GCF Project: Upscaling Ecosystem Based Climate Resilience of Vulnerable Rural Communities in the Valles Macro-region of the Plurinational State of Bolivia (RECEM-Valles)

Annex 3: Economic and Financial Analysis – Narrative Summary

Version 6

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1. Introduction

1.1 Background

The Valles Macroregion of Bolivia is experiencing increasing rainfall variability as a result of climate change. Smallholder farmers are particularly vulnerable in light of greater rainfall unpredictability, increasing land degradation and declining ecosystem services[1] in watersheds, particularly water provisioning. This project will increase the resilience of smallholder farmers to climate change in the Valles Macro-region of Bolivia by implementing of climate-resilient agriculture that strengthens farmers and communities' capacities to manage their agroecosystems to adapt to increasing variability of climate (e.g. temperature and rainfall). The project outcomes that will result in the achievement of this objective are:

- Climate resilient agroecosystem management by smallholders ensures climate adaptation and sustainable food security with sovereignty
- Integrally managed micro-watersheds and ecosystem functions and services guarantee water provision to climate vulnerable smallholders' communities
- Institutions and governance mechanisms related to water management and climate-resilient agriculture are improved and strengthened to benefit vulnerable smallholders and their communities.

The theory of change is based on the close relationship between ecosystem functions and services (primarily hydrological regulation) on one hand and climate and social-ecological resilience on the other. Therefore, agricultural production systems and watershed management that enhanced ecosystem functions and services will reduce vulnerability to climate change of communities and smallholder livelihoods in the Valles Macro-region of Bolivia.

To improve climate resilience, farmers would be required to change their agricultural practices to embrace new technologies that reduce vulnerability to climate impacts. 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.

Without GCF support, these relatively high up-front costs reduce the financial attractiveness of climate resilience investments, especially since the positive societal and economic benefits cannot be monetized by the farmers who must make the 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 climate resilient activities.

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 the following project outputs:

- Output 1.1 Climate-resilient agriculture implemented and managed by smallholders for increasing the productivity and sustainability of their agroecosystems

[1] The term "ecosystem services" is used in accordance with the terminology of The Strategic Plan for the GCF: 2020 – 2023; however, it is clarified that the term used by the Plurinational State of Bolivia is "ecosystem functions and services"

- Output 1.3 Community and associative productive enterprises that encourage implementation of climate-resilient agriculture
- Output 2.1 Enhanced and modernized on-farm climate-proofing irrigation systems
- Output 3.1 Sustainable watershed management
- Output 3.2 Afforestation and reforestation for the conservation and/or restoration of watersheds
- Output 4.4 Strengthening local participatory planning and early warning system for agricultural risks

1.3 Structure of the report

This economic and financial analysis narrative report is organized according to the following structure:

- 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 1.1, 1.3 and 2.1, the non-market benefits and the total economic benefits of the project, and a commentary on the project's overall financial and economic viability.

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 analyzed 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 prioritized 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 or unit of intervention are represented by the sum-product of

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

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

- The yield per hectare / unit of intervention (e.g., greenhouse)
- The market price per unit of yield.

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

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 12% without project (standard micro-credit lending rate)
- Evaluation horizon of 5 years (period of GCF funding) and 10 years (minimum estimated lifetime of agroforestry and other agricultural investments and project lifespan)

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 Anticipated climate impacts in Bolivia's Valles Macroregion

As noted in the Feasibility Study (Annex 2), climate change scenarios for the year 2050 in the Valles Macroregion posit an increase in temperature from +2.7ºC to +3.4ºC (see Figure 1). These changes will drastically affect the availability of water in quantity and quality, due to greater moisture loss through evaporation from soils and transpiration of vegetation[2]. This increase in temperature is accompanied by an increase in rainfall variability, including late arrival of the monsoonal rains vital for agriculture, lengthy dry spells during the rainy season, increased drought, and sudden torrential rains causing flash floods.

Deterioration of ecosystem functions is a relevant factor of vulnerability. Important factors of such vulnerability and ecosystem functions' disruption is deforestation, and related to it, soil erosion linked to run-off. On average, 3,000 hectares of forest are cleared annually in the Valleys Macroregion.[3] Linked to the previous, the findings of the climate vulnerability analysis indicate the importance to avoid land use change (particularly deforestation), to restore the soil vegetable cover (to further enhance ecosystem functions relevant to water security), and to implement an integral and efficient management of water resources (including efficient on-farm irrigation systems). The vulnerability of the water provision and the agricultural (crops and livestock) sectors to climate change impacts is high[4] since hydrological cycles are highly impacted by rainfall and temperature variability.[5] Recent studies predict that the crop and livestock sectors will be among the most affected, facing losses of 6-14% of sectoral GDP.[6] This is anticipated primarily by the corresponding predicted declines in productivity, which for a number of key staple crops could reach 17%[7].

According to the 3ie impact evaluation of agricultural insurance in Bolivia published in 2020, focus group discussions revealed that "the main threats recorded in all municipalities were drought, hail and frost." The report notes that "the consequences of [hail] are practically irreparable" with up to 100% losses[8]. However, no data was provided about the frequency of these events. As noted in the feasibility study, "Evidence from the Central Valley of Tarija, demonstrated that in the last four agricultural seasons, frost and hail resulted in a reduction of

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[2] Fundación Amigos de la Naturaleza (FAN) (2018). Estudio de la Línea Base Ambiental de la Macro-región Valles. Santa Cruz: FAN.
[3] CSF (2019). Producto 2. Plan de Gestión Social y Ambiental. La Paz: CSF.
[4] PNUD (2011). Tras las huellas del cambio climático en Bolivia: estado del arte del conocimiento sobre adaptación al cambio climático, agua y seguridad alimentaria. La Paz: PNUD.
[5] Íbid footnote 23.
[6] ECLAC (2014). Social Panorama of Latin America 2019. Santiago de Chile: CEPAL.
[7] Rambal et al. (2015). Garantía de Acceso al Agua como un Derecho Fundamental. Madrid: Rambal.
[8] https://www.3ieimpact.org/sites/default/files/2020-07/PE-TW13.1007-PIRWA-Bolivia.pdf p. 53.

between 12% and 39% of total production".[9] Bolivia is the poorest country in South America and past studies vary in terms of rigor and scope. The financial analysis relies on conservative assumptions and simplifications to quantify the impact of climate shocks on agricultural production. For example, the CIF project on green credit in Bolivia notes that "Irregularity of rain and low temperatures cause a total loss of harvests in average one every 5 years. Source: Second National Communication to UNFCCC, 2009."[10] Therefore, the financial analysis makes the following simplifying assumptions for the business-as-usual scenario:

- Anti-hail nets: moderate hail damage (40% yield reduction) every 3-4 years, and severe hail damage (75% yield reduction) every 4 years.
- Thermal blankets: moderate frost (40% yield reduction) every 3 years, severe frost (80% yield reduction) every 10 years
- Hydrogel: 30% yield reduction every 3 years due to drought

[9] Estudio de Identificación, Mapeo y Análisis Competitivo del Cluster de Uvas, Vinos y Singanis en Bolivia; CAF Alejandro Paniagua, 2012.

