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ANALYTICAL TOOLS

Module XXX

Ex-Act Software for Carbon-Balance Analysis of Investment Projects

An application to the Santa Catarina Rural Competitiveness Project in Brazil

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by

Giacomo Branca, Economist, Agricultural Development Economics Division, FAO, Rome, Italy

Katia Medeiros, Senior Environmental Officer, Investment Centre Division, FAO, Rome, Italy

for the

Food and Agriculture Organization of the United Nations, FAO

About EASYPol
EASYPol is a an on-line, interactive multilingual repository of downloadable resource materials for capacity development in policy making for food, agriculture and rural development. The EASYPol home page is available at: ***www.fao.org/tc/easypol***. EASYPol has been developed and is maintained by the Agricultural Policy Support Service, FAO.

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This module is part of a set of documents aimed at driving project developers in the process of learning and applying the EX-Ante Carbon balance Tool (EX-ACT). This case study has been developed as a result of the application of EX-ACT to a FAO/WB Project in Brazil, which was also selected for testing the software.

The analysis described in the module is the result of the work of a team of professionals from FAO: Giacomo Branca, Economist and Project Analyst and Katia Medeiros, Senior Environmental Officer.

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1. SUMMARY

This module presents a case study of Carbon-Balance Appraisal for an investment project. It is useful for people who wish to improve their skills on how to estimate climate change mitigation potential of agricultural programs/projects and to integrate it in economic analysis of projects. It is part of a set of documents aimed at driving project developers in the process of learning and applying the EX-Ante Carbon balance Tool (EX-ACT). Specifically, this case study has been developed as a result of the application of EX-ACT to a FAO/WB Project in Brazil, which was also selected for testing the software. The case study consists of: a brief description of the project; and the EX-ACT analysis of the project with a discussion of the results.

2. INTRODUCTION

Objectives

The main objective of this module is to show the results issued from a real case project (although simplified), starting with row data. Due to the fact that this exercise puts the user in a situation somehow similar to the reality faced by Carbon Balance Appraisal, it can be used in a training course, where there is no possibility to organize field visits to gather data for a practical applications of the EX-ACT software.

Target audience

This module targets current or future practitioners in formulation and analysis of investment projects, working in public administrations, in NGO's, professional organizations or consulting firms. Also academics can find this material useful to support their courses in Carbon Balance Analysis and development economics. Furthermore, students can use this material to improve their skills in Climate Change Mitigation and complement their curricula.

Required background

To fully understand the content of this module the user must be familiar with:

- Concepts of climate change mitigation and adaptation;
- Concepts of land use planning and management
- Elements of project economic analysis.

To strengthen the background of the reader and to further expand its knowledge about investment projects and Carbon Balance analysis, links with relevant EASYPol modules, further readings and references are reported both in the text and in the last section of the module.

Analytical steps of Carbon-balance ex-ante appraisal

The Ex-ante appraisal of Carbon balance of agriculture projects is a process made of three main steps:

1. Project data collection and organization
   - current land use together with land use changes in the "without project" and "with project" scenarios, with description of the relevant farming systems, livestock production, input use, and other project investments;
   - land management options which will be promoted within every sub-sector (forests, cropland, grasslands, ...)
2. Estimation of project Carbon balance using EX-ACT
3. Description of the scenarios, analysis of the results, and economic analysis.

3. PROJECT DESCRIPTION

3.1 Background

The south Brazil State of Santa Catarina (SoSC) has an estimated land area of 95,346 km² and a population of some 6.1 million, 80% of which live in urban areas. The State's economy is based primarily on the services sector (58.6% of the state's GDP), followed by the industrial sector (34.5%), and agriculture (6.9%). Nationally, the SoSC accounted for 4% of GDP (about US$37 billion) in 2006 and, by 2008, it had expanded to 5.85% outpacing the national average of 5.1%.

SoSC is characterized by a rich natural resource base, including 42% of land covered with native forests and 9% by natural grasslands. The State's water resources consist of two major river basins systems spanning 23 main watersheds. Livestock, agriculture and forestry represent 31%, 16% and 7% of the state's total land use, respectively.

Agriculture plays an important role in SoSC political economy. Though accounting for only 7% of state GDP, when considered along with agro industry, the sector generates nearly 60% of SoSC exports and employs 40% of the labor force. Agricultural export growth is consistently above 15% annually. One-half of the state's agricultural output is livestock-based, with another 41% accounted for by perennial crops and with forestry accounting for the remaining 9%. Agricultural exports consist mainly of meat (e.g. poultry and swine) and wood (e.g. furniture and cellulose).

Agriculture remains in fact vital to social well-being in the SoSC. About 20% of the SoSC's population live in rural areas, of which some 90% are farmers. Of the State's 187,000 holdings, 90% consist of small family-farms (SFFs) of 50 hectares or less (34% are 10 ha or less) which contribute 70% of the state's Agricultural GDP. SoSC has the highest proportion of very small farms among the southern states of Brazil. The main contribution of SFFs to total agricultural production of the state includes the following products: maize (70%), beans (73%), rice (67%), swine and poultry (80%), milk (83%) and onion (91%).

In spite of its strong macroeconomic performance, economic opportunities in SoSC are not equally available to all. About 12% (or 700,000 people) of SoSC population live in poverty (poverty line of US$ 1.00/day per family), 20% of which being residents in rural areas, and consisting mainly of SFFs, rural workers and indigenous people. SFFs in SoSC lack competitiveness and face a number of pressing challenges, including: (i) absence of economies of scale given the nature of prevailing agro-industrialization processes that in some cases are inadequate for SFFs; (ii) lack of capital and expertise needed to facilitate the modernization of production; (iii) poor quality of products, low productivity and value added, and insufficient diversification of production systems that are more suitable to markets and to the local agro-ecological conditions, leading to poor access to markets for a significant portion of SFFs; (iv) a fragile natural resource base and challenging requirements to comply with environmental legislation; (v) poor logistics systems and related infrastructure (roads) in many areas; and (vi) the limited scope of public policy in rural areas and a certain inability of public institutions to adapt to the evolving demands of the rural sector.

Also, mainly because of land titling irregularities, small producers face difficult to comply with environmental legislation which requires land regularization to demarcate and establish a "legal reserve" to either preserve 20% of their farmland or maintain 20% under biodiversity conservation-friendly production systems. This is key in SoSC where native forest lands are under pressure primarily as a result of past and on-going change in land use associated with conversion to agriculture, agro-forestry and livestock activities . The loss of the original vegetation cover in fragile areas (such as riparian and steep zones) and past unplanned and unmanaged occupation of land have resulted in land degradation, making the soil susceptible to erosion which, in turn, carries organic matter and sediments into the state's aquatic ecosystems. Erosion has led to silting of reservoirs, headwater areas and springs, and to less productive soils, which disproportionately affects low income farmers who are rarely able to afford the additional costs of fertilization and of making longer-term investments in improved soil management systems.

Growth in the agricultural sector has also contributed to an increase in water quantity and quality conflicts. Agriculture, along with domestic sewage, is the main source of water pollution in rural areas. Pressure is growing in SoSC to implement an integrated approach to water resources management (WRM), in particular strengthening capacity to implement key WRM instruments. In addition, the importance of appropriate land and water management is underscored by the impact of climate change associated to the increased frequency in natural disasters over the last decade, leading to high losses to the sector, and the need for improved resilience of ecosystems and production systems on such a changing environment.

3.2 The SC Rural project profile

The proposed Santa Catarina Rural Competitiveness Project (SC Rural) has the objective of increasing the competitiveness of rural family agriculture producer organizations . It will target Family Agricultural Producer Organizations (FAPOs) , both those currently existing and others to be established during project execution. Approximately 3.6 million hectares (equivalent to 37% of the state area), where economic activity is lagging and the potential for improvement and the need for support are larger, will be covered by the project. It will primarily support rural agricultural and non-agricultural small-scale producers - including SFFs), rural workers and indigenous people families, organized in associations, cooperatives, formal (with legal status) and informal networks or alliances. The project will reach some 90,000 SFFs overall, 2,000 rural workers/labourers and 1,920 indigenous people families. Out of these beneficiaries, about 25,000 (considered priority beneficiaries) will receive direct financial project support through the State's Rural Investment Fund (RIF), to support improved added-value arrangements as well as improved productive systems for rural competitiveness. A second important group of stakeholders will be the members of River Basin and Ecological Corridor's Committees, consisting of various private and public institutions and sectors.

The proposed project will support rural competitiveness in Santa Catarina on two fronts: (i) finance capital and related technical assistance to FAPOs to encourage technological innovation and diversification, raise productivity, and broaden market access; and (ii) bolster provision of needed complementary public goods and services (e.g. infrastructure, certification, sanitary, legal and environmental regulatory compliance). In line with these two fronts, the project will support beneficiaries at two levels, respectively: (i) directly, for the implementation of collective and associated individual investments included in business plans in line with the PDO; and (ii) indirectly, through the improvement of the framework for the delivery of the above-mentioned complementary public services to shore-up the effectiveness and long-term sustainability of private investments.

The project is proposed for World Bank financing: its total cost is US$ 189.1 million, with US$ 90 million consisting of World Bank loan, using a Sector Wide Approach (SWAp) that includes Government expenditures and activities from the following sectors: Agriculture, Water Resources Management, Environment, Infrastructure (rural roads and communication) and Rural Tourism.

