Transforming Rwanda's Eastern Proving through Adaptation (TREPA)

Economic and Financial Analysis – Narrative Summary

Version 11

Contents

Tables and Figures

1. Introduction

1.1 Background

As is fully described in the Feasibility Study, the Eastern Province of Rwanda already receives a low amount of rainfall and such changes in rainfall and temperature alongside increased dry spells will cause potential **water deficit** in the province in the coming years. The increased occurrence of **prolonged droughts during the drought season** will inevitably lead to food shortages. In 2016, a major agricultural drought affected Rwanda's Eastern Province, especially Kayonza, Kirehe, and Nyagatare districts, leaving 44,000 households (some 225,000 people) food insecure.[1]

Climate change is increasing the frequency and severity of drought events in Rwanda's Eastern Province while contributing to degrading the natural resources on which local population depend for adaptation. Projected impacts will further compound the already-fragile situation in these areas unless major adaptation actions are integrated in the way landscapes are managed and governed.

While there is an expected decrease in rainfall during the short rainy season, **rainfall will be unevenly distributed**. Projections show **an increase in heavy rainfall event frequenc**y (7–40 percent) **and intensity** (2–11 percent) by 2050.[2] After prolonged dry season, events of extreme rainfall will likely lead to more **floods and landslides**.[3] Major flood events have doubled in the last two decades, from 13 flood events in the period 1980 – 2000 to 30 flood events in the period 2000 – 2020.[4] Rwanda and the Eastern Province in particular, is highly susceptible to landslides and 42% of the country's area is classified with moderate to very high susceptibility.[5] The lack of vegetation cover and projected increase in rainfall intensity are the major factors for the high susceptibility to landslides in the country.

The project's objective is to lead to a paradigm shift from reliance on land that is degraded, fragile and unable to sustain livelihoods to a climate resilient landscape providing development opportunities for smallholder farmers in the Eastern Province. The project outcomes that will result in the achievement of this objective are:

- Restored landscapes support climate resilient agro-ecological systems and livelihoods in the Eastern Province,
- Markets and value chains for climate resilient agricultural and tree products and linked financial services are inclusive, and incentivize sustainably the establishment and management of agro-ecological systems and associated public and private investments,
- Local and National Institutions and governance mechanisms have enhanced capacities to implement adaptation strategies and manage climate change.

The project will ensure the resilience of the Eastern Province by targeting two layers. First, it will ensure that land and forests ecosystems are restored. This will make all investments related to agriculture development or water management and supply fully resilient in the long run. The project will increase their capacity to be more adaptive to climate threats and variability, in

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[1] USAID, 2019. Ibid.

[2] Idem.

[3] Republic of Rwanda, 2018. Third National Communication: Report to the United Nations Framework Convention on Climate Change. Republic of Rwanda, Kigali

[4] CRED/EM-DAT, n.d. emdat.be. [Online] Available at: http://www.emdat.be/disaster_list/index. html [Accessed April 2020].

[5] Idem.

particular drought. The restoration activities proposed in this project will increase the resilience of the Eastern Province agriculture sector by ensuring water catchment capacity is maximized. This will be supported by setting-up institutional and financing mechanisms that will help stakeholders such as smallholders or private partners involved in value chains relevant to the Eastern Province to cope with climate variability following the project end.

In order to improve climate resilience, farmers would be required to change their agricultural practices to embrace agroforestry and silvopastoralism, rehabilitate woodlots and establish tree plantations to restore degraded rangelands, restore and protect fragile boundary areas and reduce the overharvesting of wood for use as a cooking fuel. As indicated in the financial analysis, these climate resilience measures yield significant financial and social benefits over time. However, they impose up-front financial and opportunity costs, as indicated in the table below.

In the without-project scenario, it is assumed that the hurdle rate for these climate resilience investments is the interest rate at which farmers would have to borrow. Without GCF support, this relatively high hurdle rate reduces the financial attractiveness of climate resilience investments.

GCF support is intended to cover the incremental costs of the measures enumerated in the funding proposal, making them more attractive for farmers and thereby increasing the likelihood that farmers will adopt and sustain these measures.

1.2 Scope and objective

Annex 3 of the GCF funding proposal package describes the methodology, assumptions and results of the Economic and Financial Analysis of:

- Output 1.1 Diversified agroforestry packages scaled-up
- Output 1.2 Woodlots and tree plantations are rehabilitated and sustainably managed for productive and ecological services
- Output 1.3 Scale-up climate resilient silvopastoral packages to restore degraded rangelands
- Output 1.4 Protective restoration measures are scaled up to climate-proof fragile, ecologically sensitive and erosion prone lands
- Output 1.5 Clean and efficient cooking energy technologies promoted through support to private sector and communities to transition/reduce biomass fuel consumption

1.3 Structure of the report

Section 1 includes a brief introduction of the objective of the study and the methodology used, together with the limitations and key challenges.

Section 2 provides an overview of the key financial and economic impacts of climate change in the baseline (without-project) scenario.

Section 3 provides a description of the evaluated outputs and their intended contribution to climate resilience.

Section 4 provides a breakdown of the financial analysis of the evaluated adaptation measures

Section 5 provides a breakdown of the economic analysis of the evaluated adaptation measures, including marketable benefits from Output 1.2, 1.3, 1.4 and 1.5, the non-market benefits from ecological services and the total economic benefits of the project.

1.4 Methodology

The methodology consists of 3 steps presented below.

- **Step 1. Assess financial and economic climate impacts on the agricultural sector:** The first step requires developing a baseline assuming a "without project" Business as Usual (BAU) scenario - (i.e. with climate change but without any project measures to reduce vulnerability and build resilience). This scenario provides the counterfactual model for the agricultural sector based on the findings of the Feasibility Study (Annex 2), which has analysed data on past climate change trends and future scenarios and climate risks.
- **Step 2. Develop cost parameters and assumptions for a portfolio of adaptation measures**: The second step requires developing the adaptation scenario by gathering cost and benefit parameters for the identified prioritised adaptation measures and consulting with key stakeholders to verify underlying assumptions. These parameters are also used to develop the bottom-up project budget presented in Annex 4.
- **Step 3. Prepare an economic and financial analysis of costs and benefits of proposed adaptation measures:** The third step involves calculating the net financial and economic costs and benefits incurred by implementing the proposed adaptation measures.

The financial analysis estimates the increase in net incremental income over the baseline (business as usual) scenario as a result of investments in adaptation packages to transform agricultural systems and increase resilience to climate change by smallholder farmers. Net incremental income is calculated as the difference between the input costs for agricultural activities and the resulting revenues.

Input costs per hectare for each crop are represented by the sum-product of

- The required production inputs (e.g., seeds, fertilizer, tools)
- The quantity of each input required per hectare
- The unit price of each input.

Revenues per hectare for each crop are represented by the sum-product of

- The yield per hectare
- The market price per unit.

$$NFB = \sum_{j}^{n} (p_j * q_j^{wp} - C^{wp}) * ha_j - \sum_{j}^{n} p_j * q_j^{np} - C^{np} * ha_j$$

Where:

- NFB= Net financial benefit in agriculture
- P_j= output price of crop j
- q_j^{wp} = yield per hectare of crop j in a *with project* situation
- C^{wp}= cost per hectare in *with project* situation
- ha_j = hectares of crop j
- q_j^{np} = yield per hectare of crop j in a *without project* situation
- C^{np}= cost per hectare in *without project* situation

This method assumes *ceteris paribus*, meaning that all other factors affecting agricultural production systems remains constant. Although in practice there is a dynamic behavior of family farmers in the management of productive systems in terms of practices, use of inputs, destination of production and technological advances, among others, it is considered that in the situation with project these variables remain fixed. Therefore, the differential of financial benefits is directly related to the productive increase that is generated by the greater productive capacity of agro-ecological systems adopted by family farmers.

Both costs and benefits are estimated considering market prices of inputs and outputs. The financial analysis includes the following assumptions:

- Financial discount rate of 20% without project (standard micro-credit lending rate)
- Financial discount rate of 10% with-project (estimate benefit of financial derisking, capacity building and financing facilitation activities in Component 2)
- Evaluation horizon of 6 years (period of GCF funding) and 20 years (estimated lifetime of agroforestry, woodland and silvopastoral investments)
- Gradual adoption of adaptation packages over the 6-year project period.

2. Financial and Economic Climate Impacts on the Agricultural Sector

2.1 Impacts on agricultural production and forest resources considered in the economic and financial analysis

2.1.1 Quantification of climate impacts in the financial analysis

As noted in the Feasibility Study (Annex 2), climate change is increasing the frequency and severity of drought events in Rwanda's Eastern Province while contributing to degrading the natural resources on which local population depend for adaptation. Projected impacts will further compound the already-fragile situation in these areas unless major adaptation actions are integrated in the way landscapes are managed and governed.

The financial analysis assumes that changes to growing conditions will lead to incremental reductions in agricultural productivity, and a resultant decrease in yield per hectare for selected crops, as indicated in the table below:

Table 1 - Estimated impact of climate change on crop production

Yield in kg/ha	% annual decrease due to soil / trees degradation
Tubers	1.5%
Peanuts	1.5%
Banana	1.5%
Beans	1.5%
Corn	1.5%
Fruit	0.5%
Firewood	2.0%
Service wood	2.0%

For forest areas, the financial analysis assumes that increased pressure to increase agricultural output in the face of climate change will lead to ongoing encroachment and over-exploitation of forest resources, an overall area decrease of 20% over the next 20 years compounded by a yield decrease (m^3/ha) of 30% for timber, service wood and firewood.

For silvopastoral systems, livestock grazing typically takes place on a mix of open and shaded pasture, where farmers can harvest and sell wood products. The financial analysis assumes that climate change-induced degradation of pastureland will require a 3% per annum increase in spending on additional livestock forage and nutriments to keep animals healthy. Nevertheless, average meat and milk yield are expected to decrease by 3% due to soil and forage degradation. At the same time, climate-induced encroachment and conversion of pasture into cropland will result in an 80% decrease in timber, service wood and firewood yields.

In boundary areas and buffer zones (roadsides, lake shores, national park boundaries), wood stocks per hectare are expected to decrease by 30% over the next 20 years as climate related pressures in other areas drive over-exploitation for timber, service wood and firewood. These decreased yields would be reflected in declining revenues for farmers who harvest wood products to supplement their on-farm incomes. In addition, declining fuelwood availability is expected in the business-as-usual scenario to increase the amount of fuelwood collection time spent by women and youth from 2.2 hours per day per ha in 2019 to 3 hours per day per ha in 2028. The opportunity cost of this time is calculated using a shadow price of USD 0.41, which is the hourly equivalent of Rwanda's annual per capita GDP (2019) of USD 820.

