

The Carbon Footprint of the Agricultural Growth Project (AGP) in Ethiopia

An Application of the EX-Ante Carbon-balance Tool (EX-ACT)

by

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About EX-ACT: The *Ex Ante* Appraisal Carbon-balance Tool aims at providing *ex-ante* estimations of the impact of agriculture and forestry development projects on GHG emissions and carbon sequestration, indicating its effects on the carbon balance.

See EX-ACT [website: www.fao.org/tc/exact](http://www.fao.org/tc/exact)

Related resources

- EX-ANTE Carbon-Balance Tool (EX-ACT): (i) [Technical Guidelines](#); (ii) [Tool](#); (iii) [Brochure](#)
- See all EX-ACT resources in EASYPol under the Resource package, [Investment Planning for Rural Development, EX-Ante Carbon-Balance Appraisal of Investment Projects](#)

About EASYPol

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Acronyms

AFD	Agence Française de Développement
AGP	Agricultural Growth Project
ARDPLACs Councils	Agricultural and Rural Development Partners Linkages Advisory
ATVET	Agriculture Technical Vocational Education and Training
C	Carbon
CC	Climate change
CDM	Clean development mechanism
CH ₄	Methane
CO ₂	Carbon dioxide
CLPP	Community-level planning process
DAP	Diammonium phosphate
FAO	Food and Agricultural Organization of the United Nations
GDP	Gross domestic product
GHG	Greenhouse gas
GOE	Government of Ethiopia
GWP	Global warming potential
HAC	High activity clay
IPCC	Intergovernmental Panel on Climate Change
IRSS	Irrigation runoff returns system
LULUCF	Land use, land use change and forestry
Mt	Million tons
N ₂ O	Nitrous oxide
PAD	Project appraisal document
SLM	Sustainable land management
SNNPR	Southern Nations, Nationalities, and Peoples Region
SSI	Small-scale and micro-irrigation
t CO ₂ e ha ⁻¹	Tonnes of carbon dioxide equivalent per hectare
t CO ₂ e yr ⁻¹	Tonnes of carbon dioxide equivalent per year
TFC	Training farming centre
UNFCCC	United Nations Framework Convention on Climate Change
WB	World Bank

1 SUMMARY

Agriculture can play an important role in climate change mitigation while contributing to increased food security and reductions in rural poverty. The Ex-Ante Carbon-balance Tool (EX-ACT) can estimate the mitigation potential of rural development projects generated from changes in farming systems and land use. This study presents and discusses the EX-ACT analysis performed on the Agricultural Growth Project (AGP) in Ethiopia, which is supported by the World Bank and the Government of Ethiopia. The projected estimates of the impact of project activities on greenhouse gas emissions and carbon sequestration demonstrate that the mitigation benefits achieved through the adoption of sustainable agricultural practices (improved cropland and grassland management, soil and water conservation) not only balance the emissions associated with the increase in inputs use and the building of infrastructure (irrigation, roads and markets) but also create a carbon sink. If the project is successful in ensuring full adoption of all the proposed best practices, there will be options for mitigation financing from the public sector.

2 INTRODUCTION

The Ethiopian Government has recognized the critical importance of addressing climate change challenges in the country, particularly in the agricultural sector. The Government has signed and ratified all the Rio Conventions, namely the United Nations Framework Convention on Climate Change and its Protocol, the Bio-diversity Convention and the Conventions to Combat Desertification. The Government of Ethiopia has prepared the National Adaptation Program of Action (NAPA) to identify and promote activities that address the urgent need to adapt to the adverse effects of climate change. Of the eleven priority projects outlined in the NAPA document, diverse agriculture practices are considered high priority projects for adaptation-mitigation efforts¹.

In this context, models are being developed to estimate the mitigation potential from changes in agricultural production systems and to support project managers on CC mitigation decision making. EX-ACT (EX-Ante Carbon-balance Tool) is one such model that was developed by the Food and Agriculture Organization of the United Nations (FAO) to provide an ex-ante evaluation of the impact of rural development projects on Greenhouse Gas (GHG) emissions and carbon sequestration, thus estimating the agriculture (and forestry) sector's potential contribution to CC mitigation. The tool is now going through a testing process: case studies have been selected with the aim of representing a wide range of different ecosystems worldwide (e.g. tropical, temperate, semi-arid), agriculture activities (e.g. annual/perennial crops, forestry, livestock, grasslands) and geographic coverage.

¹ Dejene, Bekele, & Malo 2009.

Objectives: This report aims to present the results of the EX-ACT test on the World Bank (WB) and Government of Ethiopia (GOE) Agricultural Growth Project (AGP) in Ethiopia. It is worth noting that this project is one of the first cases in which the EX-ACT was applied during the appraisal and pre-start-up phases of relatively large projects. The following are preliminary results which could be subject to change as a result of possible methodology adjustments in the further development of the tool.

The report is organized as follows: Section 3 provides a description of EX-ACT and its methodology; Section 4 provides a short description of the proposed AGP and presents the EX-ACT analysis for the specific case study; Section 5 discusses the main findings in terms of AGP mitigation potential and the results of the sensitivity and economic analyses; and conclusions are presented in section 6.

Target audience : This module targets current or future practitioners in the formulation and analysis of investment projects, working for public administration offices, NGO's, professional organizations or for consulting firms. Academics may also find this material useful to support their courses in carbon balance analysis and development economics.

Required background: Readers can follow links included in the text to other EASYPol modules or references². See also the list of EASYPol links included at the end of this module³.

3 METHODOLOGY

The analysis presented in this report has been conducted applying the EX-Ante Carbon-balance Tool (EX-ACT), developed by FAO and aimed at providing ex-ante measurements of the impact of agriculture (and forestry) development projects on GHG emissions and carbon (C) sequestration, indicating its effects on the C-balance⁴, which is selected as an indicator of the mitigation potential of the project⁵. EX-ACT can be used in the context of ex-ante project formulation and is capable of covering the range of projects relevant for the land use, land use change and forestry (LULUCF) sector. It can compute the C-balance by comparing two scenarios: “without project” (i.e. the “Business As Usual” or “Baseline”) and “with project”. The tool’s main output consists of the C-balance resulting from the difference between these two scenarios (Figure 1).

The model takes into account both the implementation phase of the project (i.e. the active phase of the project commonly corresponding to the investment phase), and the

² EASYPol hyperlinks are shown in blue, as follows:

- a) training paths are shown in **underlined bold font**
- b) other EASYPol modules or complementary EASYPol materials are in ***bold underlined italics***;
- c) links to the glossary are in **bold**; and
- d) external links are in *italics*.

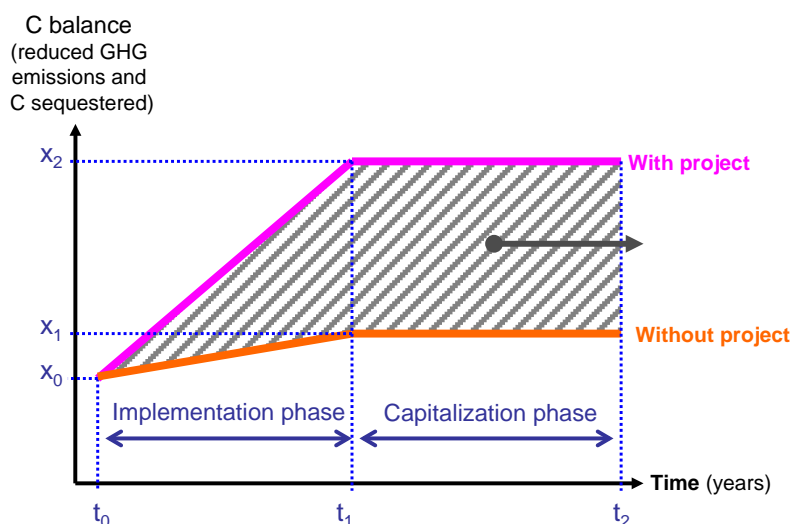
³ See all EX-ACT resources in EASYPol under the Resource package, **[Investment Planning for Rural Development - EX-Ante Carbon-Balance Appraisal of Investment Projects](#)**

⁴ C-balance = GHG emissions - C sequestered above and below ground.

⁵ EX-ACT 2010.

so-called “capitalization phase” (i.e. a period where project benefits are still occurring as a consequence of the activities performed during the implementation phase). Usually, the sum of the implementation and capitalization phases is set at 20 years. EX-ACT was designed to work at a project level but it can easily be up-scaled at programme/sector or national level⁶.

