THE EX ANTE
CARBON-BALANCE
TOOL

EASYPol
Resources for policy making

APPLIED WORK — EASYPol Module 120

First Results of Carbon Balance Appraisal on the Agriculture Rehabilitation and Recovery Support Project (ARRSP) in the Democratic Republic of Congo (DRC)

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.

E-ISSN 2219-9497

E-ISBN 978-92-5-107246-2 (PDF)

ACRONYMS

AFTEN	World bank portfolio of project dealing with environment in Africa
ARSSP	Agriculture Rehabilitation and Recovery Support Project
CAS	Country Assistance Strategy
CH_4	Methane
CO_2	Carbon dioxide
DRC	Democratic Republic of Congo
Eq-CO_2	Equivalent-CO2
ESA	Agricultural Development Economics Division of FAO
EX-ACT	EX-Ante Carbon Balance Tool
FAO	Food and Agriculture Organization of the United Nations
GDP	Gross Domestic Product
GHG	Green House Gas
Ha	Hectare
N_2O	Nitrous oxide
PAD	Project Appraisal Document
PRSP	Poverty Reduction Strategy Paper
REDD	Reducing Emissions from Deforestation and Forest Degradation
SOC	Soil Organic Content
S&B	Slash and burn
t	tonne
TCI	FAO Investment Centre
TCSP	FAO Policy Support Service

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1. SUMMARY

The ARRSP will help to achieve the long-term objective of the Democratic Republic of Congo's (DRC) Poverty Reduction Strategy Paper (PRSP) within the World Bank's Country Assistance Strategy (CAS). The project's objective is to **increase agricultural productivity and improve marketing** of crops and animal products by smallholder farmers in targeted areas. Project activities will contribute to this objective by providing seed, planting materials and advisory services, improving rice production, animal production capacity and marketing infrastructure and supporting the Ministry of Agriculture and the Ministry of Rural Development in the DRC.

This paper aims to appraise the project in terms of carbon balance with FAO support. The carbon balance appraisal has been carried out with EX-ACT (EX-Ante Carbon Balance Tool) on a selection of AFTEN[1] projects in Uganda, Ethiopia, Rwanda and the DRC, to test the relevance of such impact appraisals.

It evaluates the impact of project implementation over five years, with regard to mitigation potential, indicating whether the project contributes to more sinks of GHG than sources. Two simulations will be proposed, presenting possible improvements to make the project more efficient in terms of climate change mitigation.

EX-ACT[2] is a tool that provides ex-ante estimations of the impact of **agricultural and forestry development** projects on GHG emissions and sequestration, indicating its effects on a **carbon balance**. This tool has been developed by FAO's Policy Support Service[3], Agricultural Development Economics Division[4], and Investment Centre[5].

The model of the tool 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 sum of the implementation and capitalization phases is set at 20 years. The tool has been developed using mostly the Guidelines for National Greenhouse Gas Inventories[6]. It measures C stocks and stock changes per unit of land, as well as methane (CH_4) and nitrous oxide (N_2O) emissions expressing its results in tonnes of carbon dioxide equivalent per hectare (t CO_2e ha^{-1}). Data needed to run the tool include, in particular, information on the project area's dominant soil types and climatic conditions together with basic data on land use, land use change and land management practices foreseen under project activities as compared to a business as usual scenario.

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[1] World Bank portfolio of projects.
[2] EX-ACT website *http://www.fao.org/tc/exact/en/*
[3] FAO's Policy Assistance Support Service website *www.fao.org/tc/policy-support*
[4] FAO's Agricultural Development Economics Division *http://www.fao.org/economic/esa/esa-home/en/*
[5] FAO's Investment Centre *http://www.fao.org/tc/tci/en/*
[6] IPCC 2006.

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[7]. See also the list of EASYPol links included at the end of this module[8].

3. BACKGROUND

3.1. Economic situation in the DRC

Despite its immense natural resources, the Democratic Republic of Congo ranks as one of the poorest countries of the world, and continues to struggle with a difficult economic and social situation. More than 71 percent of the population lives below the poverty line. The per capita GDP was estimated at US$ 130 in 2006, against a Sub-Saharan African average of US$ 842. However, economic performance has improved significantly following the gradual return to peace and progress in the movement of goods and services. The annual GDP growth over the past five years was about 5 percent; this is due to the growth of activities in the service sectors (trade, transport

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[7] 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*.

