May 05, 2020

Ethiopia Resilient Landscapes and Livelihoods Project (RLLP, P163383)

SUMMARY

Economic and Financial Analysis

1. **To assess the ex-ante efficiency of the project investment, a cost benefit model is used.** Annual cost and benefit flows are estimated as the difference between without-project and with-project net benefits for direct beneficiaries (See Annex E.1: Economic and Financial Analysis for more details). Efficiency indicators include the Economic Net Present Value (ENPV) and the Economic Internal Rate of Return (EIRR), as well as impact on farm productivity, household incomes, soil erosion, and GHG emissions (carbon balance). Based on available information compiled during preparation, gross margins and representative farm models have been developed for selected cropland, non-cropland, and livestock production in the project area. Additional net benefits are analyzed from establishing Community Storage Receipts Program (CRSP) facilities.

2. In the counterfactual, without the Project, land use will continue on its current path. Continued soil erosion, water insecurity, and land insecurity leads to land degradation. It is expected that climate change will exacerbate soil erosion and water insecurity further leading to direct losses to those that rely on crop and livestock production as well as related industries for their energy use and livelihood. Production yields will go down or farmers will have to increase their input costs, such as fertilizer use, to maintain current yields. In the absence of CSRPs, farmers will continue to experience post-harvest losses. They will also be unable to capture higher crop prizes that are obtainable a few months after harvest and in larger markets. Non-agricultural land in the watershed will also continue to deteriorate without the Project due to climate change and soil erosion as well as overuse of common land through livestock grazing and firewood collection. This will put a further strain on the population who derive their livelihood from forests, woodlands, and surrounding areas. Downstream from the project area, continued land degradation will also affect areas and households through increased flood risk and sediment build-up in irrigation and hydroelectric dams.

3. Incremental benefits are estimated for investments in green infrastructure and resilient livelihoods (Component 1). It is assumed that these benefits will only accrue if the activities in the remaining 3 components are also achieved: 2. Strengthening institutions, information and monitoring for resilience; 3. Land administration and use; and 4. Project management and reporting. Investment costs include USD 165.2 million from GCF, USD 100 million from IDA, USD 19 million from MDTF, and USD 12 million from expected MDTF Contribution from the Government of Canada for a total USD 296.2 million.

4. Following World Bank guidelines, the economic analysis considers anticipated costs and benefits with and without the project, including social costs and benefits (World Bank, 2013b). This implies that funding sources and labor costs outside the GCF project must be considered. In this project, the following are included as additional costs for capacity

building and project management totaling USD 23 million (funding is provided by GIZ, USD 13 million, and by GoE, USD 10 million). In addition, the analysis includes an estimated USD 99.1 million in in-kind contributions from project beneficiaries less USD 3.8 million in price contingencies. With all costs included, the total budget included in the analysis is USD 319.2 million. In addition, as part of an exit strategy, recurrent costs in the years after Project has ended are estimated to be 2.5% of initial costs including beneficiary in-kind contributions (USD 10.4 million per year).

5. The Project will increase climate resilience in 210 major watersheds covering an area of 2.1 million ha. The 40 most vulnerable to soil erosion due to precipitation changes from climate change were selected for funding through GCF. The project supports 45 graduated watersheds from SLMP-1 to ensure that they receive the necessary support to continue capturing the gradual build-up of benefits and avoid falling back into degradation. No further yield increases in these graduated watersheds are included in the EFA and no GCF funds are used there. Based on 2007 census numbers, the Project has an estimated 4.2 million beneficiaries (or 834,000 households) in the selected 210 watersheds. Because population growth since 2007 census is estimated to be 15% or more, for the present day this is a conservative estimate.

6. Project interventions are assumed to lead to direct net benefits to crop and livestock producers as well as forests and other non-croplands through watershed management plans. These activities will reduce soil erosion and yield losses that are expected to result from climate change in the absence of Project intervention. Activities will also improve productivity and increase resilience against the negative impacts of climate change. To further increase resilience against future climate change, the Project will encourage new income generating activities through community groups including CSRPs. Project activities will also constitute a net carbon sink when analyzing impact on GHG emissions. While not included quantitatively in this EFA, benefits will also accrue from strengthening institutions and improving information and monitoring systems. Improved administration and secure tenure rights will create incentives for beneficiaries to adopt sustainable management practices. The Project is also expected to have positive impact on indirect beneficiaries in neighboring areas through informal dissemination of new management practices as well as downstream improvements from reduced floor risk and sediment build-up.

7. In the current 25-year net benefit analysis using a 5 percent discount rate, the project yields an Economic NPV of USD 3,312 million (ETB 92.7 billion) and has a benefit cost ratio of 3.8. The Economic IRR is 47%. The payback period is 5.3 years. In economic investment analyses, the Project therefore meets the requirement by yielding a rate of return higher than the economic discount rate of 5%. Note that, a 25-year model is used to account for the long-term gradual build-up of benefits from SLM interventions combined with a 5-year implementation phase followed by 20 year capitalization phase for forest plantations and green corridors.

8. World Bank guidelines recommend using a 5% economic discount rate.[1] Increasing the discount rate from 5% to 10% reduces project returns by 51% to USD 1,617 million. Project returns are still considerable at a 10% discount rate with a BCR of 3.2.

9. If the Project only reaches half of the targeted area for example due to unexpected cost increases, estimated project returns fall by 53% to USD 1,560 million and the rate of return drops from 47% to 26%.

10. If base case assumptions are too conservative or climate change leads to accelerated soil erosion in the future, the estimated net benefit of Project interventions would be higher. When assuming a 50% increase in annual soil loss by year 25 the estimated economic return is USD 3,462 million with a 47% rate of return. Under this accelerated soil erosion scenario, the estimated Project net benefit of avoiding this larger soil erosion is therefore USD 150 million across the 25-year period. In the base case, estimated value of soil erosion varies between USD 0.11 and 0.26/tonne soil per year depending on the gross margin value of different land uses. In the scenario with accelerated soil loss, this estimated value ranges between USD 0.17 and 0.38/tonne soil per year.

11. When excluding the social value of reduced GHG emissions, the net economic project return is USD 2,238 million (ETB 62.7 billion) with a benefit cost ratio of 2.9 and an EIRR of 29% and a payback period of 7.3 years. This is 3.1% of Ethiopia's GDP (in 2016 terms).

12. When excluding the GHG emissions, 49% of incremental net benefits are generated through activities on non-cropland areas, particularly due to the transformation of 41,000 ha from bush and grassland to forest plantation but also due to avoided soil erosion. This constitutes an ENPV of USD 108 per year per treated hectare and an EIRR of 43%. A substantial part of Project returns is also generated by cropland and livestock production at USD 49/ha/year and USD 39/ha/year, respectively. Much of the incremental benefit estimated from cropland comes from transforming 30,000 ha of unproductive land to green corridor plantations and some is from avoided soil erosion. With exacerbated problems from climate change, forest plantations and green corridors will enhance watershed restoration and ecological connectivity as well as extend the lifespan and resilience of drainage, irrigation, and road infrastructure.

13. In financial terms the NPV is USD 696 million (ETB 19.5 billion) with a Financial IRR of 28%, a benefit cost ratio of 2 and a payback period of 7.5 years. This estimated net return constitutes 1% of Ethiopia's GDP in 2016. In the financial analysis a 12% discount rate is used to reflect the opportunity cost of capital in Ethiopia.

14. By supporting the establishment of financially viable enterprises in the area, the Project helps build resilience and future self-sufficiency. Without Project support toward initial investment and working capital, CSRPs may be financially viable to also cover future capital maintenance costs, but only if available commercial loan interest rate is below their FIRR of 18-21% and a payback period of over 5 years. Initial information indicates that commercial

[1] World Bank (2015). Technical Note on Discounting Costs and Benefits in Economic Analysis of World Bank Projects. Washington, DC.

loans for investments may be available at this rate but not the size of loans required. It can be expected that demonstrated implementation of CSRPs can reduce commercial banks' future risk perception. CSRPs can improve their financial viability to an FIRR over 24% for example by using more of their available storage capacity, obtaining a matching investment grant and reducing their initial working capital requirements. To be financially viable, the CSRPs will require project support to cover the initial investment costs in the absence of commercial loans at favorable rates. As part of an exit strategy, this increased level of return would also enable them to cover the assumed future capital maintenance costs.

15. The National Poverty Line for Ethiopia is a measure of absolute poverty. The poverty line indicates the money required for food to provide the minimum required caloric intake (Food Poverty Line) and additional non-food items. In the financial analysis, estimated farm-level gross margins can increase by over USD 101/year/person (including the value of production used for home consumption), which is 1.2 times the Food Poverty Line (USD 85/person/year in 2018 terms), or 63% of the National Poverty Line (USD 162/person/year). This is a direct measure of increased resilience in the Project area.

16. The planned investment Project is expected to yield high returns even when considering key risk factors such as: yield and price changes; adoption rates; and project delays. As part of a risk management plan, it is particularly important to ensure that farmers can negotiate and obtain fair output prices and achieve target yields going forward. Part of the risk management plan could also be to ensure that planned CSRPs are used to their full capacity and that they receive sufficient financial support toward initial investment and working capital costs to ensure their financial viability. Close monitoring and support for target farmers and communities to implement water management plans could help increase the adoption rate. While not always avoidable, project delays can be minimized with close monitoring and by ensuring implementation does not lose momentum.

ABBREVIATIONS AND ACRONYMS

CIG	Community Interest Group
CO_2-eq	Carbon Dioxide Equivalent
CRGE	Climate-Resilient Green Economic initiative
CSR	Corporate Social Responsibility
CSRP	Community Storage Receipts Program
EFA	Economic and Financial Analysis
EIRR	Economic Internal Rate of Return
ENPV	Economic Net Present Value
EPA	Environmental Protection Agency
ESIF	Ethiopian Strategic Investment Framework
ETB	Ethiopia Birr
EX-ACT	The Ex-Ante Carbon-balance Tool
FAO	Food and Agriculture Organization
FIRR	Financial Internal Rate of Return
FNPV	Financial Net Present Value
GCF	Green Climate Fund
GDP	Gross Domestic Product
GEF	Global Environment Facility
GHG	Greenhouse Gas
GIZ	Gesellschaft fur Internationale Zusammenarbelt
GoE	Government of Ethiopia
GTPII	Growth and Transformation Plan II
ha	hectare
IDA	International Development Association
INDC	Intended National Determined Contribution
MDTF	Multi-donor Trust Fund
MOALR (MOANR)	Ministry of Agriculture and Natural Resources now Ministry of Agriculture and Livestock Resources
MOFEC	Ministry of Finance and Economic Cooperation
MOWIE	Ministry of Water, Irrigation and Electricity
NPV	Net Present Value
PES	Payment for Ecological Services, Payment for Environmental Services
SHG	Self Help Group
SLM	Sustainable Land Management
SLMP	Sustainable Land Management Project
tonne, t	Metric tonne
USD	United States Dollar
WO/P	Without Project
W/P	With Project
WUA	Water User Association

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Annex E.1: Economic and Financial Analysis

Ethiopia Resilient Landscapes and Livelihoods Project (RLLP, P163383)

1. Background

1. **This Annex contains the Economic and Financial Analysis (EFA) of the Project.** The Project Development Objective (PDO) is to improve climate resilience, land productivity and carbon storage and increase access to diversified livelihood activities in selected rural watersheds.

