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ANALYTICAL TOOLS

EASYPol Module 263

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

Irrigation and Watershed Management Case Study in Madagascar

Provisional version

EASYPol

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

Irrigation and Watershed Management Case Study in Madagascar

by

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About EASYPol
EASYPol is a multilingual repository of freely downloadable resources for policy making in agriculture and rural development and food security. The EASYPol home page is available at: ***www.fao.org/easypol***. EASYPol has been developed and is maintained by the Policy Assistance Support Service, FAO.

Acknowledgements

This module is part of a set of documents which aim at providing support to 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 Programme in Madagascar, which was selected to test the software.

The analysis described in the module is the result of the work of a team of professionals from FAO: Louis Bockel, Economist, group leader of the EX-ACT team; Martial Bernoux, FAO Consultant from IRD, main designer of the software; Giacomo Branca, Project analyst and Economist; Hermann Pfeiffer, Project formulation expert for the Tanzania case; and Marianne Tinlot, case study practitioner.

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Table of contents

1. SUMMARY

This module presents a Case Study of a Carbon-Balance Appraisal for an investment programme. It is useful for people who wish to improve their skills on how to estimate the climate change mitigation potential of agricultural programmes/projects and how to integrate it into the economic analysis of projects.

This case is part of a set of documents which intend to provide support project developers in the process of learning and applying the EX-Ante Carbon balance Tool (EX-ACT). More specifically, the EX-ACT application was tested on a FAO Programme in Madagascar and the results are demonstrated in this Case Study, which consists of a brief description of the project, guidelines for structuring project data and an appendix with project data.

2. INTRODUCTION

Objectives

The main objective of this module is to illustrate 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 a real case faced by Carbon Balance Appraisal, it can be used in a training course, where it is not possible to organize field visits to gather data for a practical application of the EX-ACT software.

Target audience

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

Readers can download the EX-ACT Tool and related flyer[1]. Links are included in the text to other EASYPol modules or references[2]. See also the list of EASYPol links included at the end of this module.

[1] EASYPol Module 210: ***EX-ACT tool*** ***EX-ACT Brochure***

[2] EASYPol hyperlinks are shown in blue, as follows:
a) training paths are shown in **underlined bold font**
b) other EASYPol modules or complementary EASYPol materials are in ***bold underlined italics***;
c) links to the glossary are in **bold**; and
d) external links are in *italics*.

Analytical steps of Carbon-balance ex-ante appraisal

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

i) 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, ...)

ii) Estimation of project Carbon-balance using EX-ACT

iii) Description of the scenarios, analysis of the results, and economic analysis.

3. PROJECT DESCRIPTION

This Case Study illustrates the use of the Ex-Act Software in the analysis of a rural development project.

3.1. Background

Country information. Madagascar is a southern African island in the Indian Ocean, located to the east of Mozambique. With a total area of 587,041 km^2, it is divided into 22 regions (faritra). The estimated population for 2009 is about 20,7 million inhabitants (CIA, 2010) 29% of whom live in urban areas.

Agriculture, Rice and Irrigation. Agriculture forms the foundation of Madagascar’s domestic economy. It contributes to about one third of the total GDP and to 40% of total exports. About three quarters of the population depend on agriculture for their livelihood. About one-half of Madagascar includes cultivable land, but little more than 5% of the land is currently used for crops, with a large part of the cultivated area used for irrigation (about 40%). Rice is the main staple crop, accounting for 70% of total farm output.

Land degradation, natural resources and land development. Land degradation is one of the most serious and widespread problems for the agricultural sector in Madagascar. The degradation dynamics in the uplands and lowlands are often linked and undermine each other. With the stagnation of yields in the irrigated lowland areas and demographic growth, farmers have extended their agricultural activities to the hillsides. Upper watershed land use is often based on extensive and unsustainable management practices, the most important being the lack of erosion control and lack of soil fertility management on agricultural plots, slash and burn agriculture (*tavy)*, and the frequent burning of pastures.

Land degradation is also caused by deforestation for agricultural purposes, causing increased carbon emissions, biodiversity loss and declining regulatory ecological services. These practices not only contribute to the degradation and low productivity of highland areas but also have a significant impact on lowland agriculture. Highland soil erosion and water surface run-off also cause sedimentation for downstream infrastructure, contributing to the reduction of cultivated, irrigated areas, local flooding of rice paddies in rainy seasons and water shortages in dry seasons.

In this situation, the **Irrigation and Watershed Management Project** intends to accelerate economic growth in rural areas, through an integrated effort aimed at increasing productivity in high potential production zones that benefit from public irrigation systems. Watersheds form integrated geographical management units with irrigation schemes: failure to address synergies between the two has lead to missed opportunities and reduced returns on investments. This project proposes to address the productivity of agriculture in both the irrigated lowland areas and rainfed watersheds, while capturing the environmental externalities associated with a more sustainable land use and management. The integrated design of the project is based on similar projects in Madagascar financed by FAO and Agence Française de Développement (AFD), and on an Africa Land and Water Initiative pilot project in Anjepy.

