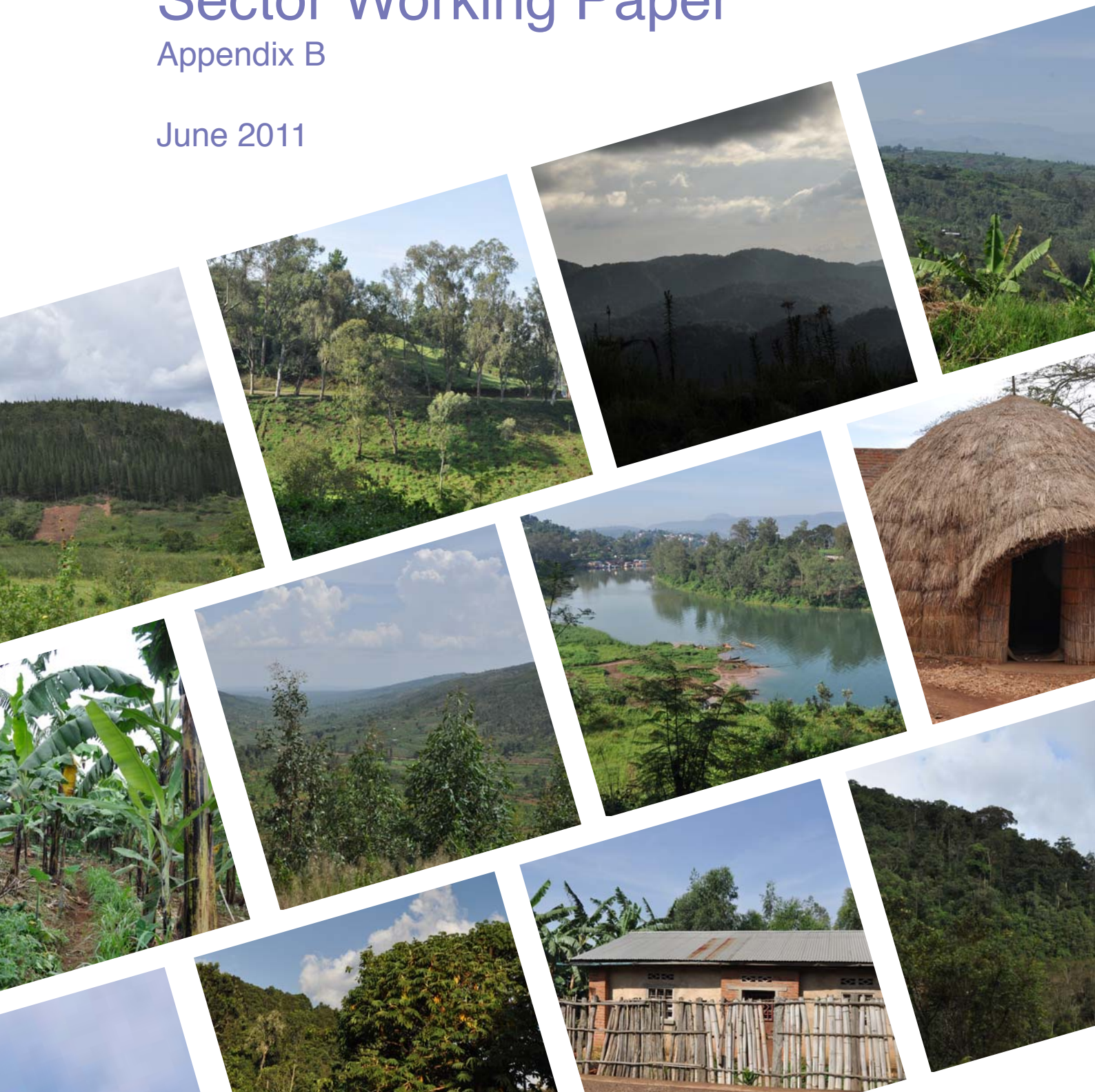
Forests and Tree-based Systems Sector Working Paper

Appendix B

June 2011



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Executive Summary

This paper is one of nine sector working papers written as part of the process of developing a National Strategy on Climate Change and Low Carbon Development for Rwanda. It follows on from the Baseline Report produced in February 2011, which provides the local context for each sector, including current programmes and development plans. This paper focuses on Rwanda's Forest and Tree-Based Systems, while the other working papers cover Energy, Water, Agriculture, Land, Transport, the Built Environment, Mining and Finance. The aim of each paper is to identify the vulnerabilities and opportunities facing the sector, to review global best practice and relevant case studies, and to propose an action plan for addressing climate change and low carbon development in the short, medium and long term. As the title suggests, the working papers are aimed at prompting discussion with stakeholders, rather than being the final word. The sector working papers, thinkpiece and stakeholder input will be used to compose the final Strategy in July 2011.

Rwanda's unique physical setting and natural resource base present a remarkable opportunity for sustainable growth that is compatible with development, mitigation and adaptation considerations. Rwanda's forestry sector is an excellent illustration of these synergies:

- The natural (primary) forests provide refuge to endemic species and rich biodiversity, which attract tourism revenues.
- Tree plantations and on-farm trees provide affordable raw materials and fuel wood that support the majority of the population's natural fiber and energy needs.
- Agroforestry contributes to food security for humans and livestock, and income generation.
- Lastly, forests provide ecosystem restoration and stabilisation services, ensuring security of the hydroelectric supplies that provide over half of Rwanda's power, and protecting waterways from heavy siltation from soil erosion.

Sustainable forest management and rehabilitation remain at the heart of the country's development strategies for conservation, transformation of agriculture, energy and the rural sector. However, the uncertain extent and condition, and emissions profiles of Rwanda's forest and tree-based systems pose a challenge to integrated management of this cross-sectoral resource. There is significant need to reconcile the varying estimations of Rwanda's forest cover to enable future planning to be grounded in robust baselines.

While Rwanda's forest and tree-based systems demonstrate relative resilience in the context of biophysical exposure and sensitivity, high levels of poverty, population growth and density, land scarcity and competition, environmental degradation, and overreliance on biomass/charcoal pose serious risks to the sector. The unavoidably crosscutting nature of natural resources demands greater levels of coordination, communication and sharing of technical resources.

To determine appropriate actions to address climate change, over 50 policies options underwent analysis to determine those that satisfy proposed principles of climate compatible development:

- Wide-reaching impacts & Scalability
- Increase adaptive capacity
- Yield net reductions in vulnerability and GHG emissions
- Sustain ecosystem services
- Reflect integrated development objectives

Five focus areas were selected.

Option 1: Community-based ecotourism

Tourism represents one of Rwanda's most vibrant industries, earning USD 202 million in 2008, and outperforming coffee and tea as the main foreign exchange earner. Based on projected growth targets, revenues are anticipated to more than double by 2020 to USD 627 million. Community-based ecotourism appears likely to provide high economic, social and environmental returns on investment.

Community-based ecotourism activities that engage the poorest households including handicrafts production and conservation education present a high-potential investment for poverty alleviation and park conservation. Despite the existence of a government run community-benefit scheme for tourism revenue sharing, insufficient resources are being availed to promote engagement and benefit sharing with the poorest households. Funds amount to a total investment of US$ 1.45 per person in its 4-year history, or an annual average of only US$ 0.36 per person.

Option 2: Afforestation, reforestation (A/R) and improved forest management (IFM)

Vision 2020 aims to increase the production of wood for fuel and other uses by expanding forest and tree cover to 30% of the national land area by 2020. A/R and IFM must be used ensure that vulnerability of forest ecosystems and plantations is not increased. Mixed-species approaches are recommended to promote ecosystem resilience.

A/R and IFM activities have a severe investment deficit, estimated at RWF 1-1.6 billion for replanting degraded plantations. A/R and IFM would help meet skyrocketing wood and charcoal energy demands. Furthermore, the potential to develop carbon credits through emissions reductions achieved from A/R and IFM projects presents an opportunity for monetary returns on investment.

Option 3: Agroforestry promotion

Agroforestry has significant potential to contribute to poverty alleviation through income generation and diversification, carbon sequestration, and energy and water security. Agroforestry also decreases soil erosion, and improves soil fertility and hydrological balance. Strong financial, capacity and institutional coordination issues are currently unmet for the agroforestry sub-sector, and warrant increased support. In order to ensure the sustainability and potential livelihoods and resilience benefits of agroforestry, it is critically important that communities and farmers are closely involved in decision making when designing interventions.

Option 4: Payments for Ecosystem Services (PES)

Payments for ecosystem services schemes promote ecosystem resilience, income generating activities, and improved functioning and reliability of water supplies and electricity generation. Further detailed analysis on the design and implementation of PES is highly recommended – particularly with the engagement of water treatment and hydroelectric utilities, tea factories and beverage companies. In the context of Rwanda, public-private schemes, appear to be particularly attractive as a way of generating markets and private capacity, while reducing burdens on government.

Conclusion:

Multiple environmental, social and economic benefits afforded by forest and tree-based systems make possible the simultaneous achievement of reductions in vulnerability to climate risk and mitigation of the CO2 emissions. To promote robust, long-term and high-return investments, immediate and predictable support should be provided to community-base ecotourism, afforestation/reforestation and improved forest management, agroforestry, payments for ecosystem services and improved cook stoves.

Contents

Acronyms and Abbreviations

A/R	Afforestation/Reforestation
AC	Adaptive Capacity
AF	Agroforestry
BAU	Business as Usual
BEST	Biomass Energy Strategy
BioCF	BioCarbon Fund
CCD	Climate Compatible Development
CDM	Clean Development Mechanism
CER	Certified Emission Reduction
DRR	Disaster Risk Reduction
EDPRS	Economic Development and Poverty Reduction Strategy
EWS	Early Warning System
FONERWA	Rwanda National Fund for the Environment
GHG	Greenhouse Gas
ICS	Improved Cookstoves
IDP	Integrated Development Programme
ISAR	Institut des Sciences Agronomiques du Rwanda
LAMA	Locally Appropriate Mitigation Actions
LAPA	Local Adaptation Programme of Action
LDCF	Least Developed Country Fund
LULUCF	Land Use, Land Use Change, and Forestry
MINAGRI	Ministry of Agriculture
MINALOC	Ministry of Local Government
MINECOFIN	Ministry of Finance and Economic Planning
MINEDUC	Ministry of Education
MINICOM	Ministry of Commerce
MININFRA	Ministry of Infrastructure
MINIRENA	Ministry of Natural Resources
NAMA	Nationally Appropriate Mitigation Actions
NAPA	National Adaptation Programme of Actions
NIE	National Implementing Entity
NLC	National Land Centre
NNP	Nyungwe National Park
NTFP	Non-Timber Forest Products
OTC	Over The Counter
PES	Payment for Ecosystem Services
RDB	Rwanda Development Board
REDD	Reduced Emissions from Deforestation and Degradation
REMA	Rwanda Environment Management Authority
SLM	Sustainable Land Management
UNFCCC	United Nations Framework Convention on Climate Change
VER	Voluntary Emission Reduction
VNP	Volcanoes National Park
WISDOM	Woodfuel Integrated Supply/Demand Overview Mapping

Introduction

Rwanda's unique physical setting and natural resource base present a remarkable opportunity for sustainable growth that is compatible with development, mitigation and adaptation considerations. Rwanda's forestry sector is an excellent illustration of these synergies:

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Given the significant economic, social and environmental benefits derived from Rwanda's forests and other tree-based systems, this report seeks to explore further benefits afforded by these critical ecosystem services in the context of climate change adaptation and mitigation. Overall, the report attempts to illuminate the links between forests and human well-being to inform policymaking for climate compatible development.

Sector Overview

1.1 Current Status

The present and future extent of forest coverage in Rwanda is central to sustainable development and climate change considerations. With an estimated 86% of Rwanda's energy provided by biomass, forest resources are under increasing pressure from a growing population and shrinking land availability [13]. The balance of current supplies with growing demand, energy access and affordability are of primary importance for low carbon growth, adaptation to climate change, and ensuring an energy secure future.

Sustainable forest management and rehabilitation remain at the heart of Rwanda's development strategies for conservation, transformation of agriculture, energy and the rural sector. In recent years, numerous studies and inventories have been carried out to establish a comprehensive baseline of natural and managed forests, and tree cover.

Since the 1960s, Rwanda's natural forest cover declined by an estimated 65% [13]. This dramatic reduction was particularly evident in the period following the 1994 conflict as returnees and refugees cleared land in protected areas. Although natural forests are under continuous pressure from encroaching communities, improved park management and the creation of buffer zones has helped to stabilise the situation. Nevertheless, sustainable management of a continuously increasing fuel wood deficit and land scarcity remains a significant challenge.

1.2 Forest Cover

In 2007, a satellite-based mapping exercise with ground truthing was completed to establish a baseline of Rwanda's forest and woodlot coverage[14]. Due to resolution constraints, only areas with a surface of 0.5 hectares or greater, tree crown coverage of more than 20% and tree height of more than 7 metres were considered. Inventory results indicate coverage of around 240,746 ha, or approximately 10% of the surface of national dry lands. The coverage includes 80,000 ha of humid natural forest, consisting mainly of two blocks in the protected areas of Nyungwe National Park in the southwest and Volcano National Park in the northwest. Other national reserves include the forests of Gishwati and Mukura, the savannah and gallery forest of the Akagera National Park and remnants of gallery forests and savannas of Bugesera, Gisaka and Umutara. Forest plantations dominated by non-native species including eucalyptus, pine and other young plantations and coppices occupy roughly 115,000 ha, with the remaining coverage consisting of smaller areas of dry forests, bamboo and bush land.

Significantly, small woodlots, scattered agroforestry and other managed trees below 0.5 ha were not included in the inventory. According to the National Forestry Policy, these forest resources represent an additional 222,520 ha equivalent to conventional forests. As a result, the official forest coverage of Rwanda is estimated at 21% of the country area, consisting of 8% natural and 13% manmade forest[13].

According to recent figures compiled by the National Forestry Authority (NAFA), as of 05 May 2011, Rwanda's total tree cover is an estimated 660,351 ha[26]. This includes 257,500 ha of natural forests and 402,851 ha of plantations with an area of more than 0.5 ha total 114,815 ha based on the 2007 satellite inventory. Overlapping with this is the estimate of plantation areas greater than 0.25 ha, totaling 134,828, as reported by District Forest Management Plans. The remaining 268,023 ha are estimated to consist of small woodlots and agroforestry. A comparison of the 2007 inventory and more recent NAFA estimates are detailed in Table 1.

Based on the 2011 NAFA figures, Rwanda has surpassed its 2012 target of increased tree-cover to 23.5%, or 616,309 ha, by 44,042 ha, reaching a total of 25% coverage. In other words, an estimated 129,789 ha of tree cover would technically be needed in order to achieve the 790,140 ha target of Vision 2020, or 30% coverage of total country area by 2020[3].

Table 1: Comparison of forest/tree coverage inventories to date and planned[14,26]

Inventory source	Baseline year	Methodology	Scope (>ha)	Natural (primary) forests	Plantation forests	Small plantations	Agro-forestry, small woodlots	Total (ha)	Total (% land cover)
MINIRENA, CGIS-NUR, ISAR	2007	Satellite (NDVI) w/ ground truthing	>0.5	80,000	115,000	NA	NA	240,746	10%
MINIFOM/ NAFA	2011 (May)	Satellite, District Forest Management Plans, BTC est.	>0.25	257,500	402,851	20,013	268,023	660,351	25%
MINIFOM, NAFA-BTC	2011 (planned)	Aerial photography	>25 cm?	TBD	TBD	TBD	TBD	TBD	TBD

There is significant need to reconcile the varying estimations of Rwanda's forest cover. In particular, plantation area estimates require a more detailed inventory and distinction between public and private areas, as well as more accurate estimates of small woodlot and agroforestry contributions. Towards this end, NAFA, in partnership with the Belgian Technical Co-operation (BTC) and the National Land Centre (NLC), plans to conduct a forensic inventory of current tree cover in Rwanda based on recently completed aerial photography surveys. The inventory work is planned to be underway in spring of 2011 and will take an estimated 16 weeks[26].

1.3 Fuelwood and charcoal sector

The production and use of fuelwood and charcoal is of critical importance to Rwanda's economy and energy supply needs. In 2007, the value of firewood and charcoal was on the order of USD 122 million, or 5% of GDP[15]. In terms of charcoal, the supply chain is not only a source of rural employment, but also a key income generating opportunity as farmers consider trees as a crop from which they can earn income and respond to market signals. In addition, work by GIZ in 2008 found that Rwanda may well be the only country in Africa where the relation between charcoal and deforestation no longer exists as virtually all charcoal is produced from planted trees on private and community lands.

As highlighted in background work for the Biomass Energy Strategy (BEST) in 2008[15], fuelwood (including charcoal) is a vital and appropriate source of energy in Rwanda for the time being due to the following attributes:

- Affordability: All convenient alternatives (electricity, LPG, etc) and others (methane from Lake Kivu) are significantly more expensive
- Security: It does not depend much on external influence or foreign exchange
- Green and renewable: It is a renewable source of energy that can be utilised in a clean, efficient and climate 'neutral' fashion.

Nevertheless, Rwanda faces a serious woodfuel deficit, which directly impacts the availability and affordability of biomass energy including charcoal. In work completed by the FAO Woodfuel Integrated Supply/Demand Overview Mapping (WISDOM) in 2011, it was found that 42% of Rwanda's rural population is in high deficit of woodfuel energy needed to meet basic needs, with 39% in medium-high deficit. Over 1.5 million people (20% of people in rural provinces) live in areas with concomitant conditions of serious woodfuel deficit and high poverty, which are cause of extreme vulnerability and overexploitation of natural resources[16]. The majority of the population is currently struggling with a deficit of subsistence energy and the gap between supply and demand is widening each year (see Figure 1). In terms of total wood demand, with a sustained yield of 1,228 thousand cubic metres and demand of 10,781 thousand cubic metres, Rwanda has a growing wood deficit of -9,553 thousand cubic metres. With population growth rates around 3%, Rwanda's wood deficit is growing. This has significant implications for the charcoal sector in particular as more efficient and improved supply and demand side management would reduce deficit burdens[13].

Analogous to forestry resources, obtaining reliable, current data on the extent of wood and charcoal demand is a challenge. Estimates of rural and urban demand splits vary, and make planning interventions difficult. Nevertheless, useful policymaking tools have emerged including the WISDOM and BEST studies, in addition to the National Forestry Policy (2010), analysed further in later sections. According to the WISDOM results, the total annual productivity of woody biomass accessible and potentially available for energy use countrywide is an estimated (1.1*10,t, oven dry). The total consumption in the residential, commercial and public sectors with the current carbonisation and stove efficiency is an estimated 2.9 Mt. Hence, the national supply/demand balance shows an annual deficit of 1.8 Mt.

The BEST strategy further informs this work by analysing supply and demand side dynamics of

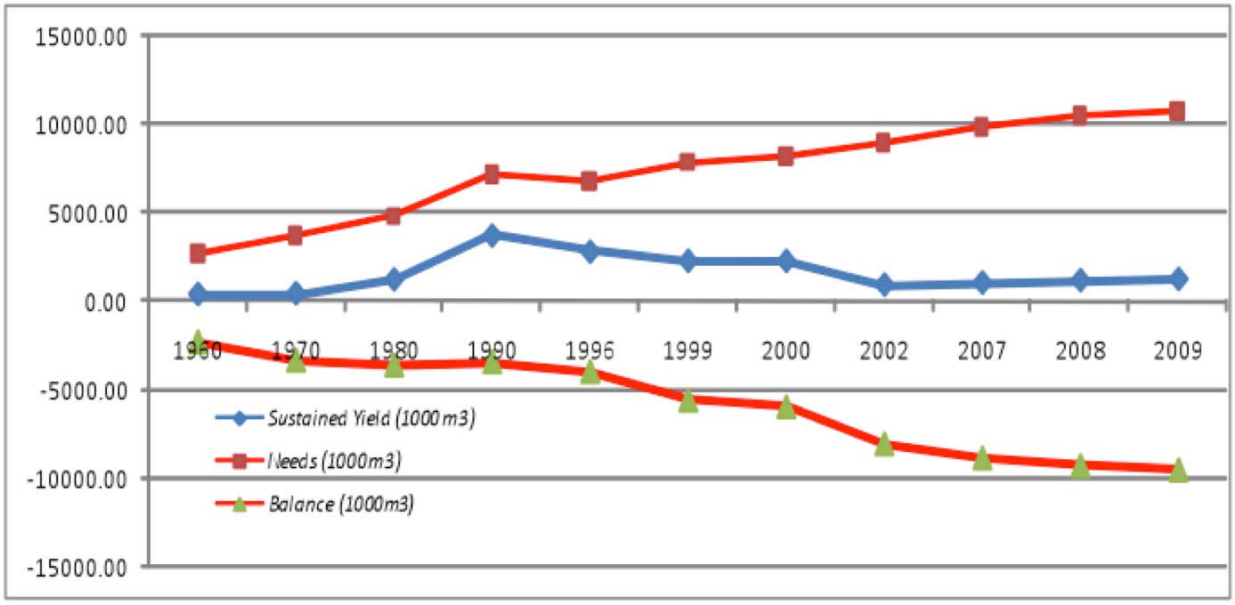

Figure 1: Supply and demand of woodfuel in Rwanda

commercial use of wood fuels and focuses on charcoal. This focus is premised on the arguable assumption that gathered wood fuels will have negligible effect on the state of wood resources because gathered firewood, dead wood, twigs or cut branches will not destroy the resource base. On the other hand, for the production of charcoal and commercially sold firewood, entire trees are cut[27]. Charcoal constitutes 8% of the secondary energy balance, but 23% of the primary energy balance – implying that small end-use reductions will have large implications on the primary supply side. According to the analysis, total national consumption of charcoal is an estimated 150,000t per year. Kigali City is the greatest consumer with 58%, followed by other urban areas with 25%, and rural areas with 17%. The efficiency of the charcoaling process is low, with average efficiency of 12% (24% on an energy basis), compared with maximum efficiencies of 20-22%[27].

