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Module XXX

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

An application to the Rio de Janeiro Sustainable Rural Development Project in Brazil

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by

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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; Aude Carro, FAO consultant, case study practitioner; 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 SoRJ is one of Brazil's 26 states and is located in the geopolitical region of the Southeast. With a total area of 43,864 square kilometres, it is divided into eight administrative regions: (i) North; (ii) Northwest; (iii) Serrana; (iv) South; (v) Coastal Floodplains; (vi) Metropolitan; (vii) Paraíba River Middle Valley; (viii) and Grande Bay Island. With a total of 92 municipalities, the SoRJ has approximately 15.4 million inhabitants (about 9% of the national population), of which 90% live in urban areas (IBGE 2007). The state economy is driven by the industrial and service sectors, which contribute to 51% and 42% of state GDP, respectively. Overall the SoRJ accounts for 15% of national GDP (US$139.0 billion in 2006).

The agricultural sector is important to the SoRJ economy and social well-being, although it contributes only to a small proportion of state GDP (0.5%). Nevertheless, outside of the metropolitan area of the city of Rio de Janeiro, agriculture's contribution to GDP rises to nearly 5%, and when agro-industrial activities are included, agriculture represents over 25% of the state GDP. The importance of agriculture is further demonstrated in terms of rural employment - it accounts for over 40% and includes an estimated 157,492 individuals (IBGE 2006) - and land use (more than 60% of total state area is dedicated to agricultural activities). Three administrative regions, including the North, the North-West Fluminense and the Serrana region, are the agricultural powerhouse of the SoRJ. With 36 municipalities and over 10% of total state population, they are responsible for more than 60% of agricultural employment and produce 66% of agricultural goods in the state, namely: coffee (99% of the state total), sugarcane (97% of the state total), cereals (90% of the state total), vegetables (67% of the state total), milk (54% of the state total), and fruit (42% of the state total). These regions also have the state's largest concentration of family farms. Small family farms represent some 80% of total land holdings, over half of which correspond to holdings of ten ha or less, and small-scale farming employs roughly twice the number of people per unit area than the larger holdings.

Despite its importance, the agricultural sector in the SoRJ faces a number of pressing challenges, the three major ones being: low productivity, poor linkages to the market and a weak natural resources base. Main causes for the low levels of productivity encountered in the agricultural sector, and especially sugarcane -the state's most important production- coffee and cattle, include: the use of simple technology, sugarcane and coffee production dominated by "boom and bust" cycles , weak farmer organization, and the widespread use of traditional, inefficient practices, especially by small farmers.

Despite its proximity to a number of large markets, due to poor market linkages the majority of agricultural products in the SoRJ are locally consumed. Four key contributing constraints identified by the State Secretariat of Agriculture, Fisheries, and Rural Development (SEAPPA) are: (i) poor conditions of rural roads; (ii) limited market information inhibiting the ability of market forces to impact producer decisions; (iii) undeveloped value chains restricting product variety and price; and (iv) limited scope of public policy in rural areas.

Although home to an extremely diverse and unique mix of vegetation and forest types, including globally-important resources in the case of the Atlantic Forest (Mata Atlântica) , such areas in the SoRJ continue to be under severe pressure primarily as a result of de-forestation (related to land conversion and charcoal production, among other things) and soil erosion (caused by, inter alia, deforestation, overgrazing, and poor agricultural practices).

Finally, poverty, especially in the North, North-West Fluminense and Serrana regions where over 60% of the state's rural population lives in poverty and about one-third of those are in conditions of extreme poverty (Centre for Social Policy 2004) , and the inability of public institutions to adapt to the evolving demands of the rural sector, attributed in particular to a lack of appropriate mechanisms to react to market forces with fixed norms and policies, and a weak local stakeholder representation in the institutional arrangements, represent other important challenges faced by the SoRJ rural sector.

The Rio de Janeiro Sustainable Rural Development (Rio Rural) Project is designed to address the aforementioned challenges by supporting interventions to improve small farmer productivity, enhance linkages with internal and national markets, strengthen the natural resources base, enhance the living conditions and incomes of small farming families, and improve the ability of public institutions to adapt to the evolving demands of the rural sector.

3.2 The Rio Rural project profile

The Rio Rural Project has the objective to increase the adoption of integrated and sustainable farming systems approaches[1]. Activities supported by the Project will contribute to the higher-order objective of increasing small-scale farming productivity and competitiveness in specific areas of the SoRJ.

The operational strategy is as follows. First, the Project will establish an institutional framework in support of the FAO-developed approach of Participatory and Negotiated Territorial Development (PNTD) and promote community driven interventions to increase the organization and capacity of small farmers. Second, the project will support, based on the above, the transition to more productive, efficient, and sustainable production systems through financing different categories of investment proposals and promoting coordination with other agricultural-related programs. Lastly, the Project will promote the replication of this methodology throughout the SoRJ by intervening in

[1] A farming systems approach is based on understanding the farm-household, the environment in which it operates, and the constraints it faces, together with identifying and testing potential solutions to those constraints. A farming system is defined as a population of individual farms systems that have broadly similar resource bases, enterprise patterns, household livelihoods, and constraints, and for which similar development strategies and interventions would be appropriate. Their analysis emphasizes horizontal and vertical integration, multiple sources of household livelihoods, and the role of the community, the environment and support services. The primary objective of this approach is to improve the well-being of individual farming families by increasing the overall productivity of the farming system in the context of both the individual and community goals, given the constraints imposed by the factors that determine the existing farming system. Thus, it is based on the development principles of improving productivity, increasing profitability and ensuring sustainability, as well as improved distribution of the final value of production.

areas outside of the targeted priority regions with the aim of mainstreaming public policies in support of sustainable rural development.

The Project will be implemented over a period of six years and will target approximately 37,000 small-farming families (some 150,000 people in total) in the SoRJ, which corresponds to roughly 30% of the total rural population in the state. The target population primarily resides in three main regions that include the North, the Northwest[2] and Serrana administrative regions, representing a total area of about 23,000 square kilometers (53% of the total area of the state). Eighty-four percent of project funds (or US$66.1 million) will be directed to small farmers within the selected communities via participatory planning, capacity building, and investment activities.

The total cost of the project is US$79.0 million with a World Bank Loan of US$39.5 million. Counterpart financing from the SoRJ through SEAPPA totals US$21.4 million, in addition to US$18.1 million in private investments.

Project activities are structured in three components as follows: (i) Support to Small Farmer Production and Competitiveness (US$66.1 million); (ii) Institutional Frameworks (US$5.2 million); and (iii) Project Coordination and Information Management (US$7.6 million).

Most of the technical activities are gathered under Component 1 (Support to Small Farmer Production and Competitiveness), which aims to support changes in rural production processes within a framework of market-driven agricultural development focused on sustainable and increased productivity of small farmers, value added, and market linkages. To do so, activities under Component 1 will be carried out in two steps through two subcomponents: (1.1) Pre-Investment and (1.2) Investments.

- *Subcomponent 1.1 (Pre-investment*) will strengthen organization, networking and capacity for agricultural productivity-focused and market-driven development across community, municipal, and regional levels, thus serving as the basic building block for investments supported under subcomponent 1.2. Specifically, this subcomponent will prepare beneficiaries and project staff for the implementation of the project's technical strategy through training and planning activities. This subcomponent will finance training, workshops and exchanges, expert services (technical assistance for local and regional development), and goods (equipment and materials).

