis will quantify and identify the best options for achieving both short and long term benefits to landowners and stakeholders at national, regional and global levels. To contribute to Kenya government commitments to the Bonn Challenge and to actualize the national restoration strategy, economic analysis of restoration options was mooted to provide a comprehensive report.

Economic analysis was grounded on '***Restoration Opportunities Assessment Methodology***' whose key analytical tool is the "***Restoration Economic Modelling and Valuation***". The economic analysis relied on seven (broad categories of forest landscape restoration opportunities) identified in the National Assessment of Forest and Landscape Restoration Opportunities Technical Report (MENR, 2016) namely: Afforestation or reforestation of degraded natural forests, Rehabilitation of degraded natural forests, Agroforestry in cropland, Commercial tree and bamboo growing on potentially marginal cropland and un-stocked forest plantation forests, Tree-based buffer zones along water bodies and wetlands, Tree-based buffer zones along roads and restoration of degraded rangelands). Based on these broad categories of restoration opportunities twelve specific interventions/options were identified and subjected to economic analysis. The twelve interventions are: Degraded natural forest to improved natural forest through enrichment planting, Degraded forest to Improved Natural regeneration with protection, Traditional Agriculture (Maize farming) to Intensive Agroforestry Maize, Grevillea, Avocado Fruit, Traditional Agriculture (Cowpeas Farming) to Intensive Agroforestry with Melia, Poorly managed woodlots to improved and well-managed Eucalyptus woodlots, Degraded woodlands to commercial *Gmelina arborea* plantations, Degraded planted forests to commercial bamboo plantations, Un-stocked plantations to fully stocked cypress plantations, Degraded riparian zones to bamboo and grass strip buffer, Degraded grasslands to grass reseeding and Degraded grassland to Silvo-pastoral system grass reseeding and acacia woodlands.

The costs and benefits for restoration transition were identified from expert discussions, activity restoration budgets and extensive review of various land use literature. The costs and benefits from each restoration transition were modelled using various assumptions over 30-year period. The benefits and opportunity costs were valued using market prices, avoided cost/ replacement cost and benefit transfer approaches. The viability per hectare (ha) of these restoration transitions were assessed using: Net Present Value (NPV), Equivalent Annual Annuity (EAA), Internal Rate of Return (IRR) and Benefit Cost ratio (BCR).

The results from economic analysis of restoration transitions have shown positive NPV (7%) for all the proposed restoration transitions per ha for the 30 year period. The transition from traditional cowpeas farming to intensive agroforestry with *Melia volkensii* has the highest NPV (KES 1,893,785) this is followed by transition from poorly managed woodlots to improved eucalyptus woodlots at KES 1,649,510 and the Silvo-pastoral system at Ksh 1,272,052. The transition from treeless roads to roads with planted trees has the lowest NPV at KES 96,972 over the 30-year period. The transition from degraded natural forest to improved natural forest through enrichment planting yielded the second lowest NPV (KES 318,559). The benefit cost ratio (BCR) of the restoration transition ranged from as low as 2.35 (Degraded riparian zones to bamboo and grass strip grass buffer) to highest of 29.2 (Transition from degraded grasslands to reseeded grassland). The cost of forest restoration using the restoration options selected ranged from KES 28,662/ha to KES 631,032/ha (current values for 2018) depending on the restoration option adopted.

Findings from financial analysis based on the financial analysis indicators of total financial outlay, owners' net cash flow, internal rate of return (IRR), NPV, payback period and benefit cost ratio (BCR) showed the commercial viability of the interventions. Intensive agroforestry ***Melia volkensii*** and cowpeas generated the highest NPV (KES 2,676,750) over the 30 year investment period followed by eucalyptus woodlot (KES 1,798,338), commercial bamboo (1,182,281) and ***Gmelina arborea*** plantations (1,103,717) respectively. Bamboo (KES 990,256), cypress plantations (KES 777,572) and grass strip Grass reseeding (KES 308,460) and had the lowest NPV. In terms of financial outlay required for the investments, Melia and cowpeas agroforestry system is the costliest at KES 621,352 followed by Bamboo and grass strip at KES 602,969, investment in ***Gmelina arborea*** and commercial bamboo plantations requires the least financial outlay at KES 52,063 and KES 177,750 respectively. All the interventions had a strong IRR values except for Bamboo and grass strip 10.65% and grass reseeding using enclosures which had an IRR value below the 12% threshold. In this case an investor would seek an investment in the order of Melia and cowpeas, cypress plantations, *Gmelina arborea* plantations and commercial bamboo plantations because they score strongly both on NPV and IRR.

At the national scale, the costs of forest landscape restorations were estimated at 1.8 trillion for the most conservative scenario of restoring 5.1 million ha to 3.7 trillion for the ambitious target of 10.2 million ha. The benefits from restoration ranged from 7.6 trillion to 14.8 trillion over a 30-year period and giving a cost benefit ratio of about 4.1.

The adoption of each of these restoration options will depend on many factors. One of the key factors will be the sources of financing with reasonable costs. The agroforestry and rangeland systems produce both private and public benefits (carbon sequestration, water flow regulation and soil protection). Though they may look feasible from private perspective, however, intensive use of inputs and competition among land uses may hinder large scale adoption of the agroforestry systems. Therefore, any decision-making on alternative restoration options will need to explore financing options and concurrence with interested parties for all the feasible options to restore degraded ecosystems in the country.

1.0 Introduction

1.1 Background Information

The Kenyan Government is currently carrying out forest landscape restoration assessments using the Restoration Opportunities Assessment Methodology (ROAM). As part of the assessments, economic analysis is necessary to assess which forest landscape restoration opportunities are viable and most appropriate for the public, private sector and individuals. This report describes economic and financial analysis of various forest and landscape interventions and proposes financial mechanisms to achieve the 5.1 million Ha (Bonn challenge) restoration target by 2030.

Forest and land degradation largely driven by many factors that range from high population growth, changing lifestyles and climate change has been identified as a serious global problem worldwide and particularly in developing countries. It is estimated that one billion people live in degraded areas, which represent 15 percent of the Earth's population, and one third of the world's population is considered to be affected by land degradation (Sabogal ***et al.***, 2015). Land degradation is defined by the UNCCD (1994) in terms of reduction or loss of the biological or economic productivity. It is also described as reduced capacity of the land to provide ecosystem goods and services, over a period of time, for human well-being (FAO, 2013). Further, forest degradation refers to reduction of capacity of forests to provide goods and services (FAO, 2011). Therefore, continued forest and land degradation pose serious obstacles to poverty alleviation, reversal of global biodiversity loss, and impedes the ability of farmers and local communities to adapt to impacts of climate change (Sabogal ***et al.***, 2015).

According to the International Soil Reference and Information Centre (ISRIC) (ISRIC, n.d.) - land degradation costs an estimated €30 billion annually worldwide and affects more than a billion people, especially in drylands. There is global concern that continued environmental degradation will have long term impacts on the overall human wellbeing. Land degradation assessment (LADA) indicated that deforestation affected areas with a total human population of some 1 billion and realizes a net loss of about 35 million metric tons (MT) of carbon per year (FAO, 2013). The areas most affected are: tropical Africa south of the Equator; Southeast Asia; South China; North-central Australia; drylands and steep-lands of Central America and the Caribbean; Southeast Brazil, the Pampas and boreal forests.

It is estimated that 1 billion to over 6 billion ha of the global landscapes are degraded (Gibbs and Salmon, 2015) through conversions to alternative land uses impacting negatively on land productivity and diminishes the flow of Ecosystem Services. For example, it is estimated that 60% of the ecosystems services are being degraded through unsustainable land use conversions leading to massive emission of Green House Gases (MEA, 2005). Forest land conversion and degradation alone is estimated to contribute 4.4Gt of CO2 emissions each year (Mathew and Van Noordwijk, 2014) and agriculture, forestry and other land-based activities accounted for 20-24% of Green- House Gas (GHG) emissions (IPCC, 2014). The monetary value of global ecosystem services loss due to land use change was estimated at $USD 4.3 to 20.2 trillion/yr between 1997 and 2011. Similarly, in Kenya, land degradation is widely considered to have continued unabated. This is driven by burgeoning population, unsustainable land use practices, illegal uses, poor governances and lack of appreciation of economic costs of degradation (Allaway and Cox, 1989, Emerton, 2014).

1.2 Extent of Forest and Land Degradation in Kenya

There are no precise and definitive assessments available concerning net land degradation in Kenya to date. The estimates of the extent of land degradation in Kenya vary depending on the source and methodologies of estimation (Mulinge ***et al.*** 2016). A study by Bai ***et al.*** (2008) indicated that about 64 % of Kenya's total land area was subjected to moderate land degradation and about 23 % to very severe degradation in 1997. More recently, Le ***et al.*** (2014) estimated for the period 1982 to 2006,- 22 % of the Kenyan land area was degraded, including 31 % of croplands, 46 % of forested land, 42 % of shrub lands, and 18 % of grasslands. Land degradation is more pronounced in the Eastern and North Eastern parts of Kenya, where 12.3 % of the land is severely degraded, 52 % moderately degraded and 33 % is vulnerable to land degradation (Muchena, 2008, UNEP, 2009).

1.3 Drivers and Impacts of Forest and Land Degradation in Kenya

The last century has seen an increased concern regarding land degradation and desertification (UNCCD, 2013). The causes of land degradation are grouped into two, namely; proximate (biophysical) and underlying (socioeconomic) causes (Mulinge ***et al.***, 2016). These causes interact together to determine the rates of degradation. Biophysical causes are factors relating to unsustainable agronomic practices, and land physical conditions, rainfall and pest and diseases. The land use/land cover changes are often associated with deforestation, loss of natural vegetation, biodiversity loss and land degradation (Kiage *et al.* 2007; Maitima *et al.* 2009). The key drivers associated with land use/ land cover changes vary depending on context and agro-ecosystem type, but may include: unsustainable fuel wood extraction, logging for charcoal and commercial timber, and land clearing for purposes of agriculture (Kiage *et al.* 2007; Mundia and Aniya, 2006; UNEP 2002; Serneels and Lambin , 2001).

High population growth rates in Kenya have increased the demand for ecosystem services. The high population pressure drives expansion of agricultural area to meet food demands and also for economic development of the rural populations (Maitima ***et al.***, 2009). This has led to expansion of cropland into marginal areas such as pastureland and forest lands sometimes with steep slopes leading to increased land degradation. Human driven anthropogenic activities is reported to be the key contributor to severe degradation of forests and woodlands in the semi-arid marginal lands (Muia and Ndunda 2013). Similarly, increased populations and land use activities in built up areas mostly residential and industrial has put pressure on forests and woodlands further contributing to landscapes degradation processes (Maitima *et al.* 2009; Mundia and Aniya, 2006; Were *et al.* 2013; Mireri, 2005). The construction of infrastructure such as roads on steep slopes without proper barriers, buildings without proper water drainage systems are also contributing factors to soil degradation and to making water in rivers less fit for human consumption.

The impacts of land degradation in the country include increased sedimentation of water bodies from soil erosion hence reducing their surface areas (Kiage ***et al.***, 2007). Deforestation has been observed to decrease infiltration rates of the land, reduced water quality and ability of catchment areas to support flow of rivers especially in the dry season (Were ***et al.***, 2013, Kiage ***et al.***, 2007). Further, land use and land cover changes in rangelands have increased human-wildlife conflicts over the scarce rangeland resources and decrease in wildlife populations and vibrancy of the country's tourism sector one of the key forex earners (Maitima ***et al.***, 2009; Campbell ***et al.***, 2003). Studies have also linked land use cover change with decline in bird species, loss in plant biodiversity, and decline in soil productivity (Maitima ***et al.***, 2009).

The communities in arid and semi-arid are dependent on pastoralism and therefore are severely impacted by recurrence of droughts. Investments in landscape restoration will result in healthy ecosystems which can enable resource-dependent populations to withstand and recover more quickly from periods of droughts

1.4 The Economic Costs of Forest and Land Degradation in Kenya

Land degradation threatens the livelihoods of millions of people, who depend on land ecosystem goods and services for their livelihoods. The fragile ecosystems like the dry lands of Kenya are the most vulnerable (Muia and Ndunda 2013). Kenya being an agricultural country and with more than 12 million people living in areas with degraded lands is a cause to worry (Bai ***et al.*** 2008; Le ***et al.***, 2014). Thus degradation is one of the main cause of falling food crop productivity and crop production over the last decade that lagged behind demands of the fast growing population (Waswa, 2012). For example, over the period 1981–2003, the productivity is reported to have declined across 40 % of croplands in the country—a critical situation in the context of a doubling of the human population (Bai and Dent 2008). On average, the productivity of the major cereal—maize—is less than 1 metric ton per hectare on most smallholder plots in the country (Muasya and Diallo, 2001; cited by Waswa, 2012). This outcome can be attributed to land degradation and the associated "nutrient mining" and this has had significant impacts on rural livelihoods and the overall economy (Maitima ***et al.*** 2009; Henao and Baanante, 2006). As the rural poor primarily depend on natural resources (especially land and water) for their livelihoods, degradation of these resources is expected to impact on them greatly (Nkonya ***et al.*** 2008a, b). Land degradation also impacts on food prices, food security and ecosystem service provision in downstream locations, beyond the source of the degradation.

The cost of land degradation due to land use and land use change (LUCC) in the country was estimated at USD 1.3 billion per year between 2001 and 2009. Moreover, the costs of rangeland degradation through loss in livestock and agricultural productivity were estimated at USD 80 million and 270 million USD per annum respectively (Mulinge ***et al.***, 2016). Degradation of forested landscapes has exacerbated mitigation costs for irrigation, flood control, hydropower generation and even increased natural resources conflicts among communities. For example, by 2011, human activities in the upper catchment of the Masinga dam resulted in the loss of water storage dam capacity by 215.26 m^3, or 13.6 %, due to sedimentation (Bunyasi ***et al.***, 2013). There is a growing concern about the loss of biodiversity and a concomitant increase in carbon dioxide emissions due to forest-cover loss. The continued degradation of these forests will certainly contribute to a growing water crisis as a result of the conversion of perennial rivers to seasonal rivers, increased storm flow, and downstream flooding (Langat et al, 2018). Poor conservation practices with soil and water resources on deforested land contribute to soil erosion and decrease crop yields in areas of high agricultural potential. If forested landscapes are not restored and the process of deforestation is not halted, reduced land productivity and vulnerability to climate change could become acute into the future (ACTS and ACC, 2011).

1.5 Emergence of Forest and Land Restoration

Over the past 20 years, ecological restoration has emerged as an important component of ecosystem management and environmental protection (Robins and Daniels, 2012). Sustainable Development Goals (SDGs) 15 has identified improving management of forests, combating desertification, reversing land degradation and preserving biodiversity as key pillars in meeting environmental, economic and social goals. Landscape restoration is a key element in achieving SDG 15. The World Resources Institute estimates that there are 2 billion hectares of deforested and degraded lands with potential for landscape restoration: 20 per cent through forest restoration and 80 per cent through 'mosaic' restoration which involves integrating forests with smallholder agriculture, agroforestry and other land uses (www.worldagroforestry.org/.../sdgs-more-holistic-approach-case-l). If One hundred and fifty million hectares of degraded land is restored by 2030, it could improve food security to 200 million people, accrue benefits to about $40 billion annually and reduce Green House Gas emissions https://newclimateeconomy.report/2014/land-use). The momentum for landscape restoration is growing, as evidenced by the 2014 New York Declaration on Forests, which calls for the restoration of 350 million hectares of deforested and degraded land by 2030.

Another global initiative is the Bonn Challenge that aims at restoring 150 million hectares of the world's deforested and degraded lands by 2020, and 350 million hectares by 2030 (www.bonnchallenge.org/content/challenge). It has been adopted is an implementation vehicle for national priorities such as water, food security, and rural development while contributing to the achievement of international climate change, biodiversity and land degradation commitments. The 2020 target was launched in Bonn in 2011 and was later endorsed and extended to 2030 by the New York Declaration on Forests of the 2014 UN Climate Summit. Regional implementation platforms for the Bonn Challenge are emerging around the world, including Initiative 20x20 in Latin America and the Caribbean, AFR100 for Africa, and ministerial roundtables in Latin America, East and Central Africa, and the Asia-Pacific region. Underlying the Bonn Challenge is the Forest and Landscape Restoration (FLR) approach, which aims to restore ecological integrity at the same time as improving human well-being through multifunctional landscapes. The Bonn Challenge is a practical method of realizing many existing international commitments, including the CBD Aichi Target 15, the UNFCCC REDD+ goal, and the Rio+20 land degradation neutrality goal.

Many restoration projects take place in areas surrounded by human communities; understanding how society values improvements to ecosystems can improve the effectiveness of these projects. Yet the restoration literature recognizes that the public values of restoration are not well understood (Weber and Stewart 2009, Robins and Daniels, 2012) and that the socioeconomic aspects of restoration are underestimated or often ignored in decisions (Aronson ***et al.*** 2010). However, a recent report indicated that investments in land restoration can create more employment opportunities and other benefits which may exceed the costs involved. On average, the benefits of restoration are 10 times higher than the costs (estimated across nine different biomes), and, for regions like Asia and Africa, the cost of inaction in the face of land degradation is at least three times higher than the cost of action (Webb ***et al.***,2017)

A recent national communication to the UNFCCC by the government of Kenya (http://www4.unfccc.int) reported the findings from a rapid assessment of returns on investment in ecosystem-based adaptation to climate change in Kenya through rangeland management. The assessment found that the ratio of the immediate returns to the local peoples' investment in managing their rangelands through their own institutions was around 24:1. But had a drought occurred, without the continued water and pasture availability in the drought reserves, local people estimated that up to 40-60% of their herds would have died. Therefore, the value of mortalities avoided through improved management would have increased the collective return on their investment up to as much as 90:1. The direct observation of immediate benefits as experienced by local people provided a useful indication of the sustainability of the ecosystem-based adaptation approach. Other longer term benefits would include improved ecosystem function and service provision and indirect effects on the local economy and society and biodiversity. These included reduced conflict, and increased political recognition for local decision making. The economic value of these other benefits could not readily be estimated during the rapid assessment. The communication noted that, national government's recognizes, that for the communities to fully benefit from community and ecosystem level adaptation, it will require adequate provisions be included in the design of adaptation funds and programs. It identified an available study of the direct use values of Ecosystem Services in Arid of the arid counties of Kenya (King-Okumu ***et al.***, 2016, 2015).

1.6 Initiatives and Laws Linked to Restoring Lands and their Associated Ecosystem Services in Kenya

In Kenya, forest restoration is a high priority on the government's agenda, and is reflected in a number of different legislations and policies. The country has very comprehensive Sustainable Land Management (SLM) policy documents which are intended to provide guidelines on land use management and administration. These include: The National Land Policy (NLP) (Sessional Paper No. 3 of 2009), The draft National Environment Policy 2013, National Water Policy 1999, National Water Management Strategy (GoK 2010a), Agriculture Sector Development Strategy (ASDS) (GoK 2010c), National Land Reclamation Policy (GoK 2013c), National Environment Change Action Plan 2013–2017 (GoK 2013d), the National Land Commission Act in 2012 (GoK 2012a), five-year National Strategic Plan to guide implementation of the NLP (GoK 2013e), National Climate Change Action Plan 2018-2022, National Adaptation Plan 2015-2030, National forest Programme 2016 (2016-2030). The relevant Acts of parliament include: Environmental Management and Co-ordination Act No. 8 of 1999 (EMCA), The Forest Conservation and Management Act of 2016 and The Community Land Act of 2016 among others.