The Project will be implemented over a period of six years and will have the following three components to achieve its objectives:

1) Family Agriculture Competitiveness and Increased Access to Markets;

2) Complementary Public Investments for Rural Competitiveness; and

3) Support to the Rural Competitiveness Program

Component 1) (Family Agriculture Competitiveness and Increased Access to Markets), with total expected expenditures amounting to US$ 95.1 million, will support family agriculture competitiveness by working with stakeholders across local, municipal and regional levels in order to increase organizational and participation skills for project implementation through capacity-building and planning activities, and through the partial financing of investments to FAPOs (beneficiaries) to operate market-focused changes with the aim of sustainably raising productivity and value added, increasing entrepreneurship and facilitating greater market access. It will finance technical assistance and training services, workshops and exchanges, expert services, studies and demonstration/adaptation activities, goods (production inputs; farming, storage and processing equipment; computers and other logistics and communications equipment) and small civil works as part of its main activities, which will include two sub-components:

a) pre-investment activities to (i) support technical, extension and training services to create and consolidate added-value arrangements among FAPOs and other commercial stakeholders; (ii) identify potential business opportunities on the part of these value-added arrangements (i.e. preparation of a business proposal or Perfil de Negócio); (iii) fully prepare the business opportunity into a Business Plan (Plano de Negócio); and (iv) build capacity among technical service providers to enhance the quality of their services provided in support of rural competitiveness. Expert services will also be financed under the component to facilitate the preparation of viable business profiles and business plans on behalf of the added-value arrangements. The main lines of activity covered by this subcomponent include: (i) Beneficiary Organization and Support to Local Productive Arrangements and Cooperation Networks; (ii) Training of beneficiaries, technical assistance providers and local authorities; and (iii) Investment Diagnostic and Planning, and Demonstration/Adaptation Activities.

b) Productive and Added Value Investments, namely capital grants under the SoSC Rural Investments Fund, to support implementation by FAPOs of viable Business Plans.

To be eligible, a Business Plan must be financially feasible and entail a concrete value-added arrangement such as a productive alliance. Subprojects will be that portion of the productive alliance's business plan that will: (i) be financed with proceeds from the proposed Loan; (ii) be implemented by FAPOs; (iii) be governed by subproject agreements signed between the FAPOs and the State's Rural Extension Enterprise (EPAGRI); and (iv) include fixed capital (e.g., plant and equipment, minor infrastructure), working capital and technical assistance expenditures. FAPOs will be responsible for a minimum of 20% of subproject financing, through their own contributions (either in cash or in-kind). The main lines of activity include: (i) diversification and improvement of production (farming) systems; (ii) agro-processing; (iii) support to meet legal environmental and sanitary requirements for market access; (iv) marketing and logistics; and (v) off-farm (non-agricultural] investments.

Component 2) (Complementary Public Investments for Rural Competitiveness), with total expected expenditures amounting to US$81.4 million, will support the improvement of the structural rural competitiveness framework through the financing of public goods activities that are crucial for the sustained competitiveness of FAPOs endeavors. It will finance training, workshops and exchanges, expert services, studies, goods (equipment, satellite images, publications and materials), and civil works in support of the implementation of the following sectoral activities: (i) water resource management; (ii) ecosystems and corridor management; (iii) environmental monitoring and education; (iv) rural infrastructure; (v) regulatory framework compliance; (vi) rural technical assistance, extension and sanitary and phyto-sanitary services; and (vii) rural tourism.

Through these activities, the project will: (i) expand the State's efforts to strengthen the capacity for participatory, integrated, basin-scale WRM at the state (central) level and in 14 river basins (out of the state total 24 river basins), including formalization of non-agricultural and agricultural water rights, the latter incorporating specific support to SFFAs compliance with WRM legislation; (ii) implement two Ecological Corridors – Timbó and Chapecó– to support ecological corridor connectivity by supporting the creation of two areas of biodiversity conservation-friendly land use mosaics, and the development and implementation of two incentive mechanisms for payment of environmental services, environmental compliance and improved productive systems; (iii) strengthen capacity to assist small farmers and other rural entrepreneurs to comply with WRM and environmental legislation, and support implementation of the state and federal environmental education policies to promote awareness, appreciation, knowledge and stewardship of natural resources; (iv) support the State's efforts to improve rural road rehabilitation and expand communication systems infrastructure essential for sustained rural competitiveness; (v) support SFFAs in ensuring the quality and safety required for their products to access formal final markets, and regularizing their land tenure to enable creditworthiness; (vi) support state's efforts to re-structure its Agricultural Extension Services to provide quality and sufficient technical assistance and rural extension to promote sustained competitiveness of family-agriculture; and (vii) support state's efforts to provide alternative non-agricultural sources of income in rural areas.

Component 3) (Support to the Rural Competitiveness Program), with total expected expenditures amounting to US$12.6 million, will promote enhanced public administration performance in support of rural competitiveness through the implementation of a results-based management approach for the main SoSC institutions involved with the rural sector. Through this component the project will finance expert services, training, workshops, studies and goods to support: (i) Central Administration Strengthening; (ii) Results-based Management at the Project, Rural and Environmental Sector Levels; and (iii) Program Coordination, Monitoring and Evaluation.

4. MEASURING THE MITIGATION POTENTIAL OF THE PROJECT: AN APPLICATION OF EX-ACT

This section describes the effects of selected project components on GHG emissions and C sequestration, indicating the overall impact on the C balance which is an indication of the overall potential mitigation impact of the project and which has been estimated using EX-ACT. Project activities will be implemented in the whole SoSC and will target Producer Organizations active in about half (936) of the 1,683 micro watersheds into which the State is divided. The project represents therefore an interesting example of application of EX-ACT at watershed level.

4.1 Structure of the analysis

The analysis takes into account the activities to be undertaken under the Components 1 (Family Agriculture Competitiveness and Increased Access to Markets) and 2 (Complementary Public Investments for Rural Competitiveness) which may have a relevant impact on the C balance of the project either directly, by determining a change in land use and management; or indirectly, by promoting actions which may have an impact on GHG emissions (input use, livestock production, energy consumption and building activities). Specifically, the analysis takes into consideration the following activities which fall below Component 1:

- expansion of training and extension services (pre-investment activities);
- diversification and enhancement of production systems (expansion of perennial crops, promotion of improved grassland and cropland management, and livestock production);
- support to the implementation of small-scale agro-industry and to the construction of sanitary installations;
- rehabilitation of the Areas of Permanent Preservation (APP - Áreas de Preservação Permanente) and Legal Reserve (RL - Reserva Legal) through the protection of existing forests and the implementation of environmentally-sound practices that facilitate forest regeneration or rehabilitation (e.g. fencing of riparian areas, agro-forestry, planting of native species in APPs and RLs for full protection).

Also, the analysis considers some activities which will be implemented under Component 2 (such as creation of ecological corridors, and rehabilitation of degraded land – analysed in section 4.7), and under Component3 (expert services, training and workshops – considered in section 4.3 together with similar activities foreseen under Component 1).

Next sections will describe the basic assumptions of the analysis and discuss the contribution of project components and activities to overall project C balance.

4.2 Basic assumptions of the analysis

The project is happening in the State of Santa Catarina in Brazil, which is considered here as "developing" country in the South American Continent: this will affect some coefficients used in the analysis, such as dairy cattle emissions or enteric emission factors. Since the area interested by project activities is quite large, data used to describe climate patterns and soil characteristics cannot take into account the big variability of existing pedo-climatic conditions and the results of the analysis should therefore be considered only as an average for the whole area.

Average climate is considered as warm temperate with a mean annual temperature equal to 18 degrees Celsius and a moisture regime classified as moist. 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 CH_4 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 by two major soil types: Low Activity Clay (LAC) and High Activity Clay (HAC) soils, the latter being mainly present in rice systems. Since rice producers are not targeted by the project, the analysis considers that the dominant soil type for the project area is LAC soils which are highly weathered soils, dominated by 1:1 clay minerals and amorphous iron and aluminium oxides. This category includes Acrisols, Lixisols, Nitisols, Ferralsols, Durisols in the FAO-World Reference Base classification; and Ultisols, Oxisols, acidic Alfisols in the USDA classification. HAC soils are taken into consideration when performing the sensitivity analysis (see section 6).

The project will be implemented over a timeframe of six years. The analysis will therefore consider an implementation phase of six years, followed by a capitalization phase of fourteen years, which will represent a period where the benefits of the investment are still occurring and may be attributed to the changes in land use and management induced by the adoption of the project. In the analysis it is assumed that the implementation phase will happen according a linear dynamic of change, as no specific information is available about the adoption rate of the project activities among project participants. Changes in the adoption rates are simulated in the sensitivity analysis (see section 6). As concerns the Global Warming Potential (GWP) coefficients[1], the present analysis uses the same values as those adopted within the Clean Development Mechanism (CDM), i.e. 21 for CH_4 and 310 for N_2O.

4.3 Expansion of training and extension services (pre-investment activities)

This set of activities falls below project Components 1 and 3, and it is aimed at supporting technical, extension and training assistance and build capacity among technical service providers to enhance the quality of their support to rural competitiveness. The implementation of these activities is therefore expected to intensify and expand the work of the technicians (trainees and extension service staff) currently operating in the area. Its main environmental impact in terms of GHG emissions can be measured in terms of fuel consumption increase.

Overall, the project is expected to use up to 160 new cars, which would substantially increase the fuel consumption. It is assumed that each technician drives about 50 km every working day (261 days/year), with an average fuel consumption of 7L/100km. Total increase of fuel consumption would therefore amount to 146.16 m^3/year (= 3.5 l/day * 261 days/year). Current fuel consumption for extension and training activities already ongoing in the area amounts to 517 and 172.3 m^3/year of gasoline and ethanol respectively. By using the same 3:1 ratio of the two fuel types, it is expected that fuel consumption "with project" will go up to 626.62 and 208.84 m^3/year of gasoline and ethanol, respectively.

The increase in fuel consumption will increase the level of GHG emissions consequent to fuel burning: it is estimated that use of gasoline will emit 2.85 tCO_2e/m^3 (default value from IPCC) while ethanol will emit only 0.51 tCO_2e/m^3 (Dias de Oliveira 2005)[2]. Therefore, total GHG emissions from fuel consumption will increase linearly as a result of project activities as computed in the EX-ACT module called "investments" and shown in table 1.