- *Subcomponent 1.2 (Investments*) will implement demand-driven investments identified and developed under subcomponent 1.1. Through the use of grants, investments will be financed to directly support improvements in farming systems and production processes. In most cases, the Project will finance a maximum of 80% of the estimated 24,400

[2] The North and Northwestern administrative regions are also known as the "North and Northwestern Fluminense" (NNWF). The NNWF is the target area of the Rio GEF Project and its two administrative regions overlap with existing territories already established by the Ministry of Agrarian Development (MDA). Each MDA territory consists of a cluster of municipalities that share cultural and socioeconomic similarities. Given that territories are social constructions, the Project is adopting a similar concept by defining the territory as a system of various levels (community/micro catchment, municipal, and regional) where different actors compete and eventually cooperate and negotiate. See Appendix 2 to this Annex for details.

investment proposals to be funded. Three types of subprojects will be eligible for support: (i) *productive*, which includes activities to increase sustainable productivity, promote value added, and develop value chains[3]; (ii) *environmental conditioning* of productive units, which includes complying with environmental laws and adopting environmentally-sound and agro-ecological practices; and (iii) *rural roads-related logistical bottlenecks*, which includes erosion control and rehabilitation of rural roads.

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, analysed using EX-ACT. The computation of the C-balance is an indication of the overall potential mitigation impact of the selected project components which were considered as relevant in this type of environmental analysis.

4.1 Structure of the analysis

Amongst the activities supported under the above-mentioned sub-components, the following activities were identified as having a potential impact on the C-balance.

a) Protection of springs and streams

The project aims at involving farmers in water conservation by using economic incentives, encouraging them to conserve forested areas around springs and forested strips around streams in their exploitation. These areas are typically threatened by wood harvesting for energy supply, and by free grazing of cattle. Practically, this activity includes: (i) installation of fences to protect forest from cattle grazing and monetary incentives for farmers to cease exploiting these zones; and (ii) plantation of native forest on most degraded zones.

b) Support to the establishment of Legal Reserves

The project supports farm-level compliance with the current Brazilian Forest Code[4], which requires to maintain under native forest all permanent preservation areas plus 20% of farm lands. When trying to match this requirement, farmers often face difficulties in particular to regulate this private reserve. The project intends to support the regularization of farmers by: (i) undertaking topographic survey, environmental

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[3] Based on a study carried out during preparation, the Project will initially look at the whole product chain of six pre-identified production chains – sugarcane, coffee, milk, fruits, vegetables and fish - (involving both market studies and adaptive research activities) as mentioned above, and the Project will support the inclusion of small farmers within those chains to increase the efficiency and quality of production. Moreover, the financing of investment proposal under this category will serve as seed money for entrepreneurs to take risks at all stages of the value chain. As a result, in addition to the pre-identified value chains, a flexible design will allow for the financing of other entrepreneurial ideas that may arise during implementation (i.e., artisan products and tourism).

[4] The Forest Code in Brazil, established in 1934, requires that 20% of properties must be conserved under forest (80% in Legal Amazon, 50% for the savannah/Cerrado zones on the Amazon fringes).

licensing and notarization of ''in-process'' Legal Reserve; (ii) providing incentives to farms that have not entered in the process and; (iii) the re-plantation of native vegetations on most degraded zones.

c) Expansion of agro-forestry

The project promotes the expansion of agro-forestry, and especially encourages its development in areas of permanent protection, such as those around springs and streams, or Legal Reserves, as allowed by the recently approved Brazilian legislation[5].

d) Improved annual crop management

The project promotes the adoption of several agricultural practices which may have environmental co-benefits. These practices include: crop diversification; integrated pest management and biological control of pest and diseases; bio-fertilization and in particular the use of compost, organic fertilizer and green manure, soil analysis and rational use of fertilizers; zero and minimum tillage, planting contour, inter/relay cropping and mulching; irrigation management.

e) Improved grassland management

The project aims to restore degraded pastures by improving rotations and supporting the production of sugar-cane forage to feed cattle.

f) Improved feeding practices of dairy cattle

The project supports the development of improved feeding practices for dairy cattle, which are already adopted for 12% of the 421,000 dairy cattle heads that counts Rio de Janeiro State.

g) Support to small agro-industry and construction of sanitary installations

The project supports the development of small agro-industry by funding the construction of the premises and the equipment, and aims to improve rural livelihood by financing the installation of sanitations.

h) Use of lime to fight soil acidification and sustainable use of agro-chemicals

[5] Instrução Normativa MMA, on 08/09/2009 and Decree 7029 on 10/12/2009.

The project supports the use of lime to combat soil acidification and, more generally, promotes a more sustainable use of agro-chemicals in cropland and grassland management.

In light of the above activities, two indirect impacts on the C balance were also taken into account:

- although project activities will emphasize sustainable agricultural practices, cropland and grasslands management is expected to increase the use of agro-chemicals, with an expected increase in GHG emissions (see section 4.9);

- project implementation – but mainly activities under subcomponent 1.1 – is expected to intensify technical assistance of 400 project executers currently operating in the area, resulting in a substantial increase in the annual fuel consumption and, again, an expected increase in GHG emissions (see section 4.10).

Last, the following two activities were not taken into account in the analysis, although they may have an impact on the C-balance:

- the establishment of fire-breaks to protect an area of 200 ha. The mitigation potential can be estimated taking into account the avoided deforestation consequent to the establishment of fire breaks, but no data on the occurrence of fire events in the state were available;

- the construction and rehabilitation of roads on strategic sloppy zones, which may have a controversial effect on GHG emissions: it can increase emissions as a result of the construction work but it can also increase the amount of C sequestration by re-vegetating areas adjacent to the roads and reducing soil erosion and thus potentially emissions from soil degradation (Lal 2005). Also, in the long run, roads in better conditions are expected to lower fuel consumption and related GHG emissions. The mitigation potential was not computed in the main scenario due to a lack of precise data, but it has been considered in the sensitivity analysis, albeit approximated.

4.2 Basic assumptions of the analysis

The project is being implemented in the State of Rio de Janeiro 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 representative for the whole area.

Average climate is considered as tropical with a mean annual temperature equal to 22 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 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 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 (although it also includes HAC, Wetland and Sandy soils in a more detailed scale). LAC soils 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 account in 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. As it will be discussed further in the analysis, the implementation phase may happen according to three different dynamics of change: immediate, linear and exponential (see figure 3.1), 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.

As concerns the Global Warming Potential (GWP) coefficients , 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.

A three–step methodological framework was used to account for each land-based project activity:

a) estimation of area interested by land use change and management;

b) characterization of the technologies/practices used in both “with” and “without project” scenarios with reference to the area concerned; and

c) quantification of the mitigation potential of the project activities using the relevant EX-ACT module.

Next sections show the implementation of this methodological approach in the case of project activities considered in the present analysis.

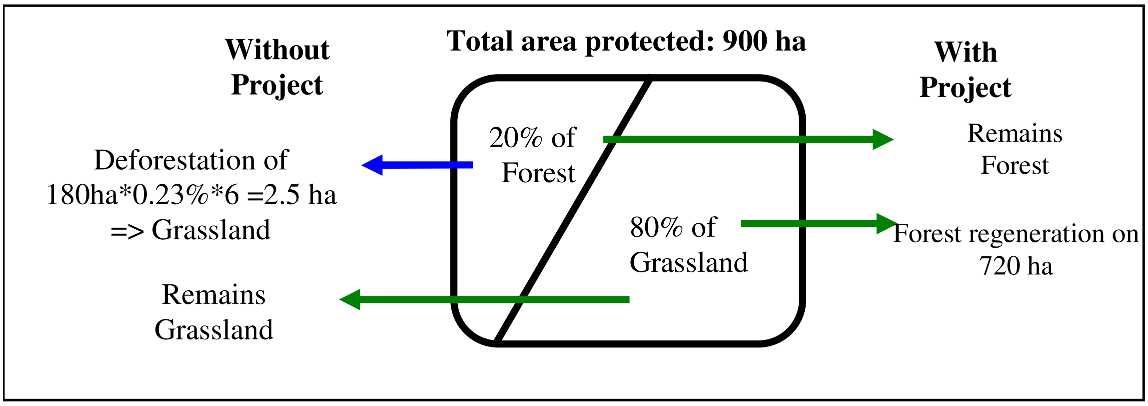
4.3 Protection of springs and streams and support to the establishment of the Legal Reserves