3. Summary of Evaluated Outputs

The projects outputs are designed to transform agricultural practices in Rwanda's Eastern Province to reduce vulnerability and enhance resilience in the face of climate change-induced hazards. The direct on-farm interventions are described in Outputs 1.1 – 1.5 below. In addition to direct financial support to help farmers overcome the up-front investment costs of climate resilient agricultural practices, GCF grant support will help farmers overcome information, capacity, policy and coordination barriers that hinder effective responses to climate hazards.

Output 1.1 Diversified agroforestry packages scaled-up

This intervention will address the lack of knowledge and capacities to implement climate resilient agroforestry landscape restoration practices and targets 100 sub areas (40,0000 ha) where soil erosion is prevalent. During project inception, potential intervention sites/plots will be selected through existing thematic maps and then prioritised based on community participatory mapping, plot characterisation (e.g. slope %) and farmer needs to ensure agroforestry packages are suited to specific context. Each sub area will have their own tree nursery and demonstration plot (1-2 ha each). 160 farmer groups will agree to sustain agroforestry systems (through an MOU and farming contracts with local authorities) and be trained on agroforestry techniques, enhanced management skills, markets linkages, and access to innovative financial services continued/scaled resilience investments and under Component 2. Support will promote practices that reduce farmers' vulnerability to crop losses caused by short-term and long-term climate change conditions and help them adopt diversified, climate resilient livelihood options. Specifically, the project builds on the existing Twigire Muhinzi system6 for effective and prompt dissemination of agroforestry knowledge and best practices on plant species. Plots will be registered in RWFA DFMP database. Regular monitoring, control, evaluation and knowledge sharing will be performed. Government staff, national and international agroforestry and landscape restoration experts will provide technical assistance in planting and management of resilient varieties. A list with suitable and resilient agroforestry species is compiled and included in Annex 1 in the Feasibility Study (Annex 2).

Output 1.2 Woodlots and tree plantations are rehabilitated and sustainably managed for productive and ecological services

This intervention will result in highly productive, climate-resilient woodlots and forestland with fully restored ecosystem services and significantly increased long term carbon sequestration. Recognizing that forest degradation contributes to erosion, increases evapotranspiration (with related water regulation impact) and decreased soil productivity, the objective of the proposed intervention is to protect local populations from livelihood loss from reduced productive capacity of woodlots and impacts of follow-on ecological service losses. Increased resilience will be achieved through a) rehabilitating the degraded smallholder woodlots within district / state owned forests while shifting from bad forest management practices to efficient, integrated and sustainable management systems and b) enhancing markets linkages, and access to innovative financial services continued/scaled resilience investments and under Component 2.

The increased woodlot productivity will support narrowing the supply and demand gap in wood biomass in the Eastern Province. The proposed intervention aims to restore 1,400 ha of very

[6] *Twigire muhinzi consist of extension system established and supported by the Rwanda Agricultural Board (RAB) across the country, where champion farmer promoters (1 per village) are trained and supported to (1) implement innovative good agriculture practices in its parcels serving as demonstration plots and to (2) train/advise/guide neighboring farmers in implementation of these goods practices.*

degraded district/state forests, to improve sustainable management of approximately 10,000 ha (50%) of State forest through long term concessions to private investors according to simplified management plans, and to identify (through community participatory mapping) and restore 6,545 ha (26%) of private smallholder woodlots to be managed (under MOU agreement with RWFA) by cooperatives of land owners who will be supported in becoming organized into FFPOs, with enhanced management skills, markets linkages, and access to innovative financial services under Component 2. Grant investments will be made available for FFPOs to manage more costly restoration actions (including anti-erosive ditches) in order to make their forest land management financially sustainable in the medium and long term. Forestry experts will also support i) district governments of Kayonza and Nyagatare and private owners to develop Simplified Forestry Management Plans (SFMP), ii) provide RWFA and Districts guidance on processes for long term concession of 10,000ha state owned forest, iii) ownership/demarcation conflict cases solving and management plan updating.

Output 1.3 Scale-up climate resilient silvopastoral packages to restore degraded rangelands

The objective of this intervention is to enhance the climate resilience of Eastern Province’s most drought-prone and degraded pastures and protect climate vulnerable pastoralist livelihoods. Food security and adoption of diversified, climate resilient livelihoods will be achieved through a) identification and characterization of climate resilient features of grazing land, designing silvopastoral plans integrated with the District Land Use Plan (under component 3) and up-scaling silvopastoral systems and adopting sustainable pasture management and b) enhancing market linkages and access to innovative financial services for continued/scaled resilience investments and under Component 2.

The current cattle stock levels in Eastern province are very high, leading to overgrazing and rangeland degradation. This work complements government strategy on shifting from high density (1.5 head/ha) involving Ankole cattle to low density (0.5 head/ha) with dairy cross breed cows adapted to the capacity of the land. This will increase incomes per hectare due to the high milk productivity of these cross-bred cows, while avoiding overgrazing. Synergies between cattle and trees mean that a combined system can produce more income than either system on its own. Silvopastoral systems will be designed to fit existing baseline activities and individual farmers’ needs by focusing more on forestry growth at some sites or sustainable cattle productivity in others. In particular, the project will increase the productivity of drought-prone pastures through the introduction of fodder trees, shrubs, grasses, and herbaceous legumes with high drought resilience potential to increase the climate adaptive capacity of the pasture lands and by promoting and training on resilient grazing management practices. Experts will support identification of knowledge gaps in management of rangelands for government extension service and farmer leaders. Experts will deliver awareness creation, promotion, training and technical assistance for species selection and acquisition, nurseries set up, management, planting and enterprise development.

Training of trainers will also be provided on management of grazing lands for climate resilient pasture productivity. To increase water security, the project will map and assess water availability and rainwater potential harvesting in 60 pastures and purchase 60 water tanks of 5,000 m^3 and construct 60 water troughs to reduce drought stress for the pastoralist communities.

Output 1.4 Protective restoration measures are scaled up to climate-proof fragile, ecologically sensitive and erosion prone lands

The objective of this proposed intervention is to climate-proof fragile, ecologically sensitive ecosystems and erosion prone areas upon which populations are dependent for ecosystem services, and increasing water demand from large scale irrigation projects, by scaling up protective restoration measures and addressing the lack of investment funds and access to climate resilient technologies. The aim is to protect or restore approximately 700 hectares of riverbanks, lakes or marshland shorelines, approximately 700 kilometres of roadside areas through activities such as tree planting and approximately 400 hectares of Akagera National Park buffer zone through natural regeneration and planting native species. Restoration activities will be coupled with community management approaches such as the establishment and support of Community Vigilance Committees (CVC), a participatory silvopastoral plan and community nurseries to ensure long term sustainability of interventions. National and international experts in protective restoration will provide technical assistance to RWFA to design required regulation for management and integrating climate resilience into the specific protected areas by the project as well as integrate new M&E in the DFMP database.

Output 1.5 Clean and efficient cooking energy technologies promoted through support to private sector and communities to transition/reduce biomass fuel consumption

This intervention will reduce pressure from biomass cooking fuel demand on forest and farmland tree resources in by raising household awareness of the differences between high and low efficiency stoves and by addressing the limited availability of high-efficiency stoves in rural markets (linked to access to attractive financial products and services to enhance affordability). This output will deliver a large-scale awareness campaign across the Eastern Province on selected improved cook stove (ICS) and cooking fuel solutions and opportunities. The output will also facilitate the access to ICSs for over 100,000 rural households, develop and establish subsidy/microcredit scheme and rules with local finance institutions and other economic actors and establish “cooking fuel and technology” hubs in 14 main local markets of TREPA intervention areas.7

Supporting private sector in biomass fuel / ICS business development and promoting the adoption of improved biomass cookstoves for rural farmers in the projects areas of intervention will contribute to sustainable biomass resource use and prevent overexploitation of forest resources thereby ensure the success of the forest landscape restoration activities described in Outputs 1.1 to 1.4 above.

Contribution of other Project Outputs

The outputs delivered under Component 2 and Component 3 are designed to improve the enabling environment for the on-farm climate resilience interventions described above, improve the financial viability of these measures, and ensure their long-term sustainability.
The success of the project and the adaptation efforts in Rwanda will largely depend on behaviour of communities, FFPOs and individual famers based on their perception of climate risk, paired with adaptive community organization, capacity building, and access to finance and other resources to incentivise land use transition. Therefore, Component 2 focuses on the

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[7] Different types of ICS will be promoted through local hubs distributed in rural areas (with sensitization/training/ face to face guidance) to better adapt ICS choice to the specific need and context of households (HHs), depending of the accessibility to firewood, pellet and/or crop residue in their area, and of the level of income which allow to afford different level of clean fuel and technologies. Through output 3.4, specific applied research will be implemented (see co-financing from DESIRA-EU) in order to support local ICS producers to improve prototypes and adapt them to the HH needs. Depending on HH income level, the ICS will be freely provided, partly subsidized or not subsidized, with possibility to access to micro-credit (specific product to be covered by output 2.3).

improvement of access to climate information, management of climate and other risks, and the enabling conditions in and around targeted agricultural and tree crop value chains, including finance. Meanwhile, Component 3 aims to effectively mainstream climate adaptation in national and sectoral strategies and to create an enabling environment for long-term and sustainable adaptation project results.

Under **Output 2.1** the project will strengthen Forest and Farm Producer Organizations (FFPOs) to actively represent member interests, to pool famer resources when adopting sustainable land use management practices, to jointly utilize data on climate risks with the aim to protect and improve their outputs in the long-term. The project will employ the Citizen Voice and Action (CVA) - a proven methodology to strengthen farmers capacity to conduct advocacy and improve social accountability by transforming dialogue between communities, government and private service providers.

The Feasibility Study showed that the general lack of technical and business skills, proper infrastructure, finance, and information remains among the principal challenges for improving climate resilience of agricultural and tree crop production and agribusinesses along the nodes of the associated value chains. Under **Output 2.2** the project further strengthen the FFPOs by identifying opportunities for marketing and value adding across a portfolio of targeted agricultural and tree crop value chains (seedling/nursery production, fruits, wood fuel, timber, and fodder, honey) for products originating from climate-resilient production systems in Component 1 but also beneficial to baseline activities in the Eastern Province. Further strengthening of FFPOs will increase their business and management capacity relevant for the targeted value chains and generating higher value added through enhanced infrastructure (processing facilities, machinery and equipment) and services (technical, business and financial).