Other sector laws supportive of SLM include; the Environment and Land Court Act, the Land Act, the Crops Act, and the Fisheries Act, the Agriculture, Fisheries and Food Authority (AFFA) Act No. 13 of 2013 the Kenya Agricultural and Livestock Research (KALRO) Act No. 17 of 2013, Crop Act No. 16 of 2013, Water Act 2002 and National Climate Change Act 2016. The Government of Kenya has put in place several high level initiatives and laws that are strongly linked to restoring lands and their associated ecosystem services. The 2010 Constitution calls for reforesting and maintaining a tree cover of at least 10% of the country (GoK, 2010c). The National Climate Change Response Strategy calls for growing 7.6 billion trees on 4.1 million hectares of land during the next 20 years (GoK, 2010b). Kenya's Vision 2030 has a flagship project underway for rehabilitating and protecting indigenous forests in the five water towers (Mount Kenya, the Aberdare Range, the Mau Forest Complex, Mount Elgon and the Cherangany Hills), with the goal of increasing forest cover and volume of water flowing from the catchment areas (GoK, 2007). The Trees-for-Jobs Programme intends to plant one billion trees to increase forest cover and at the same time create employment for youth (GoK, 2008). In addition to these restoration initiatives, Kenyan government has committed itself to restore 5.1 million hectares by 2030 (MENR, 2016). The country is also deeply involved with REDD+ Readiness Preparation. One of the priority issues in the national REDD+ Readiness process focuses on enhancement of forest carbon stocks.

Kenya is also a party to the following Multilateral Environmental Agreements (MEAs): Convention on Biological Diversity (UNCBD), United Nations Framework Convention on Climate Change (UNFCCC), Kyoto Protocol, Convention to Combat Desertification (UNCCD), Convention on the International Trade in Endangered Species of Wild Flora and Fauna, Basel Convention on the Control of Trans-Boundary Movements of Hazardous Wastes and their Disposal and Paris Agreement among others (CIA, 2017). As part of the Paris Agreement, Kenya's commitments were the following:

- Mitigation: Decrease its "Green-houses gases (GHG) emissions by 30% by 2030 relative to the Business as usual (BAU) scenario of 143 MtCO2eq." This includes the objective of achieving a 10% tree cover and the implementation of climate smart agriculture, among other activities;
- Adaptation: "Ensure enhanced resilience to climate change towards the attainment of vision 2030 by mainstreaming climate change adaptation into the Medium Term Plans and implementing adaptation actions (Ministry of Environment and Natural Resources)

Under multi-stakeholder forum the national landscape restoration strategy has been developed led by the Kenya Forest Service with support from development agencies and partners including IUCN using ROAM tool (https://portals.iucn.org/library/node/44852).

Kenya's commitment to FLR, to increasing its tree cover and restoring ecosystem services, is an important tool in helping the country to meet its economic, environmental and development goals. Scaling up these restoration initiatives was promoted through the restoration opportunities assessment conducted in 2016. In September 2014, GoK established the Landscape Restoration Technical Working Group (LRTWG) led by the KFS to carry out this assessment as a first step towards a coordinated strategy for scaling up landscape restoration in Kenya. The LRTWG includes a wide range of stakeholders and over the last two years and has held a series of landscape restoration workshops to analyse different landscape restoration options for the country. The group identified the most pressing land use challenges currently facing Kenya, and identified a list of restoration options that could help address these challenges and restore the ecosystem services. In addition, the LRTWG produced maps and associated area statistics to assist state and non-state actors to identify potential areas for FLR. The various FLR options identified include:

- Natural forests that can be enriched or even established in order to increase carbon sequestration, restore biodiversity and ecosystem services, prevent flooding, restore regulation of water flows and soil quality, as well as forest habitat for wildlife;
- Agroforestry and woodlots on cropland to reduce erosion, increase livelihood diversification, fodder production and soil fertility;
- Investment opportunities for commercial tree and bamboo plantations;
- Tree-based buffers along waterways, wetlands and roads to stabilize river banks, reduce runoff and control sedimentation; and
- Improved management practices and restoration for Silvo-pastoralism and rangeland.

1.7 Justification of the study

To help justify and articulate and mobilize resources for the national target for forest landscape restoration targets, it is essential to quantify the likely benefits and costs of various interventions over wide range of landscapes. Economic analysis of restoration options was thus initiated to help rally support for restoration efforts at national, county, community and private landowners and influence policy makers. Economic analysis is a necessary precondition to inform and justify investments in landscape. In addition, the economic analysis will be able to quantify and identify the best options for achieving both short and long term benefits to landowners and other stakeholders at national, regional and the global levels including the climate change objectives.

The basket of restoration options will enable public agencies, planners and landowners to prioritize projects that will take limited budgets and resources and deliver the most benefits. In this context, the use of Cost Benefit Analysis (CBA) in the evaluation and justification of restoration options to be undertaken to support and inform the national restoration strategy has been adopted. The current efforts are initiatives of multisector support to national restoration strategy through use of CBA to provide comprehensive report on feasible restoration options for the country (TOR-Annex 1).

2.0 Methodology

2.1 Introduction

This section explains the Economic and Financial analysis methodology applied to estimate the net benefits of forest landscape restoration in Kenya. Economic analysis was based on capturing costs and benefits (public and private) of forest restoration compared to baseline scenario of degraded landscape. The agroforestry and rangeland systems produce both private and public benefits. The private benefits were assessed using financial analysis. This sheds light on their viability for private individuals and investors. Restoration of land and forests landscapes provides society with ecosystem services (carbon sequestration, water flow regulation, soil protection and biodiversity, ecosystem resilience e.t.c. In addition restoration of land and forests landscapes, provide livelihood support and social safety net for the more vulnerable members of society. Restoration of landscapes has many positive influence on society, however this analysis did not cover; biodiversity, flood protection, air pollution, nutrient cycling, habitat protection and cultural/education values (recreation, research, spiritual or heritage values). Quantifying the indirect and induced impacts of restored landscapes on the local and national economy was not assessed because it was beyond the scope of the assignment. Costs and benefits from landscape transitions have been as much as possible considered in the analysis. There are four evaluation criteria applied in this analysis namely: Net Present Value (NPV), Equivalent Annual Annuity (EAA), Internal Rate of Return (IRR) and Benefit Cost Ratio (BCR).

2.2. Forest Restoration Scenarios

Forest and landscapes restoration scenarios analysed were those proposed in the Kenya Technical Report on the National Assessment of Forest and Landscape Restoration Opportunities (MENR, 2016). These are summarised in Table 1. The restorations options / interventions selected in this analysis are those considered feasible and have been practised with proven success with farmers, KEFRI, KFS, and other stakeholders and have reasonable amount of scientific data

The interventions considered in the analysis are not exhaustive for example; there are varied potential practices for restoration of rangeland ecosystems (Gurtner ***et al.***, 2011)

Table 1. Restoration transitions

Current Scenarios	Restoration scenarios
1. Degraded natural forest	Rehabilitation of Degraded Natural Forest - Enrichment Planting
	Natural Forest Regeneration with Protection
2. Degraded agricultural landscapes	a) Intensive Agroforestry (Maize, ***Grevillea robusta*** and fruit trees)
	b) Melia and Cowpeas Intercrop in the Dry Lands
	c) Woodlots (*Eucalyptus grandis/saligna*)
3. Low tree cover in marginal crop areas and un stocked plantations	Commercial Tree and Bamboo Plantations in Marginal Areas and Un-Stoked Plantations
	a) Commercial Tree Production in Marginal Areas *(Gmelina arborea*)
	b) Commercial Bamboo Plantation in marginal areas
	c) Planting of Exotic tree species in un stocked plantation (*Cupressus lusitanica*)
4. Degarded Buffer zones along water bodies and wetlands	Riparian planting using a combination of bamboo and grass strips buffer Zones Along Water Bodies and Wetlands
5. Bare and naked buffer along major road networks	Tree –based buffer zones along roads using indigenous tree species
6. Degraded rangelands and woodlands with traditional pastoralism and extractive activities	Grass reseeding Enclosures (Improved pastures)
	Improved Silvo-pastoral System –integration of *Acacia senegal* and natural grasses

2.3. Capturing costs and benefits for Baseline and Restoration Interventions

To achieve restoration transitions, implementation costs, opportunity and transaction costs are incurred. The study identified detailed costs for each restoration activity using detailed checklists. The checklist included activity budget for each degraded land use and restoration activity e.g. material inputs, land preparation, labour requirements, output yields, crop yields, market prices of each output for each degraded land use and activity (Annex 2, Schedule 1-5). The key categories of costs considered in this study were; **Opportunity cost:** These are the benefits foregone by investing in degraded landscape activities through restoration action that was normally generated from the degraded landscape such as grazing for livestock, crop yields, timber revenue etc. **Implementation costs:** These are the costs incurred in the transition restoration activities such as: (labour (labour-days, hours), seeds (seedlings Kg; units), Fertilizer (kg; bag), equipment hire or lease (units), Land (Ha $Year^{-1}$), **Transaction costs:** These are costs incurred that support the transition restoration activities (extension services, labour-days; hour) and labour (labour-days; hour).

The opportunity cost (benefits from the baseline) and benefits restoration scenarios were obtained from projects reports, field data and synthesis from extensive review of literature and expert discussions. The data sources and analysis for each of the scenario is described below. For each land use and restoration intervention management practices (costs) that created benefit each year were modelled. The assumptions and model estimates were presented to Agricultural and Forestry experts for validation. These analyses were undertaken with key assumptions for each restoration transition (Annex 3). For each restoration transition, the analysis considered the relevant tree species, appropriate planting density, crops used in agroforestry and the management trade-off in each restoration activity. Public and private benefits were considered in the analysis.

2.4 Monetary Valuation of Baseline Scenarios and Restoration Impacts

All identified outputs/benefits (private and public) from baseline and improved scenarios were converted to monetary values through various valuation methods (Market prices, CVM, Cost- based (Avoided cost, mitigation costs etc.), production function approach, Benefit transfer etc. A summary of valuation techniques is provided in table (Table 2). For direct benefits accruing to private entities such as firewood, timber, gums and resins, agricultural products (maize, fruits, cowpeas and bamboo culms) valuation was done using direct market prices less transaction cost (Godoy et al, 1993; Campbell and Luckert, 2002; Langat and Cheboiwo, 2010; Langat *et al.*, 2016). Carbon sequestration values were computed based on estimated carbon stock (below and above ground) in each restoration option using established IPCC 2006 procedures. The carbon dioxide equivalent was computed and valued based on the current international carbon prices. For the outputs/benefits with poor developed markets e.g. grass/fodder we applied prices of substitute/ surrogate products. Water flow regulation and soil protection values were estimated using avoided cost. In the absence of local scientific data on aesthetic, shade, air purification and the role of trees in road maintenance, benefit transfer approach was applied with economic correction factors.

Table 2. Valuation techniques, data and valuation models applied in estimating benefits for restoration transitions

Product/ service	Valuation Method	Data	Model for computation of value	Model explanation
Timber	Market prices	-Mean annual increment, Volume (M^3) -Cost of production	$T_n = (Q_i * P_i) - C_i$	Where, $\boldsymbol{T_n}$ is the economic value, $\boldsymbol{Q_i}$ is the quantity of good/product; $\boldsymbol{P_i}$ is farm gate price of the product, $\boldsymbol{C_i}$ is the cost of production
Firewood	Market prices	-Volume (M^3) -Cost of production	$T_n = (Q_i * P_i) - C_i$	
Fodder	Surrogate, Market prices	-Quantity in kg or bales - Cost of production	$T_n = (Q_i * P_i) - C_i$	
Gums and resins and myrrh	Market prices	- Yield per tree or ha, Quantity (Kg), -Cost of production	$T_n = (Q_i * P_i) - C_i$	
Agricultural crops	Market prices	-Quantity, cost of production, Market prices	$T_n = (Q_i * P_i) - C_i$	
Carbon sequestration	Market prices	-Above ground Biomass (AGB), Below ground biomass) (BGB, Soil biomass), international voluntary carbon market, total area under vegetation, IPCC carbon default values	$V_R = (Q_r * P_c) - (Q_d * P_c)$	Where $\boldsymbol{V_R}$ is the carbon sequestration value of restoration transition; $\boldsymbol{Q_r}$ is carbon sequestration (CO_2) in restored area; $\boldsymbol{P_c}$ is the international carbon sequestration price; $\boldsymbol{Q_d}$ is the is carbon sequestration (CO_2) in degraded area
Soil protection (erosion control)	Avoided cost	-cost of 1 ton of sediment removal -ratio of sediment entering rivers or reservoirs to total soil lost -Soil erosivity for restored and non-restored forest (tons/ha)	$V_k = K * S$	Where $\boldsymbol{V_k}$ is the economic value of soil-erosion regulation; -$\boldsymbol{K}$ is the cost of 1 ton of sediment removal; -$\boldsymbol{S}$- soil loss (tons/ha).
Water flow regulation	Avoided cost – water storage method	Run off per ha, cost of constructing a dam, amount of runoff water in each scenario	$V_f = S * (J_0 * K) * (R_0 - R_q) * C_{yt}$	Where $\boldsymbol{V_f}$ represents the value of water-flow regulation -$\boldsymbol{S}$ - the area under forest in hectares -$\boldsymbol{J}$ - the annual precipitation runoff of the study area; -$\boldsymbol{J_o}$ - the annual precipitation of the study area -$\boldsymbol{K}$ -the ratio of precipitation-runoff yield to the total precipitation of the study area; -$\boldsymbol{R_o}$ - the precipitation-runoff rate under degraded land; -$\boldsymbol{R_g}$ represents the precipitation under restored areas -$\boldsymbol{C_{yt}}$ - the investment cost of reservoir construction per m^3. $\boldsymbol{V_i}$- value in Kenya $\boldsymbol{V_{xx}}$ is the value of study site, USA $\boldsymbol{PPP_{GNP}}$ is the purchasing power parity GNP per capita[a] ^{E} is the elasticity of values with respect to real income, assumed ^{E}=1.00)
Aesthetic value, shade, air purification,	Benefit transfer	WTP	$V_i = V_{xi} * \left[\frac{PPP_{GNPKenya}}{PPP_{GNP\ USA}}\right]^E$	
Road damage	Benefit transfer	Avoided cost in study site, purchasing power parity (USA and Kenya)		

[a] The PPP GNP values were obtained from World Bank report (World Bank, 2017).

2.4.1 Discounting of Benefits and Costs

Restoration decisions have impacts spread over different timeframes. The Outputs (costs and benefits) were discounted to take care of the time value of money. The cost and benefits of each degradation and restored land use were discounted using the equation:

$$V_0 = \sum_{i=1}^{T} \frac{V_t}{(1+r)^t} \text{..............Eq. 1}$$

Where V_0 is the present value of streams of benefits or costs, T is the time horizon and r is the discount rate of 7 % being the discount rate applied appraisal of public environmental projects in Kenya. A 30-year period was used in appraisal all the restoration scenarios as most forest investments mature at 30-years.

2.4.2 Computing the NPV, EAA, B/C ratio and IRR of restoration options

a) Net Present Value (NPV)

The NPV of each restoration transition was computed by subtracting the NPV of each degraded land use from NPV of restoration intervention/activity. The restoration transition was considered viable when the NPV of the restoration transition was greater than zero.

$$NPV_{RT} = \sum_{t=1}^{T} \frac{(B_{RI} - C_{RI})}{(1+r)^t} - \sum_{t=1}^{T} \frac{(B_{Dt} - C_{Dt})}{(1+r)^t} \dots\dots\dots\dots\dots\dots\dots Eq\ 2$$

b) Equivalent Annual Annuity (EAA) is an annual payment that pays off the NPV of an asset during its lifetime. The Equivalent Annual Annuity was computed as follows:

$$EAA = B * NPV_{RT} \dots\dots\dots\dots\dots\dots\dots\dots\dots Eq.3$$

Where β is the annuity factor and Annuity factor

$$\beta = \left(\frac{r(1+r)^n}{(1+r)^n) - 1}\right)$$

a). Internal Rate of Return (IRR) is the interest at which the initial investment NPV is zero. IRR was computed using financial formulae in Excel 2016.

b). Benefit Cost Ratio measure the how much gain accrues with a unit expenditure of cost.

Benefit Cost Ratio for Restoration Transition is computed using equation 4 below:

$$BCR_{RT} = \frac{NPV_{RI} - NPV_D}{C_{RI} - C_D} \dots\dots\dots\dots\dots\dots\dots\dots Eq.4$$

Where BCR_{RT} is the Benefit Cost Ratio for the restoration transition, NPV_{RI} is the Net Present Value of restoration transition and C_{RI} and C_D are costs of Restoration intervention and cost of degraded landscape.

2.4.3 Estimation of costs and benefits of restoration transitions at the national level

The costs of each restoration transition on per/ha were determined for 30 years. The total costs required for the interventions at the national scale were computed on pro-rata basis using criteria and target area developed by the Landscape Restoration Technical Working Group (LRTWG) (MENR, 2016).

2.4.4 Sensitivity Analysis and Key Assumptions

The costs and benefits of restoration transitions are influenced by variable economic and ecological parameters such as market prices, discount rates, precipitation and tree growth rates. Because of the variability of these parameters there are inherent risks in restoration efforts which should accounted for in CBA. To account for this uncertainty, we have carried out sensitivity analysis by varying the discount rate from 5% to 12%.

2.5 Description of Forest Restoration Transitions and Identification of Costs and Benefits

2.5.1 Restoration of Degraded Natural Forests

a) Rehabilitation of degraded natural forests through enrichment planting

It was assumed that firewood, fodder and carbon stock are the only benefits from the degraded forest. Quantities of firewood collected was computed by assuming that degraded natural forest has 25% productivity using data from Ministry of Environment, Water and Natural Resources report (MEWNR, 2013). The carbon stock from degraded and restored (enrichment planted) was obtained from Kinyanjui ***et al.***, 2014, and MacFarlane ***et al.***, 2015 respectively. Soil loss data from degraded forest were obtained from data from a study in East Mau where it was found that degraded forest loses 3.6 ton/year (Okelo ,2008, Onyando ***et al.***, 2005). The benefits from enrichment planted forest were modelled by assuming that highly degraded natural forest areas can be restored using *Podocarpus falcutus*. This particular indigenous species was selected based on available literature (Kigomo 1992 and Cheboiwo ***et al***., 2015) and expert discussions.

b). Natural forest regeneration with protection

The less degraded natural forest with sufficient mother trees and adequate seed bank can be restored using passive restoration techniques. This was assumed to be undertaken through encouraging the natural regeneration process to occur by minimizing external negative influence through fencing and provision of adequate protection (Otuoma and Amwatta, 2015). In the degraded baseline scenario, it was assumed that grazing, firewood were the only benefits and so loss of herding and firewood collection benefits are opportunity costs incurred for the restoration activity.

In the natural regeneration scenario, it was assumed no extractive activities but regenerated forest provides public benefits such as carbon stock and soil erosion prevention. It known that recovery of natural forest to its full productivity can be achieved after seven to 15 years depending on the severity of degradation (Daily, 1995). In this analysis, it was assumed with adequate protection, the forest will recover after 10 years. The carbon benefit was modelled by assuming a gradual build-up of carbon with the age of regeneration and thus means annual growth data for forest regrowth. The soil erosion benefit was estimated by assuming that after 10 years, the soil loss in naturally regenerated forest is similar to soil loss in natural forest and a value of 0.06tons/ha (Onyando ***et al.***, 2005) was used to computed avoided cost of soil erosion. The avoided cost was computed by estimating total soil loss over the investment period and multiplying by average cost of de-silting in Kenya. The average cost of de-silting (KES 178/ton) was assumed from a study in East Mau (Langat, 2016). In the improved scenario (natural regenerated) fencing and security were the only costs.