Table 1: Released GHG associated with fuel consumption

Type of Fuel	Default value t CO2 /m3	Specific Value	Default Factor	Annual Fuel Consumption (m3/yr) Start t0	Without Project End	Without Project Rate	With Project End	With Project Rate	Emission (t CO2eq) All Period Without	Emission (t CO2eq) All Period With
Gasoil/Diesel	2.63		YES	0	0	Linear	0	Linear	0	0
Gasoline	2.85		YES	517	517	Linear	626.62	Linear	29483	34796
Ethanol		0.5165	NO	172.3	172.3	Linear	208.84	Linear	1780	2101
OPTION1 + OPTION2	**Sub-Total Without**		31262.7	**Sub-Total With**	36897.1		*Difference*	5634.4		

Source: our calculations using EX-ACT (2010)

It is worth to notice that this calculation does not take into account the emissions related to construction and transportation of the new cars. It is in fact assumed here that the process of production (and transportation) of new cars will take place independently of project activities. Also, for the sake of simplicity, the coefficient for ethanol use does

[1] 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).

[2] An alternative and slightly more optimistic value of 0.4265 tCO2eq/m3 is in Macedo et al. (2008): it represents an average of the values found for hydrous and anhydrous production of sugar-cane bio-ethanol in 2005-2006 in Brazil. Nevertheless, the adoption of this alternative coefficient will not change significantly the results.

not take into account the land-use change potentially induced by sugar-cane cropping for bio-ethanol production, although it is recognised that some studies carried out in the USA on corn bio-ethanol show that including land-use change in the calculation can significantly off-set the benefits from using bio-ethanol (Searchinger et al. 2008). For the same reasons, GHG emissions associated with fuel production and transportation are not considered here.

4.4 Diversification and enhancement of production systems

Under Component 1), the project will finance sub-projects (business plans) aimed at diversifying and improving farming systems. This will include:

a) expansion of perennial crops;

b) improved annual crop management through the adoption of improved agronomic practices, nutrient and tillage management, water management, manure application and residue management;

c) improved grassland management; and

d) improved livestock production.

a) Expansion of perennial crops

The project promotes the expansion of perennial trees (*banana, erva mate, orange, apple, palm tree, peach* and *grape*) on degraded grasslands. Overall, it is foreseen that in the "with project" scenario, 1,434 ha of degraded pastures would be converted into fruit trees. This activity is taken into account in the EX-ACT modules called "other land use change" and "perennials".

The change in land use from degraded grassland to perennials would determine a change in both biomass and soil C stock: with reference to the specific climate (warm temperate moist) and tree types, the land use change will cause an increase in biomass C stock from 1.0 to 2.1 tC/ha as a result of the land use change, corresponding to 4 tCO_2e mitigated. The biomass will also increase as a consequence of the land management. This is accounted in the module "perennials": above ground biomass growth is set using the IPCC default value of 2.1 tC/ha per year, so that total CO_2e mitigated will amount to 127.05 tCO_2e over 20 years. In fact, the module "other land use change" takes into account the calculations done by IPCC with reference to the changes in land use, while the module "perennials" considers the changes associated with the land management, helping to correct the nominal baseline according to the specific land management. Therefore, the results of the computations from the two modules should be considered as additive in this case.

The conversion from degraded land to perennials will also cause the increase in soil organic C stock from 20.8 to 63.0 tC/ha, corresponding to 7.7 tCO_2e mitigated. Perennial systems can also store C in soil: default C storage amounts to 0.7 tCO_2e/ha per year for warm moist regions.

Overall, this activity will determine a C sink of 393,687 tCO_2e, of which 194,433 tCO_2e as a consequence of land use change (5,784 from biomass C and 188,649 from soil organic C), and 199,254 tCO_2e after 20 years (182,189 from biomass C and 17,065 from soil organic C) as a consequence of the management of the land after the change in its use. This will correspond to a mitigation capacity of 13.7 t CO_2e/ha/year.

Also, the project will reverse the process of land degradation ongoing in some areas by preventing 210 ha of perennial crops (peach trees) from being abandoned and, in the end, degraded. This activity (taken into account in the EX-ACT modules named "other LUC" and "Perennial") will determine a change both in the biomass C stock (from 1 to 16.8 tC/ha) and in the soil organic C stock (from 21.7 to 63 tC/ha). The project will therefore avoid a GHG source of 41,673 tCO_2e which will represent a C sink (in terms of "avoided C source").

Overall, this set of activities will be able to mitigate a net balance of 435,360 tCO_2e over 20 years, corresponding to a mitigation potential of 13 t CO_2e/ha/year. A summary of the mitigation impact of this project activity is given in table 2.

Table 2: C balance associated with expansion of perennial crops

As a consequence of land use change

Vegetation Type	Biomass Change		Soil Change		Fire		Total Balance		Difference
	Without tCO2	With tCO2	Without tCO2	With tCO2	Without tCO2	With tCO2	Without tCO2	With tCO2	tCO2
Conservation of 210 ha of perennial crops (peach trees)	12166	0	27008	0	0	0	39174	0	**-39174**
Conversion of 1,434 ha of degraded pastures to perennial crop	0	-5784	0	-188649	0	0	0	-194433	**-194433**

As a consequence of the management of the land after the change in its use

With Project		CO_2 mitigated from Biomass		CO_2 mitigated from Soil		CO_2eq emitted from Burni		**Total Balance**		**Difference**
End	Rate	Without	With	Without	With	Without	With	Without tCO_2	With tCO_2	tCO2eq
0	Linear	0	0	0	0	0	0	0	0	**0**
0	Linear	0	0	0	0	0	0	0	0	**0**
1434	Linear	0	-182189,7	0	-17065	0	0	0	-199254	**-199254**

Source: our calculations using EX-ACT (2010)

b) Improved annual crop management

The project will have the effect to increase the adoption of sustainable land management (SLM) practices such as: improved agronomic practices (using improved crop varieties, extending crop rotations particularly with legumes crops); nutrient management (improving the efficiency of fertilizer applications); tillage management (from minimum tillage to no-tillage); water management (enhancing irrigation practices); manure application and residue management.

It is worth to notice that the project will not directly purchase agro-chemicals and that it will promote the adoption of sustainable agronomic practices in a holistic manner. Many of these improved practices may increase crop yields and thus generate higher residues with positive effects in terms of mitigation (because of increased C biomass and soil C stocks). Increasing available water in the root zone through water management can enhance biomass production, increase the amount of above-ground and root biomass returned to the soil, and improve soil organic C concentration. Some practices may also lead to reduction in N_2O and C sources. For example, integrated nutrient management can reduce emissions on-site by reducing leaching and volatile losses, improving N use efficiency through precision farming and improved fertilizer application timing (FAO 2009).

Interested crops are: beans, millet, soybeans, tomatoes, onion, rice, potato, and cassava. It is assumed that most farmers are already adopting SLM practices (90% of cropland) and that the implementation of project activities will expand the area managed sustainably, so that in the "with project" scenario 100% of annual cropland will be managed using SLM practices. This is shown in table 3.

Table 3: Cropland area under SLM (ha)

	Without project	With project
Beans	32,429	36,032
Millet	21,637	24,041
Soybeans	111,505	123,894
Tomatoes	24,944	27,715
Onion	5,856	6,507
Rice (rainfed)	46,280	51,422
Potato	2,624	2,915
Cassava	7,848	8,720
Total	253,121	281,246

Source: project data

The EX-ACT module "Annual" computes the mitigation potential of this set of activities in terms of soil C change for a 20-years time horizon using only CO_2 emissions factors for the relevant climate (warm moist) (table 4).

Table 4: Annual mitigation potential of selected SLM practices used in EX-ACT

Management Category	Annual mitigation potential using only CO_2 effect (tCO_2e/ha/year)
Improved agronomic practices	0.88
Nutrient management	0.55
Tillage/residue management	0.7
Water management	1.14
Manure application	2.79

Source: Bernoux et al. 2010b

Final emission factors reported by Smith et al. (2007) are higher because they also consider non-CO_2 emissions (i.e. emissions from other GHG). For example, it is estimated that improved agronomic practices are able to store 0.98 tCO_2e/ha/year instead of 0.88 as used in EX-ACT. Nevertheless, a conservative approach is used here: only the mitigation effect related to CO_2 emissions are taken into account; also, EX-ACT assumes that when different land management practices are applied simultaneously on the same land, the final effect will be determined by the practice with the highest mitigation potential, i.e. the model will pick the highest coefficient instead of adding up the single coefficients corresponding to each practice (Bernoux et al. 2010b). This precautionary option will also prevent the model from overestimating the impact of SLM techniques which require the simultaneous adoption of different agricultural practices such as, for example, Conservation Agriculture (CA)[3].

Total mitigation impact of the adoption of improved cropland practices is equal to 545,055 tCO_2e over 20 years (table 5). Given an area of 281,246 ha, the annual mitigation potential of these activities is equal to 0.1 tCO_2e/ha.

