The EX Ante Carbon-balance Tool

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APPLIED WORK

EASYPol Module 119

Initial Results of the Carbon Balance Appraisal on the Agriculture Technology and Agribusiness Advisory Services (ATAAS) Project in Uganda

EX-ACT Software for Carbon-Balance Analysis of Investment Projects

by

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for the

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS, FAO

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

See EX-ACT website: ***www.fao.org/tc/exact***

Related resources

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

About EASYPol

EASYPol is a multilingual repository of freely downloadable resources for policy making in agriculture, rural development and food security. The EASYPol home page is available at: *www.fao.org/easypol*. These resources focus on policy findings, methodological tools and capacity development. The site is maintained by FAO's Policy Assistance Support Service.

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Abbreviations

AFOLU	Agriculture, Forestry and Land Use
AFTEN	Africa Environment and Natural Resource Management
A/R	Afforestation and Reforestation
ARTP	Agricultural Research and Training Project
ATAAS	Agricultural Technology and Agribusiness Advisory Services
C	Carbon
CDM	Clean Development Mechanism
CH_4	Methane
CO_2	Carbon Dioxide
DAP	Diammonium Phosphate
DSIP	National Development Strategy and Investment Plan
Eq-CO_2	Equivalent of Carbon Dioxyde
ESA	FAO Agricultural Development Economics Division
EX-ACT	EX-Ante Carbon-balance Tool
FAO	Food and Agricultural Organization of the United Nations
FCPF	Forest Carbon Partnership Facility
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GoU	Government of Uganda
LAC	Low Activity Clay
IPCC	Intergovernmental Panel on Climate Change
LULUCF	Land Use, Land Use Change and Forestry
Mt	Million tons
NAADS	National Agricultural Advisory Service project
NARO	National Agricultural Research Organisation
NDP	National Development Plan
N_2O	Nitrous Oxide
PAD	Project Appraisal Document
PES	Payment for Ecosystem/Environmental Services
REDD	Reducing Emissions from Deforestation and Forest Degradation
SLM	Sustainable Land Management
SLWM	Sustainable Land and Water Management
T	Tonnes
TCSP	FAO Policy Support Service
TCI	FAO Technical Cooperation - Investment Centre
UNFCCC	United Nations Framework Convention on Climate Change
VCM	Voluntary Carbon Markets

Table of contents

1. SUMMARY

Agriculture can play an important role in climate change mitigation while contributing to increased food security and reductions in rural poverty. The Ex-Ante Carbon-balance Tool (EX-ACT) can estimate the mitigation potential of rural development projects/programmes brought on by changes in farming systems and land use. This study presents and discusses the EX-ACT analysis performed on a multi-donor-supported (World Bank, EU, IDAD, GEF, Danida) project in Uganda (the Agricultural Technology and Agribusiness Advisory Services Project - ATAAS). Based on projected estimates, the impact of project activities on greenhouse gas emissions and carbon sequestration show that the mitigation benefits achieved through the adoption of sustainable agricultural practices (intensification of agricultural lands without deforestation, improved cropland and grassland management, soil and water conservation) can balance the emissions associated with the increase in inputs use and petrol consumption due to the project. Three simulations have been carried out: first using the direct objectives of the ATAAS project; then reviewing the objectives of the project from a more pragmatic point of view; and finally reviewing the assumptions made to build the baseline scenario. The study shows possible synergies between mitigation and rural development goals, and puts forward possible options for the financing of proposed improvements.

2. INTRODUCTION

Objectives: This paper identifies and interprets the main project impacts on climate change mitigation. Due to the fact that this exercise puts the EX-ACT user in a situation somehow similar to the reality faced by carbon balance appraisal, it can be used in a training course, where there is no possibility to organize field visits to gather data for a practical applications of the EX-ACT software.

Target audience: This document particularly aims at current or future practitioners who work on the formulation and analysis of investment projects, on climate change issues and who work in public administrations, in NGO's, professional organizations or consulting firms. Academics can also find this material useful to support their courses in carbon balance Analysis and development economics.

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 follow links included in the text to other EASYPol modules or references[1]. See also the list of EASYPol links included at the end of this module[2].

3. BACKGROUND

3.1. Rationale of the present appraisal

The Agricultural Technology and Agribusiness Advisory Services (ATAAS) Project will build on the achievements of the completed Second Agricultural Research and Training Project (ARTP II) and the nearly completed National Agricultural Advisory Service Project (NAADS). The objective is to increase agricultural productivity and household incomes of participating smallholder farmers. Project activities will contribute to this objective by transforming and improving the performance of the agricultural technology development and advisory services in Uganda. It will enable the up-scaling and consolidation of research and advisory service activities supported in the previous phases, and continue to promote productivity growth at farm level. The project will be implemented over a five-year period (2010-2015).

The carbon balance appraisal has been carried out with the EX-ACT (EX-Ante Carbon Balance Tool) on a selection of AFTEN projects, including projects in Uganda, Ethiopia, Rwanda and the Democratic Republic of Congo, in order to test the relevance of such an impact appraisal. EX-ACT is a tool that provides ex-ante estimations of the impact of agricultural and forestry development projects on Green House Gas (GHG) emissions and sequestration, indicating its impacts on the carbon balance. This tool has been developed by the FAO Policy Support Service, the Agricultural Development Economics Division and the Investment Centre.

3.2. Agricultural sector in Uganda

Place of the agricultural sector in Uganda

Agriculture continues to be a mainstay of the Ugandan economy and directly accounts for 20 percent of Gross Domestic Product (GDP). The agricultural sector is important for the structural transformation of the economy through food security, value addition, export growth and employment.

Agriculture is a strategic sector for the Government of Uganda (GoU) and features prominently among the top five priority sectors for public investment in the National

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[1] 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*.

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

Development Plan (NDP), Uganda's new five-year strategic framework for economic development. Raising agricultural incomes is the focus of the Prosperity for All Program, the vision driving the NDP. Sector investments are further developed in the National Development Strategy and Investment Plan (DSIP) for the 2010-15 period.

In this context, the ATAAS project will support key activities along the technology generation–marketing continuum, mainly for research, extension and agribusiness to support farmers' involvement in key value chains. This will be done through five components: (i) Developing Agricultural Technologies and Strengthening the National Agricultural Research System; (ii) Enhancing Partnerships between Agricultural Research, Advisory Services, and other Stakeholders; (iii) Strengthening the National Agricultural Advisory Services; (iv) Supporting Agribusiness Services and Market Linkages; and (v) Programme Management.