2.5.2 Restoration of Degraded Agricultural Landscapes

There is potential to integrate trees in farmlands to regenerate agricultural land and to increase tree cover to legal threshold of 10% (Agricultural rules, 2009) and increase availability of wood products and ecosystem services. This intervention can be done through establishment of trees in cropland (agroforestry) and woodlots). In this analysis, three interventions were identified namely: ***Grevillea robusta*** robusta, Maize and Avocado in the highlands, Melia and cowpeas in the drylands and woodlots establishment using Eucalyptus tree species.

a). Intensive Agroforestry (Maize, Grevillea robusta and fruit trees)

In the baseline scenario, it was assumed the current land use is maize monoculture. Costs and benefits of traditional maize growing were modelled by assuming that farmers will continue with traditional maize growing at a spacing of 75 cm x45 cm, seed rate of 25 kg per Ha, fertilizer rate 200 kg per ha). It was assumed that farmers will benefit from sales of maize, and maize stover. Additionally, it was assumed that traditional maize growing yield public benefits in terms of carbon storage, but there is public cost of increased soil erosion. Maize productivity under traditional agriculture was estimated at 1,649 kg/ha (Olwande, 2012) and maize stover yield at 0.14 tons/ha/yr (Lukuyu ***et al.***, 2008). Soil losses under traditional maize farming vary from 8.6 ton/ha/yr (Onyando ***et al.***, 2005) to 10 to 15tons/ha/yr (Owino and Gretzmacher, 2002). An average value of 10.6 ton/ha/yr was applied.

In the agroforestry intervention, it was assumed farmers will integrate 50 ***Grevillea robusta robusta*** trees and 50 Avocados per ha at a spacing of 10 m by 10 m. The benefits in this intervention are: harvest of crops (maize), stover, firewood, and timber. Maize yield and maize stover yield were estimated at 2,175 kg/ha (Olwande, 2012) and 0.9 tons/ha/yr (Lukuyu ***et al.***, 2008) respectively. Firewood yield was estimated at 20% of timber yields and final crop harvested after 30- years with a timber recovery of 50% (Muthike Pers.com). Firewood yield in agroforestry system were estimated at 6.0m^3/ha/yr (Kamweti, 1996). Timber yields in ***Grevillea robusta*** agroforestry vary from 8 to 24m^3/ha (Kamweti, 1996, Muchiri ***et al.***, 2002, Kalinganire, 1996, Akyeampong, ***et al.***, 1995) an average of 18.1m^3 was used in this analysis. Avocado was assumed to yield 12.2 tons after the 3rd year (Muendo et al, 2004). Soil fertility is one of private benefits through increased productivity to the farmer. Soil improvement through decaying organic matter from agroforestry was assumed to yield 0.107 tons/ha of organic manure per year (Nair et al, 1999). This benefit was computed using market price of manure which was assumed to be KES 1,000/ton.

In addition, intensive agroforestry system accrues public benefits through increased carbon storage and soil erosion prevention. Carbon stock in traditional maize agriculture was estimated at 0.03tons/ha (Amado and Bayer, 2008) and 0.8 tons/ha (Kumar and Nair (Eds.) (2011)) under intensive agroforestry. Soil loss under traditional maize farming vary between 8.6 and 15tons/ha (Owino and Gretzmacher, 2002) and in this analysis an average soil loss of 10.6 tons/ha in traditional maize scenario and 4.2 tons/ha (Mohamoud, 2012) under intensive agroforestry was assumed.

b). Integration of Melia and Cowpeas Intercrop in the Dry Lands

In the baseline, it was assumed that farmers will continue with cowpeas monoculture. Costs and benefits of were modelled by assuming that farmers will continue with normal cowpeas agronomic practices with a spacing of 75 cm by 45 cm), seed rate of 30 kg per ha, fertilizer rate 150 kg per ha. The benefits in this scenario are sale of cowpeas and haulms. Additionally, it was assumed that growing traditional cow peas yields public benefits in terms of carbon storage but with increased public cost of soil erosion. Cowpeas productivity under traditional agriculture was estimated at 1800kg/ha (Karanja ***et al.***, 2008) and haulms yield of 2.4-2.5 kg /ha/yr (Rao, 2011). In addition, it assumed carbon stock under traditional cowpeas system was 0.03tons/ha (Amado and Bayer, 2008). Soil losses under traditional cowpeas farming was assumed to be 4.2 tons/ha (Mohamoud, 2012).

In the Melia and cowpeas intercrop, it was assumed farmers will integrate 240 Melia trees per ha (10m by 5m spacing). The benefits in this intervention are: harvest of cowpeas, haulms, firewood, and timber. Cowpeas yield and cowpeas haulms were estimated at 4,000 kg/ha and 2.5tons/ha/yr (Rao, 2011) respectively. Firewood yield was estimated at 20% of timber yields and trees are harvested after 30- years with a timber recovery of 50% (Muthike Pers.com). Melia yield 40 to 60 m^3 in 12 years (Luvanda ***et al.***, 2015) and we have assumed a value of 50m^3 in this analysis. Soil fertility is one of private benefits through increased productivity to the farmer. Soil improvement through decaying organic matter from agroforestry was assumed to yield 0.107 tons/ha of organic manure per year (Nair et al, 1999). This benefit was computed using market price of manure which was assumed to be KES 1,000/ton. In addition, intensive Melia and Cowpeas intercrop yield public benefits through increased carbon storage and soil erosion prevention. Carbon stock was estimated at 0.8tons/ha (Kumar and Nair (Eds.) (2011)). Soil loss of 4.2 tons/ha (Mohamoud, 2012) was assumed.

c). Poorly Managed woodlots to well-managed woodlots

It was assumed that poorly managed Eucalyptus woodlots (baseline scenario) produce small diameter poles with a density of 4500 trees per hectares ((1.5m by 1.5m on a 4-year coppice cycle. Seventy-five (75%) of poles were assumed suitable for sale. The costs in poorly managed Eucalypt woodlots were cost of inputs, maintenance and harvesting (seedlings, labour cost (staking out, pitting, planting, spot weeding, and maintenance and security, harvesting costs and soil loss). The benefits from poorly managed Eucalypts were revenue from poles and accumulation of carbon stock. Market price of KES 50 was assumed for small diameter poles. Carbon stock was estimated by assuming that mean annual increment of poorly managed Eucalyptus woodlot is 25% of well managed stands and with above ground carbon of 12.68 metric tonnes (MT) (for young Eucalyptus (Yirdaw, 2018).

In well-managed Eucalyptus woodlot tree density of 1600 trees/ha (2.5m by 2.5m) with average mean annual increment of Eucalyptus of about 55 m^3 per year (Langat and Cheboiwo, 2005) was assumed. It was assumed that there is 25% mortality in the 1st year and beating up done in the beginning of the 2nd year with 400 seedlings. The costs in the improved scenario were cost of inputs, maintenance and harvesting (seedlings, labour cost (staking out, pitting, planting, spot weeding, and maintenance and security, harvesting costs and soil loss). The benefits from well-manage eucalyptus woodlot were revenue from sale of poles and final timber crop and accumulation of carbon stock. The revenue was assumed to occur as 1st thinning at year 10 where 528 stems were harvested and sold at KES 2000 per stem. The retained (1,111) crop was allowed to maturity and harvested and sold at 30- years with a stumpage value KES 15,000 per stem (KFS undated). In addition, soil loss in Eucalyptus woodlot was assumed at 0.06ton/ha (Onyando ***et al.***, 2005) and the cost of cost of sediment removal is KES 178 per tonne (Langat, 2016).

2.5.3 Restoration of tree cover in marginal areas and un-stocked plantations

There are areas where crop production may not be economically feasible and switching to tree growing is potentially viable. Commercial tree and bamboo were identified as potential restoration opportunities in these areas. ***Gmelina arborea***, exotic bamboo species and Cypress plantings were considered in this analysis. ***Gmelina arborea*** and exotic bamboo species have been found to viable in marginal areas (KEFRI, 2016) while cypress is one of the most popular commercial timber species.

*a). **Commercial** Gmelina arborea **planting in Marginal Areas***

In the baseline scenario of marginal areas, it was assumed there are few trees (28 stem /ha) of other woody trees. It was assumed grazing was the only private benefit from marginal areas but there is a public cost due to soil erosion. The value of grazing was assumed at KES 3000/ha (50%) of grazing in high moist forest (Langat ***et al.,*** 2018). Soil loss under grazing regime was assumed to similar to that of grassland with 3.16 tons/ha/yr (Onyando ***et al.***, 2005). The only cost in degraded areas was herding cost assumed at KES 3000/month. The public benefit from marginal grazing land was carbon stock and estimated at 25.11 tons/ha (Swamy and Puri, 2005, Negi, 1990).

In the improved with commercial ***Gmelina arborea***, costs and benefits were modelled by assuming spacing of 4m by 4m. Thinning undertaken at year 7 and used as poles remaining stems harvested for timber at 30- years. The costs in the improved scenario were assumed as cost of inputs, maintenance and harvesting (seedlings, labour cost (staking out, pitting, planting, spot weeding, and maintenance and security, harvesting costs). The benefits from ***Gmelina arborea*** plantation are: firewood, timber and accumulation of carbon stock and soil erosion prevention. Firewood yield was assumed to be 20% of timber yields. It was also assumed that mean annual increment for ***Gmelina arborea*** in Kenya is 9 m^3 per annum with final potential volume of 225 m^3. The carbon stock was modelled using the annual growth increment for ***Gmelina arborea***.

b). Commercial Bamboo Plantation in un-stocked plantations areas

In the baseline scenario of un-stocked areas, it was assumed there are 333 trees (30%) of the 3m by 3m tree density of 3m by 3m (1,100/ha). It was assumed that the modal age of most un-stocked plantation in Kenya was 10 years. The only cost in un-stocked plantation was herding cost assumed at KES 3,000/month. The benefits from un-stocked planation assumed as grazing and final crop of 333 trees at maturity (30-years). The benefit from grazing was assumed at KES 3,000/ha (50%) of grazing in high moist forest (Langat ***et al.***, 2018). Soil loss under un-stocked plantation was assumed similar to that of grassland 3.16 tons/ha/yr (Onyando ***et al.***, 2005) and Carbon stock in un-stocked planted forest was computed using 30% of mean annual increment of commercial cypress plantations in high potential areas (Mathu, 1983).

In the improved scenario, it was assumed exotic bamboo (*Dendrocalamus asper*) was planted in the empty spaces. Costs and benefits were modelled in bamboo plantings by assumed spacing of 6m by 6m-277 bamboo trees per ha and bamboo and managed according to KEFRI Management Guideline (KEFRI ,2017). The costs in the improved scenario were cost of inputs, maintenance and harvesting (seedlings, labour cost (staking out, pitting, planting, spot weeding, and maintenance and security, harvesting costs). In addition, it was assumed that a fully developed bamboo clump has 75culms after 4 years and 10culms from each clump can be harvested every year after the 4th year and for KES 50 apiece. The planted bamboo provides benefits from sale of culms, increased carbon storage and soil erosion prevention. A fully developed bamboo stand was assumed to have similar carbon stock as fully stocked ***Yushania alpina***- 37.82 tons/ha (Mbae and Muga, 2018). In addition, fully developed bamboo stand was assumed similar to natural forest in soil loss - 0.06 tons/ha (Okelo, 2008, Onyando ***et al.***, 2005) and the cost of cost of sediment removal is KES 178 per tonne (Langat, 2016).

c.) Improved un-stocked Cypress plantations

It was assumed that un-stocked plantation (baseline scenario) has 528 (30%) of the fully stocked stand of 1600 trees per ha (2.5m by 2.5m spacing) and the modal age is 10 years. Under un-stocked scenario, grazing, timber and carbon stock from the existing trees were assumed as benefits. Costs and benefits were modelled based on 528 stems from year 10 to 30-years. In addition, herding, maintenance cost and harvesting of KES 3,000 per month, KES 4,800 per year and KES 300 per stem were assumed respectively. Grazing benefit was assumed to be KES 3000/ha/yr (50%) of value of grazing in natural forests in moist forest ecosystem (Langat ***et al.***, 2018). Timber value was computed with the assumption that there was no thinning till maturity and stems sold based at market unit price of 11,723 (KFS, undated). The carbon stock was computed by assuming that un-stocked stand has one third of the global mean annual increment of 13.4m^3/ha of fully stocked cypress (Ugalde and Perez, 2001). The volume of un-stocked cypress was computed and converted to carbon stock using IPCC conversion factor of 50% and shoot to root ration of 0.24 (IPCC, 2006).

It was assumed restocking of un-stocked plantation (Improved scenario) will involve planting of 1,072 cypress seedlings in empty spaces to make a plant population of 1600 (2.5m by 2.5m) and managed to 30- years for timber. Cost and benefits based were modelled based on prescribed operations (planting, pruning and thinning schedules) for Cypress commercial timber cycle in Kenya (Mathu, 1983) The costs involved in restocking cypress plantation were cost of inputs, maintenance and harvesting (seedlings, labour cost (staking out, pitting, planting, spot weeding, beating up[1] and maintenance and security, harvesting costs and soil loss). All labour days were based on KFS data for commercial Cypress plantation (KFS, undated). In addition, cost of maintenance/security costs (4800[2]/ha/year). The benefits of stocked cypress plantation were stumpage revenue (un-stocked 528 stems at 30- years), 1st thinning at 5th year (483stems), 2nd thinning at 10th year (130 stems), 3rd thinning at 15th year (118stems), 4th thinning at 20th year (57stems) and final sale of 63 stems at 30th year. The unit price per stem was obtained from KFS report (KFS, undated). The other benefits were grazing and accumulation of carbon stock. Grazing benefit was assumed to be KES 3000/ha/yr (50%) of value of grazing in natural forests in Mau forest ecosystem (Langat ***et al.***, 2018). The carbon stock was computed by summing un-stocked carbon benefit as described in the baseline scenario and carbon stock in the planted Cypress. We assumed a global mean annual increment of 13.4m^3/ha of fully stocked cypress (Ugalde and Perez, 2001) and computed volume of planted stems and converted to carbon stock using IPCC conversion factor of 50% and shoot to root ration of 0.24 (IPCC, 2006).

1 We assumed 'beating up' was to occur at the beginning of 2nd year with planting of 268 seedlings (25%)

2 Maintenance and security (8,000 per person per month for 20 ha)

2.5.4 Restoration of Degraded Buffer Zones along Water Bodies and Wetlands

a) Tree-based buffer zones along water bodies and wetlands

Most riparian areas in Kenya are bare, exposing these fragile areas to severe run off and severe erosion and sedimentation of water bodies. The planting of trees and other soil conservation measures will assist in minimizing negative impacts in these buffer zones areas. Though, these buffer zones are small, these areas play important roles in managing sediment and water quality and have the potential to enhance the flow of ecosystems services and benefits to society and environment (MENR, 2016). Bamboo and Napier grass were identified as potential restoration opportunities in these buffer zones and were selected for analysis. In the baseline scenario of degraded buffer zones, it was assumed currently used for subsistence grazing. The subsistence grazing was assumed to be KES 3000 - 50% of forest grazing in public forests (Langat ***et al.***, 2018). Public benefit through carbon stock was assumed to be 0.105 ton/ha (Yusuf ***et al.***, 2015 and Conant ***et al.***, 2017). The soil loss in degraded riparian zones was assumed to be 10tons/ha (Angima et al, 2000). The benefits and costs in the restoration scenario of bamboo and grass strip plantings were modelled based on assumption that 110/ha bamboos are planted in two rows on either side of the river and Napier and other grasses is planted in a 30 metre strip at a spacing of 0.6m*0.6m. Bamboo culms are harvested after 4 years. It was assumed that 10 culms can be harvested after the 4th year per clump and sold for KES 50 apiece. We further assumed bamboo plantation and grass strip plantings yield public benefits through increased carbon storage and soil erosion prevention. A fully developed Bamboo, Napier and grass planted buffer has carbon stock of 6 to 7.6 tons/ha (Xu and Zhuang, 2018 and Mothapo, 2017). We have assumed 6 tons/ha/yr for this analysis. In addition, fully developed bamboo, Napier/grass strips, soil loss was assumed to be 5.6 tons/ha (Angima ***et al.***, 2000.

2.5.5 Restoration of Bare and Naked Buffer along Major Road Networks

a.) Tree –based buffer zones along roads using indigenous tree species

Roads reserves are potential sites for restoration to help mitigate air pollution, water run-offs, soil erosion and air quality and storm damage reduction along the major road networks in Kenya. In this analysis, tree planting on road reserves using indigenous tree species was chosen. *Podocarpus falcutus* was chosen based on literature (Kigomo, 1987, Cheboiwo *et al.*, 2015) and discussions with experts.

In the baseline scenario of tree less road reserve it was assumed there is no private and public benefit. However, there is public cost through soil erosion and road damage. Local data on soil loss and road damage is scanty and therefore relied on data from Spain and USA, where tree-less road experience soil loss of 3 tons/ha (Pereira ***et al.***, 2015). In the improved scenario, costs benefits of tree planting were modelled by assuming planting of 110 indigenous trees per ha on both sides of the road at an interplant spacing of 6 m. Average road specification of 30m width with the road occupying 15m leaving 15m as road reserve for tree planting was assumed. Public benefits from road site planting were assumed as aesthetic value achieved after the 3rd year, shade provision from year 7th year, storm protection from 10th year, carbon sequestration maximum from the 7th year and the cost savings from road maintenance. Furthermore, it was assumed trees will be maintained in perpetuity and no harvesting is anticipated. In the absence of local quantitative data on benefits of road site tree planting –we relied on benefit transfer technique and adopted data from United States America (USA) with modification using Purchasing Power Parity (PPP) data (World Bank, 2017) between the two countries. Based on the conservative USA data (Anderson and Cordell, 1988 and Song ***et al.***, 2017) road side tree planting enhance aesthetic, air quality, shade, carbon stock and storm protection by KES 3.00, 4.42, 26.00, 2.20 and 1.82 per tree respectively.

2.5.6 Restoration of Degraded Rangelands and Woodlands

Rangelands form a large part of Kenya's land mass and provide ecosystem services and support livelihoods in drylands. Most rangelands and woodlands in Arid and Semi-Arid Lands (ASALS) are considered to be degraded and these were identified for restoration. In the 2016 Strategy (MENR, 2016), two restorations options were identified as suitable for restoration options for the rangelands namely: Grass reseeding Enclosures (Improved pastures) and Silvo-Pastoral System *(Acacia senegal* and natural grasses). These interventions are likely not to change the current land use significantly but have the potential to enhance the management of rangeland resources. Though in this analysis only two options were considered, there are a broader range of ecosystem restoration approaches for the rangelands (IPBES and WOCAT SRM Guidelines , Gurtner *et al.*, 2011).

a).Grass reseeding Enclosures (Improved pastures)

In the degraded grasslands (baseline scenario), it was assumed grazing and carbon stock are the only benefits from rangelands. Fodder productivity is influenced by many factors and there is scanty data on pasture productivity in rangelands but we relied on data from study from Karamoja region of Uganda. Therefore, under the baseline scenario, it was assumed fodder productivity is 66.7 kg/ha/yr (≈4.5 bales/ha/yr. (Egeru ***et al.***, 2014). Furthermore, it was assumed that degraded rangelands has carbon stock and 0.105ton/ha (Yusuf *et al.*, 2015, Conant *et al.*, 2017). The only private cost incurred in the baseline scenario is the cost of herding which was assumed to be KES 3,000 per month. Furthermore, it was assumed that 72 tons/ha) of soil is lost in the degraded rangelands (De graff, 1993).