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

and telecommunications) and the agriculture, agro-industry, public construction and works and mining sectors.

3.2. Agriculture sector in the DRC

Food crops comprise mainly tubers, plantains, maize, rice, groundnuts and beans. They are grown under a traditional system of crop rotation, slash-and-burn farming associated with the practice of fallowing land for periods of five or more years. Farmers do not use fertilizers and plant-care products. Animal or mechanical traction is rarely used; fewer than 10 percent of farmers use these types of traction.

The Democratic Republic of Congo is the size of Western Europe with an estimated population of 60 million. The poor performance of agriculture has made the population more vulnerable to recent increases in food prices and has put more pressure on forest resources. "Improvements in agricultural productivity and better links between producing and consuming areas would improve trade balances, reduce poverty and related malnutrition, and protect critical forest resources," said Marie Françoise Marie-Nelly, World Bank Country Director for the DRC and the Republic of Congo.

Despite this enormous potential, agricultural gross domestic product (GDP) declined by almost 40 percent (from US$ 3.4 billion to US$ 2.1 billion) between 1990 and 2001. Agricultural exports, which represented 40 percent of GDP in 1960, now account for only 10 percent. About one-third of the food consumed in the country is imported, and the net trade balance of agriculture, including both food and non-food items of agricultural origin, is now strongly negative.

Poverty is widespread; 62 percent of urban and 76 percent of rural people live below the poverty line. Much of this poverty originates in the underperforming agricultural sector. Agriculture provides employment for 70-75 percent of the active population and, through agro-industries, an additional 10 percent.

3.3. DRC natural resources and climate change mitigation

With 145 million ha of forests[9], the country has about 8 percent of the world's tropical forests. Having the world's second largest area of tropical rainforest provides the Democratic Republic of Congo with considerable leverage in the international mobilization of funds to mitigate greenhouse gas emissions. In this perspective, the DRC is a priority country within the new REDD+ strategy.

Deforestation in the DRC remained around 340 000 ha per year (0.2 percent of deforestation rate) between 1994 and 2003. Then it accelerated, reaching 400 000 ha per year in 2010 (0.3 percent of the area per year), which is still half of the world deforestation average. It generates around 300 Mt CO_2 in average annual emissions related to deforestation and degradation of forests. However annual average capacities of sequestration are around 500 Mt of CO_2. The DRC remains a net sink of CO_2. The overall distribution of the highest CO_2 emissions corresponds to the "high

[9] Source: The Democratic Republic of Congo's REDD+ Potential, December 2009

deforestation" and "medium to high biomass" areas of eastern DRC and the Equateur Province, in addition to those areas depicted as "medium deforestation" and "high carbon," such as the Opala, Ikela, Yahuma and Lodja regions.

Deforestation today is mainly driven by rural households (population density). The effect of household level slash-and-burn agricultural systems on emissions depends on the degree of fragmentation in the landscape, and the spatial distribution of forest biomass. The DRC is entering an era of stability and economic development. As with other countries with large forest estates and low deforestation, this economic development will put at risk large carbon stocks.

4. The Agriculture Rehabilitation and Recovery Support Project (ARRSP)

The project will promote growth in rural agricultural incomes, support institutional capacity building, improve access to basic services for enhancing food security and provide decentralized support to agriculture and community development. It will also help indirectly to relieve pressure on forest resources in areas contiguous to project sites. The project will be implemented over a five year period (2010-2015), with an International Development Association grant financing worth the equivalent of US$ 120 million.

The project includes three components. The first focuses on the farm level to raise productivity and give community groups access to basic technology for small-scale processing and storage. The second addresses marketing infrastructure. The third enhances the capacity of the ministries of agriculture and rural development to implement the project, provide needed services and prepare the way for revitalizing core sector functions and agro-industry.

The first component ("Improving Agricultural and Animal Production") will support activities to enhance the capacity of about 105 000 farm households (or about 735 000 people) to produce rainfed crops (Equateur), irrigated rice (Pool Malebo), small ruminants and poultry. Activities include the provision of improved seed, seedlings and animal breeds; the provision of advice to improve production management; the rehabilitation of irrigation infrastructure to improve water management; and the capacity for basic product transformation.