Output 2.3 will enhance the long-term sustainability and financial viability of the project by linking smallholder farmers (in particular women and youth) operating in value chains of climate resilient agricultural and tree products to financial service providers.

Microfinance institution staff will be trained and supported to develop new financial products, develop indicators in credit assessment, establish monitoring systems and test and evaluate financial products. The financial service providers will be enabled to:

- Develop financial products, including savings, tailored to the needs of groups involved in targeted climate resilient activities,
- Develop financial products for FFPOs, farmers and other actors in value chains for agricultural and tree products (e.g., seedling/nursery production, fruits, wood fuel, timber, and fodder, honey), and
- Assess investment opportunities while incorporating analysis of climate resilient methods of agricultural production for mainstream/staple crops.

Furthermore, impact investors will be supported to engage in investment for SMEs in the relevant value chains and connect to insurance companies that can help de-risk agricultural production in areas exposed to climate hazards.

Output 3.1 will build the enabling environment necessary to design and implement climate risk-informed landscape (supporting Component 1) and livelihoods (supporting Component 2) restoration plans in seven Districts in the Eastern Province. Technical assistance will be provided to lead participatory approaches coupled with geo-spatial analysis landscape planning tools such as Restoration Opportunity Assessment Methodology (ROAM), which will ensure a robust process and inform restoration planning. Output 3.1 will also support collaboration between government and communities to define criteria and select primary target intervention areas to restore ecological functionality.

Output 3.2 will ensure the integration of climate-related data to contribute to climate-informed decision-making, monitoring and reporting for different sectors and at community, District and national levels. Training will be provided to staff from district agencies, RAB, RWFA, RLMUA and Meteo-Rwanda, on managing information systems and integrating climate-related aspects. Activities will facilitate the sustainability and scale-up of project results and will enhance monitoring of climate information and relevant climate-related indicators at landscape level.

Output 3.3 will address the limited knowledge of and access to climate-resilient planting materials that are adapted to future climate change scenarios. Interventions aim to design and establish a national-level program for up to 25 climate resilient priority species of fruit, food, fodder and timber species to improve the seed and seedling supply system and promote climate adaptation through access to high quality and climate resilient planting material. This intervention will also improve the capacity of local entities to supply germplasm for native and resilient wood tree species from local sources. The project will develop incentives and develop business models for local fruit nursery accreditation systems to produce the 'right materials for the right place' and avoid pest and disease problems due to prolonged drought periods.

Output 3.4 will promote good practices and scaling up of climate-resilient strategies that will be built on robust evidence regarding their effectiveness to address climate risks. The intervention aims to improve inter-agency knowledge about the role of agroforestry systems and practices to contribute to the restoration of degraded agricultural land and build climate resilience.

4. Financial Analysis

4.1 Summary of Financial Results

The financial rate of return is calculated separately for each major intervention in Component 1. The measures are not perfectly separable in that many farmers may engage in multiple activities covered by the project. The costs and benefits are calculated based on the activities undertaken in the same geographic areas in the baseline scenario.

Note also the contribution made by the activities in Components 2 and 3 to the success of Component 1. In particular, Component 2 addresses the financial barriers that might prevent farmers from investing in resilience activities. The project aims to diversify and enhance the variety of financial services for farmers engaged in different project activities. The project will facilitate both group and individual loan services. The loan terms will vary depending on the crops, size of farmer groups, resilience technology, past credit history, and source of capital that the MFI is accessing to service the farmers. These will be the result of commercial agreements between the farmers/groups and MFIs – GCF funding will not cross-subsidize these loans or interest rates.

Given the broad spectrum of parameters, the financial analysis does not directly model the impacts of these different types of loans. Instead, the financial analysis assumes that these resilience measures are possibly in large part as a result of having access both to technical assistance and to greater and more affordable access to credit.

Financial returns are calculated (1) assuming business-as-usual, (2) assuming the project investments are made directly by farmers without external support, and (3) assuming GCF support and co-financing. Note that scenario (2) is considered highly unlikely, in that the project will provide considerable capacity building and support to strengthen the enabling environment. Scenario (2) assumes farmers will spontaneously overcome the information, capacity, policy and coordination barriers that hinder climate action. Furthermore, it assumes that farmers will find the means to implement these measures independently, perhaps by taking out commercial loans, when there is no evidence of this happening in reality. The estimated financial returns in Scenario (2) therefore represent the most extreme optimistic case of what is possible without GCF support.

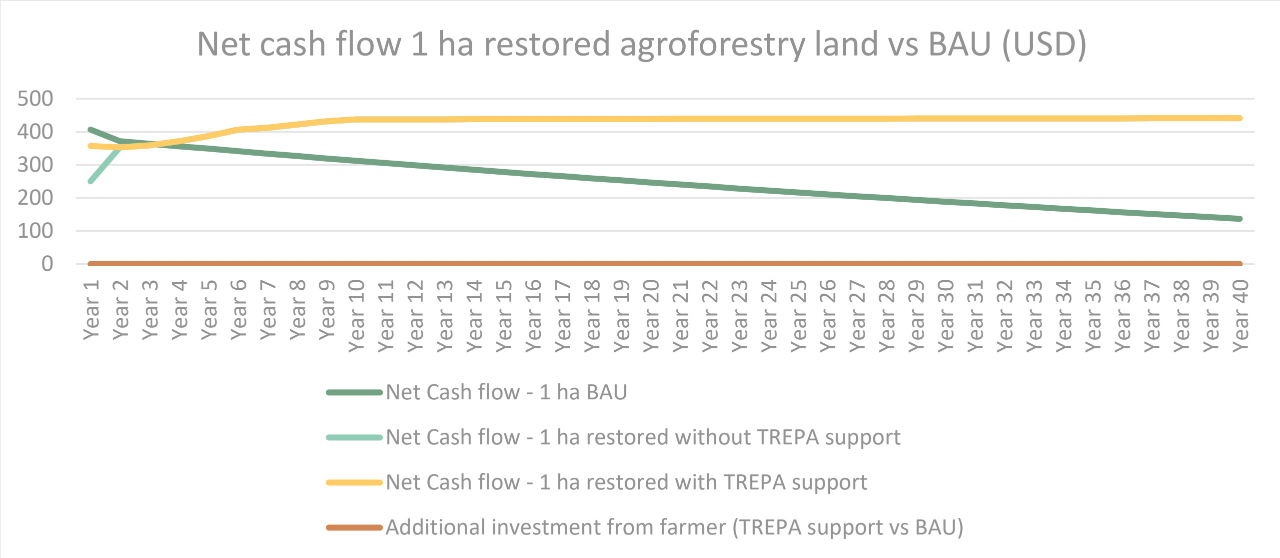
The financial analysis for each output is calculated from the private perspective using a discount rate of 15.28%. This rate was chosen by using the most recent documented interest rate on bank deposits[8] and multiplying by 2 to reflect inherent risks of agricultural activities. While most loans to farmers will have a tenor between 1-5 years, the financial analysis considers the full life of agroforestry and other landscape restoration investments. The discount rate is intended to capture the time element of risk in such an analysis. For example, a promised payoff of USD 100 in 20 years has a net present value of less than USD 6 using the 15% discount rate in this analysis.

The financial analysis for **Output 1.1 (agroforestry)** evaluates the costs and benefits of resilient agroforestry-based land restoration versus business as usual (BAU). The GCF investment case yields a lower per-hectare NPV than business-as-usual (BAU) over the initial 6-year implementation period but remains positive. With-project NPV becomes higher than BAU over 10 and 20 years as the long-lived agroforestry investments bear fruit. for agroforestry measures to generate a flow of revenues. The simple payback time for the additional up-front investments in the GCF TREPA scenario is 6 years.

[8] The World Bank lists the 2019 bank deposit rate as 7.64% https://data.worldbank.org/indicator/FR.INR.DPST?locations=RW

Table 2- Financial analysis Output 1.1

Climate resilient agroforestry	6 years	10 years	20 years
NPV - BAU	1,389.73	1,782.53	2,121.90
NPV - restored without TREPA support	1,291.06	1,804.70	2,329.77
NPV - restored with TREPA support	1,383.79	1,897.44	2,422.50
NPV - Net cash flow Increment (TREPA support vs BAU)	-5.94	114.90	300.60
IRR - Increment TREPA support vs BAU	12%	38%	43%



For **Output 1.2 (sustainable forest management),** the financial analysis examines the NPV and IRR for multiple restoration scenarios:

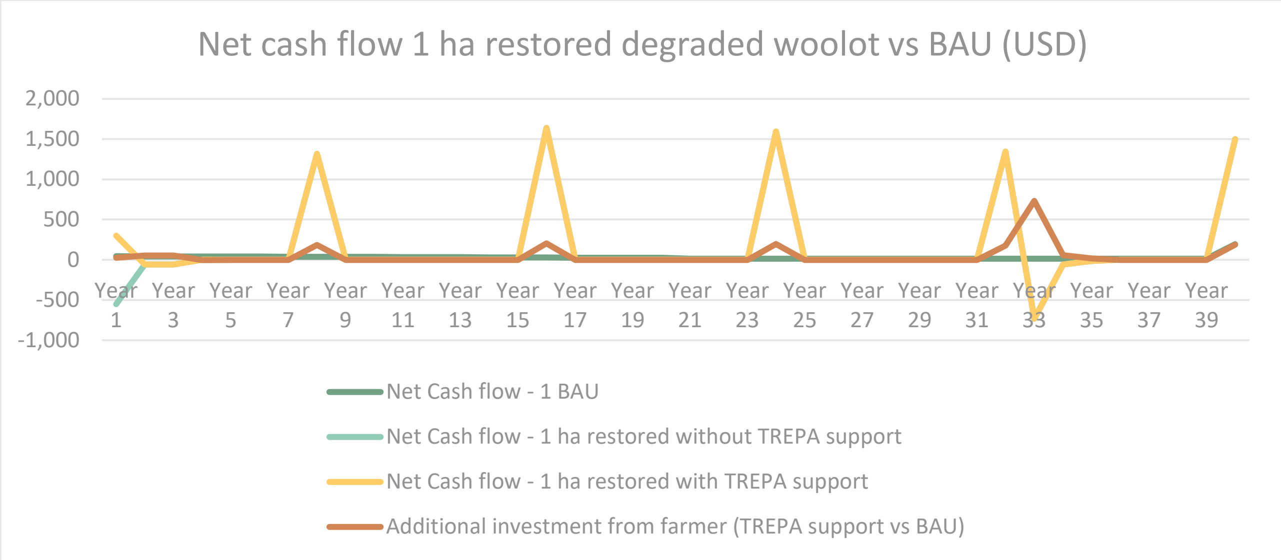
a) Restoration of 1 ha of degraded small-holder woodlot
b) Farmer family scenario with 0.5 ha of agroforestry land (including crops, fruit, fodder and wood) 0.25 ha of woodlots, and adoption of an improved cook stove (ICS)
c) A small holder forest cooperative of 100 ha (around 200 land owners) restored from year 2 to 6 (in average 20 ha per year) and set under management plan
d) Restoration of 1 ha of very degraded State forest
e) Restoration of 1 ha of very degraded State forest
f) Restoration of a State forest FMU concession of 10,000 ha, with 700 ha very degraded restored with TREPA support from year 3 to 5 and the remaining 9300 ha restored from year 3 to year 9 by a private contractor

For scenario (a) TREPA support overcomes the initial costs of restoration activities, and leads to increased cashflows during the initial clearing and during periodic woodlot rotations. As a result, NPV is higher than BAU for all periods.