2. **The Project is comprised of four components that target key development issues for millions of rural Ethiopians facing water insecurity, food insecurity, land tenure insecurity, and livelihood insecurity.** Investment costs include USD 165.2 million from GCF, USD 100 million from IDA, USD 19 million from MDTF, and USD 12 million from expected MDTF Contribution from the Government of Canada for a total USD 296.2 million. Following World Bank guideline, the economic analysis considers anticipated costs and benefits with and without the project, including social costs and benefits (World Bank, 2013b). This implies that funding sources and labor costs outside the GCF project must be considered. In this project, the following are included as additional costs for capacity building and project management totaling USD 23 million (funding is provided by GIZ, USD 13 million, and by GoE, USD 10 million). In addition, the analysis includes an estimated USD 99.1 million in in-kind contributions from project beneficiaries less USD 3.8 million in price contingencies. With all costs included, the total budget included in the analysis is USD 319.2 million. In addition, as part of an exit strategy, recurrent costs in the years after Project has ended are estimated to be 2.5% of initial costs including beneficiary in-kind contributions (USD 10.4 million per year). The components are:

i. Investment in Green Infrastructure and Resilient Livelihoods
ii. Strengthening Institutions, Information and Monitoring for Resilience
iii. Land Administration and Use
iv. Project Management and Reporting

3. Project activities in Component 1 include enabling community plans for land restoration and watershed management. The plans include physical soil conservation as well as biological conservation techniques. Beneficiary farmers will be targeted to adopt climate smart agriculture practices. Beneficiaries will also receive support to diversify their income generating activities and adopt energy efficient stoves and lights. The benefits to be captured through these interventions are enabled by strengthening institutions, policies, and information flow through Component 2. It is also necessary to strengthen participatory land use planning and secure tenure rights for beneficiaries through Component 3. This will enable them to adopt new production practices and continue operating sustainably after Project implementation is complete.

4. **The project will support households in 210 watersheds located in the Ethiopian highlands with a beneficiary population of 4.2 million people (4% of Ethiopia's population in 2016) in 834,000 households with an average of 5 persons per household.** The watersheds are located in 6 different regions. This includes 57 newly identified watersheds, continuing support for 90

watersheds initiated under SLMP-2, 18 watersheds under expected MDTF Contribution from the Government of Canada (see Table 1a), and 45 graduating watersheds supported under SLMP-1 (see Table 1b). The new watersheds were selected using comprehensive selection criteria which took into account existing levels of degradation and the share of the watershed in need of sustainable land management interventions. The new watersheds and those from SLMP2 were ranked according to their vulnerability based on projected soil erosion due to precipitation changes from climate change. Of these 165 watersheds the 40 most vulnerable were selected for funding through GCF. The 45 graduated watersheds from SLMP were included to ensure that they receive the necessary support to continue capturing the gradual build-up of benefits and avoid falling back into degradation. Table 1c shows the total area to be treated within the 210 watershed Project area to be 987,900 ha. The watersheds have a mixture of both cropland and non-cropland. There are also forests and woodland in the Project area, but these are not targeted with Project activities.

5. **Without Project intervention, beneficiaries both in the area and downstream will continue to struggle to establish or maintain their livelihoods.** It is expected that without the Project (the counterfactual), land use will continue on its current path. Continued soil erosion, water insecurity and land insecurity leads to land degradation. It is expected that climate change will exacerbate soil erosion and water insecurity further leading to direct losses to those that rely on crop and livestock production for their energy use and livelihood as well as related industries. Production yields will go down or farmers will have to increase their input costs, such as fertilizer, to maintain current yields. In the absence of CSRPs, farmers will continue to experience post-harvest losses. They will also be unable to capture higher crop prizes that are obtainable a few months after harvest and in larger markets. Non-agricultural land in the watershed will also continue to deteriorate without the Project due to climate change and soil erosion as well as overuse of common land through livestock grazing and firewood collection. This will put a further strain on the population who derive their livelihood from forests, woodlands, and surrounding areas. Downstream from the project area, continued land degradation will also affect areas and households through increased flood risk and sediment build-up in irrigation and hydroelectric dams.

6. Figure 1 illustrates how this analysis assumes a declining production without Project interventions due to soil erosion from both climate change and land management. With Project interventions the yield loss is avoided and, for some production systems (crops, livestock, and grassland), with-project yields increase over time. This yield increase is attributed to adoption of improved cultivars, improved seeds, better animal breeds, land restoration, water management, and implementing climate smart agricultural techniques. The sum of the two shaded areas in Figure 1 constitutes the incremental benefit.

7. Successful interventions to prevent or control land degradation require integrated and cross-sectoral approaches to sustainable land management. The Project will build on the wealth of technical, operational and institutional experiences and lessons learnt through the implementation of GoE's SLM Program, including SLMP-1 and SLMP-2, as well as similar initiatives supported by other bilateral and multilateral partners in the country and the region. Before the programmatic approach of the GoE's SLMP, efforts to address land degradation were piecemeal and scattered throughout the country. Despite the inherent upfront costs, adopting a programmatic approach was considered instrumental to convene financial and non-financial support, resulting in greater overall

benefits downstream (World Bank, 2014a). Continuing from those projects, coordination, supervision and implementation will include close cooperation with sector ministries for agriculture and natural resources (MOANR/MOALR), finance (MOFEC), water and electricity (MOWIE), and the Environmental Protection Agency (EPA).

8. The Project is designed to contribute to key national strategies including: The Growth and Transformation Plan II (GTPII), the Agricultural and Rural Development Policies and Strategies, the Climate-Resilient Green Economy initiative (CRGE), the Ethiopian Strategic Investment Framework (ESIF), the Environmental Policy and Strategy, the Intended National Determined Contribution (INDC), the Strategy for Conservation and Utilization of Forest Products, the emerging National Forest Sector Strategy, and the National REDD+ Strategy.

2. Rationale for Public Provision and Financing

9. **There is a strong rationale for public interventions as proposed by the project because it supplies public goods, corrects market failures and deals with externalities – all core functions of government.** Project activities encourage public goods such as: protection of ecologically sensitive landscapes; more efficient energy use; securing beneficiaries land rights, and; increasing sequestration of carbon in soils and biomass. There is also a public sector argument for funding initiatives that deal with externalities. Typical externalities of reduced soil erosion are reduced costs to operating downstream irrigation and hydroelectric dams.

10. **The current land degradation issues warrant more targeted public investments that can ensure that private sector entities adopt sustainable management practices going forward.** The proposed project helps focus attention and assistance not only on promoting sustainable land management to improve agricultural productivity, but also on helping beneficiaries become more resilient to extreme weather events. Net benefits captured through this type of intervention accrue over many years adding to the difficulty of attracting private sector investors. Incentives are also strategically different from standard productivity investments because substantial benefits are generated from avoided future yield losses. In this setting, the lack of cash and credit for working capital as well as for investments in the agriculture sector prevents farmers from adopting new practices with such long-term benefits.

3. Methodology

11. **A 25-year cost benefit model incorporating all investment costs is used to assess the ex-ante efficiency of the Project investment.** Choosing the length of analysis period for an EFA model is a trade-off between keeping it short because future projections become increasingly uncertain, and making it long enough to capture long-term benefits of SLM and climate smart agriculture interventions. As discussed in detail below, the benefits and costs from interventions are expected to build-up gradually over a number of years while degraded soils recover and while the farmer learns new production methods. In addition, the project includes restoration of degraded land using forest and green corridor plantations. To account for a full forest rotation, a 25-year analysis period is used to include a 5 year implementation phase and a 20 year capitalization phase.

See illustration of long-term benefit accrual in Figure 1. All Project interventions are considered necessary to obtain the target impact; therefore, the entire investment cost is included in this analysis. This includes USD 391.2 million from different sources plus USD 99.1 million from beneficiary in-kind contributions less 0.9% or USD 3.8 million price contingencies. In addition as part of an exit strategy, recurrent costs in the years after Project has ended are estimated to be 2.5% of initial costs including beneficiary in-kind contributions (USD 10.4 million per year). Annual net benefits are estimated as the difference between without-project (WO/P, or the counterfactual) and with-project (W/P) net benefits for direct beneficiaries.

12. **Some benefits are captured for all Project Components – directly or indirectly.** All Project activities are associated with both costs and benefits. The following incremental net benefit flows are expected – some of which are quantified while others are discussed qualitatively. Net benefits are benefits or revenue less costs. Incremental net benefits means the difference between the W/P and WO/P situations. The number of direct beneficiaries was derived by overlaying watershed boundaries on a 1x1km population density grid from the 2007 census and summing for all watersheds targeted by the project (4.2 million direct beneficiaries or 834,000 households with an average of 5 persons each). The indirect beneficiaries are the total population of woredas in which the targeted watersheds are located, which is just under 24 million. Since population growth since 2007 census is estimated to be 15% or more, for the present day this is a conservative estimate.

(a) **Direct net benefits to crop producers:** The EFA quantifies the incremental improvement in gross margins for different crops and cropping patterns on farms in the targeted watersheds. The increment includes expected WO/P yield- and price losses due to the absence of CSRPs. It also includes net benefits from establishing green corridors along field margins, eroded gullies and so on. A portion of this incremental benefit is due to avoided soil erosion caused by climate change and historical management practices. This estimate is calculated separately from the impact on yield (see illustration in Figure 1).

(b) **Direct net benefits to livestock producers:** The EFA quantifies incremental improvements in gross margins for different livestock production systems and stocking rates on farms in targeted watersheds.

(c) **Direct net benefits to forests and other non-croplands:** The EFA quantifies the net improvement in gross margins for different categories of land use including forest plantations, green corridor plantations, bush, shrub, and grassland. A portion of this incremental benefit is due to avoided soil erosion caused by climate change and historical over-grazing and firewood collection. This estimate is calculated separately from the impact on yield (see illustration in Figure 1).

(d) **Direct benefits from new CSRPs:** Due to the lack of data regarding establishing new Income Generating Activities (IGAs), this EFA only quantifies the establishment and operation of 208 facilities that enable participation in larger Community Storage Receipts Programs (CSRP) across the Project area. Net benefit is estimated from gross margins for each facility, in addition to net benefits captured at farm level described above. One of the major barriers to the implementation of resilience building measures by farmers is lack of cash. After Project completion, farmers will need cash in order to be able to continue practices introduced by the Project such as the use of improved seeds, improved farm tools, fertilizer and other inputs. The CSRP will provide immediate cash to poor farmers, improving their food security and ability to pay for other necessities as well as allowing them to improve productivity.

(e) **Global value of impact on Greenhouse Gas (GHG) emissions:** The Project impact on GHG emissions is estimated using FAOs Ex-Ante Carbon-balance Tool (EX-ACT). This considers changes in land use, land restoration and input and energy use. In line with World Bank guidance note, this analysis refers to the "shadow price of carbon" (USD/tonne CO_2-eq) being multiplied with the GHG emission reductions (tonne CO_2-eq) to estimate the "social value of GHG emissions". Other reports may refer to the social value of carbon, the social cost of carbon, impact on carbon balance, or carbon sequestration.[2] There are no actual payments of carbon credits to beneficiaries in this project, so the social value of reduced GHG emissions is included only in the economic analysis and not in the financial analysis.

13. The following incremental net benefit flows are not quantified explicitly in this analysis:

(a) **Net benefits from new Income Generating Activities (IGA):** The project will engage farmers through Self Help Groups (SHG), Community Interest Groups (CIG), and Water User Associations (WUA). Apart from CSRPs, several other possible enterprises have been noted but lack of data prevents quantification at this time: grain-, meat-, dairy-, and bamboo-processing; tree seedling nurseries; manufacturing improved cook stoves; production of improved environmental services, and private sector initiatives for Payment for Ecosystem Services (PES, also known as Payment for Environmental Services) or Corporate Social Responsibility (CSR).

(b) **Net benefits from promoting energy efficiency:** The value of promoting energy efficient technology and resulting reduced indoor air pollution is not quantified.

(c) **Net benefits from strengthening institutions and improving information, and monitoring for resilience (Component 2):** The net benefits estimated in activities in Component 1 cannot be successfully captured without the investment in Component 2 to strengthen stakeholders and provide technical assistance and mobilize communities. It is difficult to determine the share of Project benefits that can be attributed to these sub components. Therefore a separate efficiency analysis is not recommended.

(d) **Benefits from improved administration and tenure rights (Component 3):** The lack of secure tenure rights creates a dis-incentive for beneficiaries to undertake productive investments and adopt sustainable management practices. This is particularly the case when benefits accrue over a longer period of time. The direct benefits of this component are captured in Component 1 while other benefits are not

[2] World Bank (2017f) Guidance note: Different documents have been using different terms to refer to the price of carbon or GHG emission reduction used in economic analysis (shadow price of carbon, social cost of carbon, and social value of carbon). These terms refer to different approaches to calculate the price of carbon. The guidance note uses the term "shadow price of carbon," which is the price of carbon consistent with a given climate objective, as estimated for the High-Level Commission on Carbon Prices, led by Joseph Stiglitz and Nicholas Stern.

quantified due to lack of data. These other benefits could include conservation of protected areas, biodiversity, and tourism.