[10] 140430 Bolivia - Microfinance and climate resilience for smallholder farmers in Bolivia .pdf (climateinvestmentfunds.org)

3. Summary of Evaluated Outputs

The projects outputs are designed to transform agricultural practices in the Valles Macro-Region 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, 1.2, and 2.1 below. In addition, the project provides support for local and regional ecosystem restoration activities, as well as capacity building and institutional strengthening to reinforce these interventions and ensure their long-term sustainability. 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.

Table 1 - Summary of project interventions

Component 1. Agricultural systems transformed and reoriented to ensure food and income security in a changing climate
Output 1.1 ***Climate resilient agriculture implemented and managed by smallholders for increasing the productivity and sustainability of their agroecosystems***
Activity 1.1.1 Provision of climate technologies and implementation of climate resilient agricultural practices to address vulnerability and increase resilience in the Valles Macro-region.
Activity 1.1.2 Capacity building on climate resilient agricultural practices to contribute to increased resilience and productivity of agricultural systems
Output 1.2 ***Increased market access of climate resilient agricultural products***
Activity 1.2.1 Development and implementation of community and associative productive enterprises
Activity 1.2.2 Technical support and implementation of collection and marketing centres for organic and / or agroecological products.
Activity 1.2.3 Promoting climate resilient value chain for livelihood diversification according to the prioritized region.
Component 2. Smallholder water resources secured to reduce the risks from droughts and low rainfall
Output 2.1 Enhanced and modernized on-farm climate-proofed irrigation systems
Activity 2.1.1 : Improve and expand water reservoirs network to optimize water-harvesting activities linked to on-farm climate-proofed irrigation systems
Activity 2.1.2. Update the inventory of irrigation systems, to enable the implementation and revitalization of climate-proofed on-farm irrigation systems
Activity 2.1.3. Implement, revitalize and technify on-farm climate-proofed irrigation systems.
Output 2.2 Strengthened capacities for the management of on-farm climate-proofed irrigation
Activity 2.2.1 Strengthen capacities of irrigation associations, farmers and community promoters) to enable locally-owned technological innovation processes related to on-farm climate-proofed irrigation systems.
Activity 2.2.2: Replicate technological innovation processes related to on-farm climate-proofed irrigation systems to up-scale the knowledge to other communities through the strengthening of capacities of key actors, technicians and professionals in national and subnational levels,

Activity 2.2.3: Design an O&M Plan for the irrigation systems (at municipality level) including arrangements between MiRiego, Municipalities and the Irrigation Committees,
Activity 2.2.4: Promoting the signature of the legal agreements and the O&M Plans for the irrigation systems between MiRiego, Municipalities and the Irrigation Committees.
Component 3. Restored and conserved micro-watersheds and ecosystem functions and services
Output 3.1 Restored and conserved ecosystem management for enhanced climate resilient watersheds
Activity 3.1.1 Development and implementation of integral micro-watershed management and water use plans to enhance climate change adaptation.
Activity 3.1.2 : Implement restoration processes in micro-watersheds, to increase resilience and climate adaptation by enhancing ecosystem functions and services.
Output 3.2. Information and long-term monitoring system for water sources at place
Activity 3.2.1 : Develop and implement an online tool for monitoring, consolidation and dissemination of information relevant for informed climate-sensitive planning and decision-making processes related to sustainable water use ((based on climate, weather conditions, foot print of food production, water availability.
Component 4. Strengthened local governance structures for participatory climate adaptation planning and mobilization of finance
Output 4.1 Strengthening capacities for national and sub-national government entities to implement policies and norms for the climate-resilient food production under irrigation systems, integral watershed management and monitoring of ecosystem functions and services
Activity 4.1.1 Implement national and sub-national policies and plans (including PTDIs) that contribute to climate change adaptation and mitigation processes, contributing to the JAMA and to the Bolivia´s NDCs.
Output 4.2 Improved financial mechanisms that support climate-resilient agricultural production and irrigation systems to mobilize increased finance for farmers
Activity 4.2.1 Partner with existing domestic funders and financial institutions to develop innovative financial instruments that enable the implementation of climate-proofed irrigation and ecosystems restoration investments.
Activity 4.2.2 Strengthen the capacities of communities, smallholders and associations on financial management and access to innovative financial instruments relevant for climate resilient agriculture.
Output 4.3 Strengthening local governance in participatory climate adaptation, early warning systems and long-term monitoring systems
Activity 4.3.1 Capacity strengthening for local stakeholders (including smallholders, public officers, local CSOs and relevant academia) on the integration of climate change risks for decision making to increase the resilience of smallholders and communities
Activity 4.3.2 Establish coordination and consultative territorial platforms to facilitate climate change adaptation mainstreaming into the participatory implementation of policies and strategies), in accordance with the Comprehensive Management Plan for Watershed Resources and Integrated Watershed Management.
Activity 4.3.3. Enhance capacity of Municipalities to strengthen the monitoring and reporting base for the macro region related to climate change impacts.

3.1 Choice of financial instrument

During the project implementation period it is assumed that GCF support to the project will take the form of grants. A careful analysis of the financing landscape for smallholder agriculture in Bolivia concludes that this is the most appropriate financial instrument for the initial stages of the project, with a managed transition to other financial instruments planned for the post-GCF phase.

The Climate Investment Fund (CIF) proposed a green credit line for small holder farmers in Bolivia with Inter-American Development Bank as Implementing Entity in 2011[11]. The country has microfinance institutions specialized in small holder farmer finance such as Fond De Desarrollo Comunal (FONDECO)[12]. In 2008 FOGAL deployed a guarantees for loans to farmers in Bolivia. In addition, the first crop insurance scheme in Bolivia was launched in 2011[13], and an evaluation by 3ie indicates that crop insurance is instrumental in stimulating increased farmer investments[14].