3.2. **Project characterization**

Irrigation investment operations in Madagascar have had mixed experiences. While investments were generally justified in terms of increase in production, sustainability has been far from sure. The project focuses on increased production and higher value, but in particular on translating higher income into better maintenance of infrastructure through capacity strengthening and improving governance of hydraulic assets. In addition, the project invests in upper watersheds to promote sustainable land use practices, which are expected to deliver higher production of rainfed agriculture, while at the same time reduce sedimentation and thus reduce maintenance costs. The project thus adopts a three-pronged strategy: (i) increase production and farmers' income, (ii) set up mechanisms for sustainable irrigation maintenance; and (iii) reduce irrigation maintenance costs. The strategy is based among others on the experience of the BV-Lac project in PC15/Marianana (Lac Alaotra) and the GTZ-funded project in Marovoay.

The development objective of the Project is to establish the basis for viable irrigated agriculture and natural resources management in four rural 'growth poles': (i) Andapa (Sava Region), (ii) Marovoay (Boina Region), (iii) Itasy Region, and (iv) Lac Aloatra (Alaotra Mangoro Region). These four zones are characterized by medium- and large-scale public irrigation where a number of conditions have been met to ensure a rapid kick-off of growth, including relatively easy access by road, and better access to finance, inputs, markets and equipment.

The total cost of the project is estimated at US$40.5 million, to be financed by IDA, GEF and beneficiaries. The project covers about **134,200 ha, organised as follows:** irrigated rice = 21,800 ha; annual crops = 12,400 ha; watershed landscape = 100,000 ha; grassland = 40,000 ha; degraded land = 25,000 ha; and forestry shrubland = 35000 ha. .

The proposed project will be implemented over a period of 10 years and will comprise the three technical components covering major strategic orientations:

(i) Development of Commercial Agriculture;

(ii) Irrigation Development;

(iii) Watershed Development;

Table 1: Overview of the project

N.beneficiaries	30,000 households (at full implementation)
Duration	Implementation phase: 10 years Capitalization phase: 10 years
Budget	40.6 Millions US$ - Comp.1 Development of commercial agriculture (13 M.) - Comp.2 Irrigation devt (17.8 M) - Comp.3 Watershed development (5.2 M) - Comp.4 Programme Management + others (4.6 M)
Areas targeted	21,800 ha of irrigated rice 12,400 ha of other annual crops, 75,000 ha of watershed landscape

The table below provides a land use situation in with and without project situations. It corresponds to the basic data required to appraise the carbon balance of the proposed project. It can be useful for practitioners who want to use the case study as a practical exercise.

Table 1 bis: Basic data to enter in the EX-ACT tool within the proposed project

Annual rainfed cropping - ha	start	without project	with project	used technics
system 1 – unchanged	12400	12400	0	residue burning
system 2 – improved	0	0	7700	zero-tillage residue management
Total	12400	12400	7700	
Annual off-season cropping – ha	**start**	**without project**	**with project**	
system 3 – improved	0	0	4700	improved irrigation
Total	0	0	4700	
Rice flooded – ha	**start**	**without project**	**with project**	
system 1 – unchanged	13080	13080	9156	continuously flooded during cultivation
system 2 – improved	0	0	3924	SRI interim flooded
Total	13080	13080	13080	
Forestry – ha	**start**	**without project**	**with project**	
slow down <u>deforestation</u>: evolution of forest area	35000	29000	31000	forest 4
afforestation on degraded	0	0	2250	plantation 2

land				
Total	35000	29000	33250	
Grassland	**start**	**without project**	**with project**	
Degraded grasslands	40000	40000	37500	
Improved grasslands	0	0	2500	with inputs improvement
Degraded land	**start**	**without project**	**with project**	
Unchanged Degraded land	25000	25000	25000	
Degraded land to perennial			1500	
Irrigation – ha	**start**	**without project**	**with project**	
Hand moved sprinkle		0	4700	
Total		0	4700	
Inputs	**start**	**without project**	**with project**	
urea	200	200	1111	
phosphorous	92	138	625.6	
herbicides	5	5	37	
DAP (T)	200	300	1,360	

4. 4. Measuring the Mitigation Potential of the Project: An Application of EX-ACT

This section describes the effects of project activities on GHG emissions and C sequestration indicating the overall impact on the C balance, computed using EX-ACT. The analysis takes into account the three components presented before which supports all technical activities foreseen by the project, and which is therefore expected to have a relevant impact on the carbon balance:

- Reducing the current deforestation
- Widening forested areas
- Developing agroforestry
- Improving annual crops
- Improving rice crops
- Restoring grasslands
- Improving land with inputs
- Investing in some irrigation system

The project foresees to develop forestry areas by reducing the current deforestation rate and by restoring degraded lands with tree plantations. It should allow for the protection of watersheds by reducing erosion and sedimentation, but also by sequestrating carbon, which should impact positively on carbon balance.