(e) **Indirect benefits to other local areas:** Several of the incremental benefits quantified as described above will likely have other indirect benefits. For example, these include the adoption of climate smart agriculture and land restoration techniques in neighboring watersheds due to informal dissemination outside the Project area. Producers in neighboring watersheds may pay to access new CSRPs. Other industries and employment opportunities may increase through a multiplier effect to other areas and related sectors. Due to lack of data these are not quantified in the EFA.

(f) **Downstream effects:** Downstream effects or externalities from reduced soil erosion are also not quantified due to lack of data. These benefits could include reduced risk of downstream flooding and reduced costs of sediment build-up in downstream irrigation and hydroelectric dams.

(g) **Improved nutrition:** Incremental benefits from improved nutrition have not been quantified other than through value of increased production yields. The value of a more varied food production has not been estimated. This would be a direct benefit to Project beneficiaries and indirect benefit to people in neighboring areas.

14. **Efficiency and other cost-benefit indicators.** The cost-benefit analysis is based on crop-, and farm-level assumptions on yields, prices and costs in constant 2018 currency amounts for without- and with-project situations, based on a typology of farm households.[3] The Economic Net Present Value (ENPV) is calculated using the World Bank recommended discount rate of 5%.[4] The financial discount rate used is 12% to reflect the opportunity cost of capital in Ethiopia. In addition to sensitivity analyses of these discount rates, the break-even rates are calculated, i.e. the Economic and Financial Internal Rates of Return (EIRR and FIRR). Other indicators included are (units in parentheses):

(a) Land area restored, reforested and afforested with sustainable management practices (hectares)
(b) Target area in different land use categories (hectares)
(c) Number of beneficiaries (people and average 5 persons per households)
(d) Reduced soil erosion (tonnes)
(e) Production and income in representative farm households (yield and USD)
(f) Increased net benefits from CSRPs as well as their financial returns on investment in the absence of Project support (USD)
(g) Impact on GHG emissions (CO_2-eq and USD)

15. **Results are aggregated to different levels for further analysis.** The main sources of data are a gross margin study and a baseline survey prepared for SLMP (Große-Rüschkamp, 2015, and MOANR/MOALR, 2016). The Project team consulted with additional experts to obtain

[3] The foreign exchange rate used is 1 USD = 28 ETB. Ethiopia Consumer Price Index to adjust 2014 to 2018 prices = 131.7.
[4] World Bank (2015). Technical Note on Discounting Costs and Benefits in Economic Analysis of World Bank Projects. Washington, DC.

assumptions about forestry and CSRPs. The Project's impact on GHG emissions was estimated using FAO's EX-ACT model. Combining these data sources the methodology goes further than the total project results to enable analyses at different levels of aggregation:

(a) At the base of the model are data on per hectare gross margin for annual crops and avoided yield loss from soil erosion. Gross margins for livestock production are calculated per head of animal.
(b) Representative farms are defined in terms of farm size and combinations of different annual crops and livestock. This enables an analysis of estimated impact on incremental farm household income. An analysis is provided for a representative CSRP facility to determine their financial viability in the absence of Project support.
(c) Incremental net benefits on non-cropland are estimated at the watershed level. This includes any projected per hectare changes in gross margins as well as avoided yield loss from soil erosion.
(d) Establishment of CSRPs are estimated at the watershed level.
(e) Global impact on the GHG emissions is estimated at the Project level and allocated proportionally between watersheds.

16. **Cumulative target values and farmer adoption rates.** Investment costs are allocated across the initial years as detailed in the Project cost tables. Farmers' adoption of improved agricultural practices promoted by the Project is assumed to follow a progression of 5% per year. This includes a progression in farmers' revenue as well as variable costs. The Project team expects the maximum adoption rate to be 75% of the targeted farmers based on the 86% rate in the SLMP-2 baseline study (MOANR/MOALR, 2016).[5] In graduated watersheds it is assumed that farmers adopting new agricultural practices have already progressed for four years under SLMP.

17. **Conversion factors for economic analysis.** An economic analysis is concerned with value addition to the gross domestic product and excludes all transfer payments such as taxes, subsidies, grants, loans, interest- and principal payment paid to or received from beneficiaries. Because none of the agricultural products quantified in this model are imported or exported, the farm gate prices are applied both in the financial and economic analysis. The opportunity cost of unskilled labor is set to 0.75 due to limited alternative employment opportunities. It is expected that some agricultural and construction inputs are imported and should be converted from farm gate prices using an economic conversion factor (assumed to be 0.95). Much of the variable costs included in the analysis is unskilled labor. Therefore, average conversion factors are used for cropland variable costs (0.98), non-cropland variable costs (0.88), and project investment costs (0.98). All other cost assumptions are maintained from the financial analysis. As noted before, price contingencies estimated at USD 3.7 million or 0.9% of the Project budget is excluded from the analysis.

18. **The project's impact on GHG emissions is estimated using FAO's EX-ACT model.** The economic value of the Project's impact on GHG emissions (sometimes referred to as the carbon

[5] Other examples include: 74% adoption rate in the Uganda-National Agricultural Advisory Services Project (NAADS) and 70-80% adoption rate in the IFAD Rwanda Project for Rural Income through Exports (PRICE). In the Pro-poor Value Chain Project in the Maputo and Limpopo corridors (PROSUL) economic and financial analysis, an 80% adoption rate was assumed in the project area. 100% adoption rate was assumed in Malawi Shire River Basin Management Programme and the Community-Based Rural Land Development Project.

balance) is estimated from activities in the project including: bio-physical structures on degraded land; afforestation and reforestation; promoting agroforestry; introducing climate smart agriculture practices; introducing improved grassland management; and enriching forest areas with different tree species. The total GHG emission reduction is multiplied by the assumed economic value from USD 32 per tonne CO_2-eq in early years increasing to USD 68 at the end of the 25 years. No value is assigned to reduced GHG emission in the financial analysis because there are no direct payments of carbon credits to beneficiaries.[6]

19. **Sensitivity analyses identify key assumptions that should be the focus of risk management efforts.** Three different approaches are used: i) switching values, when a change in an assumption leads to a break-even ENPV, are calculated for most assumptions. ii) Elasticities are also calculated for most assumptions to show how much a 1% change in an assumption changes total ENPV; and iii) Specific cases are analyzed to further highlight key risk factors and quantify the impact of variables that cannot be analyzed with switching values and elasticities as listed below:

(a) Impact of different discount rates
(b) Failure to implement the planned number of hectares
(c) Changes in adoption rate among beneficiaries
(d) Delay in project benefits
(e) Higher yield losses from soil erosion
(f) Changes in number of animals per farm
(g) Accelerated annual soil loss due to climate change
(h) Changes in the social value of reduced GHG emissions

4. Assumptions and Results

20. Before analyzing the economic value results, the underlying assumptions are discussed starting with a financial analysis of farm-level target beneficiaries. Except where noted, the assumptions used are the same as in the recent Project Appraisal Report for the RLLP which excluded GCF and GIZ scope and funds (World Bank, 2018). Note that the value of reduced GHG emissions is not included in the financial analysis because payments for carbon credits are not expected to be distributed directly to beneficiaries during the Project.

4.1. Financial Analysis

21. **Project interventions are assumed to lead to improved crop and livestock gross margins providing there is long-term maintenance.** Tables 2 and 3 show the crop and livestock gross margins per hectare and per animal head. One farm model is established for each region based on cropping pattern and gross margin data from the SLMP-2 baseline study (MOANR/MOALR, 2016) and gross margin study (Große-Rüschkamp, 2015). It is assumed that the Project has no impact on crop prices. For livestock production, a price increase is included because Project intervention is expected to lead to use of improved breeds and quality of produce. Yield increases are expected to be small (10-14%) on irrigated crops, and larger on rain-fed crops (16-70%). To

[6] Current World Bank Guidelines suggest a shadow price of carbon of USD 30 per tonne CO_2-eq in 2015 building up to USD 80 per tonne in 2050. World Bank (2017f) Shadow price of carbon in economic analysis. Guidance note to the World Bank Group staff. Washington, DC, November 12. USD GDP Deflator to convert 2014 to 2018 prices = 105.2.

achieve these yield increases, variable costs will also increase. Gross margins on key crops are assumed to increase by between 11% and 67%. The Project will not finance herbicide and pesticide use but farmers may use these. For the purposes of this analysis for GCF, assumptions have been adjusted to emulate no herbicide or fertilizer use. This is done by reducing vegetable yields by 12% in line with Urgessa (2015).[7] Gross margins from livestock production increase, particularly in dairy (123%) and sheep rearing (60%). Any yield increases are assumed to build up over time with long-term maintenance, which is also emphasized by Schmidt and Tadesse (2017).[8] As a proxy for variable weather, it is assumed that revenue generated on cropland is reduced by 10% every 5 years due to an extreme weather event.

22. **Table 4 shows the assumed cropping patterns and number of livestock on representative farm models.** One representative farm is established for each of the 6 regions based on cropping pattern and livestock data from the SLMP-2 baseline study. There are no available data on which to base an assumption of changed cropping patterns due to the project. In recent impact studies of the SLMP-2 project there are indications that farmers who are able to increase the yields of different livestock are tending to reduce their herd size (World Bank, 2017d). This is not assumed in the base case but included in the sensitivity analysis.[9]

23. **Some crop gross margins are used as proxies for other crops when data are unavailable.** Not all crops featured in the SLMP-2 baseline study have gross margin data available. Therefore, some crops have been combined to cover 100% of farm area by region: sorghum is combined with millet. Oilseeds are combined with peas. It is assumed that 100% of potatoes are irrigated in Tigray, Amhara, Oromia, and Benishangul Gumuz. Potatoes are rain-fed in Gambella and SNNPR. Rain-fed vegetables are valued as rain-fed potatoes including 90% of vegetables in Tigray, Amhara, Benishangul Gumuz, and SNNPR, and 50% of vegetables in Gambella and Oromia. The remaining vegetables are irrigated and valued as tomatoes.

24. **Estimated farm-level gross margins increase and build resilience by over USD 101/year/person including home consumption, which is 1.2 times the Food Poverty Line.** Table 5 shows farm-level income increases by 51-64% on different representative farms. When assuming 5 persons per household farm gross margin can increase at least USD 101 per household member per year including value of production used for home consumption. This is a direct measure of increased resilience. To associate this result with a measure of absolute poverty, we use the National Poverty Line for Ethiopia. The poverty line indicates the money required for food to provide the minimum required caloric intake (Food Poverty Line) and additional non-food items. The improvement in farm gross margin is around 1.2 times the Food Poverty Line in 2018

[7] According to findings by Urgessa, T. (2015) a 1unit change in pesticide use leads to 0.12 unit change in both land productivity and labor productivity. This is interpreted as a 12% yield reduction without pesticide/herbicide use and no change in labor use. In effect, it is assumed that reduced labor at harvest is equal to increased labor during growing season such as for weed and disease management.

[8] Schmidt and Tadesse (2017) suggest that there are no measurable improvements in productivity from SLMP, although the authors also acknowledge that there are problems with the data: They found that, over the analysis period, value of production increased significantly in both treatment and non-treatment areas.

[9] In reality, cropping patterns are driven by demand and supply. However, the EFA model is deterministic and does not include a dynamic adjustment of cropping patterns between years and different farmers. The assumptions are based on the Project team's best judgement.

terms (USD 85/person/year).[10] This improvement is also about 63% of the total National Poverty Line (USD 162/person/year). Other representative farms are estimated to capture higher growth in gross margins of up to USD 135/person/year.