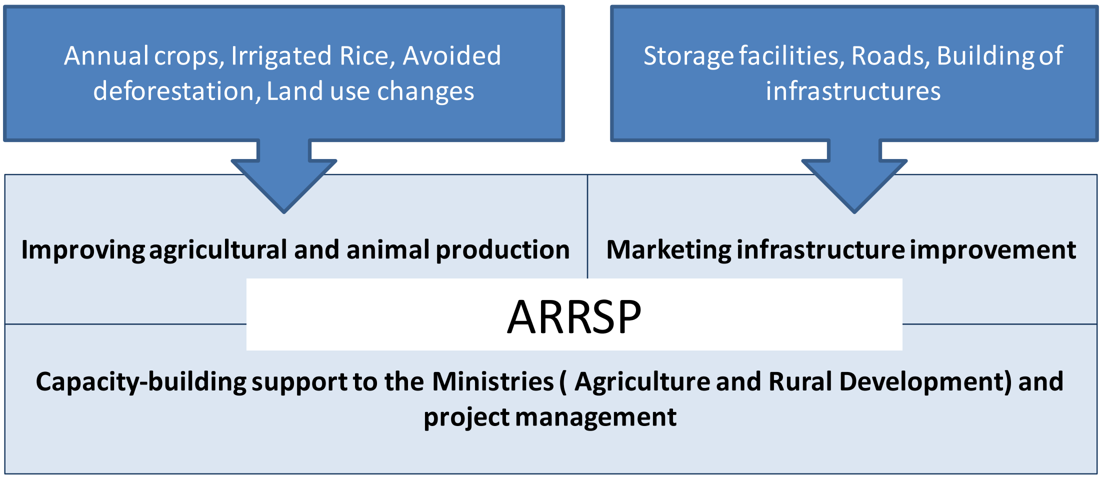
The second component ("Marketing Infrastructure Component") will include the rehabilitation of feeder roads and the rehabilitation or construction of a few local markets in Equateur Province. Results of this infrastructure component will certainly enhance more agriculture production and give better incentives to small farmers to adopt new technologies.

The third component ("Capacity-building") will support the ministries of agriculture rural development, and project management. It will also enable monitoring and evaluation of project activities.

At the end of the implementation period, the project is expected to have a positive impact on the living conditions of the target population, as it will contribute to increased household revenues through improved agricultural productivity and better access to markets. Overall, the project will make a significant contribution to poverty reduction and gender mainstreaming in accordance with the mission of the World Bank.

The project is targeting two areas: (i) The Equateur Province (103 000 beneficiary households reaching 145 000 in year 15), which was identified as one of five areas with high agricultural potential, high population density and high market access, a finding reinforced by the spatial analysis of potential investments in infrastructure; and (ii) The Pool Malebo area (2 000 beneficiary households) with high rice growth potential.

Figure 1 : Components of the ARRSP and activities accounted in the carbon appraisal



5. Data Used in With and Without Project Scenarios

The project targets have been clearly expressed in terms of land use change and transfers of cropping areas from traditional to improved cropping. The technical sustainable land management changes affecting cropping systems are expressed in terms of areas (hectares). Most data is based on the project document (PAD) and national statistics: number of agriculture households beneficiaries, areas affected, percentage of annual crops affected and percentage of households applying either low or high technology transfers.

Table 1: Main information gathered to appraise the ARRSP

	Start	Without	With
Rainfed crops			
Targeted households Equateur	103 000	103 000	103 000
Food crop area ha/household	1	1.2	1
food crops (ha)	103 000	123 600	103 000
Cash crop area ha/household	0.3	0.4	0.3
cash crops in ha	30 900	41 200	30 900
% of households using improved package	0	0	60%
Irrigated rice	1 200	1 200	3 200
Poultry	700 000	700 000	1 800 000
Women with Poultry (10% HH)	10 000	10 000	10 000
Number of chicken/ women	70	70	180
Number of producers adopting improved animal husbandry practices	0	0	63 000
Goats			
Number of animals	243 186	243 186	243 186
Number of improved animals	0	?	7 004
Roads (km)	0	?	2 500
Storage facilities (units)	0	?	16
Irrigation system	0	0	2 000

Agriculture land expansion	Start	Without	With
Areas	0	30 900	0
... from land use change 30% (set aside to annual crops)		9 270	0
... from deforestation 70% (from forests to annual crops) ha		21 630	0

6. FIRST CARBON BALANCE RESULTS IN AN INITIAL BASIS SCENARIO

6.1. Results of annual food and cash crops

Annual and cash crops have been distinguished simply between a traditional system close to the usual slash and burn systems and an improved system with improved varieties, and extended crop rotation. The table below shows the technical options of these two annual systems as they are entered within EX-ACT Annual module.