Table 3 Financial analysis Output 1.2 (scenario a)

1 ha of restored degraded Small-holders woodlot	6 years	10 years	20 years
NPV - BAU	155.63	199.90	235.75
NPV - restored without TREPA support	-558.77	-136.56	31.96
NPV - restored with TREPA support	176.66	598.87	767.39

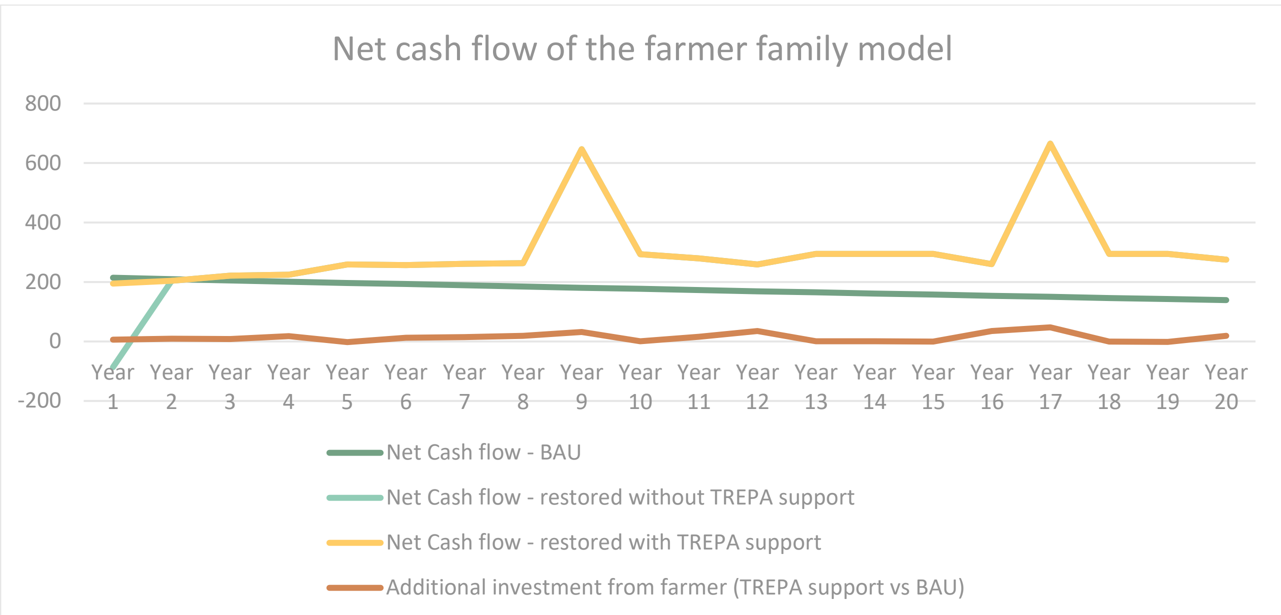
NPV - Net cash flow Increment (TREPA support vs BAU)	21.03	398.97	531.65
IRR - Increment TREPA support vs BAU	10%	N/A	N/A



The farmer family scenario (b) provides an illustration of how various project activities combine to smooth out dips and peaks in farmer income. In this scenario, with-project NPV is higher than BAU over all periods of analysis.

Table 4 Financial analysis Output 1.2 (scenario b)

Farmer family with 0,5 ha of agroforetstry land (including crop, fruits, fodder and wood), 0,25 ha of woodlot and using ICS	**6 years**	**10 years**	**20 years**
NPV - BAU	**6 years**	**10 years**	**20 years**
NPV - restored without TREPA support	771.03	993.14	1,185.00
NPV - restored with TREPA support	586.81	1,018.67	1,390.25
NPV - Net cash flow Increment (TREPA support vs BAU)	830.78	1,262.64	1,634.22
IRR - Increment TREPA support vs BAU	59.74	269.50	449.22

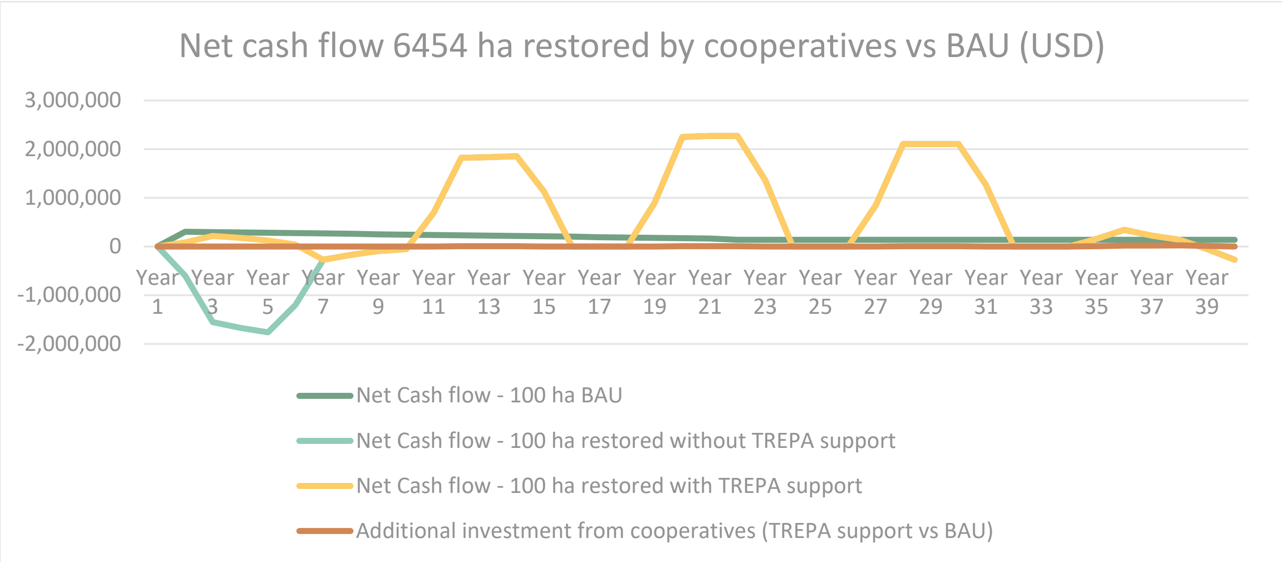


Scenario (c) compares the costs and benefits of restoration of 100 ha by a small holder forest cooperative. While each parcel must be protected during the restoration period, the cooperative undertakes this work progressively over a period of 6 years. In this way, farmers are able to continue collecting wood from other parcels, thereby reducing the short-term financial impact of this initiative.

NPV remains positive in the with-project scenario for all periods of analysis, albeit lower than BAU during the initial 6-year and 10-year timeframes. With-project cashflows dramatically outpace BAU after Year 11, as the restored forest is much more productive than the degraded baseline situation.

Table 5 Financial analysis Output 1.2 Scenario (c)

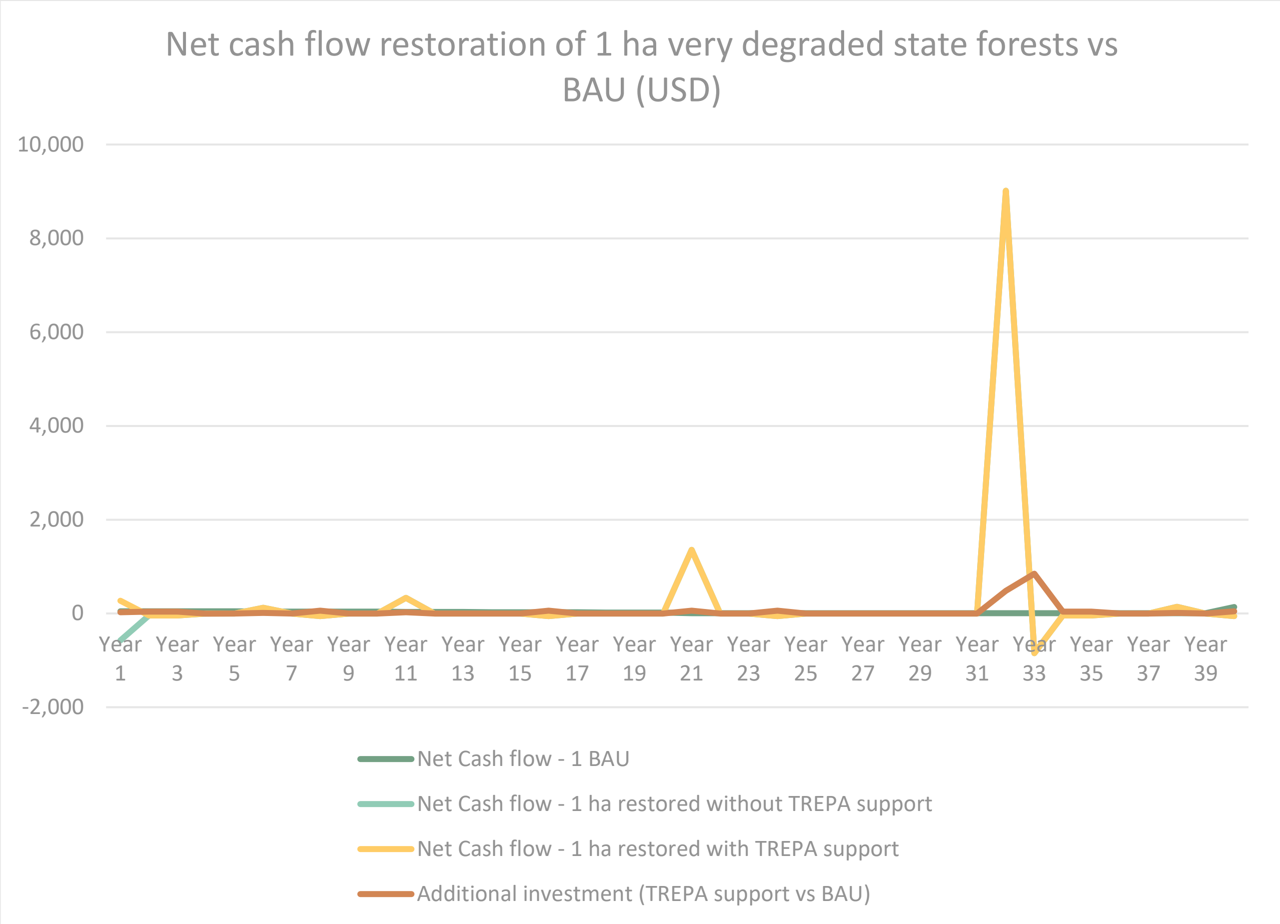
A small holder forest cooperative of 100 ha (around 200 land owners) restored from year 2 to 6 (in average 20 ha per year) and set under management plan	6 years	10 years	20 years	40 years
NPV - BAU	845,419	1,157,824	1,414,093	1,465,687
NPV - restored without TREPA support	-3,784,479	-3,978,503	-2,634,357	-2,228,217
NPV - restored with TREPA support	384,012	189,988	1,534,134	1,940,274
NPV - Net cash flow Increment (TREPA support vs BAU)	-461,408	-967,836	120,041	474,587
IRR - Increment TREPA support vs BAU	N/A	N/A	17%	20%