25. **Table 6 shows the estimated gross margins on non-cropland.** Project interventions will transform 41,000 ha from bush or grassland to forest plantations, and 30,000 ha from unproductive cropland or grassland to green corridor plantations. With exacerbated problems from climate change, this will enhance watershed restoration and ecological connectivity as well as extend the lifespan and resilience of drainage, irrigation, and road infrastructure. In this analysis it is assumed that incremental benefits generated from cropland converted to green corridors will be captured by farmers and valued as part of farm crop margins. Comparing gross margin improvements shows that incremental benefits from transforming bush or grassland to forest plantations, green corridors or agro-forestry (Table 6) are much larger than the incremental farm benefits from improved practices and reduced soil erosion (Table 5). It is assumed that gross margins do not change on most non-cropland areas. The exception is that biophysical treatment of grasslands will improve estimated gross margins by 90% due to doubled yields and increased maintenance costs.

26. **Table 7 shows estimated gross margins for CSRPs. Average capacity used is 130-209 tonnes per facility.** It is assumed that access to a CSRP will mean that farmers avoid a post-harvest yield loss of 10%, and they will be able to obtain 5% higher prices. The fee farmers pay to sell their produce via these CSRPs is assumed to be 10% of the farm gate price. Produce is purchased from farmers at 5% over original price. Variable costs also include 34 days of labor per month valued at USD 2.14 per day. For this analysis it is assumed that a CSRP runs at an annual gross margin of 10% to cover their fixed costs. An additional price premium is therefore charged to buyers to reach the 10% gross margin target. It is assumed that the warehouse capacity corresponds to 50% of each region's crop production and that 50% of this production requires storage. While Table 7 shows weighted average gross margins for two representative facilities, the analysis varies the gross margins between the six regions according to their crop production. Combining area production with the planned size of facilities (480 m^3) this constitutes warehouse capacity of 130-209 tonnes/facility because some watersheds are smaller and have lower crop production. With the current size of facilities CSRPs could probably absorb up to 100-250 tonnes depending on location and crop. While this result may indicate excess storage capacity, the Project does not cover the entire cropland area (see notes in Tables 1a-c). It is expected that CSRPs will absorb production from the entire productive area of the Project watersheds as well as from neighboring non-Project watersheds. As such, part of the risk management plan could be to ensure that the facilities are used to their capacity. Note that no CSRPs are established with IDA funds in Gambella and Benishangul Gumuz. For this analysis, the 16 planned CSRPs are proportionally allocated between larger watersheds in Tigray, Oromia, Amhara, and SNNRP regions. The 40 CSRPs established with GCF funds are allocated in the GCF watersheds.

27. **Without Project support toward initial investment and working capital, CSRPs may be financially viable to also cover future capital maintenance and management costs, but only if available commercial loan interest rate is below their FIRR of 18-21% and a payback**

[10] The 2011 National Poverty Line was 3,781 ETB/adult while the Food Poverty Line was 1,984 ETB/adult leaving Non-food Poverty Line of 1,796. Ethiopia Central Statistical Agency (2014) and World Bank (2015b). It is assumed that a household of 5 persons is 3.1 adult equivalents. These are converted to 2018 amounts using CPI factor 1.88.

period of over 5 years. Initial information indicates that commercial loans for investments and working capital may be available at an 18% rate but not for larger investments such as these, which means that the facilities will not be financially viable without investment grants but demonstrated implementation can reduce commercial banks' future risk perception. To determine whether the planned CSRPs are financially viable without Project support, annual inflows and outflows are presented in Table 8 for two representative facilities. As part of an exit strategy and to analyze their future self-sufficiency, the assumptions include annual recurrent costs to maintain the facility infrastructure after the Project has ended. When considering a 10-year period with an initial investment of USD 34,800 a CSRP facility could achieve a FIRR, before financing, of 18-21% and a payback period of 5-5.6 years. This assumes that the facility owner can obtain commercial loan to finance both initial investment costs and required working capital. Therefore the CSRP may be financially viable but only if available commercial loan interest rate is below 18-21%. Initial information obtained by the Project team indicates that microfinancing may be available for loans around USD 2,000 (ETB 60,000) at an interest rate of 18%. These enterprise investments are not eligible for lower interest rates around 9-15%. These rates are offered by private banks as well as government banks for loans up to USD 18,000 providing members of an investment group can show collateral or guarantors to the full amount of the loan until it is fully repaid. The CSRPs therefore will require project support to cover the initial investment costs in the absence of commercial loans at favorable rates. It can be expected that demonstrated implementation of CSRPs can reduce commercial banks' future risk perception.

28. **By supporting the establishment of financially viable enterprises in the area, the Project helps build resilience and future self-sufficiency. CSRPs can improve their financial viability to an FIRR over 24% for example by using more of their available storage capacity, obtaining a matching investment grant and reducing their initial working capital requirements. This may be necessary if favorable commercial loan terms are unavailable. As part of an exit strategy, this level of return would also enable them to cover estimated future capital maintenance costs.** Table 9 shows multiple cases with different assumptions that can improve or worsen the financial viability of the CSRPs. For example, CSRPs can improve their FIRR by increasing the use of their available storage capacity by absorbing production from more farmers also outside the Project area. If the CSRPs do not use their capacity, the FIRR drops to 11% and the investment becomes financially unviable. If CSRPs could obtain a 50% grant on the initial investment cost, their FIRR could increase from 18% to 26% if they also could use more of their capacity. Note that a higher working capital requirement can make CSRPs financial unviable with FIRRs below 2%. If working capital requirements were reduced to 30% of variable costs or by obtaining a 150% grant to cover the entire investment costs as well as part of the working capital, FIRR could increase to 33-42%. In combination with grants or reduced working capital requirements, a reduced corporate income tax rate from the current 30%, could also be a potential approach to ensure that facilities remain financial viable with an FIRR over 23%. This may be necessary if commercial loans are not available at a favorable rate. Note that, as part of an exit strategy, the analysis assumes that the facilities generate a return large enough to cover future capital maintenance and management costs.

29. **The Project activities help avoid yield losses caused by soil erosion. This avoided yield loss is valued based on the gross margin data on different land uses.** To establish the linkage between reductions in soil erosion with the Project activities, a Universal Soil Loss Equation (USLE), adapted to Ethiopian conditions, was used to model soil loss associated with each of the

technologies. The USLE relates soil loss from a field to local climatic conditions, soil type, topography, and land and crop management variables. Annual soil loss is given as a function of the rainfall erosivity of a given soil type, the slope length, crop cover factor, and the conservation practice on the land. Based on a review of studies linking soil loss to productivity loss, it is assumed that watersheds with between 10 and 25 tonnes/ha/year soil loss experience a 0.5% yield loss. When between 25 and 35 tonnes soil/ha/year are lost, yield loss is 1%, and if soil loss exceeds 35 tonnes/ha/year yield loss is 1.5%.[11] Graduated watersheds from the SLMP program are included in the investment and incremental net benefits from continued avoided soil erosion are captured. Because the physical treatments in those watersheds were done earlier in the SLMP program, no additional yield improvements are attributed to the RLLP.

30. **Aggregation to Project level provides an estimated return on investment in financial terms.** Net benefits as described above are aggregated up to represent the entire area of crop- and non-cropland in each watershed and in the Project overall. The aggregation includes the 41,000 ha of land transformed to forest plantation and 30,000 ha of land transformed to green corridor plantations. The total net benefit from establishing 56 CSRPs is included in the aggregation as well. All watersheds are not developed in the first year, but follow the gradual disbursement plan of the Project budget with 22% in year 1, 28% in year 2, 24% in year 3, 16% in year 4 and 10% in year 5. Within each watershed beneficiaries follow the assumed gradual adoption rate of improved farming practices increasing annually by 5% up to a max of 75% of the area. Incorporating this adoption rate includes a progression in farmers' revenue as well as variable costs.

31. **The Project's overall Financial NPV is USD 696 million (ETB 19.5 billion) with a Financial IRR of 28% and a benefit cost ratio of 2. The payback period is 7.5 years (see Table 10).** This estimated net return constitutes 1% of Ethiopia's GDP in 2016 and is also USD 13 per ha per year when including the entire project area of 2.1 million ha (treated and not treated areas). [12] The FNPV measured per person per year is 4% of the National Poverty Line and 8% of the Food Poverty Line (for 4.2 million beneficiaries).

4.2. Economic Analysis

32. As explained earlier, prices and costs used in the financial analysis are adjusted to value the economic impact of the Project. The economic net benefits also include a valuation of the Project's impact on GHG emissions. Investment costs include: the Project budget (excluding price contingencies); beneficiary in-kind contributions; and annual recurrent costs after the Project is complete.

33. **The Project interventions are expected to have a net-benefit on GHG emissions to the amount of 43.9 million tonnes of CO_2-eq over 25 years, which constitutes a discounted value of USD 1,074 million.** GHG emission calculations using the EX-ACT model are done for a 5-year project and a total 25-year time frame. The results (Table 11) show that the Project constitutes a

[11] Panagos et al. (2018) provide a review of many references on this topic showing ranges of productivity loss from less than 1% to over 20%. Gebreselassie et al. (2016) also refer to potential productivity losses of 10-30% due to soil erosion.
[12] World Development Indicators database. GDP data for Ethiopia as of 2016. Accessed 22 February 2018.

net carbon sink of 43.9 million tonne CO_2-eq emissions over a period of 25 years, resulting in 1.8 million tonne CO_2-eq per year or 44 tonne CO_2-eq/ha. Figure 2, illustrates that most of the carbon sequestration comes from afforestation and improvements to grassland and annual agriculture. Together with increased use of fertilizer, and diesel as well as building construction, the Project constitutes a net carbon sink.

34. **The ENPV is USD 3,312 million discounted at 5% over a 25 year period (ETB 92.7 billion). This generates a benefit cost ratio (EBCR) of 3.8 and an EIRR of 47% with a payback period of 5.3 years (see Table 10). In economic investment analyses, the Project therefore meets the requirement by yielding a rate of return higher than the economic discount rate of 5%.** When excluding the social value of reduced GHG emissions, the net project return is USD 2,238 million (ETB 62.7 billion) with a benefit cost ratio of 2.9 and an EIRR of 29%. Without the impact of reduced GHG emissions, the payback period is 7.3 years. This is 3.1% of Ethiopia's GDP (in 2016 terms). Without the social value of reduced GHG emissions, the ENPV is USD 43/year/ha (total project area both treated and not treated) or USD 21/year/beneficiary. Relative to the measure of absolute poverty, this is 13% of the National Poverty line and 25% of the Food Poverty Line. The annual cost and benefit flow for the Project as a whole including with impact on GHG emissions are shown in Table 12 and illustrated in Figure 3.

35. Table 10 also includes an alternative Scenario 3 where climate change leads to accelerated soil erosion in the future or if base case assumptions are too conservative. When assuming a 50% increase in annual soil loss from the current estimates, the ENPV is USD 3,462 million with a 47% rate of return. Under this accelerated soil erosion scenario, the estimated Project net benefit of avoiding this larger soil erosion is therefore USD 150 million across the 25-year period.

36. **The estimated value of soil erosion varies between USD 0.11 and 0.26/tonne soil per year depending on the gross margin value of different land uses. In a scenario with accelerated soil loss, this estimated value ranges between USD 0.17 and 0.38/tonne soil per year.** Table 13 shows the estimated amount of soil erosion avoided due to Project activities. Because the value of the avoided erosion is based on gross margins, cropland erosion on new watersheds is valued at USD 0.23/tonne soil per year versus USD 0.26/tonne soil on graduated watersheds (ETB 6.5-7.3/tonne soil). This is because the graduated watersheds are already at a higher productivity level. The gross margin values on non-cropland are lower, so the avoided soil loss is valued at USD 0.11/tonne soil per year (ETB 3/tonne soil). This is higher than the original SLMP-2 EFA where it was assumed that the value of one tonne soil was ETB 0.79 per year in 2013 terms which converts to ETB 1.1 in 2018 terms (World Bank, 2013a). Compared to the current analysis, the assumed gross margins in SLMP-2 did not distinguish between high-value crops and livestock versus low-value non-cropland. In the accelerated soil loss Scenario 3 in Table 10 the value of avoided soil loss is higher because it is assumed earlier that the rate of yield loss increases with higher soil loss. The estimated values of avoided soil erosion in an accelerated loss scenario range between USD 0.17/tonne soil per year on non-cropland and USD 0.35 and 0.38/tonne soil per year on cropland in new and graduated watersheds, respectively.