1.4 Future emissions

In May 2009, a rapid low carbon growth assessment was conducted to project Rwanda's future emissions profile based on Vision 2020 sector targets and EDPRS[29]. Within the forestry sector, Rwanda's sequestration was estimated at 7,500 Gg of CO_2 per year. This number was based on Initial National Communication estimates, which are broadly in line with the Second National Communication emissions projections for 2020 shown in figure 2, which assumes sequestration from forests remains constant over time. Despite this forest sink against future emissions growth in major economic sectors, Rwanda is projected to become a net emitter of GHGs in 2012. Changes to afforestation or deforestation would affect these projections.

The 2009 study emphasised that whilst the projections provide a useful starting point for considering low carbon pathways, they also highlight a number of uncertainties:

- Some of the Vision 2020 sectoral targets used in the projections may not be met; therefore, some of the growth forecasts might be deemed overly optimistic.
- The agriculture projections have been estimated using a simplistic approach, and would benefit

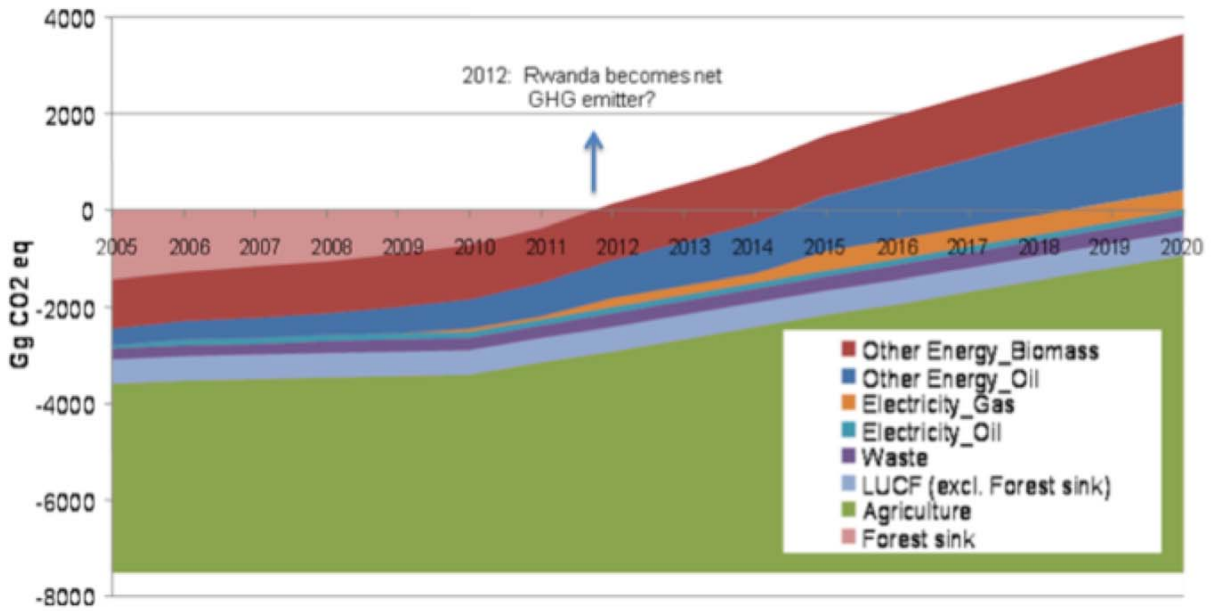

Figure 2: Projected GHG (Gg CO2 eq.) including land-use change and forest sinks from Rwanda[29].
Note: high uncertainties in projections, thus these should only be treated as indicative.

from much greater consideration. The forecasts here have high uncertainty.

- Electricity emissions could be considerably lower, if growth forecasts are too high, and Lake Kivu methane generation does not come online as expected.
- Transport emissions baselines and projections require further analytical work.

Specific to the forestry sector, it is important that projections are also adjusted to account for sector targets of 30% tree coverage by 2020, which, based on current government reports, are on track to be realised. However, as noted above, a forensic inventory based on aerial photography data will help reconcile differing forest cover estimates to date, which will inform monitoring progress towards this target. High levels of uncertainty also surrounding forest and land use sector GHG emissions and sequestration noted in the Second National Communication must also be addressed. The following action has been recommended[28]:

- Update and establish regular inventory of land use categories for forest and tree cover, and cultivated land changing from season to season.

Vulnerabilities and Challenges

Rwanda's forest and tree-based systems demonstrate relative resilience in the context of biophysical exposure and sensitivity. However, the lack of adaptive capacity of human systems, largely related to development challenges, lends higher vulnerability to the overall sector.

2.1 Low to medium biophysical exposure and sensitivity

Table 2 illustrates Rwanda's biophysical vulnerability to climate change relative to projections for the African continent. In contrast to other natural resource-based sectors such as water and agriculture, forest and tree-based activities are relatively resilient to climatic change, or less vulnerable. This is particularly the case with temperature as the majority of tree species, both natural and exotic, have large windows of favorable temperature growing conditions ranging up to 30 to 40°C. Against projected temperature increases from an average 26.7°C in 2010 to 29.2°C by 2100, or 2.5°C, most trees remain within favorable growing conditions[28,30]. Precipitation changes will likely result in greater impacts as water stress on trees or overexploited forests reduce system resilience.

Perhaps the most important impact to the biophysical vulnerability of Rwanda's forests and diverse tree species is the combination of temperature increases with potential rainfall deficits resulting in greater evapotranspiration and disruption of the hydrological balance. Evapotranspiration is one of the processes affecting agriculture temperature and precipitation locally and globally through atmospheric gas concentrations and other climatic elements such as precipitation, cloudiness, and humidity and wind distribution. It is significant because an increase in evaporation or evapotranspiration – while precipitation remains constant or is reduced – could decrease water availability for natural and agricultural systems, and human needs.

2.2 Higher vulnerability due to lower adaptive capacity

As illustrated in Table 2 – in a strictly biophysical sense – Rwanda's forest and tree-based systems are in many respects resilient to climatic changes projected over the next century. However, given that the majority of these systems are man-made or managed, there are strong linkages between these systems and the adaptive capacity of human systems which have direct and indirect effects on the vulnerability of the overall sector. Components or determinants of such 'adaptive capacity' include: managerial ability, access to financial, technological and information resources, infrastructure, and institutional environment within which adaptations occur, political influence, kinship networks, etc. [36]. The key message for Rwanda is that adaptive capacity and, by extension, vulnerability, are context-specific. Therefore, while the below table is an illustration across categories that broadly capture adaptive capacity at the national level, a more in-depth exercise based on community sensitivity, exposure and adaptive capacity should be considered for local level planning exercises.

Table 2. Rwanda forest sector biophysical vulnerability[25, 28, 30, 31]	
IPCC Impacts for African Continent	Rwanda Forest sector vulnerability
Temperature - Higher warming throughout the continent and in all seasons compared with global average. - Drier subtropical regions may become warmer than the moister tropics	Low vulnerability due to low exposure, low sensitivity, and high adaptive capacity. - Low levels of direct vulnerability as major tree species (natural and exotic) in Rwanda remain within favorable growing conditions (ranging between 14°C – 40°C) for projected temperature changes over the 2010-2100 time period, which range between 2°C and 2.5°C. There will not be a large shift in forest species distribution[28,30].
Precipitation - Decrease in annual rainfall in much of Mediterranean Africa and in the northern Sahara - Decrease in rainfall in southern Africa - Increase in annual mean rainfall in East Africa - Increase in rainfall in the dry Sahel may be counteracted through evaporation.	Medium vulnerability due to medium exposure, sensitivity and adaptive capacity. - Medium levels of direct vulnerability to climate change, as present bioclimatic conditions of tree species at lower zones will be mainly limited by totals and distribution of precipitation, and high evapotranspiration. However, effects of forest and tree cover on soil water retention and local microclimates help mediate fluctuations, enhancing overall system resilience[25].
Extreme events - Increase in frequency and intensity of extreme events, including droughts and floods, as well as events occurring in new areas.	Medium vulnerability due to medium exposure, sensitivity, and adaptive capacity. - Conversion of forest to agriculture or shrub where soils can become more compacted can lead to increases in localised peak flows and erosion. Eucalyptus and Pine forests, exhibiting limited understory growth and higher soil acidity, may be more susceptible to extreme events resulting erosion and degradation[60].

Table 3 shows potential vulnerabilities within the forestry sector. Development and climate related vulnerabilities are classified under 1) Economic/ finance 2) Social/capacity 3) Technology/R&D 4) Political 5) Legal/institutional 6) Environment and land management 7) Communication/information.

Crosscutting each of these determinants of adaptive capacity derived from vulnerability assessments conducted by Rwanda[36,28] are high levels of poverty, high population growth and density, and land scarcity and competition. Degradation of environmental services driven by high levels of poverty, population growth and density, and reliance on biomass and charcoal lead to higher levels of biophysical vulnerability through increased exposure and sensitivity, lower coping capacity of human and natural systems and higher GHG emissions from land use change, and inefficient fuel production and consumption. In the case of the woodfuel and charcoal sector, these challenges are perpetuated by the following[38,16]:

- Landholding inequalities
- Uneven distribution of forests (geographically and by ownership)
- Weak institutional and regulatory policies
- Growing population pressure pushing up wood and charcoal demand
- Supplementing of woodfuel/charcoal with agricultural residues

Table 3. Vulnerabilities & challenges across Rwanda's forest and tree-based activities

Economic/ Finance	Social/ Capacity	Technology/ R&D	Political	Legal/ Institutional	Environment & Land management	Communic-ation/ Information
- Under-financing of the sector at all levels - Over-reliance on large, donor funded projects (e.g. PAFOR, PAREF) - Unsustainable demand against domestic woodfuel and charcoal supply - Relatively long time taken for investments to yield returns, particularly native species versus exotics - Insufficient, unpredictable and unreliable donor funding commitments - Limited overall donor attention to the sector	- Large and growing populations (rural and urban) with rising fuelwood and charcoal demands - Limited technical capacity at all levels, particularly sub-District and community levels regarding sustainable forestry management, and improved charcoaling - Resistance to shifting from agriculture to forestry - Vulnerability of women/children to indoor air pollution	- Seed production limitations (quantity, quality) - Limited technical mgt. experience at all levels (esp. M&E, inadequate extension services) - Low afforestation rate due to shortage of land - Over-mature forest plantations - Wasteful timber conversion and consumption technologies - Most forests on marginal lands - Introduction of exotic species w/o prior testing by research stations - Inefficient stoves and carbonisation process - Supplementing wood/charcoal with agricultural residues	- Competing resource management needs and strategies across forestry-agriculture-energy-environment sectors - Fragmented sectoral plans and management and engagement MINALOC - Inadequate follow up, M&E of forest research - Political changes pose challenges to GoR guarantees of forest cover permanence.	- Limited coordination amongst public and private sector stakeholder - Limited understanding of carbon markets and project development opportunities - Insufficiently supported decentralisation - Limited regulatory capacity of NAFA (esp. with capacity limitations) - Limited understanding of detailed revised Forestry Law, particularly at District and sub-District levels	- Shrinking land availability for increased forest or tree cover - Skewed distribution of forest resources (West v. East) - Isolation/ fragmentation of protected areas (no corridors) -Excessive and indiscriminate cutting of forests - Hazards including fires, new pests and diseases (e.g. Cineracupressi for cypress and Leptocybeinvasa for eucalyptus) - Susceptibility of degraded lands and forest ecosystems to changing rainfall patterns and increased temperature - Biodiversity loss from degradation and changing climate patterns	- Lack of management information systems (MIS) for data management and sharing - Persistence of incomplete and contradicting baseline inventory of forest resources, condition, and GHG emissions - Incomplete understanding of fuelwood/ charcoal consumption - Reduced enthusiasm of some populations for tree planting due to various reasons - Incomplete quantification of agricultural residue use to supplement fuel deficits

Intersections between population dynamics and wood demand are illustrated in Figure 3, which is based on the high, medium and low population growth projections of the National Institute of Statistical Research (NISR)[39]. Projected wood demand growth was based on the assumption that the average Rwandan consumes approximately 1.1 m^3 of wood per year[3]. Projected demand indicates that between approximately 14.9 and 16.4 million m3 will be consumed by 2022, relative to demand of 10.8 million m^3 in 2009. Given sustained national yield totaled 1.2 million m^3 in 2009, and assuming a worst-case scenario of no production increases and maximum projected population growth, the wood deficit could reach as high as 15,176 million m^3 by 2022.

In rural areas, the reality of fuelwood and charcoal deficits is forcing households to

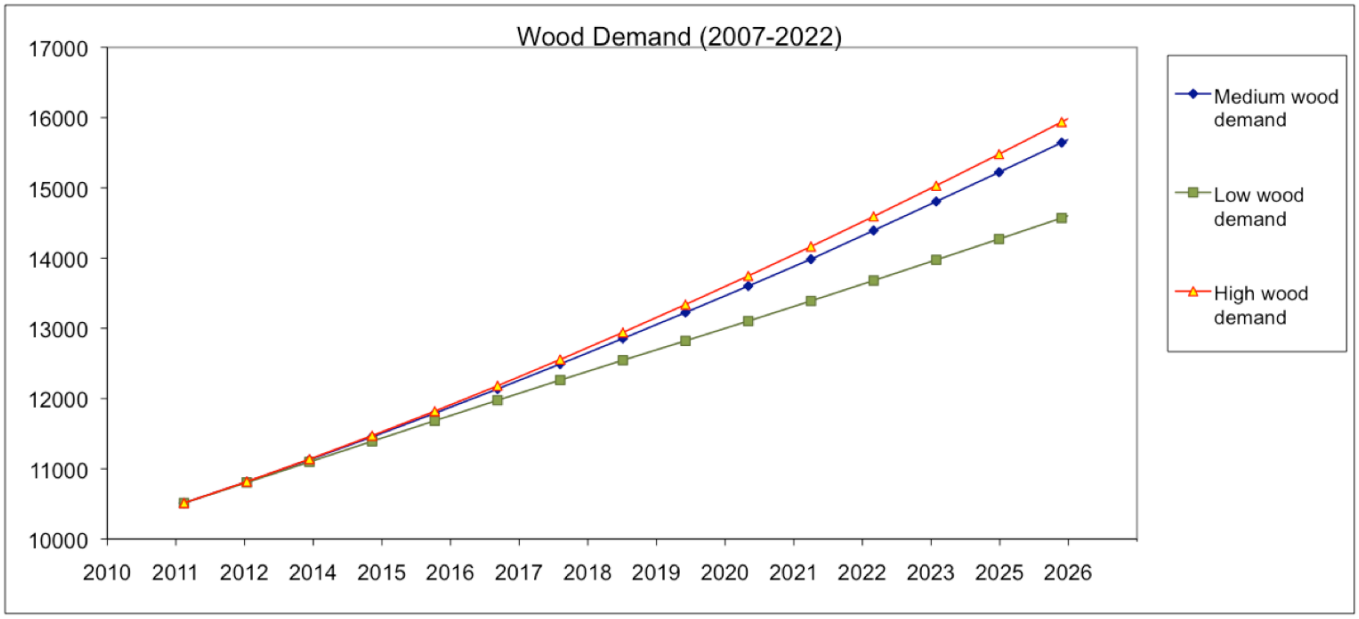

Figure 3: Wood demand projections based on high, medium and low scenario population growth (2007-2022)[39]

supplement unmet fuel needs with agricultural residues, resulting in negative soil fertility and health impacts. FAO WISDOM analysis estimates that 1.5 million rural people meet their fuel deficit with the (very cursory) estimate of 25% agricultural residues[16]. This highlights the strong link between rural subsistence energy, agricultural productivity and forest/tree products. Finding sustainable solutions to each of these issues presents a significant challenge to climate-compatible development.

Opportunities

Despite existing vulnerability, it should be equally recognised that Rwanda currently maintains a significant asset base of natural capital with respect to:

- Favorable climate conditions relative to much of the rest of Africa
- Stable natural forests (i.e. limited deforestation or degradation)

Maintaining these assets is critical to sustainable development. Table 4 outlines opportunities for government intervention to promote sustainable forestry and tree-based activities.

The value of forest and other tree-based systems is derived from the unique benefits that they provide to human consumers. These benefits are traditionally treated as though they are free for everyone to use endlessly – often resulting in their neglect and degradation. Principles of ecological economics, specifically the concept of ecosystem services, provides a useful tool to understand and reconcile the competing development demands on Rwanda's forest and tree-based systems. Fisher et al., 2008 defines ecosystem services as the aspects of ecosystems utilised (actively or passively) to produce human well-being. By focusing specifically on services with explicit human benefits, one can attach a monetary value to preserving the ecosystem. Ascribing an economic value to the services provided by forests and tree-based systems will help to make rationale policy decisions that maximise return on investment, and will enable the use of policies that promote conservation of the most valuable forests such as payments for ecosystem services (PES) and carbon credits.

Work commissioned by the European Commission in 2008 developed a framework for classification and valuation of specific ecosystem services[9]. The framework is based upon explicit distinction between ecological processes and benefits. Two types of ecological processes were considered: 'core' ecosystem processes and 'beneficial' ecosystem processes. Core processes represent basic ecosystem functions (e.g. nutrient and water cycling). Beneficial processes represent specific services that directly underpin benefits for humankind (e.g. waste assimilation, water purification). 'Benefits' are the end product of interactions between core and beneficial ecosystem processes. These benefits are discrete products of ecosystem processes that directly impact human well-being. They range from food to spiritual fulfillment [9]. Core and beneficial ecosystem processes, and classifications of end benefits are illustrated in Figure 4.

3.1 Classification of benefits from ecosystem processes in Rwanda

A mapping exercise adapted from that of Balmford et al., 2008 [27] was used to classify human benefits resulting from core and beneficial ecosystem processes across four distinctive forest types and tree-based activities representing the Rwandan context:

- Natural (primary) forest areas
- Plantation forest areas
- Agroforestry (AF) systems
- Trees for ecosystem restoration and stabilisation

Table 4. Opportunities across Rwanda's forest and tree-based activities

Economic/ Finance	Social/ Capacity	Technology/ R&D	Political	Legal/ Institutional	Environment & Land management	Communic-ation/ Information
- Environmental mainstreaming in budget & planning - FONERWA fund for the environment, including forestry - High demand for forest goods and services - Growing recognition of protected areas/ biodiversity for local tourism revenues - Possible/ current qualification for CDM, REDD+, VCM, AF, GEF/ WB, Green Fund, Other for climate adaptation and mitigation financing	- Existence of workforce in rural areas (Umuganda) -Schools, universities for data collection, M&E etc. - Training for mayors, local authorities and technicians in sustainable forestry management - Reconversion of degraded forests to improve productivity	- Intensification of production of current resources - Rationalisation of management (use of modern silviculture techniques) esp. for soils, seeds, and minimum of care (1-2 yrs), M&E - Improved buffer zones and possibly corridors (for parks) - Support for improved cook stoves and carbonisation technology & national scale up	- Political will to develop sector - Environmental protection as national priority - Signatory to UN MEAs e.g. CBD, CCD, CC; regional agreements e.g. NBI - New Forestry Law, Policy & Strategy - Vision 2020 target of 30% tree cover by 2020	- Existence of MINIFOM, NAFA and increasingly decentralised governance structures - Creation of business plans and management models for District Forestry Plans (under new Forestry Law) to regularise revenue and felling process - Inclusion of forest and biomass/ charcoal management in District Performance Contracts	- Strong synergies between adaptation and mitigation, particularly agroforestry - Protection/ stabilisation of watersheds, degraded lands, water quality/ quantity - Improved buffer zones and possibly corridors (for parks) - Maintaining Rwanda's status as a net carbon sink - Increasing interest in forests and tree-based activities for carbon credit development	- Growing public awareness of environmental services of forests (e.g. Umuganda, Forest Week, Clean Energy Week, etc.) - Demonstration activities to create awareness of agroforestry/ forestry mgt. benefits, improved charcoal making, sustainable fuelwood and cook stove use

The results of the mapping exercise are illustrated in Table 5, which reveals a plethora of benefits to human well-being derived from Rwandan forests and tree-based systems.