The project will also promote the adoption of improved agricultural practices in annual crops which should allow for both an increase in yields and a reduction in carbon emissions. Improving annual crops is expected through sustainable intensification and diversification of irrigated and rainfed agricultural systems in the project's watersheds. Improved practices will consist mainly in adopting new measures in irrigation and also foster the abandon of the tillage practice.

These activities should ensure an increase in productivity in a conservative approach that strengthens the management of natural resources to improve the environment and living conditions. It should generate substantial financial and economic benefits.

Due to the broad land cover of the project, data entered to describe the climate pattern and soil properties, do not take into account the large inter and intra regional variability of pedo-climatic conditions. The climate is described as *Tropical*, with a Mean Annual Temperature (MAT) of *22°C* and under a *Moist* moisture regime. These settings correspond to average temperatures and rainfalls for the country. We chose to describe the area soil type as *LAC* (Low Activity Clays), the most representative type for the country.

As mentioned above, the project will be implemented over a 10-year period. The carbon accounting method also integrates a capitalisation phase (10 years) which should cumulate to 20 years when summed to the project implementation phase.

A complete description of the activities carried out and the corresponding EX-ACT analysis is provided below.

4.1. **Decreasing the rate of deforestation**

The project covers 35,000 ha of tropical shrublands. Most of time deforestation leads to degraded lands making watersheds more vulnerable to any impact due to climate change. Without the intervention of a project it is expected that the forested area will decrease by about 17%. With the project, it is expected that only 11% of the current forests will be deforested. This activity is taken into account in the "***deforestation***" EX-ACT module. Thus, deforestation has been entered to show a slow down of **2,000 ha** due to the project that should ensure a reduction in carbon emissions. Changes are considered as *linear* in both scenarios.

Table 2: Screendump of the EX-ACT "deforestation" module

	Conversion details (Harvest wood product exported before the conversion, use of fire, final use after conversion)						
	Vegetation Type	HWP bifore		Fire use		Final Use after	Biomass
Name		tonne	t C exported	yes/no	% released	deforestation	1 yr after
Defor. 1	Forest4	0	0	NO	0	Degraded	1.0

...

GHG emissions									
Vegetation Type	Forested Area (ha)					Area deforested (ha)		Biomass loss	
	Start	Without Project		With Project		Without	With	Without	With
	t0	End	Rate	End	Rate			tCO2	tCO2
Defor. 1	*35000*	*29000*	*Linear*	*31000*	*Linear*	6000	4000	1093620	729080

4.2. Widening forested areas

This activity concerns watershed areas and is accounted in EX-ACT in the "***afforestation/reforestation***" module. On the one hand, the project is expected to take a lead in planting **2,500 ha** of tropical moist deciduous forest (called *plantation 2* in EX-ACT) that would have been remained as degraded lands if no project was implemented. It should tackle soil degradation, act on water management for lowlands and mitigate climate change.

Table 3: Screen dump of the EX-ACT "afforestation/reforestation" module

	Conversion details (Previous land use, use of fire before afforestation/reforestation,...)					
Name	Vegetation Type	Previous use before afforestation/reforestation	Burnt before conversion	Default Biomass	Specific Biomass	Soil k_{soil}
A/R1	Plantation1	Set Aside	NO	5.0		0.82
A/R2	Plantation2	Degraded Land	NO	1.0		0.33
A/R7	Degraded land	Degraded Land	NO	1.0		0.33

GHG emissions							
Vegetation Type	Afforested or reforested Area (ha)					Area afforested (ha)	
	Start	Without Project		With Project		Without	With
	t0	End	Rate	End	Rate		
A/R1	*0*	*0*	*Linear*		*Linear*	0	0
A/R2	*0*	*0*	*Linear*	*2250*	*Linear*	0	2250
A/R7	*0*	*0*	*Immediate*	*0*	*Immediate*	0	0

4.3. 4.3 Developing agroforestry areas

Within the watershed component of the project, **1,500 ha** of degraded lands will be converted into an agroforestry plantation of coffee. This will be accounted among the "***other land use change***" module in EX-ACT as follows:

Table 4: Screen dump of the EX-ACT "other land use change" module

		Description of LUC	
Name	**Your Nam**	**Initial Land Use**	**Final Land Use**
LUC-1	Coffe	Degraded Land	Perennial/Tree Crop

GHG emissions												
Vegetation Type		**Area concerned by LUC**				Biomass Change		Soil Change		**Total Balance**	
		Without Project		**With Project**		Without	With	Without	With	Without	With
		Area	Rate	Area	Rate	tCO2	tCO2	tCO2	tCO2	tCO2	tCO2
LUC-1	Coffe	*0*	*Linear*	*1500*	*Linear*	0	-8800	0	-179644	0	-188444

In this case, the development of agroforestry on previous degraded lands will cover the soil hence avoiding soil degradation and implies gains of biomass. This agroforestry activity will also be automatically implemented in the ***perennial*** EX-ACT module. Thus the tool takes into account both the land use change impact on carbon balance and the expected storage of carbon in soil by this plantation of coffee.