a) Protection of springs and streams

The project aims at involving farmers in water conservation by using economic incentives. It encourages them to conserve forested areas around springs and forested strips around streams in their exploitation. Practically, this activity involves 900 ha and includes installation of fences to protect land from cattle grazing and monetary

incentives for farmers to cease exploiting these zones - both resulting in natural forest regeneration; and plantation of native forest on most degraded zones.
In the "with project" scenario, it is estimated that grassland area will gradually switch into native forest through a process of natural forest regeneration (this will involve 720 ha) and that no deforestation will take place (this will involve 180 ha). On the contrary, in the "without project" scenario it is assumed that: 80% of the area (720 ha) is likely to remain grasslands *(degraded* with fire use in the management of land); the remaining 20% of the area, already forested, is likely to suffer degradations from wood harvesting for energy supply. This is accounted for in the model by applying to these areas the current rate of deforestation for the state which is equal to 0.23% [6] (figure 1).

Figure 1: "With" and "without project" scenarios for the protection of springs and streams



Source: project data

In addition, in the "with project" scenario, it is foreseen that 50 ha of degraded land will be interested by the plantation of native forest.

b) Support to the establishment of Legal Reserve

The project supports farm-level compliance with the current Brazilian Forest Code, which requires to maintain in Rio de Janeiro State 20% of the farm land surface under native forest. When trying to match this requirement, farmers often face difficulties in particular to notarize this private reserve. The project intends to support the establishment of Legal Reserves by:

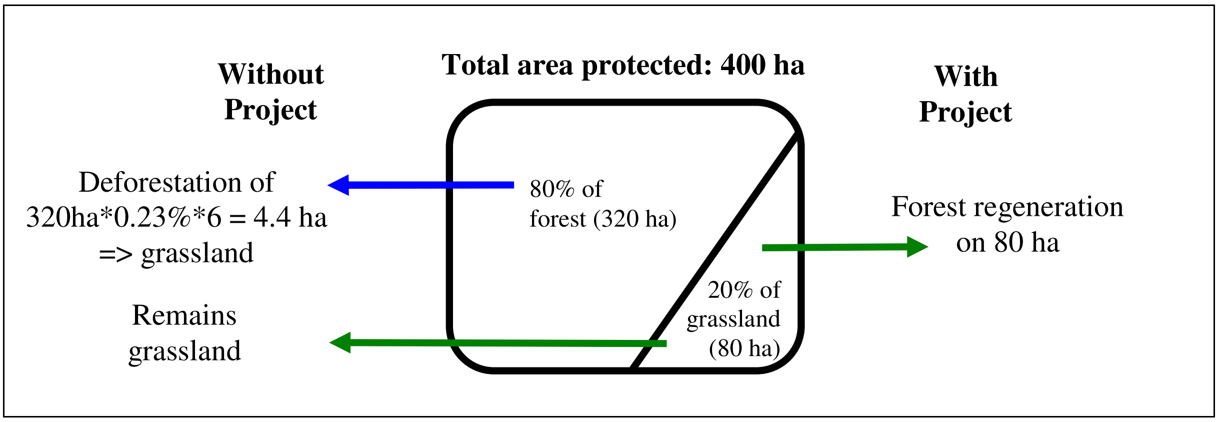
- undertaking topographic survey, environmental licensing and notarization of 300 ha of "in-process" Legal Reserve;
- providing incentives to conserve 100 additional ha for farms that are still not involved in the notarization process – resulting in forest regeneration; and
- the re-plantation of native vegetations on the most degraded zones, which concerns an additional 60 ha.

[6] Although this assumption may be strong to represent the wood harvesting, it is acceptable considering the extremely low deforestation rate in SoRJ.

Total area protected by project activities is therefore estimated at 460 ha. Of these, 60 hectares of degraded land will be interested by the re-plantation of native vegetations. It is assumed that most of the remaining 400 ha targeted by the project is under forest cover (80%) and the remaining (20%) is still predominantly under *degraded* grassland with use of fire in their management.

In the "without project" situation it is assumed that some deforestation activities will take place and that overall 4.4 ha of forest will be converted to grasslands. Also, degraded grassland is likely to remain as such in the "without project" case. On the contrary, in the "with project" scenario, no deforestation will occur, grassland area will gradually switch into native forest through a process of forest regeneration and re-plantation of native vegetations over an area of 80 ha. This is shown in figure 2.

Figure 2: "With" and "without project" scenarios for the protection of legal reserve



Source: project data

This set of project activities is taken into account in the following EX-ACT modules: "grassland", "afforestation/reforestation", and "deforestation" as explained in what follows.

Deforestation happening in the "without project" scenario is considered in the corresponding "deforestation" module. The forest was described as tropical rain forest: given that deforestation is clearly a source of GHG emissions, this represent a pessimistic setting considering that this type of forest is characterized by the highest values for above and below ground biomass. Considering local conditions and practices, it is assumed that the forest will not be burnt before conversion to grasslands. The module "deforestation" quantified in 4,302 tCO_2e the mitigation impact of the avoided deforestation of 6.9 ha of tropical rain forest. The module "grassland" considered then the impact of the corresponding increase in grassland area. It is assumed that the grassland type after deforestation will most likely be *non-degraded* and would remain under this type with no fire use. This system evolution is considered as C neutral by the tool which explains the absence of additional effect on the C balance for grasslands.

In the "afforestation/reforestation" module it is assumed that forest cover will be regenerated on 800 ha of degraded grassland through naturally re-growing stands with reduced or minimum human intervention (extensively managed forest). Given the climatic conditions of the project area, the vegetation type has been classified as natural (tropical rain) 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 11 tons of dry matter per ha and per year (t dm/ha/year), and the below ground biomass is equal to 4.07 t dm/ha/year. Default value for litter (3.65 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 while default value for soil C is set equal to 47 t C/ha.

The same “afforestation/reforestation” module takes into account the activity of re-planting native vegetations on 110 ha of degraded grassland. It is again assumed that forest regeneration and plantation of native forest will consist of tropical rain forest, which is perhaps an optimistic setting (here it is a C sink) considering that to this type of forest correspond the highest values for above and below ground biomass.

Both forest regeneration and re-planting are occurring on degraded grassland where fire use is a constant management option. The decrease in grassland is automatically accounted for in the module “grasslands”.

Overall, this set of activities is able to sequester 521,468 t CO_2e, of which 4,302 as “avoided deforestation” and 517,166 as a result of forest regeneration and plantation of native forests (table 1).

Table 1: C balance associated with the protection of springs and streams and the establishment of the legal reserve

a) Avoided deforestation

GHG emissions													
Forested Area (ha)					Area deforested (ha)		Biomass loss		Biomass gain (1yr after)		Total Balance		Difference
Start	Without Project		With Project		Without	With	Without	With	Without	With	Without	With	
t0	End	Rate	End	Rate			tCO2	tCO2	tCO2	tCO2	tCO2	tCO2	tCO2
2,5	0	Linear	2,5	*Linear*	3	0	1804	0	-69	0	1735	0	**-1735**
3,7	0	Linear	4,4	*Linear*	4	0	2670	0	-103	0	2568	0	**-2568**
											4302	**0**	**-4302**

b) Forest regeneration and plantation of native forests

GHG emissions																				
Afforested or reforested Area (ha)					Biomass Gain		Biomass Loss		Soil		Fire		Total Balance		Difference
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	tCO2
0	0	*Linear*	720	*Linear*	0	-327517	0	2803	0	-70664	0	163	0	-395214	**-395214**
0	0	*Linear*	80	*Linear*	0	-36391	0	311	0	-7852	0	18	0	-43913	**-43913**
0	0	*Linear*	110	*Linear*	0	-67697	0	428	0	-10796	0	25	0	-78040	**-78040**
											Deforestation Total		**0**	**-517166**	**-517166**

Source: our calculations using EX-ACT (2010)

4.4 Expansion of agro-forestry systems

The project promotes the expansion of agro-forestry, and especially encourages its development in areas of permanent protection, such as those around springs and streams, or in Legal Reserves[7].