A host of techniques are available to value these benefits in monetary terms. Although valuation of ecosystems' contributions to human benefits is critical to understanding their functional relationships, it was beyond the scope of this study. Based on the limited work to date, valuation of these benefits will be discussed as part of an analysis of priority options for decision makers (See *Analysis of Options* Section).

In the context of climate change, ensuring the long-term availability of these 'business as usual' (BAU) benefits is key to helping promote reduced exposure and sensitivity to climate risks, and enhanced resilience through increased adaptive capacity (e.g. income generation). These benefits help guide assessment or screening of intervention opportunities. Identified benefits also serve as strategic tools or indicators of progress to enable and strengthen Monitoring and Evaluation (M&E) systems.

3.2 Assessing opportunities for government intervention

To identify climate-compatible development opportunities, opportunities for intervention were assessed according to the following criteria:

Figure 4: Classification of ecosystem processes and benefits[27]

Table 5. Benefits to human well-being from Rwanda's forest and tree-based activities

Forest or tree-based system	Food	Fresh water	Raw materials	Energy	Property	Employ-ment	Physical well-being	Psycho-logical well-being	Know-ledge
Natural (primary) forest area	- Wild foods	- Drinking	- Timber - Fibres from wild species - Mineral deposits	- Fuelwood - Charcoal	- Public property - Tourism infrastruct-ure - Carbon credits	- Towards provision of tourism goods and services - Mining	- Medicines from wild species - Physical exercise - Cooling (shade)	- Tourism - Recreat-ion - Spiritual/ cultural - Aesthetic benefits - Nature watching	- Research - Education
Plantation forest area	- Commer-cial fruits, horticulture, edible shoots	- Drinking	- Timber - Fibres - Stakes, poles, etc.	- Fuelwood - Charcoal	- Private woodlots - Public woodlots - Carbon credits	- Extension - Private operators and supply chain - Commun-ity works	- Cultivated medicines - Cooling (shade)	- Spiritual/ cultural - Aesthetic - Nature watching	- Research - Education
Agroforestry systems	- Edible fruits, seeds, shoots - Fodder - Increased agriculture crop yield	- Drinking	- Timber - Fibres - Stakes, poles, etc. - Seedlings, cuttings	- Fuelwood - Charcoal	- Private (on-farm) trees - Public/ private demonstrati on sites -Carbon credits	- Public: extension, etc. - Private: on-farm, production and retail supply chains (e.g. charcoal)	- Cultivated medicines - Avoid-ance of infection - Improved nutrition - Cooling (shade)	- Spiritual/ cultural - Aesthetic benefits - Nature watching - Garden plants	- Research - Education
Tree-based ecosystem restoration/ stabilisation	- Edible fruits, seeds, shoots - Increased agricultural crop yield	- Drinking - Industry	- Timber - Fibres - Stakes, poles, etc. - Seeds	- Fuelwood - Charcoal - Hydro	- Public (watershed, river, lake, forest buffer zones) - Private lands - Carbon credits	- Public: extension, etc. - Private: on-farm, community works, Umuganda, other	- Cultivated medicines - Avoid-ance of infection - Improved nutrition - Cooling (shade)	- Spiritual/ cultural - Aesthetic benefits - Nature watching -Develop-ment tourism (tours)	- Research - Education

- Reduce exposure and/or sensitivity to climate risks
- Enhance resilience through increased adaptive capacity
- Provide mitigation benefits

Table 6 outlines the results. Findings indicate that there is a wide-range of options that satisfy climate-compatible development criteria. Moreover, many of these options are available within Rwanda's existing development policy. The following section seeks to further this analysis by identifying key sectoral overlaps, gaps or potential conflicts, and in turn, guide additional strategic investments in the sector and address inefficiencies resulting from present duplication of efforts or lack of coordination.

Table 6. Potential adaptation-mitigation synergies across current policy.

Source	Policy opportunity	Reduces exposure to climate risks?	Enhances adaptive capacity?	Provides mitigation benefits?	Net reduction in vulnerability & GHGs?
Relevant NAPA policy options	IWRM	✓	✓	✓	✓
	Income generating activities	±	✓	±	±
	Intensive agriculture and husbandry	✓	✓	✓	✓
	Resilient varieties	✓	✓	✓	✓
	Alternatives to biomass energy	±	✓	✓	✓
Relevant Second National Communication options	Afforestation of non-forest area	±	±	✓	±
	Regulation of timber extraction	±	✓	✓	✓
	Mixed-species forestry and genetic strengthening	✓	✓	✓	✓
	Enhance energy-related use of biomass	×	×	±	±
	Adaptation of extraction/production tech	✓	✓	✓	✓
	Monitor forest hydrology	✓	✓	✓	✓
	Research strategies and priorities, extension strategies and packages	✓	✓	✓	✓
National Forestry Policy – Preferred sector development policies	Permanent forest estate keeping	±	✓	✓	✓
	Forest-based industries promotion	±	✓	✓	✓
	Capacity building, institutional strengthening, research, training	✓	✓	✓	✓
	Urban and peri-urban forests development	✓	✓	✓	✓
	Farm forestry enhancement	✓	✓	✓	✓
	Promote profitable forest plantation co's	✓	✓	✓	✓
	Establish, rehabilitate and conserve watershed protection forests	✓	✓	✓	✓
	Supply improved, high-quality seeds	✓	✓	✓	✓
	Conserve and wise use of biodiversity	✓	✓	✓	✓
Vision 2020	Afforestation and reforestation to achieve 30% forest and tree coverage nationally	✓	±	✓	✓
ISAR – main activities	Research including phonological studies, plantation and agroforestry tree selection (exotic v. native), and wood technology	✓	✓	✓	✓
MINIFOM National Bamboo Policy – preferred policy options	Bamboo for firewood and charcoal	±	±	±	±
	Bamboo for electricity	±	±	✓	±
	Enhance agriculture: Bamboo for biogas energy, composting; leaves as feed/fodder	±	±	✓	±
	Enhance agriculture: Bamboo for terraces, greenhouses and lifting water for irrigation	±	±	✓	±
	Construction material: Bamboo for housing, buildings and bridges, fences, furniture, etc	×	±	✓	±
	Consumer products: Bamboo for manufactured products, crafts, baskets, etc	±	±	±	±

Table 6. Potential adaptation-mitigation synergies across current policy.

Source	Policy opportunity	Reduces exposure to climate risks?	Enhances adaptive capacity?	Provides mitigation benefits?	Net reduction in vulnerability & GHGs?
Environment and Natural Resources Sector Strategic Plan, and promotional policies	Rehabilitate all degraded ecosystems	✓	✓	✓	✓
	Rehabilitate, conserve and sustainably manage degraded forest ecosystems	✓	✓	✓	✓
	Protect and sustainably manage all land susceptible to erosion	✓	✓	✓	✓
	Conserve and sustainably manage all critical ecosystems for socio-economic benefits	✓	✓	✓	✓
	Protect biodiversity within and outside of conservation areas	✓	✓	✓	✓
	Promote Payments for Ecosystem Services (PES) schemes	✓	✓	✓	✓
	Promote carbon credit development	±	±	✓	±
Sustainable Tourism Develop-ment Master Plan for Rwanda	Rwanda to become leading wildlife and eco-tourism destination and a regional conference hub	✓	✓	±	✓
	Promote community-based tourism to benefit poorest of society surrounding parks	✓	✓	±	✓
	Develop 6 Destination Management Areas (DMAs) including major projected parks	±	±	±	±
	Facilitate research and conservation monitoring to climate sensitivity (e.g. reptiles, amphibians)	✓	✓	✓	✓
MININFRA Biomass program	Produce more biomass	✓	✓	✓	✓
	Resource use efficiency with improved cook stoves and charcoaling	✓	✓	✓	✓
	Alternative energy promotion	✓	✓	✓	✓
Strategic plan for the transform-ation of agriculture in Rwanda – Phase II (PSTA II)	Combine terracing with appropriate agroforestry species	✓	✓	✓	✓
	Incorporate agroforestry, including forage species into mixed cropping and livestock	✓	✓	✓	✓
	Agroforestry and crop-livestock integration for supporting intensification when used as compliments to inorganic fertilisers	✓	✓	✓	✓
	Shade trees and border agroforestry species to provide plant nutrition and material for organic fertiliser and mulching	✓	✓	✓	✓
Total	>50 (Including sub-policies)	Yes = 32 Maybe =13 No = 2	Yes - 36 Maybe = 10 No = 1	Yes = 40 Maybe = 7 No = 0	Yes = 36 Maybe = 11 No = 0

✓ Yes
± Maybe
× No

Cross-sectoral overlaps, gaps, and potential conflicts

Forest and tree-based systems represent crosscutting environmental resources that exhibit strong overlaps across traditional forestry management, agriculture, energy, environmental management, water, conservation and tourism, and biodiversity sectors, and from national to local scales. High-density communities (e.g. 600 people per km^2) at the boundaries of Rwanda's protected areas demonstrate the tension generated by strongly overlapping and conflicting demands of agricultural land, energy and other natural resources, which pose serious threats to conservation and biodiversity protection. The National Land Use Master Plan designates all land with slopes greater than 30 degrees for forests in order to stabilise soils on steep slopes. However, given the significant agricultural development currently taking place on lands of this grade (and higher), this overlap will remain a major challenge. The ever-increasing fuel wood and charcoal demands of Rwanda's growing population add a further dimension of demand on both land and tree resources. These overlaps and tensions underscore the pressing importance of integrated development at both local and national levels to address competing demands on Rwanda's natural resources.

The crosscutting nature of environment issues in Rwanda makes their isolation within a single sector a theoretical and practical impossibility. Analysis of existing sectoral overlaps, gaps and potential areas of conflict or contradiction is important for guiding future policies and investment. This analysis of government policies relevant to forests and tree-based systems aims to reveal entry points for new policies and to inform harmonisation of cross-sectoral policies Engagement with key representatives across relevant ministries, agencies and development partners informed the analysis. Table 7 provides an illustrative map of these overlaps across the four classifications of forest and tree-based systems and relevant line ministries.

4.1 Government policy and targets

In recognition of the economic and environmental benefits of sustainable forest management, the GoR is currently reforming and restructuring policy and management of Rwanda's forest and tree-based systems. The Ministry of Mining and Forestry (MINIFOM) (now within the Ministry of Natural Resources) and its implementing agency, the National Forest Authority (NAFA), are leading this process. In line with Vision 2020 and EDPRS, Rwanda is committed to environmental protection, diversification of energy sources, erosion prevention, reduced woodfuel consumption and implementation of an afforestation/ reforestation strategy. The major objective of the EDPRS for the forestry sector is to provide an adequate and sustainable supply of forest products and manage forestry resources for poverty alleviation by income and employment generation. To realise this objective, Rwanda has adopted a National Forestry Policy that aims to ensure present forest cover is well managed and increased to 30% of country total area by 2020. This target will be reiterated within the proposed Land Use Development & Development Master Plan[1,11]. In addition, revision of the 1988 Forestry Law is underway. Implementation of the Forestry Policy will be carried out in accordance with the activities

Table 7. Sectoral overlaps across forest and tree-based systems, and key line ministries.

Forest or tree-based system	MINELA, REMA, NLC	MINIFOM, NAFA	MINICOM, RDB	MINAGRI, esp. RADA	MININFRA	MINALOC
Natural (primary) forest area	- Proposed Nyungwe – Mukura – Gishwati forest corridor and buffer zones (NLUDMP) - Environment & climate management, regulation, sensitisation & enforcement	- Management of park buffer zones - Research	- Conservation and tourism policy oversight - Tourism management master plan - Draft Wildlife Policy - Coordinating park expansion - Carbon credit development	- Management of agricultural zones surrounding parks	- Biomass energy strategy - Improved cook stove & carbonisation process - Reduce illegal charcoaling	- Social protection strategy - Capacity building strategy
Plantation forest area	- Designation of >30 slopes for forestry (NLUDMP) - Carbon credit development oversight	- Promotion of >30 slopes for forestry (NLUDMP) - Management of public woodlots - Regulation of private woodlots - Support of community woodlots	- Commercial timber? - Promotion of horticultural sector? - Carbon credit development	- Horticultural plantations (avocados, bananas, etc.) - Extension?	- Biomass energy strategy - Improved cook stove & carbonisation process - Reduce illegal charcoaling	- Social protection strategy - Capacity building strategy
Agroforestry systems	- Carbon credit development oversight - Piloting AF projects as integrated environmental management	- On-farm fruit trees promotion?	- Promotion of horticultural sector - Carbon credit development	- On-farm trees promotion (avocados, bananas, fodder etc.) - Erosion control - Fodder provision	- Biomass energy strategy - Improved cook stove & carbonisation process - Reduce illegal charcoaling	- Social protection strategy - Capacity building strategy
Tree-based ecosystem restoration/ stabilisation	- Watershed management - River and lake restoration - Carbon credit development			- Extension/ training for erosion control, fodder provision, etc.	- Biomass energy strategy - Improved cook stove & carbonisation process - Reduce illegal charcoaling	- Decentralisation strategy - Social protection strategy - Capacity building strategy

*Other stakeholders not included are research institutions such as ISAR, IRST; University and educational institutions including the National University of Rwanda (NUR), KIST, and ISAE frestry school. MINEDUC is also in implementing forest sector programs including tree planting. Also note, MINELA and MINIFOM were combined to form the Ministry of Natural Resources in May, 2011.
**National Land Use Development Master Plan (NLUDMP)

detailed in the National Forestry Strategy[41] by government and development partners with the following objectives:

- Increase forest and agroforestry resources in order to meet the national needs in timber and non-timber forest products and services for public, personal and commercial uses.
- Manage forests to optimise economical as well as ecological functions such as soil erosion control, climate regulation and biodiversity conservation in a sustainable manner.
- Provide institutional support to forestry actors in order to improve the quality of products and services renders by these actors.

The fundamental overlaps of forest management illustrated in Table 7, do not necessarily imply inefficiency in investments, but rather the unavoidably crosscutting nature of natural resources. These overlaps demand greater levels of coordination, communication and sharing of technical resources (e.g. inventory data and collection responsibilities), etc. Highly sensitive issues of land use with regards to agriculture remain at the heart of such needs for cross-sectoral cooperation, particularly with regards with agroforestry needs. Based on interviews with representative stakeholders, detailed below, it is evident that improved cross-sectoral collaboration and communication are goals not yet realised. Nevertheless, Rwanda's proposed Integrated Development Program (IDP), as part of the recently approved Land Use Development & Development Master Plan, represents a strong step in the right direction.

Focus Areas

In light of the already extensive programming currently taking place or planned, as well as need for efficient use of available financial resources, priority inventions for CCD must have high probability of achieving robust, long-lasting and high returns on investment across areas of social, environmental and financial sustainability; and must provide much needed supplementary support (financial, capacity & technological) where support may be lacking.

Priority focus areas were identified based on their high potential to satisfy the following Principles:

1. **Wide-reaching impacts & Scalability** (Achieve wide-reaching impacts & opportunities for scaling up)
   - Economically
   - Geographically
2. **Adaptive capacity** (Address crosscutting factors contributing to low adaptive capacity)
   - High levels of poverty
   - High population growth and density
   - Land scarcity and competition
   - Environmental degradation
   - High reliance on biomass/charcoal
3. **Climate Compatible Development** (Meet criteria of climate compatible development)
   - Reduce exposure and/or sensitivity to climate risks
   - Enhance resilience through increased adaptive capacity
   - Provide mitigation benefits
   - Yield net reductions in vulnerability and GHG emissions
4. **Ecosystem services** (Maximise sustainable benefits of Ecosystem Services for human well-being)
   - Food
   - Fresh water
   - Raw materials
   - Energy
   - Property
   - Employment
   - Physical well-being
   - Psychological well-being
   - Knowledge
5. **Integrated development** (Support integrated cross-sectoral development plans and strategies, thereby promoting efficiencies across government at national and local scales)
   - Forestry
   - Energy
   - Agriculture
   - Conservation and biodiversity
   - Environmental management (including Water)

Based on these criteria, priority focus areas were derived from opportunities, and current or planned activities across key sector topics assessed above: Natural (primary) forests, Plantations, Agroforestry, and Trees for Ecosystem Restoration & Stabilisation, and Biomass Energy. The focus areas are outlines in Table 8.

Table 8. Priority focus areas.

Sector topic	Focus Areas and Priority Activities
Natural (primary) forest	Community-Based Eco-Tourism – *Including sustainable buffer zone management*
Plantations	Afforestation and Reforestation – *Including mixed-species forestry and Improved Forestry management (IFM)*
Agroforestry	Agroforestry Promotion – *Including integrated farming sustainable land management (SLM)*
Ecosystem restoration	Payments for Ecosystem Services – *Including watershed management and IWRM*
Biomass energy	Improved Cook Stove Promotion – *Including improved charcoaling*

The potential of these opportunities to achieve climate compatible development are informed by the case study experiences presented in the following section, and analysed in subsequent detail to inform decision making.

Review of Best Practice

Best practices related to the identified focus areas were reviewed nationally, regionally and internationally. Those examples with particular relevance to the Rwandan context or offering valuable lessons that can inform development of focus areas are highlighted. Two important caveats are emphasised with respect to presented cases:

- Context: Because determinants of vulnerability are context specific, the relevance of cases to local contexts needs to be considered. In other words, what worked or failed in a case study context may not be appropriate for Rwanda as a whole. Local-level engagement in each of the focus areas is needed to determine if a particular intervention is appropriate.
- Subjectivity: The concept of 'best' practice is inherently subjective, highlighting the need for wide stakeholder engagement to reach consensus on what is 'best'.

Table 9 presents case studies for focus area that represent 'best practice'.

6.1 Community-based eco-tourism in a women's artisan cooperative in Monteverde, Costa Rica

Relevance to Rwanda: Addresses issues of benefits to communities surrounding national parks and protected areas as sights of high-end tourism.

Highlights:

- Top generator of foreign exchange: The boom in Costa Rica's tourism market began in 1987, and by 1995 the industry was generating USD 659.6 million per annum, making tourism the top generator of foreign revenues and 7.5% of GDP.
- Benefits of ecosystem services: Tourists from all over the world come to Monteverde to observe the diverse flora and fauna and enjoy canopy tours and eco-adventures. These attractions draw over 50,000 ecotourists annually to Monteverde and its neighboring community, Santa Elena.
- Income generation: Women belonging to a local artisans' cooperative, CASEM (Comite de

Table 9. Case studies by focus area.

Focus areas	Case study
Community-based eco-tourism	1. Monteverde, Costa Rica
Afforestation / Reforestation & IFM	2. Nhambita Community Carbon Project (Mozambique)
Agroforestry promotion	3. SCC-Vi Agroforestry (Kenya)
Payments for Ecosystem Services	4. New York City – Catskill watershed management programme
Improved cook stove promotion	5. Climate Care – JP Morgan (Uganda)

Artesania Santa Elena Monteverde), starting producing crafts for ecotourists in the 1980s. Survey work conducted in 2004 addressing issues of long-term sustainability of ecotourism demonstrated an overall increase in average monthly income for women (from USD 81.66 prior to CASEM and USD 151.72 post-CSAEM) and their spouses, an increase in employment, and a decrease in income inequality of respondents.

- Positive attitudes towards conservation and ecotourism: Attitudes of the majority of women surveyed appear extremely positive and do not appear to be directly related to tourism incomes, although this is difficult to conclude with certainty.
- Wide-reaching livelihoods benefits: Women surveyed believe that ecotourism and CASEM artisan activities positively affect many parts of their lives from income to family, community, quality of life and environment in Monteverde[49,50].

6.2 Nhambita Community Carbon Project

Relevance to Rwanda: Addresses issues of soil and land degradation, biomass and charcoal energy production, and livelihood benefits through tree planting and agroforestry for smallholders.