Table 5: C balance associated with improved annual crop management

Vegetation Type	Areas					Soil CO2 mitigated		CO2eq emitted from Burning		Total Balance	
	Start	Without project		With Project		Without	With	Without	With	Without	With
	t0	End	Rate	End	Rate					tCO2	tCO2
System A1	0	0	Linear	0	Linear	0	0	0	0	0	0
System A2	1250	1250	Linear	0	Linear	0	0	0	0	0	0
System A3	0	0	Linear	8718	Linear	0	0	0	0	0	0
System A4	3033	3033	Linear	0	Linear	0	0	0	0	0	0
Beans SLM	32429	32429	*Linear*	36032	*Linear*	0	-69830	0	0	0	-69830
Beans conventional	3603	3603	*Linear*	0	*Linear*	0	0	0	0	0	0
Millet SLM	21637	21637	*Linear*	24041	*Linear*	0	-46591	0	0	0	-46591
Millet conventional	2404	2404	*Linear*	0	*Linear*	0	0	0	0	0	0
Soybeans SLM	111505	111505	*Linear*	123894	*Linear*	0	-240107	0	0	0	-240107
Soybeans conventional	12389	12389	*Linear*	0	*Linear*	0	0	0	0	0	0
Tomatoes SLM	24944	24944	*Linear*	27715	*Linear*	0	-53712	0	0	0	-53712
Tomatoes conventional	2772	2772	*Linear*	0	*Linear*	0	0	0	0	0	0
Onion SLM	5856	5856	*Linear*	6507	*Linear*	0	-12611	0	0	0	-12611
Onion conventional	651	651	*Linear*	0	*Linear*	0	0	0	0	0	0
Rainfed rice SLM	46280	46280	*Linear*	51422	*Linear*	0	-99656	0	0	0	-99656
Rainfed rice conventional	5142	5142	*Linear*	0	*Linear*	0	0	0	0	0	0
Potato SLM	2624	2624	*Linear*	2915	*Linear*	0	-5649	0	0	0	-5649
Potato conventional	292	292	*Linear*	0	*Linear*	0	0	0	0	0	0
Cassava SLM	7848	7848	*Linear*	8720	*Linear*	0	-16899	0	0	0	-16899
Cassava conventional	872	872	*Linear*	*0*	*Linear*	0	0	0	0	0	0
Total	281246	281246		281246		**Agric. Annual Total**				**0**	**-545055**

Source: our calculations using EX-ACT (2010)

Irrigated rice is also grown in project area. EX-ACT module "Rice" can compute the quantity of CH_4 emissions from this type of cultivation, together with (eventually) CO_2 emissions associated with residue management. However, in the case of this specific project, no change in management or in the extension of land cropped is foreseen, and no impact on the C balance is registered.

The model will also compute the changes in input (agro-chemicals) use corresponding to the changes in annual crop management. This is taken into account in the EX-ACT module "inputs". The results show that in the "with project" scenario, there will be an increase in the GHG emissions of 2,248,159 tCO_2e over 20 years. These include: CO_2 emissions from lime and urea application (10% of the total), N_2O emissions from N application on managed soils[4] (17%), and CO_2e emissions from production, transportation, and storage of agricultural chemicals which contribute most (73%) to total emissions from agro-chemicals (which should be considered as normal given the high energy requirements for the production, extraction and transportation process).

This is the effect of the increase in input use as a result of the increased cropland area (+ 8,718 ha) foreseen with project activities, although the implementation of SLM

[3] The adoption of Conservation agriculture (CA) requires the application of the three CA principles: minimal soil disturbance, permanent soil cover and crop rotations. CA is a way to combine profitable agricultural production with environmental concerns and sustainability and it holds tremendous potential in a variety of agro ecological zones and farming systems but it requires the simultaneous adoption of the three principles outlined above. CA is currently receiving global focus for its C sequestration potential and the significance of CA adoption to the amelioration of effects of GHG emissions on global climate change is now being evaluated, although no specific GHG coefficients for CA are available yet.

[4] These exclude manure application which is taken into accounted in the Livestock module.

practices is expected to increase the efficiency of the input use and cause, on average, a reduction of the use of agro-chemicals on a per hectare base.

c) Improved grassland management

The project supports the development and adoption of improved grassland management practices such as pasture rotations and forage production as an alternative to grazing. Overall, area interested will be 138,152 ha (95,504 ha of natural grasslands + 42,648 ha of planted grasslands in good conditions).

The fourth IPCC assessment report indicates that improved grazing land management has the second highest technical potential for mitigating C emissions from agricultural management changes (IPCC 2007). Many of the changes needed to sequester C through improved grassland management are also associated with improved rangeland productivity and rural incomes (Lipper et al. 2010). In case of degraded grasslands, land rehabilitation might include a combination of cultivation abandonment, controlled grazing, erosion control, soil fertility improvement, plant introduction and seed dispersal, and reforestation, depending on the degree of severity of degradation (Woomer et al. 2004).

This is taken into account in the EX-ACT module called “grasslands”. It is considered that in the “with project” scenario, the management of the area under consideration will change from “non degraded” to “improved without inputs management” category, without any use of fire. This will imply an increase in C stock from 63 to 71.82 t C/ha. On the contrary, it is assumed that non change in management will occur in the “without project” scenario and that the land will remain “non degraded”[5]. Overall, the adoption of improved grassland management practices on the 138,152 ha will create a C sink of 3,797,660 tCO_2e over 20 years. The module takes also into account the impact on the C balance of the management of land converted to grasslands from other uses (as a result of other project activities), so that total mitigation potential of grasslands will climb to 3,845,599 tCO_2e over 20 years (table 6).

Table 6: C balance associated with improved grassland management

	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
from Deforestation	1810	*Linear*	933	*Linear*	0	0	1451	0	1451	0	**-1451**
converted to A/R	625	*Linear*	0	*Linear*	0	6136	589	0	589	6136	**5547**
From OLUC	0	*Linear*	0	*Linear*	0	0	0	0	0	0	**0**
Converted to OLUC	55178	*Linear*	0	*Linear*	0	0	52035	0	52035	0	**-52035**
Natural grassland with prj	0	Linear	95504	Linear	0	-2625309	0	0	0	-2625309	**-2625309**
Natural grassland without prj	95504	Linear	0	Linear	0	0	0	0	0	0	**0**
Planted grass good cond with prj	0	Linear	42648	Linear	0	-1172351	0	0	0	-1172351	**-1172351**
Planted grass good cond without prj	42648	Linear	0	Linear	0	0	0	0	0	0	**0**
Total	138152		138152								
							Grassland total		54075.0	-3791524.4	**-3845599**

Source: our calculations using EX-ACT (2010)

d) Improved livestock production

The project will determine a change in livestock population as shown in table 7.

[5] This is of course a very conservative hypothesis, as it is likely that in the “without project” scenario, grassland will be degraded if not properly managed, thus becoming a source of GHG emissions.

Table 7: Impact of project activities on livestock population (number of heads)

	Start	Without Project		With Project	
	t0	End	Rate	End	Rate
Dairy cattle	160523	128419	*Linear*	144471	*Linear*
Other cattle	639776	640000	*Linear*	640000	*Linear*
Buffalo	0	0	*Linear*	0	*Linear*
Sheep	25902	28490	*Immediate*	29787	*Immediate*
Swine (Market)	1570337	1570337	*Linear*	1570337	*Linear*
Swine (Breeding)	0	0	*Linear*	0	*Linear*
Horses	14724	14000	*Linear*	14000	*Linear*
Poultry	56190050	76418468	*Linear*	76418468	*Linear*
Camels	*0*	*0*	*Linear*	*0*	*Linear*

Source: project data

EX-ACT can estimate CH_4 emissions from enteric fermentation and manure management, as well as Nitrous Oxide (N_2O) emissions from manure management. CH_4 emissions from manure management are those produced during storage and treatment of manure as well as from manure deposited on pasture, while N_2O 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 8 together with the N excretion rates adopted to compute N_2O 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 8: IPCC default values for methane emissions from enteric fermentation and manure management in S. America used in EX-ACT

	CH4 from enteric fermentation	CH4 from manure management	N excretion rate
	(Kg CH_4/head/year)	(Kg CH_4/head/year)	(Kg N/t animal mass/day)
Dairy cattle	63.00	1.00	0.48
Other cattle	56.00	1.00	0.36
Sheep	5.00	0.15	1.17
Swine (Market)	1.50	1.00	1.64
Horses	18.00	1.64	0.46
Poultry	0.00	0.02	0.82

Source: Bernoux et al. 2010b

The project is also implementing specific feeding practices for cattle and sheep, together with improved breeding management, which may contribute to reduce GHG emissions. Smith et al. (2007) showed that use of higher level of concentrates may increase CH_4

emissions per animal, but also increase productivity (meat and milk), thus resulting in an overall reduction of CH_4 emissions per unit of product (table 9).

Table 9: Reduction of CH_4 emissions consequent to the adoption of additional technical practices in S. America used in EX-ACT

	Feeding practices	Specific dietary agents	Management breeding
	(% reduction CH_4 emissions)		
Dairy cattle	6.0	3.0	2.0
Other cattle	3.0	2.0	3.0
Sheep	2.0	0.1	0.2

Source: Bernoux et al. 2010b

It is estimated that the project will have an additional technical mitigation potential consequent to the adoption of such practices as shown in table 10.

Table 10: Adoption of additional technical practices in livestock production in the "with" and "without project" scenarios

	a) Feeding practices		*b) Management breeding*	
	Without project	With project	Without project	With project
	(% of population with practices)		(% of population with practices)	
Dairy cattle	30	50	20	40
Other cattle	5	15	20	40
Sheep	5	15	20	40

Source: project data

The EX-ACT module called “livestock” computed all GHG emissions (CH_4 from enteric fermentation and manure management, N_2O from manure management) corresponding to livestock population in both “with” and “without project” scenarios, taking also into account the mitigation effect (GHG reduction) consequent to the implementation of improved feeding practices and management breeding. Overall, this set of project activities represents a net C source 288,993 tCO_2e over 20 years) (table 11).