In the improved scenario, grass reseeding and proper grass management was assumed. Costs and benefits were modelled of the transition by assuming reseeding and fencing of degraded grasslands. The costs of the intervention were assumed as the costs of reseeding and management as purchase of seeds, fencing and maintenance. The benefits of reseeding were improved pastures, enhanced carbon stock and less soil erosion. Improved and managed pastures was assumed to produce 178.2 bales/ha/yr and 287.7 kg/ha/yr of grass fodder and seeds (Manyeki ***et al.***, 2015[3])) and enhanced carbon stock from 0.105 ton/ha (Asen ***et al.***, 2014, Conant ***et al.***, 2017) to 1.00 ton/ha (Asen ***et al.***, 2014). Soil loss under grass reseeding was assumed to be 0.01 to 2.00 tons/ha (Pimentel and Kounang, 1998). Average selling price of grass seeds at KES 425/kg (Manyeki ***et al.***, 2015) and market price of hay of KES 175 per15kg-bale was assumed.

b). Traditional pastoral system to Silvo-Pastoral System (Acacia senegal and natural grasses)

In the traditional pastoral system (baseline scenario), it was assumed that livestock grazing and collection of gum from natural gum trees are the only benefits. The benefit from grazing was computed based on grass productivity in rangeland and 66.7 kg/ha/yr (Egeru ***et al.***, 2014) was assumed. Cost of herding of cost of KES 3,000 per month was assumed. Benefit from gum was estimated on assumption that there are 275/ha of gum producing trees yielding 137.5 kg of gum per annum (Muga, 2018). The average carbon stock in rangelands of 0.105 ton/ha (Yusuf ***et al.***, 2015 and Conant ***et al.***, 2017) was assumed. Furthermore, we assumed a soil loss of 72 tons/ha (de Graff, 1993).

In the improved scenario (Silvo-pastoral system), introduction and planting 400 gum producing trees in 5m by 5m spacing was assumed. The costs and benefits were modelled for 30- years. The costs in the intervention were assumed as: seedlings, planting, maintenance, livestock herding, gum and grass harvesting. The benefits of transition are: improved gum production, improved pastures, enhanced carbon stock and less soil erosion. It was assumed that planted gum trees will start producing gum from 5th year and could yield 200[4] kg of gum per year (Muga, 2018). In addition, improved silvo-pastoral system was assumed to produce 1,163.3[5] Kg/ha of livestock fodder (75.7 Bales) (Rebecca MOA Perscom on Delfino intervention) and enhanced carbon stock of 7.76 ton/ha (IPCC, 2006). Soil loss under grass under improved silvo-pastoral system grassland was assumed as 2tons/ha -highest value cited (Pimentel and Kounang, 1998). Local market prices of hay and gum were assumed as KES 150/bale and KES 100/kg respectively.

3 Data based on local study of introduced improved grass and management in Chyulu landscapes

4 Computed based on the assumption that a mature gum tree has the potential to produce 0.5kg/yr

5 We assumed a cut and carry system and that under improved scenario, natural regeneration of acacia and other species will occur.

3.0 Results and Discussion

3.1 Economic Analysis of Landscape Restoration Options

3.1.1 Restoration transition from degraded natural forests to improved natural forests

Two restoration approaches were considered in restoration of degraded natural forests: enrichment planting and natural regeneration. The transition from degraded natural forests to improved natural forests through enrichment planting would generate a NPV of KES 318,559 over the 30-year period. The economic benefits achieved through this intervention are sale of firewood, carbon sequestration water flow regulation and soil erosion prevention. The BCR for the transition is 2.75 meaning for every 1 shilling in invested in the restoration process; KES 2.75 will be generated within the 30 year period (Table 3). This transition is economically viable since; it has the ability to pay for itself within the 30 -year time period.

Forest restoration transition through natural regeneration approach would generate a NPV of KES 906,559 and BCR of 3.90 would be obtained over the 30 years. This transition is also economically viable with carbon sequestration, water flow regulation and firewood being the major economic benefits.

Table 3. Economic Analysis of transition from degraded natural forests to improved natural forests through enrichment planting and natural regeneration/ha

Transition	Land use	Economic Evaluation Criteria @ 7% discount rate	
		Net Present Value (NPV)	BCR
Degraded natural forest to improved enriched and protected natural forest	Baseline Improved Transition	649,509 968,068 318,559	2.75
Degraded forest to improved protected natural forest (natural regeneration)	Baseline Improved Transition	371,313 1,277,872 906,559	3.90

Plate 1: A degraded natural forest (left) and a natural forest (right)

Table 4. Discounted benefit flow analysis for enrichment planting in degraded natural forests/ha

Description of benefits and costs	Aggregate Discounted Values 2018 to 2048 @7%
Benefits flow	
Carbon sequestration	1,087,391
Soil prevention	23,328
Firewood	10,726
Water flow regulation	3,912
Discounted cost value	**1,125,357**
Costs	
Purchase of indigenous tree seedlings	63,084
Transportation of seedlings	4,673
Preparation of stakes	654
Staking out	2,290
Pitting	16,355
Planting	4,907
Site maintenance and security	22,336
Fencing	42,991
Discounted cost value	**157,290**
NPV	968,068
Benefit cost ratio (BCR)	6.15
Internal rate of return (IRR)	23.37%
Equivalent annual annuity (EAA)	83,060

a) Discounted benefit flow analysis of natural forest regeneration through enrichment planting

Benefit flow analysis for enrichment planting in degraded natural forests is presented in (Table 4). The benefits expected from firewood extraction which is expected to commence from year 10 when sustainable extraction of dead wood and fallen braches is allowed, carbon sequestration, water flow regulation and prevention of soil erosion. Carbon sequestration generates the highest economic benefits at KES 1,087,391 followed by soil erosion prevention (KES 23,328), firewood extraction (KES 10,726) and water flow regulation (KES 3,912) respectively over the 30-year period. Timber is not included since no extraction is allowed in the natural forests in Kenya. The discounted net cash inflow (NPV) expected from enrichment planting of 1 ha after 30 years is KES 968,068. The positive NPV indicates that investing in this intervention is economically viable. The internal rate of return for forest enrichment (cost of capital at 12%) is estimated at 23.37% which is viable given the prevailing cost of capital (interest rate) of 12%. This intervention will generate a BCR of 6.15 which is greater than 1 and EAA of KES 83,060 both indicators indicating viability of the intervention.

b) Discounted benefit flow analysis of Natural forest restoration through natural regeneration

Natural regeneration is the ability of the forest regenerate itself without external intervention. The economic benefits expected from this restoration are carbon sequestration, Water flow regulation, soil prevention and collection of firewood which is allowed from the 10th year. The discounted net cash inflow (NPV) expected from natural forest regeneration planting of 1 ha after 30 years is KES 1,277,872. The internal rate of return for natural regeneration is 17.05% which is higher than the interest rate of 12% while the benefit cost ratio (BCR) is 5.29. Equivalent annual annuity (EAA) expected from the intervention is KES 109,641 thus based on the three economic criteria the intervention is economically viable.

Table 5. Discounted benefit analysis for natural regeneration of degraded forests/ha

Description of benefits and costs	Aggregate Discounted Values 2018 to 2048 @7%
Benefits flow	
Value of carbon sequestration	1,481,113
Water flow regulation	4,285
Soil Prevention	23,327
Firewood	10,725
Discounted cost value	**1,519,450**
Costs	
Site Maintenance and security	164,008
Fencing	77,570
Discounted cost value	**241,578**
NPV	1,277,872
Benefit cost ratio (BCR)	5.29
Internal rate of return (IRR)	17.05%
Equivalent annual annuity (EAA)	109,641

3.1.2 Restoration transition from degraded agricultural landscapes to improved agroforestry systems

Agroforestry involves integration of tress with crops. In this analysis three restoration case scenarios were considered, first the integration of Grevillea robusta, maize and fruit trees this is well suited for highlands areas of Kenya mainly central Kenya and western rift valley areas. The improved scenario considered integration of Melia with cowpeas in the dryland areas of Kenya. Lastly we analyzed the improved management of poorly managed eucalyptus woodlots. The transition from degraded agricultural landscapes to improved agroforestry systems through integrating Grevillea robusta, maize and fruit trees (Avocado) would generate an NPV of KES 991,415 over the 30 year period. The economic benefits achieved through this intervention are maize, firewood, timber, fruits, carbon sequestration and soil fertility improvement. The BCR for the transition is 25.64 meaning for every 1 shilling in invested in the restoration process KES 25.64 will be generated within the 30 year period (Table 6). This transition is economically viable because it has the ability to pay for itself within the 30 year time period. Transition through integrating cowpeas and Melia trees would generate an NPV of KES 1,893,785 over the 30 year period with major benefits obtained being cowpeas, cowpeas haulms, firewood, timber, carbon sequestration and soil fertility improvement. The BCR for this transition is 22.82 which is greater than 1 hence economically viable. The woodlot restoration transition is also economically viable generating an NPV of KES 1,649,510 and a BCR of 9.77. Analysis of the three approaches indicates that in terms of NPV generated woodlot generates more benefits followed by Melia and cowpeas system and lastly Grevillea robusta, maize and fruit trees. In terms of the ratio of benefits to costs incurred in the restoration transitions Grevillea robusta, maize and fruit trees would more benefits as compared to costs incurred followed by Melia and cowpeas and lastly woodlots.

Table 6. Economic Analysis of transition from degraded agricultural landscapes to improved agroforestry systems/ha

Transition	Land use	Economic Evaluation Criteria	
Traditional Agriculture to Agroforestry *Grevillea robusta*, Maize and Avocado	Baseline	97,183	
	Improved	1,088,598	
	Transition	991,415	25.64
Traditional Agriculture (Cowpeas Farming) to Agroforestry Melia and Cowpeas	Baseline Improved Transition		22.82
Poorly managed woodlots to well managed eucalyptus wood lot	Baseline Improved Transition		9.77

a) *Agroforestry Grevillea robusta, Maize and fruit trees (avocado) in the highlands*

Benefit flow analysis for intensive agroforestry ***Grevillea robusta***, maize and fruit trees (avocado) in degraded agricultural landscapes is presented in Table 7. The benefits expected from this system


Plate 2: A typical traditional farming system (left) and trees integrated with crops (tea) (right)

Table 7. Discounted benefit flow analysis for intensive agroforestry Grevillea robusta, maize and fruit trees (avocado) /ha

Description of benefits and costs	Aggregate Discounted Values 2018 to 2048 @7%
Benefits flow	
Revenue from sale of maize	747,593
Sale of fruits (Avocado)	645,770
Firewood (1st and 2nd Thinning)	91,706
Timber (Sawn timber)	77,020
Maize Stover	18,606
Carbon sequestration	18,383
Discounted benefit value	**1,599,078**
Costs	
Maize seed	55,841
Fertilizer	99,273
Ploughing and planting maize	108,579
Weeding	62,045
Grain Harvesting and threshing costs	59,564
Packaging costs	11,168
Maintenance	59,564
Cost of *Grevillea robusta* seedlings + Transportation	12,243
Manure	584
Planting of *Grevillea robusta* and avocado seedlings	1,869
Beating up	218
Harvesting timber and fruits (Avocado)	31,483
Cost of soil erosion	9,277
Discounted cost value	**511,708**
NPV	1,087,370
BCR	2.13
IRR (%)	20.50
EAA	84,964

are; from sale of maize, maize Stover which is used as livestock feed, firewood extracted from 1st and 2nd thinning of *Grevillea robusta*, Timber (sawn), sale of fruits, soil fertility improvement and carbon sequestration. Sale of maize generates the highest economic benefits at KES 747,593 followed by sale of fruits - avocado (KES 645,770), firewood extraction (KES 91,706), timber (KES 77,020), maize stover (KES 18,606) and carbon sequestration (KES 18,368) respectively over the 30-year period. The discounted net cash inflow (NPV) expected from the 1 ha of agroforestry system after 30 years is KES 1,088,598. The positive NPV indicates that investing in this intervention is economically viable. The internal rate of return for *Grevillea robusta*, maize and fruit trees agroforestry system is estimated at 20.5% which is viable given the prevailing cost of capital (interest rate) of 12%. This intervention will generate a BCR of 2.13 which is greater than 1 and EAA of KES 84,964 both indicators indicating viability of the intervention *Grevillea robusta.*

b) ***Agroforestry Melia*** *(Melia Volkensii)* ***integrated with cowpeas*** *(Vigna unguiculata)* ***in the dry lands***

This agroforestry system integrates *Melia volkensii* a drought tolerant tree with cowpeas (*Vigna unguiculata*) in the dry lands of Kenya. The benefits expected from this system are; from sale of cowpeas, cowpeas haulms which is used as livestock feed, firewood extracted from 1st and 2nd thinning of Melia, Timber (sawn), soil fertility improvement and carbon sequestration. Sale of cowpeas generates the highest economic benefits at KES 2,978,088 followed by sale of sawn timber (KES 310,202), Cowpeas haulms (KES 50,649), firewood extraction (KES 15,107) and carbon sequestration (KES 12,832) respectively over the 30 -year period (Table 8). The discounted net cash inflow (NPV) expected from the 1 ha of agroforestry system after 30- a year is KES 2,737,074. The positive NPV indicates that investing in this intervention is economically viable. The internal rate of return is estimated at 39.68% which is viable given the prevailing cost of capital (interest rate) of 12%. This intervention will generate a BCR of 4.34 which is greater than 1 and EAA of KES 234,567 both indicators indicating viability of the agroforestry system.

Table 8. Discounted benefit flow analysis for intensive agroforestry Melia (Melia Volkensii) integrated with cowpeas (Vigna unguiculata) in the dry lands of Kenya/ha

Description of benefits and costs	Aggregate Discounted Values 2018 to 2048 @7%
Benefits flow	
Revenue from sale of cowpeas	2,978,088
Timber (Sawn timber)	310,202
Haulms from cowpeas	50,649
Firewood (1st and 2nd Thinning)	15,107
Carbon sequestration	12,832
Discounted benefit value	**3,366,878**
Costs	
Cowpeas seed	44,673
Fertilizer	119,127
Pesticides	111,682
Ploughing and planting cowpeas	107,879
Weeding	62,045
Grain Harvesting and threshing costs	99,273
Packaging costs	27,300
Total Cost of Melia seedlings + transportation	11,682
Manure	1402
Cutting stakes+ stacking out + pitting+ planting and Beating up	4860
De-budding 4 times in a year	1,495
Pruning upto 5 years	5,065
Slashing Year 4 to 7	22,120
1st and 2nd thinning at age 7 and 10	639
Harvesting	2,129
Cost of soil erosion	9,662
Discounted cost value	**631,032**
NPV	2,735,846
BCR	4.34
IRR (%)	39.68
EAA	234,567

c) *Poorly managed woodlots (Eucalyptus) to well managed woodlots*

Smallholder farmers in high potential areas of Kenya have invested in woodlots mainly eucalyptus for poles, timber and firewood. The major challenge is that most of these woodlots are poorly managed. This restoration intervention involves improving the woodlots. The benefits expected from this improvement are; from sale of poles, wood sold at stumpage value, carbon sequestration and soil prevention. Sale of poles generates the highest economic benefits at (KES 1,129,443) followed by sale of wood at stumpage value KES (963,819), carbon sequestration (KES 248,500) and avoided costs of soil loss (KES 133) respectively over the 30-year period. The discounted net cash inflow (NPV) expected from the 1 ha of the woodlot system after 30 years is KES 2,046,970. The positive NPV indicates that investing in this intervention is economically viable. The internal rate of return (IRR) is estimated at 17.18% which is viable given the prevailing cost of capital (interest rate) of 12%. This intervention will generate a BCR of 6.94 which is greater than 1 and EAA of KES 175,630 both indicators indicating viability of the woodlot system (Table 9).

Table 9. Discounted benefit flow analysis for eucalyptus woodlot /ha

Description of benefits and costs	Aggregate Discounted Values 2018 to 2048 @7%
Benefits flow	
Benefit from sale of poles (thinning)	1,129,443
Revenue from wood (stumpage value)	963,819
Carbon sequestration	293,503
Avoided costs of soil loss	133
Discounted benefit value	**2,386,898**
Costs	
Purchases of eucalyptus seedlings	20,935
transportation of seeds/ seedlings	5,607
Planting	24,469
Beating up labour	6,988
Beating up seedlings	4,891
Weeding	27,701
Maintenance and security	59,564
Harvesting	2,615
Chemicals (Termiticides)	7,710
Fencing	161,350
Manure	16,159
Fertilizer	1,939
Discounted cost value	**339,928**
NPV	2,046,970
BCR	6.94
IRR	17.18%
EAA	175,630

Table 10. Economic analysis of transition from degraded marginal crop lands and un-stocked plantations to commercial bamboo and tree plantations/ha

Transition	Land use	Economic Evaluation Criteria @ 7% discount rate	
		Net Present Value (NPV)	BCR
Degraded woodlands to commercial *Gmelina arborea* plantations in marginal area	Baseline	6,980	
	Improved	1,123,407	
	Transition	1,126,800	24.99
Degraded planted forests to commercial bamboo plantation marginal areas	Baseline	1,036,771	
	Improved	1,664,459	
	Transition	627,688	22.8
Un-stocked planted forest to stocked Cypress plantation (*Cupressus lusitanica*)	Baseline	84,218	
	Improved	787,360	
	Transition	703,142	18.18

3.1.3 Restoration transition from degraded marginal crop lands and un-stocked plantations to commercial bamboo and tree plantations

Three restoration approaches were considered in restoring degraded marginal croplands, and un-stocked plantations; commercial *Gmelina arborea* plantations and bamboo plantations marginal areas and cypress (*Cupressus lusitanica*) plantation in un-stocked plantations. The transition from degraded marginal crop lands to commercial *Gmelina arborea* plantations would generate an NPV of KES 1,126,800 over the 30 year period. The economic benefits achieved through this intervention are sale of timber, firewood, poles and carbon sequestration. The BCR for the transition is 24.99 meaning for every 1 shilling in invested in the restoration process KES 24.99 will be generated within the 30 year period (Table 10). This transition is economically viable since it has the ability to pay for itself within the 30 year time period. Establishing bamboo plantations in these marginal areas would generate an NPV of KES 627,688 and BCR of 22.8 obtained over the 30 years. This transition is also economically viable with sale of bamboo culms, carbon sequestration and soil erosion prevention being the major economic benefits. Restoration transition from of un-stocked planted forests through establishment of *Cupressus lusitanica* would generate an NPV of KES 703,142 and BCR of 18.18 obtained over the 30 years.

a) Commercial *Gmelina arborea* plantations in marginal areas

Benefit flow analysis for establishment of *Gmelina arborea* plantations in marginal areas is presented in (Table 11). Sawn timber generates the highest economic benefits at KES 886,950 followed by firewood, (KES 198,776), poles (KES, 70,054) and carbon sequestration (KES 19,690) respectively over the 30-year period. The discounted net cash inflow (NPV) expected from 1 ha of *Gmelina arborea* plantations after 30 years is KES 1,123,407. The positive NPV indicates that investing in this intervention is economically viable. The internal rate of return (IRR) is estimated at 24.39% which is viable given the prevailing cost of capital (interest rate) of 12%. This intervention will generate a BCR of 21.58 which is greater than 1 and EAA of KES 96,388 both indicators indicating viability of the intervention.