Scenario (d) evaluates the restoration of 1 hectare of very degraded State forest land from the farmer perspective. While restoration without TREPA support is financially unattractive, the with-project scenario has positive NPV across all timescales. With-project NPV is marginally lower than BAU over the 10 year period due to the timing of forest management activities, but higher in all other periods. Note that these are long-term investments; the normal rotation period for State forests is 32 years, leading to a sharp increase in revenues in the with-project scenario at this point. As noted, however, the high discount rate dramatically reduces the present value of that future income.

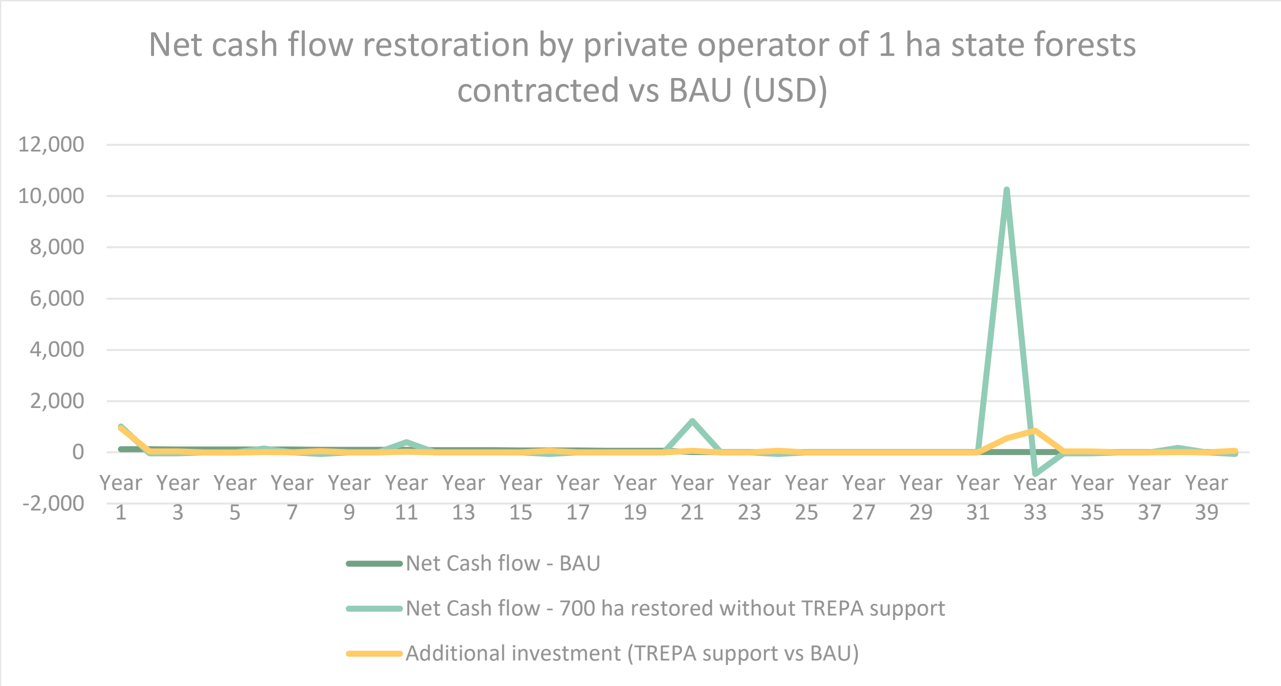
Table 6 Financial analysis - Output 1.2 (scenario d)

1ha of very degraded State forest restored	6 years	10 years	20 years	40 years
NPV - BAU	172	218	251	253
NPV - restored without TREPA support	-508	-527	-463	-309
NPV - restored with TREPA support	228	209	273	426
NPV - Net cash flow Increment (TREPA support vs BAU)	56	-9	21	173
IRR - Increment TREPA support vs BAU	N/A	17%	11%	N/A



In Scenario (e) the project provides technical support and capacity building to facilitate the restoration of degraded state forest by private small contractors. The contractor can earn income in Year 1 from the sale of cleared shrubs and stumps, and then earns income during 10-year rotations. As a result, NPV is higher in the project scenario than BAU over each time period.

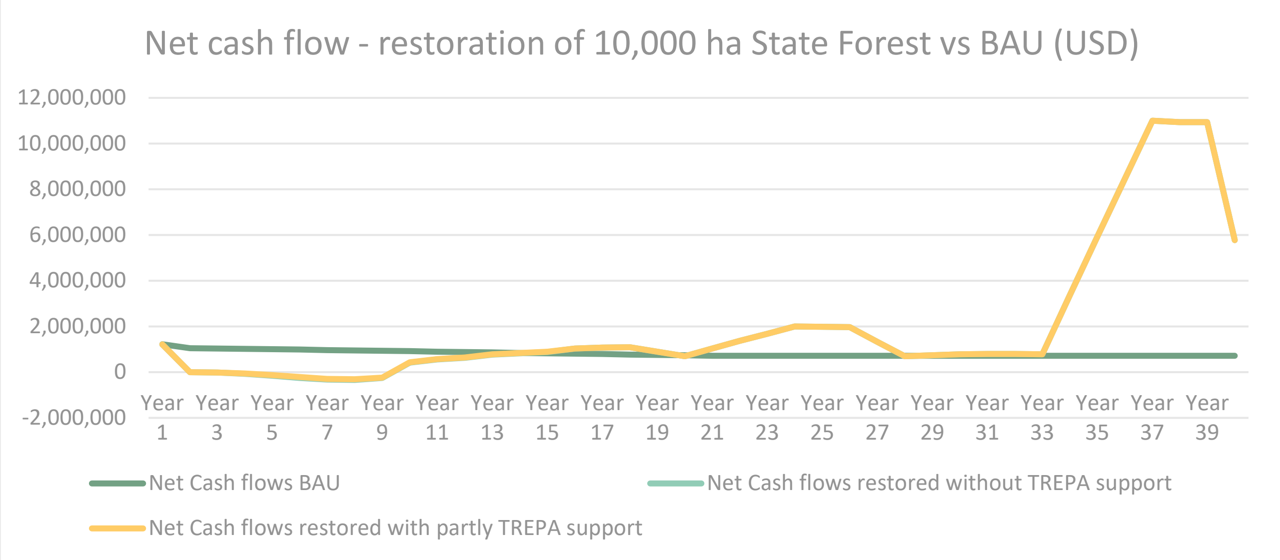
1 ha of State forest contracted to and restored by a private forest operator	6 years	10 years	20 years	40 years
NPV - BAU	432	553	648	652
NPV - 1 ha restored without TREPA support	874	855	931	1,092
NPV - Net cash flow Increment (Restored vs BAU)	442	302	283	440
IRR - Increment Restored vs BAU	-23%	2%	6%	N/A



Scenario (f) examines the costs and benefits of restoration of a state forest concession restored through a mixed management approach. Of the 10,000 ha area covered by the project, 700 ha of very degraded forest would be restored with TREPA support and the remaining 9300 ha restored privately by the contractor. NPV in the project mixed management scenario remains positive throughout the period of analysis but is lower than BAU in all periods. As noted in the Feasibility Study, demand for wood in Eastern Province is estimated at 1.65 million m^3/year while the current sustainable supply capacity of overall forest, shrubland and agroforestry tree resources is only approximately 0.53 million m3/year. The forest restoration activity is profitable for farmers and private actors, but less profitable than illegal overexploitation of forest resources.

Table 7 Financial analysis - Output 1.2 (scenario f)

State forest FMU concession of 10,000 ha, with 700 ha very degraded restored with TREPA support from year 3 to 5 and the remaining 9300 ha restored from year 3 to year 9 by the contractor	**6 years**	**10 years**	**20 years**	**40 years**
NPV - BAU	4,013,447	5,156,074	6,158,923	6,415,856
NPV - 1 ha restored without TREPA support	825,233	627,078	1,585,790	2,310,104
NPV - 1 ha restored with partly TREPA support	863,879	693,740	1,662,282	2,386,596
NPV - Net cash flow Increment (TREPA support vs BAU)	-3,149,568	-4,462,334	-4,496,640	-4,029,259
IRR - Increment TREPA support vs BAU	N/A	N/A	N/A	6%



Note also that the forest restoration activities described in Output 1.2 generate large and positive externalities beyond ensuring sustainability of supply and enhancing livelihoods:

1. Increased resiliency of the woodlots to climate impacts through sustainable forest management practices.
2. Improved climate resiliency of forests that will reduce topsoil erosion, improve water quality; protect source water; and ensure uninterrupted water supply for household needs, drinking and irrigation (Wilson and Lovell, 2016. Garrity *et al.*, 2010).
3. Reduced stormwater runoff resulting in flood risk mitigation (e.g. Matthews et al. 2004; Ranieri *et al*. 2004).
4. Increased carbon sequestration in soil and forest biomass.