The pilot schemes described above reflect the types of innovative financial mechanisms that this project seeks to mainstream. However, the pilot schemes cited focus either on other regions of Bolivia such as the Altiplano Macroregion, or else on high-value cash crops such as coffee and grapes. The small farmers in the Valles Macroregion are poorly served by those projects, and the project's main financial innovation is to work with financial intermediaries and policymakers to mainstream these financial instruments for small farmers in Valles who grow staple crops such as maize, potatoes, vegetables and tree fruit.

As noted in the funding proposal and feasibility study, project beneficiaries face multiple barriers to climate resilience, and providing loans without all the associated technical interventions will not yield the anticipated benefits. The *Global Policy* article on Bolivia's crop insurance innovation also talks about the need to choose financial instruments carefully:

> *… Miguel Solana, a programme officer who runs the Bolivia project at the ILO, says: "Credit is not the only solution." He believes farmers in Latin America have wrongly been given loans for far too long, when they would have derived greater benefit from an insurance policy instead… He argues that if a farmer wants to grow by acquiring more land or better tools, for example, it makes sense to get a loan that can be repaid after a good harvest. But for credit to work well, he adds, harvests need to be protected by insurance. Otherwise, a farmer who loses an entire crop because of bad weather will have great difficulty repaying.*[15]

To summarize, existing micro-credit schemes do not target the crops grown by the project's beneficiaries. Rolling out a loan program to climate vulnerable farmers may increase financial risk and harm poor families in the absence of a credible crop insurance scheme. At the beginning of project implementation, farmers' crops and production methods will not yet be climate resilient and there is no relevant insurance scheme in operation. While the GCF project aims to facilitate the provision of loans and insurance for climate resilience investments in the Valles Macroregion, these products are not yet widely available in that region of Bolivia. Therefore, the

[11] https://www.climateinvestmentfunds.org/sites/cif_enc/files/140430%20Bolivia%20-%20Microfinance%20and%20climate%20resilience%20for%20smallholder%20farmers%20in%20Bolivia%20.pdf

[12] http://www.fondation-farm.org/zoe/doc/farm_microfinance_conf_eng.pdf

[13] https://archive.globalpolicy.org/social-and-economic-policy/world-hunger/general-analysis-on-hunger/50634-bolivias-first-crop-insurance-scheme-promises-to-empower-farmers.html%3Fitemid=id.html

[14] https://www.3ieimpact.org/sites/default/files/2020-07/PE-TW13.1007-PIRWA-Bolivia.pdf

[15] [15] https://archive.globalpolicy.org/social-and-economic-policy/world-hunger/general-analysis-on-hunger/50634-bolivias-first-crop-insurance-scheme-promises-to-empower-farmers.html%3Fitemid=id.html

project relies on grants at the outset, with the adoption of credit and insurance mechanisms as part of the longer term sustainability and replication strategy.

Long-run financial sustainability is based on mainstreaming green credit and insurance products for small farmers who adopt climate resilient practices, in parallel with adoption of improved practices, income diversification and market access. As noted in the 3ie report on agricultural insurance in Bolivia, access to insurance over multiple years led to increased farmer expenditure on agricultural inputs, and increased yields[16]. At the project's initial stages grant financing is required due to the need to put farmers immediately on a path to climate resilience, even while the project supports financial intermediaries to develop and tailor these innovative financial mechanisms for the circumstances of local farmers in the Valles Macroregion. The virtuous circle created by reduced climate-related crop losses and increased profitability, income diversification, and improved access to credit and insurance products means that the project will be able to generate sustainable financial benefits for farmers without the need for continued grant financing.

[16] https://www.3ieimpact.org/sites/default/files/2020-07/PE-TW13.1007-PIRWA-Bolivia.pdf

4. Financial Analysis

4.1 Summary of Financial Results

The financial analysis reviews the costs and benefits, seen from the farmer's perspective of investments in climate resilient activities. Specifically, the financial analysis examines the following interventions:

Table 2 Summary of activities evaluated quantitatively

Activity	Indicator
Design, construction and management of solar tents for vegetable production.	At least 1,200 solar tents for growing vegetables have been implemented with the participation of at least 30% women and 10% young people.
Provision and implementation of anti-hail nets.	At least 600 anti-hail nets have been installed to protect fruit crops in municipalities under a high risk of hail.
Provision and implementation of thermal blankets to deal with frost.	At least 1,000 thermal blankets have been implemented in vegetable crops in municipalities under a high and very high risk of frost.
Provision and implementation of technologies to maintain soil moisture, such as hydrogel in fruit trees in areas with high vulnerability to droughts	At least 5,200 small farmers (30% women and 10% young) have incorporated the hydrogel in their fruit plantations in municipalities under a high and very high risk of drought.
Implementation of organic agriculture practices, conservation agriculture and management of agroforestry systems.	At least 500 hectares are implementing organic agriculture by small farmers and communities are trained.
	At least 1000 hectares of conservation agriculture practices are implemented (30% women and 10% young farmers beneficiaries) and receive training in conservation agriculture.
	At least 500 hectares with SAFs have been implemented by small farmers, women farmers and communities.
Promote and strengthen ecological and organic production according to national and international standards and guidelines.	Organic and/or ecological certification processes are managed by at least 120 producer associations (at least 40 of them led by women) who have received environmental and organic production training.
Technical support and implementation of collection and marketing centers for organic and / or ecological products.	At least 2 collection centers implemented.
Identification and financing of agricultural activities and productive diversification of high socioeconomic, cultural and environmental value according to the prioritized region (beekeeping, tourism, among others)	At least 20 associations of honey producers at the local level and three regional associations have been strengthened in production and marketing processes.

Activity	Indicator
Strengthen and implement water reservoirs to optimize water harvesting activities linked to resilient irrigation systems.	1,000 community reservoirs and 5,000 family water tanks have been implemented in municipalities under high and very high risk of drought.
Implement and revitalize technified and resilient irrigation systems, differentiating seasonal and perennial crops.	At least 4,448 hectares with technified and resilient irrigation systems have been revitalized and / or implemented.

Where applicable, the NPV and IRR are calculated (1) assuming business-as-usual, (2) assuming the project investments are made directly by farmers without external support, (3) assuming a concessional loan at 0.8% interest and a 5 year tenor depending on intervention, and (4) assuming grant support from the GCF project. Note that scenario (2) is considered highly unlikely, as there are significant information and capacity gaps that the project will overcome by providing 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 when there is no evidence of this happening in reality. The estimated financial returns in Scenario (2) therefore represent the most optimistic (albeit unrealistic) case of what is possible without GCF support. As described above, Scenario (3) is included for the sake of completeness even though loans are considered inappropriate in the current context. The standard microfinance interest rate in Bolivia is capped at 12% and was closer to 19% before the cap was imposed in 2014. Even though loans may appear cost-efficient from a donor perspective, this analysis ignores loan administration costs, risks of default and the implementation delays that would be incurred setting up such a scheme. Furthermore, a loan scheme may discourage the most vulnerable farmers from participating in the project.