Main issues in Agricultural sector

The Government of Uganda recognizes land degradation as a major impediment to sustainable growth in agriculture, natural resources productivity and national economic development. Land is a key strategic resource for Uganda – central to higher agricultural productivity, ecosystem stability, climate resilience and national and global environmental benefits. Although land constitutes over 50 percent of the value of the "asset basket" of poor Ugandans, current farming practices threaten soil fertility and prevent a significant share of agricultural potential from being realized. The soils of sub-Saharan Africa lose considerable fertility through poor nutrient management (ATAAS, 2010). In Uganda this problem is particularly severe: land degradation hotspots, where soil erosion (>5t/ha/year) and fertility loss are especially rampant, have been identified in the Southwestern Highlands, Lake Victoria Crescent, the Northwest and the Eastern Highlands, as well as in the Cattle Corridor. In these areas it is estimated that nitrogen, potassium and phosphorous balances are less than 85, 75, 10 kg per hectare annually. Soil erosion is estimated at above five tonnes per hectare per year[3].

Increasing climate variability will further exacerbate the problem of low and varying crop yields and declining soil fertility and degrade soils. Forecasts predict +1.5C° over the next 20 years (DFID, 2008) with increased heat waves, storms, floods and droughts.

LAC soils in Africa: Currently, sub-Saharan Africa's per capita and per hectare fertilizer use is very low compared with that of other regions. There is a need to develop integrated soil fertility management systems for the region based on better and sustainable utilization of local nutrient sources. Such systems should be supplemented with external inputs wherever that is feasible and affordable. For sustained crop production in addition to adequate supply of plant nutrients, the LAC soils also require continuous addition of organic matter for sustained integrated fertility management.

[3] World Bank SLM PER 2008.

Land use trends in Uganda

Overall, between 1990 and 2005, Uganda lost 26.3 percent of its forest cover, or around 1 297 000 hectares. This was an average of about 86 500 hectares per year, equivalent to an average annual deforestation rate of 1.76 percent. The extension of farming activities appears as a key reason for rapid deforestation in Uganda, putting heavy pressure on the eco-system. Thus, the impact of deforestation needs to be considered in some way within the carbon balance appraisal.

Based on FAOSTAT data, the growth rate of farmed land in Uganda followed a high positive trend between 1988 and 2008: on average the annual growth rates are estimated at 1 percent for banana, 3.4 percent for beans, 4.3 percent for maize, 8 percent for rice and 1.6 percent for sorghum. From 1988 to 2008, the total cropped area increased from 2.4 million ha to about 4.1 million ha, although the annual increase of maize (3.6 percent) and bean (2.6 percent) cropped areas were slightly lower during the 2001-2008 period. This represents an expansion of cropped areas of about 80-90 000 ha per year[4].

Towards more sustainable land management

The majority of soils in Uganda are classified as low activity clay soils (LAC) with a low inherent cation exchange capacity. Vast areas of rain-fed uplands currently used for traditional rain-fed food crop production are dominated by these "fragile" soils.

One of the major problems associated with extended cultivation of LAC soils is the maintenance of favourable soil physical conditions and the control of soil erosion. Significant, unfavourable changes in the soil properties also occur following forest or bush fallow clearing and cropping: soil organic matter levels decline sharply during the first few years under cropping. Continious cropping for a few years further reduces soil organic matter and soil chemical fertility levels to a minimum, unable to support any crop growth. Consequently, sustainable land management practices (e.g. conservation agriculture) have to be implemented to keep soil fertility at acceptable levels for crop growth and production.

The global environment objective of the ATAAS project is to enhance the environmental sustainability and resilience of agricultural production to land degradation and climate risks.

> With regard to this context, appraising the carbon balance of the ATAAS project could lead to a better understanding of activities that may impact on coping with climate change variability and planning for better agricultural practices and land management. Indeed climate change issues seem to be relatively new in Uganda and stakeholders need some clarification regarding the possible links (positive and negative) between climate change and agricultural development.

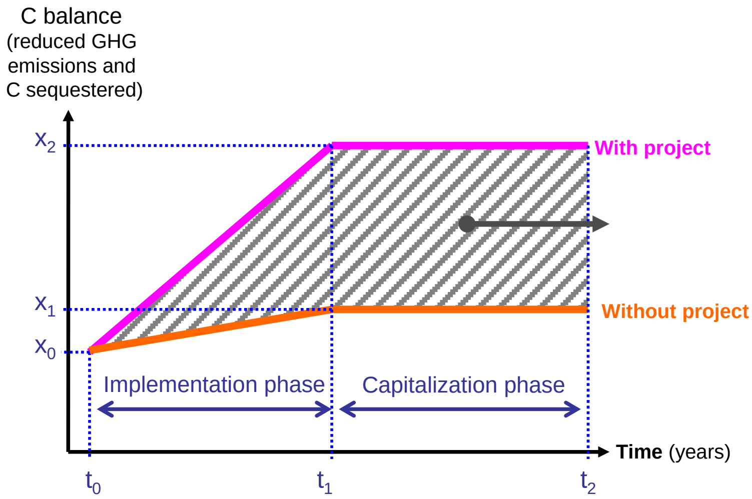
[4] It should be noted that the data reliance on estimated areas is limited in line with the high degree of crop mixing (maize – beans, cassava – groundnut...) not always adequately taken into account in available statistics.

3.3. Carbon balance appraisal using the EX-ACT tool

Main outputs of the EX-ACT tool

The carbon balance[5] obtained with EX-ACT is an indicator of the mitigation potential of the project appraised. It computes the carbon balance by comparing two scenarios: "without project" (i.e. the "business as usual" or "baseline") and "with project". The tool's main output consists of the C-balance resulting from the difference between these two alternative scenarios (Figure 1).

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



Source: Bernoux et al.

The model takes into account both the implementation phase of the project (i.e. the active phase of the project commonly corresponding to the investment phase), and the so-called "capitalization phase" (i.e. a period where project benefits are still occurring as a consequence of the activities performed during the implementation phase). Usually, the implementation and capitalization phases together last a total of 20 years.

Methodology behind EX-ACT

EX-ACT has been developed using mainly the Guidelines for National Greenhouse Gas Inventories (IPCC 2006) as well as other methodologies and a review of default coefficients for mitigation option as a base. Most calculations in EX-ACT use a Tier 1 approach[6] as default values are proposed for each of the five pools defined by the Intergovernmental Panel on Climate Change (IPCC) Guidelines and the United

[5] C-balance = GHG emissions - C sequestered above and below ground.

[6] IPCC Guidelines provide three methodological tiers varying in complexity and uncertainty level: Tier 1, simple first order approach using data from global datasets, simplified assumptions, IPCC default parameters (large uncertainty); Tier 2, a more accurate approach, using more disaggregated activity data, country specific parameter values (smaller uncertainty); Tier 3, using higher resolution and direct measurements (much lower uncertainty).