37. **Table 14 shows that, when excluding the reduced GHG emissions, 49% of incremental net benefits are generated through activities on non-cropland areas, particularly due to the transformation of 41,000 ha from bush and grassland to forest plantation.** This constitutes an

ENPV of USD 108 per year per treated hectare and an EIRR of 43%. A substantial part is also generated by cropland and livestock production at USD 49/ha/year and USD 39/ha/year, respectively. Much of the incremental benefit estimated from cropland comes from transforming 30,000 ha of unproductive land to green corridor plantations. While overall net returns to investing in CSRPs is lower, the NPV is positive and therefore economically and financially feasible when comparing to project-level discount rates (IRR = 18%). As noted earlier, part of the risk management plan could be to ensure that the CSRPs are used to their capacity of up to 100-250 tonnes compared to the currently 130-209 tonnes, which is based conservatively on absorbing only part of the production from the Project area. These results are sensitive to how Project investment costs are allocated between benefit flows. As such, the return-on-investment results by benefit flow should be interpreted with care.

38. **The ENPV of USD 108/year/ha calculated for non-cropland areas compares well to other estimates, while the cropland estimated ENPV of USD 49/year/ha may be too conservative.** Pistorius et al. (2017, Table 2) estimate the net present value of forest restoration efforts to be USD 17/year/ha for afforestation/reforestation of marginal sites and USD 183/year/ha for woodlots. They use a 20-year model without GHG emission benefits and with a discount rate of 6%. In the current EFA, this could be compared to the ENPV on non-cropland, which is USD 108/year/ha and includes a mixture of treatments (see Table 14). Hurni et al. (2015, Table 21) estimate the average net present value of SLM technologies to be between USD 192-219/year/ha in 2014 terms. They use a 30-year model with a 12.5% discount rate and no GHG emission benefits. These estimates are considerably higher than the USD 49/year/ha calculated with the current EFA assumptions – both if they are converted to 2018 terms and lower discount rate.

39. **Switching values.** A switching values analysis is reported in Table 15, where each assumption is changed until the Base Case ENPV turns zero (i.e. a break-even analysis). The Project break-even is not very sensitive to any one particular assumption. On top of the list, a 70% decrease in livestock yields or a general 145% decrease in non-cropland yields could reduce ENPV to zero. The large and unlikely changes required to turn the ENPV zero in the switching values analysis does not reveal how sensitive results are at the margin. So an alternative sensitivity analysis is performed.

40. **Elasticities.** Instead of switching values, Table 16 shows the elasticities of key assumptions. A general 1% increase in livestock yields can lead to a 1.4% increase in ENPV. A 1% increase in the discount rate can lead to a 0.8% decrease in estimated ENPV. A general 1% increase in non-cropland yields increases ENPV by 0.7%. Other variables with significant impact on Project returns are: variable livestock costs, adoption rates, crop yields, adoption rates, and shadow price of carbon. On the basis of this analysis, as part of a risk management plan, it is particularly important to ensure that farmers can negotiate and obtain fair output prices and achieve target yields going forward, for example through establishing links to CSRPs and providing technical advice that encourages adoption of improved production practices.[13]

[13] Because the Project's impact on GHG emissions is calculated in the separate EX-ANTE Carbon-balance Tool, it was not possible to run a full sensitivity analysis inside the EFA model that changes the total GHG emissions impact.

41. Some risk factors cannot be estimated well in a switching values or elasticity analysis. To analyze the impact on Project returns from selected assumptions, some specific cases are calculated. Table 17 summarizes the impact of key risk factors as discussed below.

42. World Bank guidelines recommend using a 5% economic discount rate. Increasing the discount rate from 5% to 10% reduces project returns by 51%. Project returns are still considerable at a 10% discount rate with a BCR of 3.2.

43. **If the Project only reaches half of the targeted area due to unexpected cost increases, estimated project returns fall by 53% and the rate of return drops from 47% to 27%.** The second case in Table 17 estimates the impact if costs increase and the Project is implemented in a smaller geographical area, such as due to a natural disaster. If the Project only reaches 75% of the initial target area, estimated returns fall by 27% and the EIRR drops from 47% to 36%. In only half the target area is achieved, the estimated ENPV falls by 53% and the rate of return is 26%.

44. **Increased annual adoption rate increases Project returns significantly such that a doubling of the annual adoption rate from 5% to 10% can increase ENPV by 23%.** Increasing annual adoption further to 15% can lead to 31% higher ENPV. Close monitoring and support for target farmers and implementing water management plans could help increase the adoption rate. This also includes ensuring that beneficiaries are successful at applying for commercial loans, obtaining the necessary quality inputs, and implementing their investments.

45. **Project delays can reduce returns by 6-12%.** A delay in when beneficiaries are willing and able to adopt new farming practices and implement their investments can lead to reduced project returns. Table 17 shows that a 2-year delay in benefits can reduce the ENPV by 12% and reduce the EIRR from 47% to 32%. While not always avoidable, project delays can be minimized with close monitoring and by ensuring implementation does not lose momentum.

46. **The estimated returns could fall by 5-11% if the number of animals per farm dropped by 10-20%.** Further data are needed to determine if households respond by lowering the number of livestock units they own when the yield per animal goes up as noted in a recent livestock impact study for SLMP-2 (see World Bank, 2017d).

47. **Estimated yield loss from soil erosion may be too low in the Base Case compared to some available studies.** If the yield loss factors are trebled from maximum 1.5% to 4.5% - which is still conservative in accordance with some studies (see Panagos et al. 2018, and Gebreselassie, 2016) – ENPV can increase by 8%. Note that, this analysis does not take into account climate change which may create increased future soil erosion and yield loss.

48. **Results are sensitive to the estimated impact on GHG emissions because a 10% reduction in value can reduce ENPV by 3%.** This also implies that it is important that the assumptions entered in the EX-ACT model reflect the Project accurately.

49. The main expected net benefits which could not be quantified due to lack of data include:

(a) Direct benefits from new income generating activities such as; grain-, meat-, dairy-, and bamboo-processing; tree seedling nurseries; manufacturing of improved cook stoves, production of improved environmental services; and private sector initiatives for PES or CSR.

(b) Value of reduced firewood collection and improved indoor air pollution from cook stoves.

(c) Benefits from improved administration and tenure rights such as conservation of protected areas, biodiversity and tourism.

(d) Benefits to other sectors of the economy that will take advantage of increased productivity and resilience in the agriculture sector.

(e) Benefits captured in neighboring communities through informal dissemination of improved land and water management practices.

(f) Downstream effects of reduced risk of flooding and reduced cost of sediment build-up in irrigation and hydroelectric dams.

(g) Benefits from improved nutrition such as due to a more varied food production in the area.

(h) The value of capacity building among direct beneficiaries is captured in the EFA model. Project funded capacity building and institutional development at all levels have direct value in that they increase the skill level in public sector institutions and enable them to work more efficiently in providing essential and enhanced public good services. These institutional benefits are not quantified in the EFA, but are seen as critical to ensure that the other benefits can be realized when it comes to building productive alliances with access to agricultural financing, land, and other business enabling services.

50. **In light of an ENPV of USD 3,312 million over 25 years (ETB 92.7 billion) and an ERR of 47% and the additional potential net benefits that could not be quantified yet, the project investment is expected to yield significant returns even when considering key risk factors.**

51. The project team should continue to collect more data to improve the current EFA analysis and also for evaluating the project at mid-term and completion. Particular focus could be on:

(a) Validating assumptions behind all changes in WO/P and W/P gross margins for crops, livestock, non-cropland, CSRPs together with other new IGAs.

(b) Validating the assumed farm sizes and cropping/livestock patterns of representative farms including whether Project incentives will lead to changes in cropping pattern and stocking rate.

(c) Updating the analysis when the budget cost tables are finalized and also explore how to assign shares of the costs to different benefit flows.

(d) Continuously ensuring that the EFA analysis is aligned with applicable target indicators.

(e) Refining the estimation of impact on carbon balance using the EX-ACT Model.

52. The Microsoft Excel model used to perform this EFA is available from the Project team. This also includes an online step-by-step demonstration of the Excel file. This helps document the model as well as give guidance on how to change assumptions, perform analyses, and extract results. The username for the web page is provided below (case-sensitive). The password is provided on the “Read Me” sheet in the Excel file when it is shared by the Project team:

(a) Web page: http://www.rygnestad.net/business/Ethiopia_RLLP/index.php
(b) Username: WBEthiopia

References:

African Development Bank (2017). Africa's Agricultural Commodity Exchanges, Warehouse Receipt Systems and New Standards. Abidjan, Côte d'Ivoire.

CDM-SSCWG39-A06 Draft Small-scale Methodology: AMS-II.G: Energy efficiency measures in thermal applications of nonrenewable biomass Version 05.0

Dresen, E., B. DeVries, M. Herold, L. Verchot, and R. Müller (2014). Fuelwood Savings and Carbon Emission Reductions by the Use of Improved Cooking Stoves in an Afromontane Forest, Ethiopia. Land 2014, 3, 1137-1157; doi:10.3390/land3031137

Ethiopia Central Statistical Agency (2014). Ethiopia Comprehensive Food Security and Vulnerability Analysis (CFSVA). March.

Gebreselassie, S., O.K. Kirui, and A. Mirzabaev (2016). Economics of Land Degradation and Improvement in Ethiopia. Chapter 14. In E. Nkonya et al. (eds.), Economics of Land Degradation and Improvement – A Global Assessment for Sustainable Development, DOI 10.1007/978-3-319-19168-3_14.

Große-Rüschkamp, A. (2015): Productivity and Income Contribution of Family Farm Enterprises: A Gross Margin Study on the Sustainable Land Management Program (SLMP) – Summary Report. Addis Ababa: Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH.

Hurni K, Zeleke G, Kassie M, Tegegne B, Kassawmar T, Teferi E, Moges A, Tadesse D, Ahmed M, Degu Y, Kebebew Z, Hodel E, Amdihun A, Mekuriaw A, Debele B, Deichert G, Hurni H. (2015). Economics of Land Degradation (ELD) Ethiopia Case Study. Soil Degradation and Sustainable Land Management in the Rainfed Agricultural Areas of Ethiopia: An Assessment of the Economic Implications. Report for the Economics of Land Degradation Initiative. 94 pp.

MEFCC (2017). National Forest Sector Development Programme, Ethiopia. June.

MOANR now MOALR (2016). Sustainable Land Management Project (SLMP-2) Draft Final Report. Socio-Economic and Biophysical Baseline Survey in 90 New and 45 Existing Watersheds. Ministry of Agriculture and Natural Resources now Ministry of Agriculture and Livestock Resources. December 2016.

Nune, S., Menale, K., & Mungatana, E. (2013). Forest Resource Accounts for Ethiopia. In R. M. Hassan, & E. D. Mungatana (Eds.), Implementing Environmental Accounts (Vol. 28, pp. 103-142). Springer Science + Business Media Dordrecht 2013.

Panagos P, G. Standardi, P. Borrelli, E. Lugato, L. Montanarella, and F. Bosello (2018). Cost of agricultural productivity loss due to soil erosion in the European Union: From direct cost evaluation approaches to the use of macroeconomic models. Land Degrad Dev. 2018;1–14. https://doi.org/10.1002/ldr.2879

Pistorius, T., S. Carodenuto, and G. Wathum. (2017). Implementing Forest Landscape Restoration in Ethiopia. Forests 2017, 8, 61; doi:10.3390/f8030061

Schmidt, E. and F. Tadesse (2017). The Sustainable Land Management Programs in the Ethiopian Highlands. An evaluation of its impact on crop production. ESSP Working Paper 103.

Urgessa, T. (2015).The determinants of agricultural productivity and rural household income in Ethiopia. Ethiopian Journal of Economics. Vol 24 No 2. p 63-92.