Highlights:

- Carbon credits: The Mozambique Carbon Livelihoods Trust was launched in 2007 to service the Plan Vivo Voluntary Carbon Market (VCM) standard afforestation, reforestation and agroforestry projects in Mozambique. It was formed with the assistance of WWF Mozambique. The fund currently has over USD 100,000 in future payments to farmers. Local households receive a cash payment of USD 242.60 per ha over seven years for carbon sequestered[45].
- Scaling: Over 70% of the N'hambita community are involved in project activities. In 2006-7, over 500 new farmers joint the project, and land under management of the project increased approximately 1000 ha to 8000 ha. By June 2007, approximately 500,000 trees were planted as part of project activities.
- Capacity building and extension: The training programme of extension officers has led to Nhambita community technicians completing four courses for this and other Plan Vivo projects.
- Quality recognition: The project was cited by WWF as a best Land Use, Land Use Change and Forestry (LULUCF) project of its type in 2007. It was also cited in the Stern Report.
- Knowledge sharing: Lessons learned from this pilot study are being used to guide the roll-out of work in other areas. In 2007, Envirotrade launched a new project at Cheringoma in a buffer zone of the Marrameu Reserve, as a joint initiative with Zambezi Delta land-use Project. Envirotrade also launched a project in the Quirimbas National Park in Northern Mozambique.
- Livelihood benefits: Biomass and charcoal energy production, food security, bee keeping, nursery training, carpentry, handcraft production, vegetable production and agroforestry products.
- Technical note on voluntary standard used: At the time of project establishment in 2003, the Plan Vivo Standard was one of the few available within the non-compliance or Voluntary Carbon Market (VCM). The project developers are now currently reviewing the standard in light of other options that have been developed since[46].

6.3 Using carbon finance project to scale up agricultural production through agroforestry and sustainable land management practices

Relevance to Rwanda: Addresses issues of soil and land degradation, produces biomass and charcoal for energy, and provides livelihood benefits through tree planting and agroforestry for smallholders.

Highlights:

- Carbon credits: Small-scale farmers receive carbon payments (estimated to USD 1,962,000) for advisory services as well as an economic carbon revenue distribution scheme for livelihood

Table 10. Project cost of Western Kenya Smallholder Agriculture Carbon Finance Project[46]

Activity	Details	Year/period	Cost (USD)
Preparation costs	Feasibility studies, monitoring plan, PDD, etc.)	2009-2011	50,000
Establishment costs	Site and soil preparation, seedlings, planting, weeding until planting is completed	2009-2011	50,000
Operating costs (from Planting through project duration)	Breakdown of approximate costs: 1. Salaries for Vi Agroforestry staff, 60 % 2. Logistics/transport, 15 % 3. Training/capacity building of staff, 10 % 4. Seeds and seedlings, 5 % 5. Other (insurance, office rent, electricity), 10 % Inflationary annual increment of cost is 10 %	2009-2011	
	Phase 1: • The total cost for extension in twenty seven (27) locational extension areas of concentration (paid 6000/yr*27) • One supervisor per 14 projects areas of extension Total cost phase 1: 1,026,000 USD	2009 2010 2011	310,000 341,000 375,000
	Phase 2: One extension adviser per division (6 divisions). Paid 300USD*12*6=21,600 USD per year for 6 consecutive years. (including 10% inflationary increment annually). Total cost phase 2: 162,000 USD	2012 2013 2014 2015 2016 2017	21,000 23,000 25,000 28,000 31,000 34,000
	Other costs (explain) carbon validation, 3 times	2011, 2014, 2017	172,000
	Total project costs US$		1,460,000
	Total carbon credit revenues		1,962,000
	Net profit (not including livelihoods and resilience benefits)		502,000

development. The project investment, estimated in Table 10, will be almost equivalent to carbon revenues paid to the farmers in 9 years time. Other co-benefits include the fact that smallholder farmers become aware of climate change, receive advisory services, transform their agricultural practices, improve wealth status, develop their capacities, and improve biodiversity.

- Scaling: Through financing from emissions reductions, sustainable land management and agroforestry practices activities were scaled to land in western Kenya. Project support is provided from the BioCarbon Fund by the World Bank (a carbon project sequestering 490,500 tonnes CO2eq under voluntary certification standard process targeting 40,000 small scale farmers in 6 divisions to access global carbon payments).
- Financial sustainability and high return on investments: The project investment will be almost equivalent to the carbon revenues paid to the farmers in 9 years time. Other direct and indirect benefits to human well-being are provided from ecosystem services.

- Livelihood benefits: The carbon funds target establishment of soil, tree and agriculture biomass carbon pools for direct and indirect climate change mitigation. Other benefits include income generating activities, improved health and nutrition (human, livestock), food, water and energy security, women's empowerment, education, shade and reduced heat stress.
- Environmental benefits: Improved soil fertility and reduced erosion, ground/surface water storage, water productivity, and reduction of GHG emissions.
- Net reduction in vulnerability and GHG emissions: Strategies simultaneously increase adaptive capacity, reduce vulnerability to climate risks (floods and droughts) and mitigate climate change.

6.4 New York City – Catskill watershed management programme (public payment scheme)

Relevance to Rwanda: Addresses issues of watershed degradation and water purification through ecosystem restoration and management.

Highlights:

- Ecosystem services: The Catskill/Delaware watershed system, covering 1,600 miles, remains the largest unfiltered water supply in the US. It is maintained through outreach and education, land management to encourage private landowners to protect watershed lands, land acquisition, and partnerships with non-profits and municipalities.
- Benefits to human well-being: Provision of high-quality drinking water for New York City (NYC), meeting 90% of the City's demands through natural filtration rather than construction of a new filtration plant. The use of natural filtration also avoids the need to use significantly higher levels of disinfecting chemicals needed to purify water. By-products from these chemicals are known to pose serious health risks and are limited by US Federal Law.
- High returns on investment and avoided costs: It was estimated that building a filtration plant would cost USD 6 billion to 8 billion, with yearly operation costs between USD 300 to 500 million. Instead of building a filtration plant, the city authorities decided to invest USD 1.5 billion over 10 years in a watershed programme administered by the non-profit Catskill Watershed Corporation (see Table 11).
- Sustainable financing: This public payment scheme was initiated with finance from the city of New York, the state of New York and the Federal Government. The scheme is now financed by a tax included in New York water users' bills.
- In addition to the high environmental, economic and human health benefits obtained from the protection of the watershed's natural filtration services, maintenance of these services will have important implications for the already observed changing climate of the region. There is a general pattern of warming temperatures and increased precipitation, runoff, and mean potential evapotranspiration (PET). These patterns will continue to have significant impacts on the future timing and availability of water supply in the region. Therefore, maintenance of the natural

Table 11. Costs of alternative Catskills management options [44]

Management options	Up-front capital costs ($US)	Operation and maintenance costs/year
Construct water filtration and treatment plant	6 to 8 billion	300 to 500 million
Improve farm and forestry practices to maintain natural filtration services of the Catskill/Delaware watershed	1.5 billion over 10 years	100 million
Avoided costs	4.5 to 6.5 billion	200 to 300 million

resilience and hydrological balance of the watershed will help reduce exposure and sensitivity, and overall vulnerability to climate change[44].

Context Note: The approach may not be applicable for catchment areas that are more commercially and industrially developed, and more densely populated than in the Catskill/Delaware area.

6.5 Uganda improved cook stoves

Relevance to Rwanda: Addresses issues of fuelwood, charcoal production,deforestation and indoor air pollution.

Highlights:

- Need to address fuelwood dependence: More than 95% of Ugandans rely on fuel wood for cooking, typically charcoal or wood for urban dwellers and wood for rural households.
- Need to address GHGs and air pollution: Current stoves for cooking have low efficiency, increasing the amount of fuel needed, and releasing greenhouse gas emissions and dangerous particulates that contribute to indoor air pollution and respiratory disease. UN studies show that worldwide air pollution form cooking stoves causes around 1.5 million premature deaths each year and causes debilitating illness for tens of millions more.
- Carbon credits: Validated and registered carbon credits using the Gold Standard VER under the Voluntary Carbon Market (VCM). Total emission reductions (ERs) estimated at 85,615 tonnes,
- Improved stove technology transfer: The Ugandan Stoves Project supplies efficient wood burning stoves to families and institutions in Kampala, and subsequently throughout the country for residential and institutional usage. Improved charcoal burning stoves are also being disseminated on behalf of a business client.
- Wide reaching and scalable: The project aims to install 20,000 stoves per year in initial years, with the intention of increasing the sales in later years. Each stove will have a lifespan of an estimated 3 years.
- Awareness raising, capacity building and livelihoods benefits: The project is helping improve awareness amongst the population, establishing business capacity to manufacture and market the stoves, creating jobs in retain and after-sales service. In addition, establishing quality assurance procedures, which include careful monitoring of the usage and effectiveness of the new stoves.
- Benefits to livelihoods and human well-being: Increased family incomes due to reduced expenditure on woodfuel and health benefits from less kitchen smoke.
- Environmental benefits: Reduced deforestation in Uganda, particularly in areas affected by the urban Kampala market[50].

6.6 Assessment of case studies for Rwandan context

As the above case studies illustrate, opportunities for achieving the objectives of climate compatible development are possible across diverse contexts and using diverse approaches. In some of the cases, carbon credits were obtained from project activities. In all cases, activities that developed, restored or protected the ecosystem services provided by forests and tree-based activities promoted livelihoods benefits and reduced overall vulnerability.

In the Rwandan context, past and present experiences have already demonstrated the strong synergies between environmental management, economic growth and conservation. Two particularly relavent case examples include the Nkutura hydropower station and Nyungwe National Park, which are discussed below.

6.6.1 Rwanda PES Case Study 1

Perhaps the clearest example of the effectiveness and benefits of a PES scheme for water resources in Rwanda is the public management response to the 2003-2004 energy

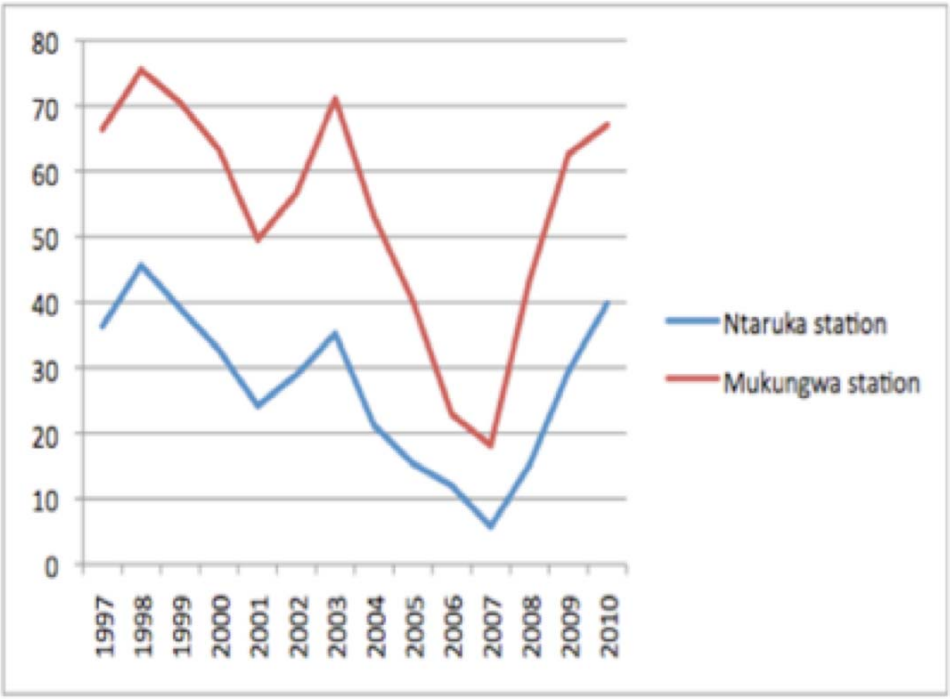

Figure 5: Power production from the Ntaruka and Mukungwa hydropower stations (GWh/Annum)[83]

crisis when Rwanda experienced a significant reduction in power supply produced by the Ntaruka hydropower station in Rwanda's Northern Province (Figure 5). As water levels in Lake Bulera – supplying the plant – fell too low for Ntaruka's three turbines to be safely operated (then) Electrogaz began to operate only one turbine at a time. The resulting loss of electricity affected Rwanda on a large scale as the Ntaruka plant supplied (then) half of the country's electric supply.

A number of factors contributed to the reduction in lake levels including 1) the declining state of generation capacity due to inadequate servicing and maintenance, 2) over-exploitation of capacity, 3) degradation of the Rugezi-Bulera-Ruhondo watershed supplying the plants, 4) population growth and limited governance capacity contributing to unclear tenure regimes. Lack of clear tenure regimes , in turn, contributed to cultivation on steep slopes which, combined with deforestation, increased surface runoff, soil erosion and siltation of the wetlands. Other issues included the planting of Eucalyptus trees, which have a high water demand, within and around these water bodies, and declining rainfall in preceding years. Collectively, processes of drainage, siltation and greater evapotranspiration contributed to a decline in the wetlands' water table. As a result, Rwanda was forced to install diesel generators to compensate for the electricity shortfall, leading to the growth in thermo-electricity production to 56% of the country's power in 2006, at a cost of USD 65,000 per day.

Rwanda proceded to halt and reverse the electricity crisis through ecosystem restoration and management, including the construction of erosion control structures, establishment of a bamboo belt and grasses around the Rugezi Wetlands, planting of trees on the surrounding hillsides, and promotion of integrated and environmentally sound farming practices, among other activities[82].

6.6.2 Rwanda PES Case Study 2

A recent example of the potential of PES schemes for the purchase of biodiversity conservation services in Rwanda's is being explored

by the European Union funded ReDirect research project in Nyungwe National Park, "Reconciling Biodiversity and Development through Direct Payments for Conservation"(http://www.redirectrwanda.com/). The three-year project (2009-2012) seeks to examine the potential for PES to achieve both conservation and development objectives. Re-Direct works with eight Cells adjacent to the park consisting of four participating cells and four control cells. A Cell is the second smallest administrative unit in Rwanda, containing between 500-1800 households.

The Nyungwe PES scheme was designed through close participation with Cell communities, local government administration and RDB park rangers. The scheme monitors biodiversity conservation by proxy, based on the level of illicit human activities in the Park including wood and bamboo cutting, snare presence, mining for minerals, beehives and new forest trails. In order to promote conservation, and in turn sustainable livelihoods through provision of alternatives to forest products, ReDirect performance-based payment schemes work with communities to monitor activities and manage community development funds. Payments to communities can be as much as RWF 15,000 per household per year, or as little as zero (never negative), depending on performance across the range of target indicators. Cells also negotiate the proportion of the reward that will be retained centrally for investment in community development activities and the proportion to be distributed at the household level [115].

In the context of climate change and from the perspectives of community respondents, Park protection is critical for two main reasons:

- the perceived benefits to local climate (64% of respondents mentioned rainfall effects); and
- benefits for biodiversity and tourism income (23% of respondents mentioned both reasons).

As a result of the PES payments for good conservation performance, the principle development activities reported by cells included the following:

- Tree planting and seedling distribution
- Supporting crop-raiding committees
- Opening SACCO accounts
- 63 goats purchased and distributed to the poorest (Shaba only)
- Reducing absences in primary schools (Shaba only)

While the expected benefits from PES payments reported by community respondents are highly diverse, the most frequently cited was the purchase of livestock. Benefits from livestock include production of fertiliser for agricultural fields, improved nutrition and reduced dependency on bush meat[115]. Despite these benefits, the long-term sustainability of the Nyungwe PES scheme strongly depends on the expansion of the ReDirect pilot project and institutional ownership by the Rwanda Development Board, which is charged with conservation and park management in Rwanda.

Analysis of Options

Borrowing from the successful lessons demonstrated in the case studies, the five focus areas selected for high potential to contribute to climate compatible development within the Rwandan context are analysed below. In order to determine if investment in the five selected focus areas is warranted in Rwanda, the following section assesses each option on the basis of its satisfying the following criteria:

1. Satisfy CCD: Satisfy 5 principles for climate compatible development
2. Meet unmet needs: Provide much needed supplementary support (financial, capacity & technological) to critical interventions where support may be lacking.
3. Returns on investment: Achieve robust, long-lasting and high returns on investment across areas of social, environmental and financial sustainability.

7.1 Community-Based Ecotourism

Definition of community-based ecotourism

Ecotourism is traveling to a natural destination such as a national park or preserve, and impacting that environment minimally in ways that are environmentally and culturally sensitive. Ecotourism also involves regulating the numbers of visitors at one time, and providing educated guides to enhance both visitors and residents about environmental awareness. Community-based ecotourism involves engagement with individuals and community groups (e.g. women) to enable benefit sharing and generation in relation to ecotourism. This may involve direct employment, provision of food to lodges, traditional dancing, craft sales, etc., as well as use of tourism revenues to better provide for environmental research, protection and education, or community facilities (schools, clinics, etc.). Engagement allows the local residents to benefit financially, and supports community ownership, empowerment and human rights [48,57].

Primary forest resource in ecotourism context

Located within the centre of the Albertine Rift, in the western arm of Africa's Rift Valley, a region considered to be the highest in species richness in Africa, Rwanda is ideal for conservation and ecotourism[56]. Over the last decade, tourism in Rwanda has been on the rise (see Figure 6), with revenues increasing from USD 26 million in 2005 to USD 210 million in 2008 (see Figure 7). Vision 2020 identified tourism as a priority sector to help achieve development goals[55,11].

With its charismatic designation, the "land of a thousand hills", Rwanda has much to offer national, regional and international leisure and business tourists. Gorilla groups in the Volcanoes National Park provide an iconic attraction. Other unique attractions include lush green scenic hills, tropical forests, mountains, lakes and a rich range of biodiversity. Rwanda's recorded fauna of over 151 different mammal species, 11 of which are currently threatened, includes antelope, zebra, buffalo, giraffe, hippopotami, leopard, golden monkeys, chimpanzees, golden cats and lions, and 670 species of birds reported, four of which are threatened with extinction[53,56]. Flora includes 2,150 species of plants, with new species still being

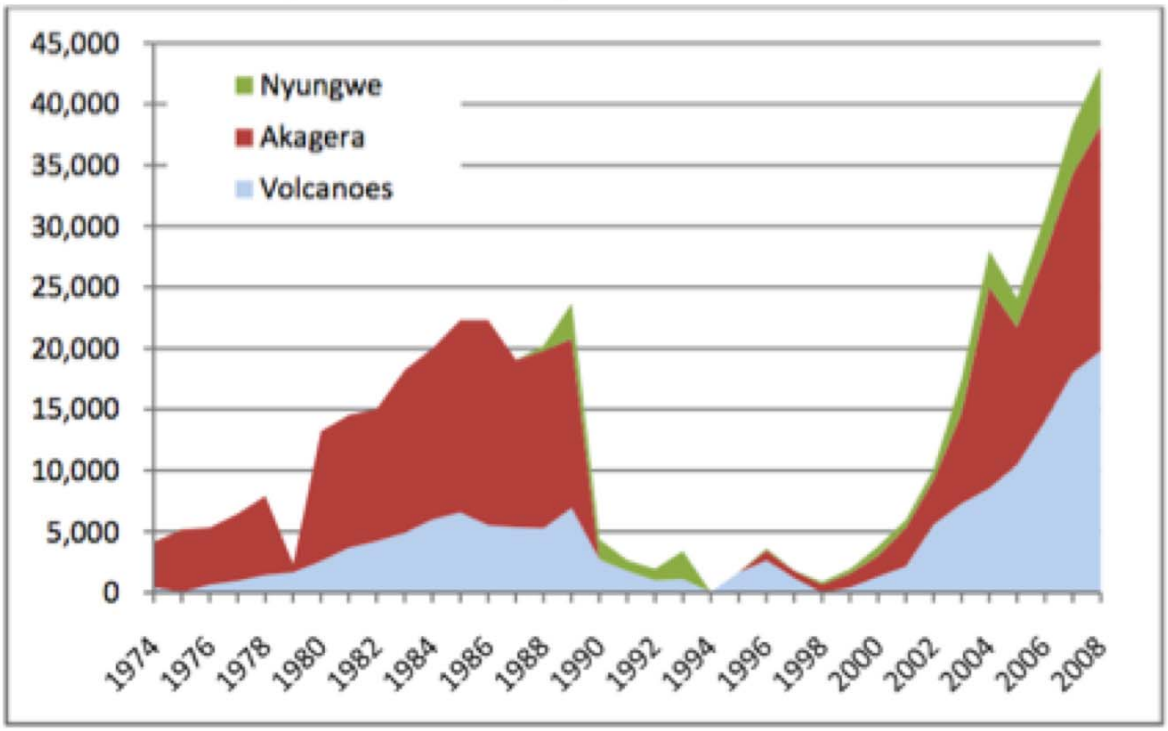

Figure 6: National park visits, 1974-2008[59]

Figure 7: Tourism revenue (USD million, current and constant 2005 prices),1992-2008[59]

discovered. Three national parks in Rwanda are transboundary and link Rwanda with the Democratic Republic of Congo and Uganda (Volcanoes National Park), with Uganda and the United Republic of Tanzania (Akagera National Park) and with Burundi (Nyungwe National Park)[56]. These are the most prominent conservation areas within the Albertine Rift, and consequently the primary focus of ecotourism development. Nevertheless, forest reserves of Gishwati, Iwawa Island Forest, Mukura Forest and Buhanga Forest retain great environmental, economic, social and cultural importance[56].