b) Commercial bamboo plantations in marginal areas

Benefit flow analysis for establishment of bamboo plantations in marginal areas is presented in Table 12. With the availability of ready market for bamboo, sale of bamboo culms would generate the highest economic benefits at KES 1,360,032 followed by carbon sequestration (KES 482,045) and soil erosion prevention (KES 133) respectively over the 30 year period. The discounted net cash inflow (NPV) expected from 1 ha of bamboo plantations after 30 years is KES 1,664,459. The positive NPV indicates that investing in this intervention is economically

Table 11. Discounted benefit flow analysis for Gmelina arborea woodlots/ha

Description of benefits and costs	Aggregate Discounted Values 2018 to 2048 @7%
Benefits flow	
Value of timber (sawn timber)	886,950
Firewood	198,776
Poles	70,054
Carbon sequestration	19,690
Discounted benefit value	**1,175,470**
Ploughing	4673
Purchase of *Gmelina arborea* tree seedlings	11,215
Manure	1,402
Transportation of seedlings	470
Planting of *Gmelina arborea* seedlings	1,863
	374
Cutting stakes	
Staking out	374
Pitting	1,495
Planting	374
Beating up 20%	374
Pruning to the 5th year	5,065
Site Maintenance and security(Slashing Year 4 to 7)	22,120
Harvesting	2,129
cost of soil erosion	135
Discounted cost value	**52,063**
NPV	1,123,407
BCR	21.58
IRR	24.39%
EAA	96,388

viable. The internal rate of return (IRR) is estimated at 35.17 %which is viable given the prevailing cost of capital (interest rate) of 12%. This intervention will generate a BCR of 9.36 which is greater than 1 and EAA of KES 142,811 both indicators indicating viability of the intervention.

c) *Cypress plantation in un-stocked forests*

Benefit flow analysis for establishment of Cypress (*Cupressus lusitanica*) plantations in un-stocked forests is presented in Table 13. Sale of wood from 1st to 4th thinning would generate the highest return with a combined income of KES 748,061, followed

Table 12. Discounted benefit flow analysis for commercial bamboo plantations/ha

Description of benefits and costs	Aggregate Discounted Values 2018 to 2048 @7%
Benefits flow	
Revenue from sale of bamboo culms	1,360,032
Carbon sequestration	482,046
Avoided cost of soil loss	134
Discounted benefit value	**1,842,212**
Costs	
Ploughing	4,673
Purchase of bamboo seedlings	51,963
Transportation of seedlings	4,673
Planting of Bamboo seedlings	5,336
Beating up of Bamboo (labour)	2620
Maintenance and security	59,564
Harvesting of bamboo	48,924
Discounted cost value	**177,753**
NPV	1,664,459
BCR	9.36
IRR(%)	35.17
EAA	142,811

by final sale of wood at stumpage value (KES 102,120), sale of un-stocked stems (KES 37,359), livestock grazing (KES 27,065), carbon sequestration (KES 9,656) and soil erosion prevention (KES 133) respectively over the 30 year period. The discounted net cash inflow (NPV) expected from 1 ha of Cypress (*Cupressus lusitanica*) plantations after 30 years is KES 787,360. The positive NPV indicates that investing in this intervention is economically viable. The internal rate of return (IRR) is estimated at 21.89 % which is viable given the prevailing cost of capital (interest rate) of 12%. This intervention will generate a BCR of 5.75 which is greater than 1 and EAA of KES 67,556 both indicators indicating viability of the intervention

Table 13. Discounted benefit flow analysis for cypress plantation in un-stocked forests/ha

Description of benefits and costs	Aggregate Discounted Values 2018 to 2048 @7%
Benefits flow	
Sale of wood (1st Thinning)	206,627
Sale of wood (2nd Thinning)	150,660
Sale of wood (3rd Thinning)	266,286
Sale of wood (4th Thinning)	124,488
Final sale of wood (Stumpage)	102,120
Livestock fodder(grazing)	27,065
Carbon sequestration	9,656
Avoided cost of soil erosion	133
Benefit from un-stocked stems	37,359
Discounted benefit value	**924,394**
Costs	
Purchases of cypress seedlings	14,026
Transportation of seeds/ seedlings	4,673
Planting	16,822
Beating up (Labour)	3,930
Beating up (seedlings)	3,277
Weeding	18,692
Maintenance and security	59,564
Harvesting of cypress	2,615
Pruning costs	8,498
Thinning costs (1st, 2nd ,3rd and 4th)	4,937
Discounted cost value	**137,034**
NPV	787,360
BCR	5.75
IRR(%)	21.89
EAA	67,556

3.1.4 Restoration transition from degraded buffer zones along rivers and wetlands to bamboo and grass strip

Restoration of degraded buffer zones along rivers involves the planting of bamboo and grass strip. This transition would generate a NPV of KES 1,105,203 over the 30 year period. The economic benefits achieved through this intervention are sale of grass, bamboo culms and carbon sequestration. The BCR for the transition is 2.35 meaning for every 1 shilling in invested in the restoration process KES 2.35 will be generated within the 30 year period (Table 14). This transition is economically viable since it has the ability to pay for itself within the 30 year time period.

a) Riparian planting using bamboo and grass

Benefit flow analysis for riparian planting using bamboo and grass (*Pennisetum purpureum*) in degraded riparian zones is presented in Table 15. The benefits expected from sale of grass (Napier), sale of bamboo culms carbon sequestration, water flow regulation and soil prevention. Sale of grass generates the highest financial return at KES 974,083 followed by Bamboo culms (KES 538,142) and carbon sequestration (KES 103,127) respectively over the 30 year period. The discounted net cash inflow (NPV) expected from riparian planting of bamboo and grass of 1 ha after 30 years is KES 1,012,250. The positive NPV indicates that investing in this intervention is economically viable. The internal rate of return for riparian planting using

Table 14. Economic Analysis of restoration transition from degraded buffer zones along rivers and wetlands to bamboo and grass strip/ha

Transition	Land use	Economic Evaluation Criteria @ 7% discount rate	
		Net Present Value (NPV)	BCR
Degraded riparian zones to bamboo and grass strip	Baseline	(92,953)	
	Improved	1,012,250	
	Transition	1,105,203	2.35

Table 15. Discounted benefit flow analysis for riparian planting using bamboo and grass/ha

Description of benefits and costs	Aggregate Discounted 2018 to 2048 @7%
Benefits flow	
Revenue from sale of grass (Napier)	974,089
Revenue from sale of bamboo culms	538,146
Carbon sequestration	103,130
Discounted benefit value	**1,615,365**
Costs	
Ploughing	4,673
Purchase of bamboo seedlings	25,701
Transportation of seedlings	4,673
Planting of Bamboo seedlings	5,336
Beating up of Bamboo (labour)	2,620
Napier Grass cuttings	51,920
Weeding	111,682
Manure	124,091
Fertilizer (CAN)	163,800
Maintenance and security	59,564
Harvesting of bamboo	48,924
Cost of soil loss	133
Discounted cost value	**137,034**
NPV	1,012,250
BCR	1.68
IRR(%)	11.80
EAA	86,851

bamboo and grass is estimated at 11.8 % ~ 12.0% % which is equal to the cost of capital this means the breaks even given the prevailing cost of capital (interest rate) of 12%. This intervention will generate a BCR of 1.68 which is greater than 1 and EAA of KES 86,851both indicators indicating viability of the intervention.

3.1.5 Indigenous trees buffer along roads

Restoration of bare buffer zones along major road networks involves the planting of indigenous trees in this scenario *Podocarpus falcatus* was chosen as an ideal tree because of its regular shape and no root off shoots characteristics. This transition would generate an NPV of KES 96,972 over the 30 year period. The economic benefits achieved through this intervention are carbon sequestration, aesthetic value, soil erosion prevention, Shade provision, air quality improvement and storm water protection. The BCR for the transition is 6.1 meaning for every 1 shilling in invested in the restoration process KES 6.1 will be generated within the 30 year period (Table 16). This transition is economically viable since it has the ability to pay for itself within the 30 year time period.

a) Indigenous trees buffer along roads

Benefit flow analysis for planting of indigenous trees buffer along bare roads is presented in Table 17. Economic benefits that accrue from this intervention include; carbon sequestration, aesthetic value, shade provision, air quality improvement, storm protection and soil erosion prevention. Carbon sequestration will generate the highest economic benefits at KES 70,687 followed by aesthetic value (KES 48,433), shade provision (KES 21,857), Air quality improvement (KES 4,736), soil erosion prevention (KES 4,208) and storm protection (KES 1,078) respectively over the 30 year period. The discounted net cash inflow (NPV) expected from roadside planting of 1 ha after 30 years is KES 122,337. The positive NPV indicates that investing in this intervention is economically viable. The internal rate of return is estimated at 21.3 % which is viable given the prevailing cost of capital (interest rate) of 12%. This intervention will generate a BCR of 4.2 which is greater than 1 and EAA of KES 10,496 both indicators indicating viability of the intervention.

Table 16. Economic analysis of transition from bare buffer zones along major road networks/ha

Transition	Land use	Economic Evaluation Criteria @ 7% discount rate	
		Net Present Value (NPV)	BCR
Bare roads to trees buffers along roads	Baseline	25,365	
	Improved	122,337	
	Transition	96,97	6.1

Table 17. Discounted benefit flow analysis for roadside planting/ha

Description of benefits and costs	Aggregate Discounted 2018 to 2042 @7%
Benefits flow	
Carbon sequestration	70,688
Aesthetic value	48,433
Shade provision	21,857
Air quality improvement	4,736
Avoided cost of soil loss	4,208
Storm protection	1,077
Discounted benefit value	**150,999**
Costs	
Cost of tree seedlings	5,140
Transportation of seedlings	2,336
Planting of trees	2,336
Beating up	873
Fencing	3,084
Maintenance and security	14,891
Discounted cost value	**28,662**
NPV	122,337
BCR	4.2
IRR(%)	21.3%
EAA	10,496

3.1.6 Restoration of degraded rangelands and woodlands

Two restoration approaches were considered in restoring degraded grasslands and woodlands; grass reseeding using improved grasses namely *Cenchrus ciliaris*, *Chloris roxbohurghiana*, *Enteropogon macrostachyus* and *Eragrostis superba* the second approach is the restoration of degraded woodlands through silvo-pastoral system where grass reseeding is done with A*cacia senegal* for gum production. The transition from degraded grasslands to reseeded grasslands would generate a NPV of KES 532,566 over the 30 year period (Table 18). The economic benefits achieved through this intervention are grass (hay), grass seed and some minimal carbon sequestration. Under the second approach it is assumed that the degraded woodlands are under traditional pastoralism through which it is improved into a silvo-pastoral system through grass reseeding and gum production. This transition would generate an NPV of KES 1,272,052. The cost benefit ratios for the two interventions are 29.2 and 21.3 respectively which are above one implying that the costs invested in the improvement of degraded grassland and woodlands pasture through reseeding and planting of acacia and grass are recovered and benefit realized.

Table 18. Economic analysis of transition from degraded rangelands and woodlands to reseeded grassland and silvo-pastoral system /ha

Transition	Land use	Economic Evaluation Criteria @ 7% discount rate	
		Net Present Value (NPV)	BCR
Transition from degraded grasslands to reseeded grassland	Baseline	(207,026)	
	Improved	325,539	
	Transition	532,566	29.2
Degraded grassland under traditional pastoralism to Silvo-pastoral system	Baseline	(107,118)	
	Improved	1,164,934	
	Transition	1,272,052	21.3

Plate 3: Grass reseeded group ranch land in Kajiado, Kenya and left community land in Turkana

a) Grass reseeding using enclosures

Benefit flow analysis for grass reseeding in degraded grasslands is presented in Table 19. The benefits expected are from, grass (hay), grass seed and carbon sequestration. Grass (hay) generates the highest economic benefits at KES 384,074 followed by grass seed KES 158,211 and carbon sequestration (KES 17,079) respectively over the 30 year period. The discounted net cash inflow (NPV) expected from grass reseeding of 1 ha after 30 years is KES 325,539. The positive NPV indicates that investing in this intervention is economically viable. The internal rate of return is estimated at 9.06%. This intervention will generate a BCR of 2.25 which is greater than 1 and EAA of KES 27,931 both indicators indicating viability of the intervention. This analysis has not factored the indirect and induced impacts of sufficient fodder in livestock production in the rangelands through added milk and meat products. For example a recent FAO assessment showed that fodder availability generates 3.5 units of benefits for every unit invested (FAO, 2018) and so this intervention is likely to have multiplier impacts on livestock sector and livelihoods.

Table 19. Discounted benefit flow analysis for grass reseeding using enclosures/ha

Description of benefits and costs	Aggregate Discounted 2018 to 2048 @7%
Benefits flow	
Revenue from grass	384,074
Revenue from grass seed	158,211
Carbon sequestration	17,079
Discounted benefit value	**559,363**
Costs	
Ploughing	4,673
Purchase of grass seeds	7,034
Planting of grass	18,820
Enclosures/Fencing	129,906
Maintenance and security	22,336
Harvesting of grass	24,818
Harvesting of grass seed	24,818
Cost of soil erosion	4,418
Discounted cost value	**236,824**
NPV	325,539
BCR	2.25
IRR(%)	9.06
EAA	27,931

b) Improved silvo-pastoral system

Benefit flow analysis for improved silvo-pastoral system in degraded woodlands is presented in Table 20. The benefits expected are from; grass (hay), grass seed, gum and carbon sequestration. Grass seed generates the highest economic benefits at KES 930,653 followed carbon sequestration (KES 250,650), gum KES (166,170) and grass (KES 140,901) respectively over the 30 year period. The discounted net cash inflow (NPV) expected from 1 ha of the silvo-pastoral system after 30 years is KES 1,164,934. The positive NPV indicates that investing in this intervention is economically viable. The internal rate of return is estimated at 21.23% which is viable given the prevailing cost of capital (interest rate) of 12%. This intervention will generate a BCR of 3.60 which is greater than 1 and EAA of KES 99,951 both indicators indicating viability of the intervention.

Table 20. Discounted benefit flow analysis for silvo-pastoral system /ha

Description of benefits and costs	Aggregate Discounted 2018 to 2048 @7%
Benefits flow	
Revenue from grass seed	930,653
Carbon sequestration	250,650
Benefit from gum	166,170
Revenue from grass	140,900
Discounted benefit value	**1,488,373**
Costs	
Ploughing	4,673
Purchases of acacia seedlings	5,048
Purchase of grass seeds	7,034
transportation of seeds/ seedlings	4,673
planting of grass	18,820
Planting of *Acaciasenegal*	5,336
Beating up	2,620
Enclosures/Fencing	129,906
Repair of micro-catchments/ weeding	14,985
Maintenance and security	59,564
Harvesting of grass	24,818
Harvesting of grass seed	41,544
Cost of soil erosion	4,418
Discounted cost value	**323,439**
NPV	1,164,934
BCR	3.60
IRR(%)	21.23%
EAA	99,951

3.2 Summary NPV and BCR of restoration transitions

The results from economic analysis of restoration transitions have shown positive NPV (7%) for all the proposed restoration transitions Per Ha for the 30 year period. The transition from traditional cowpeas farming to intensive agroforestry with *Melia volkensii* has the highest NPV (KES 1,893,785) this is followed by transition from poorly managed woodlots to improved eucalyptus woodlots at KES 1,649,510 and the silvo-pastoral system at Ksh 1,272,052. The transition from treeless roads to roads with planted trees has the lowest NPV at KES 96,972 over the 30-year period. The transition from degraded natural forest to improved natural forest through enrichment planting yielded the second lowest NPV (KES 318,559). The benefit cost ratio (BCR) of the restoration transition ranged from as low as 2.35

Table 21: NPV and BCR of restoration transitions /ha

Restoration Transition	Economic Criteria	
	NPV@7%	BCR
Degraded forest - Enrichment planting	318,559	2.75
Degraded forest -Improved Natural regeneration	906,559	3.90
Traditional Agriculture (Maize Farming) - Intensive Agroforestry with Grevillea robusta	991,415	25.64
Traditional Agriculture (Cowpeas Farming) - Intensive Agroforestry with Melia volkensii	1,893,785	22.82
Poorly managed woodlots - Improved Eucalyptus woodlot	1,649,510	9.77
Degraded woodlands - commercial *Gmelina arborea* plantations	1,126,800	24.99
Degraded planted forests - commercial bamboo plantation	627,688	22.8
Un-stocked plantations- fully stocked cypress plantations	703,142	18.18
Degraded riparian zones - bamboo and grass strip	1,105,203	2.35
Bare road - trees buffer on roadsides	96,972	6.1
Degraded grasslands - grass reseeding	532,566	29.2
Degraded grassland - Silvo-pastoral system grass reseeding and acacia	1,272,052	21.3

(Degraded riparian zones to bamboo and grass strip grass buffer) to highest of 29.2 (Transition from degraded grasslands to reseeded grassland)

3.3 Financial Analysis of Landscape Restoration Options

Analysis of the landscape restoration interventions indicates that of the 12 proposed interventions 9 provide an ideal investment opportunity for landowners and will accrue both private and economic benefits over the 30 years. These interventions are; (i) Intensive Agroforestry *Melia volkensii* and cowpeas; (ii) Intensive Agroforestry Grevillea robusta, maize and Fruit trees; (iii) commercial bamboo plantations; (iv) bamboo and grass strip in buffer zones along water bodies; (v) Cypress plantations, eucalyptus woodlots; (vi) *Gmelina arborea* plantations; (vii) grass reseeding and (viii) the silvo pastoral system. In these financial analysis private benefits (timber, firewood, fruits, maize, grass/fodder, bamboo culms and gums and resins were considered.

The remaining three interventions; enrichment planting, natural forest regeneration and roadside tree planting are expected to generate additional public benefits such as carbon sequestration, water regulation and soil erosion control.

Financial analysis for the various landscape restoration interventions has been compared based on the financial analysis indicators of total financial outlay, owners' net cash flow, internal rate of return (IRR), NPV, payback period and Benefit cost ratio (BCR). Based on the summary in Table 21, intensive agroforestry *Melia volkensii* and cowpeas generated the highest NPV (KES 2,676,750) Over the 30 year investment period followed by eucalyptus woodlot (KES 1,798,338), commercial bamboo (1,182,281) and *Gmelina arborea* plantations (1,103,717) respectively. Bamboo (KES 990,256), cypress plantations (KES 777,572) and grass strip Grass reseeding (KES 308,460) and had the lowest NPV. In terms of financial outlay required for the investments, Melia and cowpeas agroforestry system is the costliest at KES 621,352 followed by Bamboo and grass strip at KES 602,969, investment in *Gmelina arborea* and commercial bamboo plantations requires the least financial outlay at 52,063 and 177,750 respectively. All the interventions had a strong IRR values except for Bamboo and grass strip 10.65% and Grass reseeding using enclosures which had an IRR value below the 12% threshold. In this case an investor would seek an investment in the order of Melia and cowpeas, Cypress plantations, *Gmelina arborea* plantations and Commercial bamboo plantations because they score strongly both on NPV and IRR.