Figure 1: Quantifying C-balance “with” and “without project” using EX-ACT



Source: Bernoux et al. 2010b

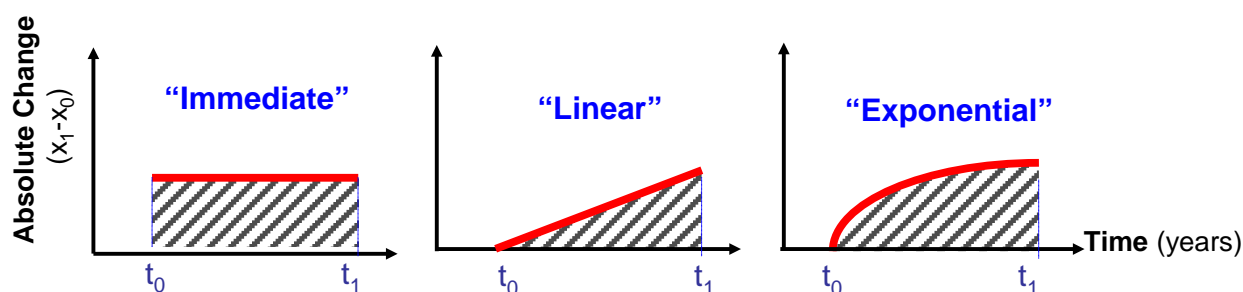
EX-ACT has been developed using mostly the Guidelines for National Greenhouse Gas Inventories (IPCC 2006) complemented with other methodologies and a review of default coefficients for mitigation option as a base. Most calculations in EX-ACT use a Tier 1 approach⁷ as default values are proposed for each of the five pools defined by the Intergovernmental Panel on Climate Change (IPCC) Guidelines and the United Nations Framework Convention on Climate Change (UNFCCC): above-ground biomass, below-ground biomass, soil, deadwood and litter. EX-ACT also allows users to incorporate specific coefficients (e.g. from project area) if they are available, therefore also working at a Tier 2 level. EX-ACT measures C stocks and stock changes per unit of land, as well as methane (CH₄) and nitrous oxide (N₂O) emissions expressing its results in tonnes of carbon dioxide equivalent per hectare (t CO₂e ha⁻¹) and in tonnes of carbon dioxide equivalent per year (t CO₂e yr⁻¹).

⁶ Bernoux et al. 2010^o.

⁷ IPCC Guidelines provide three methodological tiers varying in complexity and uncertainty level: Tier 1, simple first order approach, which uses data from global datasets, simplified assumptions, IPCC default parameters (large uncertainty); Tier 2, a more accurate approach, which uses more disaggregated activity data, country specific parameter values (smaller uncertainty); Tier 3, which makes reference to higher order methods, detailed modeling and/or inventory measurement systems driven by data at higher resolution and direct measurements (much lower uncertainty).

In terms of dynamics, land use changes associated with project activities and the rate of adoption of land management options occur only during the implementation phase. Therefore, it is assumed that all project activities will be completed within the project timeframe and that no additional change in land use and management will take place during the capitalization phase. The EX-ACT default assumption for the land use and management change is a “linear” function over time, although the software allows for adopting a different dynamic of change, e.g. “immediate” or “exponential” (Figure 2), depending on the characteristics of the specific project activity and on the information available on the adoption rate of the selected practice among project participants. This aspect is often considered in the sensitivity analysis where different rates of adoption are taken into account.

Figure 2: Schematic representation of the dynamics of change in the implementation phase



Source: Bernoux et al. 2010b

4 CARBON BALANCE ANALYSIS OF THE ETHIOPIA AGP

4.1 The project profile

The Agricultural Growth Project (AGP) aims to increase agricultural productivity and market access for key crop and livestock products in four regions with good potential for agricultural growth (Amhara; Oromiya; Southern Nations, Nationalities, and Peoples Region – SNNPR; and Tigray), including 83 *woredas*, about 2,108 *kebeles*⁸ and a total population of 9.8 million people. The AGP focuses on areas that are relatively rain- and food-secure and have considerable potential for agricultural growth. The AGP will be implemented over a period of five years and is structured around three components:

- *Agricultural Production and Commercialization*, which will strengthen the capacity of farmer organizations and their service providers to scale up best practices in agricultural production and post-harvest value addition, adopt improved technologies in production and processing, and strengthen marketing and processing of selected commodities. It includes three sub-

⁸ *Woreda* is an administrative division of Ethiopia (managed by a local government), equivalent to a district. *Woredas* are composed of a number of *Kebeles*, which are the smallest unit of local government in Ethiopia. *Woredas* are typically collected together into zones.

- components (institutional development and strengthening, scaling-up best practices, and market and agribusiness development);
- *Small-scale Rural Infrastructure Development and Management*, which will finance the construction, rehabilitation and improvement of small-scale infrastructures. It includes two sub-components (small-scale and micro-irrigation development; and small-scale market infrastructure development and management);
 - *Program Management and Monitoring and Evaluation*, which will support effective coordination and management of the AGP.

4.2 Structure and basic assumptions of the analysis

The analysis is based on the comparison between the C-balance in the “with project” scenario and the C-balance in the so-called “without project” scenario (i.e. the baseline). The “with project” case takes into account the activities carried out under Components 1 (Agricultural Production and Commercialization) and 2 (Small-scale Rural Infrastructure Development and Management). The third component (Program Management and Monitoring and Evaluation) is not relevant for the EX-ACT analysis and is therefore not taken into account.

In both the “with project” and “without project” cases, data used to describe climate patterns and soil characteristics cannot take into account the considerable variability of existing soil and climatic conditions of the area covered by the project (see Annex 1). The results of the analysis should therefore be considered only as an average for the whole area. Average climate is considered as tropical with a mean annual temperature equal to 20 degrees Celsius and a moisture regime classified as dry. These settings correspond to average temperature and rainfall for the state. Such information is essential as most coefficients used in the analysis can change drastically according to the climate. This is particularly true for the moisture regime, but also for the mean annual temperature which is affecting, for example, the level of CH₄ emissions from manure management. As for the soil characteristics – and with reference to the simplified IPCC classification where only six soil categories are listed (sandy soils, spodic soils, volcanic soils, wetland soils, high activity clay soils and low activity clay soils) – the state is characterized essentially by high activity clay (HAC) soils, which are lightly to moderately weathered soils and dominated by 2:1 silicate clay minerals⁹¹⁰.

4.3 The “without project” case

The “without project” scenario is essentially built on the results of the baseline established for AGP impact evaluation (BDS-CDR, 2010) and on the available statistics for land use and management in Ethiopia resulting from policies and strategies that have

⁹ In the World Reference Base for Soil Resources classification HAC soils include: Leptosols, Vertisols, Kastanozems, Chernozems, Phaeozems, Luvisols, Alisols, Albeluvisols, Solonetz, Calcisols, Gypsisols, Umbrisols, Cambisols, Regosols. In USDA classification HAC soils include: Mollisols, Vertisols, high-base status Alfisols, Aridisols, Inceptisols.

¹⁰ Bernoux et al. 2010b.

been designed and implemented in the past to boost agricultural productivity in the country.

Since the AGP will promote crop intensification and yield increases, it is assumed that without the project, the annual cropland would expand and that such an expansion would not happen in the “with project” case. Based on this assumption yield increases in the intensified area could be linked with a potential land-sparing. Although there is no consensus about the possible rate of substitution¹¹, it has been decided to follow the same procedure as described by Burney et al. (2010). Given that the Government of Ethiopia is currently implementing a five-year development programme entitled Plan for Accelerated and Sustained Development to End Poverty (PASDEP), which is aimed at expanding the area cultivated by 2.24 percent¹², it is assumed that without the project the annual cropland would expand by 2 percent over five years at the expense of grasslands.

Also, since farmers in the regions covered by the AGP are already implementing SLM and improved agronomic practices on approximately 10 percent of the area (BDS-CDR, 2010), it is assumed that “without the project” 10 percent of the grasslands would be taken up by soil and water conservation activities and improved agronomic practices would be promoted on 10 percent of the annual cropland. Finally, given that fertilizers (Urea and DAP) are already used by farmers operating in the regions under the AGP¹³, this is taken into account in the “without project” case (inputs module) by making the hypothesis that fertilizers would be used in the “without project” case at a rate equal to 30 percent of that adopted in the AGP.

4.4 The “with project” case

The analysis will consider an implementation phase of five years, followed by a capitalization phase of fifteen years, which would represent a period where the benefits of the investment were still occurring and could be attributed to the changes in land use and management brought on by the adoption of the project. In the analysis it is assumed that the implementation phase would happen according to a linear dynamic of change, as no specific information is available about the adoption rate of the project activities among project participants. In terms of the Global Warming Potential (GWP) coefficients¹⁴, the current analysis uses the same values as those adopted within the Clean Development Mechanism (CDM), i.e. 21 for CH₄ and 310 for N₂O.

The project would support a decentralized, community-driven, need-based approach: some activities (e.g. those foreseen under component 1 aimed at identifying and scaling up best practices) and would be built around priorities identified by farmer groups. The AGP would in fact fund investment sub-projects developed by farmer groups to address their priorities using participatory approaches and following specific guidelines. For

¹¹ Rudela et al. 2009

¹² BDS-CDR, 2010.

¹³ BDS-CDR, 2010.

¹⁴ The GWP is a measure of how much a given mass of greenhouse gas is estimated to contribute to global warming. It is a relative scale which compares the gas in question to that of the same mass of carbon dioxide (whose GWP is by convention equal to 1).

activities requiring the preparation of sub-projects, it would not be possible to have consolidated information on the land use change promoted by AGP at this stage of the project appraisal. Therefore, for those activities, the EX-ACT analysis would rely only on the data derived from making estimations on the basis of available statistical information.