Does community-based ecotourism satisfy CCD principles? *Highly likely*

With Rwanda supporting the highest population density in Africa, coupled with dependence on subsistence production systems, the primary threats to Rwanda's tourism assets are linked to population pressure and endemic poverty. These are drivers of degradation surrounding park boundaries, threatening the long-term sustainability and viability as tourist destinations[56]. In the case of Volcanoes National Park (VNP), this has been confirmed by recent studies carrying out detailed economic and social status assessments on communities in the 12 sectors adjacent to the park. Findings indicate that the poorest households around VNP are actively engaged in illegal activities in the park. It was also shown that households' use of the park was clearly linked to seasonal stresses in the dry season (July – November), or the "hungry gap", when poor households go to look for bush meat and other non-timber forest products (NTFP) as sources of income[58].

The study also found that poverty is disproportionately concentrated among households whose livelihood is subsistence agriculture. There is very little other diversification in households' income. This is important from a conservation and ecotourism perspective as the poorest households are also most likely to be illegally utilising the national park, having labour, but no land or employment on which to expend it[58].

Welfare developments require customised approaches for different income groups, exhibiting different levels of vulnerability and determinants of vulnerability as a function of different levels of adaptive capacity. Significantly, while the poorest households were found to benefit the least from development impacts of community conservation projects across income groups, the poorest groups did score favorably from projects including the buffalo wall, handicrafts production and conservation education.

Community-based ecotourism activities that engage the poorest households surrounding PNV including handicrafts production and conservation education present a high-potential investment for poverty alleviation, food insecurity during the "hungry gap" and empowerment. In turn, they promote park conservation and avoidance of GHG emissions from forest and land degradation.

Does support to community-based ecotourism meet unmet needs? *Highly likely*

In the case of Volcanoes National Park, and in line with the findings of Bush et al., 2010, existing community conservation projects show that income generating projects and social infrastructure projects focusing on key livelihoods constraints or with indirect income generating potential showed a slightly higher impact of benefits than other projects. This is attributed to the direct financial benefit or improved living conditions, which in turn are more likely to influence behavior towards the park. Nevertheless, it was found to be the case that it was most often the poorest households that obtained the least benefits from these projects, particularly women and traditionally forest-dwelling Batwa communities, as poorest households are often furthest from community centers, less likely to send children to school or able to afford healthcare, and lack the skills or resources to participate in technical improvement projects[58].

Findings from Bush et al., 2010 corroborate these results. Despite the existence of a government run community-benefit scheme for revenue sharing based on tourist lodge occupancy, insufficient resources are being availed to addresses

engagement issues and benefits obtained by the poorest households. The objectives of the revenue sharing program are to 1) increase effectiveness of the National Parks in attaining conservation objectives, 2) contributing to improved community livelihoods[106]. Since its inception in 2005, a total of RWF 1.04 billion (USD 428,248) has been disbursed to fund local community projects across 41 sectors within 12 Districts from Volcanoes National Park (40%), Akagera National Park (30%), and Nyungwe National Park (30%)[105]. Although these resources have been important initial contributions to local communities, in respect to the population density and catchment for community conservation initiatives, it amounts to a total investment of USD 1.45 per person over its 4-year history (to end of 2009), or an annual average of only USD 0.36 per person per year[58]. Despite progress to date, there is clear need for increased support for initiatives that benefit the poorest households surrounding parks. Community-based ecotourism, in combination with training and capacity building targeting these households, holds promise for helping provide this additional support.

Does community-based ecotourism provide high returns on investment? *Likely*

Given that ecotourism is the fastest growing sector of one of the world's largest industries (tourism) – with tourists spending over USD 4 trillion on vacations per year and ecotourism grossing USD 200 billion – it represents a sustainable, long-term industry for Rwanda's economic development[48,57]. As one of Rwanda's own most vibrant industries earning USD 202 million in 2008, tourism has outperformed coffee and tea as the main foreign exchange earner. Estimates for 2009 indicate that the tourism industry employs 33,800 people directly and 74,300 indirectly[59].

Representing a service industry that offers an alternative source of income to the highly climate sensitive agriculture sector, ecotourism has demonstrated that it can provide a robust, long-lasting and high returns on investment across areas of social, environmental and financial sustainability. Based on projected growth targets of Rwanda's Tourism Master Plan, which are outlined in Table 12, revenues are anticipated to more than double by 2020 to USD 627 million.

With a stated vision that "Rwanda will become established as a leading wildlife and eco-tourism destination and regional conference hub… that makes a growing contribution to the overall socio-economic development of the country", community-based ecotourism to envisioned destinations appears likely to provide high economic, social and environmental returns on investment. Success will depend on the engagement of those poorest and most vulnerable households and community groups that rely on forests for fuelwood, bush meat, and non-timber forest products, with particular emphasis on alternative income generating activities.

7.2 Afforestation and Reforestation, and Improved Forest Management

Definition of afforestation and reforestation (A/R), and improved forest management (IFM)

Defined by the UNFCCC, "Afforestation" is the direct human-induced conversion of land that has not been forested for a period of at least 50 years to forested land through planting, seeding and/or the human-induced promotion of natural seed sources. "Reforestation" follows the same definition with the exception that the land was forested and has been converted to non-forested land. If a Clean Development Mechanism (CDM) project is being

Table 12. Projected tourism revenues (2008-2020).

	Actual 2008	2009	2010	2011	2012	2020
Revenue USD m.	210.0	210.0	225	244.0	276.7	627.0
Number of Arrivals	980,000	980,000	1,031,000	1,089,000	1,199,000	2,219,000

considered for development using the Afforestation/ Reforestation (A/R) methodology, reforestation is the conversion of land that was not forested on 31 December 1989 to forested land[61]. For non-compliance or voluntary carbon markets, this definition and rule may be applied, or a custom rule established, e.g. the land must have been deforested for at least ten years preceding the project start.

Context of plantation and manmade forests in Rwanda

It is a stated goal of Rwanda's Vision 2020 to increase its production of wood for fuel and other uses by increasing forest and tree cover to 30% of the national land area by 2020, coupled with improved use efficiency and consumption reductions. At the same time, the coverage of agroforestry must reach up to 85% of farmlands due to the limited land availability for traditional plantations[11,1]. In order to achieve this, the GoR has embarked on an ambitious programme of afforestation and reforestation. This program is financed by the central government and implemented by District authorities and development partners, namely the Belgian and Dutch governments through the multi-phase PAREF program[63].

Do A/R and IFM satisfy CCD principles? *Likely*

Tree planting through afforestation or reforestation initiatives represents significant opportunities to realise CCD aims. However, it must be ensured that A/R programs or projects do not increase the vulnerability of forest ecosystems and plantations, or the communities or biodiversity that depend upon them[65]. Accordingly, it is critical that initiatives take into account a number of factors that will be determinants of exposure and sensitivity to climate risks, adaptive capacity and, in turn, vulnerability, as well as quantity of emissions reduced:

1. What species should be selected to ensure resilience to future climate risks?
2. Where should A/R plantations be established in light of land scarcity and competing food security needs on arable lands?
3. How will local communities benefit and/or what are the opportunity costs to farmers for possibly transitioning from agricultural production on all or part of their land, to forestry practices?

Through a process of integrated development planning, the GoR is working to address some of these key questions. As mentioned, all suitable lands with slopes greater than 30 degrees are proposed sites for forestry under the National Land Use Development & Development Master Plan[1]. In order to inform this and the Vision 2020 target of 30% coverage, ISAR is working to research, procure and disseminate seed varieties and management practices that simultaneously satisfy both sustainable development needs in the form of fuel and fiber from A/R plantations and are also climate resilient. This is demonstrated by the selection of both regionally appropriate exotic species across that provide beneficial products, as well as native species that help maintains soil fertility and stability. It is interesting to note how these species mixes are split across lowland, midland and highland regions. As illustrated in Figure 8, the majority of exotic species selected for lowlands where they are better adapted to dryer conditions, while native species benefit higher altitude regions with higher average rainfall. In addition, use of native species promotes increased resilience to evaporation and evapotranspiration by creating more understory growth and ground coverage than the more rapid growing species with higher water demand and nutrient uptake. The latter can result from exotics such as Eucalyptus and Pinus, leading to increased soil acidity and limited ground cover, and resulting in higher levels of evaporation and evapotranspiration[31].

In the context of Rwanda, not only the type of species selected for A/R or improved forest management are important, but also the location of plantations given the severely limited land availability and national agricultural development targets. The strata of tree coverage will depend both on slope steepness and soil fertility[1,31]. It has been recommended that Eucalyptus species, which supply fuelwood and fibers, be grown on the highest

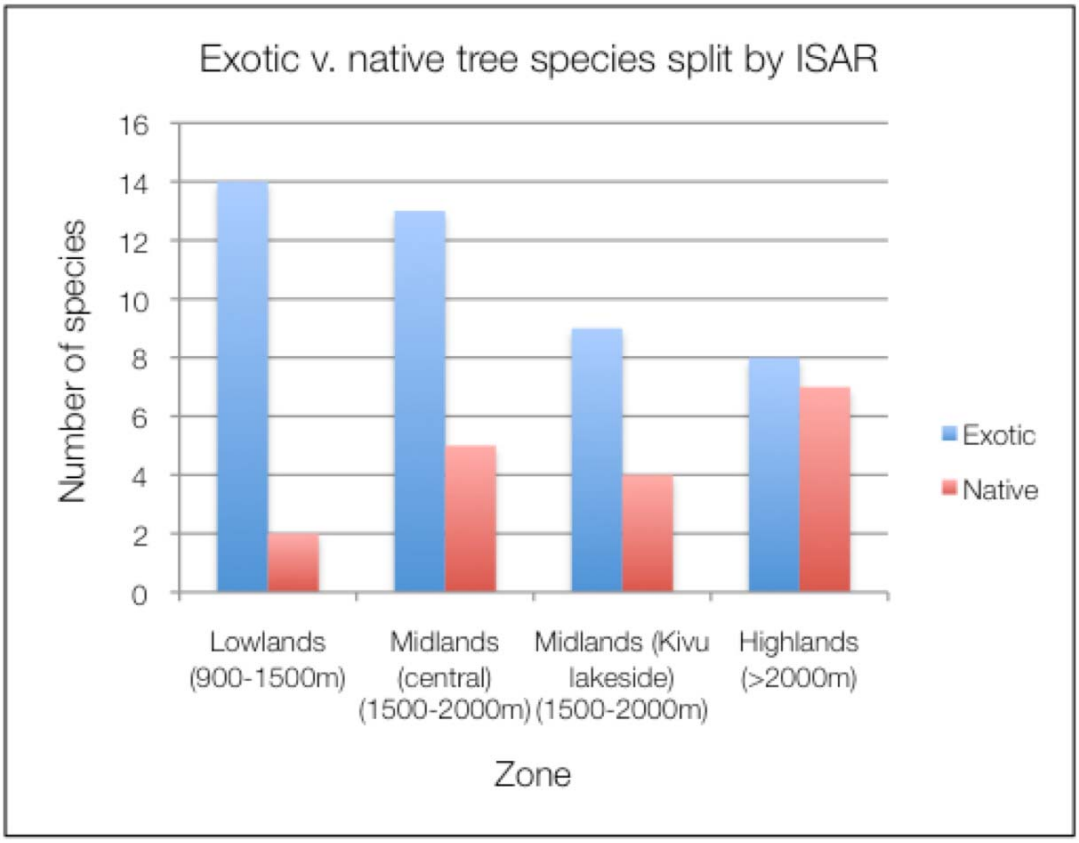

Figure 8: Exotic versus native species recommended by ISAR[66].

grades of land where slopes are too steep and rocky for productive agriculture. On slopes above 30 degrees, a mixed species approach of exotics and natives is recommended in order to promote increased soil organic matter, hydrological balance and reduced evapotranspiration. Arable soils on slopes below 30 degrees would in turn be dedicated to agriculture and agroforestry where appropriate. See Appendix 2 for a list of tree species and their appropriate growing conditions.

In terms of community benefits, high calorific trees provide firewood and charcoal. Under the Vi Life programme, diversified woodlots of long-term trees for fuelwood production such as Acacia polycantha, Acacia melanoxiolon, Acacia meansii helped over 50% of Rwandan participants to achieve at least 6 months of firewood self sufficiency [101].

Does support to A/R and IFM meet unmet needs? *Highly likely*

One of the greatest challenges facing Rwanda's forestry and agroforestry sector is a lack of adequate financing. As illustrated in Figure 9, although budget allocations to the forestry have steadily increased over the last 10 years, they still pale in comparison with other technical ministries including MININFRA and MINAGRI.

PAREFII technical analysis demonstrates that current levels of investment cannot meet the increased productivity Rwanda requires. Box 1 provides estimates of the levels of support required to achieve sector benchmarks.

Additional support to afforestation and reforestation, and improved forest management activities in Rwanda would certainly meet presently unmet needs for resources to achieve sustainable development objectives [26,67].

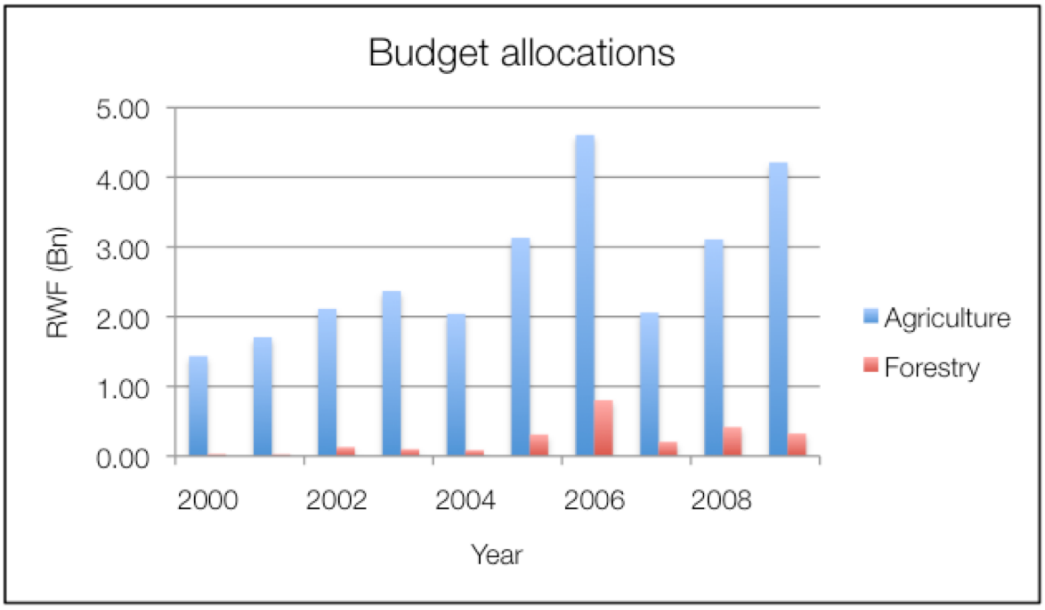

Figure 9: Budget allocations for agriculture and forestry in Rwanda from 2000 to 2009

Box 1. Investment needs to achieve plantation productivity through IFM

- *Assumption 1:* Total area of woodland plantations above 0.5 ha found by the mapping of 2007: 115,000
- *Assumption 2:* Area to (re)plant to (i) improve the productivity of existing plantations and i(i) increase the national woodland area of the country 1.5 x 115,000 ha (all plantations do not need to be replanted but, conversely, 115,000 ha underestimates the total area of existing plantations in the country, so the assumption is fair.
- *Assumption 3:* Period of time to (re)plant the area calculated with the Assumption 2 = 20 or 30 years

Result 1: USD 6000 to USD 8000 ha to (re)plant per year, respectively for 30 or 20 years, which from the material point of view is a massive effort;

Result 2: Annual cost of this (re)planting: USD 2,200,000 to 3,200,000 / year or

➡ Total (re)planting cost = RWF 1.3 to 1.9 billion /year

Key message: Against the allocated budget of RWF 324,418,000 in 2009/2010, there is an investment deficit of

➡ Total investment deficit = RWF 1 to 1.6 billion/year

Source: Data [14], exchange rate US$ 1 = RWF 592 (xe.com, May 2011)

Do A/R and IFM provide high returns on investment? *Highly likely*

As experience in Rwanda to date has shown, afforestation and reforestation activities provide important returns on investment, when carried out through environmentally and socially sensitive methods[68]. Environmental benefits include soil and water conservation, drought resistance and reduced evaporation and evapotranspiration, enhanced soil organic matter content, forest and biodiversity conservation[64]. Direct benefits to human well-being from the resulting core and beneficial ecosystem services include access to foods, fuels, and fibers that promote high-value income generation, energy security and water security, as well as shade and aesthetic benefits of natural beauty that have proven beneficial for psychological well-being[9]. In addition, A/R programs reduce burdens on women and promote community empowerment in taking responsibility for managing local resources such as community woodlots[3].

Figure 10: Alley cropping agroforestry at Cooperative ya Zumuka

The potential to development carbon credits through emissions reductions achieved from afforestation and reforestation projects also presents opportunity for monetary returns on A/R investments in Rwanda. Relative to other developing regions (namely Asia and South America), African countries have been largely been overlooked for carbon development opportunities. However, in recent years, this trend has begun to change[69]. Within the continent, East Africa has emerged as the "preferred destination" for carbon investors[69]. Most of these projects are non-Kyoto Protocol compliant (CDM), and select from Voluntary Carbon Market (VCM) project methodologies. A/R and improved forest management carbon development activities warrant serious consideration, particularly in light of Vision 2020 objectives for A/R and IFM, which remain underfinanced.

7.3 Agroforestry Promotion

Definition of Agroforestry

Agroforestry is a new word for an old farming method[74]. Although practices vary widely, agroforestry can be defined simply as an ecologically based natural resource management system in which trees are integrated in farmland and/or rangeland[72]. It involves the combination or integration of trees and shrubs with crops and/or animals in a farming system. In contrast to conventional agriculture, trees and shrubs may be grown either at the same time as crops, or in rotation[74].

Context of agroforestry promotion in Rwanda

Agroforestry systems have become critically important to Rwandans' well-being due to multiple stressors including the precipitous decline of natural forests by 65% during the 1960-2007 period, rapid population growth, high density, and fuelwood/charcoal demand, coupled with shrinking availability land[11,14,15,16]. The diverse range of ecosystem services provided by agroforestry include fuel, food, fodder, fiber, improved water quality and quantity, promotion of biodiversity, soil stability and increased

organic matter (fertility), and increased agricultural yields on rehabilitated degraded lands[74].

As a result, Rwanda has identified agroforestry as a core objective of national policies and strategies. Rwanda's strategic plans for the forestry, agriculture and environment sectors each outline objectives to increase forest and agroforestry resources in order to meet national timber and non-timber forest products and services, promote improved agricultural productivity, and reduce soil erosion and degradation[37,39,41]. Integrating these plans is Rwanda's National Land Use and Development Master Plan, which proposes that coverage of agroforestry must reach up to 85% of farmlands in order to help meet the national coverage target of 30% by 2020[11,1]. Strategies include aims to 1) increase the area and diversity of national forest resources; 2) promote growing of multipurpose trees in all farming systems; 3) avail improved seeds; and 4) introduce, promote and support innovative financing mechanisms such as eco-taxes, trusts, payments for ecosystem services, carbon development, etc.[41]

Does agroforestry promotion satisfy CCD principles? *Highly Likely*

Agroforestry systems have high potential to achieve climate compatible development principles on a number of levels for Rwanda. They have a significant role to play in helping smallholder farmers sustain agricultural systems that are resilient to climate change by reducing exposure and sensitivity to climate risks of flood and drought. Although research into the contributions of agroforestry in buffering against climate variability is not well advanced, field trials and the up-scaling of integrated farming systems using agroforestry techniques are yielding very positive results in Eastern and Southern Africa[75,76]. In the case of Malawi, these systems have greatly improved maize yields on degraded soils where nitrogen is limiting production[75].

Agroforestry increases farm profitability in several ways[42]:

1. Nutrients are continuously recycled in the system
2. Total output per unit area of tree/crop/livestock combinations is greater than any single component alone
3. Water management is an integrated part of the system
4. Crops and livestock protected from wind are more productive
5. New products add to the financial diversity, and flexibility of farming enterprises and make households less vulnerable

In addition, agroforestry systems have significant potential for contributing to objectives of poverty alleviation through income generation and diversification, fuelwood, energy and water security[76]. In the case of work by Vi-Agroforestry in East Africa, one of the greatest achievements of introduced agroforestry systems has been meeting the pressing demand for household firewood.