The financial analysis for each output is calculated from the private perspective. VAT in Bolivia is 13% and is included in the final price for goods and services. Therefore, the costs presented in the financial analysis are inclusive of VAT. According to PwC, the legislation does not provide a registration mechanism or procedure for non-established businesses[17]. Because the main project beneficiaries are small family farmers who sell their goods at local markets, we assume that VAT is not payable on their income.

Solar tents / greenhouses

Table 3 Financial analysis results - - greenhouses

Financial analysis - summary	5 Years	10 Years
NPV - BAU	13,146	20,605
IRR - BAU	cannot calculate	cannot calculate
NPV - project without GCF grant	-14,581	-11,919
IRR - project without GCF grant	-34%	-9%
NPV - project with GCF loan	-11,717	-9,055
IRR - project with GCF loan	cannot calculate	-13%
NPV - project with GCF grant	3,204	5,866
IRR - project with GCF grant	69%	74%
Payback period - adaptation without GCF, years	10	
Payback period - adaptation without loan, years	10	

[17] https://www.pwc.com/gx/en/tax/pdf/a-guide-to-vat-gst-sut-in-the-americas-2020.pdf

Payback period - adaptation with grant, years	10

As summarized in Table 3 above, the up-front costs of tomato production with artisanal greenhouses / solar tents make this investment uneconomic without GCF support over the 5-year project period, as the implied IRR is considerably lower than the presented discount rate. Over 10 years the intervention remains unattractive compared to BAU. IRR cannot be calculated for the BAU scenario because financial returns remain positive throughout the period of analysis. A 5-year loan at 0.8% spreads out the costs of the intervention but does not address the poor cash flow situation over the GCF implementation period. On the other hand, GCF grant support covers the up-front costs of the investment, making the climate resilience measure financially viable over all periods. The greater returns as a result of GCF support, demonstrate the incremental benefit of project investment.

Anti-hail nets

Table 4 Anti-hail nets

Financial analysis - summary	5 Years	10 Years
NPV - BAU	9,882	15,174
IRR - BAU	cannot calculate	cannot calculate
NPV - project without GCF grant	5,059	13,295
IRR - project without GCF grant	49%	60%
NPV - project with GCF loan	113	8,348
IRR - project with GCF loan	16%	64%
NPV - project with GCF grant	12,623	20,859
IRR - project with GCF grant	cannot calculate	cannot calculate
Payback period - adaptation without GCF, years	6	
Payback period - adaptation without loan, years	10	
Payback period - adaptation with grant, years	2	

Under the BAU scenario peach production is highly profitable in good years, but with the risk of significant losses due to hail. Without project support, the use of anti-hail nets reduces peach production losses due to hail damage, but the high up-front investment reduces NPV and makes the measure unattractive compared to BAU. The need to pay interest on the GCF loan further reduces financial attractiveness from the farmer perspective. GCF grant support reduces the up-front investment cost, shortens payback time and results in much higher financial NPV.

Thermal blankets

Table 5 Financial analysis results - thermal blankets

Financial analysis - summary	5 Years	10 Years
NPV - BAU	985	661
IRR - BAU	cannot calculate	-10%
NPV - project without GCF grant	-1,008	-1,440

IRR - project without GCF grant	cannot calculate	cannot calculate
NPV - project with GCF loan	-946	-1,377
IRR - project with GCF loan	cannot calculate	cannot calculate
NPV - project with GCF grant	836	404
IRR - project with GCF grant	cannot calculate	0.3%
Payback period - adaptation without GCF, years	10	
Payback period - adaptation without loan, years	10	
Payback period - adaptation with grant, years	6	

The analysis assumes minor frosts affecting pea output in years 3 and 6, and early severe frosts every 10 years. In reality the timing of moderate and severe frosts is unpredictable. In the absence of GCF support and in the loan scenario, the NPV of the thermal blankets intervention is negative – the recurring investment costs outweigh the increase in yields. GCF grant support helps farmers overcome these financial barriers during the project period, resulting in positive NPV over the 5- and 10-year periods of analysis.

Hydrogel

Table 6 - Financial analysis results - Soil management / hydrogel application

Financial analysis - summary	5 Years	10 Years
NPV - BAU	7,651	11,712
IRR - BAU	cannot calculate	cannot calculate
NPV - project without GCF grant	6,807	10,712
IRR - project without GCF grant	cannot calculate	cannot calculate
NPV - project with GCF loan	6,807	10,712
IRR - project with GCF loan	cannot calculate	cannot calculate
NPV - project with GCF grant	7,223	11,127
IRR - project with GCF grant	cannot calculate	cannot calculate
Payback period - adaptation without GCF, years	10	
Payback period - adaptation without loan, years	10	
Payback period - adaptation with grant, years	10	

The use of hydrogels and other soil moisture retaining measures for peach production provides attractive returns to farmers. These measures reduce labor costs for irrigation during dry periods and simultaneously help to improve yields during these periods. Without this intervention farmers face highly variable revenues and increased risk of losses. However, the analysis shows that up-front costs mean NPV is lower than BAU without GCF support, and as noted earlier, the without-GCF counterfactual scenario ignores the need for outreach, technical assistance and capacity building to deliver these interventions. Partial (80%) GCF support improves NPV and makes the intervention more financially attractive to farmers. A greater grant contribution (90%

or more) would further incentivize adoption in the near term by making the NPV higher than BAU.

Organic agriculture and certification of production processes

Table 7 Financial analysis results - Organic agriculture

Financial analysis - summary	5 Years	10 Years
NPV - BAU	29,900	45,715
IRR - BAU	cannot calculate	cannot calculate
NPV - project without GCF grant	26,577	42,295
IRR - project without GCF grant	cannot calculate	cannot calculate
NPV - project with GCF loan	25,117	40,835
IRR - project with GCF loan	cannot calculate	cannot calculate
NPV - project with GCF grant	27,908	43,626
IRR - project with GCF grant	cannot calculate	cannot calculate
Payback period - adaptation without GCF, years	10	
Payback period - adaptation without loan, years	10	
Payback period - adaptation with grant, years	10	

Organic production systems are expected to increase and stabilize yields that are threatened by climate change, while certification will result in higher prices per kilogram. The production and certification of organic tomatoes yields positive returns compared in both the GCF grant scenario and the no-GCF counterfactual, than in the loan scenario. However, the without-GCF counterfactual scenario ignores the need for outreach, technical assistance, and capacity building to deliver these interventions. A greater grant contribution (90% or more) would further incentivize adoption in the near term by making the NPV higher than BAU.