World Bank (2013a). Ethiopia Sustainable Land Management Project II (SLMP-2). Project Appraisal Document. PAD525. October 29, 2013.

World Bank (2013b). Investment Project Financing Economic Analysis Guidance Note. Washington, DC. April 2, 2013.
World Bank (2014a). Ethiopia Sustainable Land Management Project (SLMP-1). Implementation Completion and Results Report. Report No. ICR3074. March 24, 2014.
World Bank (2015a). Technical Note on Discounting Costs and Benefits in Economic Analysis of World Bank Projects. Washington, DC.
World Bank (2015b). Ethiopia Poverty Assessment 2014. Report No. AUS6744. January.
World Bank (2017a). Ethiopia Agricultural Growth Project. Implementation Completion and Results Report. Report No. ICR00004303. December 15, 2017.
World Bank (2017b). Ethiopia Livestock and Fisheries Sector Development Project. Project Appraisal Document. Report No. PAD2396. November 17, 2017.
World Bank (2017c). Ethiopia Oromia National Regional State Forested Landscape Project. Project Appraisal Document. Report No. PAD1634. March 16, 2017.
World Bank (2017d). Assessment of Livestock Impact on NRM Interventions of SLMP-2 and Recommendations for the Design of Resilient Landscape Livelihood Project (RLLP). Ethiopian Sustainable Land Management Project II (SLMP-2). Final Report. December.
World Bank (2017e). Assessment of Household Energy Options in RLLP Intervention Areas. Draft Final Report. February 2017.
World Bank (2017f). Shadow price of carbon in economic analysis. Guidance note to the World Bank Group staff. Washington, DC, November 12.
World Bank (2018). Ethiopia Resilient Landscapes and Livelihoods Project (RLLP). Project Appraisal Document. PAD2484. Draft May 25, 2018.

Table 1a: Area Targeted for Treatment by Land Use Category and Region: 165 Watersheds

Project Area, ha	Tigray	Gambella	Amhara	Oromia	Benishangul Gumuz	SNNPR	Total
# watersheds	22	6	44	48	11	34	165
Bush+Shrub	56,653	9,385	34,331	17,680	27,433	21,716	167,199
Cropland	65,500	1,308	153,366	152,343	17,379	107,284	497,181
Grassland	8,073	20,452	65,608	29,234	14,371	24,194	161,932
Bareland	26,190	7	48,895	4,385	428	1,683	81,588
Total Treated Area	156,416	31,153	302,200	203,643	59,611	154,877	907,900
Share Treated Area	17%	3%	33%	22%	7%	17%	100%

Note:

- Area data extracted from remote-sensed data of the Project watersheds. Treated areas: 0% of forest and woodland; 57% of cropland (497,181 ha); and 92% of remaining land use categories (410,719 ha).

Table 1b: Area Targeted for Treatment by Land Use Category and Region: 45 Graduated Watersheds

Project Area, ha	Tigray	Gambella	Amhara	Oromia	Benishangul Gumuz	SNNPR	Total
# watersheds	4	3	10	14	4	10	45
Bush+Shrub	0	0	0	0	0	0	0
Cropland	0	0	0	0	0	0	0
Grassland	5,764	633	19,417	27,110	6,412	20,664	80,000
Bareland	0	0	0	0	0	0	0
Total Area	0	0	0	0	0	0	0
Share of Total	5,764	633	19,417	27,110	6,412	20,664	80,000

Note:

- Area data extracted from remote-sensed data of the Project watersheds. Treated areas: 0% of forest and woodland; 35% of cropland (80,000 ha); and 0% of remaining land use categories.

Table 1c: Area Targeted for Treatment by Land Use Category and Region: All Watersheds

Project Area, ha	Tigray	Gambella	Amhara	Oromia	Benishangul Gumuz	SNNPR	Total
# watersheds	26	9	54	62	15	44	210
Forest	0	0	0	0	0	0	0
Woodland	0	0	0	0	0	0	0
Bush+Shrub	56,653	9,385	34,331	17,680	27,433	21,716	167,199
Cropland	71,264	1,941	172,783	179,454	23,791	127,948	577,181
Grassland	8,073	20,452	65,608	29,234	14,371	24,194	161,932
Bareland	26,190	7	48,895	4,385	428	1,683	81,588
Total Area	162,180	31,786	321,617	230,754	66,023	175,540	987,900
Share of Total	16%	3%	33%	23%	7%	18%	100%

Note:

- Area data extracted from remote-sensed data of the Project watersheds. Treated areas based on Tables 1a and 1b: 0% of forest and woodland; 52% of cropland (577,181 ha); and between 72% and 77% of remaining land use categories (410,719 ha).

Figure 1: Illustration of Incremental Benefits

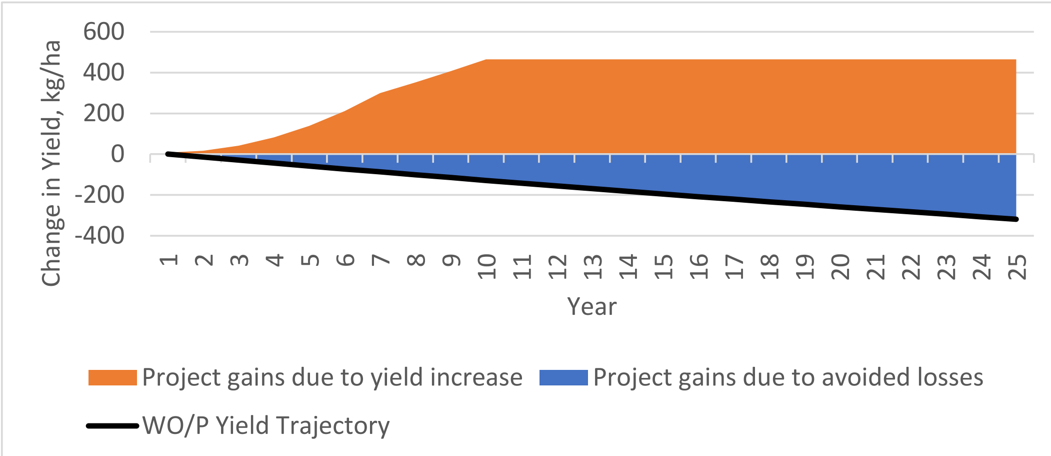


Table 2: Crop Gross Margins Without and With Project –Financial Analysis

		Wheat		Barley		Maize		Teff	
Description	**Unit**	**WO/P**	**W/P**	**WO/P**	**W/P**	**WO/P**	**W/P**	**WO/P**	**W/P**
Yield net of loss	kg/ha	2,200	2,855	2,054	2,392	2,570	3,562	1,579	2,174
Increase	**% of WO/P**		**30%**		**16%**		**39%**		**38%**
Revenue	USD/ha	558	724	483	563	442	613	508	699
Variable Costs	USD/ha	230	271	197	179	157	190	147	168
Gross Margin	USD/ha	328	453	287	384	285	423	361	531
Increase	**% of WO/P**		**38%**		**34%**		**48%**		**47%**
		Potato Rain-fed		**Millet**		**Faba Bean**		**Chickpea**	
Description	**Unit**	**WO/P**	**W/P**	**WO/P**	**W/P**	**WO/P**	**W/P**	**WO/P**	**W/P**
Yield net of loss	kg/ha	2,608	3,922	1,818	2,182	940	1,552	1,015	1,397
Increase	**% of WO/P**		**50%**		**20%**		**65%**		**38%**
Revenue	USD/ha	311	468	327	392	356	588	340	468
Variable Costs	USD/ha	159	265	73	101	47	73	35	52
Gross Margin	USD/ha	152	202	254	292	309	515	305	416
Increase	**% of WO/P**		**33%**		**15%**		**67%**		**37%**
		Cabbage, irrig.		**Potato, irrigated**		**Tomato, irrigated**			
Description	**Unit**	**WO/P**	**W/P**	**WO/P**	**W/P**	**WO/P**	**W/P**		
Yield net of loss	kg/ha	18,333	18,446	3,573	3,459	13,050	12,632		
Increase	**% of WO/P**		**1%**		**-3%**		**-3%**		
Revenue	USD/ha	2,578	2,594	419	406	2,762	2,674		
Variable Costs	USD/ha	1,122	789	202	212	306	321		
Gross Margin	USD/ha	1,456	1,804	217	194	2,456	2,353		
Increase	**% of WO/P**		**24%**		**-11%**		**-4%**		

Note:

- WO/P = Without Project (Baseline); W/P = With Project. Annual average allowing for a 7-year linear increase.
- Assumes a 10% post-harvest yield loss in the absence of CSRPs. Excludes benefits and costs from access to CSRPs.
- Revenue includes value of home consumption (e.g. fodder). Costs exclude farmer's own labor.
- Some adjustments made to original source data by Project team to obtain more conservative gross margin improvements on irrigated potatoes and tomatoes and to emulate removal of pesticide and herbicide use on vegetables with a 12% yield loss (Urgessa, 2015)
- Source: Große-Rüschkamp, A. (2015): Productivity and Income Contribution of Family Farm Enterprises: A Gross Margin Study on the Sustainable Land Management Program (SLMP)
- Exchange rate: 1 USD = ETB 28

Table 3: Average Annual Gross Margins Without and With Project – Livestock Farmers - Financial Analysis

		Milk Production		Bull Fattening		Sheep Rearing		Egg Production	
Description	**Unit**	**WO/P**	**W/P**	**WO/P**	**W/P**	**WO/P**	**W/P**	**WO/P**	**W/P**
Years until full change			2		1		3		2
Yield	Liter, kg or egg/animal	254	332	1	1	2.2	2.3	139	146
Increase	**% of WO/P**		**31%**		**0%**		**5%**		**5%**
Revenue	USD/ha	151	198	317	333	58	91	14	15
Increase	**% of WO/P**		**31%**		**5%**		**57%**		**10%**
Variable Costs	USD/ha	114	115	250	262	15	19	6	6
Gross Margin	USD/ha	37	83	67	70	43	72	7	9
Increase	**% of WO/P**		**123%**		**5%**		**66%**		**15%**

Note:

- WO/P = Without Project (Baseline); W/P = With Project. Assumes a linear change of yields and costs from WO/P to W/P situation over the number of years indicated in table.
- Revenue includes value of home consumption (e.g. milk, eggs). Costs exclude farmer's own labor.
- Some adjustments made to original source data by Project team to obtain more conservative gross margin improvements on irrigated potatoes and tomatoes.
- Source: Große-Rüschkamp, A. (2015): Productivity and Income Contribution of Family Farm Enterprises: A Gross Margin Study on the Sustainable Land Management Program (SLMP)
- Exchange rate: 1 USD = ETB 28

Table 4: Cropping Pattern WO/P and W/P on Representative Farms and Land Area Included in Analysis, by Crop and Livestock

	Farm A	Farm B	Farm C	Farm D	Farm E	Farm F
Share of 1 ha farm	**Tigray**	**Gambella**	**Amhara**	**Oromia**	**Benishangul Gumuz**	**SNNPR**
Wheat	18.0	9.2	19.0	12.7	4.1	10.4
Barley	14.6	8.7	14.2	9.3	0.3	10.9
Maize	12.2	40.5	8.2	20.9	25.0	22.7
Teff	22.8	3.4	15.9	15.0	6.4	11.9
Potato, Rain-fed	3.8	9.6	3.5	4.3	5.9	21.9
Millet	12.7	14.0	10.6	13.1	31.8	5.6
Faba Bean	3.2	0.9	7.3	3.3	2.0	4.6
Chickpea	6.9	1.0	9.2	7.1	17.6	6.1
Cabbage, irrigated	0.2	4.1	0.2	2.1	0.3	0.7
Potato, irrigated	0.8	0.0	7.2	5.5	1.7	0.0
Tomato, irrigated	0.2	4.1	0.2	2.1	0.3	0.7
Unproductive to green corridors	4.5	4.5	4.5	4.5	4.5	4.5
Total	100	100	100	100	100	100
Livestock (heads/farm)						
Milk, local breed	2.0	7.5	3.9	2.7	3.9	6.9
Bull fattening	2.0	7.5	3.9	2.7	3.9	6.9
Sheep rearing	6.2	3.4	6.2	3.8	4.2	3.0
Egg production	8.2	13.9	4.8	6.2	10.3	5.6
Total TLU	3.5	11.0	6.1	4.3	6.0	10.0
% households with animals	91%	50%	88%	82%	78%	87%