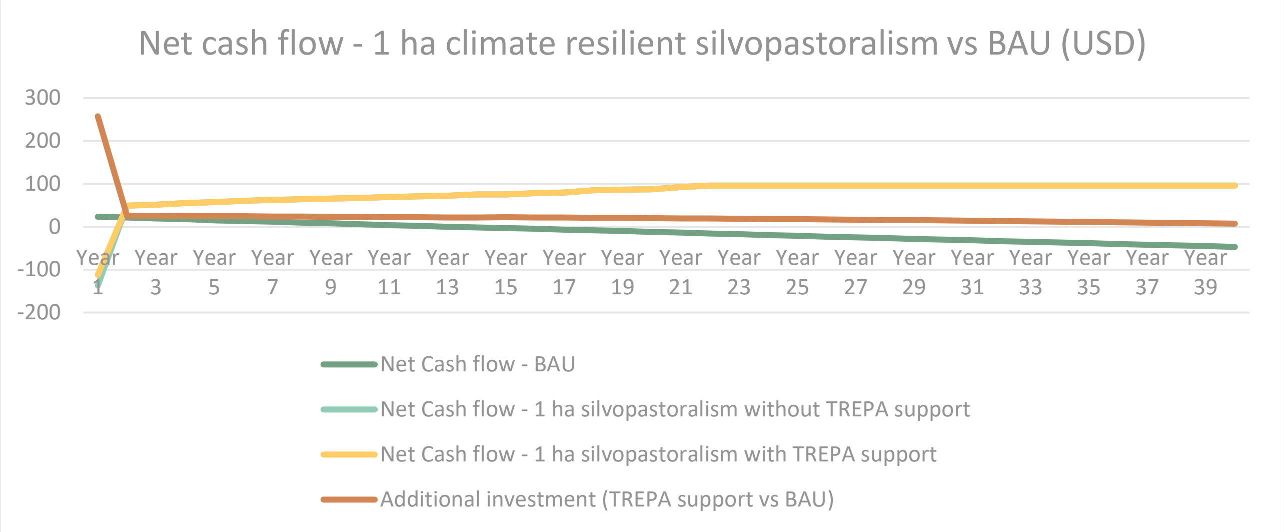
These benefits, while significant, are not captured by the farmers who restore the forests and collect wood and are therefore not included in the financial cost-benefit analysis.

As indicated in the analysis above, most of the climate resilient forest restoration activities present better returns than BAU, and even the ones that do not present positive financial returns for participating farmers over all periods of analysis.

For **Output 1.3 (silvopastoralism)**, investments in resilience activities would yield a negative per-hectare NPV over 6- and 10-year timeframes. GCF support results in a positive financial return for farmers over all timeframes, although lower than BAU during the 6- and 10-year periods as a result of high up-front investment costs on the part of participating farmers.

Table 8 Financial analysis - Output 1.3

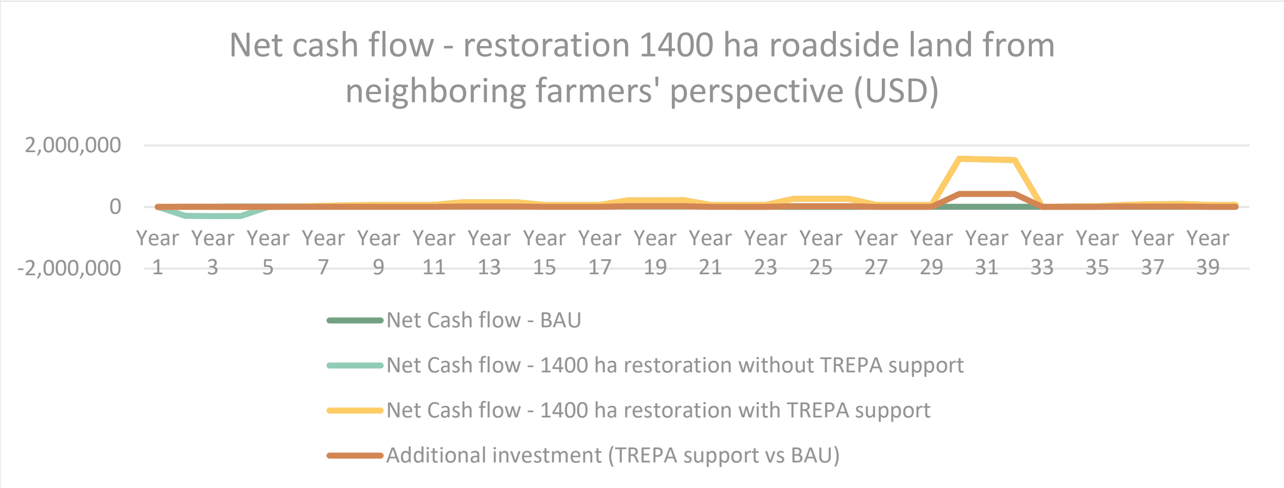
Silvopastoralism	6 years	10 years	20 years	40 years
NPV - BAU	72.02	83.00	80.51	72.16
NPV - 1 ha restored without TREPA support	36.66	114.77	205.47	239.73
NPV - 1 ha restored with TREPA support	58.35	136.45	227.16	261.42
NPV - Net cash flow Increment (TREPA support vs BAU)	-13.67	53.46	146.65	189.26
IRR - Increment TREPA support vs BAU	11%	25%	31%	31%



Output 1.4 focuses on restoring forest and woodland along roadsides and riversides, and in the Akagera National Park Buffer Zone. For the roadside and river / lake shore resoration activities, GCF investment mean that climate resilient restoration activities yield net financial benefits over all periods of analysis. During the initial 6-year period NPV is lower than BAU, and becomes significantly higher in subsequent periods.

Table 9 Financial analysis - Output 1.4 (Roadside, river & lake shore)

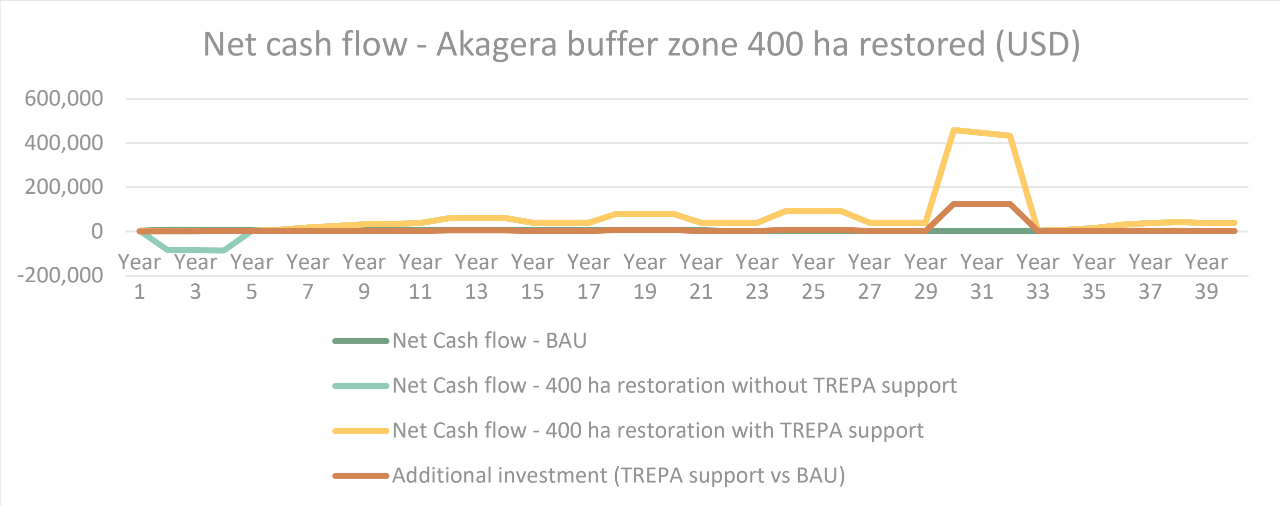
Roadside and river / lake shore 1400 ha	6 years	10 years	20 years	40 years
NPV - BAU	40,972	55,040	68,782	71,544
NPV - 1400 ha restored without TREPA support	-560,841	-494,508	-344,959	-250,413
NPV - 1400 ha restored with TREPA support	18,759	85,093	234,642	329,187
NPV - Net cash flow Increment (TREPA support vs BAU)	-22,213	30,053	165,860	257,644
IRR - Increment TREPA support vs BAU	N/A	36%	49%	49%



For the Akagera buffer zone activity financial returns are positive for every period of analysis. Project returns are lower than BAU for the 6- and 10- year periods, and higher thereafter. These results are indicative of the degree of overexploitation of resources in the base case and the investment in time and resources required to restore forest productivity.

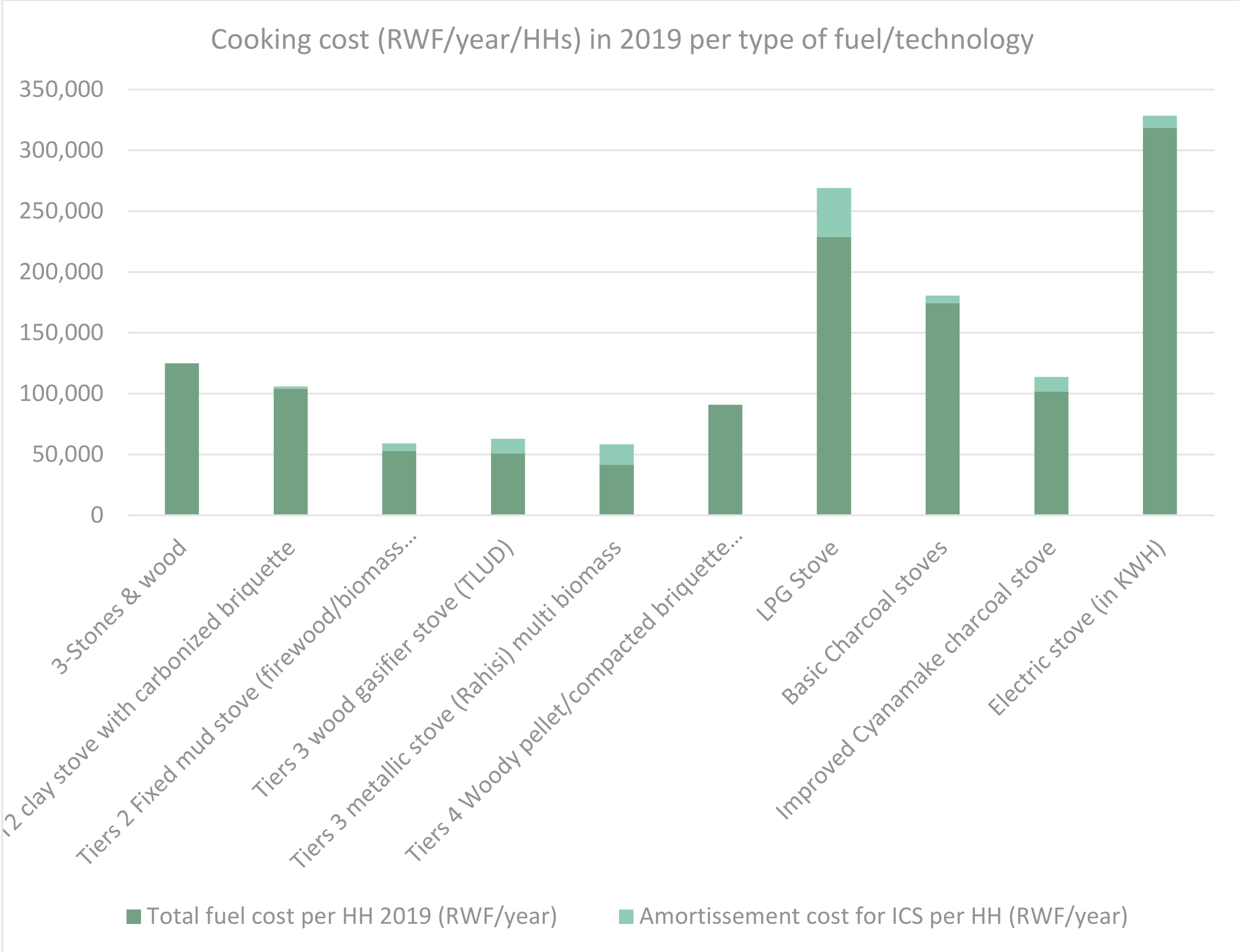
Table 10 Financial analysis - Output 1.4 (Akagera)