Sustainable agroforestry

Table 8 Financial analysis results - Sustainable agroforestry

Financial analysis - summary	5 Years	10 Years
NPV - BAU	-2,101	2,098
IRR - BAU	-10%	21%
NPV - project without GCF grant	-573	408
IRR - project without GCF grant	-7%	18%
NPV - project with GCF loan	-819	162
IRR - project with GCF loan	-16%	14%
NPV - project with GCF grant	-288	694
IRR - project with GCF grant	2%	24%
Payback period - adaptation without GCF, years	5	
Payback period - adaptation without loan, years	5	
Payback period - adaptation with grant, years	5	

Sustainable agroforestry is a long-term investment for farmers. Returns are negative over the 5-year period of analysis with both loans and grants. They remain marginal in the loan scenario over a 10-year period but are more strongly positive with GCF grant support, improving over even longer (20-year) periods of analysis. The concessional loan scenario does not smooth cashflows sufficiently to make this intervention attractive to farmers. A greater grant contribution (90% or more) would further incentivize adoption in the near term by making the NPV higher than BAU.

Conservation agriculture

Table 9 Financial analysis results -conservation agriculture

Financial analysis - summary	5 Years	10 Years
NPV - BAU	7,731	11,812
IRR - BAU	cannot calculate	cannot calculate
NPV - project without GCF grant	6,217	14,971
IRR - project without GCF grant	cannot calculate	cannot calculate
NPV - project with GCF loan	5,447	14,201
IRR - project with GCF loan	cannot calculate	cannot calculate
NPV - project with GCF grant	6,957	15,710
IRR - project with GCF grant	cannot calculate	cannot calculate
Payback period - adaptation without GCF, years	5	
Payback period - adaptation without loan, years	6	
Payback period - adaptation with grant, years	5	

The implementation of conservation agriculture is less attractive than BAU over 5 years in the without-GCF, loan and grant scenarios. The relatively high initial investments / opportunity costs are rewarded by greatly increased revenues in future years, especially as climate-related temperature and precipitation changes affect yields under BAU. GCF grant funding provides incremental support that makes NPV more attractive in both the short and longer term.

Apiculture

Table 10 Financial analysis results -Apiculture

Financial analysis - summary	5 Years	10 Years
NPV - BAU	4,312	9,840
IRR - BAU	74%	83%
NPV - project without GCF grant	2,464	13,908
IRR - project without GCF grant	21%	38%
NPV - project with GCF loan	-1,072	10,372
IRR - project with GCF loan	6%	33%
NPV - project with GCF grant	7,788	19,232
IRR - project with GCF grant	58%	69%
Payback period - adaptation without GCF, years	4	
Payback period - adaptation without loan, years	6	
Payback period - adaptation with grant, years	2	

Expanded beekeeping and honey production (apiculture) requires significant upfront investments that outweigh future gains and make 5-year NPV unattractive compared to business as usual, in the absence of GCF grant investment. GCF support reduces these up-front costs, shortens the payback period compared to BAU and makes this intervention much more attractive to farmers.

Water harvesting

Table 11 Financial analysis results -water harvesting

Financial analysis - summary	5 Years	10 Years
NPV - BAU	15,722	24,276
IRR - BAU	cannot calculate	cannot calculate
NPV - project without GCF grant	12,969	29,230
IRR - project without GCF grant	74%	82%
NPV - project with GCF loan	2,113	18,374
IRR - project with GCF loan	60%	93%
NPV - project with GCF grant	25,519	41,780
IRR - project with GCF grant	cannot calculate	cannot calculate
Payback period - adaptation without GCF, years	4	
Payback period - adaptation without loan, years	9	
Payback period - adaptation with grant, years	1	

In the absence of water harvesting investments, farmers face decreased yields and increased labor costs during drought periods. Water harvesting investments are expected to increase yields and decrease labor costs, resulting in higher net cash flows over time. However, the up-front costs of these investments make them relatively unattractive in the short term without GCF grant support – NPV is considerably lower than BAU over 5 years and only marginally better over 10 years. Loans are significantly less attractive over both periods. GCF grant support reduces these up-front costs and makes this intervention much more attractive to farmers over both timeframes.

Resilient on-farm irrigation

Table 12 Financial analysis results - irrigation

Financial analysis - summary	5 Years	10 Years
NPV - BAU	15,722	24,276
IRR - BAU	cannot calculate	cannot calculate
NPV - project with GCF loan	9,416	20,709
IRR - project with GCF loan	80%	88%
NPV - project without GCF grant	6,245	17,539
IRR - project without GCF grant	265%	269%
NPV - project with GCF grant	17,805	29,099
IRR - project with GCF grant	cannot calculate	cannot calculate

Payback period - adaptation without GCF, years	9
Payback period - adaptation without loan, years	10
Payback period - adaptation with grant, years	2

The upfront costs of resilient on-farm irrigation systems result in an extended payback period that makes these investments unattractive without GCF grant support – even taking into account the likelihood of reduced long term yields under BAU that are expected as a result of climate change. NPV without GCF grant investment is lower than BAU over the 5-year and 10-year periods of analysis, and even lower in the concessional loan scenario. GCF grant support reduces these up-front costs, shortens payback periods, and makes this intervention much more attractive to farmers.

4.2 Summary of findings

The financial analysis of the proposed climate resilience interventions indicates that many of these measures might be expected to provide profitable returns on farmers' cash investments over the longer term, irrespective of GCF involvement. However, the barrier analysis presented in Section B.2 of the funding proposal highlights a great need for external intervention. This points to the key barriers for these interventions being less "financial" in terms of overcoming discount / hurdle rates, and more "structural" in terms of farmers' risk aversion, access to capital, and knowledge and prevailing practice constraints.

4.3 Sensitivity analysis

A sensitivity analysis performed for each of the above interventions examined the impact on NPV from a range of discount rates between 5% and 20%, and also from a 10% and 25% reduction in net cash flows (either due to increased input prices or reduced sales revenues). As can be seen in the tables below, increasing the hurdle rate and reducing cashflows both reduce NPV; however, NPV stays positive across all of these scenarios.

