EASYPol

On-line resource materials for policy making

APPLIED MATERIAL

EASYPol Module 222

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

An Application to the Accelerated Food Security Project in Tanzania

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

An application to the Accelerated Food Security project in Tanzania

by

Louis Bockel, Policy Officer (Economist), Policy Assistance Support Service, Policy and Programme Development Support Division, FAO, Rome, Italy

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

Marianne Tinlot, FAO Consultant, Rome, Italy

for the

Food and Agriculture Organization of the United Nations, FAO

Acknowledgements

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 Tanzania, 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, Consultant, Project Formulation expert for the Tanzania case; and Marianne Tinlot, FAO Consultant, case study practitioner.

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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 the climate change mitigation potential of agricultural programmes/projects and how to integrate it in the economic analysis of projects.

This case 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 Tanzania, which was selected to test the software. The case study 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 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 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 the formulation and analysis of investment projects, working for public administration offices, NGO's, professional organizations or for consulting firms. Academics may also find this material useful to support their courses in carbon balance analysis and development economics. 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.

To strengthen users' background and to further expand their knowledge on 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.

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.

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 a 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. Estimate of project Carbon-balance using EX-ACT

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

3. PROJECT DESCRIPTION

3.1. Background

The United Republic of Tanzania is located in the Centre East part of Africa, bordering the Indian Ocean and located between Kenya and Mozambique. With a total area of 947,087 km^2, it is divided into 26 regions. The estimated population for 2010 is about 45 million inhabitants (United Nations, 2009). Over 75% of the population lives in rural areas where agriculture and the use of natural resources are crucial for their livelihood.

The state economy is driven by the services sector, which contributes to 47.3% of the state GDP. Agriculture makes up a great part of the state economy as it contributes to 28.2% of the state GDP, thus making agriculture the second important economic sector after industry. The importance of agriculture is demonstrated in terms of rural employment as it accounts for over 80% (CIA, 2010) of employment and 75% of rural household incomes (World Bank, 2009).

Only 3% of the land area is covered by arable crops. Rangelands and pastures represent about 40% of the land area, forests and woodlands account for 38%. There are 44 million hectares (ha) of unexploited arable land with natural resources,50 million ha of rangeland, underground water and several ecological zones, which could potentially permit an expansion in crop and livestock production. However, environmental

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[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*.

constraints such as severe land degradation (especially in the central east part of the country), erosion, low to medium climatic production potential, and the access to natural resources, are binding constraints. Thus only 23% of the arable land is cultivated.

However, Tanzania maintains a potential for growing a wide range of crops (staples, cash and horticultural) across different agro-ecological zones. The livestock population is composed of poultry (47 million), cattle (17 million), goats and sheep (14 million). It contributes to 30% of the agricultural GDP. Tanzania produces on average 95% of its food requirements from local production. The most popular staple crops for Tanzanians are maize, rice, banana, grain, legumes and cassava, followed by sorghum, millet, sweet potato and wheat. Depending on the region, some of these crops (e.g. rice, maize, beans, sorghum, chickpea and millet) are regarded as food and cash crops. Export crops include coffee, cotton, cashew nut, tobacco, sisal, pyrethrum, tea, cloves, horticultural plants, oil seeds, spices and flowers.

Agriculture in Tanzania is mainly lead by smallholder peasants cultivating an average farm of about 0.5 hectares: some 3.5 million farm families cultivate almost 4.5 million ha of arable land. About 70% of Tanzania's crop land is cultivated by hand hoe, 20% by ox plough, and 10% by tractor; women are the primary agricultural labour force in the country.

Crop yields are only at 20% to 40% of their potential. Indeed, the application of fertilizers in the country was reported at 8 kg per hectare in 2005/06, while the depletion of soil nutrients was found to be at about 61 kg per hectare (World Bank, 2009). The use of improved seeds is also extremely low, and most of the planted seeds are self-produced and recycled. According to IFPRI, based on the 2002/03 agricultural census, only 24% of farmers use the improved varieties of maize, especially in the North. Improved seeds not only allow farmers to increase yields but also to increase the quality of the agricultural products. The current rate of combined use of both fertilizers and improved seeds is extremely low, being only 0.5% in Eastern, Central and Lake Regions, and about 11.5% in Southern Highlands (World Bank, 2009).

The maize and rice sectors contribute largely to the overall economy. According to the Social Accounting Matrix of the CGE model prepared by IFPRI, the maize sector made up about 4.75% of the national GDP, while the rice sector accounted for 2.66% of the national GDP in 2007. This translates into 25% and 14% of the agricultural GDP, respectively.

Tanzania is the largest producer and consumer of rice in the East, Central and Southern African regions after Madagascar (Banwo & al. 2001). It is estimated that 626,300 ha had rice cultivations in 2002/03, with an overall production of 1,283,700 tons. The major producing areas are the coastal zones, western zones, the Lake Victoria basin, the Kilombero valley and the southern plains. Rice is cultivated under different agro-ecological conditions (upland, lowland and irrigated environments). Because it grows in many parts of the country and is cultivated according to different management systems (rain-fed and irrigation), the pest problems and management tactics vary. Unfortunately, and until recently, issues related to pest management in rice production were given low priority importance (Banwo & al. 2001).