Note:

- WO/P = Without Project (Baseline); W/P = With Project
- Tropical Livestock Units (TLU) conversion factors: Cattle = 0.7, Sheep = 0.1, Chicken = 0.01.
- Developed from SLMP-2 baseline study (MOANR/MOALR, 2016) and gross margin study (Große-Rüschkamp, 2015)

Table 5: Representative Farm Models, Crop + Livestock Gross Margins, Financial Analysis

Average Annual Farm Gross Margin			Farm A Tigray	Farm B Gambella	Farm C Amhara	Farm D Oromia	Farm E Benishangul Gumuz	Farm F SNNPR
WO/P		Avg. USD/ha/ year	659	784	760	654	666	857
W/P			1,083	1,187	1,232	1,033	1,066	1,360
	Change		**424**	**403**	**472**	**379**	**401**	**503**
	% Change		**64%**	**51%**	**62%**	**58%**	**60%**	**59%**
WO/P		Avg. USD/farm /year	882	1,049	1,017	876	891	1,146
W/P			1,449	1,589	1,648	1,382	1,426	1,819
	Change due to Project		**567**	**540**	**631**	**507**	**536**	**673**
WO/P		Avg. USD/pers on/year	176	210	203	175	178	229
W/P			290	318	330	276	285	364
	Change due to Project		**113**	**108**	**126**	**101**	**107**	**135**

Note:
- WO/P = Without Project (Baseline); W/P = With Project;
- Includes value of home consumption (e.g. grains, vegetables, fodder, milk, eggs). Costs exclude farmer's own labor.
- Excludes benefits and costs from having access to CSRPs.
- Average 5 household members per farm. Average farm size 1.338 ha. Exchange rate: 1 USD = ETB 28
- Source: Analysis results based on crop and livestock assumptions. Includes agro-forestry on green corridors.

Table 6: Gross Margins on Non-cropland Without and With Project –Financial Analysis

Description	Unit	Plantation Forest	Plantation Green Corridors	Bush+ Shrub	Grassland, WO/P	Grassland, W/P
Fuel wood yield	m3/ha	103.70	103.70	0.70		
Round wood yield	m3/ha	75.10	75.10			
Other yield	m3/ha, kg/ha				2,500.00	5,000.00
Fuel wood price	USD/m3	19.36	19.36	19.36	19.36	19.36
Round wood price	USD/m3	28.88	28.88	28.88	28.88	28.88
Other price	USD/ha or kg	0.19	0.19	0.19	0.19	0.19
Non-cropland Revenue	USD/ha	4,176	4,176	14	483	966
Change	**% of WO/P**	**0.0%**	**0.0%**	**0.0%**		**100.0%**
Fuel wood variable input	units/ha	103.70	103.70	0.70		
Round wood variable input	units/ha	75.10	75.10			
Other variable input	units/ha	150.00	150.00	1.00	0.00	36.00
Fuel wood unit cost	USD/unit	2.89	2.89	2.89		
Round wood unit cost	USD/unit	4.14	4.14			
Other unit cost	USD/unit	1.46	1.46	1.07	1.46	1.46
Variable Costs	USD/ha	830.76	830.76	3.10	0.00	52.71
Change	**% of WO/P**	**0.0%**	**0.0%**	**0.0%**		**-**
Gross Margin	USD/ha	3,345.05	3,345.05	10.45	482.75	912.79
	% of revenue	80.1%	80.1%	77.1%	100.0%	94.5%
Change	**% of WO/P**	**0.0%**	**0.0%**	**0.0%**		**89.1%**

Note:
- WO/P = Without Project (Baseline); W/P = With Project. Annual average allowing for a 7-year linear increase.
- Revenue includes value of home consumption (e.g. fodder, firewood). Costs exclude farmer's own labor.
- Source: Project team communications with Oromia Forest and Wildlife Enterprise and Nune et al. (2013).
- Exchange rate: 1 USD = ETB 28

Table 7: Gross Margins from CSRPs.

Description	Unit	CSRP (IDA), Weighted Average	CSRP (GCF) Weighted Average
Number of CSRPs	# of facilities	16	40
Facility size	m3	480	480
Share of warehouse effective storage	%	50%	50%
Average volume of crops	m3/tonne	1.60	1.60
Times emptied	times/year	12	12
Warehouse capacity (from area production)	kg/facility/year	2,505,294	1,565,809
Average Capacity	kg/facility	208,774	130,484
Weighted average Financial Price	USD/kg	6.55	6.48
Avoided yield loss	% of yield	10.0%	10.0%
Increase in farm gate price due to CSRP	% of price	5.0%	5.0%
Fee paid to CSRP by farmer	% of price	10.0%	10.0%
Additional price to meet gross margin target	% of price	1.2%	1.2%
Financial Price	USD/kg	7.65	7.58
Revenue	USD/facility	19,167	11,862
Variable Costs	USD/facility	17,250	10,676
Gross Margin	USD/facility	1,917	1,186
Assumed Gross Margin Target	% of revenue	10.0%	10.0%

Note:

- Assumes: Share of production requiring storage = 50% of yield. Project area production absorbed in a Project CSRP = 50% of production.
- Variable costs include purchase of produce from farmers, 30 days per month for a worker and 4 days per month for labor transporting produce to market.
- Exchange rate: 1 USD = ETB 28

Table 8: Return on Investment - CSRPs - Financial Analysis

	CSRP (IDA), Weighted Average				CSRP (GCF), Weighted Average			
1,000 USD	Year 1	Year 2	…	Year 10	Year 1	Year 2	…	Year 10
Inflow								
Revenue	342.3	684.5		616.1	211.8	423.6		381.3
Grant	0.0	0.0		0.0	0.0	0.0		0.0
Residual Value	0.0	0.0		18.3	0.0	0.0		18.3
Total Inflow	342.3	684.5		634.4	211.8	423.6		399.5
Outflow								
Investment Cost	34.8	0.0		0.0	34.8	0.0		0.0
Incremental Working Capital	154.0	0.0		30.8	95.3	0.0		19.1
Variable Operating Costs	308.0	616.1		554.5	190.6	381.3		343.1
Recurrent capital maintenance costs	0.0	13.0		11.8	0.0	8.3		7.6
Corporate income tax	0.0	16.1		10.7	0.0	9.7		8.4
Total Outflow	496.9	645.2		607.7	320.8	399.3		378.2
Incremental net benefit before financing	-154.6	39.3		26.6	-108.9	24.4		21.4
Cumulative Incremental net benefit	-154.6	-115.3		204.3	-108.9	-84.6		118.2
FIRR @ 10 yrs, before financing				21%				18%
FBCR @ 12%, 10 yrs, before financing				1.02				1.01
Payback, before financing				5 Years				5.6 Years

Note:

- Grant is received free of tax (see cases in Table 9). Facility is depreciated over 20 years. Residual value after 10 years included in analysis. Recurrent cost after project investment for capital maintenance and management = 2% of budget and 2% of variable costs. Corporate income tax rate = 30% per year. Working Capital = 50% of variable costs. Commercial loan must be obtained for any necessary debt.
- See detailed capacity and gross margin assumptions in Table 7
- Exchange rate: 1 USD = ETB 28

Table 9: Case Analyses - Return on Investment - CSRPs

	CSRP (IDA), Weighted Average				CSRP (GCF), Weighted Average			
FIRR @ 10 yrs, before financing	**Grant (% of investment cost)**				**Grant (% of investment cost)**			
Capacity used (% of base case use)	**0%**	**25%**	**50%**	**75%**	**0%**	**50%**	**100%**	**150%**
50%	16%	19%	22%	26%	11%	18%	31%	63
100%	21%	23%	25%	28%	18%	23%	31%	42%
200%	25%	26%	28%	29%	23%	26%	30%	35%
	Grant (% of investment cost)				**Grant (% of investment cost)**			
Working Capital (% of variable costs)	**0%**	**25%**	**50%**	**75%**	**0%**	**50%**	**100%**	**150%**
30%	41%	46%	51%	59%	33%	45%	68%	133%
50%	21%	23%	25%	28%	18%	23%	31%	42%
100%	3%	4%	4%	5%	2%	4%	6%	9%
	Grant (% of investment cost)				**Grant (% of investment cost)**			
Corporate income tax rate (% per year)	**0%**	**25%**	**50%**	**75%**	**0%**	**50%**	**100%**	**150%**
0%	34%	36%	39%	42%	29%	36%	46%	61%
15%	28%	30%	32%	35%	23%	30%	38%	52%
30%	21%	23%	25%	28%	18%	23%	31%	42%

Note:
- See detailed capacity and gross margin assumptions in Table 7 and annual benefit and cost flows in Table 8. Grey shade indicates the initial assumptions with no grants provided.

Table 10: Economic and Financial Analysis – Key Efficiency Indicators

	Scenario 1 Base Case	Scenario 2	Scenario 3	Scenario 4
	Economic Analysis	**Economic Analysis excl. GHG emissions**	**Economic Analysis with accelerated soil erosion**	**Financial Analysis**
USD million Project Budget	311	311	311	319
USD Budget per Project area ha	148	148	148	152
USD Budget per Beneficiary	75	75	75	77
Net Present Value, million USD	3,312	2,238	3,462	696
Benefit Cost Ratio (BCR)	3.8	2.9	3.9	2.0
Internal Rate of Return (IRR)	47%	29%	47%	28%
Payback Period	5.3 Years	7.3 Years	5.3 Years	7.5 Years
NPV as share of 2016 GDP	4.6%	3.1%	4.8%	1.0%
NPV, USD/ha	1,575.0	1,064.5	1,646.52	331.0
NPV, USD/year	132,476,270	89,532,936	138,487,847	27,843,388
NPV, USD/year/ha	63	43	66	13
NPV, USD/year/household	159	107	166	33
NPV, USD/year/beneficiary	32	21	33	7
Share of National Poverty Line	20%	13%	20%	4%
Share of Food Poverty Line	37%	25%	39%	8%

Note:
- In this table, Project budget excludes beneficiary contributions and recurrent costs but includes price contingencies. The benefit cost analysis includes beneficiary contributions and recurrent costs but excludes price contingencies.
- Economic discount rate = 5%. Financial discount rate = 12%. Analysis period is 25 years.
- Total 25-year GHG emission reduction from EX-ACT model = 43.9 million tonne CO_2-eq. Economic CO_2-eq value = USD 32/tonne to USD 68/tonne by year 25.
- Impact on GHG emissions includes ENPV of USD 1,074 million from EX-ACT estimation.
- Accelerated soil erosion scenario defined as climate change gradually escalating annual soil loss by 50% by year 25.
- Project area (treated and not treated) = 2.1 million ha. Number of beneficiaries (population) in Project area = 4.2 million or 4% of Ethiopia's population. Number of people per household = 5.
- 2011 National Poverty Line, 2018 amount = USD 162 /person/year. 2011 Food Poverty Line, 2018 amount = USD 85 /person/year. 2016 GDP = million USD 72,374.