Nations Framework Convention on Climate Change (UNFCCC): above-ground biomass, below-ground biomass, soil, deadwood and litter. It should be noted that EX-ACT also allows users to incorporate specific coefficients (e.g. from project area) in case they are available, therefore working at Tier 2 level too. EX-ACT measures C stocks and stock changes per unit of land, as well as methane and nitrous oxide emissions expressing its results in tonnes of eq-CO2 per hectare and per year.

4. ATAAS PROJECT DESCRIPTION

4.1. Purposes of the ATAAS projects

The Project Development Objective (PDO) is to increase agricultural productivity and incomes of participating households by improving the performance of agricultural research and advisory service systems in the Republic of Uganda. Its main global environmental objective is to enhance the environmental sustainability and resilience of agricultural production to land degradation and climate risks. It will be implemented in the beginning of 2011.

The total project is worth US$ 665.5 million, of which the IDA allocation is US$ 120 million. A US$ 7.2 million GEF grant to co-finance SLM will be fully blended to respond to land degradation and climate risks.

The project will support key activities through five components:

- (i) Developing Agricultural Technologies and Strengthening the National Agricultural Research System;
- (ii) Enhancing Partnerships between Agricultural Research, Advisory Services and other Stakeholders;
- (iii) Strengthening the National Agricultural Advisory Services;
- (iv) Supporting Agribusiness Services and Market Linkages; and
- (v) Programme Management.

The objectives of Component 1 are to develop agricultural technologies through research, and to strengthen agricultural research institutions. The objectives of Component 2 are to enhance the efficiency and effectiveness of technology development and dissemination by supporting closer linkages among NARO, NAADS and other stakeholders. The objectives of Component 3 are to support improved delivery of demand-driven and market-oriented advisory services to farmers to promote their progression from subsistence to market-orientation. The objectives of Component 4 are to promote the integration of smallholders in value chains by supporting collaboration among agribusiness, farmers, advisers and researchers to create viable, sustainable market and agribusiness linkages.

The project will be carried out through two implementing institutions, NARO and NAADS. The project structure makes it possible to: (i) increase the emphasis on the critical role of the joint activities requiring the two institutions to work together more effectively to achieve the PDO; and (ii) more clearly demonstrate the support to agricultural commercialization under the programme, aligning with the objectives of the newly developed NDP and the DSIP.

4.2. Activities that may count regarding the carbon balance appraisal

Especially within the first two components, implementation of the ATAAS project will lead to some changes in the agriculture and forestry sector.
As it will deal with cropland intensification, it will imply the adoption of practices that may have direct impact regarding climate change mitigation (e.g. use of improved seed, nutrient management, incorporation of manure on soils…). Intensifying could also avoid the expansion of annual cropland. Consequently it could lead to reduced deforestation and different land use changes that could be a source or sinks of GHG.

Within EX-ACT, all the activities affecting the management of annual, perennial, pasture and forestry lands will be accounted. The use of fertilizers and the consumption of different fuels for the purpose of the project will be integrated in the appraisal.

> The following appraisal will finally reflect the mitigation potential of the ATAAS project that was not directly formulated to act on climate change, putting forward another potential co-benefit of ATAAS.

5. Data used to appraise the ATAAS carbon balance

5.1. Type of data used

The project targets clearly show transfers of cropping areas from traditional to improved cropping, in terms of land use change. The technical changes related to sustainable land management and improved cropping systems are expressed in terms of areas (hectares). Data is based on national agriculture statistics (2008) multiplied by the percentages of farming household beneficiaries, of annual crops affected and of households applying either low or high technology levels on their farm.

There is a discrepancy between physical areas cropped and areas under mixed cropping, mainly due to the way they are measured. For instance, 862 000 ha of equivalent areas of maize – at standard densities – in FAOSTAT correspond to about 1 090 000 ha of land cropped with maize – at lower densities, as it is intercropped. Consequently conservative FAOSTAT figures are chosen to avoid double counting.

Table1: Area covered in the situation "with project"

	Ha cropped land 2008	Ha covered by ATAAS Optio=50%	Area growth/ year
Maize	862,000	431,000	0%
Beans	896,000	448,000	0%
Sorghum	321,000	160,500	0%
Finger millet	448,000	224,000	0%
Cassava-root	1,070,000	535,000	0%
Groundnut	244,000	122,000	0%
Rice	128,000	64,000	0%

Source: FAOSTAT, 2008

5.2. Scope of the ATAAS project

Of 4.2 million farming households, it is expected that the ATAAS project will effectively reach about 50 percent or the equivalent of 2.1 million households. The area covered will be considered to be 50 percent of the total cropped areas by smallholders (outside industrial agriculture).

5.3. Expansion of croplands

The with project situation is assumed to gradually halt the expansion of cropped areas in the project area and to promote farming intensification, improved mixed farming and agro-forestry practices. These practices should prevent further land impoverishment as well as rehabilitate the soil organic content of current agriculture land, while diversifying farming systems. The integration of food crops and forages with multi-purpose tree species in agro-forestry and alley farming systems have received much attention in recent years as an alternative, low chemical input management opportunity for improved LAC soil management[7].

The without project scenario integrates the impact of no policy action on agriculture land expansion, implying further deforestation and switches from grassland and fallow land aside to annual crops. Based on an aggregated expansion of cropped land of about 195 538 ha for annual crops and about 128 271 ha for banana plantations, it was estimated that about one third of the new cropped areas would originate from deforestation (107936 ha), another third from pasture and the final third from fallowed land (107936 ha each).

[7] Kang and Tripathi, 2010.

Table 2: Without project: agriculture area expansion in annual and bi annual crops

	Growth rate	2020 area (ha)	Incremental Area (ha)
Annual crops (total)			**195 ,538**
Maize	1.5%	515,311	84,311
Beans	1.5%	535,637	87,637
Sorghum	0.0%	160,500	-
Finger millet	0.0%	224,000	-
Cassava-root	0.0%	535,000	-
Groundnut	1.0%	137,473	15,473
Rice	1.0%	72,117	8,117
Biannual crops (total)			**128,271**
Banana	1.2%	961,771	128,271
Total			**323,809**

The project will promote area expansion on perennials (such as coffee and fruit trees) through agro forestry support and tree planting promotion. On banana it will promote intensification (including alley cropping) and mixed-cropping.

Table 3: Evolution of biannual and perennial crops in ATAAS

	2008 area (ha)	Part in ATAAS	Equivalent (Ha)	Growth rate per year	2020 area (ha)
Bi annuals					
Banana-pineapple	1,667,000	50%	833,500	0.0%	833,500
Perennials					
Fruit trees	45,000	50%	22,500	4.0%	36,023
Coffee	216,000	50%	108,000	2.0%	136,970

In line with ongoing cropping systems, cereals (mostly maize) are associated – especially during the first cycle - with beans, roots and tubers (cassava, sweet potato, yams) and groundnuts. Annual crop improvements (traditional, improved technology and high technology) are therefore defined for the two main crop groups: cereal-beans and cassava-groundnut. Traditional technology still includes residue/biomass burning. The first technology package (improved) is limited to improved agronomic practices (improved varieties, crop rotation) and improved nutrient management. The second technology package (bio-tech) is adding manure or applying bio solids.