Results from 2010 showed a dramatic improvement in the percentage of households with at least 6 months of sufficiency in firewood (see Figure 11). Rwanda reached its target of over 50% self-sufficient households. Critical to this achievement was the promotion of more efficient and alternative sources of energy and high calorific value short-term and long-term trees for firewood and charcoal production. These included direct sowing of short-term trees for charcoal production such as Calliandra, Leucaena and Sesbania[101].

Despite the importance of agroforestry as a carbon sequestration strategy, it has not been adequately recognised or exploited in Africa or Rwanda. As an illustration of mitigation potential, average carbon storage by agroforestry practices has been estimated as 9, 21, 50, and 63 Mg C per ha in semiarid, sub-humid, humid and temperate regions. For smallholder agroforestry systems in the tropics, potential carbon sequestration rates range from 1.5 to 3.5 Mg carbon per ha per year[77].

Agroforestry promotion in the Rwandan context constitutes a high-potential management strategy for reducing vulnerability to climate risks, increasing adaptive capacity and quality of life, as well as achieving energy security and emissions reduction.

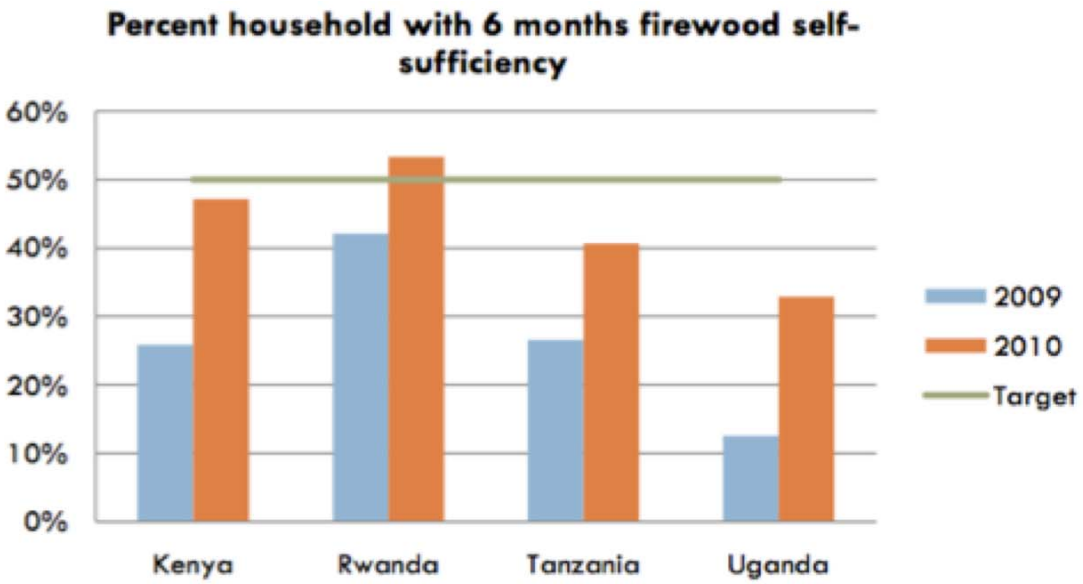

Figure 11: Percentage of households with at least 6 months of sufficiency in firewood between 2009-2010[76].

Does agroforestry support unmet needs? *Highly Likely*

Although the institutional mandate for supporting agroforestry activities in Rwanda was originally under the Ministry of Agriculture (MINAGRI), in more recent years it was combined under the forestry and environment sector in different institutional configurations. As detailed in the above budget analysis for the forestry sector, agroforestry managed by forestry and environment sectorare under-supported. The hybrid nature of agroforestry activities between agriculture and forestry sectors has also led to confusion and subsequent neglect across technical ministries and extension levels[63]. Limited technical capacity has in turn resulted in a lack of institutional ownership and monitoring of agroforestry development in Rwanda. In the context of climate change, these problems are beginning to be recognised. Significantly, among the chief recommendations of Rwanda's Second National Communication to the UNFCCC is the creation of a National Agro-Forestry Coordinating Committee at the central government policy making level[28].

Strong financial, capacity and institutional coordination issues are currently unmet for the agroforestry sub-sector, and warrant increased support across these areas to realise the climate compatible development potential of agroforestry systems in Rwanda.

Does agroforestry promotion promote high returns on investment? *Highly Likely*

Agroforestry promotion in Rwanda has the proven ability to yield high returns on investment across environmental, social and economic areas of benefit[76,78]. It also holds significant potential to generate from voluntary carbon credit projects on smallholder farms, in conjunction with experienced extension and technical operators (e.g. locally-based NGOs), as demonstrated by the success of piloting and up-scaling such projects in Eastern and Southern Africa[45,69].

In the context of Rwanda, key environmental and related development returns on investments in agroforestry relate to the ability of systems to fight soil erosion, improve soil fertility and hydrological balance[78]. This is demonstrated by field research by Roose and Ndayizigiye, 1997. After 2 years of growth, living hedges (leucaena, calliandra, and calliandra with setaria) (twice replicated) reduced runoff to less than 2% and erosion to 2 t/ha/year, compared to 10 to 40% runoff and 20 to 300 t/ha/

year under conventional systems of maize and beans/peas and sorghum. In addition, introduced agroforestry systems produced fire wood and high quality leguminous forage (3 to 8 kg/m) and returned to the soil as much as 80 to 120 kg/ha/year of nitrogen, 3 kg/ha/year of phosphorous, 30 to 60 kg/ha/year of calcium and potassium, and 10 to 20 kg/ha/year of magnesium – critical micronutrients limiting growth and productivity. Significantly, these systems were primarily useful in conserving soil and water, but do not increase productivity efficiently. Therefore, it is important to compliment such systems with appropriate corrections to soil acidity, aluminum toxicity, phosphorus and nitrogen deficiency through combinations of manure and organic compost, along with mineral fertilisers[78].

In order to ensure the sustainability and potential livelihoods and resilience benefits of agroforestry systems, it is critically important that communities and farmers are closely involved in decision making when designing interventions. This often requires demonstration and experimentation, as well as access to new technologies and sensitisation about new species and their potential benefits, e.g. farm visits or virtual 'farm tours'. Close community involvement also addresses key concerns of risk averse farmers regarding the impacts of trees, namely competing water demands with agricultural crops. Key concerns that must be addressed include the following[68]:

- Will the AF species meet objectives for which it was planted? E.g. fuelwood, timber, stakes, medicine, etc.
- Intercropping ability, i.e. allelopathic effects (the inhibition of growth in one species of plants by chemicals produced by another species), competition with crops and/or other trees, shade effects, etc.
- Effects on soil.
- Growth parametres (primarily height)
- Disease and pest problems.
- Other possible uses, etc.

Each of these questions and concerns need to be clearly addressed in any intervention program. Following with this, a key subject to address is the required investment of at least a few years, and potentially more depending on the species or fruit tree variety, required for different agroforestry systems. This closely aligns with the need of experienced and trained extension support systems that help sensitise farmers to the long-term benefits afforded by agroforestry investments, as well as the time required to realise them[74]. In the context of changing climatic risks over coming decades, such long-term investments in resilience and adaptive capacity will be particularly important for ensuring robust livelihood systems that support Rwanda's long-term economic growth and sustainable investment objectives.

7.4 Payments for Ecosystem Services (PES)

Definition of Payments for Ecosystem Services

Payments for Ecosystem Services (PES) are generally defined as a contractual transaction between a buyer and a seller for an ecosystem service or a land use/management practice likely to secure that service[43]. A more narrow set of criteria frequently cited includes[79]:

- A voluntary transaction by the provider of ecosystem service
- A 'well-defined ecosystem service'
- At least one ecosystem service buyer
- At least one ecosystem service provider
- 'Conditionality' – where the ecosystem service buyer only pays if the provider consistently provides the defined ecosystem service overtime.

Context of PES schemes in Rwanda

Awareness of payments for ecosystem services schemes and their potential to provide innovative support (publically or through private operators) is high in Rwanda[81]. Across major policy documents and strategies, direct or indirect mention is frequently made to PES or similar schemes in which non-market environmental benefits are compensated by supporting the costs of maintaining the healthy function of ecosystems. For

example, beneficial services of a watershed or wetland providing natural filtration of water for use down stream or in surrounding areas [37,39,41]. Despite stated recognition of PES scheme potential across forest and tree-based systems to provide a financial alternatives to traditional command and control environmental regulation, private or user-funded PES schemes have yet to materialise. However, awareness workshops are being conducted and feasibility studies budgeted for to better understand how PES might work for Rwanda[37,41,82]. To date, the majority of interventions related to PES activities, have been the mandate of the Rwanda Environment Management Authority (REMA) to ensure provision of ecosystem goods and services. This management and oversight function was particularly the security and functioning of Rwanda's hydroelectric power supply, which provides over 60% of the country's electricity[81].

Does PES satisfy CCD principles? *Highly Likely*

The use of payments of environmental services lies at the heart of the ethos behind ecological economics and sustainable development. The concept captures the fundamental need to address "tragedy of the commons" and the general degradation of public goods resulting from their non-market nature under conventional economics[12]. Following from this, carbon credit development and transactions constitute a type of PES scheme – compensating for the ecological service of carbon sequestration from the atmosphere. As a result, promotion of any carbon credit development supports the concept of monetising environmental goods and services and represents strong, direct linkages to climate compatible development. Analogous to forestry and agroforestry related systems discussed above, PES have the high potential to deliver services that promote resilience to climate risks. Intact and functioning ecosystems have a greater ability to absorb shocks such as floods and droughts, thereby reducing the exposure and sensitivity of human systems dependent on them, e.g. water purification and hydroelectric generation plants[83]. High potential PES schemes for Rwanda include the following[84]:

- Carbon offsets
- Water quality enhancement
- Biodiversity

In light of the potential for PES schemes to promote ecosystem resilience to climate risks and promote income generating activities, improved functioning and reliability of electricity supplies (with high economic multiplier effects), further detailed analysis on the design and implementation of PES to service poverty alleviation, reduced vulnerability and mitigation to climate change is warranted[84].

Does support to PES meet unmet needs? *Highly Likely*

Although interventions addressing high levels of environmental degradation have made considerable achievements over the last decade, the extent and pace of natural resource degradation will likely increase rather than decrease, driven largely by demographic change[85]. Exacerbating this situation is the limited available resources allocated to the environment sector to finance ecosystem rehabilitation and protection through tree-based sustainable land management practices. This limitation is illustrated in Figure 12, which details actual budget execution by the environment sector, which reflects allocations.

While activities for tree-planting are to a large extent mainstreamed through the Ministry of Local Government (MINALOC), the severely limited budget availed to the environment sector demonstrates a clear need for added support in order to achieve environmental management and protection objectives, particularly to both enable technical training for implementation at sub-national levels[82].

Does PES promote high returns on investment? *Highly Likely*

Promotion of PES schemes has significant potential for yielding high returns on investments across environmental, social and economic areas. This can be demonstrated by Rwanda's already numerous examples of successful restoration and

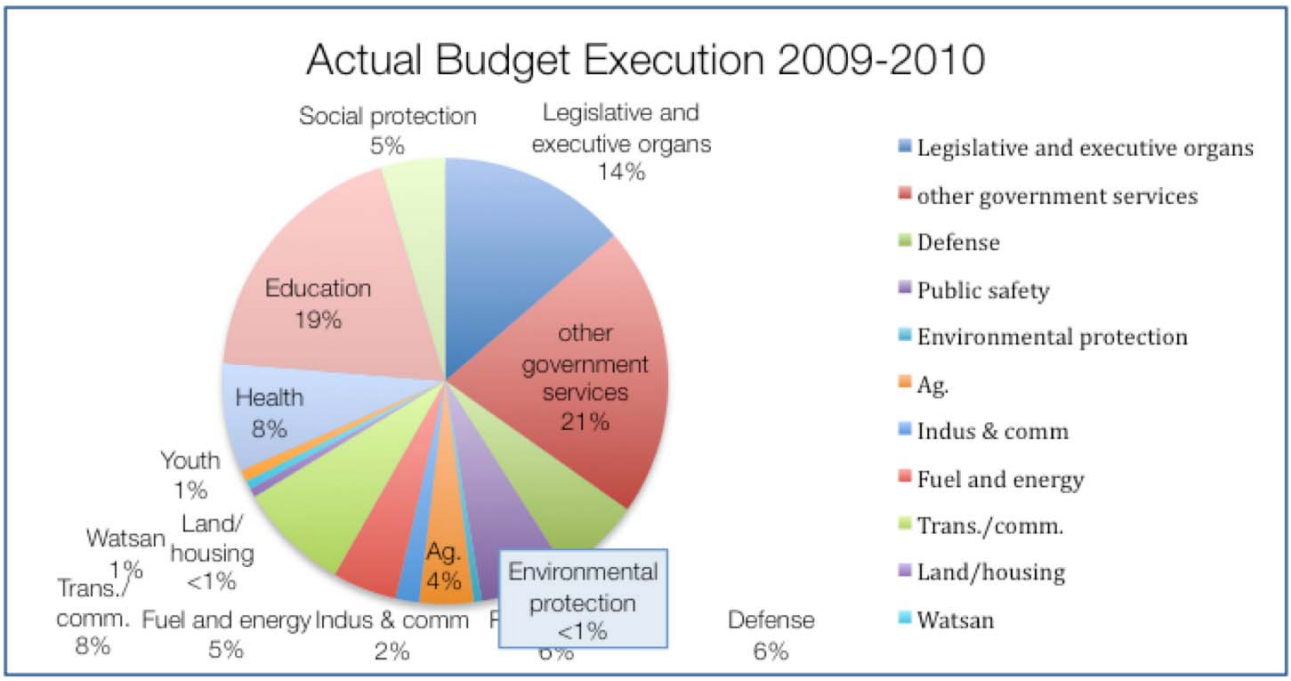

Figure 12: Actual budget execution 2009-2010[86].

management of degraded ecosystems, enabled by public institutions and financing, led by REMA.

Despite Rwanda's successful management of the Ntaruka and Mukungwa hydropower stations, discussed in the above case study section, problems of heavy siltation of waterways resulting in increased costs of electricity production and water purification. The Gihira water treatment and micro hydro power plants demonstrates this issue as the costs of water treatment continue to risk due to siltation, rising from RWF 65,000 in 1971 to RWF 2 million in 2009 per month, representing an increase of 96.6%. In contrast to the costs at Gihira, the Musanze water treatment station, which uses only 200 thousand RWF/month due to stability of upper watersheds.

Water treatment and production plants such as Gihira represent promising opportunities to pilot PES schemes in Rwanda. It is recommended that various models are also considered to identify which options work best, and are found to be most financially and institutionally attractive. Types of PES scheme arrangements include:

- Public PES schemes: Under public schemes, a public entity acts as the sole or primary buyer of a specified ecosystem service or, more commonly, a related land use or management practice. This entity acts also acts as the administrator and executor of the PES scheme (e.g. a municipality, local or national government). This arrangement is analogous to those restoration efforts that have proven successful.
- Private (self-organised) schemes: In private schemes, both buyers and sellers are private entities (companies, NGOs, farmers' associations or cooperatives, etc.). The buyers make payments based on an agreed contract.
- Public-private schemes: These schemes are a specific sub-set of private schemes in which the buyer is a public utility (e.g. municipal water-supply company or public power utility). PES contracts are in turn administered by a third-party PES-management entity in the same manner as private schemes.

7.5 Improved Cook Stove (ICS) Promotion

Definition of Improved Cook Stoves

An improved cooking stove is a stove that utilises fuels in the form of either charcoal or wood, more

efficiently than traditional cooking methods such as three-stone fires. While there is no international standard indicating the exact fuel savings for a stove to be considered improved, ICS commonly have fuel savings of around 50% in field tests, along with reductions in smoke and indoor air pollution.

Context of Improved Cook Stoves in Rwanda

The biomass energy sub-sector in Rwanda – and Africa as a whole – is the primary source of household energy, with an estimated 98% of Rwandan families relying on biomass for daily cooking (see Table 13). This includes households connected to the electricity grid in urban areas[107]. Over the years, there have been a number of large-scale initiatives to disseminate ICS into urban and rural households. In addition, an active private sector has also contributed to the uptake of a wide variety of stove types, which range in price, lifetime, and efficiency, across charcoal and wood burning, portable and non-portable stoves. Major improved stove types include the Darfur stove, Rocket stove, and the combination metal/ceramic stove locally known as the canamaké, which originated as the Kenya Ceramic Jiko stove. In 2010, MININFRA contracted Practical Action Consulting to conduct the "Dissemination of Improved Cook Stoves (ICS) in Rural Rwanda" project. Under the inception phase, a baseline rapid assessment of improved stoves currently used and consultations with stakeholders on willingness to pay for various stove types was carried out. The main fuels for cooking as a percentage of households is summarised in Table 14 below, with firewood and derivatives supplying over 92% of fuel sources on average in the sample survey across Rwanda's provinces. Although gathered firewood is the primary fuel source for the majority of households, 84% of surveyed households reported having a problem gathering it, highlighting the growing fuelwood deficit[107]. As a result, many households are resorting to burning agricultural residues and other available forms of biomass including grasses[109].

Does ICS promotion satisfy CCD principles? *Highly Likely*

Improved cookstove promotion satisfies objectives of climate-compatible development by reducing pressure on Rwanda's national resources though technologies requiring less biomass energy for cooking, thereby enhancing environmental protection and reduced exposure to dangerous indoor air pollution. According to the World Health Organisation (WHO), an estimated 1.5 million people die prematurely each year due to exposure to the smoke and other air pollutants from burning solid fuels. In addition, millions suffer from breathing difficulties, stinging eyes and chronic respiratory disease that disproportionately affects women and children. As a result, WHO identifies indoor smoke from solid fuels among the top 10 health risks, responsible for an estimated 2.7 percent of the global disease burden[111]. Although the extent of indoor air pollution's contribution to Rwanda's disease burden is currently uncharacterised, an indication of its likely significant contribution comes from national records of outpatient consultations at clinics and hospitals. In 2008, there were over five million new outpatient consultations in Rwanda, with pulmonary infections being the principal cause of visits (34.1%), followed by malaria (11.3%)[112]. In addition to reduced fuel demand and health benefits, implications of ICS for in Rwanda include reduced GHG emissions from environmental

Table 13. Households primary energy source by region[107]

Provinces	Gas	Electricity	Wood	Charcoal	Biogas	Residues	others
Southern	0.4	0.4	91.7	4.3	0.1	2.5	0.7
Western	0.5	0.9	88.0	9.5		0.6	0.5
Northern	0.3	0.3	94.0	3.8		0.9	0.7
Eastern	1.1	0.8	94.5	2.3		0.5	0.8
Total	0.6	0.6	91.9	5.1	0.0	1.1	0.7

degradation, and improved soil fertility as crop residues are reincorporated into soils rather than burned when fuelwood is not available.

Does ICS promotion support unmet needs? *Highly Likely*

Given the growing pressure on natural resources from increasing fuelwood and charcoal demand, substantial efforts have been made to distribute ICS in rural and urban areas. Data from the Practical Action work shows that although 62% of the surveyed households desired to have and improved stove, it was also indicated that 53% already had ICS. This was interpreted as an indication that households are not satisfied with the improved stove they already have. Similar findings were found in Kigali City surveys in which stoves classified as improved, with 40% market penetration, were found by the Practical Action team to be of low quality, with lifetimes of 3-4 months rather than years[110].

Does ICS promote high returns on investment? *Highly Likely*

Across economic, social and environmental considerations, the benefits of ICS interventions relative to costs are substantial. Economic returns on investment include the cost savings of fuelwood and charcoal purchased and time saved in fuel collection. Three main improved stove types are available including the 3-stone stove, Rocket stove and Darfur type. In the case of the Darfur type, assessments found woodfuel consumption savings of 28.43% and time saving of 21.49% in collection, and the Jiko has an efficiency rating of 28.97%[110]. Social and environmental returns on investment are equally powerful. In the case of social returns, health benefits of improved stoves have been studied extensively. Wilkinson et al. identified substantial benefits for reducing acute lower respiratory infection in children, chronic obstructive pulmonary disease, and ischaemic heart disease through and ICS programme in India. The avoided burden of disease was estimated to be 12,500 fewer disability-adjusted life-years (DALYS) and a saving of 0.1 to 0.2 megatonnes of CO2 equivalent per million population in one year, mostly in short-lived greenhouse pollutants[113]. Hence, ICS as a household energy intervention offers important economic, social and environmental co-benefits.