Maize is the most important source of energy and protein in Tanzania. It accounts for one-third of calories and protein intake. Moreover, its importance is increasing as it tends to replace some traditional staple foods (sorghum, cassava). It is grown in all the agro-ecological zones as it has adapted to a wide range of altitudes, and it requires an optimum rainfall of 1800 mm. It is estimated that 2,810,490 ha had maize cultivations in 2002/03, with an overall production of 3,415,600 tons (MAFS, 2004). In terms of percentage contribution in 2002/03, the southern highlands are the largest maize production zone in Tanzania with 45% of the national production, followed by the northern zone (11.0%) and the western zone (10%). The southern highlands supply 90% of the strategic grain reserve, thus the highlands are the national grain basket.

Current productivity of maize and rice farmers remains very low. For example, in 2007, the average national maize yield was only 0.88 tons per hectare (IFPRI, 2010). These average yields are lower than in most neighbouring countries and reach only between 8 and 22% of the potentially achievable yields in Tanzania (IFPRI, 2008). The simultaneous application of fertilizers and improved seeds could increase maize yields by about 57% (FAO, 2009) compared to the Tanzanian farmers who do not use this technology.

In this perspective, the project will address food security by improving agricultural production and productivity through improved access to inputs, as shown below. Since support is provided to the high potential areas that produce the major food crops including the southern and northern highlands as well as in the western region, the increased output and yields projected in the targeted areas will also increase the national production and yield indicators, as well as lead to a significant growth in the overall GDP.

3.2. Project characterization

The proposed Accelerated Food Security Project (AFSP) of the United Republic of Tanzania, aims at contributing to higher food production and productivity in targeted areas by improving farmers' access to critical agricultural inputs so as to avert potential food crises in the light of fluctuating food and input prices.

The total cost of the proposed Project is about US$299 million. The World Bank has recently approved funds for US$220 million in the AFSP. These funds will support the scale up of the Government's efforts to boost domestic food production, availability and stability by providing support to the ongoing government programme called the National Agricultural Inputs Voucher Scheme (NAIVS). AFSP is a project that finances urgent and time-bound interventions that supplement the Government's medium- and long-term agriculture development agenda currently being supported by IDA and four other Development Partners[3] through a basket fund for the Agriculture Sector Development Program (ASDP).

[3] International Fund for Agricultural Development, the Government of Japan, Irish Aid and the African Development Bank.

Geographically, the Project targets high potential areas to produce maize and paddy rice, such as the southern and northern highlands, and western regions. It will take into account those households with no more than 1 ha of land planted with maize and rice. The programme should cover about 2.5 million maize and rice producing farmers at full implementation of the project in 65 districts. These households account for about 70% of total maize production and 50% of total rice paddy production. In addition, the programme will also target the major irrigated rice growing areas in other regions: this option aims at increased economic returns of irrigation investments but also at reducing risks for the voucher scheme.

The Project will be implemented over a period of seven years starting from 2007 and will consist of the following three components:

- Improving access to critical agricultural inputs (fertilizers and seeds);
- Strengthening the input supply chains; and
- Project management and monitoring and evaluation (M&E).

Table 1: Overview of the Accelerated Food Security Project in Tanzania

Project title	Accelerated Food Security Project in Tanzania
Project objectives	To contribute to higher food production and productivity in targeted areas by improving access to agricultural inputs
No. of beneficiaries	2,5 million farmers (at full implementation)
Duration	Implementation phase: 7 years Capitalization phase: 13 years
Budget	US$299 Million • Comp.1 Improving access to agricultural inputs *(total cost US$283,4 M)* • Comp. 2 Strengthening input supply chain *(total cost US$12,2M)* • Comp. 3 Project management and monitoring and impact evaluation *(total cost US$3,5 M)*
Crops targeted	972,570 ha of maize 85,815 ha of rice

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 component 1 (Improving access to agricultural inputs) which supports all technical activities foreseen by the project, and which is therefore expected to have a relevant impact on the C balance:

i) Provide input vouchers
ii) Improve management of maize production;
iii) Improve management of rice production;
iv) Install irrigation systems

For the sake of simplicity, components 2 and 3 are not taken into account in the development of the present case study.

The first activity targeted by the project is the provision of input packages to maize and rice farmers, consisting in three vouchers: urea, phosphorous/nitrogen synthetic fertilizers, and seeds (hybrid/open-pollinated maize and rice varieties).

The project will also promote the adoption of improved agricultural practices in maize and rice production, which should allow farmers to reduce carbon emissions. Improved practices will consist mainly of adopting improved seed varieties, extending crop rotations and introducing efficient nutrient management (tackling the efficiency of N use and the precision in spreading fertilizers). Furthermore, the project will not burn crop residues: this is expected to have a direct impact on the C-balance.