Table 11 Released GHG associated with livestock production

Methane emissions from enteric fermentation

Choose Livestocks:	IPCC factor	Specific factor	Default Factor	Head Number: Start t0	Head Number: Without Project End	Head Number: Without Project Rate	Head Number: With Project End	Head Number: With Project Rate	Emission (t CO2eq) per year: Start	Emission per year: End Without	Emission per year: End With	Total Emission (tCO2eq) All Period: Without	Total Emission (tCO2eq) All Period: With
Dairy cattle	63		YES	160523	128419	*Linear*	144471	*Linear*	212372	169898	191135	3525388	3886413
Other cattle	56		YES	639776	640000	*Linear*	640000	*Linear*	752377	752640	752640	15052010	15052010
Buffalo	55		YES	0	0	*Linear*	0	*Linear*	0	0	0	0	0
Sheep	5		YES	25902	28490	*Immediate*	29787	*Immediate*	2720	2991	3128	59829	62553
Swine (Market)	1,5		YES	1570337	1570337	*Linear*	1570337	*Linear*	49466	49466	49466	989312	989312
Swine (Breeding)	1,5		YES	0	0	*Linear*	0	*Linear*	0	0	0	0	0
Horses	18		YES	14724	14000	*Linear*	14000	*Linear*	5566	5292	5292	106661	106661
Poultry	0		YES	56190050	76418468	*Linear*	76418468	*Linear*	0	0	0	0	0

Methane emissions from manure management

Livestocks:	IPCC factor	Specific factor	Default Factor	Head Number: Start t0	Head Number: Without Project End	Head Number: Without Project Rate	Head Number: With Project End	Head Number: With Project Rate	Emission (t CO2eq) per year: Start	Emission per year: End Without	Emission per year: End With	Total Emission (tCO2eq) All Period: Without	Total Emission (tCO2eq) All Period: With
Dairy cattle	1		YES	160523	128419	Linear	144471	Linear	3371	2697	3034	55959	61689
Other cattle	1		YES	639776	640000	Linear	640000	Linear	13435	13440	13440	268786	268786
Buffalo	1		YES	0	0	Linear	0	Linear	0	0	0	0	0
Sheep	0,15		YES	25902	28490	Immediate	29787	Immediate	82	90	94	1795	1877
Swine (Market)	1		YES	1570337	1570337	Linear	1570337	Linear	32977	32977	32977	659542	659542
Swine (Breeding)	1		YES	0	0	Linear	0	Linear	0	0	0	0	0
Horses	1,64		YES	14724	14000	Linear	14000	Linear	507	482	482	9718	9718
Poultry	0,02		YES	56190050	76418468	Linear	76418468	Linear	23600	32096	32096	616427	616427

Nitrous Oxide emissions from manure management

Livestocks:	IPCC factor	Specific factor	Default Factor	Annual amount of N manure* (t N per year): Start t0	Annual amount of N manure*: Without Project End	Annual amount of N manure*: Without Project Rate	Annual amount of N manure*: With Project End	Annual amount of N manure*: With Project Rate	Emission (t CO2eq) per year: Start	Emission per year: End Without	Emission per year: End With	Total Emission (tCO2eq) All Period: Without	Total Emission (tCO2eq) All Period: With
Dairy cattle	0,01		YES	11249,5	8999,6	Linear	10124,5	Linear	54801	43841	49321	909698	1002858
Other cattle	0,01		YES	25640,3	25649,3	Linear	25649,3	Linear	124905	124949	124949	2498842	2498842
Buffalo	0,01		YES	0,0	0,0	Linear	0,0	Linear	0	0	0	0	0
Sheep	0,01		YES	309,7	340,7	Immediate	356,2	Immediate	1509	1660	1735	33191	34702
Swine (Market)	0,01		YES	26320,1	26320,1	Linear	26320,1	Linear	128217	128217	128217	2564330	2564330
Swine (Breeding)	0,01		YES	0,0	0,0	Linear	0,0	Linear	0	0	0	0	0
Horses	0,01		YES	588,4	559,4	Linear	559,4	Linear	2866	2725	2725	54929	54929
Poultry	0,01		YES	16817,7	22872,0	Linear	22872,0	Linear	81926	111420	111420	2139911	2139911

Additional Technical Mitigation

Livestocks	Dominant Practice*	Factor	Percent of head with practices (0% =none;100%=all): Start t0	Percent of head: Without Project End	Percent of head: Without Project Rate	Percent of head: With Project End	Percent of head: With Project Rate	Emission (t CO2eq) per year: Start	Emission per year: End Without	Emission per year: End With	Total Emission (tCO2eq) All Period: Without	Total Emission (tCO2eq) All Period: With
Dairy cattle	Feeding practices	0,060	30%	30%	Linear	50%	Linear	-3823	-3058	-5734	-63457	-108947
	Specific Agents	0,030	0%	0%	Linear	0%	Linear	0	0	0	0	0
	Management-Breed	0,020	20%	20%	Linear	40%	Linear	-849	-680	-1529	-14102	-28543
	No Option	0,000	50%	50%	Linear	10%	Linear	0	0	0	0	0
Other cattle	Feeding practices	0,030	5%	5%	Linear	15%	Linear	-1129	-1129	-3387	-22578	-60963
	Specific Agents	0,020	0%	0%	Linear	0%	Linear	0	0	0	0	0
	Management-Breed	0,030	20%	20%	Linear	40%	Linear	-4514	-4516	-9032	-90312	-167081
	No Option	0,000	75%	75%	Linear	45%	Linear	0	0	0	0	0

Total Emission (tCO2eq)	Without	With	Difference
Total "Livestocks"	**29355793**	**29644786**	**288993**

Source: our calculations using EX-ACT (2010)

4.5 Support to the implementation of small-scale agro-industry and to the construction of sanitary installation

The project will promote value added investments which could help farmers on increasing their competitiveness. This would include mainly the support to the development of on-farm agro-processing activities and the construction of sanitary installations needed to meet the sanitary requirements for market access. It is important to specify that the present analysis is conducted at farm-gate level and not at value-chain level: therefore only on-farm activities will be taken into consideration here.

The development of agro-processing on-farm activities and the installation of sanitary equipments will have an environmental impact by increasing GHG emissions associated with electricity consumption and infrastructure building. It is in fact expected that over the whole project duration the total on-farm consumption of electricity will increase from 5,000 to 25,000 MWh; and total building area will be expanded from 18,700 to 80,000 square meters of industrial buildings (concrete) and from 3,300 to 15,000 square meters of garage construction (concrete).

The computation of GHG emissions associated with electricity consumption considers the annual consumption at the beginning of the project and at the end of the implementation phase. Default GHG emissions factors used in the model come from the Electricity Information Database provided by the International Energy Agency (IEA) and reported by the US Department of Energy. They correspond to the average values for the 1999-2002 period and vary depending on the origin of the electricity consumed:

the coefficient used for Brazil is 0.093 tCO_2e/MWh. A default addition of 10% is also accounted for the losses occurring during electricity transportation.

GHG emissions associated with construction activities are computed using default values from the tool developed by the Agence de l'Environnement et de la Maîtrise de l'Energie (ADEME), i.e. 0.82 and 0.65 tCO_2e/m^2 of industrial building (concrete) and garage (concrete), respectively.

Results of the EX-ACT analysis show that overall this set of project activities will represent a source of GHG emissions of 60,290 tCO_2e over 20 years, of which 2,042.5 from electricity consumption and 58,248 tCO_2e from building construction (table 12).

Table 12: C balance associated with electricity consumption and construction activities

Total Electricity Consumption (MWh)			Origin of Electricity	Associated tCO2eq
Without Project	5000		Brazil	2372,4
With Project	25000		Brazil	11862,0
Type of construction	**surface (m2)**		**Emission (t CO2eq)**	
	Without	With	Without	With
Housing (concrete)			0.0	0.0
Agricultural Buildings (metal)			0.0	0.0
Industrial Buildings (concrete)	18700	80000	15427.5	66000.0
Garage (concrete)	3300	15000	2164.8	9840.0
Offices (concrete)			0.0	0.0

Source: our calculations using EX-ACT (2010)

4.6 Improved/legalized production systems

Under this set of activities, sub-project beneficiaries will be asked to fully protect existing forests and implement environmentally-sound practices that facilitate forest regeneration or rehabilitation, including:

a) fencing of riparian areas through forest regeneration_and planting of native species in so-called Areas of Permanenent Preservation (APP - *Áreas de Preservação Permanente*) and Legal Reserve (RL - *Reserva* Legal); and

b) expanding agro-forestry systems.

The project will also promote sustainable forest management in degraded RLs and APPs through the introduction of native species or a mixed system of native and exotic species of fruits, trees and ornamental plants. Nevertheless, the environmental impact on GHG emissions and C sequestration of this type of activities cannot be analysed using EX-ACT, therefore they are not considered here.

a) Fencing of riparian areas through forest regeneration and planting of native species in APPs and RLs

The project will promote the implementation of activities aimed at regenerating the forest cover in sensitive areas as established by the federal legislation. It is estimated that under project activities 625 ha of degraded land, 625 ha of grasslands and 1,250 ha of annual cropland will be covered by regenerated subtropical humid forest. This is considered in the EX-ACT module named "afforestation/reforestation" as shown in table 13.

It is assumed that the forest cover will be regenerated through naturally re-growing stands with reduced or minimum human intervention (extensively managed forest). Given the climatic conditions of project area, the vegetation type has been classified as natural (subtropical humid) forest. This affects the growth rate of trees and the process of biomass gains and losses: for less than 20 years old natural forests, it is estimated that above ground biomass is equal to 7 tons of dry matter per ha and per year (t dm/ha/year), and the below ground biomass is equal to 1.4 t dm/ha/year. Default value for litter (17.5 t C/ha) is based on the average between values for broadleaf deciduous and leaf deciduous forests, while soil C estimates are based on default references for soil organic C in mineral soils at a 30 cm depth (Bernoux et al. 2010b). There are no estimates available for dead wood C stocks; therefore the corresponding value is set equal to 0. The model takes also into account the loss in biomass C stock related to land conversion. In the specific case, it is estimated that the biomass C stock for annual is equal to 5 t C/ha, and for degraded land amounts to 1 t C/ha. In both cases, there will be no use of fire.

Overall, this set of activities is able to sequester 896,371 t CO_2e, i.e. 17.9 t CO_2e/ha/year (table 13).

