THE ECONOMICS OF LAND DEGRADATION

Insights from capacity building on the economics of land degradation in Rwanda

An Economics of Land Degradation capacity building process carried out in the framework of the “Reversing Land Degradation in Africa through Scaling-up Evergreen Agriculture” project.

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Suggested citation:
ELD Initiative (2020). "Insights from capacity building on the economics of land degradation in Rwanda." Report for the Economics of Land Degradation Initiative in the framework of the "Reversing Land Degradation in Africa through Scaling-up Evergreen Agriculture" project. Available from: www.eld-initiave.org

Economics of Land Degradation Initiative:

Insights from capacity building on the economics of land degradation in Rwanda

Report of the Economics of Land Degradation (ELD) Initiative carried out in the framework of the project “Reversing Land Degradation in Africa through Scaling-up Evergreen Agriculture” project

April 2020

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Acronyms and abbreviations

BAU	Business as usual
ELD	Economics of Land Degradation Initiative
FAO	Food and Agriculture Organization of the United Nations
ICRAF	World Agroforestry Centre
LDN	Land degradation neutrality
NPV	Net present value
SDGs	Sustainable Development Goals
SFM	Sustainable forest management
SLM	Sustainable land management
UNILAK	University of Lay Adventists of Kigali
UR	University of Rwanda

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Executive Summary

This report synthesises the processes and outputs from capacity building activities that exposed three groups of trainees in Rwanda to the Economics of Land Degradation Initiative's 6+1 step methodology.

Land degradation in Rwanda is a pervasive problem. High population density, steep slopes and plentiful precipitation combine with poverty and unsustainable land management practices in the context of a changing climate, causing high levels of soil erosion and deforestation. Improving Rwanda's conservation of land resources is essential to the long-term viability of agriculture and the livelihoods it underpins, yet policymakers lack numerical information about the economic losses linked to inaction on land degradation, as well as the gains to be made through investments in conservation efforts. To adequately undertake environmental valuation requires capacity building, and a pool of trained, in-country personnel with the skills and knowledge to apply the necessary methodological approaches. The role of the ELD Initiative in the framework of the *Reversing Land Degradation in Africa through Scaling-up Evergreen Agriculture project* targets this need.

Over the period 2018-2020, The ELD Initiative held training workshops on the use of different environmental valuation and research methods, culminating in the development and execution of research studies linked to topics of national interest when it comes to tackling land degradation. Capacity building activities involved a range of classroom based lectures from international experts, discussion groups, site visits and computer based exercises. Application of these new skills took place through primary data collection and analysis, through studies that applied the ELD 6+1 step methodology and which were designed and executed by the trainees.

Studies led by the University of Rwanda (UR) focused on the economic valuation of two land degradation cases, one in each of Western and Eastern Rwanda. The Eastern study focused on an urbanisation gradient in Nyagatare, considering the role of trees as providers of ecosystem services. The Western study examined the proposed Gishwati-Mukura forest corridor, estimating costs and benefits of planned reforestation and afforestation activities for land users and the costs of relocation for those who would have to move outside the area to enable its conservation. The University of Lay Adventists of Kigali (UNILAK) led the study in Southern Rwanda, which examined soil and water conservation strategies including agroforestry and terracing.

All groups undertook primary data collection and provided estimations of the costs and benefits associated with different sustainable land management options, with a view to identifying those practices that are economically viable over their chosen time frames. All groups found that taking action and moving away from the Business as Usual case is generally more profitable in the long run. In turn, such actions could support progress towards international goals and targets seeking land degradation neutrality.

As capacity is built further and more wide-ranging studies are undertaken, building on the environmental valuation skills base developed through this project, decision-makers and administrators can gain new insights into the economic consequences of land degradation and the costs and benefits associated with different options for action. Provision of further valuations could also be used to inform budgetary allocation to support specific sustainable land management measures, helping advance Rwanda's progress towards the Sustainable Development Goals.

About the ELD Initiative and the "Reversing Land Degradation in Africa through Scaling-up Evergreen Agriculture" project

Land degradation, desertification, and drought are widespread global issues that increasingly threaten our environment. They lead to a loss of services from land and land-based ecosystems that are necessary for human livelihoods and economic development. Food production, water availability, energy security, and other services provided by ecosystems are jeopardised by the ongoing loss of land and soil productivity.

Desertification already affects around 45 per cent of the African continent (ELD Initiative 2017), indicating an urgent need for action. Failure to act on this threat would have serious negative impacts on economic and sustainable development opportunities.

The Economics of Land Degradation (ELD) Initiative is a global initiative established in 2011 by the European Union (EU), the German Federal Ministry for Economic Cooperation and Development (BMZ) and the United Nations Convention to Combat Desertification (UNCCD). The Initiative provides specific scientific support to decision makers at national and international levels. A broad network of partner experts and institutions supports the Initiative, which aims at transforming the global understanding of the economic value of productive land and improving stakeholder awareness of socio-economic arguments to promote sustainable land management.

The ELD Initiative provides ground-truthed tools and assessments that allow stakeholders to undertake cost-benefit analyses of land and land uses through total economic valuation and include this information in decision-making. The Initiative is coordinated by the ELD Secretariat, hosted by the Sector Project BoDeN within the German International Cooperation (GIZ) in Bonn, Germany.

Land degradation is explicitly included in objective 15 of the United Nations' sustainable development goals (SDGs), which have been adopted in 2015. SDG 15 aims at *"protecting, restoring and promoting sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss"*.

SDG targets 15.3 and 15.9 aim at achieving land degradation neutrality as well as at the integration of ecosystems and biodiversity values into national and local planning. At the international level, the United Nations Convention to Combat Desertification (UNCCD) has been appointed as custodian agency for SDG 15.3 and, by developing economic arguments, the ELD Initiative complements the work of the scientific and technical committee of the Convention.

Land degradation is a complex problem, affecting many aspects of human life, which means that it cannot simply be eliminated by implementing technical or technological measures. The fight against degradation rather requires holistic measures, which will then simultaneously enable progress to reduce poverty (SDG 1), improve food security (SDG 2), sustainably manage water and waste water (SDG 6), enhance economic development (SDG 8), encourage sustainable consumption and production (SDG 12), improve adaptation to climate change (SDG 13), and to contribute to freedom and justice (SDG 16).

The Project *Reversing Land Degradation in Africa by Scaling-up EverGreen Agriculture* started in 2017, and aims to improve livelihoods, food security and climate change resilience by restoring ecosystem services. The project target countries are Ethiopia, Ghana, Kenya, Mali, Niger, Rwanda, Senegal, and Somalia. The action is financed by the European Union and co-financed by the German Ministry for Economic Cooperation and Development (BMZ). It is carried out jointly by the ELD Initiative and the World Agroforestry Centre (ICRAF).

The role of the ELD Initiative within this project is to raise awareness of the threats and opportunities of different land use options by supporting and communicating cost-benefit analyses in each target country. At the same time, the Initiative extends the capacity of national institutions and experts to assess the economic benefits of investments in sustainable land management in consideration of the costs of land degradation.

01 Introduction

More than 3.2 billion people globally are affected by land degradation (IPBES, 2018). Land degradation reduces the ability of natural capital to deliver ecosystem services and benefits to people. This in turn reduces food, energy and water security, undermining human wellbeing and progress towards the Sustainable Development Goals (SDGs) and the broader 2030 Agenda for Sustainable Development.