It is worth noting that fallowing and adding organic mulches may correct chemical soil degradation resulting from continuous cultivation; at the same time, it may also increase the efficiency of fertilizer use.

Table 4: Growth scenarios of crop improvements

Annuals	Year 0 (ha)	Without project (ha)	With project by 2020		Land use change by 2020 (ha)	
			%	(ha)	Without	With
Cereals - Beans -Traditional	1,039,500	1,211,448	50%	519,750	171,948	-
Cereals- Beans -Improved			30%	311,850		
Cereals- Beans -High tech.			20%	207,900		
Cassava–Groundnut-Traditional	657,000	672,473	50%	328,500	15,473	-
Cassava-Groundnut -Improved			30%	197,100		
Cassava-Groundnut -High tech.			20%	131,400		
Rainfed rice	64,000	72,117		64,000	8,117	
Bi annuals						
Banana cropping system	833,500	961,771		416,750	128,271	-
improved banana cropping system				416,750		
Perennials						
Fruit trees	22,500	22,500		36,023	0	13,523
Coffee	108,000	108,000		136,970	0	28,970
Total annual crop expansion					323,809	
Total perennial crop expansion						42,493

In the business-as-usual scenario, the land use change (new cropped areas and plantations) is considered as using equally three different types of lands: fallow or set aside land (33 percent); (ii) forest areas (33 percent); and (iii) grassland (33 percent).

In the project situation, actions of perennial planting will be taken to minimize areas issued from deforestation. The new perennials will be implemented on deforested land (20 percent) in favour of fallows (40 percent) and grasslands (40 percent).

5.4. Adoption of sustainable land and water management

Other sustainable land and water management (SLWM) practices specified in the ATAAS project are listed in Table 5, expressed in the equivalent of areas improved.

Table 5: SLWM foreseen within the ATAAS project

Other SLWM improved areas	Areas (ha)
Improved pasture 100 spots with 200 ha	20 000
Terraces	440
Low/zero tillage	550
Watershed reforestation	3 300
Agro-forestry	825
Contour bunds planted	225

5.5. Input use

Input use has been recalculated on the basis of Uganda national fertilizer imports (2007 figures: 25,000 T urea, 10,000 T of other N fertilizers, 60,000 T of NPK fertilizers, 22,000 T of DAP fertilizers and 5,000 T of MRP). About all NPK have been considered as applied to industrial crops (sugar cane, tea, soybean, sunflower, sesame...). All NPK is for industrial crops and half of urea is for food crops. Other N fertilizers are for horticulture, which is included in other crops. Half of DAP is used for industrial crops. Half of the fertilizer volume from other crops is currently applied in the ATAAS project area.

Table 6: Input use

Total fertilizer imports 2007	Total Tons (T)	Industrial crops (t)	Other crops (t)	ATAAS 50% in (t)	Equiv Urea (t)
Urea (46-0-0)	25,000	12,500	12,500	6,750	6,750
Other N fertilizers (18-0-0)	10,000	0	10,000	5,000	1,956
NPK fertilizer (16.20-0)	60,000	60,000	0	0	0
DAP fertilizer (18-46-0)	22,000	11,000	11,000	5, 500	2,152
Total	117,000	74,000	335,000	17,250	10,858

Considering that within the improved option, fertilizer use is going to increase on the following basis, the aggregated fertilizer volume consumed per year has been estimated.

Fertilizers: *It is worth seeing that poorly managed soils in Uganda lead to the loss of organic matter and acidification of soil, as well as the loss of Ca and Mg (Kang and Juo, 1983). The arbitrary application of exotic, high-input food crop production technologies on these fragile soils therefore often leads to rapid chemical, physical, and biological degradation. It is not sufficient to apply higher quantities of mineral fertilizers to sustain crop productivity: an integrated soil fertility management, including organic and mineral fertilizers, is needed while socio-economic constraints also need to be overcome.*

Table 7: Evolution of input use

Equiv in Kg /ha of urea	Year 0	Without project	With project
Normal	4.0	4.0	4.0
Low tech			15.0
High tech			30.0
Tonnes of equivalent urea	**Year 0**	**Without project**	**With project**
Aggregated volume per year	10,898	12,193	38,227

5.6. Fuel consumption

Incremental petrol consumption is estimated below on a basis of 250 cars and 500 motorbikes purchased for the project.

Table 8: Petrol consumption

	Nb	Km/year	Consumption	Total l/year
Cars	250	20,000 km/year	12 l/100 km	480,000
Motor bikes	500	5,000 km/year	200 l/year	100,000

Finally the following table summarizes the assumptions taken for the three situations (start, without project and with project).

Table 9: Data used within EX-ACT to build the ATAAS carbon balance

	Average area (ha)		
	Start	Future without project	Future with project
DEFORESTATION (in ha)			
Deforestation for annual crop expansion		107, 936	0
Deforestation for perennial crop expansion		0	8, 499
FOREST LAND USE CHANGE			
From degraded land to plantation	0	0	3, 300
From set aside land to plantation	0	0	225
NON FOREST LAND USE CHANGE			
From set aside to coffee and fruit plantation			16, 997
From set aside to agro-forestry			825
From set aside to annual crops		107,936	
From degraded land to terracing			440
From grassland to annual crops		107,936	
From grassland to coffee and fruit plantation			16, 997
ANNUAL AND BIANNUAL CROPS			
Cereal & pulses Tradit	1, 039, 500	1, 039, 500	519, 750
Cereal & pulses LT			311, 850
Cereal & pulses HT			207,900
Cassava & other Trad	657, 000	657,000	328,500
Cassava & other LT			197, 100
Cassava & other HT			131, 400
Banana -pineapple trad	833, 500	833, 500	416, 750
Banana-pineapple improved			416, 750
GRASSLAND			
Moderately degraded		20, 000	
Moderately degraded			20, 000

6. First carbon balance results in an initial basis scenario

The overall C balance of the project is computed as the difference between C sinks and sources over 20 years (10 years for the implementation phase and 10 years for the capitalization phase).

The following table summarizes the carbon results by project component and type of mitigation generated (CO_2 biomass, CO_2 soil, N_2O, CH_4).