4.4. Improving annual crops

The totality of the **12,400 ha** of annual crops covered by the project will be improved. This activity is taken into account in the "***annual***" EX-ACT module. Two kinds of improvements are foreseen within the project: i) the water management for the annual off-season cropping, and ii) the no tillage management for the annual rainfed cropping. Moreover, the practice of burning residues will be abandoned by the project. Thus, three types of annual systems (unchanged rainfed agriculture, improved, off-season) are reported in the EX-ACT module as follows and are expected to both reduce carbon emissions and store carbon in the soil:

Table 5: Screen shot of the "annual" EX-ACT module

	Your description	Improved agro-nomic practices	Nutrient management	NoTillage/residue management	Water management	Manure application	Residue/Biomass Burning	tonnes dm/ha
Annual System1	**Rainfed agriculture**	NO	NO	NO	NO	NO	YES	10
Annual System2	**Conservation Agr**	NO	NO	YES	NO	NO	NO	10
Annual System3	**Off-Season cropping**	NO	NO	NO	YES	NO	NO	10

Mitigation potential					
Vegetation	Areas				
Type	Start	Without project		With Project	
	t0	End	Rate	End	Rate
Annual System1	12400	*12400*	*Linear*	*0*	*Linear*
Annual System2	0	*0*	*Linear*	*7700*	*Linear*
Annual System3	0	*0*	*Linear*	*4700*	*Linear*

The off-season cropping will benefit from an investment of drip irrigation system that will be accounted in the "*investment*" EX-ACT module as follows:

Table 6: Screen shot of the "investment" EX-ACT module

Released GHG associated with installation of irrigation systems			
Installation of irrigation system	surface (ha)	Type of irrigation syster	Associated tCO2eq
Without Project	0	Hand moved sprinkle	0.0
With Project	4700	Trickle	1463.1

Within EX-ACT, each improved practice implies a corresponding mitigation potential. The biggest potential in our case comes from the adoption of improved water management, followed by no tillage/residue management (Table 6). Both CH_4 and N_2O emissions are converted in eq-CO_2 to calculate the impact of the practice of burning crop residues.

Table 7: Coefficients used in EX-ACT

	Practise				
	Water management	NoTillage/residue management	**Residue/biomass burning**		
			CH4 kg	N2O kg	t eq-CO2
Corresponding mean potential in t eq-CO_2 /ha/yr	1.14	0.7	22	0.56	0.6

The coefficient used represents annual soil carbon change rate for a 20-year time horizon in the top 30 cm of the soil.

4.5. Improving rice crops

This activity is reported in the "***rice***" EX-ACT module. The project covers 21,800 ha of non-upland rice but only **13,080 ha** will be improved. It will proceed progressively during implementation phase (option used: *linear* adoption dynamic). The improvements foreseen by the project with mitigation impact are focused on water management. Indeed, if irrigation is found to have the strongest positive impact on rice yields, then rice crops are one of the most important source of methane release in the atmosphere when the soil if full of water.

The organic amendment remains similar (farm yard manure) with the adoption of the project. Three types of rice are considered as follows:

Table 8: Rice systems

Rice system	Cultivation period	During the cultivation period	Before the cultivation period
Conventional water management	180 days	Continuously flooded	Non flooded preseason (>180 days)
Water improvement		Intermittently flooded	Non flooded preseason (<180 days)
Unchanged management	150 days	Continuously flooded	Non flooded preseason (>180 days)

On the one hand, there will be less rice cropped under "conventional water management" in favour of the development of a new cropping system called "water improvement" that adopts the techniques of the SRI system (consisting in planting single seedlings instead of multiple seedlings in a clump to increase root growth, and not keeping irrigated paddy fields flooded during the rice plants' vegetative growth stage). By reducing the surface that is continuously flooded it is expected that the carbon balance will improve in comparison to the situation without project. The last type of rice corresponds to the areas that remain without any improvements (Table 9). Thus this last rice system does not act on carbon balance as no changes are foreseen, but it is accounted to keep a balanced surface.

Table 9: Areas of the different rice systems

Rice system	Start (ha)	Without (ha)	With (ha)
Conventional water management	13,080	13,080	9,156
Water improvement	0	0	3,924
Unchanged management	8,720	8,720	8,720

Table 10: Print screen of the EX-ACT "rice" module

CH4 emission from rice systems					
Areas (ha) of the different options					
	Start	Without Project		With Project	
Type	t0	End	Rate	End	Rate
…					
Rice1	*13080*	*13080*	*Linear*	*9156*	*Linear*
Rice2	*0*	*0*	*Linear*	*3924*	*Linear*
Rice3	*8720*	*8720*	*Linear*	*8720*	*Linear*

The water regime reflects the potential methane emissions due to anaerobic decomposition of organic matter as shown below:

Table 11: Coefficients used in the EX-ACT "rice" module

Rice system	Water regime during the cultivation period	Water regime before the cultivation period	Rate (t)	CH_4 IPCC coefficient kg/ha/day
Conventional water management and unchanged management	Continuously flooded	Non flooded preseason (>180 days)	5.5	1.24
Water improvement	intermittently flooded	Non flooded preseason (<180 days)		1.02

4.6. Restoring grassland

The restoration of grassland is covered in the "***grassland***" module. The current option of improving **2,500 ha** on grasslands with the project stays a low target option which leaves over 90% of grasslands degraded. Grasslands are expected to be moderately degraded. The 2,500 ha will be improved by the use of different inputs: including rotational grazing, using fire control, enrichment planting with fodder grasses and legumes.