The SDGs comprise 17 goals and 169 associated targets. SDG 15 urges countries to *protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss.* SDG Target 15.3 *aims to: combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world by 2030.* The indicator adopted to measure achievement of SDG target 15.3 is the proportion of land that is degraded over the total land area, while land degradation neutrality (LDN) is assessed at country level using three indicators: soil organic carbon, land use change and net primary production.

In Rwanda, land degradation is a pervasive problem. Challenges of a high population density, steep slopes and plentiful precipitation combine with poverty and unsustainable land management practices in the context of a changing climate. Improving Rwanda's conservation of land resources is essential to the long-term viability of agriculture and the livelihoods it underpins. The necessity of doing this is acknowledged within national policies that seek to advance towards sustainability and support the SDGs. The country further joined the Bonn Challenge in 2011, a global effort to restore 150 million hectares (ha) of the world's deforested and degraded land by 2020. As part of this initiative, Rwanda pledged to achieve countrywide reversal of degradation, restoring 2 million ha by 2020. With such promises being made on the international stage, it becomes increasingly important not just to restore degraded ecosystems but also to better consider the impact of human actions and land management practices that both cause and can remediate environmental degradation.

Economic valuation of ecosystem services offers an approach that can provide numerical estimates that can inform decision-makers about the economic losses linked to inaction on land degradation, as well as the gains to be made through investments in conservation efforts (ELD, 2015). The value of Rwanda's ecosystems has not yet been fully explored and this can result in undervaluation of the country's environmental assets. At the same time, to adequately undertake environmental valuation requires capacity building, and a pool of trained, in-country personnel with the skills and knowledge to apply the necessary methodological approaches.

The work presented in this report synthesises the processes and outputs from capacity building activities that exposed three groups of trainees in Rwanda to the Economics of Land Degradation Initiative's 6+1 step methodology (ELD, 2015). Groups were trained in the use of different methods, with the capacity building culminating in their development and execution of research projects linked to topics of national interest when it comes to tackling land degradation. Groups provided estimations of the costs and benefits associated with different sustainable land management options, with a view to identifying those practices that are economically viable over their chosen time frames. As capacity is built further and more wide-ranging studies are undertaken, these kinds of valuations can start to provide decision makers and administrators with new insights into the economic consequences of land degradation and options for action. Provision of further valuations could also be used to inform budgetary allocation to support specific sustainable land management measures.

The lead institutions engaged in the learning process and undertaking data collection were the University of Rwanda (UR; the only public University in Rwanda) and the University of Lay Adventists of Kigali (UNILAK; a private university owned and operated by the Federation of Adventist Parents Associations for the Development of Education in Rwanda). UR's efforts focused on the economic valuation of two land degradation cases, one in each of Western and Eastern Rwanda. The Eastern study focused on an urbanisation gradient in Nyagatare, considering the role of trees as providers of ecosystem services. The Western study examined the proposed GishwatiMukura forest corridor, considering costs and benefits of planned reforestation and afforestation activities for

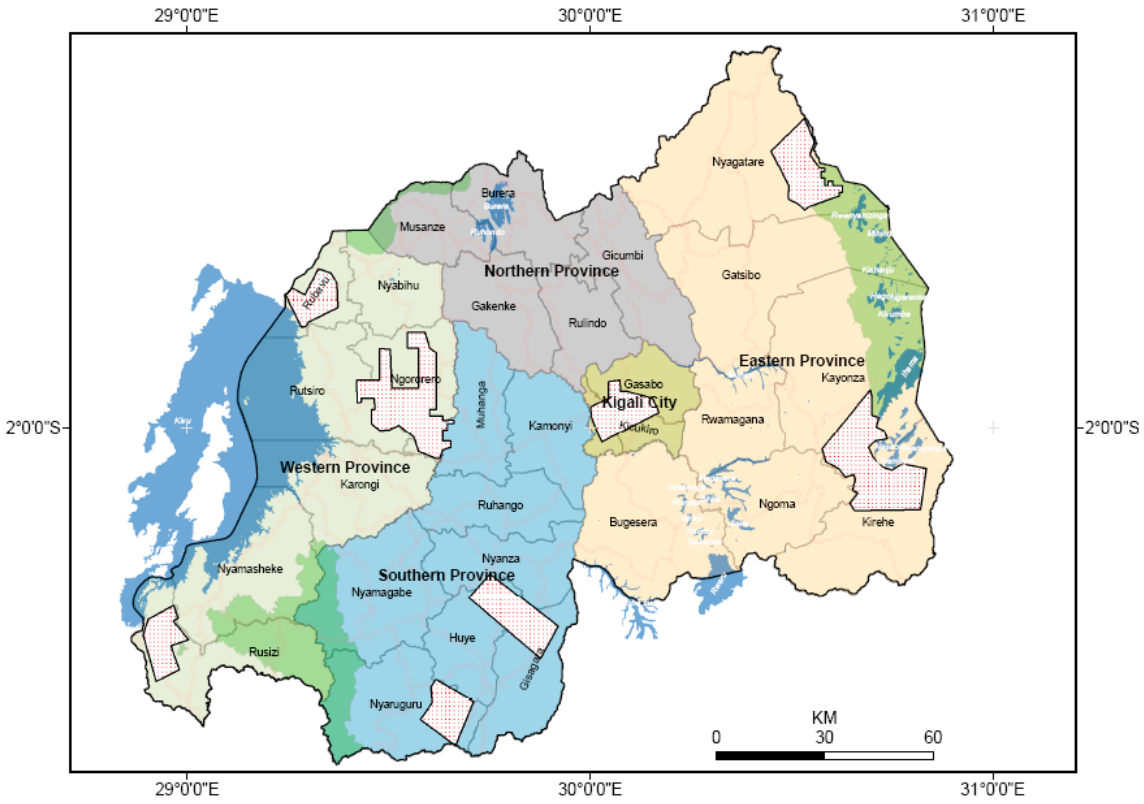
land users with different dominant crop types and the costs of relocation for those who would have to move outside the area to enable its conservation. UNILAK led the case study in Southern Rwanda, which examined soil and water conservation strategies including agroforestry and terracing in a catchment in the District of Nyanza, Busasamana Sector, Kibinja Cell. Appendix 1 lists the participants in each of the three case study groups. Groups were heavily male dominated, despite efforts to engage female trainees in the process.

The broad focal topics for groups to consider were initially identified in a participatory kickoff workshop in March 2018, which also involved processes of stakeholder consultation to ensure policy priorities were reflected in the topic areas. Topics were further refined to develop the three case studies during an ELD Training event held in July 2018. Study concept notes were developed by the group members in a demand driven approach between July and October 2018. Refinement of the concept notes was made following site visits in October 2018, which were informed by recent maps of land degradation developed for the country (Figure 1). Further training during the site visits guided creation of the research methodologies and protocols of questions to be answered.

Training on data collection and analysis was also provided in February and August 2019, with the bulk of the primary data collected between July and November 2019. Reports for each case study were drafted by the three study groups (Bizimana et al., 2019; Ndamage et al., 2019; Nyamihana et al., 2019), with results disseminated to regional and national decision-makers and other key stakeholders through the presentation of posters in a wider ELD dissemination workshop held in Kigali in March 2020. Dissemination processes feed into efforts to raise awareness and support decisions that deliver social and economic gains from sustainable land management practices in the respective regions of Rwanda. They also underscore the need for further capacity building activities to support environmental valuation studies in Rwanda, creating a critical mass of personnel trained in environmental valuation methodologies, in line with country needs.

FIGURE 1:

Map showing LDN hotspots (demarcated by stippled polygons) in Rwanda.