Table 10: Carbon balance provided with the EX-ACT tool for the initial basic scenario

Project Summary	
Name	Uganda ATAAS
Continent	Africa
Climate	Tropical Moist
Dominante Soil	LAC Soils

Area (Initial state in ha)		
Forest/Plantation		116435
Cropland	Annual	2530000
	Perennial	0
	Rice	0
Grassland		127936
Other Land	Degraded	3740
	Other	107936

Components of the Project	Balance (Project - Baseline) All GHG in tCO2eq		CO2 Biomass	CO2 Soil	N2O	CH4
Deforestation	**-64003892**	**this is a sink**	-54680458	-7254379	-626374	-1442681
Afforestation and Reforestation	**-1415413**	**this is a sink**	-1124406	-291006	0	0
Non Forest Land Use Change	**-12894152**	**this is a sink**	-180204	-12420785	-232431	-60732
Agriculture						
Annual Crops	**-45093920**	**this is a sink**	0	-31232408	-3836669	-10024844
Agroforestry/Perennial Crops	**-6649313**	**this is a sink**	-6194474	-454839	0	0
Rice	**0**		0	0	0	0
Grassland	**-846846**	**this is a sink**	0	-846846	0	0
Other GHG Emissions			CO2 (other)			
Livestock	**0**		---		0	0
Inputs	**1430995**	**this is a source**	896220		534775	---
Other Investment	**24903**	**this is a source**	24903		---	---
Final Balance	**-129447637**	**It is a sink**	**-61258419**	**-52500263**	**-4160699**	**-11528257**
Result per ha	**-44.9**		**-21.2**	**-18.2**	**-1.4**	**-4.0**

The project would be able to avoid the emission of 130.1 Mt of eq-CO_2 while emitting about 1.46 Mt of eq-CO_2. Finally the net effect of the project, according to the previous assumptions, is to create a sink of 129.4 Mt of eq-CO_2 during 20 years.

Since the project works on about 2.9 million ha, the average mitigation potential of the project is equal to about 2.2 T of GHG avoided/sequestrated per hectare per year or 44.9 T of eq-CO_2 on 20 years.

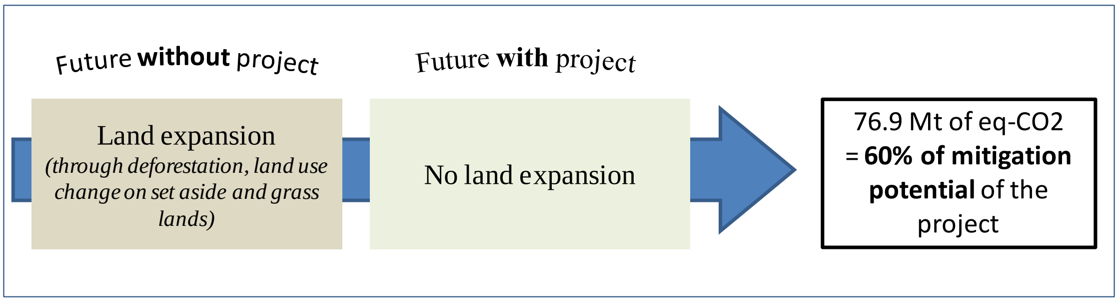
Most of the project activities' mitigation potential is related to the prevention of deforestation linked to the intensification of agriculture lands, as well as the improvements implemented for annual crops.

6.1. Carbon impact linked with avoided deforestation (BAU scenario)

Considering that the without project business as usual situation would translate to 107 936 ha of additional deforestation (due to agriculture land expansion) and that the with project situation would stop the expansion of annual crops, the incremental impact due to avoided deforestation is by far the widest GHG emission reduction impact (64 million tonnes) or 50 percent of the GHG avoided.

When added to avoided switch from pasture land and set aside land to annual crops (2 x 107 936 ha) equivalent to 12.9 million tonnes, that will generate an incremental impact of 76.9 million tonnes of eq-CO_2, equivalent to 60.24 percent of the global mitigation impact of the project.

However such impact of avoided deforestation highlights a question on the realness of the business as usual scenario and the real capacities of the project to nearly stop deforestation.



Fuelwood impact?

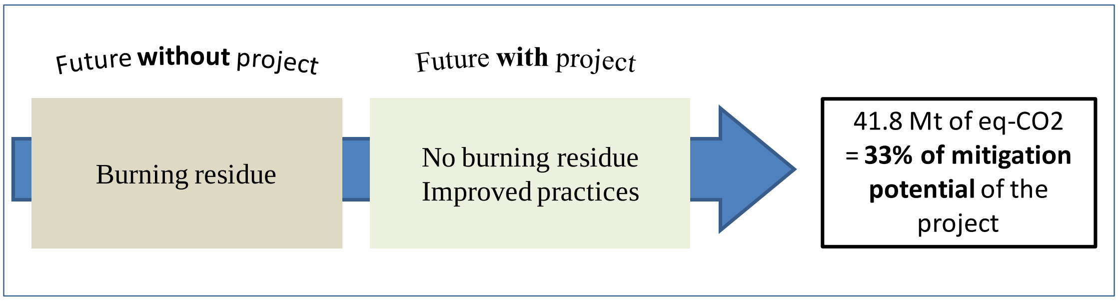
It is worth noting that in Uganda deforestation is carried out to meet the demand for fuel wood as well as agricultural expansion. About 92 percent of the energy comes from wood sources, the other sources being petrol (7 percent) and electricity (1 percent). Consequently each year, 22 million tonnes of firewood and 4 million tonnes of charcoal are used (MWLE, 2002).

That means that intensifying agriculture may not stop deforestation, as the demand for fuel will remain. It is important to make sure that forestry lands are managed to allow for both wood demand and regeneration of forest lands. Otherwise, the energy situation will become critical. Possible alternative energy sources should also be considered.

At the moment, degraded lands are given to people to plant trees, which is already being done by farmers and investors. However this is sometimes limited to the planting of trees without the monitoring of the trees' growth.

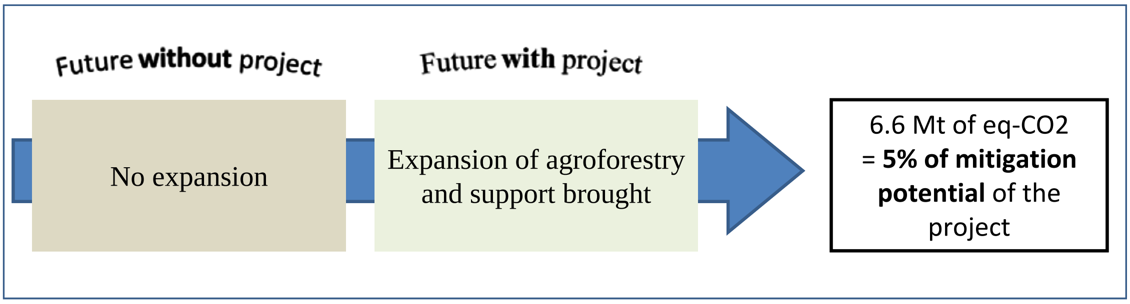
6.2. Carbon impact linked to improvement of cereal–beans and cassava-groundnut and banana cropping systems

Incremental soil carbon fixed during 20 years in cereal–pulses cropped areas and cassava-groundnut is around 20.9 million tonnes of eq-CO_2 (85 percent) and reduced biomass burning is around 3.1 million tonnes of eq-CO_2 (15%). 10.2 million tonnes of eq-CO_2 are generated in soil carbon within improved banana cropping systems to add to a reduction of 5.8 million tons of biomass burning on banana cropping systems. Aggregated, it represents 34.5 percent of the global carbon mitigation impact with 45.1 million tonnes of eq-CO_2 reduced or the equivalent of 2.2 million tonnes of eq-CO_2 reduction per year.