Table 12: Screen shot of the EX-ACT grassland module

Description of Grassland type, their management and areas (ha)							
Name of the Systems		Succession type		Fire used to manage			
			Final state	Without project		With project	
Default	Your name	Initial state	without or with project	Fire*	Frequency	Fire	Frequency
Grass-1	degraded	Moderately Degraded	Moderately Degraded	YES	5	YES	5
Grass-2	improved	Moderately Degraded	Improved with inputs improvement	YES	5	NO	5

Default	Start (refers to initial state) t0	Without project End	Without project Rate	With Project End
…				
Grass-1	40000	40000	Linear	37500
Grass-2	0	0	Linear	2500

By improving grasslands through the project it is expected that more carbon will be sequestered hence there will be an improvement in the carbon balance.

The coefficients applied in the EX-ACT module are the followings:

Table 13: Grassland coefficients

Avalaible options for Grassland	Soil C (tC/ha)
Moderately Degraded	62.4
Improved without inputs management	75.4

Default Biomass Aboveground in t dm /ha	Combustion % released of prefire dm	CH4 (kg GES / tonne dm)	N2O (kg GES / tonne dm)	tCO2eq for one combustion
6.2	0.77	2.3	0.21	0.541

4.7. Improving lands with inputs

Aggregated needs in inputs accounted in the "***input***" module have been estimated for the whole project, Table 14.

Table 14: Use of inputs

Inputs used per year	Start	Without project	With project
Urea (T)	200	200	1,111
DAP (T)	200	300	1,360
Pesticides (herbicides) (T)	5	5	37

The different fertilizers do not have the same emission potential, which depends on the molecule that contains N and P in different proportion, as shown in Table 15.

Table 15: Quantity of N and P_2O_5 in fertilizers

Type of input	N quantity (%)	P_2O_5 quantity (%)
Urea	46	0
DAP	18	46

Thus, the assessment of fertilizers is realized as follows:

Table 16: Quantity of N and P_2O_5 in fertilizers

Amounts in t/year/ha	Start (t/year)	With the project (t/year)	Without the project (t/year)
Amount of synthetic N from urea	92	92	511.06
Amount of synthetic N from DAP	36	54	244.8
Amount of phosphorus synthetic fertilizer	92	138	625.6

Thus the EX-ACT module will be filled in as shown below:

Table 17: Print screen of the input module

Carbon dioxide emissions from Urea application

Amount of Urea in tonnes per year

	IPCC factor	Specific factor	Default Factor	Start t0	Without Project End	Without Project Rate		With Project End	With Project Rate
Urea	0.2		YES	200	200	Linear		1111	Linear

N_2O emissions from N application on managed soils (except manure management see above)

Amount of N Applied (t per year)

Type of input	IPCC factor	Specific factor	Default Factor	Start t0	Without Project End	Without Project Rate		With Project End	With Project Rate
Chemical N Fertiliser	0.01		YES	128	146	Linear		755.86	Linear

CO_2 equivalent emissions from production, transportation, storage and transfer of agricultural chemicals

Amount in tonnes of product (active ingrediente for Pesticides)

Type of input**	Default factor*	Specific factor	Default Factor	Start t0	Without Project End	Without Project Rate		With Project End	With Project Rate
Chemical N Fertiliser	4.8		YES	128	146	Linear		755.86	Linear
Phosphorus synthetic fertilizer	0.7		YES	92	138	Linear		625.6	Linear
Herbicides (Pesticides)	23.1		YES	5	5	Linear		37	Linear

EX-ACT takes into account the expected GHG emissions due to production, transformation and application of fertilizers, as shown by the corresponding default coefficients proposed by IPCC and used in the EX-ACT estimations (Table 18).

Table 18: IPCC coefficients (in t eq-CO_2) used in the input module for one ton of inputs applied

Inputs applied	Coefficient (t eq-CO_2)
Urea (regarding CO_2 emissions)	0.2
Chemical N fertilizers (regarding N_2O emissions)	3.1
N fertilizers in non upland rice (regarding N_2O application)	0.9
Chemical N fertilizers (regarding CO_2 emissions from the production, transportation...)	4.8
Phosphorous synthetic fertilizers (regarding CO_2 emissions from the production, transportation...)	0.7
Pesticides (Herbicides)	23.1

5. EX-ACT RESULTS

5.1. Land use and changes

This section provides an overview of land use for project area and of the changes in land use foreseen by project activities.