This report synthesises the core background and main capacity building processes followed by groups working on three case studies, targeting different aspects of the major types of land degradation across Rwanda. Together, the studies contribute to national level SDG visions of achieving LDN by building capacity to offer more detailed information on the kinds of sustainable land management practices that could be implemented, and the related costs and benefits. Overall, these efforts help to contribute positively towards achieving SDG target 15.3.

The case studies form a core part of the ELD Initiative's role within the overall *Reversing Land Degradation in Africa by Scaling-up EverGreen Agriculture project*. Within the project, the ELD Initiative aims to raise awareness on the threats and opportunities of different land use options by building capacity to support and communicate cost-benefit analyses in each target country. At the same time as furthering the skills of the individuals involved, the ELD Initiative's role extends the capacity of national institutions to assess the economic benefits of investments in sustainable land management in consideration of the costs of land degradation.

The present report has been developed in the framework of such a process at the national level and represents a synthesis of the main capacity building activities. While the specific study areas in Western, Eastern and Southern Provinces do not precisely spatially coincide with the tree planting efforts of the wider Reversing Land Degradation in Africa project undertaken by the World Agroforestry Centre (ICRAF), each case study explicitly includes a tree component. The case study from Western Province in the Gishwati-Mukura Corridor considers scenarios that involve planting both native and non-native tree species. The case from Eastern Province in two cells of Nyagatare (Akagali and Barija) assesses the value of trees along an urban-rural continuum. Finally, the case study from Southern Province focuses on Kibinja Cell, Busasamana Sector, Nyanza District in the Mayaga agro-ecological zone, and assesses agroforestry as one of its scenarios. Locations of the case studies are shown in Figure 2.

FIGURE 2:

Map of case study areas

Source: www.cartedumonde.net

Overall, the case studies form a major part of the training process. Engagement in the case studies exposes trainees to new skills and methodologies so that they can provide quantitative information that can help reduce the impacts of the major land degradation processes, drivers and pressures faced by the country, as well as shedding light on a range of possible responses and their economic implications. Drivers and pressures include high levels of soil erosion (especially in the west and north) and challenges of deforestation. Around 40 per cent of Rwanda is classified by the Food and Agriculture Organization of the United Nations (FAO) as being at very high erosion risk, with 37 per cent requiring soil retention measures prior to cultivation (State of the Environment Outlook, 2015). Despite these challenges, by 2016, 78 per cent of the country's terrestrial area was protected against soil erosion and 4 per cent had secured access to irrigation. Between 1960 and 2007, Rwanda's native forests declined considerably, from an area coverage of 659,000 hectares (ha) to 240,747 ha. In addition to quantitative losses, forests have declined in condition and become fragmented, driven largely by encroachment for agriculture, ill-advised development projects and overharvesting of forest products. Despite the enabling policy and institutional environment, adoption of sustainable forest management (SFM) and sustainable land management (SLM) remains limited in degraded areas, despite the range of possible responses that could be used.

Overall options to support SLM and SFM include measures such as terraces on steeper slopes (which are often in areas of high population density), on-farm soil and water conservation measures such as tree belts, contour belts, grass strips, contour bunds, ridge planting of fodder grasses and climate-smart agricultural practices (e.g. intercropping, use of cover crops, mulching, improved fallow, reduced or zero tillage, crop rotation and agroforestry) (Giger et al., 2015). These practices reduce the erodibility of the soil, improve the soil structure and its nutrient and water holding capacities, enhance soil biodiversity and generally help to support resilience (WOCAT, 2007). In degraded forest areas, responses cover reforestation, natural forest regeneration, use and access restrictions and creation of new wood lots to support demand for wood as an energy source.

Rwanda has developed voluntary targets for LDN with a view to strengthening SLM monitoring and progress in several other frameworks and policies, including the Rwanda Land Use and Development Master Plan. The country has mainstreamed the SDGs into several of its national programmes, including the National Strategy for Transformation and Prosperity, as well as into National Budgetary allocations. SDG indicators and targets are currently being integrated into appropriate sector and local government plans and budgets, alongside the development of appropriate monitoring and evaluation frameworks. Rwanda recognises that although progress towards LDN is reported at a national scale, solutions will need to target multiple scales and embrace the LDN hierarchy in its entirety through efforts that avoid, reduce and reverse land degradation (Orr et al., 2017) in both rural and urban areas.

In addition to the ELD Initiative's focus on SLM, several other organisations have been working to develop decision support tools and methodologies to support investments in efforts to achieve LDN. It is important that outputs from the capacity building exercises described here are viewed in context together with other reports from organisations such as Mott Macdonald, Terrconsult, as well as ICRAF's work beyond the Regreening Africa project.

In many countries the policy and development landscapes are poorly aligned, with efforts in one sector undermining efforts in another. Research from a range of African countries (England et al., 2017, 2018; Antwi-Agyei et al., 2018) highlights the importance of cross-sector coordination and the need to harness synergies and complementarities amongst land management options so that multiple SDGs can be achieved through SLM and restoration. Rwanda is one of the Africa's leaders in moving towards a more integrated and collaborative approach through joint programming and land use planning that takes into account the implications of decisions for multiple sectors. Bringing together the work and tools developed by different groups forms an important part of this process.

Highlights from some of the country's many policies that are relevant to ensuring land quality in Rwanda are synthesised in Table 1 (note: this list is not exhaustive). Each of these policies can benefit from the kinds of economic valuation methodologies and capacity building exercises presented in this report.

TABLE 1:

Selected national policies relevant to the ELD case studies in Rwanda (compiled from Nyamihana, 2018)

Policy	Key aspects relevant to land quality in Rwanda
Rwanda Vision 2050	Aims to achieve upper middle income country status by 2035 and high income status by 2050. Underpinned by high quality and standards of life; modern infrastructure and livelihoods (including smart green cities); transformations for prosperity; values such as self-reliance and self-determination, equity, good governance and accountability, community participation, dignity and unity; and international cooperation and positioning, free from aid dependence. Food security is seen as key to achieving this and is not possible without SLM.
National Environmental Policy of Rwanda (2003)	Aims to improve human wellbeing and achieve sustainable use of natural resources, protecting ecosystems for future generations through decentralisation and good governance and participation for improved environmental management. The policy recognises the importance of biodiversity conservation and tackling land degradation.
Rwanda Biodiversity Policy (2011)	Provides a framework to harness the economic potential of biodiversity and identifies unsustainable land management practices, alongside land use change (e.g. conversion of forest to agricultural use and urban development) as key drivers of biodiversity loss. Aims to conserve the diversity of landscapes, ecosystems, habitats, communities, populations, species and genes through comprehensive land use planning and restoration and rehabilitation of degraded ecosystems.
Rwanda Climate Change and Low Carbon Development Strategy (2011)	Aims for agriculture and industry to have a minimal negative environmental impact, for Rwanda to be self-sufficient as far as possible, achieved through low carbon domestic energy resources and practices and become a developed climate-resilient low-carbon economy by 2050. Seeks to reduce the country's contribution to climate change and support other African countries in responses to climate change. Supports green industry and avoidance of deforestation; sustainable land use planning and integrated water resources management; protection of ecosystem services; social protection and disaster risk reduction that reduces vulnerability to climate change impacts; and sustainable forestry, agroforestry and biomass energy (including controlled tree planting and urban tree planting).
National Land Use and Development Master Plan (2010)	Supports moves towards integrated planning and SLM through use of GIS and establishment of a National Information Sharing and Access Policy.
National Agricultural Policy (2004)	Seeks agricultural intensification, improvement of measures to protect and conserve soils and water, and conservation and transformation of agricultural practices and products (including mechanisation).
Strategic Plan for Agriculture Transformation in Rwanda (PSTA4; 2018-2024)	Outlines plans to move away from subsistence agriculture towards market agriculture. Incorporates sustainable land husbandry to protect resources and enhance productive capacity of land and soil by reducing erosion, improving infiltration and water holding capacity, enhancing soil nutrient supplies and increasing soil biodiversity, in the context of the country's different agro-ecological zones.
National Forestry Policy (2010, 2017)	Aims to locate the forestry sector as a core foundation of the economy and national ecological balance, with a view to providing sustainable benefits to society, achieved through private sector participation and investment in forestry, sustainable land use supporting soil, water and biodiversity conservation and tree planting, community participation and on-farm forestry to produce timber, wood fuel and non-timber forest products. Grounded in agroforestry principles, especially through use of multipurpose nitrogen fixing species.
National Land Policy (2004)	Aims to establish a land tenure system that guarantees tenure security for all and guide land reform to underpin rational use of national land resources. Key aspects are to develop actions that protect land from degradation; to promote participation and sensitise the public on SLM practices; and to promote wetland conservation and sustainable use.
Rwanda National Land Use and Development Plan (SDUTA, 2010)	Sets out binding directives for central and local governments, the public and private sector to adhere to regarding land use changes up to 2020. Especially relevant to urban planning.
National Fertiliser Policy (2014)	Aims to increase agricultural production, economic returns and income through increased and sustainable access to and use of fertilisers. Supports a private, liberalised and competitive fertiliser subsector and recognises the challenges of low soil fertility as a result of poor land management practices. Emphasises the diversification of fertiliser products and associated technologies (e.g. improved seeds, lime, soil conservation) to enhance efficient use of fertilisers alongside integrated nutrient management and conservation agriculture.