6.3. Carbon impact linked with agro-forestry and perennial expansion through land use change

On agro-forestry and perennials, the expected expansion of coffee plantations and support to the planting of fruit trees should represent an expansion of 42 493 ha. It will account for 6.6 million tonnes of eq-CO_2 fixation (around 5 percent of the global mitigation impact) mostly in biomass (6.2 million tonnes) and in soil (0.45 MT) with an increase of 32 tonnes of carbon soil per ha in 20 years.



Conclusion: The current results reflect the mitigation potential of the initial assumptions drawn within the project proposal. The project may not reach all of its targets. Many socio-economic constraints will remain, making it difficult to completely halt expansion towards new cropped areas. Consequently, the adoption of changes will be reviewed to provide a more pragmatic implementation scenario of the project and its foreseen carbon benefits.

7. Results in a more pragmatic scenario

This scenario keeps the same data employed in the normal scenario, except:

- the expansion of annual agriculture crops – the main source of deforestation – particularly maize, beans and banana is not stopped with the adoption of the project but reduced from initial growth rates to 0.5 percent, 0.3 percent and 0.3 percent respectively; and
- the application of sustainable land practices on annual crops; manure is not applied in the bio-tech package for cassava-groundnut, cereals-beans and banana.

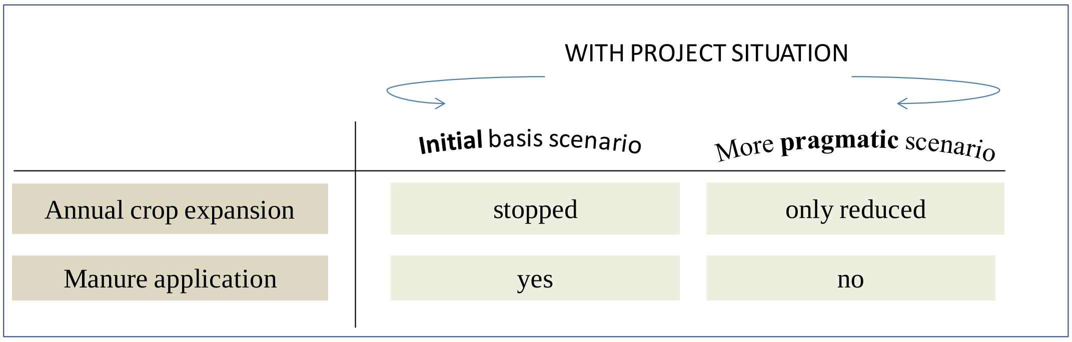


Table 11: Revised data used within EX-ACT to build the more pragmatic simulation

	Average area		
	Start	Future without project	Future with project
DEFORESTATION (in ha)			
Deforestation for annual crop expansion		107, 936	24, 495
Deforestation for perennial crop expansion		0	8, 499
FOREST LAND USE CHANGE			
From degraded land to plantation	0	0	3, 300
From set aside land to plantation	0	0	225
NON FOREST LAND USE CHANGE			
From set aside to coffee and fruit plantation			16, 997
From set aside to agro-forestry			825
From set aside to annual crops		107,936	24, 495
From degraded land to terracing			440
From grassland to annual crops		107,936	24,495
From grassland to coffee and fruit plantation			16, 997
ANNUAL AND BIANNUAL CROPS			
Cereal & pulses Tradit	1, 039, 500	1, 039, 500	519, 750
Cereal & pulses LT			311, 850
Cereal & pulses HT			207,900
Cassava & other Trad	657, 000	657,000	328,500
Cassava & other LT			197, 100
Cassava & other HT			131, 400
Banana -pineapple trad	833, 500	833, 500	416, 750
Banana-pineapple improved			416, 750
GRASSLAND			
Moderately degraded		20, 000	
Moderately degraded			20, 000

Feasibility of manure application in Uganda: The importance of enriching soils in organic matter also leads to ways of encouraging the use of farm-produced manure. A project has already been carried out; however, it still needs to be promoted at field level. In northern Uganda, most farmers are interested in using manure in their fields; however they lack animals to efficiently improve their soil fertility. In other districts they either do not know about the use of manure or have a bad image of manure.

With the revised assumptions for the with project situation, the project should be able to avoid the emission of 93.7 Mt of eq-CO_2 while still emitting about 1.5 Mt of eq-CO_2. Finally the net effect of the project, according to the previous assumptions, is to create a sink of 92.2 Mt of eq-CO_2 during 20 years.

Since the project works on about 2.8 million ha, the average mitigation potential of the project is equal to about 1.6 T of GHG avoided/sequestrated per hectare per year or 32 tons of eq-CO_2 in 20 years.

Table 12: Carbon balance provided with the EX-ACT tool for the more pragmatic scenario

Project Summary	
Name	Uganda ATAAS
Continent	Africa
Climate	Tropical Moist
Dominante Soil	LAC Soils

Area (Initial state in ha)		
Forest/Plantation		116435
Cropland	Annual	2530000
	Perennial	0
	Rice	0
Grassland		127936
Other Land	Degraded	3740
	Other	107936

Components of the Project	Balance (Project - Baseline) All GHG in tCO2eq		CO2 Biomass	CO2 Soil	N2O	CH4
Deforestation	**-48399794**	**this is a sink**	-41192221	-5608070	-484225	-1115279
Afforestation and Reforestation	**-1415413**	**this is a sink**	-1124406	-291006	0	0
Non Forest Land Use Change	**-9975034**	**this is a sink**	-50870	-9698044	-179277	-46843
Agriculture						
Annual Crops	**-26381682**	**this is a sink**	0	-12520170	-3836669	-10024844
Agroforestry/Perennial Crops	**-6649313**	**this is a sink**	-6194474	-454839	0	0
Rice	**0**		0	0	0	0
Grassland	**-846846**	**this is a sink**	0	-846846	0	0
Other GHG Emissions			CO2 (other)			
Livestock	**0**		---		0	0
Inputs	**1430995**	**this is a source**	896220		534775	---
Other Investment	**24903**	**this is a source**	24903		---	---
Final Balance	**-92212184**	**It is a sink**	**-47640848**	**-29418975**	**-3965395**	**-11186966**
Result per ha	**-32.0**		**-16.5**	**-10.2**	**-1.4**	**-3.9**

The main differences between the first and second appraisal are due to the change in assumptions. The current simulation implies the deforestation of 24 495 ha of forest to expand annual cropland in the with project situation, whereas the first simulation stopped the expansion of annual crops, hence no area was deforested in the with project situation. Then the main difference is due to not adopting the recommended practices.