In order to estimate the emissions reduction and carbon credit potential of ICS in the Rwandan context, calculations were carried out for the SAVE80 and Jiko cookstove types. The latter type is particularly significant as it features in the Rwandan-adapted stoves introduced in the GoR-Practical Action pilot project to train artisans, potters and communities in the methods and benefits to ICS. The program is currently operating in 15 Districts, with plans to scale up to all 30 Districts. The relative costs, carbon offset, lifetime and carbon credit potential of these stoves is summarised in Table 14.

Although the SAVE80 stove is estimated to last up to 10 years, and the improved Rwandan Jiko 4 years, the cost of the Jiko is much more affordable. As up-front costs are a significant barrier to consumers the high costs of the SAVE80 need to be strongly considered. Lastly, annual carbon credit potential of the Jiko stoves are equivalent to roughly US$4 at carbon prices of USD 10 per tCO2 equivalent. Hence, the carbon credit could surpass the value of the Jiko stove after 2.5 years. Parametres for these calculations were taken from the Atmosfair approved Nigerian CDM project and Rwanda's BEST strategy, 2009, and from interviews with the Biomass programme representatives at

Table 14. Comparison of the CO2e offset of two improved cookstoves, SAVE80 and Jiko

Improved Cook Stove	Cost (USD)	Offset (tCO2e/year)	Life Expectancy	Lifetime Offset (tCO2e)	Value at USD 10/tCO2e
SAVE80	100	0.47	10 years	4.7	Can$47.00
Jiko	10	0.4	4 years	1.6	Can$16.00

MININFRA[114, 15, 38]. Details can be found in the Appendices of the Finance Sector Working Paper.

Strategic Framework

8.1 Institutional framework

Improved coordination and collaboration is necessary between the technical ministries responsible for forestry and tree-based systems including MINICOM/ RDB, MINIRENA, MINAGRI, and MININFRA. In the short-term, this may be done by the formation of a technical cadre drawing across the core conservation (MINICOM/RDB), forestry and environmental protection (MINIRENA), agriculture (MINAGRI), and energy (MININFRA) expertise to address issues that cut across the sectors. Within this group, critical technical and planning issues can be discussed (e.g. inventories, locations of trees, species choice, etc.). Particularly important will be more coordinated discussions around the management of park buffer zones, sustainably meeting of fuelwood and charcoal demands, avoidance of losses to agricultural productivity from burning agriculture residues, and the technical implementation of agroforestry, PES and carbon development in particular.

Improved coordination is also necessary across levels of government, particularly between the above technical ministries and Rwanda's Ministry of Local Government, which is the fulcrum around which local development takes place. To this end, the Integrated Development Programme (IDP) hosted by MINALOC offers a significant opportunity to better harmonise implementation of climate compatible development, and improve the effectiveness of sector development policies. In the short, medium and long term, it will be critical for the IDP and proposed forest and tree-based technical cadre (among others) to expand traditional thinking to incorporate issues of social protection, Disaster Risk Reduction (DRR) and climate risk reduction to address determinants of vulnerability (exposure, sensitivity and adaptive capacity). This will necessarily require expanded non-traditional collaborations between social ministries (e.g. MIDIMAR, MIGEPROF), the technical ministries managing forest and tree-based systems, and MOH and MINEDUC to address monitoring, implementation and data collection with/by communities[92]. MINALOC has already incorporated critical elements of this integrated thinking into its flagship social protection policy, Vision Umurenge Programme (VUP)[92,93], and recently adopted Social Protection Strategy, proposing a technical working group for stakeholders involved in early warning, risk mitigation, climate adaptation and disaster management[88]. This, and the currently considered weather Early Warning System (EWS)[90] as well as seasonal forecasting, should feature in the agenda of a technical cadre on forest and tree-based systems and the IDP, whose activities promote both resilience and mitigation of climate risk.

8.1.1 Suggested innovations

Local Adaptation Programmes of Action (LAPAs)

Borrowing from the lessons of developing a National Adaptation Programme of Action (NAPA), Rwanda can consider institutionalising this process on the ground using the innovative LAPA approach pioneered in Nepal. LAPAs perform the following functions:

- Enable communities to understand the changing uncertain future climatic conditions and engage effectively in the process of developing adaptation priorities.

- Implement climate resilient plans that are flexible enough to respond to changing climate risks and vulnerability conditions.
- Inform sectoral programmes and catalyse integrated approaches between sectors.

Locally Appropriate Mitigation Actions (LAPAs)

Analogous to LAPAs, and building on the concept of Nationally Appropriate Mitigation Actions (NAMAs), the GoR could sensitise and support District and sub-District formulation of Locally Appropriate Mitigation Actions (LAMAs). These will help raise awareness and harness the ability of communities to collaboratively generate low carbon development strategies that are locally appropriate and promote ownership and empowerment.

8.2 Financial framework

Above analysis reveals that current forest and environment sector budgets supporting forest and tree-based systems are severely underfunded relative to other sectors such as agriculture and energy. Strategic approaches are needed to satisfy currently unmet financial needs, better enabling forest and tree-based systems to realise their potential for delivering climate compatible development objectives. Central to this objective, is the need to attach economic value to the multiple direct human benefits derived from core and beneficial ecosystem processes. Key benefits include wood for fuel, stakes/poles and construction, clean water for drinking and use in industry, tourism, non-timber forest products such as medicinal plants, honey and raw materials for crafts. Valuing theses benefits strongly corresponds to CCD and Rwanda's initiative to promote a Green Economy[103].

Strategies to address financing needs vary in accordance with the type of forest or tree-based system considered. Primary sources of current and potential finance relevant to each selected CCD focus area are listed across public (domestic) sources, private sources, and bilateral and multilateral sources in Table 15.

8.2.1 Public (domestic) finance

National and sub-national public investment remains the primary source of finance for forest and tree-based systems, and it is imperative that their annual sector budgets are increased. Nevertheless, in recent years significant strides have been made in generating alternative sources of funding based on environment and fiscal reforms. These sources of financing result from revenues generated by[82]:

- Competitive bidding for property rights to use forest resources: From selective harvesting alone, more than RWF 232 million has been raised from the plantation of Nyungwe National Park.
- District forestry tariffs: Permits for trade in timber, charcoal trading, carrying timber, loading timber, etc.

Further opportunities not yet realised by NAFA include licensing management of all or part of a classified forest to a private company, within a public-private partnership framework. Such a frameworkis being considered for the overgrown pine buffer zone surrounding Nyungwe National Park, which exhibits high erosion rates and requires rehabilitation[26,82]. Revenues could in turn be channeled through the newly proposed environment fund, FONERWA, which will replace the existing Forest Fund[93].

An additional source of public finance mechanism whose creation has also been proposed is the VUP Risk Management Fund, which aims to support the 'climate proofing' of Rwanda's flagship social protection program[92]. The fund could provide much needed prevention and risk management for the lowest income households surrounding Volcanoes National Park during the "hungry gap" from July to November when food stock and water availability are low, thereby reducing encroachment threats to the park[58].

8.2.2 Private finance

Primary sources of private finance for the sector include tourism revenues; private individuals, businesses and cooperatives, that finance woodlots and on-farm trees; and, to a more limited extent, industries, including tea producers, that require high

Table 15. Sources of current and potential finance for CCD focus areas

Focus area	Public (domestic)	Private	Bi/ Multilateral
Community-based ecotourism	- National budget - Sub-national budgets (District and local government)	- Tour/lodge operators/companies - Tourists - NGOs - Donations	- DP GBS - DP SBS - Carbon markets - Adaptation Fund - Congo Basin Fund - REDD+
Afforestation/ reforestation & improved forest management	- National budget - Sub-national budgets (District and local government)	- Private companies (e.g. tea, brewery industry) - Individuals - NGOs - Donations	- DP GBS - DP SBS - Carbon markets - Adaptation Fund - World Bank GEF - UNFCCC Fast-Track Funds - UNFCCC Green Fund - REDD+ - Other bi/multilateral
Agroforestry promotion	- National budget - Sub-national budgets (District and local government)	- Private company (e.g. horticultural) - Individuals - NGOs - Donations	- DP GBS - DP SBS - Carbon markets - Adaptation Fund - World Bank GEF - UNFCCC Fast-Track Funds - UNFCCC Green Fund - REDD+ - Other bi/multilateral
Payments for Ecosystem Services	- National budget - Sub-national budgets - Parasitical water treatment and hydropower utilities	- Private companies (e.g. tea, brewery industry) - Individuals - NGOs - Donations	- DP GBS - DP SBS - Carbon markets - Adaptation Fund - World Bank GEF - UNFCCC Fast-Track Funds - UNFCCC Green Fund - REDD+ - Other bi/multilateral
Improved cook stove promotion	- National budget - Sub-national budgets	- Private company - Individuals - NGOs - Donations	- DP GBS - DP SBS - Carbon markets - World Bank GEF - UNFCCC Fast-Track Funds - UNFCCC Green Fund - REDD+ - Other bi/multilateral

DP = Development Partner, GBS = General Budget Support, SBS = Sector Budget Support

levels of wood for drying, which is typically sourced from their own private plantations and local sellers[95]. Other sources include local NGOs or international conservation groups.

8.2.3 PES scheme financial arrangements

Payments for ecosystem services represent a particularly promising mechanism through which to provide additional support to climate compatible development objectives.

Whilst a range of PES arrangements is available, it will be an important exercise for Rwanda to characterise these potential opportunities and match them with appropriate implementation models through extensive sensitisation and stakeholder engagement of potential buyers and sellers. In particular, there is need to bring Rwanda's tea, coffee and brewery businesses on board, as well as water treatment and hydroelectric utilities.

The primary financial arrangements available for implementing public, private or public-private PES schemes are presented below[43].

- Financial arrangements for *sellers*:
  - Direct compensation: Involves compensation of a seller for providing a specified land use or management practice such as tree planting to reduce soil erosion, or ecosystem indicators (e.g. number of flora and fauna per ha) deemed to deliver the desired ecosystem service, per unit of hectare (e.g. RWF/ha).
  - Investment or development funds: Payments from buyers are accumulated in a trust fund, which in turn, is deployed by the PES schemes to invest in practices or activities enhancing ecosystem services. The advantage is that 1) funds can be deployed in a variety of ecosystem service practices and activities, and 2) the scheme provides flexibility to adopt investment as opportunities and needs arise. The disadvantage is that committed buyers do not explicitly know what types of services and benefits they will receive. A possible solution is to form a board of trustees upon which buyers are members and can participate in decision-making on fund deployment.
- Financial arrangements for *buyers*:
  - Customer-charged payments: Participating utilities (e.g. water treatment and hydroelectric utilities) and, less commonly, industries (e.g. the breweries, tea factories) may charge their PES contributions directly to their customers through a previously negotiated set premium.
  - Lump-sum contributions: Participating buyers contribute annual lump sums (or even one-off payments in the case of trust funds). Contributions may be set 1) arbitrarily as an outcome of negotiations under the PES agreement, or 2) as a fraction of the turnover or profit of participating utilities or industries.
  - Tax-based contributions: Public schemes may be financed through taxes. To qualify as a "payment" and be different from ordinary subsidies, the tax must be explicitly raised and spent for the purpose of the ecosystem service to be acquired.

Although PES schemes are gaining global recognition, little attention has been paid to research on views of local people in their potential roles as service providers[79]. Findings from such surveys reveal three main requirements important for the design of pro-poor PES:

1. Thorough scoping studies to ensure that schemes are based on sound understanding of potential providers' perspectives and context.
2. Such studies should emphasise qualitative research and draw on participatory tools (e.g. participatory rural appraisal), to facilitate open dialogue and co-learning by researchers and participants.
3. Policy makers should consider designing hybridised schemes, in which PES concepts are combined with integrated conservation and development.

A recently completed inventory of PES in Eastern and Southern Africa identified a series of barriers to successful implementation and functioning of PES schemes. These barriers and suggested solutions are detailed in Table 16[80].

Table 16. Barriers and suggested solutions to PES schemes

Barrier type	Description	Suggested solution
Informational	- Limited knowledge of technical PES opportunities (e.g. CDM) -Potential buyers of ecosystem services (consumers, businesses, utilities, NGOs, etc.) often unaware of their dependence on ecosystem services. - Potential sellers unaware of PES payments and markets, or how to find buyers - Shortage of service providers and project developers to provide technical assistance	- "One-stop-shop" for PES: - Clear need for designated national and/or regional institutions that can serve as a repository of information on 'how to' guidelines, regulations, national priorities and other key issues.
Technical	- Lack of individual or organisational capacity or knowledge to organise, design and implement PES effectively, even when buyers and sellers are available. - "Best practices" have not yet been established through extensive on-the-ground experience and examples in the East and Southern African region. - Technical barriers of sellers are significant, with few having specialised skills. - Robust or proven models for bundled (e.g. carbon, water, biodiversity) are especially weak	- Technical capacity building and training for potential PES buyers, sellers and policy makers including: - Market analysis, - Enterprise analysis, - Contract familiarity, - Project design, - Implementation, and - Monitoring and evaluation.
Policy and regulatory	- Unsupportive policy frameworks (e.g. flow of funds and benefits of sales) - Policy confusion exists related to whether ecosystem service payments should be 'bundled' to ensure the full set of ecosystem objectives are met, or whether payment or market systems should focus on particular ecosystem services valued by interested buyers. -Uncertainty over tenure rights for land and natural resources, increasing the risks of long-term ecosystem service agreements.	- Establishment of "pro-poor" PES legislative and regulatory frameworks that take all these issues into consideration including policies/regulations for the establishment or certification of service providers for PES.
Institutional	- Lack of necessary institutions such as certification bodies, financial intermediaries, national registries for ecosystem services, etc. – across the value chain from seller to buyer that increase current PES transaction costs.	- PES-friendly institutional mechanisms to provide economies of scale and scope in finding and negotiating with buyers, bundling multiple ecosystem services for different markets, and achieving efficiencies in management, monitoring and certification. - Establish PES enterprise support centers for advisory and capacity-building services. - Community-level institution engagement to train prospective sellers, as well as financial institutions at the community-level for efficient delivery of payment

8.2.4 Carbon Finance

A number of carbon markets have been created for trading carbon credits, which denote a reduction of greenhouse gas emissions. These are discussed in detail in the Finance Sector Working Paper. This section focuses specifically on the potential for Rwanda to develop forestry carbon projects. To date, attempts have not been very successful, suffering from limited in country technical capacity, low levels of emissions, and high costs of project development.

Carbon markets can be divided into two categories: mandatory markets, such as the Clean Development Mechanism (CDM); and voluntary markets. The difference between the two lay in whether those purchasing carbon credits have legally binding emissions reduction commitments. Currently, projects that "reduce emissions from deforestation and degradation" (REDD+) and receive payments for not harvesting a piece of land, are not eligible to be traded over the CDM. REDD modalities still being negotiated internationally. Afforestation and Reforestation (A/R) projects are eligible; however, they are not allowed to be sold on the European Emission Trading Scheme (ETS), which is the largest market for CDM credits[21]. As of May 1, 2011, there were 17 registered CDM A/R projects in the pipeline, and only one in Africa: the "Humbo Ethiopia Assisted Natural Regeneration Project", managed by the BioCarbon Fund (BioCF) through the International Bank for Reconstruction and Development (IBRD). See Appendix 1 for a list of available CDM methods under Afforestation/ Reforestation designations.

In contrast, Africa's VCM market has witnessed much more vibrancy and innovation over the last decade. As of 2008, 23 forestry-based carbon sequestration projects were identified across 14 African countries, nine of which are in East Africa. Therefore, the GoR's best approach to access carbon finance for forestry will likely be to put itself in a position to access the CDM once it becomes more established, and for the time being support A/R and REDD projects that aim to access voluntary carbon markets.

There are a number of voluntary standards that forestry projects could adhere to for quality assurance including Plan Vivo, the Gold Standard, the Voluntary Carbon Standard (VCS), and ISO 1464, among many others. To meet these standards, and enable carbon credits A/R and IFM projects on public land, the GoR will need to guarantee their permanence. In other words, to be eligible for carbon credits, planted trees will need to be standing for decades.

Despite the opportunities to develop A/R projects within voluntary carbon markets, considerable challenges remain. These include high transaction costs for projects with smallholders, technical complexity of standards, insecure land tenure, political risks, a limited niche investment base, buyer reluctance to forest credits with impermanence and leakage risks, social sustainability, among others[69].

In the case of Rwanda, due to its small size and relatively high level of organisation and governance, many of these obstacles have the potential to be overcome. Particular to reducing high transaction costs, this challenge has been overcome in East African voluntary carbon projects by organising farmers into small groups of 10-12 people, and achieving scale through work with cooperative groups[45,76]. Rwanda appears to offer an especially unique comparative advantage in this respect (See use of Umuganda under capacity building). In addition, Rwanda's selected definition of a forest of having low minimum tree height of 3 metres and minimum forest area of 0.05ha facilitates diverse agroforestry opportunities for carbon development projects[17].

In regards to REDD, a 2008 Wildlife Conservation Society feasibility study in Rwanda concluded that it was not yet feasible to develop a REDD project due to a lack of data on demonstrable threats to the forest. To produce carbon credits, sufficient social and remote sensing [or aerial photography] must become available and demonstrate a clear and unambiguous threat to this or other parks[60]. The UN-REDD programme was recently been established to provide financial and technical assistance to countries that are preparing national

REDD+ strategies. During the first phase of the programme, funding is limited to nine pilot countries (Bolivia, DR Congo, Indonesia, Panama, Papua New Guinea, Paraguay, Tanzania, Vietnam, Zambia). Rwanda can apply to sit as an observer on the UN-REDD Policy Board. As an observer, Rwanda would not only benefit from UN-REDD's resources, workshops, knowledge, and networks, it would be well placed to become a participant in the second phase.

8.2.5 International Climate Funds

Within the forestry sector, a number of international mechanisms in support of adaptation activities exist that support direct interventions to promote resilience in the forestry sector. These include the Least Developed Country Fund (LDCF), Adaptation Fund, and newly proposed Green Fund (which also supports low-carbon development). While funds represent significant potential sources of international financing opportunities, it is important to examine alternative sources including bilateral and private that are more likely to come on stream in the short and medium term [96,97,98]. Nevertheless, Rwanda is progressively applying for Fast Track Financing under the UNFCCC (identifying A/R as a proposed project), and is in the process of registering its National Implementing Entity (NIE) in order to access Adaptation Fund finance [99]. More information on international climate funds is available in the Finance Sector Working Paper and the accompanying Climate Funds Toolkit.

8.2.6 Suggested Innovation

FONERWA

Pooling the fragmented sources of finance available for environment and climate activities into Rwanda's forthcoming fund for the environment, FONERWA, could help address underfinanced climate compatible development initiatives related to forest and tree-based activities systems. Critically, FONERWA will also serve as a strategic "attractor" that increases visibility and awareness of Rwanda's progressive CCD objectives.

8.3 Technology and R&D

Technology development and transfer, as well as research and development will be critical to promoting the resilience of forestry and tree-based systems, and the benefits to human well-being they provide. Perhaps most critical is the need to address two recurrent fundamental problems:

1. The scarcity of operational human resources – discussed in the following section
2. Lack of good quality seeds

Without tackling these issues, "simply planting of more trees of low quality and low viability…would be putting the cart before the horse." In order to address the root causes of these problems, building national capacities in forestry is the first order response, followed by developing the good reproduction material and management tools, and implementation of concrete activities of A/R, improved forest management and agroforestry [63]. It is clear that increased support for the work of ISAR and its seed centre in Butare is necessary to realise these objectives[64].

8.4 Capacity building and knowledge management

Analogous to other technical sectors, Rwanda's forestry and agroforestry sector struggles with a severe lack of capacity across all institutional levels, from central to district, sector, cell and villages. The problems of staffing frequently met in the forestry sector can be summarised as:

- Insufficient numbers
- Background outside forestry, frequently agriculture and other rural development fields
- Limited experience or technical training

New generations of foresters (or agro-foresters) receive their education in the institutions listed in the below table. Notably, the National University of Rwanda (NUR) does not currently have a forestry department or offer a technical degree in forestry; however a Masters curriculum in Agro-Forestry is now functional. The forestry education institutions that most need strengthening are the secondary

schools (due to the need of good field technicians) and the Higher Institute of Agriculture and Animal Husbandry (ISAE) in Busogo[64].

Despite the creation of the National Forestry Authority (NAFA) to oversee implementation of national programs, Rwanda has struggled to restore its technical and professional capacity in the forestry (and agroforestry) sector. Currently, NAFA employs 5 professionals under temporary contract, and some of these officers have limited professional experience. Following the decentralisation policy of 2006, Rwanda appointed 30 District Foresters. The 226 forest extension workers currently employed in the administrative sectors by NAFA at the sector level are woodland wardens, with limited technical forestry role or expertise[63].