Sensitivity dashboard – Solar Tents

Discount rate	10 yr NPV w/o GCF	Discount rate	10 yr NPV w/ GCF		Reduction in cash flows	10 yr NPV w/o GCF	Reduction in cash flows	10 yr NPV w/ GCF
12.0%	-11,919	12.0%	5,866		0%	-11,919	0%	5,866
5%	-10,251	5%	8,902		10%	-10,727	10%	5,280
10%	-11,568	10%	6,588		25%	-8,940	25%	4,400
20%	-12,691	20%	3,760					

Sensitivity dashboard – anti-hail nets

Discount rate	10 yr NPV w/o GCF	Discount rate	10 yr NPV w/ GCF		Reduction in cash flows	10 yr NPV w/o GCF	Reduction in cash flows	10 yr NPV w/ GCF
12.0%	13,295	12.0%	20,859		0%	13,295	0%	20,859
5%	21,005	5%	29,073		10%	11,965	10%	18,773

10%	15,113	10%	22,815

25%	9,971	25%	15,644

Sensitivity dashboard – thermal blankets

Discount rate	10 yr NPV w/o GCF	Discount rate	10 yr NPV w/ GCF
12.0%	-1,440	12.0%	404
5%	-1,896	5%	245
10%	-1,546	10%	375
20%	-1,140	20%	447

Reduction in cash flows	10 yr NPV w/o GCF	Reduction in cash flows	10 yr NPV w/ GCF
0%	-1,440	0%	404
10%	-1,296	10%	363
25%	-1,080	25%	303

Sensitivity dashboard - hydrogel

Discount rate	10 yr NPV w/o GCF	Discount rate	10 yr NPV w/ GCF
12.0%	10,712	12.0%	11,127
5%	14,660	5%	15,141
10%	11,655	10%	12,087
20%	7,929	20%	8,288

Reduction in cash flows	10 yr NPV w/o GCF	Reduction in cash flows	10 yr NPV w/ GCF
0%	10,712	0%	11,127
10%	9,641	10%	10,014
25%	8,034	25%	8,345

Sensitivity dashboard – organic agriculture

Discount rate	10 yr NPV w/o GCF	Discount rate	10 yr NPV w/ GCF
12.0%	42,295	12.0%	43,626
5%	57,960	5%	59,581
10%	46,029	10%	47,435
20%	31,305	20%	32,393

Reduction in cash flows	10 yr NPV w/o GCF	Reduction in cash flows	10 yr NPV w/ GCF
0%	42,295	0%	43,626
10%	38,065	10%	39,264
25%	31,721	25%	32,720

Sensitivity dashboard

Discount rate	10 yr NPV w/o GCF	Discount rate	10 yr NPV w/ GCF
12.0%	408	12.0%	694
5%	1,209	5%	1,535
10%	592	10%	888
20%	-93	20%	158

Reduction in cash flows	10 yr NPV w/o GCF	Reduction in cash flows	10 yr NPV w/ GCF
0%	408	0%	694
10%	367	10%	625
25%	306	25%	520

Sensitivity dashboard – conservation agriculture

Discount rate	10 yr NPV w/o GCF	Discount rate	10 yr NPV w/ GCF
12.0%	14,971	12.0%	15,710
5%	22,149	5%	23,035
10%	16,651	10%	17,428
20%	10,183	20%	10,797

Reduction in cash flows	10 yr NPV w/o GCF	Reduction in cash flows	10 yr NPV w/ GCF
0%	14,971	0%	15,710
10%	13,474	10%	14,139
25%	11,228	25%	11,783

Sensitivity dashboard - apiculture

Discount rate	10 yr NPV w/o GCF	Discount rate	10 yr NPV w/ GCF
12.0%	13,908	12.0%	19,232

Reduction in cash flows	10 yr NPV w/o GCF	Reduction in cash flows	10 yr NPV w/ GCF
0%	13,908	0%	19,232

5%	24,254	5%	29,952
10%	16,336	10%	21,761
20%	6,988	20%	11,941

10%	12,518	10%	17,309
25%	10,431	25%	14,424

Sensitivity dashboard - water harvesting

Discount rate	10 yr NPV w/o GCF	Discount rate	10 yr NPV w/ GCF
12.0%	29,230	12.0%	41,780
5%	44,652	5%	58,039
10%	32,875	10%	45,653
20%	18,687	20%	30,401

Reduction in cash flows	10 yr NPV w/o GCF	Reduction in cash flows	10 yr NPV w/ GCF
0%	29,230	0%	41,780
10%	26,307	10%	37,602
25%	21,923	25%	31,335

Sensitivity dashboard - resilient irrigation

Discount rate	10 yr NPV w/o GCF	Discount rate	10 yr NPV w/ GCF
12.0%	20,709	12.0%	29,099
5%	31,447	5%	40,396
10%	23,248	10%	31,790
20%	13,360	20%	21,190

Reduction in cash flows	10 yr NPV w/o GCF	Reduction in cash flows	10 yr NPV w/ GCF
0%	20,709	0%	29,099
10%	18,638	10%	26,189
25%	15,532	25%	21,824

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 costs for the economic analysis include all costs incurred by the project, both the GCF investment and co-financing. As noted previously, farmers in the project area face multiple non-financial barriers to climate resilience, and all of the proposed interventions are required to overcome those barriers and deliver the expected project benefits.

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, 1.2, 1.3 and 2.1

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 and co-finance from partners and Government during the project period as presented in Annex 4 (Detailed Budget Description).

Project benefits include the cumulative net financial benefits for participating farmers compared to business-as-usual, assuming that the project is rolled out progressively to 25% of farmers during each of the first four years of implementation.

The net present value (NPV) of the project-level investment is calculated using a discount rate of 12%, as mandated by the Government of Bolivia for public-interest projects[18]. The sensitivity analysis is performed using alternative discount rates of ranging from 5% to 20%.

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 5-year implementation period, and for an estimated 10-year investment lifetime.

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

[18] https://journals.sagepub.com/doi/full/10.1177/1091142119890369 "Social Discount Rates for Seventeen Latin American Countries: Theory and Parameter Estimation"

Table 13 - Economic results, marketable benefits only

Economic results, base case	5 YEARS	10 YEARS
Project EIRR, marketable benefits	cannot calculate	-2%
Project NPV, marketable benefits	- 41,634,906	- 22,009,522

As indicated in Table 13, the project's discounted net present value is negative over the 5-year implementation period and remains negative over 10 years, when only marketable benefits (those that can be captured directly by private actors) are counted. This result reflects the long-lived nature of many project interventions, as well as the contribution that non-market benefits make to the project's viability.