Table 13: Fencing of riparian areas through forest regeneration and planting of native species in APPs and RLs

Afforested or reforested Area (ha)					Biomass Gain		Biomass Loss		Soil		Fire		Total Balance	
Start	Without Project		With Project		Without	With	Without	With	Without	With	Without	With	Without	With
t0	End	Rate	End	Rate	tCO2	tCO2	tCO2	tCO2	tCO2	tCO2	tCO2	tCO2	tCO2	tCO2
0	0	*Linear*	625	*Linear*	0	-193912	0	2292	0	-82222	0	0	0	-273842
0	0	*Linear*	1250	*Linear*	0	-387823	0	22917	0	-76086	0	0	0	-440992
0	0	*Linear*	625	*Linear*	0	-193912	0	12375	0	0	0	0	0	-181537

	Without	With	Difference
Deforestation Total	**0**	**-896371**	**-896371**

Source: our calculations using EX-ACT (2010)

b) Expanding agro–forestry systems

The project will promote the expansion of agro-forestry systems, with a different level of cropping intensity and biological complexity depending on the ecological conditions of project area. The project will promote the integration between woody perennials with crops, shrubs, and/or animals on the same land management unit, with a consequent change in land use (table 14).

Table 14: Expansion of agro-forestry systems in project area

Previous land use	Ha
Degraded land	533
Degraded grassland	7,538
Area under reforestation	8,718
Annual cropland	3,033
Natural grassland	37,042
Non degraded planted grassland	18,136
Total	75,000

Source: project data

The expansion of agro-forestry activities will cause a change in both biomass and soil C stock and is taken into account in the EX-ACT modules “other land use change” and “perennials”. It should be specified that currently no default values for agro-forestry systems are available from IPCC. Therefore, the analysis has adopted default values for perennial crops, although in some cases a conservative approach is followed, by considering a smaller area in order not to overestimate the mitigation potential. The mitigation effect of the expansion of agro-forestry depends on the land quality of the area interested by expansion.

The expansion of agro-forestry activities on degraded land (533 + 7,538 ha) is assimilated to the expansion of perennial trees on degraded grasslands. EX-ACT has estimated that this activity will determine a C sink of 2,215,795 tCO_2e over 20 years, i.e. 13,7 tCO_2e/ha per year.

Similarly, the expansion of agro-forestry on annual cropland (3,033 ha) will determine an increase in soil organic C (184,614 tCO_2e) and an increase in biomass C (421,435 tCO_2e) after a small decrease on the first year as a result of the land use change (32,250 tCO_2e). The net effect is a C sink of 573,798 tCO_2e over 20 years, i.e. 9.4 tCO_2e/ha per year.

On the contrary, it is assumed that the expansion of agro-forestry on area under reforestation (8,718 ha) will cause a reduction in the biomass C as a consequence of the decreased tree intensity and a reduction in soil organic C content as a consequence of the change in land use. The effect will be a net source of 1,011,594 tCO_2e over 20 years, i.e. 2.1 tCO_2e/ha per year.

Last, the expansion of agro-forestry systems on grassland (37,042 + 18,136 ha) will represent a source of GHG emissions (667,654 tCO_2e) due to the loss in biomass C as a consequence of the change in land use, while it is assumed that there will be no change in soil organic C. Nonetheless, as a consequence of land management over the first year and in subsequent years, the system will accumulate biomass C so that the net effect will be a sink of 7.05 $MtCO_2e$ over 20 years, i.e. 6.4 tCO_2e/ha per year.

Overall, this set of activities will create a net C sink of 8,829,363tCO_2e over 20 years (table 15), corresponding to a net C sequestration capacity of 5.9 tCO_2e/ha per year.

Table 15: C-balance associated with the expansion of agro forestry systems

Previous land use	tCO_2e
Degraded land (including degraded grasslands)	-2,215,795
Area under reforestation	1,011,594
Annual cropland	-573,798
Grassland (natural and non degraded planted)	-7,051,364
Total	-8,829,363

Source: our calculations using EX-ACT (2010)

4.7 Ecological corridors and land rehabilitation

This set of activities, which falls under Component 2, will implement two ecological corridors by creating two areas of biodiversity conservation-friendly land use mosaics established on private lands, supporting ecological corridor connectivity in project watersheds; and will promote the rehabilitation, preservation or improvement of degraded land in order to obtain certification and/or to comply with environmental legislation[6].

The implementation of these activities will be mainly based on the valorisation of environmental assets (preserved forests) through the commercialisation of "Conservation credits". This is expected to determine a 50% reduction in the deforestation rate, with environmental benefits in terms of reduced emissions from deforestation. It is in fact estimated that the area deforested will decrease from 1,810 ha in the "without project" scenario, to only 933 ha as a result of project implementation.

In both "with" and "without project" scenarios it is assumed that no fire will be used to clear the forest, and that the area deforested will be used as natural pasture (grasslands). The level of Harvested Wood Product (HWP) would be equal to 100 t dm/ha. The amount of C exported is determined using the default C content of 0.47. It should be noted that the amount of C in HWP is not included in sources nor sinks in the final C balance as some HWP will act as sinks (e.g. wood used in construction) and other as sources (e.g. wood used for charcoal production, if not used as fuel source): therefore the final figure will not change significantly[7].

Given that the area deforested is covered by natural subtropical humid forest, it is estimated that the biomass loss caused by deforestation would be equal to 362 tCO_2e/ha. Therefore, total biomass loss would amount to 337,707 tCO_2e with the project (933 ha deforested), as opposed to 655,145 tCO_2e without the project (1,810 ha deforested). This is considered in the module "deforestation". In the same module, EX-ACT is also taking into account the biomass of the vegetation cover following deforestation. Specifically, since grasslands biomass contains 6.3 t C, it is estimated that the system will "gain" 21,706 t CO_2e in the "with project" scenario, and 42,110 t CO_2e in the "without project" one.

As a result, total C balance is equal to 613,036 tCO_2e ("without project") and 316,001 tCO_2e ("with project"), therefore the impact of this set of project activities would represent a C sink of 297,034 tCO_2e (table 16).

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[6] The federal legislation on APP and RL mandates that agricultural properties in Brazil maintain forest cover in sensitive areas (riversides, high slopes) as well as in 20% of the property's total area located in the biome Atlantic Forest, which is the case of State of Santa Catarina, originally fully covered by this biome's vegetation. The project will promote the adoption of a system to promote the commercialization of "Conservation Credits" associated with the valorisation of environmental assets (preserved forests) mainly focused on farmers who are willing to "sell" their excess/extra forest (> 20% of farm land) as a "conservation credit" (hence, receiving a payment), instead of increasing their productive area. In fact, the legislation allows this "purchase" of credit – called servidão florestal - if the two farms are within the same river basin and the same biome, in this case Atlantic Forest.

[7] It should also be added that this is a complicated issue object of the ongoing negotiation on deciding if including (or not) HWP estimates in national inventories (Bernoux et al. 2010b).

Table 16: C balance associated with establishing ecological corridors and rehabilitating land

Area deforested (ha		Biomass loss		Biomass gain (1yr a		Soil		Fire		Total Balance	
Without	With	Without tCO2	With tCO2	Without tCO2	With tCO2	Without tCO2	With tCO2	Without tCO2	With tCO2	Without tCO2	With tCO2
1810	933	655145	337707	-42110	-21706	0	0	0	0	613036	31600

Source: our calculations using EX-ACT (2010)

Also, the module "grasslands" takes into account the mitigation effect associated with the use of fire in grasslands management: since the project will reduce the land which will be deforested and transformed into grasslands, it will be able to mitigate 1,451 tCO_2e over 20 years.

5. EX-ACT RESULTS

The overall C balance of the project is computed as the difference between C sinks and sources over 20 years (6 years of implementation phase and 14 years of capitalization phase). The project is in fact able to sequester 14.9 $MtCO_2e$ while emitting "only" 2.7 $MtCO_2e$ so that the net effect of project activities is to create a sink of 12.2 $MtCO_2e$ (table 17). Since total project area amounts to 661 thousands ha, the average mitigation potential of the project is equal to 0.92 tCO_2e/ha per year.

Table 17: C-balance of the SC Rural project

C-balance elements	Mt	EX-ACT modules
Total GHG mitigated	-14.9	Avoided deforestation, afforestation, cropland management, agro-forestry, grasslands
Total GHG emitted	2.7	Other land use change, livestock, inputs, other investments
C-balance	-12.2	Project is a C sink

Source: our calculations using EX-ACT (2010)

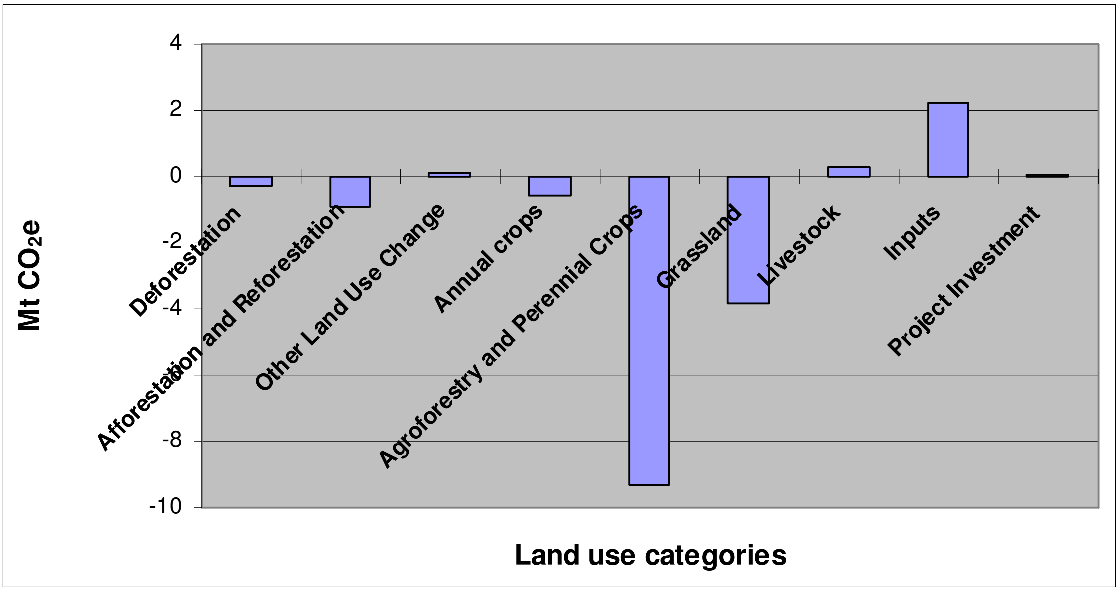
Table 18 and figure 1 show the mitigation potential of the project by category of land use change (corresponding to the EX-ACT modules).