The total project area covers **112,250 ha** of land. This surface can be divided into two kinds of lands: the croplands and the non-cropped watershed areas. The croplands are composed of rice and other annual crops. Reducing deforestation, afforestation and restoring grasslands are the main non-cropped watershed areas. There is no land use change within the project for the croplands and the grasslands as project activities are fostering the implementation of changes in land management and not in land use. However there are land use changes in some watershed areas. Indeed the project allows reducing degraded lands in favour of the growth of forested areas (2,250 ha reforested, 1,500 ha of agroforestry) but it does not convert all the degraded land into other land uses.

The land use matrix indicates that the area with and without project are balanced and that the aggregated results obtained are consistent with land use and changes promoted by project activities.

Table 19: Screenshot of the EX-ACT matrix of land-use and land-use changes

Without Project			FINAL							
			Forest/ Plantation	**Cropland** Annual	**Cropland** Perennial	**Cropland** Rice	**Grassland**	**Other Land** Degraded	**Other Land** Other	Total Initial
INITIAL	**Forest/Plantation**		29000	0	0	0	0	6000	0	35000
	Cropland	Annual	0	12400	0	0	0	0	0	12400
		Perennial	0	0	0	0	0	0	0	0
		Rice	0	0	0	21800	0	0	0	21800
	Grassland		0	0	0	0	40000	0	0	40000
	Other Land	Degraded	0	0	0	0	0	3750	0	3750
		Other	0	0	0	0	0	0	0	0
		Total Final	29000	12400	0	21800	40000	9750	0	112950

With Project			FINAL							
			Forest/ Plantation	**Cropland** Annual	**Cropland** Perennial	**Cropland** Rice	**Grassland**	**Other Land** Degraded	**Other Land** Other	Total Initial
INITIAL	**Forest/Plantation**		31000	0	0	0	0	4000	0	35000
	Cropland	Annual	0	12400	0	0	0	0	0	12400
		Perennial	0	0	0	0	0	0	0	0
		Rice	0	0	0	21800	0	0	0	21800
	Grassland		0	0	0	0	40000	0	0	40000
	Other Land	Degraded	2250	0	1500	0	0	0	0	3750
		Other	0	0	0	0	0	0	0	0
		Total Final	33250	12400	1500	21800	40000	4000	0	112950

5.2. **Project C-balance analysis**

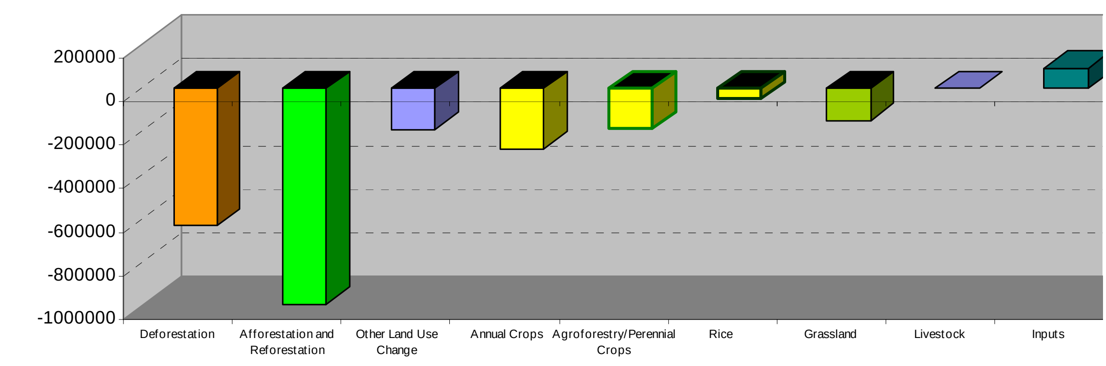
The rough result directly provided by the software includes a presentation of carbon balances of every project physical component; components are then summed within an aggregated Carbon Balance for the whole project (showing either a carbon source or sink).

The project creates a total emission of 92,611 tons of equivalent CO_2, but also creates a total sink of about 2.5 million tons of eq-CO_2, hence a net sink carbon balance of almost **2.4 million tons** of eq-CO_2. Thus the project shows a mitigation potential generated at over 86% by watershed management (forest management, afforestation and grassland, land use change). The project also promotes the adoption of more sustainable practices in annual crops (water management, no tillage/residues management). Indeed as the result of demographic growth and stagnation of yields, rainfed crops tend to be extended on hill slopes often by removing forests and applying inappropriate farming practices. Tackling both watershed and agriculture should achieve the dual objective of higher productivity and reduced soil degradation and erosion.