NAFA is seeking to address the lack of technical capacity by appealing the Belgian Government for support to finance higher degrees for over 100 prospective students. Ideally, this will include 90 Bachelors, 20 Masters, and 5 PhD candidates to study regionally and internationally[26].

Recently, projections of Rwanda's baseline capacity needs for implementation of its National Forestry Plan have been produced by LTS International. These human resource needs reach across extension agents, certificate level holders, diploma holders and graduate holders. Table 17 summarises the additional training needs per year according to two scenarios of increased annual wood production, indicating that *there is a direct correlation between human capacity and the productivity of Rwanda's forestry resources*[26].

A key recommendation is to improve the capacity and training of those district officers and extension workers currently in field. In addition, it is recommended that the extension capacity for forestry – currently 200 persons – be doubled to from 1 worker per 2 sectors, to 1 worker per sector[26]. This would require supporting an extra 216 persons, given there are 416 sectors the costs for which are estimated in Table 18. Also included in the estimate is the cost of transport to support the existing 200 workers.

The estimated initial year capital, labor and operation and maintenance costs of having a fully staffed forest extension program are approximately 1.13 billion or US$ 1,902,838. This cost exceeds than the entire forestry budget for the 2009/2010 fiscal year (RWF 324.5 million) by approximately RWF 802 million, dramatically demonstrating the lack of adequate funds to support capacity needs in the forestry sector.

The Lands & Forests Research Center of ISAR, a much older institution than NAFA, also needs reinforcements to fulfill its mission. Currently, only one engineer is available to launch a program of seed quality improvement (tree breeding) and organise the supply of improved seeds to all afforestation schemes countrywide. Further, in the private sector and civil society, private companies implementing contracts of forestry workers (nurseries, plantations, etc) are recognised to have no professional qualifications in forestry in most cases. National NGOs, such as Vi Life, ICRAF and IFDC, and structured and professional cooperatives

Table 17. Training needs assessment for increasing forest productivity scenarios.

Category	10 million cubic metres wood/year		5 million cubic metres wood/year	
	Each year	Over 5 years	Each year	Over 5 years
Extension agents	560	2,800	280	1,400
Certificate level holders	44	220	22	110
Diploma holders	12	60	6	30
Graduate holders	3	15	2	10
Total	616	3,095	310	1,550

Table 18. Training needs assessment for increasing forest productivity scenarios[26]

Cost category	Unit cost RWF	No. Persons	Initial year investment costs RWF
Salary	150,000	216	32,400,000
Transport (motorbike)	2,500,000	416	1,040,000,000
Fuel costs	80,000	416	33,280,000
O&M costs	50,000	416	20,800,000
Total cost per person	2,780,000		
	Total program cost		1,126,480,000

active in forestry are rare. Private professional nurseries and wood processing industries are also few in numbers and need strengthening[63].

8.4.1 Suggested Innovations

Entrepreneurial and vocational training, with focus on women, youth and vulnerable groups

Address low levels of local capacity by promotion of entrepreneurial and vocational training with a focus on women (especially single headed household), youth and vulnerable (HIV, survivors) groups. This activity could be spearheaded by the Rwandan Development Board (RDB), and supported across relevant technical ministries and local government.

Joint-extension

Address current and (likely persisting) sector-level capacity through joint-extension training exercises to increase extension agent capacity, coordination and knowledge sharing across agriculture, forestry/agroforestry, and environment management sectors. This should be done through the MINALOC Integrated Development Program (IDP), as MINALOC represents the fulcrum around which local development is implemented.

Umuganda as carbon development and adaptation platform

A key activity will be to harness Rwanda's high level of community organisation and regular gathering under the monthly, Umuganda, to both sensitise communities on climate change risks offer a platform upon which appropriate carbon development programs might be based. This would promote scaling, community participation and lower transaction costs.

8.5 Data and information

There is presently a lack of technical consensus in Rwanda on the quantified levels of tree coverage, system type, carbon emissions profile and forest condition. As previously noted, the GoR is addressing this by commissioning a 16-week, forensic mapping exercise using recently produced aerial photography at the 25 cm scale in partnership with the Belgian Government[26,41]. Addressing these data and information gaps in the short and medium term will be critical for Rwanda's long-term planning for investments in plantations and woodlots.

In addition, there is a clear need to monitor the dissemination and use of improved cook stoves in Rwanda; and negative practices such as burning of agricultural residues and overcutting need to be better understood at local levels, and monitored to avoid negative feedbacks with soil fertility and human health.

Communication of climate risks and mitigation opportunities is extensive in Rwanda relative to neighboring East African countries. Credit for this achievement is due in large part to the wide-range of sensitisation activities carried out by the Rwanda Environment Management Authority. Mediums include radio, television and print materials disseminated nationally, as well as capacity building

and technical workshops, studies, pilot projects and research conducted to better understand and communicate climate-development linkages – and their critical importance to Rwanda's sustained economic growth[104].

Building on this progress, there is a need to improve communication across multiple scales. These include:

- Enhanced inter and intra-sectoral awareness of strategic climate issues, and the importance of their being addressed.
- Enhanced external communication of specific climate related risks and adaptation and mitigation opportunities and synergies that would benefit from increased support, such as promotion of agroforestry, improved cooking stoves or piloting innovative PES schemes.
- Communication and education of visitors to Rwanda (particularly business tourists), and their potential contribution to the sustainable development and risk reduction of communities, as well as conservation and biodiversity in and around Rwanda's protected areas.
- Education and awareness raising amongst local communities and industries about potential climate risks, and how afforestation/reforestation, improved forest management and agroforestry practices can provide income, food, water and energy security.
- Communication and sensitisation to promote ownership and pride in Rwanda's healthy environment and ecosystems, which in turn reduce exposure and sensitivity to climate risks, and increase natural adaptive capacity – demonstrated by the restoration of the Rugezi-Bulera-Ruhondo watershed, and importance of maintaining ecosystem integrity.
- Education of women and girls in family planning as a robust method of addressing Rwanda's rapid demographic growth and accompanying pressure and overexploitation of Rwanda's forest and tree-based natural resources.

8.5.1 Suggested Innovations

Community data collection

Engaging local communities including schools and cooperatives in data collection exercises to increase the resolution and monitoring of local conditions represents an attractive future option. This would also help supplement lack of extension capacity and better sensitise the population about climate risks and their livelihoods implications. In addition, it could offer an income generation opportunity by compensating active community members or groups.

Eco-labeling, certification and fair trade

Better quantify, capture and communicate the benefits of community-based ecotourism activities and climate friendly production activities (e.g. foods grown through sustainable integrated agroforestry methods) through adoption of eco-labeling or fair trade schemes. This would enable Rwanda to demonstrate value addition and product uniqueness to exploit a market niche.

Summary

Rwanda is not adequately adapted to current climate and variability. In terms of mid to late century projections, global climate models broadly agree that temperatures in the region will rise 2 to 2.5 degrees, though precipitation projections show far less consensus and are highly uncertain. From this background, forest and tree-based systems present Rwanda with a strategic opportunity. To realise this opportunity, Table 19 provides a list of crosscutting recommendations and suggested innovations across all forest and tree-based systems.

Multiple environmental, social and economic benefits afforded by forest and tree-based systems make possible the simultaneous achievement of reductions in vulnerability to climate risk and mitigation of the CO2 emissions that contribute to it. To promote robust, long-term and high-return investments, immediate and predictable support should be provided to community-base ecotourism, afforestation/reforestation and improved forest management, agroforestry, payments for ecosystem services and improved cook stoves.

Table 19. Strategic policy actions by focus area

Focus area WHY	Policies and Actions WHAT	Stakeholders WHO	Timescale WHEN	Measurables HOW	Sources of Finance
Community-based ecotourism	- Increase community benefit sharing scheme to 10% of tourism revenues - Increase engagement of vulnerable community members in development of Destination Management Areas - Improve food security, and income generating alternatives amongst the poorest HHs - Ensure adequate provision of credit facilities -Supply water to communities around Virunga Volcanoes - Couple community conservation projects with law enforcement and monitoring - Expand the conservation education programme - Improve coordination and synergies between conservation and development projects - Sponsor school field trips to the parks	- MINICOM, RDB, MINAGRI, MINALOC, MINECOFIN, MININFRA, MIDIMAR, MINIRENA, MINEDUC, NGOs and civil society including women's groups, youth groups	Short, medium term (1- 5 years)	- Target lowest income quintiles near parks - Percentage of vulnerable HH reached; % female headed HHs - HH Food consumption scores (FCS) and average annual incomes - Percentage of HHs with credit access - Percentage of HHs with potable water access - Registered entrepreneurial activities and community patrols, - % trained community eco-tour guides - Number of joint projects - Number of school field trips to parks	- Tourism revenue sharing scheme (10% of park revenues to communities) - Public and private finance - Conservation NGOs (e.g. WCS, IUCN) - Donations from tourists - Microfinance and other credit facilities - Community revenue generating schemes (e.g.guided tours, traditional dance, food sales to lodges)

Table 19. Strategic policy actions by focus area

Focus area WHY	Policies and Actions WHAT	Stakeholders WHO	Timescale WHEN	Measurables HOW	Sources of Finance
Afforestation/ Reforestation & Improved Forest Management	- Enhance cross-sectoral links through Forestry TWG to inform IDP - Double sector-level extension from 200 to 416 agents - Joint extension with agriculture - Complete aerial photography baseline inventory and land suitability survey (slopes, soils) - Augment extension training/support for tech transfer & capacity building (esp. min care) - Incorporate DRR, social protection and education into planting programs - Increased private management of plantations - Community data collection - Explore CDM and VCM development opportunities - Establish wood production and consumption targets - R&D for high-yielding varieties (wood, fruit, carbon, etc.) - Assess and restore degraded plantations - Achieve 30% coverage target	- MINICOM, RDB, MINIRENA, MINAGRI, MININFRA, NAFA, MIGEPROF, MIDMAR, MINALOC, MINEDUC, MINESANTE, ISAR, NUR, KIST, NGOs and civil society including women/ youth groups	Short, medium term (1- 5 years) Medium-term (5 -10 years) Long-term (10years +)	- Quarterly meetings integrated TWG - Percentage of agents hired and equipped with transport (moto) - Joint training sessions per year - Inventory complete by 2012 - Percentage of cooperatives trained - Percentage of vulnerable HHs reached - Percentage privately owned plantations - Percentage involved villages/individuals - Number of carbon credits generated - Reduced per capita dependence on biomass/ charcoal - Percentage distribution of improved varieties - Measured productivity increases - Survival rates and coverage of trees planted	- Public (domestic) finance through forestry tariffs, supplying FONERWA - Private (woodlots, etc) - PES schemes, emphasising public-private model - Carbon credits from CDM (A/R, IFM), or VCM (multiple standards) - Multilateral (Green Fund, Adaptation Fund, BioCarbon Fund, GEF, etc)
Agroforestry	- Enhance cross-sectoral links through Forestry TWG to inform IDP -Complete aerial photography baseline inventory and land suitability survey (slopes, soils), areas above & below 0.5 ha - Generate Joint Strategy for agroforestry promotion - Explore VCM development opportunities - R&D for high-yielding, multipurpose species (fuelwood, food, medicines, nitrogen, carbon) and limited crop competition - Include agroforestry in educational curriculum - Incorporate into DRR and social protection - Achieve 30% tree coverage target through 85% agroforestry	- MINICOM, RDB, MINIRENA, MINAGRI, MININFRA, NAFA, REMA, ISAR, MINEDUC, MINALOC, MINESANTE, MIDIMAR, MIGEPRO, NGOs and civil society including women/ youth groups	Short, medium term (1- 5 years) Medium to long term (5-10+ years)	- Quarterly meetings integrated TWG - Inventory complete by 2012 - Joint training sessions per year - Percentage distribution of improved varieties; production increases - Percentage of schools with demonstration areas - Percentage of vulnerable HHs reached - Survival rates and coverage of trees planted	- Public (domestic) finance - Private (woodlots, etc) - PES schemes, emphasising public-private model - Carbon credits from VCM (multiple standards) - Multilateral (Green Fund, Adaptation Fund, GEF, BioCarbon Fund, etc

Table 19. Strategic policy actions by focus area

Focus area WHY	Policies and Actions WHAT	Stakeholders WHO	Timescale WHEN	Measurables HOW	Sources of Finance
Payments for Ecosystem Services (PES)	- Establish "One-stop-shop" and enterprise support on PES as part of Climate and Environment Bazaar (ECB) - Establish pro-poor PES legislative and regulatory frameworks - Establish PES – friendly institutional mechanisms to promote economies of scale and scope - Technical capacity building and training for potential PES buyers, sellers and policy makers - Community-level institutional engagement	-MINIRENA, REMA, MINICOM, RDB, NAFA, Private sector: tea & beverage factories, water treatment and hydroelectric utilities, NGOs and civil society including women/ youth groups, cooperatives	Short, medium term (1-10 years)	- Establish Climate & Environment Bazaar - Establish PES legislative and regulatory framework - Number of PES schemes established - Amount of land under PES protection - Amount of transactions	- Public (domestic) fiancé schemes - Private schemes - Public-private schemes - Various financial arrangements for buyers and sellers
Improved Cook Stoves (ICS) & carbonisation	- Join Global Alliance for Clean Cookstoves - 100% ICS distribution - Investigate sustainability criteria of biomass use to obtain carbon credits (CDM, VCM) from national cookstove program - Target energy insecure HHs, particularly women - Ensure ventilation (eaves) accompany installation	- MININFRA, MINIRENA, REMA	Short, medium to long term (1-10+ years)	- Participation in Alliance forums - Percentage ICS distribution - Percentage unsustainably sourced wood/ charcoal - Percentage vulnerable HHs participating - Percentage ventilation installations	- Public (domestic) finance through forestry tariffs, supplying FONERWA - Private (foundations etc) - PES schemes, emphasizing public-private model - Carbon credits from CDM (A/R, IFM), or VCM (multiple standards) - Multilateral (Green Fund, Adaptation Fund, BioCarbon Fund, GEF, etc)

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Appendices

Appendix 1. Approved Clean Development Mechanism project methodologies for afforestation and reforestation projects

Among the 180 approved CDM methodologies, major project types are detailed in the below table, along with the number of times the CDM projects in the pipeline have used an approved methodology as reported by the UNEP RISO Centre[22].

Table of CDM project methodologies available to date		
Method Number	Method title	Number of projects using method
Large-scale		
AR-AM0002	Restoration of degraded lands through A/R	9
AR-AM0004	Reforestation or afforestation of land currently under agricultural use	3
AR-AM0005	A/R project activities implemented for industrial and/or commercial uses	9
AR-AM0006	A/R with trees supported by shrubs on degraded land	8
AR-AM0007	A/R of land currently under agricultural or pastoral use	
AR-AM0009	A/R on degraded land allowing for silvopastoral activities	1
AR-AM0010	A/R project activities implemented on unmanaged grassland in reserve/protected areas	1
AR-AM0011	A/R of land subject to polyculture farming	
AR-AM0012	A/R of degraded or abandoned agricultural lands	
AR-AM0013	A/R of lands other than wetlands	
Consolidated methodologies		
AR-ACM0001	Afforestation/reforestation of degraded land	
AR-AC0002	Afforestation/R of degraded land without displacement of pre-project activities	
Small-scale		
AR-AMS0001	A/R projects activities implemented on grasslands or croplands with limited displacement of pre-project activities	
AR-AMS0002	A/R project activities implemented on settlements	
AR-AMS0003	A/R project activities implemented on wetlands	
AR-AMS0004	A/R project activities under the CDM	
AR-AMS0005	A/R implemented on lands having low inherent potential to support living biomass	
AR-AMS0006	Silvopastoral A/R project activities under the CDM	
AR-AMS0007	A/R implemented on grasslands or croplands	
	Total	19

Appendix 2. Tree species and appropriate planting locations for afforestation, reforestation, and agroforestry

Low Lands: Imbo, Mayaga, Bugesera, Easternsavannalands, Eastern plateau (Rusizisouth, Gisagara, Nyanza Est, Bugesera, Gatsibo, Ngoma, Eastern Kicukiro, Southern Nyarugenge)		
Nº	Species	Purpose
1	Senna spectabilis	on-farm, road side, gardens
2	Grevillearobusta	on-farm, wood lot , road side
3	Markhamiaplaticalyx (UMUSAVE)	on-farm, wood lot , road side
4	Albizialebbek	on-farm, ranches
5	Maesopsisemnii (UMUHUMURO)	on-farm, wood lot , road side
6	Eucalyptus tereticornis	wood lot , road side
7	Eucalyptus camaldulensis	wood lot , road side
8	Eucalyptus microcorys	wood lot , road side
9	Jacaranda mimosaefolia	on-farm, wood lot , road side, gardens
10	Callitrisrobusta	wood lot , road side
11	Cedrelaserrata	on-farm, wood lot , road side
12	Acacia polyacantha	on-farm, ranches
13	Acacia sieberana	on-farm, ranches
14	Terminaliamenthalii	gardens
15	Bamboo	River & lake side, road side, gardens, woodlots
16	Acrocarpusfraxinifolius	on-farm, wood lot , road side, gardens

Middle Lands: Central plateas, Granitichills,Bumbogo and Buriza plateau and Impala (Huye, Nyanza, Ruhango, Muhanga, Kamonyi, Rusizi, Nyamasheke, Westhern Kicukiro, Northern Nyarugenge, Gasabo)		
Nº	Species	Purpose
1	Polysciafulva (UMWUNGO)	on-farm, road side, gardens, woodlots
2	Podocarpusfalcatus (UMUFU)	on-farm, road side, gardens, woodlots
3	Entandrophragmaexcelsum	on-farm, woodlots
4	Cupressus spp	wood lot , road side
5	Grevillearobusta	on-farm, wood lot , road side
6	Markhamiaplaticalyx (UMUSAVE)	on-farm, wood lot , road side
7	Croton megalocarpus	on-farm, road side, gardens, woodlots, ranches
8	Maesopsisemnii (UMUHUMURO)	on-farm, wood lot , road side
9	Eucalyptus tereticornis	wood lot , road side
10	Eucalyptus microcorys	wood lot , road side
11	Jacaranda mimosaefolia	on-farm, wood lot , road side, gardens
12	Callitrisrobusta	wood lot , road side
13	Cedrelaserrata	on-farm, wood lot , road side
14	Casuarinaequisetifolia	on-farm, road side, gardens, woodlots
15	Bamboo	River & lake side, road side, gardens, woodlots
16	Spathodeacampanulata	Gardens, road side

Middle Lands: Kivu Lakesides (Nyamasheke, Karongi, Rutsiro, and Rubavu South)		
Nº	Species	Purpose
1	Grevillearobusta	on-farm, wood lot , road side
2	Markhamiaplaticalyx (UMUSAVE)	on-farm, wood lot , road side
3	Croton megalocarpus	on-farm, ranches
4	Maesopsisemnii (UMUHUMURO)	on-farm, wood lot , road side
5	Eucalyptus tereticornis	wood lot , road side
6	Eucalyptus globulus spp. maidenii	wood lot , road side
7	Jacaranda mimosaefolia	on-farm, wood lot , road side, gardens
8	Callitrisrobusta	wood lot , road side
9	Cedrelaserrata	on-farm, wood lot , road side
10	Casuarinaequisetifolia	wood lot , road side
11	Bamboo	River & lake side, road side, gardens, woodlots
12	Araucaria cunninghmii	Gardens, road side
13	Acrocarpusfraxinifolius	on-farm, wood lot , road side, gardens

High Lands: Lava lands, Congo-Nil Crest, High lands of Buberuka (Nyabihu, Musanze, Rubavu, Nyamagabe, Karongi, Ngororero, Burera)		
Nº	Species	Purpose
1	Polysciafulva(UMWUNGO)	on-farm, road side, gardens, woodlots
2	Podocarpusfalcatus (UMUFU)	on-farm, road side, gardens, woodlots
3	Entandrophragmaexcelsum	on-farm, woodlots
4	Alnusaccuminata	on-farm, wood lot , road side
5	Markhamiaplatycalix (Umusave)	on-farm, wood lot , road side
6	Mimosa scabrella	on-farm, road side
7	Croton megalocarpus	on-farm, ranches
8	Maesopsisemnii (UMUHUMURO)	on-farm, wood lot , road side
9	Acacia mearnsii	Road side, woodlot
10	Acacia melanoxylon	Road side, woodlot
11	Entandrophragmaexcelsum	wood lot , road side
12	Acacia polyacantha	on-farm, ranches
12	Chamaecytisuspalmensis	wood lot , road side
13	Eucalyptus globules spp. maidenii	wood lot , road side
14	Eucalyptus tereticornis	wood lot , road side
15	Bamboo	River & lake side, road side, gardens, woodlots

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