Specifically, the project will promote the plantation of native forest on 1,100 ha of degraded grassland (table 2).The trees species planted are generally composed by two third of native species and one third of exotic commercial species. General more than 20 native species are planted among Angico *sp., Inga spp., Cassia grandis, Cassia imperials, Ipê amarelo,Pau Ferro, Pau Brasil, Guapuruvu Quaresmeira*, *Jequitiba*, *Saboneteira, Nim, Pequiá, Pacová,* associated to fruits (*abacate, jambo, jaca, guava, caju, graviola, abiu, açaí, lemon, orange*), vegetables (*Manihot esculenta, inhame, cará*) and wood species (*Cedro australiano sp., Eucaliptus grandis sp.*) so that the biomass is expected to be closest from a native forest type.

Table 2: Land use change related to the expansion of agro-forestry systems in the Rio Rural project (data in ha)

Project activity	Start	Without project	With project	Technologies used
Agro-forestry systems	0	0	1,100	Plantation of native and exotic forestry species on degraded grassland
Total	0	0	1,100	

Source: project data

[7] This activity is therefore very much linked with the previous one aimed at protecting springs and streams and supporting the establishment of the Legal Reserves.

This activity will determine 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". As there are currently no default values for agro-forestry systems from IPCC, the analysis has adopted default values for perennial crops. The expansion of agro-forestry systems on degraded grassland (1,100 ha) would determine a change in both biomass and soil C stock, as explained next.

With reference to the specific climate (tropical moist) and tree types, it is expected that an increase in biomass C stock from 1.0 to 2.6 tC/ha will take place as a result of the land use change, corresponding to 6,453 tCO_2e mitigated over 20 years. This is considered in the module "other land use change" which takes into account the calculations done by IPCC with reference to the changes in land use. The biomass will also increase as a consequence of the land management, as accounted for in the module "perennials" which helps to correct the nominal baseline according to the specific land management: above ground biomass growth is set using the IPCC default value of 2.1 tC/ha per year, corresponding to 139,755 tCO_2e mitigated from biomass over 20 years (table 3). Therefore, total amount of CO_2 mitigated from biomass, as a result of the expansion of agro-forestry systems is equal to: 6,453+139,755=146,208 tCO_2e over 20 years. In fact, the results of the computations from the two modules should be considered as additive here.

The conversion from degraded land to perennials will also cause the increase in soil organic C stock, which for the climate and soil characteristics of project area is estimated to increase from 15.5 to 47.0 tC/ha, corresponding to 107,958 tCO_2e mitigated. Perennial systems can also store C in soil: default C storage amounts to 0.7 tCO_2e/ha per year for temperate moist regions, so that total mitigation potential is equal to 13,090 tCO_2e. Similarly to mitigation from biomass, the results of the computations from the two modules should be considered as additive: total amount of CO_2 mitigated from biomass, as a result of the expansion of agro-forestry systems is equal to: 107,958+13,090=121,048 tCO_2e over 20 years (table 3).

Table 3: C balance associated with the expansion of agro-forestry systems

GHG emissions	Area concerned by LUC				Biomass Change		Soil Change		Fire		Total Balance		Difference
	Without Project		With Project		Without	With	Without	With	Without	With	Without	With	
	Area	Rate	Area	Rate	tCO2	tCO2	tCO2	tCO2	tCO2	tCO2	tCO2	tCO2	tCO2
Expansion of agro-forestry systems	0	Linear	1100	Linear	0	-6453	0	-107958	0	0	0	-114412	-114412
Other LUC total											0	-114412	-114412

Mitigation potential	Areas					CO₂ mitigated from Biomass		CO₂ mitigated from Soil		CO₂eq emitted from Burni		Total Balance		Difference
Vegetation Type	Start	Without project		With Project		Without	With	Without	With	Without	With	Without	With	
	t0	End	Rate	End	Rate							tCO_2	tCO_2	tCO2eq
System P1	0	0	Linear	0	Linear	0	0	0	0	0	0	0	0	0
System P2	0	0	Linear	0	Linear	0	0	0	0	0	0	0	0	0
OLUC to Perennial	0	0	Linear	1100	Linear	0	-139755	0	-13090	0	0	0	-152845	-152845

Source: our calculations using EX-ACT (2010)

Total mitigation potential of the expansion of agro-forestry is computed by adding the mitigation potentials from biomass and soil C: overall, this activity will create a net C sink of 146,208+121,048=267,256 tCO_2e over 20 years, i.e. 12.1 tCO_2e/ha per year.

4.5 Improved annual crop management

The project promotes the adoption of several sustainable agricultural practices summarized in table 4. Many of these improved practices may increase yields and 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 GHG emission sources. For example, integrated nutrient management can reduce on-site emissions by reducing leaching and volatile losses, improving N use efficiency through precision farming and improved fertilizer application timing (FAO 2009).

Table 4: Details of the sustainable agricultural practices promoted by project activities

Improved agronomic practices	Crop diversification Integrated Pest Management (IPM) Biological Control of pest and diseases Transition toward agro-ecological systems
Nutrient management	Green manure Organic fertilizer Soil analysis and rational use of fertilizers Bio-fertilization Composting
Tillage / residues Management	Minimum tillage Inter/Relay Cropping Contour/ Strip Contour Cropping Mulching
Water management	Irrigation management

Source: project data

Total cropland in the project area is 225,104 ha. The improved practices will involve 4,110 ha as reported in table 5.

Table 5: Land use change related to the promotion of sustainable agricultural practices promoted by the Rio Rural project (data in ha).

Description of farming systems	Start	Without project	With project	Technologies used
Improved agronomic 1	0	0	300	Improved agronomic practices, tillage/residues management, nutrient management and manure application
Improved agronomic 2	0	0	240	Improved agronomic practices
Improved agronomic 3	0	0	305	Improved agronomic practices, tillage/residues management and manure application
Nutrient management 1	0	0	1,320	Nutrient management and manure application
Nutrient management 2	0	0	310	Nutrient management
Nutrient management 3	0	0	475	Nutrient management, tillage/residues management and manure application
Tillage/residue management	0	0	950	Tillage/residues management and manure application
Water management	0	0	210	Water management
Current system (not improved)	225,104	225,104	220,994	Manure application and residue/biomass burning
Total improved systems	0	0	4,110	
Total	225,104	225,104	225,104	

Source: project data

This activity is taken into account in the module named "annual" which computes the total 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. 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)[8].

Total mitigation impact of the adoption of improved cropland practices is equal to 18,334 tCO_2e over 20 years (table 6). Given an area of 225,104 ha, the annual mitigation potential of these activities is equal to 0.08 tCO_2e/ha.