These activities should enable farmers to increase production of maize and paddy rice yields, and should generate substantial financial and economic benefits. Indeed, without the project, most farmers will not be able to buy fertilizers and seeds at full market prices due to the risk implied (cash or credit access, risk...). Subsidizing farmers for some years will enable the generation of a cash flow to purchase inputs at market prices in the following years.

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 as being under a *Moist* moisture regime. These settings correspond to an average temperature 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.

The project will be implemented over a 7-year period. The carbon accounting method also integrates a capitalisation phase (13 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. Provide input vouchers

Benefiting farmers will obtain an adapted 'input package' consisting of three vouchers: one voucher for N (Nitrogen) fertilizer; one for P (Phosphorous) fertilizer (2 options depending on each farmer's choice based on market prices and location-specific technical efficiency. For the sake of simplicity, only the first option is taken into account in this case study); and one Seed voucher that would cover 0.5 ha and 0.25 ha for maize and rice, respectively.

For rice, 50% of the seed needs (direct seeding) are proposed to increase the spread of new varieties: as self-pollinated crops, good quality rice seeds could easily be bulked-up at the farmers' level. The nutrient supply for the voucher set should be 32 kg N and 23.3kg P_2O_5, which corresponds to the optimal average recommendation (0.5 ha) for maize across agro-ecological zones and soil types in Tanzania (Mowo & al, 1993).

To boost the productivity of crops, farmers needed to rebuild the nutrient stock of the soil. This is the reason why the project planned to bring 64 kgN/ha during the first three years of the project. After these three years, it is estimated that the soil has recovered its potential to increase yields. Farmers can then buy half of the application to keep the same improved yield at the same price (as the vouchers were sold at half the market price) but with half less product, which also allows farmers to decrease GHG emissions. On the one hand, the larger use of inputs during the first three years is expected to damage the carbon balance of the project in terms of carbon emissions; on the other hand, by facilitating the intensification of fertilizers use, the project could mitigate the process of soil degradation in Tanzania.

This activity is taken into account in the "*input*" EX-ACT module in order to build the "with project" scenario which concerns 85,815 ha of rice and 972,570 ha of maize. On the contrary, it is assumed that farmers generally apply double of the national fertilizer application estimated at 8 kg units of fertilizers and that they will not change this practice if no project is implemented in the future.

Table 2: Application of fertilizers expected

Equivalent application of fertilizer per hectare	With project (kg units/ha)	Without project (kg units/ha)
Urea	100	8
DAP	100	8

The different fertilizers do not have the same emission potential, depending on the molecule that contains N and P in different proportions, as shown in Table 3.

Table 3: Quantity of N and P_2O_5 in fertilizers

Type of input	N quantity (%)	P2O5 quantity (%)
Urea	46	0
DAP	18	46

It is now possible to calculate the different amounts of fertilizers in t/year/ha.

Table 4: Amount of fertilizers in t/year/ha

Amounts in t/year/ha	With the project (t/year/ha)	Without the project (t/year/ha)
Amount of urea	(100/1000) = 0.1	(8/1000) = 0.008
Amount of synthetic N fertilizer	(46*100+18*100)/1000/100= 0.064	0.00512
Amount of phosphorus synthetic fertilizer	0.046	0.00368

To get the amounts used with and without the project in t/year, the land surfaces where fertilizers have been applied have to be indicated, taking into account the differences between conventional and improved management for maize and rice crops.

Table 5: Surfaces concerned in the project

Surface in ha	Management	Start (ha)	Without (ha)	With (ha)
Areas using UREA	no improvement	1,058,385	1,058,385	260,100
	with improvement	0	0	798,285
Areas of annual crops using Synthetic N fertilizer	no improvement	972,570	972,570	260,100
	with improvement	0	0	712,470
Areas of non upland rice using Synthetic N fertilizer	no improvement	85,815	85,815	0
	with improvement	0	0	85,815
Phosphorus synthetic fertilizer - all crops	no improvement	1,058,385	1,058,385	260,100
	with improvement	0	0	798,285

Then multiply those land surfaces by the different amounts in t/year/ha (rate) to get results in t/year, as shown in Table 6.

Table 6: Amount of fertilizers in t/year depending of the agricultural management

Amounts in t/year	Management	Rate	Start (t/year)	Without (t/year)	With (t/year)
Amount of UREA	no improvement	0.008	8,467	8,467	2,081
	with improvement	0.1	0	0	79,828
Amount of Synthetic N fertilizer in annual crops	no improvement	0.00512	4,980	4,980	1,332
	with improvement	0.064	0	0	45,598
Amount of Synthetic N fertilizer in non upland rice	no improvement	0.00512	439	439	0
	with improvement	0.064	0	0	5,492
Amount of phosphorus synthetic fertilizer	no improvement	0.00368	3,895	3,895	957
	with improvement	0.046	0	0	36,721

The total amounts of fertilizers (with and without improvement) in t/year are presented next:

Table 7: Total amount of fertilizers in t/year

Amount of fertilizers in t/year	Start (t/year)	Without (t/year)	With (t/year)
UREA in all crops	8,467	8,467	81,909
Synthetic N fertilizer in annual crops	4,980	4,980	46,930
Synthetic N fertilizer in non upland rice	439	439	5,492
Phosphorus synthetic fertilizer - all crops	3,895	3,895	37,678

It has to be taken into account that the fertilizers are not spread in the same quantity every year throughout the duration of the project. The voucher programme is expected to be phased over 3 years of full implementation, to trigger an accelerating effect on input use at farm level and to generate a high level of organic dry matter production used to enrich the soil carbon level. After these three years of full voucher, farmers will progressively lower the level of input use (by about 50%). This means that an average of the amounts of fertilizers in the "with project" situation have to be calculated. The average for each amount of fertilizers is calculated as follows:

Table 8: Example for urea

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	8467	8467	Linear	47098	Immediate
								Sub-Total I-2

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

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	4980	4980	Linear	26985	Immediate
N Fertiliser in non-upland Rice*	0.003		YES	439	439	Linear	3158	Immediate
Sewage	0.01		YES	0	0	Linear	0	Linear
Compost	0.01		YES	0	0	Linear	0	Linear
N_2O emissions from upland rice is should be included in the First line								Sub-Total I-3

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	5419	5419	Linear	30143	Immediate
Phosphorus synthetic fertilizer	0.7		YES	3895	3895	Linear	21665	Immediate
Potassium synthetic fertilizer	0.6		YES	0	0	Linear	0	Linear

$$(3*100\%*81909 + 17*50\%*81909)/20 = 47098 \ t/year.$$

As we calculated an average throughout the application of the project, we assumed that the dynamic adoption is *immediate* for the "with project" situation.

Finally, in the "with project" scenario 47,098 tons of urea, 30,143 tons of synthetic N fertilizers, and 21,665 tons of phosphorous synthetic fertilizers will be provided respectively.

Table 9: Inputs spread in the three scenarios

Inputs	Start (t/year)	Without Project (t/year)	With project (t/year)
Urea	8,467	8,467	47,098
Synthetic N fertilizers (maize)	4,980	4,980	26,985
Synthetic N fertilizers (non upland rice)	439	439	3,158
Phosphorous synthetic fertilizer	3,895	3,895	21,665

The EX-ACT module will look like this:

Table 10: Screenshot of the EX-ACT inputs 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	8467	8467	Linear	47098	Immediate	
								Sub-Total I-2	

N_2O emissions from N application on managed soils (except manure management see Livestock Module)								
				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	4980	4980	Linear	26985	Immediate
N Fertiliser in non-upland Rice*	0.003		YES	439	439	Linear	3158	Immediate
Sewage	0.01		YES	0	0	Linear	0	Linear
Compost	0.01		YES	0	0	Linear	0	Linear
N_2O emissions from upland rice is should be included in the First line								Sub-Total I-3

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	5419	5419	Linear	30143	Immediate
Phosphorus synthetic fertilizer	0.7		YES	3895	3895	Linear	21665	Immediate
Potassium synthetic fertilizer	0.6		YES	0	0	Linear	0	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 11).

Table 11: 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 production, transportation...)	0.7

4.2. Improved management of maize production

The project promotes several agricultural practices as described below:

Table 12: Practices supported by the project

Improved agronomic practices	Using improved seeds and varieties
	Extending crop rotation
Nutrient management	Improving N use efficiency
	Using synthetic fertilizers
	Bio-fertilization (incorporation of crop residues)
Tillage / residues Management	Adoption of conservation agriculture including reduced, minimum or zero tillage
Burning practises	Abandon the practice of burning crop residues

All the agricultural practices that are undertaken in the project are reported in the ***annual*** module of EX-ACT. These practices are expected to restore the natural characteristics of the soil and to contribute to the accumulation below ground of C stocks. Subsequently, some practices such as no tillage management should have positive impacts on avoiding erosion and thus soil degradation.

The agronomic practices and nutrient management are expected to increase yields and generate higher inputs of carbon residue that can lead to increased soil carbon storage. The adoption of reduced tillage may also result in soil carbon gain. It can have positive mitigation effects on CO_2 and N_2O emissions (Smith & al, 2007). Lastly, by abandoning the practice of burning residues, it is expected that GHG emissions will be reduced. The adoption of the previous practices corresponds to mitigation options that should improve the economic and environmental sustainability as improved yields should lead to better economic returns and require less land for new cropland (intensification) (IPCC, 2006). By adopting these practices, the project may act on implementing sustainable land management practices.

The project includes 972570 ha of maize crops but it does not increase the total land surface of maize crops; it focuses on about 73% of the surface. It was assumed that the adoption of the changes follows a *linear* dynamic trend.

Table 13: Description of the annual systems in the three scenarios

Annual system	Area (ha)		
	Start	Without Project	With Project
Current conventional System	972,570	972,570	260,100
Improved agronomic practices	0	0	712,470
TOTAL (ha)	972,570	972,570	972,570

In the EX-ACT module, the different improvements in practices and surfaces concerned have to be filled in as shown in Table 14.