02 The 6+1 step approach of the ELD Initiative

The ELD component of the capacity building activities presented in this report follows the 6+1 step methodological approach of the ELD Initiative, which comprises six steps of evaluation followed by an action phase:

1. Inception
2. Determination of geographical characteristics
3. Identification of types of ecosystem services
4. Estimation of the total economic value of each ecosystem service
5. Description of land degradation patterns and drivers and
6. Subsequent analysis of cost and benefits of different options

+1 Step: Take action!

There are overlaps between the different steps allowing for flexible, non-linear application of the methodology to fit each study context, according to local demands and capacities.

Step 1: Inception

Each group identified the scope, location, spatial scale and strategic focus of their study, based on stakeholder consultation and secondary data. This exposed the groups to methods such as literature review of both academic and grey literature, policy review, site visits and stakeholder consultations, allowing them to prepare background materials on the socioeconomic and environmental context of their assessment. Boxes 1 – 3 summarise the main environmental and socioeconomic contexts in each case study.

BOX 1:

Profile of Western Province – Gishwati-Mukura corridor

Gishwati-Mukura National Park is located in one of the most densely populated areas of Rwanda, with high concentrations of refugees and resettling Rwandans. The forest area covers 34.58 km^2 (15.70 km^2 of which is Mukura forest and 19.88 km^2 of which is Gishwati forest, separated by approximately 26 km). The two forests are remnants of a continuous native forest that once covered the Congo-Nile Ridge. The area is characterised by high mountains (2000 – 3000 m) and deep narrow valleys.

Population pressure and various unsuitable development projects led to deforestation of these areas as they were converted for human settlements, grazing land, crop land and tree plantations (mostly Eucalyptus), while unsustainable agricultural practices have led to reduced yields and driven forest adjacent communities to seek alternative livelihoods. This has led to increasing pressure on the remaining natural forests in form of growing encroachment, poaching and other types of illegal resource extraction.

The two remnant forests were established as a national park in 2015 by the Law N°45/2015 of 15/10/2015 (Government of Rwanda 2016) to protect the remaining flora and fauna. The area is prone to erosion, soil fertility loss, landslides and flooding. Major stakeholders in this region are farmers who will benefit from restoration and other stakeholders in local government who need essential information to aid the implementation of SLM practices.

BOX 2:

Profile of Eastern Province – Nyagatare administrative area

Nyagatare is a town in Rwanda's Eastern Province close to international borders with Tanzania and Uganda. The wider Nyagatare administrative area covers an area of 158 km² with a growing population of >100,000 people. Altitude ranges from 1333 – 1541 m, with slope gradients of 2 – 15 per cent. Nyagatare faces challenges of environmental degradation due to high biomass consumption, deforestation and rapid urbanisation.

Currently, the area outside the main urban centre is largely used for livestock and farming, with low numbers of trees (mostly eucalyptus) in residential areas, and sparse tree cover around compounds. The district has rolled out a draft master plan for construction of a new town for about 19,000 people as part of a vision to become a key national commercial city. Building and equipping model villages according to modern settlements in the newly urbanised areas is among the priorities. Currently there is one such village and 13 more will be built to have one in each sector. At the same time, a need has been identified for watershed rehabilitation and afforestation, including trees in urban areas.

BOX 3:

Profile of Southern Province – Mayaga agro-ecological zone

Mayaga is a low altitude, dry and hot savannah region in the south of Rwanda that harbours 0.14 per cent of native forests and 10 per cent of man-made plantations of Rwanda's total forested area. The 555 ha of native forests and the many scattered patches of indigenous forests host important biodiversity and carbon stocks and provide critical watershed services to the agricultural landscapes surrounding them. Forest degradation has taken three pathways in Mayaga: quantitative loss, qualitative loss and fragmentation caused largely by encroachment for agriculture and overharvesting of forest products. Land degradation is widespread, with 22 per cent of land in Mayaga being affected by flooding, landslides or destructive rains that wash away the soil. SLM practices such as agroforestry and terracing have been identified as suitable for the area. Preferred tree species include *Eucalyptus, Greveria, Caryandra, Licena* and fruit trees such as avocado, mango, orange, lemon and papaya. While *Eucalyptus* is the dominant species, fruit trees are used for agroforestry.