The analysis is conducted at sub-component level in order to highlight the impact of each set of foreseen project activities on the C-balance.

4.5 Component 1 (agricultural production and commercialization)

4.5.1 Institutional strengthening and development

The EX-ACT analysis takes into account the GHG emissions related to the implementation of the training activities on the basis of the estimated fuel consumption, which is the first indicator selected to estimate the impact of this sub-component. It is in fact assumed that most activities implemented under this sub-component would, in the end, determine an increase in fuel consumption (e.g. participation to meetings and workshops, provision of equipment, purchases of motorcycles).

The AGP will fund meetings, a workshop and the participation of ARDPLAC members in monitoring and reviewing project interventions aimed at improving service delivery, especially extension. Also the project will promote planning and funding of the extension agenda (e.g. assistance to prepare project-specific training modules) and will provide support to the functioning of training centres (rehabilitation of buildings, provision of essential furniture and equipment, purchase of motorcycles and bicycles and use of demonstration farms to share innovations) and to the upgrading of training facilities in specialised institutions (e.g. Agriculture Technical Vocational Education and Training [ATVET] and agricultural universities).

The AGP will provide analytical equipment, chemicals and training to promote improved fertilizer use based on soil analysis, assist with the reclamation of problems of soils (e.g. acid soils), increase the production of lime to reclaim acid soils (before any investment is made, two studies will be conducted to assess the needs). The AGP will also help to equip regional animal health laboratories, *woreda* veterinary clinics, and *kebele* animal health posts, together with developing training activities for professional staff. Finally, the AGP will promote, train and build capacity of farmers' organizations and facilitate exchange visits between groups.

It is assumed that only 50 percent of the participants use their own transportation (which is a reasonable assumption given that vehicles are often shared and many participants often use public transportation). Also, it is assumed that transportation would be needed only for meetings at federal level. For meetings at regional, *woreda* and *kebele* level, it is assumed that attendees would either walk, hitch-hike or use public transportation to reach their destination (training centres). This would only be for short distances, so it would not have a significant impact in terms of GHG emissions.

The impact of this set of activities on the C-balance of the project is obtained by considering the number of meetings, trainings and workshops organized under this sub-component; the number of participants attending such meetings; the average distance covered and the number of vehicles (car/motorcycles) used. Information was derived from the AGP Project Appraisal Document (PAD) and was integrated with field data collection. It was estimated that the average speed was 40 km/h and that the consumption of fuel was 0.11/km.

Trainings and meetings are organised at federal, regional/zonal, *woreda* and *kebele* level but with different frequency. At federal and regional level, there is on average a training once a year or once every two years. Normally, one person per region would attend the federal meeting (in total there are nine regions) and four to five people from each *woreda* (experts) would attend the regional meeting. The average travel time is estimated to be around 90 minutes for the federal zone and 50 minutes for the regional zone with transportation.

At *woreda* level, trainings happen on average once or twice a year, where one leader is training four to five experts, each from a different domain. These experts would then directly train others in their *woreda*. The average travel time to get to a *woreda* center is estimated to be around 90 minutes with transportation. At *kebele* level, three different methods of training are used: (i) individual training (every week, or month), a trainer goes to the community; (ii) mass method (every month or season), a trainer goes to the community; (iii) development group method (twice a month or season), participants go to the nearest Training Farming Centre (TFC). Only one farmer per *kebele*, normally the leader, would attend. In general there are five leaders and around 20 participants. The average travel time for the *kebele* zone is 20 minutes with transportation.

Overall, in five years 103,911 training sessions/meetings would take place (15 federal; 214 regional/zonal; 2,341 *woreda* and 101,341 at *kebele* level) under this sub-component. It was estimated that the implementation of this set of activities would cause an overall consumption of 213 m³/year of diesel for the main scenario. Also, during the implementation phase, around 10 motorcycles (at *woreda* level) and 12 bikes (at *kebele* level) would be distributed to the farmers: the fuel consumption related to the use of the motorcycles, with respect to the activities planned under this sub-component, is included in the above computation. Therefore, total fuel consumption determined by this sub-component for the main scenario amounts to 213 m³/year. In order to estimate the GHG emissions from fuel consumption, EX-ACT analysis uses the Gasoil/Diesel default value of 2.63 t CO₂/ m³ (Table 1).

The second indicator chosen to estimate the impact of this sub-component is the area of buildings (training centres) that would be rehabilitated in order to deliver extension services at the *kebele* level. It was estimated that the project would rehabilitate 210,000 m² of buildings for training activities (each training centre having a size of 500 m²; rehabilitating one centre each 5 *kebeles*, i.e. 400 centres). EX-ACT analysis takes into account the GHG emissions related to the rehabilitation of buildings using default values from the tools developed by the Agence Française de Développement (AFD), which shows that the GHG emissions related to the building of new offices (concrete) amount to 0.469 t CO₂e/m². Given that the project is only rehabilitating existing structures, it is assumed here that the GHG emissions from rehabilitation are equivalent

to 1/3 of the emissions for new constructions (i.e. 156 Kg CO₂e/m² from 210,000 m² or, which is the same, 0.469 t CO₂e/m² from 70,000 m², corresponding to 32,830 t CO₂e).

The results of the EX-ACT analysis for this sub-component, as computed using the module called “other investments”, are shown in Table 1. The results show that overall, the set of activities related to institutional strengthening and development will be a net source of GHG emissions of 42,643 (9814 + 32,830) tCO₂e.

Table 1: Released GHG associated with institutional strengthening and development

Fuel consumption

Released GHG associated with Fuel consumption (agricultural or forestry machinery, generators...)										
Type of Fuel	Default value t CO ₂ /m ³	Specific Value	Default Factor	Annual Fuel Consumption (m ³ /yr)				Emission (t CO ₂ eq)		
				Start t0	Without Project End	Rate	With Project End	Rate	All Period Without	With
Gasoil/Diesel	2.63		YES	0	0	Linear	213.0	Linear	0	9814
OPTION1 + OPTION2		Sub-Total Without		Sub-Total With		9813.8	Difference		9813.8	

Building rehabilitation

Released GHG associated with building of infrastructure							
Type of construction or infrastructure	Default value t CO ₂ /m ²	Specific Value	Default Factor	surface (m ²)		Emission (t CO ₂ eq)	
				Without	With	Without	With
Offices (concrete)	0.469		YES	0	70000	0.0	32830.0
Subtotal				0.0	32830.0	Difference 32830.0	

Source: our computations using EX-ACT (2010)

4.5.2 Scaling up best practices

This sub-component will help identify best practices to be scaled up through sub-projects proposals developed by all participating groups in the AGP *woredas*. The AGP will then fund investment sub-projects developed by farmer groups to address their priorities (demand-based proposals) and which are aimed at implementing best practices. The EX-ACT analysis is therefore based only on preliminary estimates of the possible sub-projects the farmers will submit, among a list of pre-approved best practices such as: improved agronomic practices and manure application for main annual crops; improved natural resource management (e.g. grasslands rehabilitation, reclamation of acid soils and lime treatment, vermiculture and compost production); increased planting material/seed/breed multiplication (fruits/vegetables/coffee/tree seedlings; mini hatchery; fingerling production); and improved livestock management (dairy cattle and small ruminants; poultry; bee-keeping; aquaculture). The high rate of uncertainty in making these estimates will inevitably be reflected in the results of the analysis.

The impact of this sub-component on the C-balance is estimated as follows:

- (i) EX-ACT takes into account the GHG emissions related to the implementation of the training activities supporting the preparation of the sub-projects. As in the previous sub-component, fuel consumption is the

indicator selected to estimate the impact of this set of activities. For this sub-component, it has been estimated that the overall diesel consumption would be 4,193 m³/year of diesel.