Figure 2: Screenshot of the EX-ACT annual module

	Your description	User-defined practices Name	Rate in tC/ha/yr	Improved agronomic practices	Nutrient management	NoTillage/residues management	Water management	Manure application	Residue/Biomass Burning	t dm/ha
Reserved system A1	from Deforestation	NO		No	No	No	No	No	YES	5
Reserved system A2	Converted to A/R	NO		?	?	?	?	?	NO	10
Reserved system A3	Annual From OLUC	NO		No	No	No	No	No	YES	5
Reserved system A4	Converted to OLUC	NO		?	?	?	?	?	NO	10
Annual System1	maize, cassava trad	NO		No	No	No	No	No	YES	5
Annual System2	maize cassava improved	NO		Yes	?	?	Yes	?	NO	10
Annual System3		NO		?	?	?	?	?	NO	10
Annual System4		NO		?	?	?	?	?	NO	10
Annual System5		NO		?	?	?	?	?	NO	10
Annual System6		NO		?	?	?	?	?	NO	10
Annual System7		NO		?	?	?	?	?	NO	10
Annual System8		NO		?	?	?	?	?	NO	10
Annual System9		NO		?	?	?	?	?	NO	10
Annual System10		NO		?	?	?	?	?	NO	10

Positive value= gain for soil

Description/example of the different options — See FAOSTA

Improved agronomic prac	using improved varieties, extending crop rotation...
Nutrient management:	precision farming, improve N use effciency
Tillage / residues Manag	Adoption of reduced,minimum or zero tillage, with or without mul
Water management:	Effective irrigation measure
Manure application	Manure or Biosolids application to the field as input

In the table below some annual crop areas are entered for each annual system, translating the switch of 133 900 ha from traditional to 80 340 ha of improved system. Indeed only 60 percent of the households are expected to adopt the improved annual system according to the PAD.

The choice of linear dynamic translates in a progressive switch during all project duration (five years in this case). This annual crop improvement should allow fixing 2.2 million tonnes of eq-CO_2, mostly by improving soil carbon content (1.6 million tonnes of eq-CO_2).

Figure 3: Screenshot of the EX-ACT annual module

Mitigation potential

Vegetation Type	Areas: Start t0	Without project End	Rate	With Project End	Rate	Soil CO2 mitigated: Without	With	CO2eq emitted from Burn: Without	With	Total Balance: Without tCO2	With tCO2	Difference tCO2
System A1	0	21630	Linear	0	Linear	0	0	118705	0	118705	0	-118705
System A2	0	0	Linear	0	Linear	0	0	0	0	0	0	0
System A3	0	9270	Linear	0	Linear	0	0	50874	0	50874	0	-50874
System A4	0	0	Linear	0	Linear	0	0	0	0	0	0	0
Annual System1	133900	133900	Linear	53560	Linear	0	0	839821	398915	839821	398915	-440906
Annual System2	0	0	Linear	80340	Linear	0	-1602783	0	0	0	-1602783	-1602783
Annual System3	0	0	Linear	0	Linear	0	0	0	0	0	0	0
Annual System9	0	0	Linear	0	Linear	0	0	0	0	0	0	0
Annual System10	0	0	Linear	0	Linear	0	0	0	0	0	0	0
Total Syst 1-10	133900	133900		133900								
Agric. Annual Total										1009400	-1203868	-2213268

6.2. Results of deforestation in without project situation

Figure 4: Screenshot of the EX-ACT deforestation module

GHG emissions

Vegetation Ty	Forested Area (ha): Start t0	Without Project End	Rate	With Project End	Rate	Area deforested (ha): Without	With	Biomass loss: Without tCO2	With tCO2	Biomass gain (1yr after): Without tCO2	With tCO2	Soil: Without tCO2	With tCO2	Fire: Without tCO2
Defor.1	0	0	Linear	0	Linear	0	0	0	0	0	0	0	0	0
Defor.7	21630	0	Linear	21630	Linear	21630	0	17632047	0	-396550	0	2345593	0	309899

This table is filled with 21 630 ha of Congolese forest deforested in the without project situation. The carbon appraisal of the deforestation impact is realized from the data provided by the FRA 2010[10].