Table 14: Screenshot of the EX-ACT annual module

	Your description	Improved agro- -nomic practices	Nutrient management	NoTillage/residues management	Water management	Manure application	Residue/Biomass Burning
Annual System1	Conventional Mgmt	NO	YES	NO	NO	NO	YES
Annual System2	Improved	YES	YES	YES	NO	NO	NO

Mitigation potential					
Vegetation Type	Areas				
	Start	Without project		With Project	
	t0	End	Rate	End	Rate
Annual System1	972570	972570	Linear	260100	Linear
Annual System2	0	0	Linear	712470	Linear
Total Syst 1-10	972570	972570		972570	

Agric. Annual Total	**12199918**	**-416643**	**-12616561**

The nutrient management is the only improved practice that is used for conventional crops.

Within EX-ACT, each improved practice implies a corresponding mitigation potential. Biggest potential comes from the adoption of improved agronomic practices, followed by no tillage/residue management and improved nutrient management (Table 15). 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 15: Coefficients used in EX-ACT

	Corresponding mean potential in t eq-CO_2 / ha / yr			
	Improved agronomic practices	Nutrient management	No tillage/ residue management	**Coefficient used**
Conventional Maize	0	0.55	0	0.55
Improved maize	0.88	0.55	0.7	0.88

The coefficient used represents annual soil carbon change rate over a 20-year time horizon in the top 30 cm of the soil. It corresponds to the maximum potential of all selected management practices, within a very conservative approach, supposed to be the best choice. Literature states that some measures are not additive when applied simultaneously.

As shown below, the adoption of improved practices has a relevant mitigation potential, even if the practice of burning residues impacts strongly on GHG emissions. Overall, EX-ACT indicates that the management of annual crops reduces GHG emissions and allows for the sequestering of C.

Table 16: Screenshot of the EX-ACT annual results

Your description	Soil CO2 mitigated		CO2eq emitted from Burning		Total Balance		Difference
	Without	With	Without	With	Without tCO2	With tCO2	tCO2
Conventional Mgmt	0	7249382	12199918	3932986	12199918	11182368	-1017550
Improved	0	-11599012	0	0	0	-11599012	-11599012

4.3. Improved rice management

The project aims to improve the management of flooded rice crops: this is considered in the ***rice*** module of EX-ACT.

Two kinds of irrigation management are taken into account: continuously flooded management; and rainfed management. The first type of irrigation management corresponds to the rice fields that are flooded throughout the rice growing season and which only dry out for the harvest. The second type of irrigation management depends solely on precipitation when fields are flooded for a significant period of time. The water regime (Table 17) and the cultivation period (150 days) are not expected to change with the adoption of the project.

Table 17: Water regime of the rice system

Rice system	During the cultivation period	Before the cultivation period
Conventional management of irrigated rice	Continuously flooded	Flooded pre-season (>30 days)
Improved management of irrigated rice		
Conventional management of rainfed rice	Rainfed and deep water	Non flooded pre-season (>180 days)
Improved management of rainfed rice		

Improving the above crops according to the terms of the project imply changing the organic amendment. Thus, instead of burning the residue it will be incorporated more than 30 days before cultivation. It should allow farmers to increase carbon levels in soils and thus achieve higher yields. The introduction of more productive rice types coupled with innovative but low-cost irrigation techniques, should also allow farmers to increase their average harvests. Thus the adoption of techniques promoting rain fed irrigation is designed to reduce the decline in soil fertility and raise the sustainability of crop production for many years to come.

Indeed, if irrigation is found to have the strongest positive impact on rice yields, rice crops are one of the most important sources of methane release in the atmosphere when the soil if full of water. In the rainfed management areas, the supply of water is insecure but it has a lower emission potential than irrigated rice areas (IFPRI, 2009).

Thus we can expect that new practices in rice production will be less damaging to the final carbon balance than conventional management techniques, especially because farmers will abandon the practice of burning residues. In the adoption of the project the residue will not be burnt but incorporated. On the one hand the incorporation of residue will increase the nutrients in the soil, on the other hand, it is expected to infer with the carbon balance. The incorporation has to be carried out long before cultivation occurs as it also causes methane emissions. Field drainage during the growing period should reduce the methane emissions. Yet, field drainage may induce weeds and the possible reduction of rice grain yields. Farmers need to find the optimal drainage period during the optimal growth stage of the rice plants in order to obtain practical mitigation impacts.

The total area involved in the project is 85815 ha of rice crops an area which is expected to be improved following a *linear* change adoption.