- (ii) EX-ACT takes into account the GHG emissions related to the implementation of the training activities supporting the preparation of the sub-projects. As in the previous sub-component, fuel consumption is the indicator selected to estimate the impact of this set of activities. No data on the location of the trainings foreseen for this sub-component were available. Therefore, an average of the distances between the four different zones was used: the average travel time would be 52 minutes, which is equivalent to 35km. It is assumed that only a few participants would use a car – which would also be shared among several participants – and that most would make use of public transportation. For this sub-component, 2 480 trainings will take place (all levels included) over five years. It has been estimated that the implementation of this set of activities would cause an overall consumption of 3,193.24 m³/year of diesel, which also includes the fuel consumed by the use of the motorcycles purchased by the project.
- (iii) EX-ACT takes into account the expected effect of the adoption of the best practices. Given that at this stage of the project appraisal, data on the size of the land on which the different practices will be implemented are not yet available. In fact the AGP will adopt a demand-driven approach funding projects proposed by farmers' groups – the EX-ACT analysis has been based on preliminary estimates of the potentials for implementing best practices on most represented crops in AGP woredas, i.e. annual crops which occupy more than 75 percent of land¹⁵. Specifically, it has been estimated that AGP will be successful in expanding the adoption of sustainable land management (SLM) practices on 163 089 ha of annual cropland. In fact, annual crops in the AGP woredas are grown on around 8.6 million ha: since the application rate of SLM practices in the AGP woredas is around 29 percent, as estimated in the AGP Baseline for Impact Evaluation (BDS-CDR 2010), the potential for expansion of SLM practices on annual cropland is around 2.5 million ha; given that the rate of adoption of best practices is equal to 6.5 percent of households in the “with project” scenario (BDS-CDR 2010), it is estimated that improved practices could be potentially implemented on 162,500 ha (6.5 percent of 2.5 million) of annual cropland. Nevertheless, supposing that only 50 percent of targeted farmers would adopt the practices promoted by the project, EX-ACT estimated the impact of best practices (e.g. nutrient and water management, residue management, and manure application) only on half of the potential area (i.e. 81,545 ha).
- (iv) Since the AGP will also support seed production for self-pollinated crops (staple cereals like teff and wheat) in order to provide a greater supply of breeder and/or basic seed, the analysis takes into consideration the increase in planting material/seed/breed multiplication promoted by the project.

¹⁵ FAO 2010.

Extension support would in fact target community-based seed production through groups and the AGP would support groups engaging in seed production and implementation of best nutrient management practices¹⁶. It is assumed that such best practices would be implemented on 4 960 ha where improved seeds will be produced. In fact, seed production would be based in 2 480 demonstration groups: it is assumed an average size of 2 ha per each demonstration group.

- (v) It is also considered that the AGP would promote the adoption of best practices on grasslands, which cover 9 percent of land area¹⁷. Specifically, it is assumed that 19 649 ha of grasslands¹⁸ would be improved from moderately degraded to improved (without input management) as the result of the adopted best practices.
- (vi) The EX-ACT analysis has also considered the increase in the use of chemicals which the implementation of best practices would determine: the fertilization rate of 0.1 t/ha for urea and 0.1 t/ha for the diammonium phosphate (DAP) is adopted on the 163 089 ha where the improved practices would be implemented; the application rate of 0,001 t/ha of Malathion (2,4 D) is used for pesticides. The analysis has also considered the use of agrochemicals on the area (4 960 ha) where improved seed production would take place (same application rates of fertilizers and pesticides applied).

Since no data on the adoption of improved livestock management practices were available at this stage and no estimates were possible due to the lack of necessary information, the adoption of best management practices in the livestock sector was not taken into account here.

The results of the EX-ACT analysis for this sub-component, as computed using the modules “other investments”, “inputs”, “annuals” and “grasslands”, are shown in Table 3.2. It is worth noting that the model considers that improved agronomic practices are able to store 0.29 tCO₂e/ha/year, while the adoption of integrated nutrient management practices can store 0.26 tCO₂e/ha/year and manure application 1.54 tCO₂e/ha/year for the specific climate considered in the analysis¹⁹. Also, the improvement of severely degraded grasslands would determine an increase in the C stock of 1.39 tCO₂e/ha/year. The increase in fertilizer use is expected to determine an increase in GHG emissions (carbon dioxide emissions from Urea application, N₂O emissions from N application on

¹⁶ WB 2010.

¹⁷ FAO 2010.

¹⁸ This value is computed following the same procedure as for the annual cropland: grasslands in the AGP *woredas* cover around one million ha: using the application rate of SLM practices in the AGP *woredas* is around 29 percent (BDS-CDR 2010), the potential for expansion of SLM practices on annual cropland is around 300 000 ha; given that the rate of adoption of best practices is equal to 6.5 percent of households in the “with project” scenario (BDS-CDR 2010), it is estimated that improved practices would be implemented on 19 469 ha of grasslands.

¹⁹ Bernoux et al. 2010b.

managed soils and CO2 equivalent emissions from production, transportation, storage and transfer of agricultural chemicals).

The results show that GHG emissions associated with training activities amount to 0.19 MtCO2e. The implementation of best practices on cropland and grasslands would have the direct net effect of sequestering soil C (2.5 and 0.5 MtCO2e respectively) and the indirect effect of avoiding emissions from the expansion of annual cropland on grasslands (0.16 MtCO2e). The impact of the increase in fertilizer use is estimated to be a net source of GHG emissions of 1.87 Mt CO2e. Overall, the set of activities related to scaling up best practices would be a net source (0.11 MtCO2e over 20 years).

Table 2: C-balance associated with scaling up of best practices

Implementation of training activities

Type of Fuel	Default value t CO2/m3	Specific Value	Default Factor	Annual Fuel Consumption (m3/yr)				Emission (t CO2eq)		
				Start t0	Without Project End	Rate	With Project End	Rate	Without	With
Gasoil/Diesel	2.63		YES	0	0	Linear	4193.0	Linear	0	193190
OPTION1 + OPTION2		Sub-Total Without	0.0	Sub-Total With		193190.0	Difference		193190.0	

Improved practices on annual cropland and improved seed production

Vegetation Type	Areas	Without project				With Project				Soil CO2 mitigated		CO2eq emitted from Burn		Total Balance		Difference tCO2
		Start t0	End	Rate	End	Rate	Without	With	Without	With	Without tCO2	With tCO2				
System A1		0	0	Linear	0	Linear	0	0	0	0	0	0	0	0	0	0
System A2		0	0	Linear	0	Linear	0	0	0	0	0	0	0	0	0	0
System A3		0	3500	Linear	0	Linear	0	0	0	0	0	0	0	0	0	0
System A4		0	0	Linear	0	Linear	0	0	0	0	0	0	0	0	0	0
Annual System1		0	0	Linear	81545	Linear	0	-413841	0	0	0	0	-413841	0	-413841	-413841
Annual System2		0	0	Linear	4960	Linear	0	-22568	0	0	0	0	-22568	0	-22568	-22568
Annual System3	168049	151245	0	Linear	0	Linear	0	0	0	0	0	0	0	0	0	0
Annual System4	0	0	0	Linear	81544	Linear	0	-2197611	0	0	0	0	-2197611	0	-2197611	-2197611
Total Syst 1-10	168049	168049			168049											
Agric. Annual Total												-85280	-2634020	-2548739		

Adoption of best practices on grasslands

Description of Grassland type, their management and areas (ha)											
Name of the Systems			Succession type	Fire used to manage				Carbon Stock		Delta C*	
Default	Your name	Initial state	Final (with or without project) State of the Grassland	Without project Fire*	Interval (yr)	With project Fire*	Interval (yr)	Cstart t C/ha	Cend t C/ha	tCO2eq/ha/yr	
Reserved system G1	from Deforestation	Non degraded	Non degraded	NO	5	NO	5	38.00	38.00	0.00	
Reserved system G2	converted to A/R	Non degraded	Non degraded	NO	5	NO	5	38.00	38.00	0.00	
Reserved system G3	From OLUC	Non degraded	Non degraded	NO	5	NO	5	38.00	38.00	0.00	
Reserved system G4	Grassland to OLUC	Non degraded	Non degraded	NO	5	NO	5	38.00	38.00	0.00	
Grass-1	SLM on grazing land	Moderately Degraded	Improved without inputs manage	NO	5	NO	5	36.48	44.08	1.39	

Default		Without project		With Project		Soil C variations (tCO2eq)		Total CO2 eq from fire		Total CO2eq		Difference		
		End	Rate	End	Rate	Without	With	Without	With	Without	With	tCO2eq		
System G1	from Deforestation	0	Linear	0	Linear	0	0	0	0	0	0	0		
System G2	converted to A/R	0	Linear	0	Linear	0	0	0	0	0	0	0		
System G3	From OLUC	0	Linear	0	Linear	0	0	0	0	0	0	0		
System G4	Grassland to OLUC	0	Linear	3500	Linear	0	0	0	0	0	0	0		
Grass-1	SLM on grazing land	0	Linear	19649	Linear	0	-479108	0	0	0	-479108	-479108		
Grassland total												0.0	-479108.1	-479108.1

Avoided expansion of annual on cropland

Your Name	Description of LUC			Burnt before conversion	Default C Stocks (tC/ha)				Delta (tCO2)	
	Initial Land Use	Final Land Use	Alert		Biom. Ini.	Biom. Fin.	Soil Ini.	Soil Fin.	Biomass	Soil /yr *
avoided expansion of annual	Grassland	Annual Crop		NO	3.5	5.0	38.0	22.0	5.6	-2.9

*Soil effect limited to 20 year

	Area concerned by LUC				Biomass Change		Soil Change		Fire		Total Balance		Difference	
	Without Project		With Project		Without tCO2	With tCO2	Without tCO2	With tCO2	Without tCO2	With tCO2	Without tCO2	With tCO2	tCO2	
avoided expansion of annual	3500	Linear	0	Linear	-19507	0	179218	0	0	0	159711	0	-159711	
Other LUC total												159711	0	-159711