Conclusion:

This second scenario reflects how project carbon balance can be affected if the adoption of the recommended practices falls below expectations. It highlights the need to further question the current gap of incentives to farmers to apply new techniques. Innovative incentive mechanisms may need to be promoted to ensure that the practices are adopted sustainably during the first years of implementation, since the benefits of adopting such practices may not be readily apparent to the farmers. However, these incentives could be reduced once it becomes clear that the sustainable management practices result in increased yields.

The project may lead to a reduced carbon balance (about -30 percent) reconsidering the three previous assumptions. Support should be provided to make the first project scenario assumptions feasible and allow for a good carbon balance. The following part proposes a final simulation on revised options in the business as usual scenario.

8. Reconsidering the "without project situation": simulation with limited deforestation

This last simulation is based on a reviewed "without project" situation with more limited agriculture area expansion. Except for Northern Uganda, there are limits[8] to sustainable area expansion in most parts of Uganda as land is a fixed factor whereas the population growth rate in Uganda is escalating[9].

	WITHOUT PROJECT SITUATION	
	Initial *basis scenario*	Reconsidered *scenario*
Maize expansion/year	1.5 %	1 %
Rice expansion/year	1 %	0.5 %
Beans expansion/year	1.5 %	0.5 %
Bananas expansion/year	1.2 %	0.5 %

The annual expansion rate for the agriculture area is now planned to stay at 1 percent for maize, 0.5 percent for beans and rice and at 0.5 percent for banana in the business as usual situation.

8 Source: http://www.ambkampala.um.dk/NR/rdonlyres/0210A26B-97D8-4886-A512-218C5D9B1ABF/0/UGrowthProgrammeDocumentFINAL.pdf
9 http://www.monitor.co.ug/OpEd/Commentary/-/689364/858892/-/airvkqz/-/index.html

Table 13: Revised "Without project" situation: expansion of cropped areas (Ha)

	Growth rate	2020 area	Incremental area
Maize	1.0%	485, 662	54, 662
Beans	0.5%	475, 632	27, 632
Rice	0.5%	67, 947	3, 947
Banana	0.5%	884, 908	51, 408
		Total	137, 649

This agriculture area expansion is still assumed to be at one third based on land from deforestation (45, 883 ha), one third from grassland and the last third from set aside land.

Table 14: Revised data used within EX-ACT to build the last simulation

	Average area		
	Start	Future without project	Future with project
DEFORESTATION (in ha)			
Deforestation for annual crop expansion		45, 883	24, 495
Deforestation for perennial crop expansion		0	8, 499
FOREST LAND USE CHANGE			
From degraded land to plantation	0	0	3, 300
From set aside land to plantation	0	0	225
NON FOREST LAND USE CHANGE			
From set aside to coffee and fruit plantation			16, 997
From set aside to agro-forestry			825
From set aside to annual crops		45, 883	24, 495
From degraded land to terracing			440
From grassland to annual crops		45, 883	24,495
From grassland to coffee and fruit plantation			16, 997
ANNUAL AND BIANNUAL CROPS			
Cereal & pulses traditional	1, 039, 500	1, 039, 500	519, 750
Cereal & pulses LT			311, 850
Cereal & pulses HT			207,900
Cassava & other traditional	657, 000	657, 000	328,500
Cassava & other LT			197,100
Cassava & other HT			131, 400
Banana -pineapple traditional	833, 500	833, 500	416, 750
Banana-pineapple improved			416, 750
GRASSLAND			
Moderately degraded		20, 000	
Moderately degraded			20, 000

By changing the without project situation the final carbon results are strongly affected. The project should actually be able to avoid the emission of 62.3 Mt of eq-CO_2 while still emitting about 1.5 Mt of eq-CO_2. Finally the net effect of the project, according to the previous assumptions, is to create a sink of 60.8 Mt of eq-CO_2 during 20 years.

Since the project works on about 2.7 million ha, the average mitigation potential of the project is equal to about 1.1 tonnes of GHG avoided/sequestrated per hectare per year or 22.6 tonnes of eq-CO_2 on 20 years.

Table 15: Carbon balance provided with the EX-ACT tool for the last scenario

Project Summary	
Name	Uganda ATAAS
Continent	Africa
Climate	Tropical Moist
Dominante Soil	LAC Soils

Area (Initial state in ha)		
Forest/Plantation		54382
Cropland	Annual	2530000
	Perennial	0
	Rice	0
Grassland		65883
Other Land	Degraded	3740
	Other	45883

Components of the Project	Balance (Project - Baseline) All GHG in tCO2eq		CO2 Biomass	CO2 Soil	N2O	CH4
Deforestation	-24474149	this is a sink	-20510808	-3083796	-266268	-613276
Afforestation and Reforestation	-1415413	this is a sink	-1124406	-291006	0	0
Non Forest Land Use Change	-2580054	this is a sink	276769	-2800542	-44622	-11659
Agriculture						
Annual Crops	-26381682	this is a sink	0	-12520170	-3836669	-10024844
Agroforestry/Perennial Crops	-6649313	this is a sink	-6194474	-454839	0	0
Rice	0		0	0	0	0
Grassland	-846846	this is a sink	0	-846846	0	0
Other GHG Emissions			CO2 (other)			
Livestock	0		---		0	0
Inputs	1430995	this is a source	896220		534775	---
Other Investment	24903	this is a source	24903		---	---
Final Balance	-60891558	It is a sink	-26631796	-19997200	-3612784	-10649779
Result per ha	-22.6		-9.9	-7.4	-1.3	-3.9

It translates in a final balance to 60.9 million tonnes of GHG (expressed in tons of eq-CO_2 mitigated through project activities in comparison to a situation without project. This last result comes from a voluntary wish to work out a minimal impact (agriculture area expansion reducing and deforestation rate improving in without project situation compared with recent trends).

Importance of the business as usual scenario: validating the different assumptions chosen to build the business as usual scenario is extremely important as it affects the final carbon balance. The value added from a good carbon balance could be used to reward people who carried out practices that positively contributed to climate change mitigation.