Table 22: Summary of Financial Analysis for Landscape Restoration Interventions over the 30 years

Forest Landscape Restoration Intervention	Total cash outlay (KES)	Owners net cash inflow over 30 Years (KES)	IRR (12% interest threshold)	NPV (KES)	Payback period (years)	BCR
Intensive Agroforestry Grevillea and Maize	502,417	3,292,882	14.05%	1,078,279	8	2.15
Intensive Agroforestry Melia and cowpeas	621,352	7,824,401	30.7%	2,676,750	5	4.31
Commercial bamboo plantations	177,750	3,399,690	26.2%	1,182,281	6	6.65
Bamboo and grass strip	602,969	2,493,236	10.65%	909,256	10	1.51
Cypress plantations	137,033	2,493,360	21.87%	777,572	6	5.67
Eucalyptus Woodlot	294,924	9,143,176	16.87%	1,798,338	10	6.10
Gmelina arborea plantations	52,063	7,370,180	21.20%	1,103,717	7	21.20
Grass reseeding using enclosures	236,825	938,663	8.90%	308,460	11	2.18
Silvo-pastoral system	323,439	2,519,660	17.39%	914,284	7	2.83

In terms of payback period (time taken for an investment to recoup initial outlay) Melia and cowpeas investment will payback after 5 years while grass reseeding will take the longest time (11 years) payback for the other interventions range between 6 and 10 years.

3.3 Sensitivity Analysis of Restoration Transitions Options

3.3.1 Sensitivity Analysis of Net Present Value (NPV) of Restoration Transitions

A sensitivity analysis of the impacts of discount rates on NPV of the restoration transitions was undertake by varying the discount rates at 5%, 7%, 10% and 12% respectively. The analysis shows that results are sensitive to the discount rates. Table 21, summarizes the sensitivity of NPV of restoration transition measured in KES/ha for the 30 year period. The NPV for the transitions reduce drastically when the discount rates are varied from 5% to 12%. These variations are the likely outcomes within unpredictable climate of economic performance and attendant change in inflation rate in the economy.

3.4 Discounted Costs and Benefits of Restoration Interventions

3.4.1 Cost of restoration per ha

Figure 1 shows results from activity budgets indicating costs for each restoration transition. The transition from traditional cowpeas farming in drylands to intensive and integrated with *Melia volkensii* is the costliest intervention from the analysis. Over the 30-year period the transition would cost approximately about KES 631,032 compared with continuing traditional cowpeas farming. This was followed by restoration of degraded riparian zones using bamboo

Table 23. Sensitivity analysis of Net Present Value (NPV) of restoration transitions @ 5%, 7%,10% and 12% dicount rate

Restoration Transition	Discount rate (%)			
	NPV @5%	NPV @7%	NPV @10%	NPV @12%
Degraded forest - Enrichment planting	498,256	318,559	151,091	81,025
Degraded forest -Improved Natural regeneration	1,389,135	906,559	473,104	298,390
Traditional Agriculture (Maize Farming) - Intensive Agroforestry Grevillea	1,313,811	991,415	685,864	553,129
Traditional Agriculture (Cowpeas Farming) - Intensive Agroforestry Melia	2,484,747	1,893,785	1,350,462	1,120,096
Poorly managed woodlots - Improved Eucalyptus woodlot	2,684,890	1,649,510	819,200	516,413
Degraded woodlands - commercial *Gmelina arborea* plantations	1,882,780	1,126,800	550,593	355,638
Degraded planted forests - commercial bamboo plantation	732,469	627,688	498,292	428,218
Un-stocked plantations- fully stocked cypress plantations	937,159	702,142	472,124	368,425
Degraded riparian zones - bamboo and grass strip	1,417,550	1,105,203	793,678	651,915
Bare road - trees buffer on roadsides	131,939	96,972	62,752	47,545
Degraded grasslands - grass reseeding	682,137	532,566	371,669	300,535
Degraded grassland - silvo-pastoral system grass reseeding and acacia	1,592,899	1,272,052	907,525	750,044

and Napier grass at the cost of KES 603,115 over 30-year period. Planting of tree buffers on roadsides is the cheapest restoration would cost KES 28,662 over the course of 30- years. Intensive agroforestry combining Grevillea robusta, maize and fruits would cost KES 511,708. Planting of *Gmelina arborea* in degraded marginal areas would cost 52,063 while bamboo plantation would cost KES 177,753 over the investment period the difference is likely due to the high cost of bamboo seedlings and operational costs. Planting of cypress in poorly stocked plantations would cost KES 137,034. Enrichment planting in degraded natural forest would cost KES 157,290 as compared to natural regeneration with protection (KES 241,578) due to increased costs of fencing and security required. Restoration of degraded grasslands by grass reseeding is cheaper at KES 236,824 as compared to silvo-pastoral system at KES 323,439.

3.4.2 Cost of Restoration at the National Scale

Under the conservative scenario it will require Ksh 1.8 trillion to restore 5.1 million ha (Table 22). This scenario represents a lower proportion of the land area to be restored by the year 2030; this target of 5.1 million ha would increase the forest cover by 9%. Under the intermediate scenario it will require KES 2.8 trillion to restore 7.6 million Ha of land; this scenario is more ambitious as it would target to achieve 10% tree cover on farms and 75% of restoration of buffer zones along water bodies and roads as well as 11.25% rangelands. The ambitious scenario aims at restoring 10.2 million ha by 2030; this would require Ksh KES 3.7 trillion. This is the most ambitious completely achieving the Agriculture (Farm Forestry) Rules, 2009 (GoK, 2009) which requires at least 10% tree cover on farm

3.4.3 Benefits of restoration per ha

The restoration intervention is expected to bring numerous benefits over the 30 year period. Figure 1 shows the discounted benefits expected from restoration of 1 Ha. Intensive agroforestry of *Melia volkensii* and cowpeas would generate the highest discounted benefits per ha at KES 3,368,106 followed by Eucalyptus woodlot with KES 2,386,898, commercial bamboo plantation at 1,842,212. Restoration of degraded riparian zones using bamboo and Napier grass yield KES 1,615,365 over 30-year period. Planting of tree

Table 24: Costs of Restoration Targets at National Scale (In KES' 000,000)

Restoration Transition	Conservative	Intermediate	Ambitious
Degraded forest - Enrichment planting	15,229	30,458	45,687
Degraded forest -Improved Natural regeneration	169,104.6	265,735.8	338,209.2
Traditional Agriculture (Maize Farming) - Intensive Agroforestry Grevillea robusta	153,512.4	268,646.7	396,573.7
Traditional Agriculture (Cowpeas Farming) - Intensive Agroforestry Melia volkensii	883,444.8	1,262,064	1,640,683.2
Poorly managed woodlots - Improved Eucalyptus woodlot	33,992.8	59,487.4	42,491
Degraded woodlands - commercial *Gmelina arborea* plantations	10,412.6	15,618.9	20,825.2
Degraded planted forests - commercial bamboo plantation	53,325.9	53,325.9	88,876.5
Un-stocked plantations - fully stocked Cypress plantations	13,703.4	13,703.4	27,406.8
Degraded riparian zones - bamboo and grass strip	60,311.5	60,311.5	60,311.5
Bare road - trees buffer on roadsides	5,732.4	5,732.4	8,598.6
Degraded grasslands - grass reseeding	153,935.6	236,824	307,871.2
Degraded grassland - silvo-pastoral system grass reseeding and *Acacia senegal*	307,267.05	517,502.4	711,565.8
Total	**1,859,972.05**	**2,789,410.4**	**3,689,099.7**

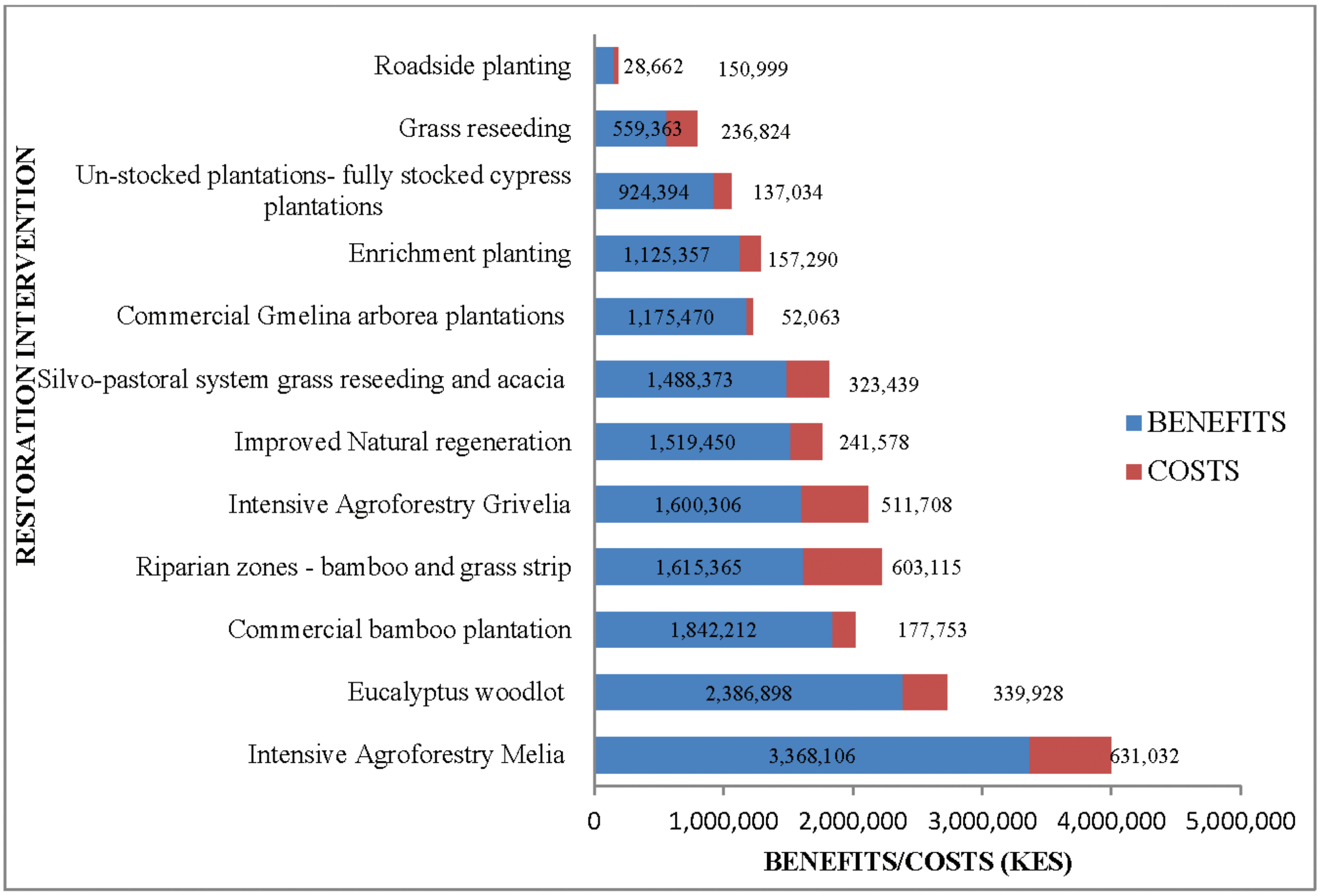

Figure 1: Discounted benefits and costs of restoration (KES)/ha at 7%

buffers on roadsides accrue the lowest benefits of KES 150,999 over the course of 30- years. Intensive agroforestry combining Grevillea robusta, maize and fruits would generate KES 1,600,306, natural regeneration with protection (KES 1,519,450), silvo-pastoral system at KES 1,488,373, ***Gmelina arborea*** KES 1,175,470, Enrichment planting KES 1,125,357 while cypress plantation KES 924,394 and grass reseeding KES 559,363.

3.4.4 Net Present Value of Restoration Transitions (NPV)

The results from economic analysis of restoration transitions have shown positive NPV for all the proposed transitions (Figure 2). The transition from traditional agriculture (cowpeas) to intensive agroforestry with *Melia volkensii* has the highest NPV (KES 1,893,785) this is followed by poorly managed woodlots to improved eucalyptus woodlots at KES 1,649,510, and Silvo-pastoral system at Ksh 1,272,052. The transition from treeless roads to roads with planted trees has the lowest NPV at KES 96,972 over the 30- year period. This probably because the tree density assumed was low and there no anticipated direct benefits. The transition from degraded natural forest to improved natural forest through enrichment planting yielded the second lowest NPV (KES 318,559) this is because the transition requires high initial investments (seedlings, planting and maintenance of young seedlings before full recovery).

3.4.5 Benefits from Restoration Targets

If implemented to the latter the country stands to gain numerous economic benefits from the landscape restoration. If the conservative scenario of 5.1 million ha is restored at a cost of KES 1.8 trillion the Country will gain KES 7.6 trillion (Table 23), this gives a benefit cost ratio (BCR) of 4.1 implying that the costs invested in the restoration scenario are recovered and benefit realized. The Intermediate scenario and ambitious scenarios would generate economic benefits valued at KES 11.2 and 14.8 trillion respectively.

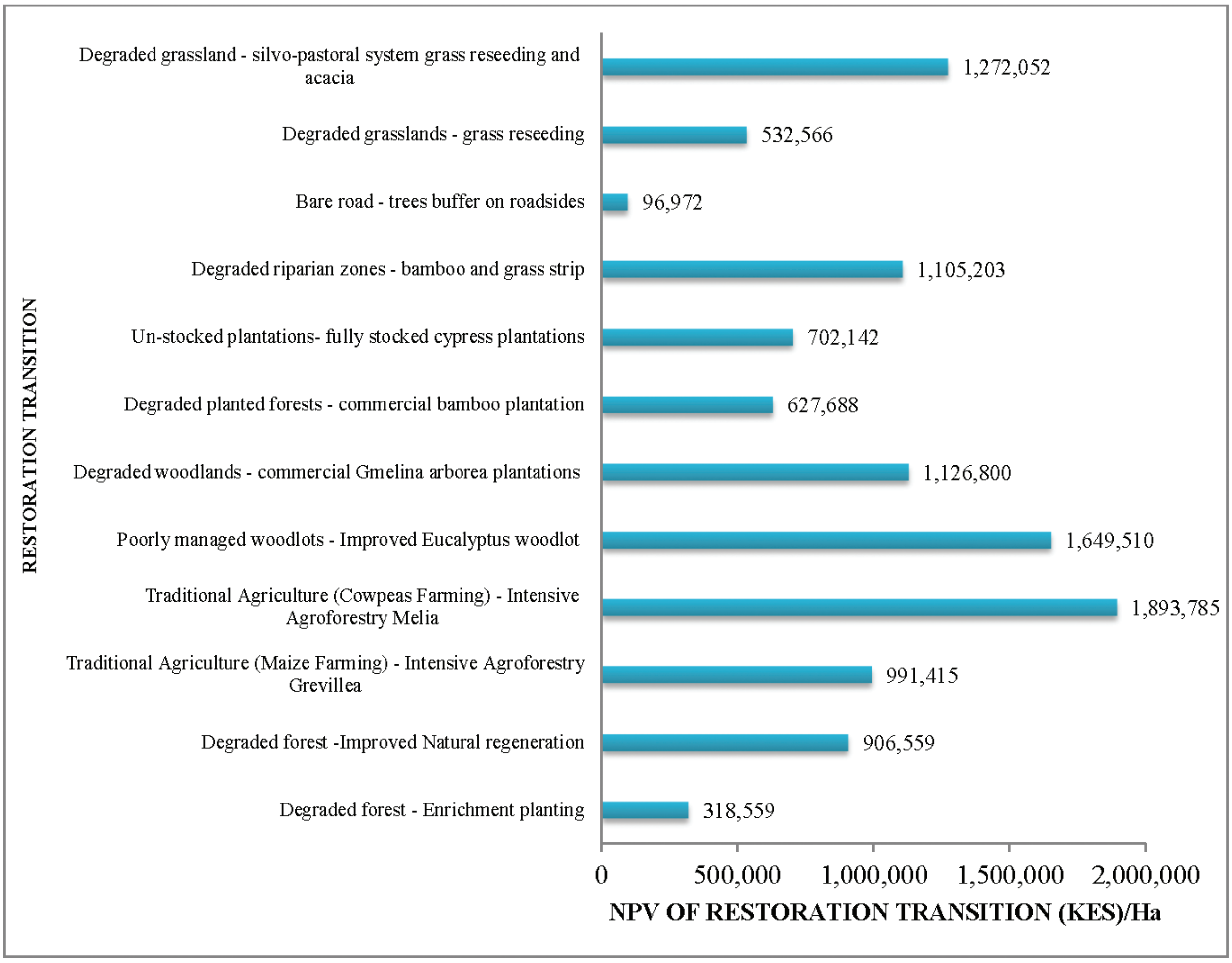

Figure 2: NPV of the restoration transition (KES) /ha at 7% Discount for 30 years

Table 25. Benefits from Restoration Targets (In KES' 000,000)

Restoration Transition	Conservative	Intermediate	Ambitious
Degraded forest - Enrichment planting	96,806.8	193,613.6	290,420.4
Degraded forest -Improved Natural regeneration	894,510.4	1,405,659.2	1,789,020.8
Traditional Agriculture (Maize Farming) - Intensive Agroforestry Grevillea	326,579.4	571,513.950	843,663.45
Traditional Agriculture (Cowpeas Farming) - Intensive Agroforestry Melia	3,831,903.6	5,474,148	7,116,392.4
Poorly managed woodlots - Improved Eucalyptus woodlot	204,697	358,219.75	255,871.25
Degraded woodlands - commercial *Gmelina arborea* plantations	224,681.4	337,022.1	449,362.8
Degraded planted forests - commercial bamboo plantation	499,337.7	499,337.7	832,229.5
Un-stocked plantations- fully stocked Cypress plantations	78,736	78,736	157,472
Degraded riparian zones - bamboo and grass strip	101,225	101,225	101,225
Bare road - trees buffer on roadsides	24,467.4	24,467.4	36,701.1
Degraded grasslands - grass reseeding	211,600.35	325,539	423,200.7
Degraded grassland - Silvo-pastoral system grass reseeding and *Acacia senegal*	1,106,687.3	1,863,894.4	2,562,854.8
Total	**7,601,232.350**	**11,233,376.1**	**14,858,414.2**

4.0 Funding Opportunities for Forest Landscape Restoration in Kenya

4.1 Status and Opportunities Preparatory- Readiness Investment

In Kenya forest conservation including restoration work is coordinated and financed by the Ministry of Environment and Forestry (ME & F) through public agencies and working closely with multilateral agencies and non-state and community organizations. The key activities include baseline forest restoration assessments, assessment of the status of land use and land use change, stakeholder analysis, ecosystem valuations, forest assessment analytical techniques, carbon stock assessments, economic and financial analysis of the FLR opportunities, analysis agricultural and livestock components of the landscape, restoration technology options, sustainable forest management and watershed management options. The key public agencies involved in the activities include Kenya Forest Services (KFS), Kenya Forestry Research Institute (KEFRI), Kenya Water Tower Agency (KWTA), Climate Change Directorate, National Environmental Management Authority (NEMA), Water Resources Authority (WRA) among others. Other international and local agencies that are involved include United Nations Environment Program (UNEP), UNDP, WWF, IUCN, Nature Kenya, FAO, KWF, KFWG, Green Belt Movement (GBM), Forest Action Network, Lake Victoria Basin Commission, Nile Initiative, Laikipia Wildlife Forum, Africa Forest Forum, (AFF), among others. Private sector institutions have also joined the forest conservation efforts through various platforms such as corporate social responsibility, foundations and trust, and community associations to mobilize resources to support target activities such small scale rehabilitation, electric fencing, and awareness creation forums. Among the key donors in the forest sector are EU, Finland (FINNIDA), Denmark (DANIDA), Japan (JICA), Germany (GIZ), United Kingdom (DfID).