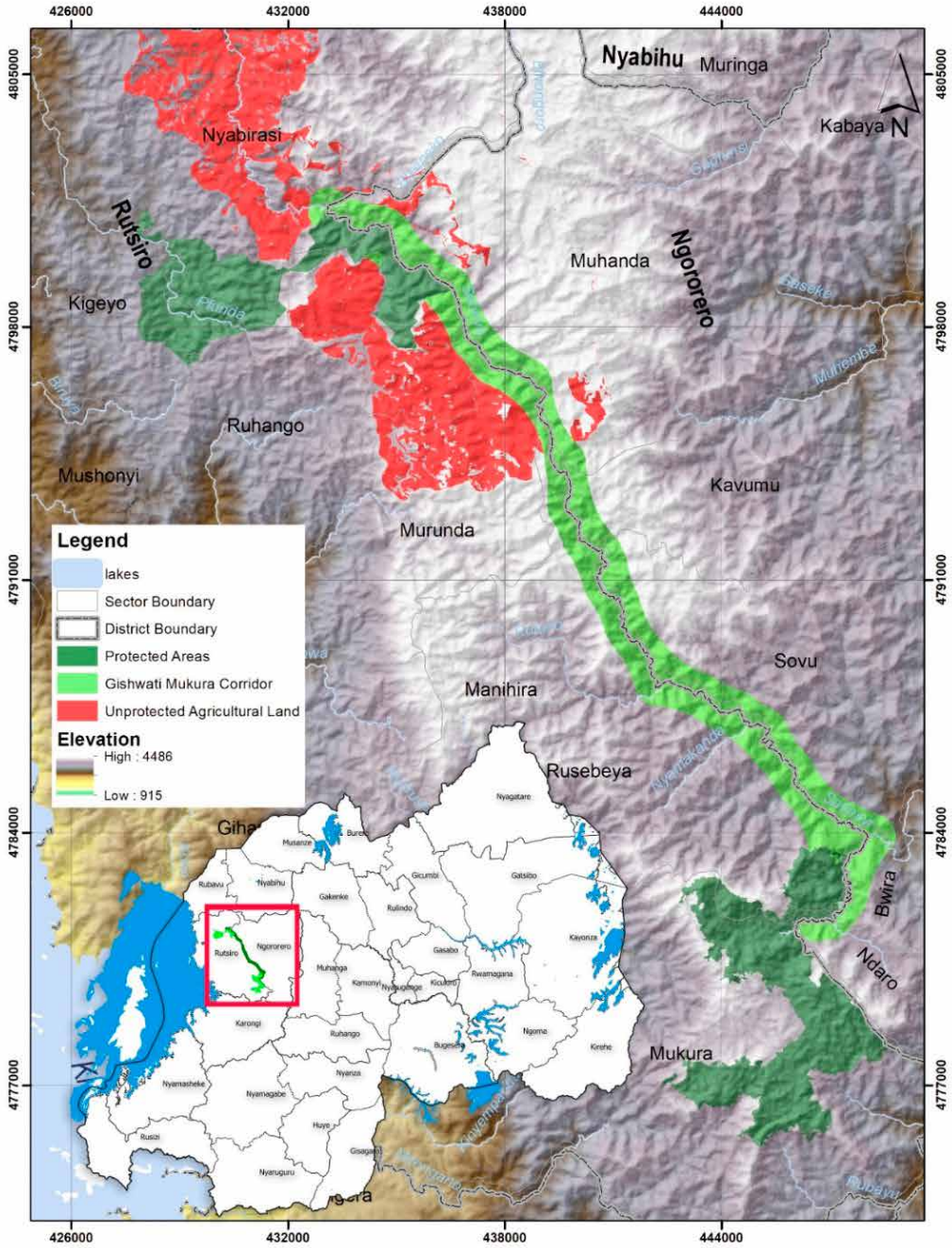
Kibinja cell which is the focus of this case study, has a population of 3,514 people, 88 per cent of which depends on agriculture undertaken on small and fragmented plots of land. The main crops include beans, maize, banana, cassava, soya, sweet potato, Irish potato and sorghum, as well as cash crops such as rice and coffee. Most of the land is not irrigated. Most crops are grown for subsistence purposes, with the sale of agricultural products not being due to surpluses but because households need cash to meet other needs such as medical bills, school fees and other household needs.

Step 2: Geographical characteristics

Step 2 involves defining the geographic and ecological boundaries of the study areas identified in Step 1. Groups undertook an assessment of quantity, spatial distribution and ecological characteristics of land cover types that are categorised into agro-ecological zones and analysed the information through a Geographical Information System (GIS). Maps are shown below to illustrate this step (Figure 3a-c). Methodologically, this encompassed land cover mapping and analyses of secondary land use data, while site visits provided additional information to augment the information collected in Step 1.

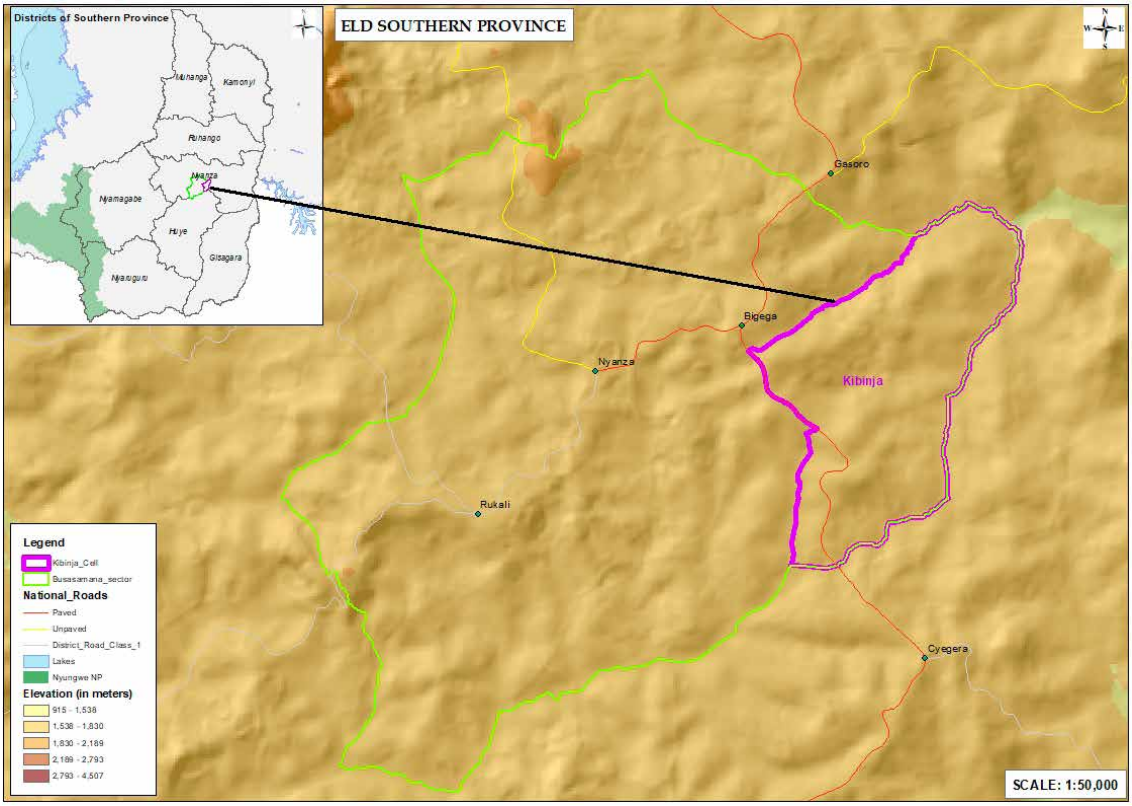
FIGURE 3:

Study site locations for the (a) Western; (b) Eastern and (c) Southern Provinces, as presented in the individual group reports.



(a) Western Province – Gishwati-Mukura corridor site location

(b) Eastern Province – Nyagatare administrative area group study site location



(c) Southern Province – Mayaga agro-ecological zone

Step 3: Types of ecosystem services

The third step in the ELD '6+1' methodology involves identifying and analysing stocks and flows of all ecosystem services for each land cover category identified in Step 2. Acknowledging the constraints of limited available resources and time, groups instead categorised the possible ecosystem services in the study areas using the Millennium Ecosystem Assessment's four categories (provisioning, regulating, supporting and cultural) and prioritised which categories to focus on in Step 4 following group discussions (Figure 4).

All groups focused mostly on provisioning services given these are key to livelihoods in the case study areas. For example, in Western Province, the majority of people around Gishwati and Mukura National Park are farmers who prioritise growing multiple crops to support their livelihoods, including Irish potatoes, maize, peas, wheat and tea. This meant that provisioning services were very important here. Alongside these, the Western and Eastern Province groups also included climate regulation (carbon storage) for one of their scenarios.