Table 18: Area involved in the annual system

Annual system	Area (ha)		
	Start	Without Project	With Project
Conventional management of irrigated rice	22,950	22,950	0
Improved management of irrigated rice	0	0	22,950
Conventional management of rainfed rice	62,865	62,865	0
Improved management of rainfed rice	0	0	62,865

In the EX-Act module, the cultivation period, the water regime, and organic management have first to be filled out as shown below (Table 19) then the surfaces concerned have to be inserted:

Table 19: Screenshot of the EX-ACT rice module

	Your description	Cultivation period (Days)	Water Regime: During the cultivation Period	Water Regime: Before the cultivation period need help	Organic Amendment type (Straw or other)
Rice1	irrigated rice conventional	150	Irrigated - Continuously flooded	Flooded preseason (>30 days)	Straw burnt
Rice2	non irrigated rice conventional	150	Rainfed and deep water	Non flooded preseason >180 days	Straw burnt
Rice3	irrigated rice improved	150	Irrigated - Continuously flooded	Flooded preseason (>30 days)	Straw incorporated long (>30d) before cultivation)
Rice4	non irrigated rice improved	150	Rainfed and deep water	Non flooded preseason >180 days	Straw incorporated long (>30d) before cultivation)

CH4 emission from rice systems

Areas (ha) of the different options

Type	Start t0	Without Project End	Without Project Rate	With Project End	With Project Rate
Rice1	*22950*	*22950*	*Linear*	*0*	*Linear*
Rice2	*62865*	*62865*	*Linear*	*0*	*Linear*
Rice3	*0*	*0*	*Linear*	*22950*	*Linear*
Rice4	*0*	*0*	*Linear*	*62865*	*Linear*

The water regime reflects the potential methane emissions due to anaerobic decomposition of organic matter. The burning of straw will also emit CH_4 and N_20 but the CO_2 emissions are not counted as it was assumed that the carbon release during combustion will be reabsorbed by the rice during the next growing season. Lastly, the incorporation of straw should enable to sequestrate carbon in the soil.

Table 20: Coefficients used in the EX-ACT rice module

Type of rice	Water regime during the cultivation period	Water regime before the cultivation period	Organic amendment	Rate (t)	CH_4 IPCC coefficient kg/ha/day	Straw Burnt t eq-CO_2
Irrigated rice conventional	Irrigated - Continuously flooded	Flooded preseason	Straw burnt	5.5	2.47	0.34
Non irrigated rice conventional	Rainfed and deep water	Non flooded preseason		5.5	0.24	0.34
Irrigated rice improved	Irrigated - Continuously flooded	Flooded preseason	Straw incorporated long	5.5	4.34	0.00
Non irrigated rice improved	Rainfed and deep water	Non flooded preseason		5.5	0.42	0.00

4.4. Other investments

Some maize crops that will not come under the improved practices will benefit from an investment concerning irrigation systems. Indeed the project foresees to install **a** hand-manoevered sprinkle irrigation system in a total area of **3924 ha,** which is to be counted in the ***investment*** module of the EX-ACT tool, as it is expected to contribute to carbon emissions. It aims to increase the economic returns of irrigation investments but also to manage the risks for the voucher scheme that deals with the management of the majority of the annual crops.

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 concerns **1,058,385 ha** of croplands. There are two types of croplands: the annual croplands that correspond to the maize crops and the flooded rice areas. There is no land use change within the project as project activities are only fostering the implementation of changes in land management but not in land use, as shown in Table 21.

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

Table 21: Screenshot of the EX-ACT matrix of land-use and land-use changes

Without Project			FINAL							
			Forest/ Plantation	**Cropland**			**Grassland**	**Other Land**		
				Annual	Perennial	Rice		Degraded	Other	Total Initial
INITIAL	**Forest/Plantation**		0	0	0	0	0	0	0	0
	Cropland	Annual	0	972570	0	0	0	0	0	972570
		Perennial	0	0	0	0	0	0	0	0
		Rice	0	0	0	85815	0	0	0	85815
	Grassland		0	0	0	0	0	0	0	0
	Other Land	Degraded	0	0	0	0	0	0	0	0
		Other	0	0	0	0	0	0	0	0
		Total Final	0	972570	0	85815	0	0	0	1058385

With Project			FINAL							
			Forest/ Plantation	**Cropland**			**Grassland**	**Other Land**		
				Annual	Perennial	Rice		Degraded	Other	Total Initial
INITIAL	**Forest/Plantation**		0	0	0	0	0	0	0	0
	Cropland	Annual	0	972570	0	0	0	0	0	972570
		Perennial	0	0	0	0	0	0	0	0
		Rice	0	0	0	85815	0	0	0	85815
	Grassland		0	0	0	0	0	0	0	0
	Other Land	Degraded	0	0	0	0	0	0	0	0
		Other	0	0	0	0	0	0	0	0
		Total Final	0	972570	0	85815	0	0	0	1058385

5.2. Project C-balance analysis

The project creates a total emission of about 7 million tons of eq-CO_2, but it also creates a total sink of 12.6 million tons of eq-CO_2, hence there is a net sink carbon balance of almost **5.6 million tons** of eq-CO_2, after 20 years.

As expected, the project represents a significant source of GHG emissions due to rice crops, distribution of significant quantities of inputs and investment in structures for irrigation. Nevertheless, the project also promotes the adoption of sustainable agronomic practices on a wide surface of maize crops (972,570 ha) creating a significant C sink, given the size of the area involved. The net effect of the project is a C sink.