5.2 Non-Market Benefits from Ecological Services

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

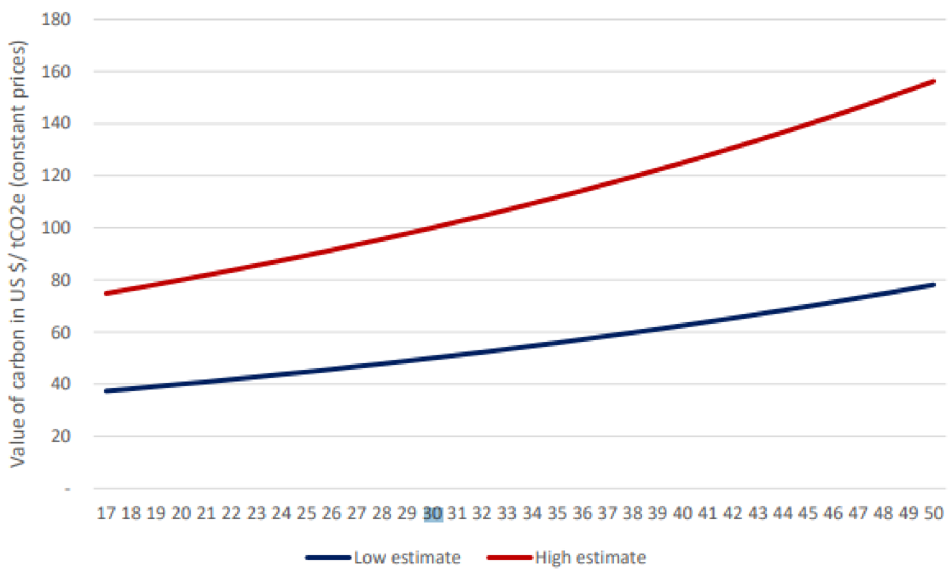
1. Reduced GHG emissions that would have resulted from loss of forest cover and wetland cover
2. GHG sequestration from agroforestry activities
3. Reduced soil erosion
4. Improved water quality.

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. Because data is lacking on shadow prices for the value of reduce soil erosion and water quality in Bolivia, this analysis focuses only on the GHG benefits that accrue from project activities. As a result, the analysis should be considered conservative as it understates the value from ecological services.

As indicated in the World Bank's 2017 guidance note on the shadow price of carbon in economic analysis[19], a low estimate of the shadow price would be USD 40/tCO_2e in 2020, rising to USD 63/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 report uses the 2020 value of USD 40/tCO_2e and holds this figure constant for the 10-year period of analysis.

[19] http://documents1.worldbank.org/curated/en/621721519940107694/pdf/2017-Shadow-Price-of-Carbon-Guidance-Note.pdf

Figure 1 – World Bank 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	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
Low	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	55	56	57	58	60	61	63	64	65	67	68	70	71	73	75	76	78
High	75	77	78	80	82	84	86	87	89	91	94	96	98	100	102	105	107	109	112	114	117	120	122	125	128	131	134	137	140	143	146	149	153	156

Carbon sequestration is associated primarily with the wetlands protection, forest management and reforestation activities in Component 3. GHG sequestration figures are estimated as follows:

Carbon sequestration figures from wetland and forest protection were taken from the publication *Sistemas agroforestales en la Amazonía boliviana: una valoración de sus múltiples funciones a partir de estudios de caso*[20] , which estimates this figure at 97.68 tonnes CO_2/hectare per year. For wetlands, the analysis assumes a baseline area of 2,000 hectares, with 10% lost each year due to climate change and human activity. The project aims to implement measures that enlist farmers and communities as farmers to protect these wetland areas and identify alternatives to their conversion.

Table 14 Carbon benefits of wetland protection / restoration

	Año 1	Año 2	Año 3	Año 4	Año 5
Annual loss of wetland surface - no project	200	180	162	146	131
Annual loss of wetland surface – with project	0	0	0	0	0
Net avoided emissions with project	**19,536**	**17,582**	**15,824**	**14,242**	**12,818**
Value of avoided emissions at USD 40/tCO2	**781,440**	**703,296**	**632,966**	**569,670**	**512,703**

[20] Sistemas agroforestales en la Amazonía boliviana: una valoración de sus múltiples funciones a partir de estudios de caso / Editores: Vincent A. Vos; Olver Vaca; Adrián Cruz. -- La Paz: Centro de Investigación y Promoción del Campesinado, 2015. 196 p.; 15,5 x

Forest management activities are expected to establish protected areas and establishment of conservation programs, thereby eliminating deforestation in these areas. Starting with a forested area of 1.22 million hectares, the business as usual scenario anticipates an annual deforestation rate of 0.34%, resulting in a loss of 20,590 hectares of the 5-year period. Project activities are intended to halt or slow this deforestation, resulting in an incremental GHG savings of 1.5 million tonnes CO2 over 5 years.

Table 15 Carbon benefits of sustainable forest management

Annual change in forested coverage	Year 1	Year 2	Year 3	Year 4	Year 5	TOTAL
Estimated effectiveness of forest management activities	75%	75%	75%	75%	75%	
Annual forest protected, ha	3,110	3,099	3,088	3,078	3,068	15,443
Net CO2 savings, tCO2	303,744	302,711	301,682	300,656	299,634	1,508,428
Annual economic value, Bs.	80,998,397	80,723,003	80,448,544	80,175,019	79,902,424	402,247,388
Annual economic value, USD	**12,149,760**	**12,108,450**	**12,067,282**	**12,026,253**	**11,985,364**	**60,337,108**

For the reforestation activity, a conservative figure of 1.5 t CO2[21] figure was applied to the 2,658 hectares to be restored over the 5-year project period. Assuming the degraded area is reforested at a steady pace, this yields total sequestration of 15,600 tCO2 over the project period.

Table 16 - Carbon benefits of reforestation

2,658 hectares reforested	year 1	year 2	year 3	year 4	year 5	TOTAL
Hectares reforested	1,658	1,000	-	-	-	2,658
Sequestration, at 1.5 t/ha per year	1,658	3,487	3,487	3,487	3,487	15,606
Annual economic value, Bs.	442,133	929,867	929,867	929,867	929,867	4,161,600
Annual economic value, USD	**66,320**	**139,480**	**139,480**	**139,480**	**139,480**	**624,240**

The total value of carbon sequestration / emission reductions over these activities is presented below:

Table 17 - Combined value of non-marketable benefits

Non-Marketable Project Benefits	5-YEAR TOTAL	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**

[21] Net Carbon Emissions from Deforestation in Bolivia during 1990-2000 and 2000-2010: Results from a Carbon Bookkeeping Model, Lykke E. Andersen ,Anna Sophia Doyle,Susana del Granado,Juan Carlos Ledezma,Agnes Medinaceli,Montserrat Valdivia,Diana Weinhold, https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0151241

Component 3 - Wetlands	3,200,075	781,440	703,296	632,966	569,670	512,703
Component 3 - Forest management	60,337,108	12,149,760	12,108,450	12,067,282	12,026,253	11,985,364
Component 3 - Reforestation	624,240	66,320	139,480	139,480	139,480	139,480
Total Non-Marketable Benefits, USD	**64,161,423**	**12,997,520**	**12,951,226**	**12,839,728**	**12,735,403**	**12,637,546**

5.3 Total Economic Benefits

Combining the non-market benefits from ecosystem services dramatically changes the cost-benefit ratio for the project. 5-year and 10-year project NPV become strongly positive compared to the scenario where only marketable benefits are considered.