FIGURE 4:

Rwanda Landscape

Step 4: Roles of ecosystem services and economic valuation

Based on the ecosystem service categories listed above, each group developed a set of scenarios to test against a Business as Usual (BAU) scenario that estimated the economic value of the chosen ecosystem services in terms of costs and benefits of the current (baseline) situation. All groups used a combination of methods such as secondary data analysis, focus group discussions, benefit transfer methods (drawing on figures from similar contexts if no locally available data could be found) and interviews with key informants. This provided information on known or estimated costs and benefits under current conditions. The same methods were used to collect comparable data under a range of action scenarios summarised under Step 6. The group working in Eastern Province considered carbon storage values as a key part of their study and in addition to information gathered through interviews and focus group discussions, inventoried four plots of indigenous forest and seven plots in areas of other land use, in order to measure key variables related to carbon storage in trees and biomass (Figure 5).

FIGURE 5:

Tree measurements around Mvumba River, Eastern Province intended to measure key variables related to carbon storage.

Step 5: Patterns and pressures

The groups cross-checked the major pressures and patterns of land degradation, along with its drivers that they had identified from the literature with information from key informants, focus group participants and other stakeholders. Participatory processes that engage stakeholders such as land users in data collection can provide a useful kind of ground-truthing and offer important insights that are not necessarily available in the literature (Stringer, 2009). On the basis of the new information gleaned under Step 5 and combined with the knowledge gained under Steps 1–4, each group identified various actions that could address the main land degradation challenges in each location.

Step 6: Cost-benefit analysis and decision-making

In addition to BAU scenarios, each group developed a range of other action scenarios to test, allowing them to identify whether the proposed land management strategies would result in net benefits over defined time frames. This helped them to provide information on which actions are economically desirable. If there is a long return on investment period, this kind of information can indicate where policy support could assist land users through mechanisms such as subsidies, which have been shown elsewhere to be useful policy options in reducing the upfront investment costs to land users (Dallimer et al., 2018). The scenarios selected by each case study group are synthesised in Table 2.

TABLE 2:

Action scenarios for the three Rwanda case studies*

Group	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Western Province	BAU	SLM (terracing and soil fertility management)	Restoration with nonnative species and resettlement	Restoration with indigenous species and resettlement
Eastern Province	BAU	Retention of indigenous trees	Afforestation	-
Southern Province	BAU	Terraces	Agroforestry	Agroforestry and terracing

** More detail is provided on the scenarios for each group in Section 3.*

For each of the scenarios, groups collected information on the input costs (including the physical materials such as seeds, labour, fertilisers, manure and pesticides, tree seedlings, terraces and any compensation paid to land users if they were relocated as per the Western Province case, as well as the costs of labour and any equipment used). Transport costs and opportunity costs for SLM options where land was taken out of production were not considered. Benefits were calculated in relation to market prices of harvests (of crops and timber products) and the market prices of carbon and tourism income, where applicable.

Sampling and stakeholder participation

Throughout the application of the ELD 6+1 Step methodology, each group adopted a slightly different approach to the selection of stakeholders, key informants and focus group participants. It was often important to first meet with the Sector Executive Secretaries of sampled sectors in order to explain the purpose of the research, meet local cultural expectations and gain recommendations about who should be involved. Although it is recognised that this can introduce bias to participant selection processes, the relevance of focus group participants could be assured in relation to the specific questions being answered. For example, in the Western Group, focus group participants all used land in the study area and comprised farmers, pastoralists, tea growers, forest owners, miners and bee keepers. This ensured participants from a range of different groups were involved. In this case, six focus groups were convened, with the total number of participants being 72 people.

For the group working in Eastern Province, primary data collection began with a reconnaissance survey that involved physical observations and discussions with Nyagatare residents and other stakeholders in the district. This informed selection of Nyagatare cell (urbanised) and Barija cell (due to be urbanised) for more in-depth data collection to take place using focus groups. Within each cell, two villages were selected for sampling, with ten households sampled in each (total n=40) using a systematic stratified random sampling method. Selection of participants covered households that had lived in

the area for at least five years, while also seeking a gender balance as far as possible.

In the work undertaken in Southern Province, individuals from the local administration and the Sector Executive Secretaries were first consulted in interviews. For the BAU focus group, community members were selected from the population of 3,514 inhabitants of four villages in Kibinja Sector, ensuring upstream, central and downstream parts of the area were covered. Snowball sampling was then used to identify focus group participants, starting with each village leader. To be eligible to take part in the focus groups, participants had to own land in Kibinja Sector of at least 0.5 ha, be a farmer with regular production, and have residence in Kibinja. Each village provided eight members, giving a total number of 24 participants. The same process was followed in the sampling process to obtain data for the other scenarios, with each of the three scenario discussions involving eight participants. For participation in the scenario focus groups, it was necessary to ensure participating farmers used terraces, agroforestry and a combination of both agroforestry and terraces.

03 Results

Western Province

The group working in Western Province compared the cost and benefits of four different scenarios for the restoration or continued use of the Gishwati and Mukura corridor. The scenarios were:

1) **Business as usual (BAU),** which represented the current patterns of farming and land use;
2) **Implement sustainable land management practices** including terracing and soil fertility management while continuing to allow farming within the corridor;
3) **Implement forest restoration by planting and retention of non-native eucalyptus tree species**. Under this scenario, a further cost is the relocation and resettlement of communities currently living and farming within the corridor. Benefits were firewood, pole and timber production;
4) **Implement forest restoration by planting and retention of native tree species** (e.g. *Hagenia abyssinica, Poliscias fulva, Newtonia buchananii, Parinari excelsa, Myrianthus holstii, Sapium ellipticum and Macarianga mildbraedii*). As with Scenario 3, a further cost is the relocation and resettlement of communities currently living and farming within the corridor. Additional benefits included tourism revenues and carbon sequestration.

Costs associated with farming for Scenarios 1 and 2, and plantation establishment and management for Scenarios 3 and 4 are presented in Table 3. Benefits were calculated for each Sector that the corridor would cover and included outputs from farming and forestry activities as well as ecotourism and carbon sequestration for Scenario 4 (restoration with native species).

For calculation of net present values (NPVs), the group used a discount rate of 9.18 per cent and a 20-year time horizon (Table 4). Sensitivity analyses explored how altering the discount rate, input prices and output prices by increases and decreases of 25 per cent, 50 per cent and 100 per cent led to proportional changes in the NPV for the four scenarios. The Group concluded:

(i) For Scenario 1 (BAU), NPV was most sensitive to alterations to the output prices received by farmers, such that a 25 per cent increase in output prices leads to a 176 per cent increase in NPV;
(ii) For Scenario 2 (Sustainable Land Management), a doubling of the discount rate led to a 349 per cent increase in NPV;
(iii) For Scenario 3 (Restoration by Non-native Species), NPV is more or less equally sensitive to variation in discount rate, input and output prices; and
(iv) For Scenario 4 (Restoration by Native Species), NPV was most sensitive to alterations in output prices, followed by the discount rate, and then input prices.

TABLE 3:

Western Province land uses, costs (USD) of management and total cost per hectare per scenario

The highest total cost per hectare is for Scenario 4 (restoration with indigenous species). Land management according to the BAU scenario is the cheapest.