The implementation of the improved practices also allows for the restoration of the soil nutrient content and allows farmers to tackle land degradation, which is a serious issue in Tanzania. Farmers obtain easier access to inputs in the food security programme in a long-term framework, as it is foreseen that they first recover the soil depletion by applying an important amount of half financed fertilizers, and then they progressively reduce the use of fertilizers as the soil will have recovered its potential for higher yields as the subsidies decrease.

These results underline the critical importance of adopting sustainable land management practices, The project is finally a net sink which depends solely on the adoption of these practices in maize crops. The mean carbon sink per ha per year seems to be quite small (0.28 t/year/ha), hence the importance of carrying out such practices throughout the whole life of the project in as many hectares as possible to be able to see any significant impacts. If the farmers fail to implement these practices, there may be a risk that the overall C balance is affected, as the maize management was the only component that compensated the other sources triggered by the project. It is therefore also important to have worked on the conventional maize management in case the improved maize management does not succeed.

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

Table 22: Screenshot of the EX-ACT tool results

Components of the Project	Balance with Project (tCO2eq)		Mean per year
Deforestation	0		0
Afforestation and Reforestation	0		0
Other Land Use Change	0		0
Agriculture			
Annual Crops	-12616561	this is a sink	-630828
Agroforestry/Perennial Crops	0		0
Rice	2607667	this is a source	130383
Grassland	0		0
Other GHG Emissions			
Livestock	0		0
Inputs	4187055	this is a source	209353
Project Investment	235	this is a source	12

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

Final Balance	**-5821604 This is a sink**	
	Total Area (ha)=	1058385
Mean per ha		**-5.5**
Mean per ha / yr		**-0.28**

Although not designed with the goal to mitigate climate change, the national programme to enhance food security in Tanzania represents a good example of the synergies between agriculture development and mitigation. The support brought by the project can restore soil nutrient depletion, increase yields and allow farmers to increase food production. Thus, it gives both an immediate response to food security and a longer-term response (i.e., access to inputs is facilitated for many years and as the soil potential is recovered, farmers have to buy a minimum amount of inputs to keep high yields).

Nevertheless, the increase in inputs use may create negative consequences on ecosystems, pollute water resources, especially if the use of inputs is not carried out at the right time (for example, if urea is spread on soils just before it rains, the active substance will go directly into the surface water, causing pollution and will have no impact on soils and yields). With the assumed increase in crop yields it is expected that the demand for chemicals will also increase, with negative effects on public health and the environment especially if banned or inappropriate substances are used. Moreover, uncontrolled use of fertilizers could have a strong impact on the final carbon balance, reducing the mitigation potential itself, hence the need to enforce public institutions in monitoring and providing training along the value chain.

The adoption of long-term sustainability practices (conservative agriculture, rainwater management) by smallholders is difficult and has to be accepted by shareholders. If no additional financing is proposed, farmers will not be able to change their production systems. To be accepted, it is really important to show the benefits that the improved system can bring to smallholders; make them understand that by using the proposed practices will reduce losses and risks of crop failure, increase yields…

The carbon balance results also show the trade-offs between management options aimed at increasing food security and those with climate change mitigation benefits. For example, the «improved» practices in rice crops damage the carbon balance but help in food security.

The controversial aspects described above should make policy makers think of possibilities to avoid and manage the risks of such a project, which aim to increase food production and productivity by providing fertilizers. The tool can also help to simulate other project options to achieve the project goals without compromising its sustainability.

6. SCENARIO ANALYSIS

6.1. Simulation proposed

An alternative scenario was built based on the assumption that the use of inputs will follow the same scheme as before, but will adopt different agronomic practices.

It is considered that only 40% of farmers will adopt all the improved practices promoted by the project (improved agronomic management, nutrient management, no burning residues). The other 40% of farmers will use nutrient management and stop burning residues, but will fail in adopting improved agronomic management. The remaining 20% of farmers are just expected to use nutrient management but will continue burning residues without any improved management practices. Indeed, the adoption of new improved practices may require more technical knowledge or know-how. It is obviously not easy for smallholders and may be socially unaccepted. The “without project” scenario and the current scenario remain unchanged.

Table 23: Sum up of the new scenario about the annual crops management

	Without project					With project				
	Surface (ha)	Improved management				Surface (ha)	Improved management			
		Agronomic	nutrient	no tillage	no burning		Agronomic	nutrient	no tillage	no burning
Conventional	972570		✓			260100		✓		
Management 1						284988	✓	✓	✓	✓
Management 2						284988		✓		✓
Management 3						142494		✓		
Total area	972570 ha					972570 ha				

6.2. Results

Under the simulated scenario, the project would create a total carbon emission of almost 7 million tons of eq-CO_2, but it would also create a total sink of 8.4 million tons of eq-CO_2, hence a net sink carbon balance of about 1.6 million tons of eq-CO_2 after 20 years.