Use of agrochemicals

Carbon dioxide emissions from Lime application																
Type of lime	IPCC factor	Specific factor	Default Factor	Amount of Lime in tonnes per year						Emission (t CO2eq) per year			Total Emission (tCO2eq)		Difference	
				Start t0	Without Project		With Project	End	Rate	Start	End		Without	With		
					End	Rate					Without	With				
Limestone	0.12		YES	0	0	Linear	0	0	Linear	0	0	0	0	0	0	0
Dolomite	0.13		YES	0	0	Linear	0	0	Linear	0	0	0	0	0	0	0
Not precised	0.125		YES	0	0	Linear	0	0	Linear	0	0	0	0	0	0	0
Sub-Total I-1										0	0	0	0.0	0.0	0	

Carbon dioxide emissions from Urea application															
Type of input	IPCC factor	Specific factor	Default Factor	Amount of Urea in tonnes per year						Emission (t CO2eq) per year			Total Emission (tCO2eq)		Difference
				Start t0	Without Project		With Project	End	Rate	Start	End		Without	With	
					End	Rate					Without	With			
Urea	0.2		YES	0	5602	Linear	16805	16805	Linear	0	1120.3333	3361	19606.8	58818	39212
Sub-Total I-2										0	1120.3333	3361	19605.8	58817.5	39212

N2O emissions from N application on managed soils (except manure management see Livestock Module)															
Type of input	IPCC factor	Specific factor	Default Factor	Amount of N Applied (t per year)						Emission (t CO2eq) per year			Total Emission (tCO2eq)		Difference
				Start t0	Without Project		With Project	End	Rate	Start	End		Without	With	
					End	Rate					Without	With			
Urea	0.01		YES	0	2614	Linear	7842	7842	Linear	0.0	8103.7	24311.2	141816	425447	283631
N Fertiliser (other than Urea)	0.01		YES	0	3585	Linear	10755	10755	Linear	0.0	11113.5	33340.5	194486	583459	388973
N Fertiliser in non-upland Rice*	0.003		YES	0	0	Linear	0	0	Linear	0.0	0.0	0.0	0	0	0
Sewage	0.01		YES	0	0	Linear	0	0	Linear	0.0	0.0	0.0	0	0	0
Compost	0.01		YES	0	0	Linear	0	0	Linear	0.0	0.0	0.0	0	0	0
*N fertilizer from upland rice should be included above (N fertilizer)										0.0	19217.2	57651.7	336301.8	1008905.3	672604
Sub-Total I-3										0.0	19217.2	57651.7	336301.8	1008905.3	672604

CO2 equivalent emissions from production, transportation, storage and transfer of agricultural chemicals															
Type of input**	Default factor*	Specific factor	Default Factor	Amount in tonnes of product (active ingrediente for Pesticides)						Emission (t CO2eq) per year			Total Emission (tCO2eq)		Difference
				Start t0	Without Project		With Project	End	Rate	Start	End		Without	With	
					End	Rate					Without	With			
Urea	4.8		YES	0	2614	Linear	7842	7842	Linear	0.0	12460.6	37381.8	218060	654181	436121
N Fertiliser (other than Urea)	4.8		YES	0	3585	Linear	10755	10755	Linear	0.0	17088.5	51265.5	299049	897146	598098
N Fertiliser in non-upland Rice*	4.8		YES	0	0	Linear	0	0	Linear	0.0	0.0	0.0	0	0	0
Phosphorus synthetic fertilizer	0.7		YES	0	2577	Linear	7730	7730	Linear	0.0	1889.6	5668.7	33067	99202	66134
Potassium synthetic fertilizer	0.6		YES	0	0	Linear	0	0	Linear	0.0	0.0	0.0	0	0	0
Limestone (Lime)	0.6		YES	0	0	Linear	0	0	Linear	0.0	0.0	0.0	0	0	0
Dolomite (Lime)	0.6		YES	0	0	Linear	0	0	Linear	0.0	0.0	0.0	0	0	0
Generic Lime	0.6		YES	0	0	Linear	0	0	Linear	0.0	0.0	0.0	0	0	0
Herbicides (Pesticides)	23.1		YES	0	0	Linear	0	0	Linear	0.0	0.0	0.0	0	0	0
Insecticides (Pesticides)	18.7		YES	0	0	Linear	170	170	Linear	0.0	0.0	3179.0	0	55633	55633
Fungicides (Pesticides)	14.3		YES	0	0	Linear	0	0	Linear	0.0	0.0	0.0	0	0	0
* from Lal (2004) Table 5 - central value -IC02t/product										0.0	31438.7	97495.0	550176.4	1706161.7	1155985
** tonnes of N, P2O5, K2O and CaCO3										0.0	31438.7	97495.0	550176.4	1706161.7	1155985
Total "Inputs"										0.0	31438.7	97495.0	550176.4	1706161.7	1155985

Source: our computations using EX-ACT (2010)

4.5.3 Market and agribusiness development

This sub-component will promote investments in value-chain development, which is considered as a key condition for a sustained agricultural production programme. The AGP supports the establishment and operationalization of innovation and demonstration funds (for technology acquisition and transfer, support and capacity building to identify new markets and best business practices and access information). It also funds capacity building and technical assistance for the private and public sector (training). It promotes linkages with credit and sectoral analysis of constraints and value chain development (workshops and trainings). It also helps to strengthen supply systems of key inputs, e.g. seed sector support, support for community-based crop and forage seed production, genetic background of livestock (especially dairy cattle) improvement.

EX-ACT takes into account the GHG emissions related to the implementation of the training activities supporting the establishment and operationalization of innovation and demonstration funds. As in the previous sub-component, fuel consumption is used to estimate the impact of this set of activities. In total, 630 trainings will take place (all levels included) over five years, mainly technicians and assistant farmer/community inseminators. For this sub-component no details on the zone where the trainings will be organized were available. Therefore, an average of the distances between the four different zones was used: the average travel time would be 52 minutes, which is equivalent to 35km. It is assumed that there is no federal meeting. All participants would therefore walk or take public transportation. Accordingly, the total fuel consumption of this sub-component is equal to 154 m3/year.

AGP also supports the increase in seed (including forage) availability and finances a mix of public and private investments in animal genetic improvement (upgrade facilities of artificial insemination centre, purchase breeding stock for breed multiplication farms, develop regional semen collection and processing centres, training for new and existing technicians and centre staffs). EX-ACT estimated the GHG emissions related to this mix of investments by considering the activity of upgrading livestock breeding facilities (Table 3) and the purchase of stock (Table 4).

Table 3: Upgrade of livestock breeding facilities financed by AGP

Type of building	m2
Semen collection centre: laboratory house	400
Bull sheds	300
Forage/hay sheds	400
semen collection area	200
offices	600
guard post	40
service centre	200
Store	200
Clinic	200
car shed	160
Total	2,700

Source: WB 2010

Table 4: Purchase of stock financed by AGP

Animal species	n. animals
heifers	300
jersey heifers	300
bulls	40
cows	400
poultry	10000
local breeding ewes	1000
rams	40
total	12080

Source: WB 2010

EX-ACT analysis takes into account the GHG emissions related to the upgrade of livestock breeding facilities (2,700 m2) in the module “other investments”, using default values from the tools developed by AFD, which shows that the GHG emissions related to the building of agricultural buildings (concrete) amount to 0.656 t CO₂e/m².

The purchase of livestock is considered in the module “livestock”. EX-ACT can estimate CH₄ emissions from enteric fermentation and manure management, as well as

N₂O emissions from manure management. CH₄ emissions from manure management are those produced during storage and treatment of manure as well as from manure deposited on pasture, while N₂O emissions are produced, directly or indirectly, during storage and treatment of manure (solid and liquid).

Since EX-ACT adopts a Tier 1 approach, only animal population data are needed to estimate the relative emissions. Default values for CH₄ emissions from enteric fermentation and manure management used in EX-ACT computations are shown in Table 5 together with the N excretion rates adopted to compute N₂O emissions from manure management. The mean annual temperature chosen at the beginning of the analysis is a critical parameter here as it affects both enteric fermentation and manure management and relative emissions.

Table 5 IPCC default values for methane emissions from enteric fermentation and manure management in Africa used in EX-ACT

	CH ₄ from enteric fermentation	CH ₄ from manure management	N excretion rate
	(Kg CH ₄ /head/year)	(Kg CH ₄ /head/year)	(Kg N/t animal mass/day)
Dairy cattle	40.00	1.00	0.60
Other cattle	31.00	1.00	0.63
Sheep	5.00	0.15	1.17
Poultry	0.00	0.02	0.82

Source: Bernoux et al. 2010b

Although a detailed value-chain analysis has already been conducted in the project area²⁰, the details of the activities foreseen under this component will be determined at the appraisal. Only some idea of the project strategy is already available²¹. Therefore, the resulting EX-ACT analysis (shown in Table 6) should be considered only as partial. Nevertheless, since the EX-ACT methodology does not adopt a value-chain approach, the bias introduced in the analysis by not considering the agri-business activities the project will promote is very small.

²⁰ Bekele 2010a, 2010b, 2010c, 2010d.