Table 18: Mitigation potential of the SC Rural project, by EX-ACT module

EX-ACT modules	Mt	% of total GHG mitigated	% of total GHG emitted
Deforestation	-0,3	2,0	-
Afforestation and Reforestation	-0,9	6,0	-
Annual crops	-0,5	3,7	-
Agroforestry/Perennial Crops	-9,3	62,5	-
Grassland	-3,8	25,8	-
Total GHG mitigated	-14,9	-	-
Livestock	0,3	-	10,7
Inputs	2,2	-	83,3
Project Investment	0,1	-	2,4
Other Land Use Change	0,1	-	3,5
Total GHG emitted	2,7	-	-
C-balance	-12.2	-	-

Source: our calculations using EX-ACT (2010)

Figure 1: Mitigation potential of the Santa Catarina Rural Competitiveness Project, by EX-ACT module



Source: our calculations using EX-ACT (2010)

Most mitigation potential of project activities is related to the expansion of agro-forestry and perennial crops (62.5%) and to grasslands (25.8%).

The relevant mitigation potential of the expansion of agro-forestry systems very much depends on the size of the area interested by the change as shown in the land use matrix developed for the two scenarios “without” and “with” projects (figure 2). The matrix shows clearly that the project is determining a significant increase of the area under perennial crops from 41,629 ha to 100,837 ha (+ 141%) essentially as a result of the expansion of agro-forestry systems.

On the contrary, the mitigation potential of grasslands is essentially related to the specific management practices implemented on the grasslands area (pasture rotations and forage production) more than on the size of the area which in fact decreases by 29% with respect to the initial status (before project begins). It is also interesting to notice that most of the grasslands is changing land destination towards improved use such as agro-forestry and forest land.

Last, an important contribution comes also from the rehabilitation of 10,130 ha of degraded land converted to perennial crops, agro-forestry and forest regeneration/plantation.

Figure 2: Land use matrix of the Santa Catarina Rural Competitiveness Project

Without Project			FINAL							
			Forest/ Plantation	**Cropland**			**Grassland**	**Other Land**		
				Annual	Perennial	Rice		Degraded	Other	Total Initial
INITIAL	**Forest/Plantation**		76316	0	0	0	1810	0	0	78126
	Cropland	Annual	0	285529	0	0	0	0	0	285529
		Perennial	0	0	41629	0	0	210	0	41839
		Rice	0	0	0	51422	0	0	0	51422
	Grassland		0	0	0	0	193955	0	0	193955
	Other Land	Degraded	0	0	0	0	0	10130	0	10130
		Other	0	0	0	0	0	0	0	0
		Total Final	76316	285529	41629	51422	195765	10340	0	661001

With Project			FINAL							
			Forest/ Plantation	**Cropland**			**Grassland**	**Other Land**		
				Annual	Perennial	Rice		Degraded	Other	Total Initial
INITIAL	**Forest/Plantation**		77193	0	0	0	933	0	0	78126
	Cropland	Annual	1250	281246	3033	0	0	0	0	285529
		Perennial	0	8718	33121	0	0	0	0	41839
		Rice	0	0	0	51422	0	0	0	51422
	Grassland		625	0	55178	0	138152	0	0	193955
	Other Land	Degraded	625	0	9505	0	0	0	0	10130
		Other	0	0	0	0	0	0	0	0
		Total Final	79693	289964	100837	51422	139085	0	0	661001

Source: our calculations using EX-ACT (2010)

By examining the mitigation potential by project activity (table 19), it is possible to note that among the activities which represent a net GHG source, cropland management contributes most with almost 83% of emissions - essentially as a result of the increased use of inputs - followed by livestock production. On the other side, consistently with the changes in land use discussed above, most mitigation potential comes from the expansion of agro forestry systems (61.7%) and from improved grassland management (26.9%).

Table 19: Mitigation potential of the SC Rural project, by project activity

Project activities	Mt	% of total GHG mitigated	% of total GHG emitted
Expansion of training and extension services (pre-investment activities)	0.01	-	0.3
Improved annual crop management	1.7	-	82.8
Improved livestock production	0.3	-	14.0
Support to the implementation of small-scale agro-industry and to the construction of sanitary installation	0.1	-	2.9
Total GHG emitted	2.1	-	100.0
Improved grassland management	-3.8	26.9	-
Expansion of perennial crops	-0.4	3.0	-
Fencing of riparian areas	-0.9	6.3	-
Expanding agro-forestry systems	-8.8	61.7	-
Ecological corridors and land rehabilitation	-0.3	2.1	-
Total GHG mitigated	-14.3	100.0	-
Total C-balance	-12.2	-	-

Source: our calculations using EX-ACT (2010)

6. SENSITIVITY ANALYSIS

6.1 Main parameter sensitivity

A parameter sensitivity analysis has been carried out in order to determine how EX-ACT is "sensitive" to changes in the value of the parameters. By showing how the model results respond to changes in the values of main parameters, sensitivity analysis is a useful tool in model building as well as in model evaluation. Therefore, the results of the sensitivity analysis will also represent a useful test for the tool itself.

Parameter sensitivity analysis helps building confidence in the model by studying the uncertainties that are often associated with parameters in models. Many parameters in C dynamics represent quantities that are very difficult, or even impossible to measure to a great deal of accuracy in the real world. This is particularly true for a Tier 1 approach as that one adopted in EX-ACT. This parameter sensitivity is performed here as a series of tests in which different parameter values cause a change in the dynamic behaviour of the C stocks, helping to understand dynamics of the agro ecosystems.

In the model, average climate is considered as *warm temperate* with a moisture regime classified as *moist*, which correspond to average temperature and rainfall for the State. Parameter sensitivity has been tested by introducing extreme values instead of average ones for the moisture regime (*dry* instead of *moist*). Also the soil characteristics have been changed considering High Activity Clay (HAC) soils – which are present in the project area – instead of Low Activity Clay (LAC) soils. The results (table 20) show that a change in moisture regime will cause a decrease in the total mitigation potential of the project: this is reasonable as a drier climate is expected to lower the biomass growth, above and below ground. On the other hand, a change in soil characteristics (from LAC to HAC) will increase the sequestration potential, because of the higher C stocks and overall soil fertility. The change in the final balance consequent to the change in moisture regime and soil parameters is approximately within the -20/+20%, which may be considered reasonable for this case.

Table 20: Parameter sensitivity for the SC Rural project

Climate	Moisture regime	Soil	Results	
			Final balance	Change
			MtCO2e mitigated	%
Warm temperate	Moist	LAC	13.09	-
Warm temperate	Dry	LAC	10.41	-15
Tropical	Dry	LAC	11.88	-3
Warm temperate	Moist	HAC	15.02	23
Tropical	Moist	HAC	14.00	15

Source: our calculations using EX-ACT (2010)

6.2 Scenario sensitivity

A second level of sensitivity analysis is carried out to deal with the uncertainty of the results which depends on the uncertainty of some data used to perform the analysis. Therefore, two different scenarios are built here, one more "pessimistic" and a second one more "optimistic" with respect to the main scenario outlined above. The results obtained will be compared with those already shown in section 5 and an intermediate scenario is built ("most likely" scenario).

The alternative scenarios have been built by changing the values of variables related to: the rate of adoption of the practices promoted by the project; change in land use and management; and, more in general, implementation of project activities.

The "pessimistic" scenario is built under the following assumptions, with respect to the main scenario outlined above: a 20% increase in fuel consumption (both gasoil/diesel and gasoline) and a 30% increase of electricity consumption; a 30% decrease of the cropland area which will be managed with SLM practices; a 50% reduction of the grassland area interested by the introduction of improved grassland management options; reduction in the % of livestock population interested by additional technical practices (feeding and management-breeding ones). The results show that the mitigation potential of the SC project in the "pessimistic scenario" is equal to 10.0 MtCO_2e, corresponding to a 17% reduction with respect to the main scenario.

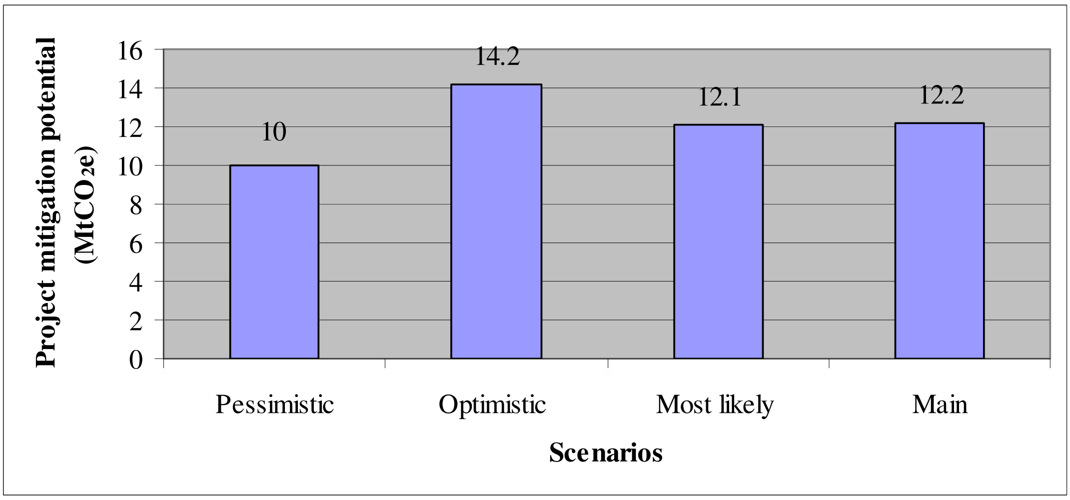
The "optimistic" scenario is built by assuming that the adoption rate of the activities promoted by farmers will be faster than expected. In the main scenario it is prudentially assumed that the adoption dynamic will be linear, while here it is assumed as exponential (see figure 2.2) for most project activities: management of grasslands and annual crops, expansion of perennial crops, fencing of riparian areas, expansion of agro-forestry systems, creation of ecological corridors and land rehabilitation.