9. Economic value and new perspectives

9.1. Estimated public value of the carbon mitigation effect

The huge amount of avoided GHG emissions could lead to financing incentives to work on climate change mitigation. The value generated could be attributed to farmers working on agriculture intensification as well as collective intervention to follow efforts in progress (payment for environmental services, watershed management...).

Table 16: Value generated per year during 20 years

	Final carbon balance in t of eq-CO_2 (during 20 years)	Value generated per year (during 20 years)		
		2$/t eq-$CO_2$	5$/t eq-$CO_2$	10$/t eq-$CO_2$
Initial basic scenario	129 447 637	12 944 764	32 361 909	64 723 819
More pragmatic scenario	92 212 184	9 221 218	23 053 046	46 106 092
Revised scenario	60 810 845	6 081 085	15 202 711	30 405 423

9.2. Derived Cost and performance indicators

The total area affected by project activities is estimated at 2.72 million hectares. The area with direct support to project beneficiaries is limited to annual crops and perennial plantations which amount to 2.65 million hectares. The areas effectively improved by farmers are limited to 1.3 million hectares.

Table 17: Value generated per hectare* per year during 20 years

	Final carbon balance in t of eq-CO_2	Area (ha)	Value generated per ha (5$/t eq-$CO_2$)	
			During 20 years	Per year
Initial basic scenario	129 447 637	1 288 525	502	25
More pragmatic scenario	92 212 184		358	18
Revised scenario	60 810 845		236	12

** the value has been calculated on the basis of the land that is directly improved, hence the new plantations of agro-forestry, the annual crops improved, as well as the improved grasslands.*

The aggregated carbon balance could be first computerized as a value generated by hectare of project direct support. A second estimation could be based on only the improved areas to appraise the potential public carbon value generated by hectare improved.

9.3. Fund mobilization in Uganda

There is increasing potential for African countries to be involved in voluntary markets for carbon and international market mechanisms such as the CDM (Clean Development Mechanism). Knowledge and strategies to reduce carbon emissions through community-based afforestation and reforestation projects, agro-forestry and reduced deforestation and degradation (REDD) are being generated, but need to be tested and adopted. These strategies have the potential to create synergies for increasing productivity and achieving the multiple functions of agriculture for the benefit of smallholders.

Most of the SLM interventions have strong ecosystem rehabilitation attributes and carbon sequestration elements and hence can benefit from CDM mechanisms. However, CDM methodology does not yet include the agriculture sector. Additionally, Uganda's action plans and programmes provide an enabling environment for Payment for Ecosystem Services (PES). Uganda has also entered/ engaged (2009) in the Forest Carbon Partnership Facility (FCPF) and taken the lead in promoting PES throughout the East African region. Activities undertaken by Eco-Agriculture and Katoomba Group – Forest Trends and other partners are good starting initiatives. These initiatives provide opportunities for incentives to promote SLM interventions (Uganda SLM, 2010).

There are fund opportunities to promote climate change mitigation and adaptation through SLM in Uganda but implementation mechanisms remain at the design or under testing phase. In the present context, the fund opportunities include:

- increased use of the CDM to finance afforestation and reforestation (A/R) projects;
- increased use of voluntary carbon markets (VCM) and carbon mitigation funds to test and demonstrate methodologies for a wider range of agriculture, forestry and land use (AFOLU) activities;
- increased use of adaptation funds to support SLM priority activities.

9.4. Carbon-based Payment for Environmental Services as an incentive's option for farmers?

Payments for Environmental Services (PES) are one type of economic incentive for those that manage ecosystems to improve the flow of environmental services that they provide. Existing initiatives have focused on three kinds of activity:

- restoring natural habitat or tree planting;
- maintaining existing natural habitats and protecting them from incursion (forest, grasslands conservation…);
- improving existing land use (soil conservation, efficient inputs use…).

Carbon friendly sustainable land management practices carry implicit costs for farmers as they may internally transfer biomass resources and change labour distribution. Effective application of such practices will need incentives during the first years in order to reach a dramatic increase of crop yields linked with improved soil performance.

The challenge is to find operational channels to mainstream carbon income support systems as incentives to apply carbon-fixing improved practices directly contributing to better land management. Currently income support systems used to give incentives without distorting market need to be tested in real situations in Uganda agro systems.

It should be piloted at the micro level with full support of selected local institutions such as a cooperative, a union of farmers, a union of value chain stakeholders or a district (local government), using performance-based criteria. Farmers' carbon income delivery should be community-managed and locally monitored for effective application of recommended practices.

In the lowest impact scenario, using the medium assumption of carbon price (5US$ /T of eq-CO_2) with an assumed carbon funding of 15 million US$ per year, the project could potentially ensure Payment for environmental services for almost 20 percent of the target farmers (400 000 farmers) at a rate of US$ 45 per year.

10. Conclusions and recommendations

The results show to some extent how a project covering such a large area, focused on agriculture intensification, is contributing to the slowing down of agriculture area expansion and considerably reducing the deforestation rate. It sends a positive message towards the REDD+ initiative on integrating agriculture intensification.

The analysis of this project underscores the importance of focusing efforts on agriculture intensification to positively contribute to climate change mitigation, especially in a context of population growth and increasing demand.

Three simulations of ATAAS's carbon impacts have been carried out, reflecting how important the adoption of recommended practices is with regard to the final carbon result. They have also shown the importance of the baseline scenario regarding the final impact due to the implementation of the project.

If the carbon balance appraisal shows how far the ATAAS project may have on positively impacting climate change mitigation with regard to the adoption of more sustainable management, it is worth seeing how that can be remunerated to farmers who are adopting new improved practices. Encouraging farmers to undertake sustainable agriculture management is important. Knowledge on the main issues needs to be shared, justifying the promotion of such practices. Farmers could be encouraged, for example, to use farm-produced manure and invest in materials to transport manure to their fields to help enrich their soils in organic matter.

Some ideas have been explored through this document, such as the implementation of payment for environmental services, and the mobilization of market-based funds.

Whichever ways are used to promote the adoption of sustainable land management, the implementation of a monitoring system may be built so as to check the efficiency of the ATAAS project at field level. The carbon indicator may be an appropriate proxy to reflect it. The monitoring should also allow for assessing possible links between the efficiency of the adoption of pro-mitigation practices in building the resilience of both poor farmers and agri-ecosystems.

The current carbon balance appraisal is a first step toward mainstreaming climate change within rural development projects. It puts forward the possible mitigation potential of the ATAAS project as both an externality, a co-benefit of sustainable management and a possible proxy to encourage innovative incentives to remunerate farmers for adopting improved agricultural practices.

11. Links to other EASYPol materials

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

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

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

12. Further Readings

FAO. 2010. Country Support Strategic framework 2010-2014.

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