²¹ World Bank 2010.

Table 6 C balance associated with market and agribusiness development

Training activities

Released GHG associated with Fuel consumption (agricultural or forestry machinery, generators...)										
Type of Fuel	Default value t CO2 /m3	Specific Value	Default Factor	Annual Fuel Consumption (m3/yr)					Emission (t CO2eq)	
				Start t0	Without Project		With Project		All Period	
Gasoil/Diesel	2.63		YES	0	0	Linear	154.0	Linear	0	7095
OPTION1 + OPTION2		Sub-Total Without	0.0	Sub-Total With	7095.5		Difference		7095.5	

Livestock breeding facilities

Released GHG associated with building of infrastructure								
Type of construction or infrastructure	Default value t CO2 /m2	Specific Value	Default Factor	surface (m2)		Emission (t CO2eq)		
				Without	With	Without	With	
Agricultural Buildings (concrete)	0.656		YES	0	2700	0.0	1771.2	
Subtotal				0.0	1771.2	Difference		1771.2

Purchase of livestock

Methane emissions from enteric fermentation										
Choose Livestocks:	IPCC factor	Start t0	Head Number			With Project		Total Emission (tCO2eq)		
			Without Project		Rate	End	Rate	All Period		Difference
		End	Rate	End				Rate	Without	
Dairy cattle	40	0	0	Linear	700	Linear	0	10,290	10,290	
Other cattle	31	0	0	Linear	340	Linear	0	3,873	3,873	
Buffalo	55	0	0	Linear	0	Linear	0	0	0	
Sheep	5	0	0	Linear	1,040	Linear	0	1,911	1,911	
Swine (Market)	1.5	0	0	Linear	0	Linear	0	0	0	
Swine (Breeding)	1.5	0	0	Linear	0	Linear	0	0	0	
Poultry	0	0	0	Linear	10,000	Linear	0	0	0	
Camels	46	0	0	Linear	0	Linear	0	0	0	
Camels	46	0	0	Linear	0	Linear	0	0	0	
User Defined- Specified value		0	0	Linear	0	Linear	0	0	0	
User Defined- Specified value		0	0	Linear	0	Linear	0	0	0	
Sub-Total L-1							0	16,074	16,074	

Methane emissions from manure management										
Livestocks:	IPCC factor	Start t0	Head Number			With Project		Total Emission (tCO2eq)		
			Without Project		Rate	End	Rate	All Period		Difference
		End	Rate	End				Rate	Without	
Dairy cattle	1	0	0	Linear	700	Linear	0	257	257	
Other cattle	1	0	0	Linear	340	Linear	0	125	125	
Buffalo	1	0	0	Linear	0	Linear	0	0	0	
Sheep	0.15	0	0	Linear	1,040	Linear	0	57	57	
Swine (Market)	1	0	0	Linear	0	Linear	0	0	0	
Swine (Breeding)	1	0	0	Linear	0	Linear	0	0	0	
Poultry	0.02	0	0	Linear	10,000	Linear	0	74	74	
Camels	1.92	0	0	Linear	0	Linear	0	0	0	
Camels	1.92	0	0	Linear	0	Linear	0	0	0	
User Defined- Specified value		0	0	Linear	0	Linear	0	0	0	
User Defined- Specified value		0	0	Linear	0	Linear	0	0	0	
Sub-Total L-2							0	513	513	

Nitrous Oxide emissions from manure management										
Livestocks:	IPCC factor	Start t0	Annual amount of N manure* (t N per year)			With Project		Total Emission (tCO2eq)		
			Without Project		Rate	End	Rate	All Period		Difference
		End	Rate	End				Rate	Without	
Dairy cattle	0.01	0	0	Linear	42	Linear	0	3,594	3,594	
Other cattle	0.01	0	0	Linear	14	Linear	0	1,153	1,153	
Buffalo	0.01	0	0	Linear	0	Linear	0	0	0	
Sheep	0.01	0	0	Linear	12	Linear	0	1,060	1,060	
Swine (Market)	0.01	0	0	Linear	0	Linear	0	0	0	
Swine (Breeding)	0.01	0	0	Linear	0	Linear	0	0	0	
Poultry	0.01	0	0	Linear	3	Linear	0	255	255	
Camels	0.01	0	0	Linear	0	Linear	0	0	0	
Camels	0.01	0	0	Linear	0	Linear	0	0	0	
User Defined- Specified value				Linear		Linear	0	0	0	
User Defined- Specified value				Linear		Linear	0	0	0	
Sub-Total L-3							0	6,062	6,062	

0	22650	22,650
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Source: our computations using EX-ACT (2010)

The results show that GHG emissions associated with training activities amount to 7 095.5 tCO₂e; those associated with upgrading livestock breeding facilities to 1 771.2 tCO₂e; and those related to the purchase of livestock to 22 650 tCO₂e. Overall, the set of activities related to market and agribusiness development will be a net source of GHG emissions of 31 516 tCO₂e.

4.6 Component 2 (small-scale rural infrastructure development and management)

This component will support the construction, rehabilitation/improvement and management of small-scale rural infrastructure to address key production constraints, improve productivity, and develop and increase the efficiency of value chains through better market access.

4.6.1 Small-scale Agricultural Water Development and Management

Investments foreseen under this sub-component will include infrastructure development for new small-scale and micro-irrigation schemes on 18 000 ha (13 000 ha under small scale irrigation schemes and 5 000 ha under micro-irrigation technologies). This will include the establishment of micro-dams and groundwater recharge structures, gravity and pump diversions and groundwater development, the construction of ponds/tanks/wells, the supply of portable diesel irrigation pumps, mechanical pumps, family drip systems and similar technologies for 200 selected demonstration sites.

The sub-component will provide support for the implementation of soil and water conservation practices on 75 000 ha. This will include: protecting and rehabilitating watersheds where small-scale irrigation and/or water harvesting and micro-irrigation schemes are envisaged, promoting gully rehabilitation, area closures, plantation of multipurpose trees, groundwater recharge interventions; physical/biological measures to stabilize hillsides, degraded private and communal lands – e.g. check dams, gabions, reshaping/cultivation with multipurpose perennial trees, shrubs and grasses.

The AGP will also contribute to establishing and/or strengthening Water User Groups/Associations (training), and support capacity building in watershed management through short-term and tailor-made training, visits and study tours etc.

EX-ACT analysis related to the development of irrigation schemes is considered in the module “other investments”, which estimates the GHG emissions associated with infrastructure building (2,729 tCO₂e). The implementation of soil and water conservation practices is considered in the module “grasslands”, which assimilates these types of activities to reduce land degradation, with the effect of increasing soil C stock by 2.37 MtCO₂e.

EX-ACT takes into account the GHG emissions related to the training activities for small-scale agricultural water development and management. As discussed earlier, fuel consumption is used to estimate the impact of this set of activities. A total of 2 370 trainings will take place (all levels included) in five years. As in the previous sub-component, there was no detailed information about the distances covered by people

attending the meetings. Therefore, an average of the distances between the four different zones was used: the average travel time would be 52 minutes, which is equivalent to 35km. It was estimated that the implementation of this set of activities for this sub-component would cause an overall consumption of 634 m³/year of diesel (this also includes the fuel consumed by the use of the motorcycles purchased by the project). It results in an emission of 29 211 tCO₂e.

The results (Table 7) show that overall, the set of activities related to small-scale agricultural water development and management will be a net sink of 5.06 MtCO₂e.

Table 7: C balance associated with small-scale agricultural water development and management

Development of irrigation schemes

Released GHG associated with installation of irrigation systems

Installation of irrigation system	surface (ha)	Type of irrigation system	Associated tCO ₂ eq		
Without Project	0	Hand moved sprinkle	0.0		
With Project	5000	Trickle	1556.5		
	13000	Surface with IRSS	1172.6	<i>Difference</i>	1556.5
					2729.1

Soil and water conservation practices

Description of Grassland type, their management and areas (ha)										
Name of the Systems			Succession type	Fire used to manage				Carbon Stock		Delta C*
Default	Your name	Initial state	Final (with or without project) State of the Grassland	Without project		With project		Cstart	Cend	tCO ₂ eq/ha/yr
				Fire*	Interval (yr)	Fire*	Interval (yr)	t C/ha	t C/ha	
Reserved system G1	from Deforestation	Non degraded	Non degraded	NO	5	NO	5	38.00	38.00	0.00
Reserved system G2	converted to A/R	Non degraded	Non degraded	NO	5	NO	5	38.00	38.00	0.00
Reserved system G3	From OLUC	Non degraded	Non degraded	NO	5	NO	5	38.00	38.00	0.00
Reserved system G4	Grassland to OLUC	Non degraded	Non degraded	NO	5	NO	5	38.00	38.00	0.00
Grass-2	s&WC 1	Moderately Degraded	Improved with inputs improvement	NO	5	NO	5	36.48	48.93	2.28
Grass-3	without project	Moderately Degraded	Severely Degraded	NO	5	NO	5	36.48	26.60	-1.81
Grass-4	s&WC 2	Moderately Degraded	Improved without inputs managem	NO	5	NO	5	36.48	44.08	1.39

Default		Without project		With Project		Soil C variations (tCO ₂ eq)		Total CO ₂ eq from fire		Total CO ₂ eq		Difference
		End	Rate	End	Rate	Without	With	Without	With	Without	With	tCO ₂ eq
System G1	from Deforestation	0	Linear	0	Linear	0	0	0	0	0	0	0
System G2	converted to A/R	0	Linear	0	Linear	0	0	0	0	0	0	0
System G3	From OLUC	0	Linear	0	Linear	0	0	0	0	0	0	0
System G4	Grassland to OLUC	0	Linear	3500	Linear	0	0	0	0	0	0	0
Grass-2	s&WC 1	0	Linear	37500	Linear	0	-1497746	0	0	0	-1497746	-1497746
Grass-3	without project	84649	Linear	0	Linear	0	-2683232	0	0	0	-2683232	-2683232
Grass-4	s&WC 2	0	Linear	37500	Linear	0	-914375	0	0	0	-914375	-914375
Grass-5	s&WC 3	10000	Linear	0	Linear	0	0	0	0	0	0	0
Grassland total								0.0	-5095353.5	-5095353.5		

Training activities

Released GHG associated with Fuel consumption (agricultural or forestry machinery, generators...)