The results of the EX-ACT analysis performed as describes in previous sections are summarised here:

Table 20: Screen shot of the EX-ACT tool results

Components of the Project	Balance (Project - Baseline) All GHG in tCO2eq		CO2 Biomass	CO2 Soil	N2O	CH4
Deforestation	-628907	this is a sink	-357207	-271700	0	0
Afforestation and Reforestation	-989278	this is a sink	-719813	-269466	0	0
Other Land Use Change	-188444	this is a sink	-8800	-179644	0	0
Agriculture						
Annual Crops	-277879	this is a sink	0	-161220	-32290	-84370
Agroforestry/Perennial Crops	-183225	this is a sink	-167475	-15750	0	0
Rice	-48612	this is a sink	0	0	0	-48612
Grassland	-146396	this is a sink	0	-146396	0	0
Other GHG Emissions			CO2 (other)			
Livestock	0		---		0	0
Inputs	91148	this is a source	62790		28358	---
Project Investment	1463	this is a source	1463		---	---
Final Balance	**-2370130**	**It is a sink**	**-1189041**	**-1044176**	**-3931**	**-132981**
Result per ha	**-21.0**		**-10.5**	**-9.2**	**0.0**	**-1.2**



The performance per hectare is around 21 tons of CO_2 equivalent on 20 years which includes 10.5 tons of biomass generated and 9.2 tons of incremental soil carbon content per hectare in equivalent CO_2.

5.3. Economic analysis and use of generated carbon funds

Integration in Economic analysis

Carbon balance values can be roughly estimated with an opportunity price between US$ 2 and 5 (the difference between current market value of Agriculture based carbon CER and foreseen value by 2010). It comes to a value range between US$ 4.7 and 11.9 million at an average of US$ 8.3 million of public value. It is the equivalent of US$ 415 000 per year.

It could be added as an incremental public value within the welfare generated by the project in economic project analysis.

Table 21: Simulation of economic analysis with Carbon Value integrated at different prices

	Carbon constant price US$ / ton	Total public value million US$	Project Net present value million US$	Internal IRR
without Carbon value	*0*	*0*	*9.1*	*14.7%*
with carbon valued at	2	4.7	10.5	15.3%
with carbon valued at	5	11.9	12.7	16.2%
with carbon valued at	**3.5**	**8.3**	**11.6**	**15.8%**
carbon price increasing between 2010 and 2020	from 2 to 20	38.7	17.8	17.7%
carbon price increasing from 2010 to 2020	from 2 to 10	20.4	13.9	16.5%

The table above also shows simulations which consider a progressive increase of price of carbon on next 10 years from US$ 2 to US$ 10 and from US$ 2 to US$ 20 These projections seem realistic in the perspective of IPCC projections of carbon price by 2020 (US$ 40-60 market price).
This proves how agriculture project's current internal returns usually between 10 and 15% can reasonably increase and stay closer to industry – service related investment returns (13-20%) when environmental return is considered. Furthermore the Net Present Value is increasing by over 25% with carbon valued at a conservative rate of US$ 3.5 per ton.

Table 22: Appraising the carbon potential rent at different levels of possible use within project implementation

at low carbon price of US$ 3.5	Annual Equivalent	Agregated amount
Carbon value per ha	US$ 3.7	US$ 72
Carbon value per farmer	US$ 14	US$ 276
Equiv Carbon financial rent per village	US$ 1 400	US$ 27 600
Equivalent carbon financial rent per watershed	US$ 104 000	US$ 2.1 million

Assuming that the estimated virtual carbon value of US$ 8.3 million over 20 years is effectively allowing for funds mobilisation, with a conservative assumption of annual delivery, there would be an opportunity of annual funding of US$ 415 000.

When divided by the number of farmers or by the number of hectares, this carbon rent represents very low value, insignificant in the perspective to increase the farmers' annual income. However cumulated at community level (village), with US$ 1400, it can fund equivalent to 3 full time permanent village workers (US$ 40 per month) or a team of 12 workers during 3 months or at watershed level (four watersheds in the project: Andapa, Marovoay, Itasy, Alaotra), it can provide regular yearly funds for all kinds of environment services (control and reduced deforestation, afforestation work). For every watershed considered, the carbon rent could fund equivalent of 40-45000 man-days of public work (200 workers at 20 days per month during 7-8 months per year in every watershed). These figures are provided to illustrate **the potential employment generation in the area of Paid Environmental Services (PES) through regular carbon annual monetary inflows**.

It is therefore important to deliver PES through a limited number of workers from vulnerable households in a situation of hidden unemployment or of dairy workers (or landless farmers) and to propose them either full time of low-season-targeted environmental work

Table 23: Options of Payment of Environment Services (PES) within a simulation of increasing carbon price to all farmer / Social Safety Nets (SSN)

at increasing carbon price of US$	equivalent by 2015 at US$ 9 / ton	equivalent by 2020 at US$ 12 / ton	equivalent by 2025 at US$ 15 / ton
Annual Carbon value (US$ million)	1.1	1.4	1.7
Carbon value per ha per year	US$ 9.5	US$ 12.6	US$ 16
Carbon value per farmer per year	US$ 35	US$ 55	US$ 77
Equivalent carbon fund per village per year	US$ 3500	US$ 5500	US$ 7700
Equivalent carbon fund per watershed per year	US$ 275 000	US$ 350 000	US$ 425 000

In such a perspective, the potential of mobilised annual funds would allow for a much wider set of payments of environmental services combined as a subsidy per ha per year of improved annual crop, the environment and reforestation annual budget per village or other community services are to be considered.