The simulation does not focus on the rice crops, the distribution of inputs or the installation of irrigation systems, so it was expected to keep the same net C source as in the previous scenario for those modules. However, the only sink of carbon provided by the maize crops is lower than in the previous scenario. The promotion of sustainable agronomic practices was less efficient, as only 40% of the surface will be implemented by all the recommended practices that are expected to create a C sink. Therefore, the final balance is a smaller sink than the previous scenario as shown below:

Table 24: Results given by the EX-ACT tool

Components of the Project	Balance with Project (tCO2eq)		Mean per year
Deforestation	0		0
Afforestation and Reforestation	0		0
Other Land Use Change	0		0
Agriculture			
Annual Crops	-8353397	this is a sink	-417670
Agroforestry/Perennial Crops	0		0
Rice	2607667	this is a source	130383
Grassland	0		0
Other GHG Emissions			
Livestock	0		0
Inputs	4187055	this is a source	209353
Project Investment	235	this is a source	12

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

Final Balance	-1558440	This is a sink
Total Area (ha)=	1058385	
Mean per ha	-1.5	
Mean per ha / yr	-0.07	

On the one hand, with an adoption rate of only 40% for improved cropland management, the carbon balance is lower by 75%, hence the need to implement sustainable practices over a wide area in order to have better mitigation potential. On the other hand, the productivity of crops is also expected to be lower than in the "with project" scenario.

7. CONCLUSIONS

The analysis of the ex-ante carbon-balance results shows that the project according to its current design, has a mitigation potential of more than five million tons of eq-CO_2 over 20 years, it therefore actively reduces anthropogenic emissions and tackles climate change. The mitigation impacts were not considered in the formulation of the project, and they should be considered as positive externalities. In a context of rising concern of governments and civil society for Global Warming, this externality should represent a further incentive to support sustainable rural development in Tanzania.

This case study reflects how an intensive accelerated project that acts on food security by increasing the use of inputs, can also be designed in terms of its mitigation potential. It particularly points out the fact that synergies are possible between food security and agriculture mitigation. The project gives both a short-term response by using large amounts of financed inputs and a longer-term response by progressively reducing the amounts of inputs used.

8. READERS' NOTES

The exercise can be 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.

8.1. EASYPol links

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

- **EX-ANTE Carbon-Balance Tool : Technical Guidelines**
- **EX-ANTE Carbon-Balance Tool : Brochure**

8.2. 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 (draft paper prepared for the FAO Policy Learning Programme 2009)

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9. FURTHER REFERENCES

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IFPRI. 2010. Agricultural Growth, Poverty, and Nutrition in Tanzania, by Karl Pauw and James Thurlow, *Discussion paper 00947*, Development Strategy and Governance Division.

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Smith, P., D. Martino, Z. Cai, D. Gwary, H. Janzen, P. Kumar, B. McCarl, S. Ogle, F. O'Mara, C. Rice, B. Scholes, O. Sirotenko. 2007. *Agriculture. In Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* [B. Metz, O.R. Davidson, P.R. Bosch, R. Dave, L.A. Meyer (eds)], Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

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The United Republic of Tanzania. 2009. *Agricultural Sector Development Program (ASDP), Integrated Pest Management Plan (IPMP)* by Brigitte Nyambo.

United Nations. 2008. *World Population Prospects : The 2008 Revision. Population Database*. http://esa.un.org/unpp/p2k0data.asp

Ramonyaid, D. & Konstant, H. 2006. *Country Profile of the United Republic of Tanzania* (Agriculture trade)

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World Bank, 2009. *Tanzania - Accelerated Food Security Project* *http://web.worldbank.org/external/projects/main?pagePK=64312881&piPK=64302848&theSitePK=40941&Projectid=P114291*

MODULE METADATA

1. EASYPol module	222

2. Title in original language	
English	EX-ACT Software for Ex-ante Carbon-Balance Appraisal of Investment Projects
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3. Subtitle in original language	
English	An Application to the Accelerated Food Security Project in Tanzania
French	
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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 Tanzania, which was also selected for testing the software. The case study consists of: a brief description of the project; guidelines for structuring project data; and an appendix with project data.

5. Date

March 2010

6. Author(s)

Louis Bockel, Agricultural Policy Support Service, Policy and Programme Development Support Division, FAO, Rome, Italy

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

Marianne Tinlot, FAO Consultant, Rome, Italy

7. Module type

- ☐ Thematic overview
- ☐ Conceptual and technical materials
- ☐ Analytical tools
- ☒ Applied materials
- ☐ Complementary resources

8. Topic covered by the module

- ☐ Agriculture in the macroeconomic context
- ☐ Agricultural and sub-sectoral policies
- ☐ Agro-industry and food chain policies
- ☒ Environment and sustainability
- ☐ Institutional and organizational development
- ☒ Investment planning and policies

	☒ Poverty and food security ☐ Regional integration and international trade ☐ Rural Development
9. Subtopics covered by the module	
10. Interlinked material	**Investment planning for rural development**
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