Table 6: C balance associated with improved annual crop management

Vegetation Type	Areas					Soil CO2 mitigated		CO2eq emitted from Burning		Total Balance		Difference
	Start	Without project		With Project		Without	With	Without	With	Without	With	
	t0	End	Rate	End	Rate					tCO2	tCO2	tCO2
System A1	0	0	Linear	0	Linear	0	0	0	0	0	0	0
System A2	0	0	Linear	0	Linear	0	0	0	0	0	0	0
System A3	0	0	Linear	0	Linear	0	0	0	0	0	0	0
System A4	0	0	Linear	0	Linear	0	0	0	0	0	0	0
Current system	225104	225104	Linear	220994	*Linear*	0	194937	2823705	2779882	2823705	2974819	**151115**
Improved agronomic 1	0	0	Linear	300	*Linear*	0	-14229	0	0	0	-14229	**-14229**
Improved agronomic 2	0	0	Linear	240	*Linear*	0	-3590	0	0	0	-3590	**-3590**
Improved agronomic 3	0	0	Linear	305	*Linear*	0	-14466	0	0	0	-14466	**-14466**
Nutrient management 1	0	0	Linear	1320	*Linear*	0	-62608	0	0	0	-62608	**-62608**
Nutrient management 2	0	0	Linear	310	*Linear*	0	-2899	0	0	0	-2899	**-2899**
Nutrient management 3	0	0	Linear	475	*Linear*	0	-22529	0	0	0	-22529	**-22529**
Tillage/residue management	0	0	Linear	950	*Linear*	0	-45059	0	0	0	-45059	**-45059**
Water management	0	0	Linear	210	*Linear*	0	-4070	0	0	0	-4070	**-4070**
Total Syst 1-10	225104	225104		225104								
Agric. Annual Total										**2823705**	**2805370**	**-18334**

Source: our calculations using EX-ACT (2010)

The EX-ACT module "inputs" also computes the changes in input (agro-chemicals) use corresponding to the changes in annual crop management. Improved annual crop management is expected to increase input use (table 7). Except for vegetables cropping systems, project activities may intensify the use of lime and chemical fertilizers as well as the use of pesticides for annual crops such as corn and beans, or semi-perennial crops (sugarcane). In these cropping systems, current agricultural practices are conducted at a very low technological level and often on degraded soils, turning out invariably to very low productivity rates. In these cases, inputs are needed to restore soil fertility and amend soil constrains to ensure a good environment for plant growing and to raise crop productivity. For vegetables crops, on the contrary, the business as usual intense and irrational use of agro-chemicals tend to be reduced by the project by promoting a rational fertilization with less use of chemical fertilizers and pesticides.

[8] 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.

Table 7: Use of agro-chemicals in cropland management

Type of Input	Consumption in m^3/year		
	Start	Without project	With project
Limestone	73.6	126.6	146.4
Dolomite	110.3	84.4	97.6
Urea	45.4	50.9	72.6
Chemical Nitrogen fertilizer	6.8	7.7	10.9
Phosphorus synthetic fertilizer	26.8	30.6	37.9
Potassium synthetic fertilizer	50.9	57.8	73.8

Source: project data

The results show that in the “with project” scenario, there will be an increase in the GHG emissions of 2,495 tCO_2e over 20 years: CO_2 emissions from lime and urea application (6% of the total), N_2O emissions from N application on managed soils[9] (28%), and CO_2e emissions from production, transportation, and storage of agricultural chemicals (66%).

Overall, improved cropland management will create a net C sink of 18,334 – 2,495 = 15,839 tCO_2e over 20 years.

4.6 Improved grassland management

The project will promote the restoration of *moderately degraded* grassland by improving pasture rotations (resulting in *non degraded* grassland) and supporting the production of sugar-cane forage (resulting in *improved* grassland *with inputs improvement*), as shown in table 8.

Table 8: Land use change related to the promotion of improved grassland management by the Rio Rural project (data in ha)

Initial state	Start	Without project	With project	Technology used	Final state
Moderately degraded	0	85	290	Improved through pasture rotation	Non degraded
Moderately degraded	0	21	401	Improved through sugar cane forage production	Improved with inputs improvement
Moderately degraded	691	585	0	System unchanged	Moderately degraded
Total	691	691	691		

Source: project data

[9] These exclude manure application which is taken into accounted in the “livestock” module.

Overall, this activity will involve 691 ha and is taken into account in the EX-ACT module named “grasslands”. It is considered that in the “with project” scenario, all 691 ha will be interested by the adoption of improved management practices, while this will happen only for 106 ha in the “without project” case. This is expected to create a mitigation potential: in fact, the change from moderately degraded to non degraded grassland (through the adoption of pasture rotation) implies a slight increase in C stock from 45.12 to 47 tC/ha; and the change from moderately degraded to improved with inputs improvement grassland (through the promotion of sugar cane production) implies a significant increase in C stock from 45.12 to 60.52 tC/ha. Therefore, this activity is expected to have an overall mitigation potential of 19,437 tCO_2e over 20 years, i.e. 28,1 tCO_2e/ha per year (table 9).

Table 9: C balance associated with improved grassland management

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
Grass-1	Pasture rotations	85	Linear	290	*Linear*	0	-1201	0	0	0	-1201	**-1201**
Grass-2	Sugarcane forage	21	Linear	401	*Linear*	0	-18235	0	0	0	-18235	**-18235**
Grass-3	Land equilibrium	585	Linear	0	*Linear*	0	0	0	0	0	0	**0**
Total Syst 1-10		691		691								
								Grassland total		0,0	-19437	**-19437**

Source: our calculations using EX-ACT (2010)

4.7 Improved feeding practices of dairy cattle

The project supports the adoption of improved feeding practices for dairy cattle. This is already practiced over 12% of the 421,000 dairy cattle heads bred in Rio de Janeiro State, but the project will increase this percentage to 20%. It is assumed that a slight improvement from 12 to 13% will occur in the “without project” case too (table 10). It is also assumed that the herd size is steady in both “with” and “without project” scenarios.

Table 10: Rate of adoption of improved feeding practices (% of heads)

	Start	Without project	With project
Feeding practices	12	13	20

Source: project data

The module “livestock” takes into account the mitigation effect (GHG reduction) consequent to the implementation of improved feeding practices. Smith et al. (2007) showed in fact 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. In the specific case of feeding practices, the default value of 6% reduction of CH_4 emissions is adopted.

Overall, livestock production is responsible for emitting: 11,139,660 tCO_2e over 20 years as CH_4 emissions from enteric fermentation; 176,820 tCO_2e over 20 years as CH_4 emissions from manure management; and 2,874,501 tCO_2e over 20 years as NO_2 emissions from manure management. Since the project is not introducing any change in livestock population, the same level of emissions will occur in both “with” and “without project” scenarios, so the C balance is equal to 0. Nevertheless, the project will have a mitigation effect determined by the adoption of the improved feeding practices as mentioned above, and quantified as 39,769 tCO_2e over 20 years (table 11).

Table 11: C balance associated with improved feeding practices of dairy cattle

Methane emissions from enteric fermentation

IPCC factor	Specific factor	Default Factor	Head Number: Start t0	Without Project: End	Without Project: Rate	With Project: End	With Project: Rate	Emission (t CO2eq) per year: Start	End: Without	End: With	Total Emission (tCO2eq) All Period: Without	All Period: With	Difference
		YES	421000	421000	Linear	421000	*Linear*	556983	556983	556983	11139660	11139660	**0**

Methane emissions from manure management

IPCC factor	Specific factor	Default Factor	Head Number: Start t0	Without Project: End	Without Project: Rate	With Project: End	With Project: Rate	Emission (t CO2eq) per year: Start	End: Without	End: With	Total Emission (tCO2eq) All Period: Without	All Period: With	Difference
		YES	421000	421000	Linear	421000	Linear	8841	8841	8841	176820	176820	**0**

Nitrous Oxide emissions f[redacted]nagement

IPCC factor	Specific factor	Default Factor	Annual amount of N manure* (t N per year): Start t0	Without Project: End	Without Project: Rate	With Project: End	With Project: Rate	Emission (t CO2eq) per year: Start	End: Without	End: With	Total Emission (tCO2eq) All Period: Without	All Period: With	Difference
		YES	29503.7	29503.7	Linear	29503.7	Linear	143725	143725	143725	2874501	2874501	**0.0**