6. Scenario Analysis

6.1. Simulate project options : resizing watershed component

The project case study was in actual fact re-dimensioned at the start due to the gap in funding resources. The watershed component has been to some extent sacrificed (component at US$ 4.58 million). This simulation will be used to resize the watershed component within a perspective of project option with incremental funding (which could be implemented through appropriate integration in phase 2 of the present project).

Within this project option, the watershed component targets 65,000 ha of improved watershed on the total watershed area which is around 100 000 ha. It will include:

(i) 15,000 ha of afforested areas,

(ii) 6,000 ha of avoided deforestation,

(iii) 34,000 ha of improved pasture and

(iv) 10,000 ha of agro forestry.

These figures will replace the initial figures used in project for afforestation, deforestation, improved pasture...as shown below:

Table 23: Watershed activities among the project and in the new scenario proposed

	With the project (ha)	New scenario (ha)
Afforested areas	2,250	15,000
Avoided deforestation	2,000	6,000
Improved pasture	2,500	34,000
Agro forestry	1,500	10,000
Total of surface improved	8,250	65,000
Total Surface of watershed component	100,000	100,000

The incremental improved areas will require additional funding to be computed on the following cost per ha: US$ 1500 / ha reforested, US$ 300 / ha of avoided deforestation, US$ 400 per ha of improved pasture, US$ 1000 per ha of agro forestry. These area figures will allow for the recalculation of the Watershed component budget.

6.2. Results

Table 24: Print screen of the EX-ACT results among the new simulation

Components of the Project	Balance with Project (tCO2eq for 20 yrs)		Mean per year
Deforestation	-1886720	this is a sink	-94336
Afforestation and Reforestation	-6595188	this is a sink	-329759
Other Land Use Change	-1256292	this is a sink	-62815
Agriculture			
Annual Crops	-277879	this is a sink	-13894
Agroforestry/Perennial Crops	-1221500	this is a sink	-61075
Rice	-48612	this is a sink	-2431
Grassland	-1270720	this is a sink	-63536
Other GHG Emissions			
Livestock	0		0
Inputs	91148	this is a source	4557
Project Investment	1463	this is a source	73

Final Balance	-12464299	This is a sink
Total Area (ha)=		134200
Mean per ha		-92.9
Mean per ha / yr		-4.6

Positive value = Source of GHG
Negative value = Sink of GHG

This watershed component is estimated at US$ 47.9 million. The aggregate project budget will go up to around **US$ 83 million (+103%).** It generates 12.4 million tons of carbon sink effect with 89% of carbon mitigation issued from watershed management (6.6 million tons from afforestation, 1.9 million from reduced deforestation, 1.3 million tons from grassland. We are up to 4.6 tons of carbon reduction per ha per year and to 92 tons per ha on 20 years.

By doubling the budget of the project in this scenario, and by allocating the incremental funds for the watershed management, the benefits in term of carbon balance are not doubling but multiplied by six!

6.3. Economic analysis and use of generated carbon funds

❖ **Carbon value used in project co-funding**

In Table 25 below, the possibility to fund the incremental project option through carbon funding shows very reliable in ant carbon price option. Furthermore it allows incremental balance of around 69.5 million US$ on 20 years, or the equivalent of US$ 3.3 million per year for PEMS and other use.

Table 25: Carbon value used in project co-funding among the new simulation

	Carbon price US$ / ton	Total public value of carbon (a) million US$	project cost (b) million US$	Incremental project option cost ©	Remaining balance for PEMS and other public uses (a)-(c)
Min	6	74	83	42.5	31.5
Max	12	149	83	42.5	116.5
Average	**9**	**112**	**83**	**42.5**	**69.5**

7. Conclusions

The analysis of the ex-ante carbon-balance results shows that the project in its current design has a mitigation potential of almost 2.4 million tons of eq-CO_2 over 20 years, thereby participating in the global effort to lower anthropogenic emission and tackle climate change. The mitigation impacts were considered in the formulation of the project as co-benefits. It reflects the significant effect on incrementing project at watershed level. It particularly points out the fact that synergies are possible between watershed management and agriculture mitigation.

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.

This module belongs to a set of EASYPol modules and other related documents: EASYPol Module 210:

- **EX-ANTE Carbon-Balance Tool version beta 1: Software**
- **EX-ANTE Carbon-Balance Tool : Technical Guidelines**
- **EX-ANTE Carbon-Balance Tool : Brochure**

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.*

Bockel L..2009. Climate Change and Agricultural Policies, How to Mainstream Climate Change Adaptation and Mitigation into Agriculture Policies, ***EASYPol Module 240***, Prepared for the FAO Policy Learning Programme 2009, FAO, Rome.

FAO. 2009. *Food Security and Agricultural Mitigation in Developing countries: Options for capturing Synergies.*

9. FURTHER REFERENCES

CIA. 2010. The World Factbook. Available at :
https://www.cia.gov/library/publications/the-world-factbook/geos/ma.html