Akagera buffer zone 400 ha	6 years	10 years	20 years	40 years
NPV - BAU	26,277	35,713	44,690	45,612
NPV - 400 ha restored without TREPA support	-160,353	-128,292	-62,759	-29,797
NPV - 400 ha restored with TREPA support	11,818	43,880	109,413	142,375
NPV - Net cash flow Increment (TREPA support vs BAU)	-14,458	8,167	64,723	96,763
IRR - Increment TREPA support vs BAU	N/A	25%	40%	41%



In each climate resilience scenario, GCF investment makes the project interventions more financially attractive for farmers, forest harvesters and pastoralists, than would be the case if the measures were undertaken without GCF support. GCF support provides incentives for long-term sustainability beyond the implementation phase.

Finally, the financial analysis is used in Output 1.5 to identify the technological interventions that will be used to reduce the use of biomass fuel for cooking and thus reduce reliance on climate sensitive forest resources. The interventions in Output 1.5 are complementary to the measures in Outputs 1.1 – Output 1.4, in that they reduce demand for fuelwood and thereby reduce the demand-supply imbalance that must be addressed by the on-farm resilience activities. These efficiency measures are presented as a separate Output because the nature of the interventions is qualitatively different than for the on-farm resilience activities. Here, the BAU scenario is continued use of traditional 3-stone fires and inefficient charcoal stoves. Project activities are focused on promotion of improved stoves, with subsidies provided only for the poorest households. Affordability is ensured by facilitating access to short term credit, buttressed by the financial and time savings that come from adoption of ICSs.



Since most households will have to make the investment themselves, simple payback period is the critical financial measure for this analysis. The results identify four stove types where the initial investment plus ongoing fuel costs make financial sense for unsubsidized households, meaning they will recoup their initial investment within the lifetime of the product. On the other hand, two improved stove types (LPG and electric) are not cost-effective and will not be promoted by the project because poor households would never recoup their initial investment based on typical usage patterns without subsidies.

Table 11- Payback analysis for efficient stoves in Output 1.5

Payback period: Tier 3 wood gasifier stove (TLUD) without TREPA, years	0.2
Payback period: Tier 3 metallic stove (Rahisi) multi-biomass without TREPA, years	0.3
Payback period: Tier 4 Woody pellet/compacted briquette gasifier stove without TREPA, years	0.0
Payback period: LPG Stove without TREPA, years	NA
Payback period: Improved Cyanamake charcoal stove without TREPA, years	1.4
Payback period: Electric stove without TREPA, years	NA

5. Economic Analysis

An economic analysis of the project was performed to assess the net incremental benefits the project yields for society. The economic analysis compares costs and benefits in the counterfactual (business-as-usual) scenario versus the costs and benefits that accrue in the improved (with-project) scenario.

The analysis considers two types of benefits: (1) marketable benefits that come from avoiding climate change related losses and increasing production in climate resilient agricultural systems, and (2) non-market benefits that result from the provision of ecosystem services as a result of project activities. Since most of these ecosystem services represent public goods, they are not captured by markets and are not usually included in farmers' decision-making processes.

5.1 Marketable Benefits from Outputs 1.1 - 1.5

The incremental economic benefit from agriculture comes from a cost-benefit analysis, which considers the increase in production in climate resilient agricultural systems, comparing the situation with and without project. It considers the same methodology and assumptions that are specified in the financial analysis, but with the difference that the full costs of project implementation are included, as are societal benefits that might not be captured by individual farmers. These costs include GCF investment, co-finance from partners and Government during the project period as presented in Annex 4 (Detailed Budget Description). It also includes continued Government financial support for the remainder of the 20-year investment lifetime[9].

Project benefits include the cumulative net financial benefits for participating farmers compared to business-as-usual, as well as financial benefits for improved cook stove manufacturers / retailers, and non-financial benefits like the value of time savings and environmental protection.

The net present value (NPV) of the project-level investment is calculated using a discount rate of 12.1%. This figure represents the Rwanda Central Bank interest rate for a 10-year Treasury bill, as of September 2020[10]. The use of the Government bond rate is justified as this is the rate at which the Government would have to borrow to fund equivalent investments in the absence of grant financing. The sensitivity analysis is performed using alternative discount rates of 8% and 20% (the latter being higher than the average commercial borrowing rate).

The project return varies depending on the period of analysis. The figures below present the NPV and Economic Internal Rate of Return (EIRR) for the 6-year implementation period, and for an estimated 20-year investment lifetime. Given the project's focus on long-term agroforestry, landscape restoration and silvopastoralism activities that often last for 40 years or more, the 20-year investment lifetime is considered most appropriate for this analysis.

The cost-benefit analysis spreadsheet (Annex 3) presents these calculations in detail, with the results summarized below:

[9] These are commitments that the Government of Rwanda has made as a result of the planned project activities, and therefore represent an opportunity cost for the Government.

[10] Source: https://www.bnr.rw/browse-in/financial-market/money-market-interest-rates/monthly-interest-rates/

Table 12 - Summary - Economic Costs & Benefits

Direct Project Costs (USD) - including GCF costs, cofinance, ongoing post-project expenditure (and excluding -30% taxes paid on staff)	6-YEAR TOTAL	20-YEAR TOTAL
Total Direct Costs (USD)	**- 49,716,472**	**- 80,168,769**
Marketable Project Benefits (USD) - direct - attributed to Component 1	**6-YEAR TOTAL**	**20-YEAR TOTAL**
Total Marketable Benefits - direct (USD)	**8,420,724**	**205,793,387**
Nonmarketable GHG Benefits (USD) - direct - attributed to Component 1 outputs	**6-YEAR TOTAL**	**20-YEAR TOTAL**
Total GHG Benefits (USD), direct	**52,312,744**	**386,538,582**
Time savings - fuelwood collection	**43,332,201**	**163,847,414**
SUMMARY	**6-YEAR TOTAL**	**20-YEAR TOTAL**
Net Benefit, direct (marketable)	- 48,348,397	103,681,161
Net Benefit, direct (marketable + non-marketable)	47,296,548	654,067,157

Net present value and economic internal rate of return are presented below:

Table 13 - ENPV and EIRR summary

Economic returns, Discount rate 12.1%		
Direct, marketable benefits only	6 Years	20 Years
NPV	-35,435,968	-6,575,924
EIRR	N/A	10.1%

When only marketable benefits are considered, project NPV is negative over the 6-year and 20-year timeframes. As noted in the financial analysis discussion, the agroforestry, silvopastoralism and forest management outputs require up-front investments that take between 10 and 30 years to mature fully. These future benefits are depressed by the use of a high discount rate that downplays the importance of long-term investments. In addition, the direct marketable benefits are presented in comparison to baseline revenues that result from severe overexploitation of forest resources.

5.2 Non-Market Benefits from Ecological Services

Key non-market benefits from the project include the following:

1. Reduced topsoil erosion[11];
2. Improved water quality;

[11] Karamage, et. al. 2016. Extent of Cropland and Related Soil Erosion Risk in Rwanda. *Sustainability* **2016**, *8*, 609; doi:10.3390/su8070609

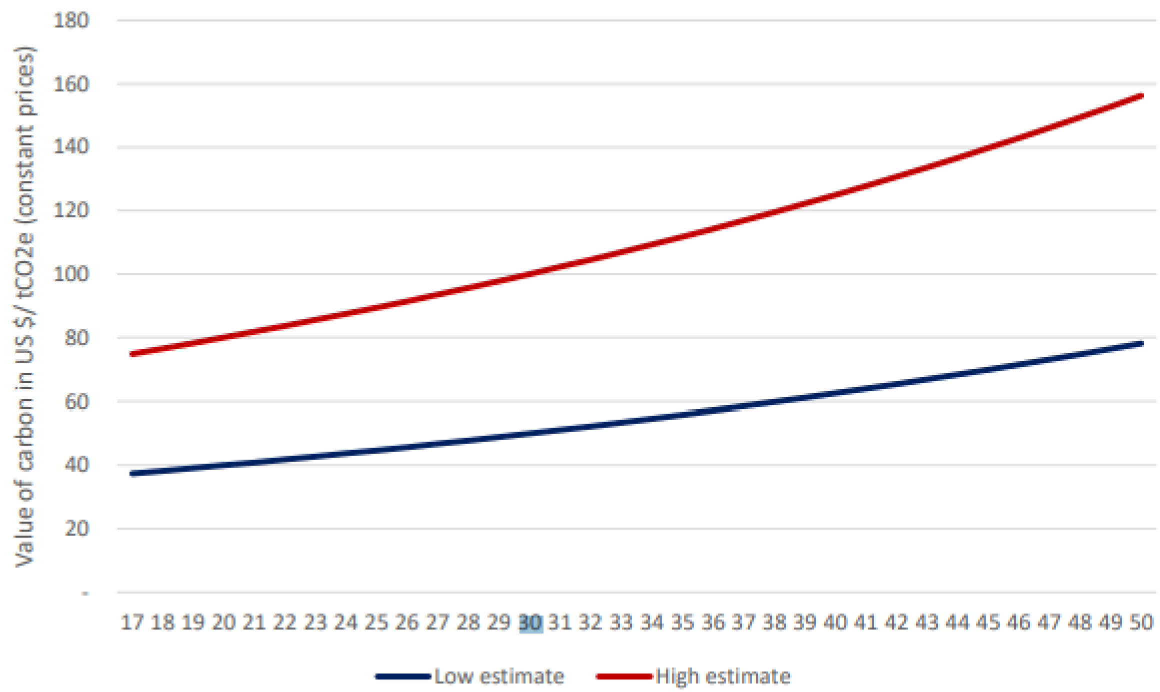
3. More reliable water supply for household needs, drinking and irrigation (Wilson and Lovell, 2016. Garrity *et al.*, 2010);
4. Reduced stormwater runoff resulting in flood risk mitigation (e.g. Matthews et al. 2004; Ranieri *et al*. 2004);
5. Time savings, especially for women and girls who traditionally collect fuelwood;
6. Increased carbon sequestration in soils and trees;
7. Reduced GHG emissions from the use of non-renewable biomass as a cooking fuel.