Dominant Practice*	Factor	Percent of head with practices (0% =none;100%=all): Start t0	Without Project: End	Without Project: Rate	With Project: End	With Project: Rate	Emission (t CO2eq) per year: Start	End: Without	End: With	Total Emission (tCO2eq) All Period: Without	All Period: With	Difference
Feeding practices	0.060	12.0%	13.0%	Linear	20.0%	Linear	-4010	-4344	-6684	-85887	-125655	**-39769**
Specific Agents	0.030	0%	0%	Linear	0%	Linear	0	0	0	0	0	**0**
Management-Breed	0.020	0%	0%	Linear	0%	Linear	0	0	0	0	0	**0**
No Option	0.000	88%	87%	Linear	80%	Linear	0	0	0	0	0	**0**
								Total "Livestocks"		**14105095**	**14065326**	**-39769**

Source: our calculations using EX-ACT (2010)

4.8 Support to small agro-industry

The project supports the development of small agro-industry activities through funding the construction of the premises and the installation of equipment, which will also indirectly lead to increased electricity consumption (table 12).

Table 12: Construction and electricity consumption in support to agro-industry

Type of construction	Surface (m^2): Without project	Surface (m^2): With project
Housing (concrete)	0	10,380
Agricultural Buildings (metal)	9,600	10,800
Industrial Buildings (concrete)	4,300	10,540
	Electricity consumption (Mwh)	
Electricity Consumption	Without project	With project
	1,030	1,300

Source: project data

The effect of this set of activities on GHG emissions is computed in the module “other investments” and shown in table 13. Default GHG emissions factors used in the model (0.093 tCO_2e/MWh) come from the Electricity Information Database provided by the International Energy Agency (IEA) and reported by the US Department of Energy, while 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. 0.436 tCO_2e/m^2 for housing (concrete), 0.22 tCO_2e/m^2 for agricultural buildings (metal), and 0.825 for industrial building (concrete).

Overall, this set of activities represents a source of GHG emissions which has been computed by adding the GHG associated with electricity consumption to the GHG associated with infrastructure building, i.e. 468.8 + 9,937.7 = 10,406.5 tCO_2e.

Table 13: C balance associated with support to small agro-industry

Released GHG associated with Electricity Consumption							
Annual Electricity Consumption (MWh/yr)					Emission (t CO2eq)		
Start	Without Project		With Project		All Period		
t0	End	Rate	End	Rate	Without	With	
850	1030	Linear	1300	Linear	2049	2517	
	Sub-Total Without	2048,6	Sub-Total With	2517,4		Difference	468,8

Released GHG associated with building of infrastructure						
Type of construction	surface (m2)		Emission (t CO2eq)			
	Without	With	Without	With		
Housing (concrete)	0	10380	0,0	4525,7		
Agricultural Buildings (metal)	9600	10800	2112,0	2376,0		
Industrial Buildings (concrete)	4300	10540	3547,5	8695,5		
		Subtotal	5659,5	15597,2	Difference	9937,7

Source: our calculations using EX-ACT (2010)

4.9 Use of lime to fight soil acidification and sustainable use of agro-chemicals

The project supports the use of lime to combat soil acidification, common under these climatic conditions. This is taken into account in the module "inputs", together with the change in the use of agro-chemicals as a result of the adoption of improved annual crop management which has been already discussed in section 4.5.

4.10 Technical assistance for project implementation

Project implementation is expected to intensify the work of the 400 technicians currently operating in the 59 municipalities and 270 micro watersheds/rural communities that will be targeted by the project.

Overall, project activities are expected to triple total fuel consumption, from $189m^3$ to $630m^3$, resulting in significantly increased GHG emissions. In order to cope with this expected source of emissions, the project is expected to increase the use of ethanol as fuel source, thus reducing oil consumption. The project will in fact promote the use of cars equipped with a new technology which allows using 100% ethanol as fuel. It is expected that 40% of the cars used during project activities will be run with 100% ethanol, with the remaining 60% still running with 20% ethanol. This will imply that on the first year of the project 83 cars equipped with the new technology will be purchased, since 10% of the current 330 cars are already equipped with the proper technology. Fuel consumption "with" and "without" project, computed by taking into account the increased use of ethanol, is shown in table 14.

Table 14: Fuel consumption related to technical assistance for project implementation

Type of fuel	Consumption in m^3/year		
	Start	Without project	With project
Gasoline	7.60	7.60	15.12
Ethanol	1.89	1.89	16.38

Source: project data

The increase in fuel consumption will increase the level of GHG emissions consequent to fuel burning (table 15). EX-ACT 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)[10], therefore overall GHG emissions from fuel consumption will increase by 579 tCO_2e.

Table 15: C balance associated with technical assistance for project implementation

Released GHG associated with Fuel consumption (agricultural or forestry machinery, generators...)										
				Annual Fuel Consumption (m3/yr)					Emission (t CO2eq)	
Type of Fuel	Default value t CO2 /m3	Specific Value	Default Factor	Start	Without Project		With Project		All Period	
				t0	End	Rate	End	Rate	Without	With
Gasoil/Diesel	2,63		YES	0	0	Linear	0	Linear	0	0
Gasoline	2,85		YES	7,56	7,56	Immediate	15,12	Immediate	431	862
Ethanol		0,510	NO	1,89	1,89	Immediate	16,38	Immediate	19	167
				Sub-Total Without	450,4	ub-Total With	1029,3		Difference	578,9

Source: our calculations using EX-ACT (2010)

This calculation does not take into account the emissions related to the construction and transportation of new cars as it is reasonably assumed that the cars will be produced even without this project. Also, the coefficient used for the 100% ethanol fuel represents the emission occurring during sugar cane cropping, harvest and ethanol production. Avoided emissions from biomass and electricity surplus, as well as from ethanol use were not taken into account here. The coefficient also does not account for the land-use changed potentially induced by sugar-cane cropping. If some studies carried out in the US on corn-based 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), in Brazil this seems not being the case as sugar-cane production is concentrated in the Centre-South of the country and its impact on Amazonian deforestation is not so obvious.

[10] 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.

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 fact able to sequester 0.86 $MtCO_2e$ while emitting 0.01 $MtCO_2e$ so that the net effect of project activities is to create a sink of 0.85 $MtCO_2e$ (table 16). Since total project area amounts to 227,811 ha, the average mitigation potential of the project is equal to 0.2 tCO_2e per ha per year.

Table 16: C-balance of the Rio Rural project

C-balance elements	Mt	EX-ACT modules
Total GHG mitigated	-0.86	Avoided deforestation, afforestation, cropland management, agro-forestry, grasslands, livestock, other land use change
Total GHG emitted	0.01	Inputs, other investments
C-balance	-0.85	Project is a C sink

Source: our calculations using EX-ACT (2010)