Type of Fuel	Default value t CO ₂ /m ³	Specific Value	Default Factor	Annual Fuel Consumption (m ³ /yr)				Emission (t CO ₂ eq)		
				Start	Without Project		With Project		All Period	
				t0	End	Rate	End	Rate	Without	With
Gasoil/Diesel	2.63		YES	0	0	Linear	634.0	Linear	0	29211
OPTION1 + OPTION2				Sub-Total Without	0.0	Sub-Total With	29211.2	Difference	29211.2	

Source: our computations using EX-ACT (2010)

4.6.2 Small-scale Market Infrastructure Development and Management

Interventions under this sub-component include: feeder road development (800 km of small-scale feeder roads, roadside drainage and footbridges); market centre construction/improvement/development (40 primary, 20 secondary and eight terminal market centres); and institutional development and capacity building of relevant implementing and advisory agencies (establishing and training road maintenance groups for repair and maintenance of community-owned transport infrastructure, establishing and/or strengthening market centre management committees).

EX-ACT estimates the GHG emissions related to road development in the module “other investments”: road for medium traffic in asphalt is assumed, with a default value of 0.073 tCO₂e emitted per m². The same module also provides the estimates for the construction of market centres: it is assumed that the primary, secondary and terminal market centres will have a surface of 200, 500, and 1000 m² respectively. Therefore, a total of 24 000 m² of agricultural buildings (metal) will be built (default value of 0.22 tCO₂e emitted per m²).

EX-ACT takes into account the GHG emissions related to the training activities for small-scale market infrastructure development and management. Again, fuel consumption was used to estimate the impact of this set of activities. A total of 468 trainings will take place in five years. Given an estimated average travel time of 52 minutes (equivalent to 35km), it is estimated that the implementation of this set of activities will cause an overall consumption of 17 m³/year of diesel (this also includes the fuel consumed by the use of the motorcycles purchased by the project). The results (Table 9) show that: GHG emissions associated with training activities amount to 783 tCO₂e; emissions related to road construction and building of market centres amount to 225 280 tCO₂e; and overall, the set of activities related to small-scale market infrastructure development and management will be a source of 226 063 tCO₂e.

Table 8: C balance associated with small-scale market infrastructure development and management

Training activities

Released GHG associated with Fuel consumption (agricultural or forestry machinery, generators...)										
Type of Fuel	Default value t CO ₂ /m ³	Specific Value	Default Factor	Annual Fuel Consumption (m ³ /yr)				Emission (t CO ₂ eq)		
				Start t0	Without Project End	Rate	With Project End	Rate	Without	With
Gasoil/Diesel	2.63		YES	0	0	Linear	17.0	Linear	0	783
OPTION1 + OPTION2			Sub-Total Without	0.0	Sub-Total With	783.3	Difference	783.3		

Road construction and building of market centres

Released GHG associated with building of infrastructure							
Type of construction or infrastructure	Default value t CO ₂ /m ²	Specific Value	Default Factor	surface (m ²)		Emission (t CO ₂ eq)	
				Without	With	Without	With
Road for medium traffic (asphalt)	0.073		YES	0	3000000	0.0	220000.0
Agricultural Buildings (metal)	0.220		YES	0	24000	0.0	5280.0
Subtotal				0.0	225280.0	Difference	225280.0

Source: our computations using EX-ACT (2010)

5 RESULTS AND DISCUSSION

5.1 Main results

The project is essentially promoting changes in land management. Nevertheless, it is assumed that in the “without project” case, annual cropland will expand at the expense of grasslands. This is shown in Table 1, which summarizes the changes in land use in both “with” and “without project” scenarios.

Table 9: Land use matrix of the AGP

Without Project			FINAL						Total Initial
			Forest/ Plantation	Cropland			Grassland	Other Land	
INITIAL	Forest/Plantation	Annual	Perennial	Rice	Degraded	Other			
	Forest/Plantation	0	0	0	0	0	0	0	
	Annual	0	168049	0	0	0	0	168049	
	Perennial	0	0	0	0	0	0	0	
	Rice	0	0	0	0	0	0	0	
	Grassland	0	3500	0	0	94649	0	98149	
	Degraded	0	0	0	0	0	0	0	
	Other	0	0	0	0	0	0	0	
	Total Final	0	171549	0	0	94649	0	266198	

With Project			FINAL						Total Initial
			Forest/ Plantation	Cropland			Grassland	Other Land	
INITIAL	Forest/Plantation	Annual	Perennial	Rice	Degraded	Other			
	Forest/Plantation	0	0	0	0	0	0	0	
	Annual	0	168049	0	0	0	0	168049	
	Perennial	0	0	0	0	0	0	0	
	Rice	0	0	0	0	0	0	0	
	Grassland	0	0	0	0	98149	0	98149	
	Degraded	0	0	0	0	0	0	0	
	Other	0	0	0	0	0	0	0	
	Total Final	0	168049	0	0	98149	0	266198	

Table 9 summarizes the overall C balance of the project, computed as the difference between C sinks and sources over 20 years (five years of implementation phase and 15 years of capitalization phase). The project is able to sequester 8.3 MtCO₂e while emitting 2.4 MtCO₂e so that the net effect of project activities is to create a sink of 5.9 MtCO₂e, which corresponds to a unitary mitigation potential of 1.1 tCO₂e/ha per year.

Table 9: C-balance of the AGP

C-balance elements		MtCO ₂ e over 20 years
Total mitigated	GHG	-8.3
Total emitted	GHG	2.4
C-balance		-5.9

Source: our calculations using EX-ACT (2010)

Table 10 shows the mitigation potential of the project by category of land use change (corresponding to the EX-ACT modules). Mitigation potential is linked to the changes in the management of annual cropland and grasslands (improved agronomic practices, soil and water conservation) and to the “avoided” expansion of annual cropland on grasslands. Most GHG emissions are determined by the increase in input use associated with the scaling up of the best practices on cropland.

Table 10: Mitigation potential of the AGP, by EX-ACT module

EX-ACT modules	MtCO ₂ e over 20 years	% of total GHG mitigated	% of total GHG emitted
Annual crops	-2.5	30.8	-
Grassland	-5.6	67.3	-
Non Forest Land Use Change	-0.2	1.9	
Total GHG mitigated	-8.3	100	-
Livestock	0.02	-	0.6
Inputs	1.9	-	47.9
Other Investments	0.5	-	5.5
Total GHG emitted	2.4	-	100
C-balance	-5.9	-	-

Source: our calculations using EX-ACT (2010)

Table 11 summarizes the results of the EX-ACT analysis by project component. It is evident from the table that most of the project's mitigation potential is determined by the adoption of soil and water conservation measures, which in fact can reduce soil erosion, increase soil capacity to store C and improve the overall soil fertility (see the sub-component small-scale agricultural water development and management). It is interesting to observe that scaling up best practices results in a C sink, although it promotes the intensification of agricultural production through an increase in the use of inputs. In fact, although inputs use represents a source of GHG emissions, the soil C sequestered through the adoption of sustainable land management practices offsets such emissions and the overall component ends up being a net C sink. This shows that the adoption of sustainable agricultural practices could be seen as complementary to the use of agro-chemicals not only for the relevant agronomic implications, but also for the climate change mitigation side. It is also interesting to observe that neither the implementation of training activities nor the construction/rehabilitation of infrastructures (irrigation, markets) are causing a significant production of GHG emissions. Given the importance of such activities in project implementation, this is an important result.