In this scenario it is also assumed that the impact on GHG emissions from production, transportation and storage of agricultural chemicals will be lower than in the main scenario. The default values used to estimate this impact are in fact extremely uncertain and correspond to world averages, considering that in most cases the production of agricultural inputs is realised outside the country of the project with high level of emissions due to transportation. This is certainly true for most developing countries. Nevertheless, in the case of Brazil, it is plausible to assume that project developers could organize the procurement of agro-chemicals on a national basis, avoiding purchasing inputs produced abroad. Therefore, in the "optimistic" scenario, a specific factor corresponding to the lower limit in the range provided by Lal (2004) is used instead of the EX-ACT default that corresponds to the central values of the same range, with a reduction of 61% in GHG emissions from production, transportation and storage of agricultural chemicals.

The results show that the mitigation potential of the SC project in the "optimistic scenario" is equal to 14.5 MtCO_2e, corresponding to a 20% increase with respect to the main scenario.

It is therefore estimated that the SC Rural project will "most likely" be able to mitigate 12.2 MtCO_2e, computed as the average of the "optimistic" and "pessimistic" scenarios (figure 3). It is interesting to note that this value is very close to what has been estimated in the main scenario (12.1 MtCO_2e), showing the robustness of the analyses outlined above and of the EX-ACT results.

Figure 3: Scenario sensitivity analysis for the SC Rural project



Source: our calculations using EX-ACT (2010)

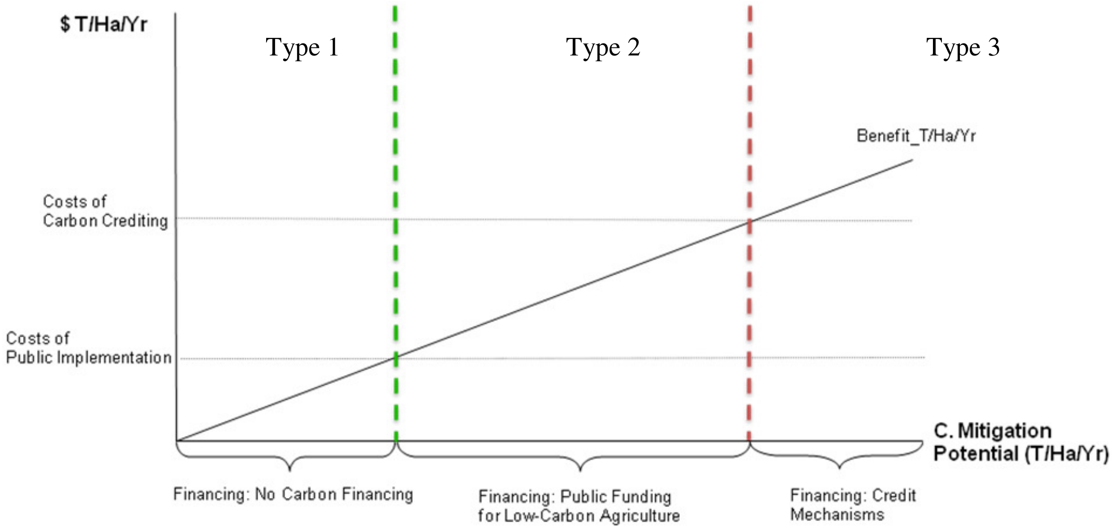
7. ECONOMIC ANALYSIS

The average mitigation potential of the project is equal to 0.92 tCO2e/ha per year. It could be valued using a price of 3 US$/tCO2e, which is the average C price for agricultural soil C at retail level on the voluntary C market in 2008 (Hamilton et al. 2009). Therefore, the value of the average mitigation potential of the project amounts to 2.76 US$/tCO2e (per hectare and per year). Since this value is below the level of transaction cost for public implementation (4 US$/tCO2e)[8], the project would not have

[8] For the purpose of this note, it is assumed that the transaction costs for public implementation are equal to 4 US$/t CO2e (per hectare and per year) which is an arbitrary but plausible value based on some literature available (Cacho et al. 2005; Lipper at al. 2010; Mooney et al. 2004). 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 certification (Cacho and Lipper 2006).

any feasible option of being financed on the C sector falling within “type 1” projects (see figure 4).

Figure 4: Financing options for agriculture development and mitigation projects



Source: adapted from FAO 2009.

However, it is interesting to note that a relatively limited change in project design could slightly increase the mitigation potential of the project and transform it in a type 2 one. For example, the mitigation potential of the project in the “optimistic scenario” outlined above is equal to 1.1 tCO2e/ha per year. Clearly, if the project is designed with explicit multiple objectives (e.g. the current goal of increasing the competitiveness of rural family agriculture producer organizations could be integrated by a specific mitigation objective) and with specific mitigation activities, it will be easily increase its mitigation potential.

If the corresponding mitigation potential value exceeds the level of transaction costs for public implementation, the project could then be potentially considered for public financing for low-Carbon agriculture. Being this the case, since yearly mitigation potential of the SC Rural project would be equal to 0.6 MtCO_2e, mitigation benefits would be worth 1.8 million US$/year at the price of 3 US$/t$CO_2$e. Given that total average project cost is 31.5 US$ million/year, public C finance would potentially cover about 6% of these costs.

8. CONCLUSIONS

The analysis of the ex-ante Carbon-balance results shows that the SC Rural project will be able to mitigate 12.2 MtCO_2e through the implementation of the activities aimed at increasing the competitiveness of rural family agriculture producer organizations, i.e. expansion of training and extension services, diversification and enhancement of production systems, support to the implementation of small-scale agro-industry, land rehabilitation and forest conservation, creation of ecological corridors and expansion of agro-forestry systems.

The design of the SC Rural project could be slightly changed to increase the mitigation potential of the project so that it could be taken into consideration for public C financing. EX-ACT could therefore be used also as a guidance tool during the project design process – assisting project developers to refine project components so to increase the environmental benefits of the project itself – and to provide a basis to enter a C financing logic by highlighting the most C intensive practices in the project which could be extended either during the project implementation phase or in future loans.

The SC Rural project could also benefit from using EX-ACT in the future by applying it at local/micro catchment level, where a more detailed data set will be likely available as a result of the comprehensive diagnostic and planning approach adopted. Also, since EX-ACT is a specific tool aimed at estimating the mitigation potential of project activities, it could be used together with other tools or methodologies adopted to assess environmental services linked to agricultural production and farming systems development.

8. READERS'NOTES

The exercise can be fruitfully used in a training course, where there is no possibility to organize a field visit to gather data for the application of EX-ACT to a practical situation.

The Ex-ACT software can be downloaded at:
EASYPol Module xxx www.fao.org/easypol

This module belongs to a set of EASYPol modules and other related documents:
These are the following EASYPol modules:

- EX_ACT Technical guidelines: http://www.fao.org/docs/up/easypol/780/ex-act-tech-guidelines_210en.pdf
- EX-ACT Flyer: http://www.fao.org/docs/up/easypol/780/ex-act_flyer-jan_2010.pdf

These are the other related documents:

- Bernoux M., Branca G., Carro A., Lipper L., Smith G., Bockel L., 2010. Ex-ante greenhouse gas balance of agriculture and forestry development programs. *Sci. Agric. (Piracicaba, Braz.), v.67, n.1, p 31-40, January/February 2010.*

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Module metadata

1. EASYPol module

2. Title in original language

English	EX-ACT Software for Ex-ante Carbon-Balance Appraisal of investment projects
French	
Spanish	
Other language	

3. Subtitle in original language

English	An application to the Santa Catarina Rural Competitiveness Project in Brazil
French	
Spanish	
Other language	

4. Summary

This module presents a case study of Carbon-Balance Appraisal for an investment project. It is useful for people who wish to improve their skills on how to estimate climate change mitigation potential of agricultural programs/projects and to integrate it in economic analysis of projects. It is part of a set of documents aimed at driving project developers in the process of learning and applying the EX-Ante Carbon balance Tool (EX-ACT). Specifically, this case study has been developed as a result of the application of EX-ACT to a FAO/WB Project in Brazil, which was also selected for testing the software. The case study consists of: a brief description of the project; the EX-ACT analysis of the project with a discussion of the results.

5. Date

April 2010

6. Author(s)

Giacomo Branca, Economist, Agricultural Development Economics Division, FAO, Rome, Italy
Aude Carro, FAO Consultant, Rome, Italy
Katia Medeiros, Senior Environmental Officer, Investment Centre Division, FAO, Rome, Italy

7. Module type	☐ Thematic overview ☐ Conceptual and technical materials ☒ Analytical tools ☐ Applied materials ☐ Complementary resources
8. Topic covered by the module	☐ Agriculture in the macroeconomic context ☐ Agricultural and sub-sectoral policies ☐ Agro-industry and food chain policies ☒ Environment and sustainability ☐ Institutional and organizational development ☒ Investment planning and policies ☒ Poverty and food security ☐ Regional integration and international trade ☐ Rural Development
9. Subtopics covered by the module	
10. Training path	**Investment planning for rural development**
11. Keywords	Carbon balance, Carbon sequestration, Carbon sinks, Carbon sources, mitigation potential, EX-ACT, GHG, IPCC