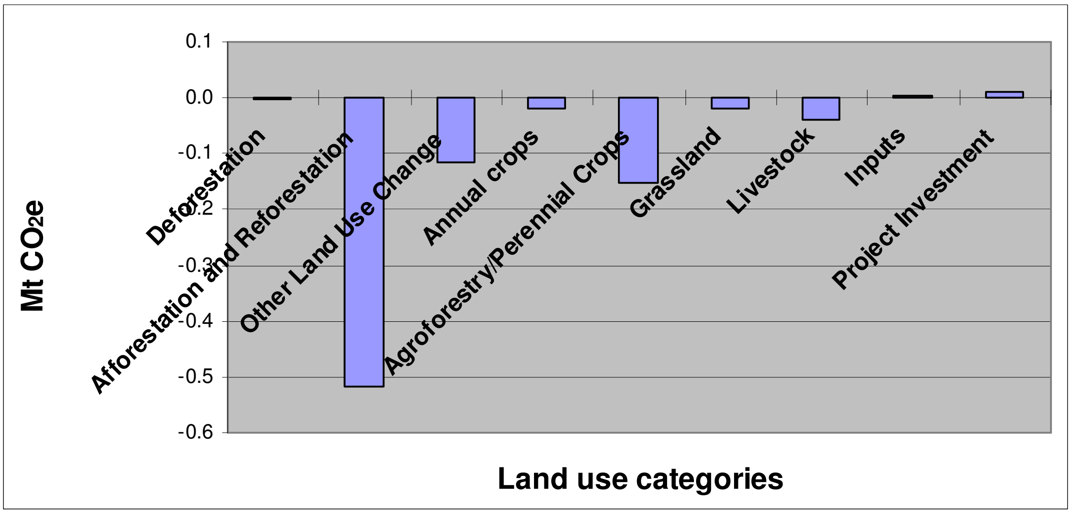
Most mitigation potential is related to changes in the expansion of land under forest cover through forest regeneration and plantation of native forests (59.7%) and to the expansion of agro-forestry systems (17.6%) as shown in table 17 and figure 3.

Table 4.17: Mitigation impact of the Rio Rural project, by EX-ACT module

EX-ACT modules	Mt	% of total GHG mitigated	% of total GHG emitted
Deforestation	-0.004	0.5	-
Afforestation and Reforestation	-0.517	59.7	-
Other Land Use Change	-0.114	13.2	-
Annual crops	-0.018	2.1	-
Agroforestry/Perennial Crops	-0.153	17.6	-
Grassland	-0.019	2.2	-
Livestock	-0.040	4.6	-
Total GHG mitigated	-0.866	100.0	-
Inputs	0.002	-	18.5
Project Investment	0.011	-	81.5
Total GHG emitted	0.013	-	100.0
C-balance	-0.85	-	-

Source: our calculations using EX-ACT (2010)

Figure 3: Mitigation potential of the Rio Rural Project, by EX-ACT module



Source: our calculations using EX-ACT (2010)

This is essentially the effect of the activities aimed at enhancing the areas of permanent protection: establishment of the Legal Reserves, protection of springs and streams, expansion of agro-forestry systems especially in these areas – as shown in table 18 which takes into consideration the mitigation potential by project activity. This set of activities is also responsible for the most relevant change in land use promoted by the project: from grasslands to forest/plantation and, above all, from degraded land to forest/plantation and perennials (figure 4).

Table 18: Mitigation potential of the Rio Rural project, by project activity

Project activities	Mt	% of total GHG mitigated	% of total GHG emitted
Protection of springs and streams and support to the establishment of the Legal Reserves	-0.52	60.6	-
Expansion of agro-forestry systems	-0.27	31.1	-
Improved annual crop management	-0.02	2.1	-
Improved grassland management	-0.02	2.3	-
Improved feeding practices of dairy cattle	-0.04	4.6	-
Total GHG mitigated	-0.86	100.0	-
Support to small agro-industry	0.010	-	94.7
Technical assistance for project implementation	0.001	-	5.3
Total GHG emitted	0.011	-	100.0
Total C balance	-0.85	-	-

Source: our calculations using EX-ACT (2010)

Figure 4: Land use matrix of the Rio Rural Project

Without Project			FINAL							
			Forest/ Plantation	Cropland			Grassland	Other Land		
				Annual	Perennial	Rice		Degraded	Other	Total Initial
INITIAL	Forest/Plantation		0	0	0	0	6,2	0	0	6
	Cropland	Annual	0	225104	0	0	0	0	0	225104
		Perennial	0	0	0	0	0	0	0	0
		Rice	0	0	0	0	0	0	0	0
	Grassland		0	0	0	0	691	0	0	691
	Other Land	Degraded	0	0	0	0	0	2010	0	2010
		Other	0	0	0	0	0	0	0	0
		Total Final	0	225104	0	0	697	2010	0	227811

With Project			FINAL							
			Forest/ Plantation	Cropland			Grassland	Other Land		
				Annual	Perennial	Rice		Degraded	Other	Total Initial
INITIAL	Forest/Plantation		6,2	0	0	0	0	0	0	6
	Cropland	Annual	0	225104	0	0	0	0	0	225104
		Perennial	0	0	0	0	0	0	0	0
		Rice	0	0	0	0	0	0	0	0
	Grassland		0	0	0	0	691	0	0	691
	Other Land	Degraded	910	0	1100	0	0	0	0	2010
		Other	0	0	0	0	0	0	0	0
		Total Final	916,2	225104	1100	0	691	0	0	227811

Source: our calculations using EX-ACT (2010)

6. SENSITIVITY ANALYSIS

6.1 Main parameter sensitivity

A sensitivity analysis has been carried out in order to determine how EX-ACT is "sensitive" to changes in the value of the main parameters.

In the model, average climate is considered as *tropical* 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* and *wet* 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 19) show that a change in moisture regime from moist to dry 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 contrary, a change in moisture regime from moist to wet will increase total mitigation potential as a consequence of the accelerated biomass growth caused by increased water availability in the root zone. A change in soil characteristics (from LAC to HAC) will also 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 very limited (between -6 and +11%), showing that the model is well calibrated.

Table 19: Parameter sensitivity for the Rio Rural project

Climate	Moisture regime	Soil	Results	
			Final balance	Change
			$MtCO_2e$ mitigated	%
Tropical	Moist	LAC	0.85	-
Tropical	Dry	LAC	0.80	-6
Tropical	Wet	LAC	0.94	11
Tropical	Moist	HAC	0.93	10

Source: our calculations using EX-ACT (2010)

6.2 Scenario sensitivity

A second level of sensitivity analysis is conducted to deal with the uncertainty of the results caused by the uncertainty of data used to perform the analysis. Therefore, by changing the values of variables related to project implementation and land use change and management, two different scenarios are built here: one more “pessimistic” and a second one more “optimistic” with respect to the main scenario outlined above, so that an intermediate scenario is built (“most likely” scenario).

The “pessimistic” scenario is built considering that the rate of adoption of the agricultural practices proposed by project activities among farmers could be lower than 100% (as implicitly assumed in the main scenario) because of the extra investment needs in terms of capital and labour. Therefore, in the “pessimistic” scenario, it is assumed that the rate of the adoption of some of the practices with more capital and labour requirements is 50%. The results show that the mitigation potential of the Rio Rural project in the “pessimistic scenario” is equal to 0.52 MtCO2e, corresponding to a 39% reduction with respect to the main scenario.