The landscapes that were targets of past restoration efforts include Mt Kenya, Mau Forest Complex, Mt Elgon, Cherangany Hills, Aberdares Range. The activities undertaken include promotion of integrated and sustainable management of forest landscapes including catchment and sub-catchments, strengthening institutional capacities, resource mobilization, efficient forest product processing and value addition. Others are promotion on investment in forest-based ecotourism; facilitation civil society organizations (CSOs) and Non-Government Organizations (NGOs) to support forestry governance. Other supportive activities include generation of comprehensive and reliable forestry data for use by policymakers, private investors and the general public. Supportive activities on REDD+ performance and payments include the strengthening capacities for regulation of illegal extraction, utilization and trade in forest products, increased forest revenue collection and management through streamlining procedures and licensing, adhering to accountability and transparency the principles and enhancing compliance. The Climate Change Act of 2016 operationalized two key instruments the Climate Change Directorate and opening of Climate Change Fund at Treasury making them the latest developments.

4.2. Status, Opportunities and Recommendations for Sustained Financing of FLR

Forest landscape restoration is a long-term process which requires sustained financing. Forest restoration have in the past relied on government or public financing, donor, NGO's and grants from multilateral agencies. However, with many demands on government exchequer, there is need to expand funding opportunities for forest landscape restoration. The government of Kenya has an ambitious plan of restoring 5.1 million ha by 2030 to achieve the 10% forest cover. The following avenues could be explored to expand the financing of forest restoration. The diverse combinations of financing options range from national budgets and resources, national environmental funds, development cooperation, climate finance, private sector and non-governmental funding. The investments with greater return to investments will attract private funds but low-return and long term investments like restoration of degraded public forests will depend on public and development partners funding hence. Given the array of land uses targeted and evaluated there should be a deliberate move to match the type of funding with potential returns to landscape investments opportunities. The potential financing mechanisms for both short and long-term investment in forest landscape and rangeland restoration fall in the following key categories:

1. Financing from domestic sources and levies and fees
2. Market and payment for environmental services
3. Climate Funds
4. Multilateral funds
5. Private Sector funds
6. NGOs/CBOs Funds
7. Development partner funds
8. Crowd funding- Harambee model

4.2.1. Financing from domestic public sources

The government provides funding to various public agencies for purposes of forest protection and conservation that include restoration efforts of key natural forests, ASAL woodlands and farm lands. In 2018-2019 approximately KES 10 billion was allocated to the key public agencies Kenya Forest Services (KFS), Kenya Forestry Research Institute, (KEFRI), Kenya Water Tower Agency (KWTA) and National Environmental Management Authority (NEMA). Some of the funds will be used in forest restoration activities. In 2018-2019 the National Treasury set aside KES 500 million to finance Climate Change Fund (CCF) 2018 being provisions for loans and equity for climate change research and innovation.

To improve proper utilization of funds by government agencies, there is need to improve the capacity of agencies to prudently utilize the finances. The study has demonstrated that forest landscape restoration does generate positive public benefits to the tune of KES 7.6 trillion under conservative scenario with benefit cost ratio of 4:1. The improved public financing is justified by the positive externalities from restoration efforts. Some option include tax measures targeting likely users or beneficiaries of restoration efforts. For example, restoration of Water Towers will improve water quantity and quality and thus primary water users like hydropower and water service providers can be taxed to support restoration. In addition, it is possible to set up special forest restoration fund, designed and synergized with other financing mechanism such as Climate Change Fund and NETFUND.

4.2.2. Market and payment for environmental services

Forest restoration provides public benefit like carbon sequestration, hydrological services, soil protection and provide habitat for biodiversity. These benefits accrue to wider range of stakeholders and there is need to develop a mechanism to support restoration. For example, restoration is expected to improve the accumulation of carbon stock, water flow for hydro power generation, domestic (drinking) and industrial uses. Payment for Ecosystem Services is an opportunity to explore potentials for mobilizing resources for restoration of degraded landscapes.

4.2.3. Climate Funds

Many climate financing instruments have been developed within the context of UNFCCC that are relevant to forest landscape restoration. The mitigation- based financing instruments such as Clean Development Mechanism (CDM) that can be accessed to support forest landscape restoration. Voluntary carbon finance provided by various transnational corporations can be explored to acquire finances to support restoration efforts by private, community or individuals contribution to FLR. There are opportunities for local and international companies with proven carbon print to buy carbon credits from restored forests. REDD + readiness funding opportunities like UN-REDD program, Forest Carbon Partnership Facility, Global Environment Facility (GEF) and Community Based REDD + Grants (CBR+) are some of the global funding platforms that can be harnessed in FLR.

There are opportunities in climate change adaptation funding for FLR from international and instruments such as adaptation fund, International Climate Initiative, GEF small grants for community-based adaptation and local community adaptation funds. In addition, FLR activities can be supported through instruments bridging adaptation and mitigation such as Green Climate Fund and National Climate Fund.

4.2.4. Multilateral Framework Support

At global level the Green Environmental Fund (GEF) established after Rio Summit in 1992 has mobilized USD 17.9 billion and another USD 93.2 billion in co-financing. The Green Climate Fund (GCF) is the leading capitalized climate related funding mechanism that currently funds 76 projects worldwide worth 1.4 billion with 28 projects located in Africa accounting for 36.8% of the total. The third funding is the UNFCC with capacity the disburse USD 77 billion yearly.

4.2.5. National Public Private Partnerships: Corporate Social Responsibility

There are few variants of PPPs that focus more on corporate responsibility through financial support to awareness creation and rehabilitation of water towers in collaboration with KFS and KWS. Some of projects include electric fencing whose objective is to keep wild animals away from farms not only to minimize conflicts between local communities and public agencies involved in management of forests and wildlife but also to protect forests from drivers of degradation. Such projects have facilitated fund raising and building of strong relationships between government, local communities, private individuals and corporations in the conservation of some key water ecosystems in the country through boundary fencing. The key projects undertaken through the initiatives are construction and maintenance of electric fences to protect Mount Kenya, Arabuko Sokoke forests in Kilifi County and Eburu of East Mau Forest block.

Public-private partnerships have also played critical role in putting up governance structures for implementation and monitoring of key forest ecosystems. Some of the activities include water for life campaigns to create awareness on the importance of forests in water provisioning in the key water towers of Aberdares Forest through Ndakaini Dam Marathon, Mau Forest Complex (Mau Forest Marathon) and Cherangany Hills (Cherangany Forest Marathon), and the number is growing. The private sector players include Safaricom Foundation, Kenya Commercial Bank Foundation, among others. The awareness campaigns have enhanced the visibility of key water towers to greater public and motivate communities' participation in forest restoration and conservation.

Table 26: Potential sources of Restoration finance

NAME	GLOBAL ENVIRONMENT FACILITY
Description of the fund	The GEF administers several trust funds and provides secretariat services, on an interim basis, for the Adaptation Fund
Project type	Focus on projects that address GEF focal area strategies mostly Biodiversity, International Waters, and Land Degradation
Geographical focus	GEF funds are available to developing countries and countries with economies in transition to meet the objectives of the international environmental conventions and agreements.
Weblink	Kenya GEF Secretariat, Focal Point MEF,
NAME	BIOCARBON FUND (BIOCF) OF THE WORLD BANK
Description of the fund	Based on a public/private partnership model which aims to deliver cost-effective emission reduction and support biodiversity conservation and poverty alleviation.
Project type	AFOLU PROJECTS: AFFORESTATION, REFORESTATION, REDD, AGRICULTURE
Geographical focus	Open
Case Study	Reforestation for Guangxi Watershed Management in Pearl River Basin in China Afforestation of 4,000 ha, 75% with native species and 25% eucalyptus. Social benefits are additional employment, direct income increases through sale of non-timber products and benefits from CER.
Weblink	http://wbcarbonfinance.org/Router.cfm?Page=Funds&ItemID=24670
Name	COMMUNITY DEVELOPMENT CARBON FUND (CDCF) WORLD BANK
Description of the fund	Spread benefits of carbon finance to the poorest countries and poor communities in all developing countries, which would otherwise find it difficult to attract carbon finance because of country and financial risk. It is a multi-donor Trust Fund - a public/private partnership.
Project type	All CDM projects, including AFOLU, are eligible.
Geographical focus	Open
Case Study	Target group Least Developing countries – community benefits are a requirement.
Weblink	http://wbcarbonfinance.org/Router.cfm?Page=CDCF&ItemID=9709&FID=9709
NAME	CASCADE PROGRAMME
Description of the fund	Description of fund Aims at enhancing African expertise to generate carbon credits to open up opportunities for African participation in the CDM and voluntary carbon markets. The project was launched in December 2007 at the Bali UNFCCC conference. Its duration will be three years. Project type AFOLU sector, REDD and bioenergy activities.
Project type	AFOLU sector, REDD and bioenergy activities.
Target groups	Enhancing expertise to generate African carbon credits in AFOLU as well as bioenergy activities.
Geographical focus	Seven target countries (Benin, Cameroon, Democratic Republic of the Congo, Gabon, Madagascar, Mali, Senegal).
Case Study	Case study Madagascar: Large scale application of restoration techniques and management of soil fertility, especially in cropping systems with permanent vegetative cover minimum tillage in the region Bongolava in an area of 1000 ha over five years. Senegal: Improving the living conditions of the local population of the Sine-Saloum Delta through mangrove ecosystem restoration over 14 years on 410 ha of mangrove plantations.
Weblink	www.cascade-africa.org/Accueil_en/tabid/56/language/en-US/Default.aspx
NAME	GERMAN CLIMATE PROTECTION
Description of the fund	The International Climate Protection Initiative has been working since 2008 with annual funds of 120 million Euros. The All projects run one to five years.
Project type	Promoting a climate-friendly economy, - promoting measures for adaptation to the impacts of climate change and – conserving biodiversity with climate relevance (carbon sinks, especially of forests and other ecosystems such as wetlands)
Target groups	Project can be carried out by federal implementing agencies, government organisations, NGOs, business enterprises, universities and research institutes, and by international and multinational organisations and institutes, e.g. development banks, United Nations bodies and programmes.
Geographical focus	Focus Developing, newly industrialising and transition countries. Financial support between € 500,000-€ 2,500,000 per project
Case study	Mexico: Climate Change Mitigation in Five Representative Ecosystems: The project will maintain existing carbon reservoirs in forests and wetlands and will enable the affected regions and their populations to better adapt to climate change impacts. Philippines: Adaptation to climate change and Protection of biodiversity (GTZ, National Department of Environment and Natural Resources)
Weblink	http://www.bmu-klimaschutzinitiative.de/en/home_i

NAME	GLOBAL ENVIRONMENT FACILITY
NAME	GEF SMALL GRANTS PROGRAMME: CLIMATE CHANGE
Description of the fund	Grants are given towards climate change abatement, prevention of land degradation and climate change adaptation.
Project type	Removal of barriers to energy efficiency and energy conservation; promoting the adoption of renewable energy by removing barriers and reducing implementation costs; conservation and restoration of arid and semi-arid areas; efficient stoves and biogas to reduce forest loss; integrated watershed management; soil conservation; afforestation; prevention of forest fires; and organic farming.
Target groups	NGOs and Community Based Organizations (CBO).
Geographical focus	Open Financial Support The maximum grant amount per project is US$50,000, but averages around US$20,000. Grants are channelled directly to CBOs and NGOs.
Weblink	http://sgp.undp.org/index.cfm?module=projects&page=FocalArea&FocalAreaID=CC
NAME	NEP'S RURAL ENERGY ENTERPRISE DEVELOPMENT (REED) PROGRAMME
Project type	Initiative offering enterprise development services and start-up financing to 'clean energy' enterprises. Since beginning in 2000, REED has financed 44 enterprises that are now returning capital each year to an investment fund that is then re-invested in new enterprises.
Target group	Open
Geographical focus	Five African countries (AREED), Brazil (B-REED) and China (C-REED).
Weblink	Weblink www.unep.fr/energy/activities/reed/areed.htm
NAME	EVERDE VENTURES
Description of the fund	Investment fund of Conservation International
Target group	Funds projects which promote biodiversity conservation
Weblink	http://web.conservation.org/xp/verdeventures
Name	ECO ENTERPRISES FUND
Description of the fund	Managed by The Nature Conservancy (TNC).
Target group	Works mainly in Latin America and the Caribbean. Invest in small and growing environmentally- and socially-responsible ventures in sustainable agriculture (including apiculture, aquaculture and community-based energy), sustainable forestry, ecotourism and non-timber forest products, as well as carbon, biodiversity offsets and climate change mitigation and adaptation.
Weblink	Website www.ecoenterprisesfund.com/index.htm
NAME	ROOT CAPITAL
Description of the fund	Non-profit social investment fund.
Target group	Pioneering finance for grassroots businesses in the developing world. Work with artisan and farmer associations that build sustainable livelihoods and transform rural economies in poor, environmentally vulnerable places.
Weblink	www.rootcapital.org/index.php
NAME	GATSBY CHARITABLE FOUNDATION
Description of the fund	
Type of fund	Promotes income generation through selected programmes and grants
Target group	Supporting basic agriculture and small scale manufacturing and enterprise in selected African countries.
Weblink	www.gatsby.org.uk/developing.html
NAME	ALLIANCE FOR A GREEN REVOLUTION IN AFRICA (AGRA)
Type of fund	African led partnership with initial support from the Rockefeller Foundation and the Bill & Melinda Gates Foundation.
Target group	Target Grants for projects and programmes which develop practical solutions to boost farm productivity and incomes for poor. They only give grants for charitable purpose.
Weblink	Website www.agra-alliance.org

5.0. Conclusion and Recommendations

5.1 Conclusions

Forest and land degradation is a serious threat to sustainable development. Forest landscape restoration is an opportunity to reverse this trend. Economic and financial analysis of forest landscape restoration is a very important step in the fight against degradation. Forest restorations interventions require massive resources in the short term; however, benefits accrue after many years. Costs and benefits for various forest landscape interventions were modeled and estimated over for 30 year period. Each restoration scenario was analyzed using Net Present Value (NPV), Equal annual annuity (EAA), Internal Rate of Return (IRR) and Benefit Cost Ratio (BCR). The benefit from forest restorations interventions outweighs costs at 5%, 7%, 10% and 12. All restoration transitions have shown positive NPV implying that all the landscape restoration are viable and are justified. The transition from traditional cowpeas farming to intensive agroforestry with *Melia volkensii* has the highest NPV (7%) at KES 1,893,785 this is followed by the transition from poorly managed woodlots to improved eucalyptus woodlots at (KES 1,649,510) and silvo-pastoral system at Ksh 1, 272,052 respectively. The transition from treeless roads to roads with planted trees has the lowest NPV at KES 96,972 over the 30 year period. The transition from degraded natural forest to improved natural forest through enrichment planting yielded the second lowest NPV (KES 318,559). The benefit cost ratio ranged from low of 2.75 (Degraded forest to enrichment planting) to highest of 29.2 (grass reseeding). The cost of forest restoration using the restoration options selected ranged from KES 28,662/ha to KES 631,032/ha (current values for 2018) depending on the restoration option adopted. The IRR and BCR for all restoration options ranged from 9.06 to 39.68 and 6.1 and 29.2 respectively. Forest restorations accrue benefits at private and public levels and investors/stakeholder may directly benefit from the restoration action. For example, agroforestry system produces both private and public benefits (carbon sequestration, water flow regulation and soil protection). Though it may look feasible from public perspective, however, intensive use of inputs may hinder large scale adoption of these systems.

Some benefits of large scale restoration accrue benefits to a wide range of stakeholders e.g. carbon sequestration which accrue to global community yet have not incurred cost in provision of this ecosystem system. It may therefore be prudent that local communities, agencies and national government are incentivised through a benefit transfer mechanism. There is need to explore financing options for all the feasible options to restore degraded ecosystems.

Findings from financial analysis indicators of total financial outlay, owners' net cash flow, and internal rate of return (IRR), NPV, payback period and benefit cost ratio (BCR) showed the commercial viability of the interventions. Based on IRR, NPV, payback period and (BCR) ranking - Intensive Agroforestry *Melia volkensii* and cowpeas, Eucalyptus woodlots, commercial bamboo plantations, cypress plantations and Agroforestry combination of Grevillea robusta, maize and Fruit trees provide a good investment opportunity for the landowners

At the national scale, the costs of forest landscape restorations were estimated at 1.8 trillion for the most conservative scenario of restoring 5.1 million ha to 3.7 trillion for the ambitious target of 10.2 million ha. The benefits from restoration ranged from ranged from 7.6 trillion to 14.8 trillion over 30-year period and giving a cost benefit ratio of about 4.1. Even though the benefits from restoration interventions are enormous, we require substantial financial resources for these benefits to be realised in the long-term.

5.2 Recommendations

1. Establish national coordinated strategy for FLR

The FLR is multi-agency, multi-stakeholder undertaking across different landscapes, tenures and likely to impact different land use sectors. The government in consultation with stakeholders should define priority areas for intervention so as to maximize on environmental benefits and minimize conflicts with other land uses such as agriculture. This criterion should be based on maximum societal restoration benefits with the lowest costs. For this process to have higher societal benefits, all agencies (environment, agriculture and livestock) should harmonize their plans and minimize conflict.

2. Implement mechanisms that incentivize restoration by land owners

As earlier mentioned in this report, landscape restoration has many public benefits where beneficiaries do not incur costs of restoration. The government should motivate these actors by developing a mechanism of supporting those individuals /groups active in restoration through tax incentives or subsidize the costs of inputs e.g. cost of seeds and tree seedling production and equipment for monitoring and management of grazing areas and watering points. In large restoration efforts with high public benefits, it is desirable to design a payment scheme (PES) to motivate institutions or investors.

3. Build capacity for large scale restoration

As mentioned in 1 above, it is important to recognize the critical role of good governance in the overall restoration strategy. There is need to have a coordinated approach that minimizes institutional conflicts and risks. Another barrier which needs to be surmounted is the paucity of data. From our experience, during the course of this study, we experienced challenges to find data on ecosystem services flows and stocks and there is need to develop long-term framework for assessing costs and benefits of restoration so that we can predict outcomes with certainty. We also need to develop capacity in the use ecosystem modelling tools (ARIES, InVEST, ECOMETRIX, EVT, TESSA, CO$TING NATURE and SWAT) to support investments in forest landscape restoration.

5.3 Limitations of the Study and Areas for Further Research

This analysis only focused on twelve restoration interventions and these proposed interventions may not be applicable in all different biophysical and socio-economic conditions prevailing in most parts of Kenya. There is therefore need to explore other potential interventions. There is also need to assess the hydrological impacts using ecosystem models of the proposed interventions and how it impacts on community's resilience to drought.

Forest and landscape restoration interventions have long term horizons and there is need to have accurate data to predict likely outcomes (costs and benefits) during the investment period. This analysis relied on some few scientific data and local experiences to model costs and benefits over the investment period and this may have under or overestimated costs and benefits. However, the results can be considered the best estimates under the prevailing conditions.

Changing climatic conditions, anthropogenic factors, pest and diseases and price instability changes in prices affect growth and recovery of restored landscapes. How these factors are likely to influence restoration were not taken into consideration. Forest and landscape recovery is influenced by many interactive factors and this analysis relied on many assumptions to predict benefits which may not hold or remain constant over the investment period.