Table 11: Economic Analysis – Greenhouse Gas Mitigation Potential

Project Activities, tonnes CO_2-eq Positive = source / negative = sink	Without project	With Project	Net Carbon Balance
Land Use Changes			
Deforestation	0	0	0
Afforestation	0	-23,901,838	-23,901,838
Other Land Use Changes	0	0	0
Agriculture			
Annual	0	-10,569,200	-10,569,200
Perennial	0	0	0
Rice	0	0	0
Grassland & Livestock			
Grassland	0	-14,521,650	-14,521,650
Livestock	0	0	0
Degradation	0	0	0
Inputs & Investments	0	5,126,559	5,126,559
Total	0	-43,866,129	-43,866,129
Per hectare	0	-44	-44
Per hectare per year	0.0	-1.8	-1.8

Note:

- EX-ACT model Version 5.2 – Standard Edition. Tropical Montane climate. Moist regime. Dominant soil type: HAC soils. Implementation phase 5 years. Capitalization phase 20 years. Dynamics of implementation are assumed linear over the project period. Default Tier 1 coefficients are used. Using Global Warming Potentials from the Fourth IPPCC Assessment report.
- Calculations from EX-ACT model based on the following assumed evolutions in land use/category, ha

Land Use	Initial/Without	With Project
Forest/Plantation	0	71,000
Annual Crop	522,000	504,500
Perennial Crop	0	0
Rice	0	0
Grassland	422,400	412,400
Degraded Land	43,500	0
Other Land	0	0
Organic Soils	0	0
Total Area	987,900	987,900

Categorization in Table 11 of Annex E.1.	Description in Ex-ACT	RLLP Estimate of Total Area of Treatment (ha)
Forest/Plantation (Afforestation-Reforrestation)	Degraded Land	43500
	Annual Crop	17500
	Grassland	10000
	Total	71000
Cropland	SWC 1 on cropland	179500
	SWC 2 on cropland	177000
	CSA	148000
	Total	504500
Grassland	Communal 1 (physical plus bio-physical treatment)	39500
	Communal 2 (physical plus bio-physical treatment in lesser degraded area)	150000
	Communal 3 (physical, bio-physocal treatment and area closure)	222900
	Total	412400
Grand Total		**987900**

- Assumed inputs include 19,626 tonnes of nitrogen from urea, 3,317 m^3 of gasoil/diesel per year, and 103,037 m^2 of concrete agricultural buildings.

Figure 2: Economic Analysis – Greenhouse Gas Mitigation Potential

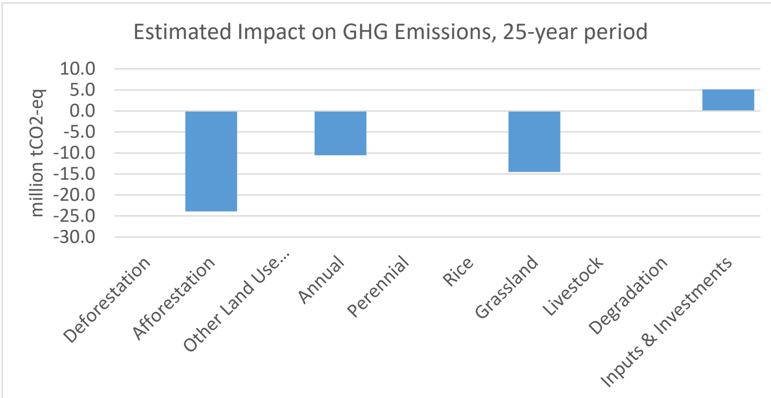
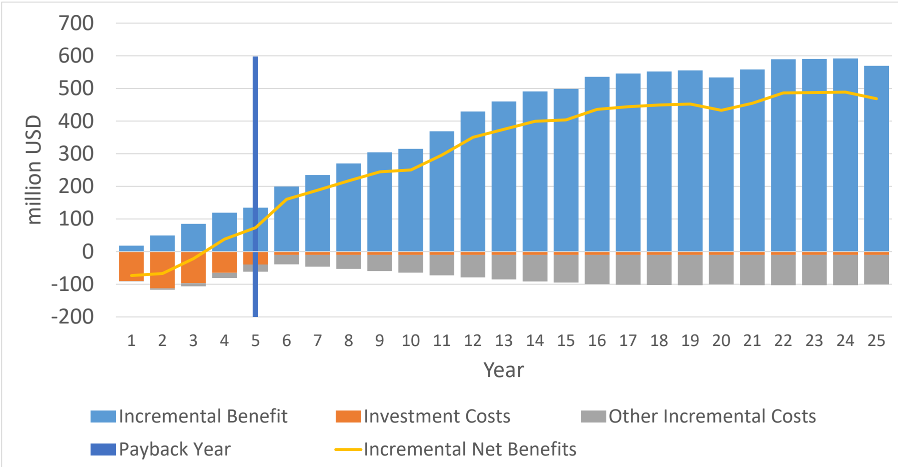


Table 12: Economic Analysis - Estimated Annual Flow of Benefits and Costs

Year million USD	Incremental Benefit	Investment and Recurrent Costs	Other Incremental Costs	Incremental Net Benefits	Discounted Incremental Net Benefits
1	18	-90	-1	-73	-70
2	50	-113	-4	-67	-61
3	85	-97	-10	-21	-18
4	119	-65	-16	38	31
5	135	-40	-22	73	57
6	199	-10	-30	160	119
7	234	-10	-36	188	134
8	270	-10	-43	217	147
9	304	-10	-50	244	158
10	315	-10	-55	250	153
11	369	-10	-63	296	173
12	429	-10	-70	350	195
13	460	-10	-76	375	199
14	491	-10	-82	399	202
15	499	-10	-86	403	194
16	535	-10	-91	436	200
17	545	-10	-92	444	194
18	552	-10	-93	449	187
19	555	-10	-94	452	179
20	533	-10	-91	433	163
21	558	-10	-94	455	163
22	589	-10	-94	486	166
23	590	-10	-94	487	159
24	592	-10	-94	488	151
25	569	-10	-91	468	138
Total	9,594	-606	-1,574	7,430	
Total (discounted)					3,312
		EBCR @ 5%, 25 yrs		ratio	3.81
		ENPV @ 5%, 25 yrs		million USD	3,312
		EIRR @ 25 yrs		%	46.6%
		Payback Year		Years	5.3 Years

Figure 3: Economic Analysis - Estimated Annual Flow of Benefits and Costs



Note:

- EFA model calculations. See Table 12.

Table 13: Value of Avoided Soil Erosion – Economic Analysis excluding Carbon Balance

Description	Unit	New Watersheds	Graduated Watersheds
Cropland Cumulative Soil loss due to erosion	1,000 tonnes over 25 years	111,364	25,112
Average Value of Avoided Soil Erosion	ETB/tonne soil/year	6.53	7.31
	USD/tonne soil/year	0.23	0.26
Non-cropland Cumulative Soil loss due to erosion	1,000 tonnes over 25 years	81,091	
Average Value of Avoided Soil Erosion	ETB/tonne soil/year	3.16	
	USD/tonne soil/year	0.11	

Note:

- Values are calculated as an average per year and are not discounted for time value of money. Analysis period is 25 years.
- Exchange rate: 1 USD = ETB 28

Table 14: Economic Analysis – Key Efficiency Indicators by Benefit Flow excl. GHG Emissions

Benefit Flow	ENPV Benefit, million USD	ENPV Cost, million USD	ENPV, million USD	EIRR	ENPV/year, million USD	ENPV/ yr/unit, USD	Unit
Cropland	935	322	614	22%	24.5	49	504,105 ha
Non-cropland	1,436	343	1,093	43%	43.7	108	403,795 ha
Livestock	787	291	496	26%	19.8	39	504,105 ha
CSRPs	228	214	14	18%	0.6	10,141	16 + 40 CSRPs
Cropland, Graduated watersheds	30	9	21	18%	0.8	11	80,000 ha
Carbon Balance	0	0	0	-	0.0	0	987,900 ha
Total	3,417	1,179	2,238	29%	89,532.9	91	987,900 ha

Note:

- Economic discount rate = 5%. Analysis period is 25 years.
- Costs include variable costs and investment costs. Results are sensitive to allocation of investment costs between benefit flows. Results should be interpreted with care.
- Excludes social value of carbon. Compare to Scenario 2 in Table 10.
- Exchange rate: 1 USD = ETB 28

Table 15: Sensitivity Analysis of Economic Efficiency - Switching Values

Rank	Assumptions	Unit	Base Case Assumption	Switching Value	% change from Base Case
1	W/P Yield Sensitivity Factor, Livestock	% of yield	-	-70%	70%
2	W/P Variable Cost Sensitivity Factor, Livestock	% of price	-	114%	114%
3	W/P Yield Sensitivity Factor, Non-cropland	% of yield	-	-145%	145%
4	Farm Gate Variable Cost, Bull fattening, W/P	ETB/animal/year	7,345	20,377	177%
5	W/P Yield Sensitivity Factor, Crops	% of yield	-	-205%	205%
6	Sensitivity Factor, Shadow Price of Carbon	% of value	-	-313%	313%
7	Farm Gate Variable Cost, Milk, local breed, W/P	ETB/animal/year	3,209	16,292	408%
8	W/P Variable Costs Sensitivity Factor, Crops	% of cost	-	732%	732%
9	Sensitivity Factor, Investment Costs	% of inv. costs	-	735%	735%
10	Discount Rate	% per year	-	47%	835%

Note:

- WO/P = Without Project (Baseline); W/P = With Project.
- Switching value is the assumption value that causes the Base Case ENPV to turn zero (Break-even point).
- Exchange rate: 1 USD = ETB 28

Table 16: Sensitivity Analysis of Economic Efficiency - Elasticities

Assumptions	Unit	Base Case Assumption	ENPV elasticity
W/P Yield Sensitivity Factor, Livestock	% of yield	0%	1.4
W/P Variable Cost Sensitivity Factor, Livestock	% of price	0%	-0.9
Discount Rate	% per year	5%	-0.8
Yield net of losses, Bull fattening, W/P	animal/year	1.00	0.7
W/P Yield Sensitivity Factor, Non-cropland	% of yield	0%	0.7
Farm Gate Variable Cost, Bull fattening, W/P	ETB/animal/year	7,345.14	-0.6
W/P Yield Sensitivity Factor, Crops	% of yield	0%	0.5
Adoption rate - annual	% of area	5%	0.4
Yield net of losses, Milk production, local breed, W/P	ltr/animal/year	332.00	0.4
Adoption rate - Max	% of area	75%	0.4
Sensitivity Factor, Shadow Price of Carbon	% of value	0%	0.3
Cropland	% of LUC area	57%	0.3
Non-cropland Revenue (financial), Plantation Forest, W/P	ETB/ha	116,923	0.3

Note:

- WO/P = Without Project (Baseline); W/P = With Project.
- Elasticity is measured as the %-change in Base Case ENPV with a 1% change in one assumption at a time. Economic Analysis

Table 17: Sensitivity Analysis of Economic Efficiency - Cases

Case		ENPV – 25 Years		Benefit Cost Ratio – 25 Years	Economic IRR	Payback Period
		million USD	% change			
Base Case		3,312	0%	3.8	47%	5.3
1.	Economic Discount Rate changed to 8%	2,290	-31%	3.5	47%	5.3
	Economic Discount Rate changed to 10%	1,617	-51%	3.2	47%	5.3
2.	75% of target area achieved	2,433	-27%	3.5	36%	6.2
	50% of target area achieved	1,560	-53%	2.9	26%	7.5
3.	Adoption rate - annual increased by 10%	4,084	23%	3.9	57%	4.2
	Adoption rate - annual increased by 15%	4,334	31%	4.0	83%	3,6
4.	1 year Benefits Delay (0=no delay)	3,107	-6%	3.7	37%	6.2
	2 years Benefits Delay (0=no delay)	2,901	-12%	3.6	32%	7.0
5.	W/P # animals per farm = 90% of WO/P	3,130	-5%	4.5	45%	5.4
	W/P # animals per farm = 80% of WO/P	2,949	-11%	6.0	43%	5.5
6.	Yield Loss Factors from Erosion increased by 100%	3,449	4%	3.9	47%	5.3
	Yield Loss Factors from Erosion increased by 200%	3,571	8%	4.0	48%	5.2
7.	Accelerated annual soil loss incr. by 50% by year 25	3,462	5%	3.9	47%	5.3
	Accelerated annual soil loss incr. by 70% by year 25	3,476	5%	3.9	47%	5.3
8.	Social Value of GHG Emissions reduced by 10%	3,205	-3%	3.7	45%	5.5
	Social Value of GHG Emissions increased by 10%	3,419	3%	3.9	49%	5.2

Note:

- WO/P = Without Project (Baseline); W/P = With Project.
- 5% discount rate - Economic Analysis