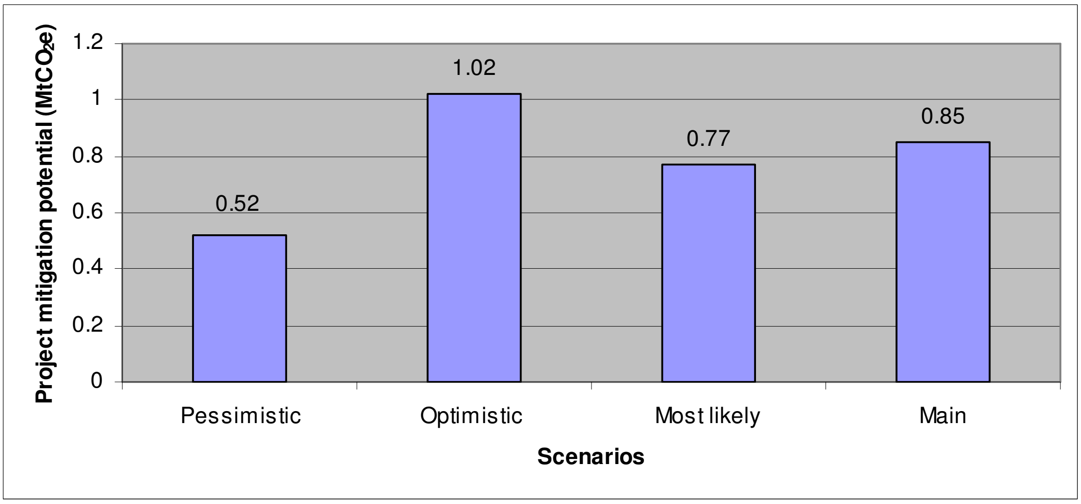
The “optimistic” scenario has been built by taking into account that the Rio Rural project is also planning to rehabilitate rural roads in many areas. As already mentioned, this activity is not considered in the main scenario because of lack of precise data. It is expected that recovering and maintaining 1,300 Km of rural roads will produce socio-economic benefits in terms of reduced transportation costs and increased people mobility, but it may also have environmental benefits as overall reduction of GHG emissions in the long run: road rehabilitation will temporarily increase fuel consumption as a result of the construction work, but in the end it will reduce erosion and GHG emissions from soil degradation. Also, roads in better conditions will lower fuel consumption and relative GHG emissions[11]. In the same scenario it is also assumed that

[11] It is interesting to note that road maintenance would also improve water quality by reducing sediments from erosion, thus decreasing the amount of chemicals used to treat water and the GHG emissions

the expansion of the improved feeding practices in livestock production will be higher than expected (50% of heads with practices instead of 20% as hypothesised in the main scenario), therefore the additional technical mitigation of this activity will be higher. The results show that the mitigation potential of the Rio Rural project in the "optimistic scenario" is equal to 1.02 $MtCO_2e$, corresponding to a 20% increase with respect to the main scenario.

It is therefore estimated that the Rio Rural project will "most likely" be able to mitigate 0.77 $MtCO_2e$, computed as the average of the "optimistic" and "pessimistic" scenarios (figure 5). It is interesting to note that this value is close to what has been estimated in the main scenario (0.85 $MtCO_2e$), showing the robustness of the results outlined above.

Figure 5: Scenario sensitivity analysis for the Rio Rural project



Source: our calculations using EX-ACT (2010)

7. ECONOMIC ANALYSIS

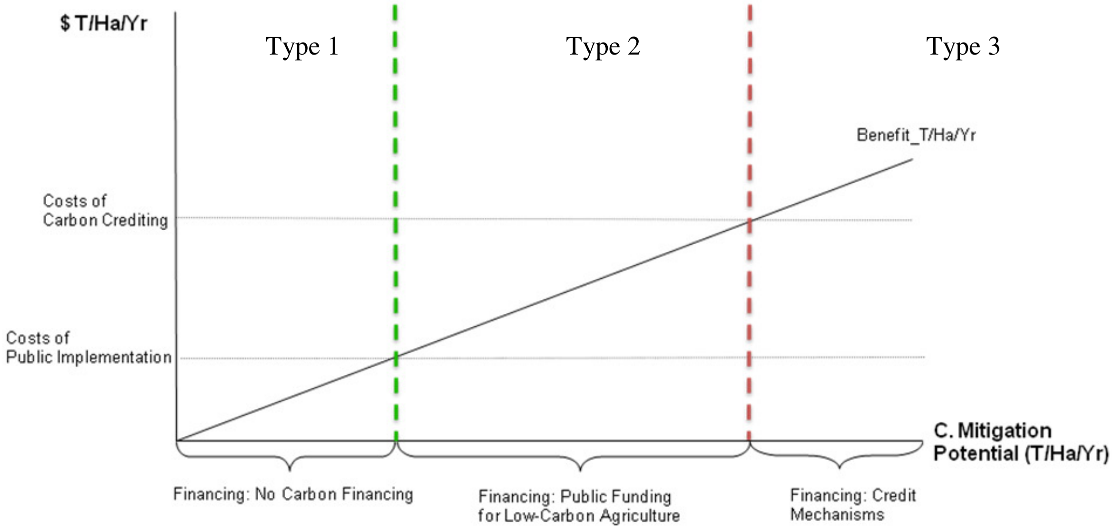
The average mitigation potential of the project is equal to 0.19 tCO2e/ha per year. It could be valued using a price of 3 US$/tCO2e, which is the average C price for agricultural soil C at retail level on the voluntary C market in 2008 (Hamilton et al. 2009). Therefore, the value of the average mitigation potential of the project amounts to 0.57 US$/tCO2e (per hectare and per year). Since this value is below the level of transaction cost for public implementation (4 US$/tCO2e)[12], the project would not have

associated with the production and use of such chemicals. Nevertheless, this type of indirect effects is not taken into account here.

[12] 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 should be highlighted that these environmental benefits could be eventually included into Payments for Ecosystem Services (PES) bundled schemes, together with watershed protection and biodiversity conservation benefits, for a public (or mixed public-private) financed initiative.

8. CONCLUSIONS

The analysis of the ex-ante carbon-balance results shows that the Rio Rural project can mitigate 0.85 MtCO_2e while increasing small-scale farming productivity and competitiveness essentially through the adoption of integrated and sustainable farming systems approaches (e.g. protection of springs and streams, support to the establishment of Legal Reserves, expansion of agro-forestry systems, improved annual crop and grassland management, improved cattle feeding practices, support to small agro-industry and sustainable use of agro-chemicals).

EX-ACT could 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.

This process could be applied to the Rio Rural project in order to increase its overall mitigation potential. The mitigation benefits of the Rio Rural project could be already taken into consideration in a public funded PES initiative, possibly together with other positive externalities of the project (e.g. biodiversity conservation, watershed protection). Nevertheless, the project could expand support to implement Legal Reserves and Areas of Permanent Preservation – which are in fact among the activities which contribute most to determine the mitigation potential of the SC Rural project. For historical reasons, most agricultural properties in the State of Rio de Janeiro, as in most regions across the country, are currently not meeting the legislation[13] which requires maintaining forest cover in sensitive areas (riversides, high slopes) as well as in 20% of agricultural properties' total area.

This extended support to forest conservation and land rehabilitation would be a combination of efforts from activities undertaken in both components 1 (technical assistance and financial incentives to farmers who do not comply with the legal requirements) and 2 (through a long-term financing mechanism for sustainable rural development activities). The project would help address this situation in a pragmatic manner, promoting a gradual process towards a higher level of compliance through the implementation of economically feasible measures:

(i) Component 1 (areas already considered in current EX-ACT analysis), by requiring sub-project beneficiaries to fully protect existing forests and implement environmentally-sound practices that facilitate forest regeneration in degraded areas (e.g. fencing of riparian areas) through financial incentives, environmental awareness-raising and the production of seeds of native tree species; and

(ii) Component 2 (areas not yet included in EX-ACT analysis), by supporting the creation of a long-term financing mechanism for sustainable rural development activities, including up scaling the establishment of Legal Reserves to a bigger number of farmers. In fact, national legislation foresees that in less then two years all farmers should be complying with the legal requirements and many small farmers will be asked to enroll in the national program aimed specifically at assisting small farmers to comply with this legislation (*Mais Ambiente* - Decree 7029/09). The Rio Rural project would therefore help farmers to enroll in this national program through rural extension and new financing mechanism for sustainable rural development activities.

The Rio 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.

[13] The already mentioned federal legislation on *Areas de Preservação Permanente* and *Reserva Legal* (addendum 2166-67 to Federal Law 4771/65, CONAMA Resolution 369/06, Decree 6514/08 e and other related Normative Instructions issued in 2009)

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	

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English	An application to the Rio de Janeiro Sustainable Rural Development 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

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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
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10. Training path	**Investment planning for rural development**
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