Non-market benefits are valued using shadow prices that attempt to reflect the amount that people would have to pay to obtain an equivalent benefit via the market. In Rwanda, there is limited research about the economic costs of soil erosion, water quality and availability and flood risk. These non-market benefits result from improved agricultural and forest management practices, which also result in reduced forest degradation and increased adoption of agroforestry and silvopastoralism. Therefore, this analysis conservatively uses the social value of carbon sequestration as a proxy for all of these benefits. This approach is reasonable because climate change related weather impacts exacerbate the challenges of soil erosion and water quality, forest degradation, water availability and flood risk. The social cost of carbon is a shadow price that captures the combined impacts of climate change on ecosystem services.

As indicated in the World Bank's 2017 guidance note on the shadow price of carbon in economic analysis[12], a low estimate of the shadow price would be between USD 40 and USD 75 per tCO_2e in 2020, rising to between USD 63 and USD 125 per tCO_2e in 2040. However, these figures are global estimates, and the guidance note acknowledges that there may be considerable variation between countries. To ensure conservatism, this analysis uses the low-value of USD 40/tCO2e and holds this figure constant for the 20-year lifetime of the investment.

[12] *Guidance note on shadow price of carbon in economic analysis (English)*. Washington, D.C. : World Bank Group. http://documents.worldbank.org/curated/en/621721519940107694/Guidance-note-on-shadow-price-of-carbon-in-economic-analysis

Figure 1 - Recommended shadow price in USD per 1 metric tonne CO2 equivalent (constant prices)



Year	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
Low	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53
High	75	77	78	80	82	84	86	87	89	91	94	96	98	100	102	105	107

Year	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
Low	55	56	57	58	60	61	63	64	65	67	68	70	71	73	75	76	78
High	109	112	114	117	120	122	125	128	131	134	137	140	143	146	149	153	156

Carbon sequestration is associated with each of Outputs 1.1 through 1.4. As noted previously, the promotion of clean and efficient cooking energy technologies is intended to reduce the demand for fuelwood and thereby contributes to the sequestration totals presented in the other Outputs.

GHG sequestration figures are estimated according to the following methodology:

The “above ground” volume has been converted into tonnes of CO_2 sequestered as follow: one m^3 of woody biomass standing above the ground is equivalent to:

- 1 m^3 above ground = 1 x (1+0.29) = 1.29 m^3 above and underground woody biomass, using the **root-shoot ratio of 0.29**[13]
- 1.29 m^3 woody biomass = 1.8 x 0.5075 tonne / m^3 = 0.655 tonne of dry woody biomass (average **oven dry wood density of 0.5075** ton/m^3)[14];
- 0.655 tonne of dry woody biomass = 0.655 x 0.5 = 0.327 tonne of carbon (**1 tonnes of dry wood = 0.5 tonnes of carbon**[15]); and finally
- 0.327 tonne of carbon = 0.327 x 3.67 = circa 1.2 tonne of CO_2 sequestered (**1 tonne of carbon = 3.667 tonne of CO_2**).

The aggregated conversion factor is therefore: <u>1 m^3 of woody biomass above the ground is associated to 1.2 tonne of CO_2 sequestered.</u>

[13] 0.29 according to the IPCC table 4.4 (internationally accepted default value

[14] “Allometric equations, wood density and partitioning of aboveground biomass in the arboretum of Ruhande, Rwanda”, *Trees, Forest, People* (3) 2021. https://www.sciencedirect.com/science/article/pii/S2666719320300509

[15] 50% is the IPCC default value for carbon content of dry biomass. https://www.ipcc-nggip.iges.or.jp/public/gpglulucf/gpglulucf_files/Chp3/Chp3_2_Forest_Land.pdf

Outputs 1.1 – 1.4 support the restoration of degraded forest land and increased tree density on farm and pasture land. Meanwhile, Output 1.5 reduces the use of non-renewable biomass by replacing inefficient traditional cook stoves with more efficient models.

Total carbon sequestration / emission reduction over these five outputs is presented below:

Table 14 - Value of ecosystem benefits from project activities

	6 year total	20 year total
Direct carbon sequestration / emission avoidance, tCO2e	1,307,819	9,663,465
Value at USD 40/tCO2e	52,312,744	386,538,582

Time savings

Output 1.5 generates non-marketable benefits in the form of time savings. Under BAU, women and girls are expected to spend approximately 2.2 hours per day on fuelwood collection. According to the WB, 2019 per capita GDP in Rwanda was USD 820, equivalent to USD 2.25 per day. Valued at the USD 2.25/day shadow cost of time, this yields a BAU implicit cost of USD 226 per year spent on fuelwood collection per household. In the with-project scenario traditional stoves with an estimated efficiency of 16% are replaced with improved varieties at 40% efficiency, yielding a 60% reduction in fuelwood consumption. The adoption of improved cook stoves therefore is expected to reduce fuelwood collection time by 60.2 days per year, with an implicit value of USD 135 per household.

The analysis assumes that the project's 100,000 ICS are adopted over the first four years of the project, and that adoption falls by 5% each year after the GCF funding period ends.

Table 15 - Non-marketable benefits - time savings

Other non-marketable benefits	*6-YEAR TOTAL*	*20-YEAR TOTAL*
Time savings - fuelwood collection	43,332,201	163,847,414

The combined value of non-marketable benefits is indicated below:

Table 16 - Combined value of non-marketable benefits

Total value of non-marketable benefits	*6-YEAR TOTAL*	*20-YEAR TOTAL*
	95,644,945	550,385,996

5.3 Total Economic Benefits

Combining the non-market benefits from ecosystem services dramatically changes the cost-benefit ratio for the project. Project NPV shifts from negative when only marketable benefits are considered, and become strongly positive for the 6- and 20-year periods of analysis.

Table 17 - Economic returns including marketable and ecosystem benefits

	6 Years	20 Years
ENPV	20,504,468	160,764,861
EIRR	41%	62.07%

5.4 Sensitivity Analysis

A sensitivity analysis was performed to evaluate how project returns are affected by changing parameters. This analysis is useful when the long-term applicability of project assumptions cannot be guaranteed. The sensitivity analysis looks at the impact of increasing the discount rate, which has the effect of reducing the weight assigned to costs and benefits that occur in the future. As noted previously, this project stimulates long-term investments in landscape restoration, so increasing the discount rate is expected to dramatically decrease economic net present value.

Economic returns – lower discount rate		8%
Marketable benefits only	6 Years	20 Years
NPV	- 39,064,290	9,748,389
EIRR	N/A	10%

Marketable and non-marketable benefits	6 Years	20 Years
NPV	27,376,404	248,680,242
EIRR	41%	62%

Economic returns – base case		12.1%
Marketable benefits only	6 Years	20 Years
NPV	- 35,373,663	- 6,513,618
EIRR	N/A	10%

Marketable and non-marketable benefits	6 Years	20 Years
NPV	20,504,468	160,764,861
EIRR	41%	62.07%

Economic returns -higher discount rate		20%
Marketable benefits only	6 Years	20 Years
NPV	-29,655,367	-18,134,661
EIRR	N/A	10%

Marketable and non-marketable benefits	6 Years	20 Years
NPV	11,262,680	75,336,516
EIRR	41%	62%

The sensitivity analysis does not dramatically affect views of project viability. The only shift that occurs when reducing the discount rate to 8% is that the discounted present value of the project's marketable benefits become slightly positive over a 20-year timeframe. No significant changes occur when the discount rate increases to 20% - the present value of marketable benefits remain negative, and the present value when non-marketable benefits are included remain strongly positive.

A further sensitivity analysis was conducted to explore the effect of different assumptions regarding the social cost of carbon. Table 18 below shows the how adjusting the carbon price estimate between USD 5 (the typical price for REDD+ projects) and USD 75 (the WB high estimate for the year 2020) affects ENPV.

Table 18 - Sensitivity analysis - shadow carbon price vs ENPV

	Social Carbon Price, USD	Project 6-Yr NPV	Project 20-Yr NPV
	Base case: $40	20,504,468	160,764,861
REDD+ market price	$5.00	- 5,719,492	64,404,855
	$7.50	- 3,846,352	71,287,713
	$10.00	- 1,973,212	78,170,570
	$20.00	5,519,348	105,702,001
	$30.00	13,011,908	133,233,431
WB low value	$40.00	20,504,468	160,764,861
WB high value	$75.00	46,728,428	257,124,867

Over the 6-year implementation period, the project requires a carbon price just over USD 12.63 to reach a positive NPV. Over the longer 20-year time period the project time savings from reduced fuelwood collection are sufficient to generate positive NPV, even if the carbon price were set to zero.

6. Conclusion

The results of the economic analysis show that the project does not generate sufficient financial returns to be undertaken without GCF funding. At the same time, the project generates robust economic benefits from a societal perspective, contributes to the long-term sustainability of productive landscapes in Rwanda, and supports the GCF's goal of low-carbon and climate resilient development.

The results of the financial analysis show clearly that the project activities would not be undertaken by farmers without GCF support. In many cases, the project activities undertaken individually generate lower (but still positive) returns than unsustainable BAU practices, but when taken together (as in the farmer family model) remain financially attractive to farmers when GCF support.