Table 18 - Economic returns including marketable and ecosystem benefits

Economic results, base case	5 YEARS	10 YEARS
Project EIRR, marketable & non-marketable benefits	34%	56%
Project NPV, marketable & non-marketable benefits	4,698,187	24,323,571

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 explores how project returns change over the 5- and 10-year periods as a result of:

1) Changes to the discount rate used to calculate ENPV;
2) Reductions in the expected flow of marketable and non-marketable benefits;
3) Project benefits are delayed even while costs are incurred as normal

The discount rate reflects the fact that costs and benefits in the near future are valued more highly than costs and benefits that occur further into the future. Increasing the discount rate magnifies the impact of near term financial and economic flows, while decreasing the discount rate makes the future stream of benefits more important. The baseline economic analysis was conducted using a social discount rate of 12.67%. The sensitivity analysis uses discount rates of 5%, 10%, 15% and 20%. Over the 5-year implementation period the analysis yields the following results:

Table 19 - Discount rate sensitivity analysis - 5 years

NPV marketable benefits, 5 years, USD			NPV marketable and non-marketable benefits, 5 years, USD	
Base case 12%	-	41,634,906	Base case 12%	4,698,187
5%	-	47,890,110	5%	7,706,360
10%	-	43,264,170	10%	5,447,301

12%	-	43,264,170	12.00%	5,447,301
15%	-	39,391,913	15%	3,710,197
20%	-	36,112,665	20%	2,363,340

When the 5 years after GCF funding are included (10 years total) the sensitivity analysis of discount rates yields the following results:

Table 20 - Discount rate sensitivity analysis - 10 years

NPV marketable benefits, 10 years, USD			NPV marketable and non-marketable benefits, 10 years, USD	
Base case			Base case	
12%	-	22,009,522	12%	24,323,571
5%	-	15,798,258	5%	39,798,212
10%	-	20,768,727	10%	27,942,744
12%	-	20,768,727	12.00%	27,942,744
15%	-	23,309,565	15%	19,792,545
20%	-	24,408,469	20%	14,067,537

As indicated in the preceding tables, even significant changes to the discount rate do not change the overall economic attractiveness of the project. The marketable benefits remain only marginally attractive over the 5-year timeframe to make the project attractive, although the situation improves over the 10-year period, as these long-lived investments continue to yield financial returns. The positive externalities (non-marketable benefits) make the project extremely desirable over all timeframes. These positive externalities take the form of public goods and demonstrate the importance of GCF investment.

Reducing the flow of project benefits also reduces project NPV. This analysis assumes that project costs remain unchanged but the project is less successful than anticipated at protecting farmer incomes and generating positive externalities. In all cases, the analysis shows that while reducing project benefits reduces NPV in all scenarios, marketable benefits continue to yield a positive NPV for the 10-year timeframe, and combined marketable & non-marketable benefits yield a positive NPV across both timeframes.

Table 21 - Impact of reduced project benefits on ENPV, 5 years

Reduced project benefits - marketable, 5 years			Reduced project benefits - non marketable, 5 years	
Base case no reduction	-	41,634,906	Base case no reduction	4,698,187
5%	-	39,553,161	5%	4,463,278
10%	-	37,471,415	10%	4,228,369
15%	-	35,389,670	15%	3,993,459
20%	-	33,307,925	20%	3,758,550

Table 22 Impact of reduced project benefits on ENPV, 10 years

Reduced project benefits - marketable, 10 years		Reduced project benefits – marketable and non marketable, 10 years	
Base case no reduction	- 22,009,522	Base case no reduction	24,323,571
5%	- 20,909,046	5%	23,107,392
10%	- 19,808,570	10%	21,891,214
15%	- 18,708,094	15%	20,675,035
20%	- 17,607,618	20%	19,458,857

Finally shifting the *timing* of project benefits also reduces ENPV. The realization of benefits might be delayed by, for example a natural disaster that destroys farmers' crops or blocks access to markets for an entire season. The sensitivity analysis assumes that project marketable and non-marketable benefits are delayed by 1 year and 2 years, with no attempt to reduce or delay project expenditure. In both cases, the analysis shows that delaying project benefits reduces NPV. For the 1-year delay, marketable and combined marketable / non-marketable benefits yield a negative (uneconomic) NPV for the 5 year time-frame but a positive NPV over 10 years. This result is unsurprising since the project would be comparing 5 years of costs to 4 years of (discounted) benefits. For the 2-year delay scenario, marketable benefits yield a negative NPV for both the 5- and 10-year periods of analysis. Combining marketable and non-marketable benefits yields a negative NPV over the 5-year period but still manages to yield a positive NPV over 10 years, with IRR of 24%.

Economic results, 1 year delay	5 YEARS	10 YEARS
Discount rate	*12.0%*	*12.0%*
Project EIRR, marketable benefits	cannot calculate	-4%
Project NPV, marketable benefits	- 42,950,274	- 26,025,424
Project EIRR, marketable & non-marketable benefits	-5%	25%
Project NPV, marketable & non-marketable benefits	- 7,984,015	15,343,410

Economic results, 2 year delay	5 YEARS	10 YEARS
Discount rate	*12.0%*	*12.0%*
Project EIRR, marketable benefits	cannot calculate	-9%
Project NPV, marketable benefits	- 44,516,196	- 32,382,907
Project EIRR, marketable & non-marketable benefits	-19%	15%
Project NPV, marketable & non-marketable benefits	- 19,748,473	4,553,551

Taken together, these sensitivity analyses show that the project design is relatively resilient to negative shocks and changes to the underlying assumptions.

6. Conclusion

The results of the economic analysis show that the project does not generate sufficient financial returns for farmers over the five-year implementation period to be undertaken without GCF funding. At the same time, the project generates robust economic benefits over the longer term, and especially from a public perspective, contributes to the long-term sustainability of rapidly deteriorating forests and wetlands in Bolivia, 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, despite the significant positive externalities and public goods generated by this initiative.