Scenario	Land use	Area (ha)	Land compensation	Terracing	Seeds	Labour	Fertilisers and manure	Pesticides	Total cost	Cost per hectare
1. Business as usual	Irish potatoes	880	0	0	1,639,694	357,598	330,746	79,586	2,407,623	2,736
	Maize	504	0	0	25,324	97,959	39,844	0	163,127	324
	Wheat	335	0	0	8,544	74,281	23,338	0	106,163	317
	Forest	317	0	0	18,722	125,236	0	0	143,958	455
	Ranching	209	0	0	129,966	89,962	0	0	219,927	1,052
	Total	2,245	0	0	1,822,250	745,035	393,927	79,586	3,040,799	1,355
2. Sustainable Land Management	Irish potatoes	880	0	2,431,804.47	1,608,652	408,265	405,935	175,090	4,623,812	5,254
	Maize	504	0	1,392,843.64	8,875	138,509	121,278	0	1,540,228	3,056
	Wheat	335	0	926,572.77	10,610	73,875	79,737	0	1,011,058	3,015
	Total	1,719	0	4,751,220.88	1,628,138	620,650	606,950	175,090	7,175, 098	4,173
3. Restoration by non-native species	Eucalyptus forest	2,986	34,104,095	0	316,913	1,587,147	0	0	36,008,155	12,057
4. Restoration by native species	Indigenous forest	2,986	34,104,095	0	5,581,786	1,071,367	0	0	40,757,248	13,647

TABLE 4:

Summary of total costs and annual benefits and NPV associated with each scenario in the Western Province

Scenario	Total cost*	Annual benefits*	NPV*
Business as Usual	3,040,799	8,198,476	21,915,103
Sustainable land management practices	7,175,098	8,089,977	34,048,664
Restoration with non-native tree species	36,008,155	13,402,788	-9,494,382
Restoration with native tree species	40,315,659	33,450,724	40,690,478

** Costs shown in USD*

Note: These results are based on calculations by the group working in Rwanda's Western Province.

Key recommendations according to the study by the Western Province group

Further data collection and analyses are required to verify the costs and benefits presented here and to validate the conclusions. However, based on the data and calculations presented by the Western Group as part of their training, suitable initiatives for the ELD 6+1 Take Action Step could include the following actions:

Possible actions for land users:

- Farmers in Western Province should invest in sustainable land management practices such as terracing, as doing so offers them higher yields and a better NPV in comparison to the BAU scenario.
- Given the sensitivity of NPV of the scenarios to both input and output prices, farmers would benefit from being able to better negotiate the prices for their agricultural products. Improved organisation of farmers into cooperatives could help with achieving this.

Possible actions for the private sector:

- Sensitivity to input prices has substantial impact on NPV so there is a need for the private sector (including agricultural dealers) to provide agricultural inputs (fertilisers, pesticides and veterinary medicines etc) at affordable prices. Achieving this may require dialogue with policy makers to ensure fairness to both farmers and the private sector.

Possible actions for policy and decision-makers:

- Government Ministries could consider subsidising SLM practices to encourage their uptake, especially where farmers currently bear the burden of upfront costs.
- Adequate agricultural extension and training is needed particularly to help farmers to keep records of their investments in the land and to raise awareness of the returns on investment for different SLM options.
- Government Ministries should facilitate the use of indigenous tree species for afforestation projects, given the high NPV this scenario offers.
- The Government should avoid the promotion and use of non-native species for afforestation projects as their NPV is low, or even negative, and they offer fewer additional benefits compared to native species.

Eastern Province

The group working in Eastern Province conducted cost-benefit analyses (CBA) of three different scenarios for the planned expansion and urbanisation in and around Nyagatare City. Their chosen scenarios were:

1. Business as usual (BAU). This scenario represented the current patterns of urban expansion, farming and land use;
2. Retaining indigenous trees in the landscape;
3. Increasing forest cover via afforestation.

For all scenarios, the Eastern Province group included the economic value of commercial timber species, fuelwood, wood for local construction and non-timber forest products (such as fruits and medicinal plants). The market price of carbon sequestered was also included. The group used their own tree survey data under the different land uses that the three scenarios represent to underpin calculations of costs and benefits. The Eastern

Group did not include the costs and benefits associated with agriculture nor with the conversion of land to urban uses in their analyses. Results, therefore, solely refer to how the value of forest products and carbon vary across the three scenarios.

For calculation of NPVs in this CBA, the group used a discount rate of 9.18 per cent and a 17 year time horizon (Table 5). The NPV for the Afforestation Scenario was substantially higher than the other scenarios. Sensitivity analyses explored how altering the discount rate, input prices and output prices by increases and decreases of 25 per cent, 50 per cent and 100 per cent altered the NPV for the scenarios. In all but one case, the Afforestation Scenario still offered the best NPV (Table 6).

TABLE 5:

Net present value, total benefits and total costs, in USD, associated with three scenarios for tree and forest management for the Nygatere City, Rwanda.

Scenario	NPV	Total benefit	Total cost
Business as Usual	58,454	248,679	107,949
Retention of indigenous trees	59,393	28,731	12,601
Afforestation	248,117	107,849	122,110

TABLE 6.

Sensitivity analyses exploring the impact on NPV (in USD) of altering discount rate, input and output prices for the three scenarios.

Green shading indicates the best NPV across the scenarios for each sensitivity analysis. With the exception of a 50% decrease in input prices, the Afforestation Scenario always offers the best NPV.

Scenario	Variable	NPV baseline	25% decrease	% change	25% increase	% change	50% decrease	% change	50% increase	% change	100% increase	% change
BAU	Discount rate	58,454	119,248	104%	12,739	-78%	201,128	244%	-22,056	-138%	-69,678	-219%
Retaining indigenous species	Discount rate	59,395	73,328	23%	48,597	-18%	91,597	54%	40,097	-32%	27,806	-53%
Afforestation	Discount rate	248,117	289,416	17%	215,597	-13%	342,557	38%	189,670	-24%	151,699	-39%
BAU	Input Price	58,454	185,905	218%	-60,529	-204%	555,557	850%	-183,747	-414%	-430,181	-836%
Retaining indigenous species	Input Price	59,395	64,811	9%	53,979	-9%	70,227	18%	48,562	-18%	37,730	-36%
Afforestation	Input Price	248,117	291,863	18%	204,372	-18%	204,372	-18%	335,608	35%	160,627	-35%
BAU	Output Price	58,454	-80,435	-238%	-80,435	-238%	-219,324	-475%	336,233	475%	614,011.28	950%
Retaining indigenous species	Output Price	59,395	37,730	-36%	79,912	35%	18,360	-69%	100,429	69%	141,463.55	138%
Afforestation	Output Price	248,117	160,627	-35%	334,147	35%	36,569	-85%	459,666	85%	671,215.18	171%

Key recommendations according to the study by the Eastern Province group

Further data collection and analyses would be required to verify conclusions. However, based on the data and calculations presented by the Eastern Group as part of their training, suitable initiatives for the ELD 6+1 Take Action Step would be:

Possible actions for land users:

- Land users in Nyagatare city should carry out afforestation due to its higher NPV. Benefits include a contribution to climate change mitigation.

Possible actions for the private sector:

- Given the benefits associated with trees in urban areas, the private sector needs to take a lead in prioritising green urbanisation. Real estate developers should seriously consider findings from environmental impact assessments during implementation of construction projects and actively seek ways to make their developments greener.
- Financial institutions could usefully avail assistance to residents who want to invest in afforestation by offering loans that are subsidised.

Possible actions for policy and decision-makers:

- Due to the high NPV and wider societal and environmental benefits associated with trees in urban areas, policies should be streamlined to promote the retention and planting of trees as urbanisation proceeds.
- Policy and decision makers should provide practical decision support tools to help local populations select and plant suitable and profitable native tree species, as well as ensuring tree nurseries are supported.