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Annex 1: Terms of Reference

Terms of Reference for the Consultancy for the Economic Analysis of Restoration Opportunities in Kenya (Quantifying Climate Mitigation and Adaptation Benefits of Forest Landscape Restoration)

1. Background

The International Union for Conservation of Nature (IUCN) is currently carrying out forest landscape restoration assessments using the Restoration Opportunities Assessment Methodology (ROAM) in 26 countries. As part of the assessments, economic analysis is carried out to assess which forest landscape restoration opportunities are viable and most appropriate for countries, private sector and individuals.

The assessments underpin the work IUCN and its partners are doing on Forest Landscape Restoration (FLR) in support of the Bonn Challenge, a global goal to initiate restoration of 150 million hectares of deforested and degraded lands by 2020 and 350 million hectares by 2030. In Kenya, the Kenya Forest Service is undertaking ROAM and IUCN is supporting this process and it is on this basis that we are seeking a landscape restoration economist to undertake the economic analysis to assess which forest landscape restoration opportunities are viable, most appropriate and those that will generate a positive rate of return on investment from public sector, private sector and individuals in Kenya.

The economic analysis should make a strong case and justification for the need to restore the identified degraded areas, especially among policy makers (treasury and finance), private sector players as well as individual farmers. In addition, the economic analysis should quantify and provide a clear indication of "best bets" for achieving climate mitigation and adaptation benefits from forest landscape restoration interventions in Kenya quantified as short-term and long-term economic benefits.

2. Objectives of the assignment

The key objectives of the economic analysis are to:

i. Establish costs and identify benefits of investments in forest landscape restoration in the potential areas and ensuring that the restoration opportunities identified are economically viable and appropriate, and will generate a positive rate of return on investment from public sector, private sector and individuals, while generating appropriate mitigation and adaptation benefits e.g., from avoided deforestation, carbon sequestration, and improved resilience and disaster risks reduction for local communities and ecosystems;

ii. Identify and analyze the types of finance and resourcing options available to support the implementation of forest landscape restoration interventions;

iii. Recommend a finance mix suitable and feasible for the different types of forest landscape restoration interventions emerging from the assessment (e.g., public and private, national and international.

3. Specific tasks

1. Produce a methodology and work-plan for the work to be agreed and signed off by the client. This will include working with a team of government economists to more closely define the economic and finance questions to be addressed, policy target audiences and the level of economic, finance and broader (crop, livestock, carbon, water, biodiversity, food security etc,) benefit data that is available, or can be collected within the scope of the project. These analyses could operate at a number of levels of which the following are indicative:

a. CBA of selected pre-identified interventions at the national level,

b. CBA/economic and financial documentation of actual restoration examples in selected landscapes (e.g. agroforestry in Kiambu County, dryland restoration in Kajiado County)

c. Predictive CBA of farmer/pastoralist selected mixes of trees and crop species in targeted landscapes (e.g. maize, beans and mahogany; grasses and gum Arabic);

2. Collect and review available information, and existing reports, with regards to existing restoration activities in Kenya, to get a deep understanding of restoration initiatives in the country, including compiling a list of priority restoration projects that can yield valuable economic data;

3. Based on best practice, available data and the above consultations, develop a robust methodology to quantify costs and benefits of implementing restoration practices and actions such as dry rangelands, agroforestry, afforestation, reforestation, natural regeneration, riparian vegetation restoration/riverine buffer zoning and other interventions detailed in the Kenya's Restoration Assessment Report. This would include developing ecosystem service models that capture crop production, watershed conservation, timber growth, carbon, erosion, soil fertility enhancement, and other important variables;

4. Collect and collate existing (or collect new) data/case study information from representative priority landscapes to carry out the analysis based on the proposed methodology, and for at least 3 landscape restoration scenarios;

5. Quantify both adaptation and mitigation benefits for the restoration scenarios;

6. Carry out a sensitivity analysis, to quantify the risks of adopting each restoration activity on key risk dimensions, including market prices, production/yield, climate change, etc;

7. Based on results, build compelling economic case targeting national and local stakeholders, for investment in forest landscape restoration at national and subnational levels as outcome from the ROAM processes by identifying appropriate sources of funding and a finance mix.

4. Duration of the assignment and deliverables

The assignment will be carried out within a 3-month period (March to June, 2018). The final report is expected for delivery on June 1, 2018.

1.	Inception report outlying review of available information with proposed methodology, work-plan and stakeholder engagement report for the economic analysis (specific tasks 1 and 2) and methodology for assessing adaptation and mitigation benefits.	March 5, 2018
2.	List of landscapes where existing restoration projects has or can provide valuable economic data and a work-plan for relevant analysis and if required data collection	March 15th, 2018
3.	Draft report with CBA analysis from a priority landscape, including mitigation and adaptation benefits (tasks 3, 4, 5 and 6)	May 15th, 2018
4.	Final report (task 7)	June, 1, 2018

Table 1: Work plan Cost Benefit Analysis of Restorations options

Specific tasks	Activities	Methods/ approaches	Period			
			March	April	May	June
Produce Methodology and Work plan	Draft a work plan for discussion	Desktop and discussion with client				
Collect and review available information of forest landscape restoration and compile a list of priority projects that can yield valuable data	Literature review (local) Compile a list of local restoration projects	Desktop , visits to institutional libraries, expert discussions, government agencies, CBO's, NGO's and donor agencies				
Develop A robust methodology to undertake CBA of various restorations options	Literature review , Expert discussions, stakeholders engagement	Desktop, Delphi (expert discussions), consultations with key stakeholders				
Stakeholder consultative meeting	Discussion on methodology, data sources and agreeing on restoration transitions and scale of analysis	Delphi (expert discussions), consultations with key stakeholders				
Carry out CBA for at least 3 landscape restoration scenarios	Identification of relevant sites based on restoration assessment report Data collection (primary and secondary)- acquisition of data	Household surveys, CVM, Collation of secondary data,				
Quantify both adaptation and mitigation benefits for the restoration scenarios	Identification of potential impacts (costs and benefits)	Checklist, expert discussions, project data , modeling impacts, data analysis				
Carry out sensitivity analysis using key risk dimensions	Isolate key parameters likely to have major influence on restoration outputs	Data analysis, simulations				
Develop recommendations based on economic analysis for investment and allocations of resources in forest landscape restoration	Draft report	Desktop and stakeholder engagements, consultations with client				
Stakeholder consultative meeting	Discussion on the draft report	Discussions and consultations with key stakeholders				

Annex 2: Schedules for capturing costs and benefits for restoration options

Schedule 1: ***Cost and benefit schedule for natural forest restoration***

Item	Unit	Unit price	Quantity per ha	Total Value (KES)	Time interval
Labour					
Land preparation	Labour days				
Planting	Labour days				
Establishment of fire line	Labour days				
Patrolling	Labour days				
Maintenance of fire lines	Labour days				
Material inputs					
Seedlings	No.				
Transport cost	Km				
Equipment					
Watering can	No.				
Hoe	No.				
Machete	No.				
Pruning saw	No.				
Wheelbarrow	No.				
Ropes	No.				
Axe	No.				
Revenues					
Carbon stock	Ton/ha				
Soil protection (soil erosion control)	(Tons/ha)				
Water flow regulation	Vol/ha				

Schedule 2: *Cost and benefit schedule for agroforestry on crop land (Woodlot, boundary planting and intercropping)*

Item	Unit	Unit price	Quantity per ha	Total Value (KES)	Time interval
Labour					
Nursery set up and operation	Days				
Land preparation					
Digging	Hole				
Planting	Days				
Weeding	Days				
Watering	Days				
pruning	Days				
Material inputs					
Seedlings	No.				
Fertilizer	Kg				
Pesticides	Kg				
Crop Seeds	Kg				
Equipment					
Watering can	No.				
Hoe	No.				
Machete	No.				
Pruning saw	No.				
Wheelbarrow	No.				
Ropes	No.				
Axe	No.				
Harvesting					
Crop harvest	Days				
Fuel wood harvest	Days				
Transport cost Km					
Benefits					
Crop					
Crop 1, crop 2,	kg				
Fuelwood	Head load				
Carbon stock	Ton/ha				

Schedule 3: *Cost and benefit schedule for commercial tree and bamboo plantations in marginal areas or Un-stoked plantations*

Item	Unit	Unit price	Quantity per ha	Total Value (KES)	Time interval
Labour					
Nursery set up and operation	Days				
Land preparation					
Digging	Hole				
Planting	Days				
Weeding	Days				
Watering	Days				
pruning	Days				
Fire protection	M2				
Clearing for fire line	Days				
Material inputs					
Seedlings	No.				
Fertilizer	Kg				
Pesticides	Kg				
Crop Seeds	Kg				
Equipment					
Watering can	No.				
Hoe	No.				
Machete	No.				
Pruning saw	No.				
Wheelbarrow	No.				
Ropes	No.				
Axe	No.				
Harvesting					
Crop harvest	Days				
Fuel wood harvest	Days				
Transport cost Km					
Revenues					
Poles					
Fuel wood	Head load				
Timber	M3				

Schedule 4: *Cost and benefit schedule for riparian protection (Bamboo, Grass and tree planting)*

Item	Unit	Unit price	Quantity per ha	Total Value (KES)	Time interval
Labour					
Establishment costs					
Lay out					
1. Pegs	Number				
2. Strings	Pcs				
3. Labour	Days				
Other establishment costs					
1. seedlings	Number				
2. Digging -labour	Days				
3. Planting -labour	Days				
4. Watering	Days				
Annual maintenance					
1. Slashing-labour	Days				
2. Pruning- labour	Days				
Equipment					
Watering can	No.				
Hoe	No.				
Machete	No.				
Pruning saw	No.				
Wheelbarrow	No.				
Harvesting					
Grass harvesting	Days				
Poles/timber/Fuel wood harvest	Days				
Benefits(Revenues)					
Grass (fodder)	DM				
Timber	M3				
Poles	Number				3
Fuel wood	Kg/ton				3-25
Carbon stock	Ton/ha				25
Soil erosion control	Ton/ha				1-25

Schedule 5: *Cost and Benefit schedule for rangelands management / ha*

Item	Unit	Unit price	Quantity per ha	Total Value (KES)	Time interval
Labour					
Establishment costs					
1. Pegs	Number				
2. Strings	Pcs				
3. Labour	Days				
Other establishment costs					
1. seedlings	Number				
2. Digging -labour	Days				
3. Planting -labour	Days				
4. Watering	Days				
Annual maintenance					
1. Slashing-labour	Days				
2. Pruning- labour	Days				
Equipment					
Watering can	No.				
Hoe	No.				
Machete	No.				
Pruning saw	No.				
Wheelbarrow	No.				
Harvesting					
Crop harvest	Days				
Fuel wood harvest	Days				
Transport cost					
Benefits(Revenues)					
Grass (fodder)	DM				
Timber	M3				
Poles	Number				3
Fuel wood	Kg/ton				3-25
Carbon stock	Ton/ha				25
Soil erosion control	Ton/ha				1-25

Annex 3: Assumptions Used in the analysis

Table 1: ***Assumptions used to calculate costs and benefits for each land use and restoration intervention***

Restoration transition	Assumptions
Traditional Agriculture (Cowpeas Farming) to Intensive Agroforestry Melia and Cowpeas	1. Cost of cowpeas seed is KES 120 per kg 2. 1 ha requires 30 kg of cowpeas seeds 3. Fertilizer is applied at the rate of 150 kg per Ha 4. Timber to firewood ratio is 20% 5. Cost of sediment removal is KES 178 per tonne (Langat, 2016) 6. The Price of cowpeas haulms is KES 1666 per tonne 7. Cost of manure per tonne is KES 1000 8. Price of Melia firewood is KES 2000 per m^3 9. Benefits from soil fertility/improvement are realised after the first Year 10. No of Melia trees per ha is 240 using 10*5 m spacing 11. Four trees require 1 wheelbarrow of manure (25kg) 12. Weeding costs @250 per day for 20 Labour days 13. Mean annual increment of Melia is 4 m^3 per year/ha 14. Firewood harvested at year 7,10 and 25 (firewood is 20% of total timber yield)
Traditional Agriculture (Maize Farming) to Intensive Agroforestry Grevillea robusta, Maize and Avocado	1. Normal Maize agronomic 2. Timber to firewood ratio is 20% 3. Harvesting cost of maize under traditional agriculture include: stacking, De-husking, transport and threshing@ KES 2500,3500,2100 and 1750 4. Harvesting cost under improved agroforestry of maize include: stacking, De-husking, transport and threshing@ KES 2500,4500,2850 and 4750 5. Cost of manure per tonne is KES 1000 6. Benefits from soil fertility/improvement are realised after the first Year 7. No allelopathic relationship between the trees and crops 8. Maize stovers for fodder and Grevillea robusta leaves used as fodder 9. The Price of maize stover is KES 50 per 30 kg bag 10. Fruit trees start producing at the end of 3 years 11. Grevillea robusta pruning's are used as firewood after 4 years and harvested for timber at 25- years. 12. Price of Grevilea firewood is KES 2000 per m^3 13. On average households use 1 M^3 of firewood per year
Poor managed planted woodlots to well managed woodlots	1. Poorly managed woodlots is assumed to have 4500 trees/ha (1.5m by 1.5m) 2. It is assumed that poorly managed woodlots are raised for small diameter poles (withies) on a 4-year coppice cycle and 75% of the materials are suitable for sale 3. Mean annual increment of overstocked eucalyptus is 25% of well managed stands 4. Above ground carbon is 12.68 Metric Tonnes (MT) in young Eucalyptus (Yirdaw, 2018) 5. The price per pole was assumed to be KES 50 per piece 6. The cost of harvesting was assumed at KES a piece 7. Maintenance/security costs per ha (3,000 per month) 8. In well- managed Eucalyptus wood we assumed density of 1600 trees/ ha (2.5m by 2.5m) 9. Average Mean annual increment of Eucalyptus is about 55 m^3 per year (Langat and Cheboiwo, 2005) 10. Average price per m^3 =4000 (KFS) 11. Beating was done in the beginning of the 2nd year and 25% of tree population replanted (400 trees) 12. 1st thinning is done at year 10 as pole wood sold at KES 2000 per stem and retaining 1111 as final timber crop 13. Final crop was harvested at year 25 for timber with assumed stumpage value of KES 15,000 per stem 14. Harvesting cost was assumed to be KES 300 per stem 15. Cost of sediment removal is KES 178 per tonne (Langat, 2016)

Restoration transition	Assumptions
Un-stocked Cypress plantation to Stocked Plantation	1. Un-stocked planted forest holds about 30% plant density (2.5*2.5 spacing)-528 stems 2. The Modal age of un-stoked plantation is 10 Years 3. In the baseline scenario no thinning and harvesting o final crop at 25th year 4. Grazing is allowed in un-stocked planted cypress and grazing is allowed after the first thinning at age 5 in the improved scenario 5. The average value of forest grazing in Mau is about KEs 6,000 per ha per year we assume 50% benefits from degraded marginal forest (Langat ***et al.***, 2018) 6. In the improved (stocked cypress) 1072 seedlings planted 7. Normal sivicultural operation assumed (Mathu, 1983) 8. Soil erosion is imputed based on soil loss in both scenarios by assuming the cost of sediment removal is KES 178 per tonne (Langat, 2016) 9. Carbon stock in un-stocked cypress computed assuming one third of global mean annual increment of 13.4m^3/ha and computing expected volume and converting to carbon stock using IPCC tier 1 methodology (IPCC, 2006) 10. The revenues were computed using market prices based KFS report (KFS, undated)
Degraded planted forests to commercial bamboo plantation	1. Un-stocked planted forest holds about 30% Plant density (3*3 spacing 2. Timber to firewood ratio is 20% 3. Cost of sediment removal is KES 178 per tonne (Langat, 201The Modal age of un-stoked plantation is 10 Year 4. Cost of unsustainable extraction is estimated at 5% of total benefits
Degraded riparian zones to bamboo and grass strip	1. The dimension of the buffered 1 ha is (30 m width by 334 m length) 2. Value of subsistence grazing is KES 3000/ha (Langat ***et al.***, 2018) 3. Napier Grass spacing=0.6*0.6 m 4. Yield of Napier per ha is 15.7 Metric Tonnes (MT) 5. Manure is applied at rate of 10 Metric Tonnes (MT) per ha @ KES 1000 per tonne 6. Conversion factor from green to dry matter for Napier is 0.3 7. Price of one bamboo culm is 50/- 8. Bamboo spacing is 6*6 9. Extraction rate of bamboo is sustainable (there is regeneration no net loss
Degraded woodlands to commercial gmelina arborea plantations in marginal areas	1. Timber recovery is 40% and Timber to firewood ratio is 20% 2. Cost of sediment removal is KES 178 per tonne (Langat, 2016 3. Cost of manure per tonne is KES 1000 4. Price of Gmelina firewood is KES 2000 per m^3 5. Price of Gmelina timber is 25000/= per m^3 6. Benefits from soil fertility/improvement are realised after the first Year 7. Four trees require 1 wheelbarrows of manure (25kg) 8. Mean annual increment of Gmelina is 9 m^3 per ha per year 9. The final volume based on an annual increment is 225 m^3 10. Volume of timber (50% recovery) = 112.5 m^3 11. A degraded woodland is assumed to have 10% cover (LUCC) 12. Price of pole is KES 500/= 13. Woodlands do not have substantial extraction of wood
Degraded grasslands to grass reseeding	1. Soil Loss (Tons/ha)-72 tons/ha in degraded scenario 2. Grass seed yield per ha 30kg/ha in un-improved and 287.7kg in improved scenario 3. 4.5 bales in un-improved and 178.25 bales in improved scenario 4. Maintenance and security (3,000 per person per month for 20 ha 5. Average selling price of grass seeds in Kenya is KES 425/= (Manyeki et al,2015) and price per bale is KES 175
Acacia Senegal plus grass planted using Vallerani System (1 Ha) 25- years rotation	1. Acacia Senegal seedlings costs KES 10/= per seedling 2. Herding cost = KEs 3000/month 3. Yield of grass seed per ha is 75 kg per year 4. Price of 15 kg (1 bale of grass is KES 150) 5. Direct value from pastoralism is ($9) -Nyariki 2004 6. Annual carbon stock increase is 0.4t/ha 7. Carbons stock in grasslands in dry areas = 3.8 based on IPPC default value 8. Yield of gum /tree =0.5kg after 5th year

<table>
<tr><th>Restoration transition</th><th>Assumptions</th></tr>
<tr><td>Degraded forest to Improved protected natural forest (Enrichment planting)</td><td rowspan="2">1. Grazing and firewood collection will continue in the baseline
2. The average value of forest grazing in degraded forest is KES 3,000 per ha per year- we assume 50% benefits from degraded natural forest (Langat et al., 2018)
3. No extractive use of the enrichment planted area (grazing, timber) in rehabilitated forest for the first 10 years thereafter licensed extraction is permitted
4. Cost of unsustainable extraction is 5% of total benefits
5. Degraded natural forest holds about 10% -plant population (2*2 spacing) (10%)
6. Price of carbon sequestered is $6 per tonne
7. Cost of sediment removal is KES 178 per tonne (Langat, 2016)
8. Maintenance and security (3,000 per person per month for 20 ha)
9. Average annual increment in aboveground biomass in natural regeneration by broad category (Metric Tonnes (MT) dry matter/ha/year) = 5 Metric Tonnes (MT) DM
10. Benefit from water flow regulation is142,000 per ha-1yr after 6 years when there is full canopy closure</td></tr>
<tr><td>Degraded forest to Improved protected natural forest (Natural regeneration)</td></tr>
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