Table 11: Mitigation potential of the AGP, by project component (MtCO₂e over 20 years)

Component 1: Agricultural production and commercialization	
Institutional strengthening and development	0.04
Scaling up best practices	-1.1
Market and agribusiness development	0.03
Component 2: Small-scale rural infrastructure development and management	
Small-scale Agricultural Water Development and Management	-5.1
Small-scale Market Infrastructure Development and Management	0.2
C-balance	-5.9

Source: our calculations using EX-ACT (2010)

5.2 Sensitivity analysis

The analysis presented has taken into account the possible impact on GHG emissions of the training activities, which will be conducted during project implementation. It is worth noting that this represents an innovative approach in the application of the ex-ante C-balance analysis and is therefore interesting to estimate the C footprint of this set of activities. An alternative scenario is built by excluding the GHG emissions related to fuel consumption consequent to the training activities: under this scenario (the so-called “no training”) a reduction by 10 percent of overall GHG emissions from project activities is recorded. Under this scenario the final balance amounts to -6.1 MtCO₂e over 20 years with an almost negligible change of the unitary mitigation potential (1.15 tCO₂e/ha per year, i.e. +4%).

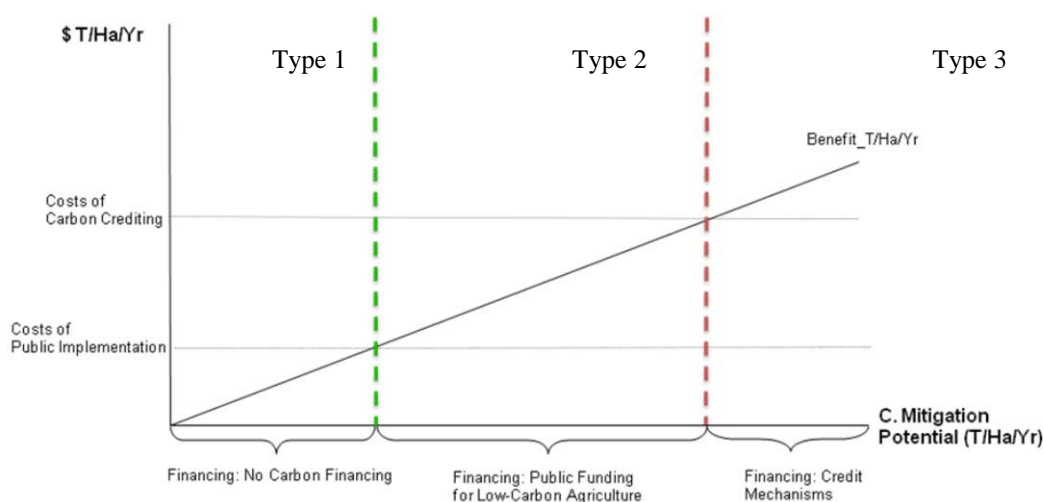
A second scenario is built on the hypothesis that the adoption of best farming practices will be wider than in the main scenario. Under this so-called “optimistic” scenario, it is assumed that all farmers in the potential area (i.e. 162,500 ha) will adopt the improved practices. As a result, the overall C balance will amount to -7.9 MtCO₂e over 20 years, with an increase of 33 percent in the C sequestered. The corresponding unitary mitigation potential will be equal to 1.5 tCO₂e/ha per year.

5.3 Economic analysis

Public and private mitigation financing for agriculture can play two important roles: providing increased investment flows to the agricultural sector of developing countries, and/or providing increased incomes to farmers in the form of C payments. Mitigation finance could be either public or market-based and integrated with existing official development assistance (ODA). Rural development projects involving the implementation of sustainable land management practices could therefore obtain funds from C finance related to mitigation benefits²².

It is possible to classify projects that are of interest for agricultural development into four categories depending on their mitigation potential. Type 0 projects have no mitigation potential (e.g. they are a net source of GHG emissions) and cannot benefit from any additional financing from the C sector. Type 1 projects have a low mitigation potential so that the mitigation benefits are smaller than the costs for monitoring, reporting and verifying (MRV) C mitigation activities. There would be no space for additional project financing from C mitigation sources (ODA public funds remain the main financing source for this category of projects). For type 2 projects, the benefits of pursuing low-C agricultural strategies may be greater than the costs associated with the adoption of basic MRV for public implementation. In this case, public funding may be a possible financing source which could integrate ODA funds, as project offsets are considered as public goods and therefore purchased by a public institution. For type 3 projects, mitigation benefits are greater than the costs of adopting and meeting C crediting MRV requirements (presumably higher than MRV for public sector options) so that C crediting mechanisms are a suitable source of financing for this category of projects. This is the case, for example, of projects aimed at producing C credits from agriculture in developed countries to be sold on the (voluntary or mandatory) C markets (see Figure 3).

Figure 3: Financing options for agriculture development and mitigation projects



Source: adapted from FAO 2009.

²² Branca et al 2010.

It is not easy to estimate the transaction costs related to the accounting of C activities at public or market level, given the lack of information and the fact that data available are not in standard format to allow accurate comparison. Therefore more research is needed on this topic. Nevertheless, for the purpose of this note, it is assumed that the transaction costs for public implementation are equal to 4 US\$/ha (per year) which is an arbitrary but plausible value based on some available literature²³. The transaction costs for selling C credits on the market will be obviously higher, given the number and type of requirements, e.g. establish baseline and C flows of the project, design monitoring plan, establish permanent sampling plots, prepare project design document, design individual farm plans, monitor C stocks reported by farmers, verification and certification²⁴.

The preliminary estimates from EX-ACT have shown that the average mitigation potential of the AGP is equal to 1.1 tCO₂e/ha per year which could be valued using a price of 3 US\$/t CO₂e, computed as the average C price for agricultural soil C at retail level on the voluntary C market in 2008²⁵. Therefore, the value of the average mitigation potential of the AGP amounts to 3.3 US\$/ha. Since this value is below the level of transaction costs for public implementation 4 US\$/ha (see above), the AGP can be classified as type 1 project. Nevertheless, the sensitivity analysis has shown that under the “optimistic scenario” the net unitary mitigation potential of AGP will amount to 1.5 tCO₂e/ha corresponding to a value of 4.5 US\$/ha. Under this scenario, the AGP would be classified as a type 2 project and could therefore be taken into consideration for C financing from the public sector.

6 CONCLUSIONS

The paper describes the ex-ante C-balance analysis performed for the Agricultural Growth Project (AGP) in Ethiopia. The results show that overall the net effect of AGP is to create a C sink of 5.9 MtCO₂e over 20 years, which represents the balance between the GHG emitted (mainly as a consequence of the increased use in agro-chemicals and of the infrastructure building planned) and C sequestered (essentially through scaling up of best practices).

These results represent an interesting case: the AGP is promoting an intensification of crop and livestock production over a relevant land area (more than 266,000 ha) at national scale, supporting an increase in input use and building infrastructure, thus resulting in a relevant GHG emissions source. Nevertheless, the project will also fund the adoption of several sustainable agricultural practices (soil and water conservation, improved agronomic practices), which are not only offsetting the emissions of project activities but also contributing to create a C sink. The adoption of sustainable agricultural practices could therefore be seen as complementary to the intensification of crop production not only for the relevant agronomic implications, but also from an environmental (climate change mitigation) point of view.

²³ Cacho et al. 2005; Lipper et al. 2010; Mooney et al. 2004

²⁴ Cacho and Lipper 2006.

²⁵ Hamilton et al. 2009.

The unitary mitigation potential of 1.1 tCO₂e/ha per year is in line with similar cases where sustainable land management practices are introduced on annual cropland and land degradation halted thanks to soil and water conservation measures²⁶. Nevertheless, an expansion in the land interested by the adoption of the best practices could certainly increase the AGP mitigation potential and improve the overall C value of the project. This is demonstrated in the hypothetical case of full adoption of the best practices among all farmers in project area. In this “optimistic” scenario, the higher value of the C co-benefits would make the project worth being financed by the public C sector.

Interestingly, fuel consumption consequent to training activities is shown to have a very small impact on GHG emissions and on the overall project C-balance, although a relevant set of capacity-building activities will be put in place. This is certainly determined by the limited use of private transportation and by the relatively small distances to be travelled (also thanks to the well structured locally organized training sessions).

The results presented here are only preliminary estimates based on available information (or derived on the basis of working hypotheses) at this stage of the project appraisal. In fact, since many project activities are demand-driven, consolidated information will be available only during the implementation of the project (e.g. when the sub-projects will be fully developed). Also, the analysis was conducted at national level in order to include the 83 *woredas* which will be part of the project: data on climate characteristics, soil conditions, agricultural land use and management adopted represent only an average for the country. The uncertainty in the data availability and the significant number of assumptions made are inevitably reflected in the results discussed.

7 LINKS TO OTHER EASYPOL MATERIALS

This module belongs to a set of EASYPol modules and other related documents. See EASYPol Module 101 below:

- [EX-ante Carbon-Balance Tool : Software](#)
- [EX-ante Carbon-Balance Tool : Technical Guidelines](#)
- [EX-ante Carbon-Balance Tool : Brochure](#)

See all EX-ACT resources in EASYPol under the Resource package, [Investment Planning for Rural Development - EX-Ante Carbon-Balance Appraisal of Investment Projects](#)

8 FURTHER READING/ REFERENCES

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