Southern Province

The group working in Southern Province compared the costs and benefits of three different scenarios for the uptake of sustainable land management practices across a catchment. The scenarios were:

1. Business as usual (BAU). This scenario represented the current patterns of farming of beans, maize and cassava in the absence of proposed SLM. Analysis assumed the initial use of organic fertilisers in farming, good quality seeds, in the absence of any pesticide;
2. Implementing the SLM practice of terraces in addition to current farming practices for the same three crops considered under the BAU scenario (beans, maize and cassava);
3. Implementing the SLM practice of agroforestry;
4. Implementing both terracing and agroforestry.

For all scenarios, the group working in Southern Province included the costs and benefits associated with producing the main three crops. For the SLM practices, additional costs associated with the construction and maintenance of the practice were included. Additional benefits included changes to yields for crops and, for agroforestry, timber and non-timber products. Market prices for all products were used to translate yields into output prices.

For calculation of NPVs as part of their CBA, the group used a discount rate of 9.8 per cent and a time horizon from 2019 to 2030. An end point of 2030 was chosen in order to map on to the end of the SDGs. All calculations were performed for a 0.5 ha plot of land, with two seasons of crop production per year, but data are presented per one ha. The group also carried out sensitivity analyses to explore how altering the discount rate by increases and decreases of 25 per cent, 50 per cent and 100 per cent altered the NPV for the scenarios (Table 7). Across all three crops, undertaking some form of SLM practice offered higher NPVs than continuing to farm under the BAU scenario. For beans and cassava, agroforestry and terracing offered the highest NPV, irrespective of discount rate. For maize, sensitivity analyses revealed that in some circumstances undertaking agroforestry alone could offer a higher NPV than doing it in conjunction with terracing. The higher NPVs associated with SLM practices were due to increased yields and, for agroforestry, as a result of profits from timber and non-timber products.

TABLE 7.

Sensitivity analyses exploring the impact on NPV (in USD) of altering discount rate by 25, 50 and 100% across the four scenarios.

Green shading indicates the best NPV across the scenarios for each sensitivity analysis. In all cases implementing an SLM practice involving agroforestry (either with or without terracing) offers farmers a higher NPV than the business as usual scenario.

				NPV					
Scenario	**Crop**	**Total cost**	**Total benefit**	**Baseline**	**25% decrease**	**25% increase**	**50% decrease**	**50% increase**	**100% increase**
BAU	Beans	951	1,371	1,687	1,870	1,535	2,090	1,406	1,203
Terraces	Beans	1,133	2,819	8,609	9,955	7,486	11,583	6,542	5,062
Agroforestry	Beans	864	1,762	6,771	7,504	6,158	8,387	5,641	4,825
Terraces and Agroforestry	Beans	999	3,382	17,972	19,918	16,345	22,262	14,972	12,808
BAU	Cassava	1,152	8,290	53,817	59,642	48,943	66,662	44,833	38,352
Terraces	Cassava	1,111	9,948	66,625	73,837	66,625	82,527	55,503	47,481
Agroforestry	Cassava	599	4,974	32,983	36,553	29,996	40,856	27,477	23,506
Terraces and Agroforestry	Cassava	537	11,938	85,950	95,253	78,166	106,464	71,602	61,252
BAU	Maize	1,409	1,371	-292	-323	-265	-361	-243	-208
Terraces	Maize	1,280	3,290	8,040	9,302	6,987	10,828	6,102	4,716
Agroforestry	Maize	1,222	1,645	5,256	8,820	10,173	7,692	11,808	5,256
Terraces and Agroforestry	Maize	1,155	1,842	8,927	10,285	7,795	11,925	6,843	5,350

Key recommendations according to the study by the Southern Province group

Further data collection and analyses would be required to verify the figures and conclusions. However, based on the data and calculations presented by the Southern Group as part of their training, suitable initiatives for the ELD 6+1 Take Action Step would be:

Possible actions for land users:

- Land users should implement agroforestry as an economically sound SLM practice. Terracing can be used if slopes are suitable. The combination of terracing and agroforestry offers the highest NPV for farmers across three crop types (beans, maize, cassava).

Possible actions for the private sector:

- The private sector could assist in the uptake of SLM practices through enhancing farmer access to finance so that they can invest in the upfront costs of SLM practices.

Possible actions for policy and decision-makers:

Given the clear benefits in terms of NPV for farmers implementing SLM practices, policy and decision makers should:

- Continue to enhance knowledge on SLM application at all levels.
- Set up policies to support investment in agriculture and provide incentives and/or subsidies for users of SLM practices.
- Promote practical tools to estimate the contribution from agroforestry given its additional climate change mitigation benefits and help the population in the selection of suitable and profitable tree species.
- Provide maps at country level that indicate suitable areas for terracing or agroforestry and where a combination of the two systems can be applied according to the national ecological zones.

04 Take action / Step "6+1"

The emphasis of the ELD Initiative's role in the overall project was on building the capacity to undertake economic assessments of different sustainable land management (SLM) options. While the broad patterns that emerged from the studies carried out by trainees indicated that economic benefits are to be gained over the longer term through shifts away from BAU approaches towards appropriate SLM practices, results and figures should be considered indicative rather than absolute. Findings should be followed up with further studies to gain more comprehensive insights and valuations that can reliably inform policy.

Investment is required in further capacity building to identify which SLM options are most economically viable for which groups in Rwanda across different parts of the country, and where additional policy supports (subsidies, Payments for Ecosystem Services etc) might be needed to shift land management practices towards sustainability. The research underpinning the capacity building process indicated a range of different SLM activities are taking place in Rwanda with involvement of non-government organisations and the private sector. Policy and decision makers should ensure there is no duplication of efforts and that all actors are aware of the different tools and findings. Further synthesis is needed to ensure maximum value is extracted from all available information.

The capacity building activities suffered from a lack of female involvement in the training programme. Research by Okpara et al. (2019) has shown that opportunities to address land degradation are unequal between women and men and that globally, gender concerns are poorly considered in efforts to achieve SDG target 15.3 to date. Future efforts to promote capacity building in Rwanda need to explicitly address this challenge and take proactive steps to ensure opportunities for training are structured in such a way that meets the different needs of women and men.

The structure of the capacity building programme over a period of two years in this project presented both advantages and disadvantages for participants and trainers. A more condensed period of training – for example, training over a three-month period, grounded more strongly in problem-based learning as a pedagogical strategy – could prove more effective in ensuring deeper learning and enable greater focus and prioritisation of the training. A problem-based learning recommendation for future training and capacity building endeavours follows research findings from health sciences and other disciplines where such approaches consistently demonstrate superior efficacy in terms of both longer term retention of knowledge and skills, and their application (Yew and Goh, 2016).

In general, problem-based learning is an iterative process comprising a problem analysis phase, a phase of self-directed learning and then a reporting phase. This kind of approach better supports active and group learning and would fit well with the group work model applied here. By consolidating the training into a shorter period, it would reduce the need for constant reminders and refreshers of previous material because the trainees would be completely absorbed in learning for a more intense period of time, while also allowing the trainers to better support those learners who are struggling with particular concepts and methods. Relevant institutional structures and processes to ensure availability of resources for this kind of approach are also needed.

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Appendices

Appendix 1: Group members

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Co-funded by the European Union

german cooperation
DEUTSCHE ZUSAMMENARBEIT

Implemented by giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

Regreening Africa

Australian National University

SEI

ICARDA

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Co-Funded by the European Union (EU) and the German Federal Ministry for Economic Cooperation and Development (BMZ).

The results and recommendations in this paper represent the opinions of the trainees, who took part in the capacity building training. Their opinions have been synthesised. The views expressed herein can in no way be taken to reflect the official opinion of the ELD Initiative, GIZ, BMZ or the EU, nor the ELD partner institutions that supported the studies.

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