Table 2 summarizes the data used to characterize the Congolese forest.

Table 2: Congolese forest data used (FRA 2010)

	tC/ha
Above-ground biomass	102.75
Below-ground biomass	24.66
Litter	2.10
Dead wood	0
Soil carbon	65

With deforestation being offset by project activities, it provides a net GHG balance of over 15.4 million tonnes on 20 years, or about 36 tons of eq-CO_2 per year per ha of avoided deforestation.

6.3. **Results of other land use changes in without project situation**

Figure 5: Screenshot of the EX-ACT Non forest land use change module

Mitigation potential												
Vegetation	Areas					Soil CO2 mitigated		CO2eq emitted from Burni		Total Balance		Difference
Type	Start	Without project		With Project		Without	With	Without	With	Without	With	
	t0	End	Rate	End	Rate					tCO2	tCO2	tCO2
System A1	0	21630	Linear	0	Linear	0	0	118705	0	118705	0	-118705
System A2	0	0	Linear	0	Linear	0	0	0	0	0	0	0
System A3	0	9270	Linear	0	Linear	0	0	50874	0	50874	0	-50874
System A4	0	0	Linear	0	Linear	0	0	0	0	0	0	0
Annual System1	133900	133900	Linear	53560	Linear	0	0	839821	398915	839821	398915	-440906
Annual System2	0	0	Linear	80340	Linear	0	-1602783	0	0	0	-1602783	-1602783
Annual System3	0	0	Linear	0	Linear	0	0	0	0	0	0	0
Annual System9	0	0	Linear	0	Linear	0	0	0	0	0	0	0
Annual System10	0	0	Linear	0	Linear	0	0	0	0	0	0	0
Total Syst 1-10	133900	133900		133900								
							Agric. Annual Total			1009400	-1203868	-2213268

Other land use changes, from set aside to annual crops, concern 9 270 ha in the without project situation. The land use change from set aside to annual crop imply a source of GHG, whereas the land use change from set aside to paddy rice implies a sink. It should generate a net balance of 500 637 tonnes of eq-CO_2 in the without project which will be accounted as an avoided GHG emission in the project appraisal. Finally, the land use changes gathered reflect avoided emissions in the project appraisal, reaching 579 606 tonnes of eq-CO_2.

[10] FAO. 2010. Evaluation des ressources forestières mondiales 2010, rapport national, République Démocratique du Congo.

6.4. **Rice results**

Figure 6: 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)	rate tonne	Specific C change Delta C* tCO2eq/ha/yr	Default IPCC calculation kg CH4 per ha/day	Default IPCC calculation kg CH4 per ha	Straw Burnt t CO2 eq
Reserved system R1	from Deforestation	150	Please select water regime	Please select preseason water regime	Please select type of Organic Amendment	5.5		0.00	0.0	0.00
Reserved system R2	converted to A/R	150	Please select water regime	Please select preseason water regime	Please select type of Organic Amendment	5.5		0.00	0.0	0.00
Reserved system R3	from OLUC	150	Irrigated - Intermittently flooded	Flooded preseason (>30 days)	Straw burnt	5.5		1.38	207.5	0.34
Reserved system R4	Rice to OLUC	150	Please select water regime	Please select preseason water regime	Please select type of Organic Amendment	5.5		0.00	0.0	0.00
Rice1	irrigated rice not impr	150	Irrigated - Continuously flooded	Flooded preseason (>30 days)	Straw burnt	5.5		2.47	370.5	0.34
Rice2	irrigated rice improved	180	Irrigated - Intermittently flooded	Flooded preseason (>30 days)	Straw burnt	5.5		1.38	249.0	0.34

CH4 emission from rice systems — **Change over the period (t CO2eq)**

Areas (ha) of the different options						Soil C changes All period		CH4 emitted All period		Straw burning		Total t CO2 eq		Difference tCO2eq
Type	Start t0	**Without Project** End	Rate	**With Project** End	Rate	Without	With	Without	With	Without	With	Without	With	
System R1	*0*	*0*	*Linear*	*0*	*Linear*	0	0	0	0	0	0	0	0	**0**
System R2	*0*	*0*	*Linear*	*0*	*Linear*	0	0	0	0	0	0	0	0	**0**
System R3	*0*	*0*	*Linear*	*2000*	*Linear*	0	0	0	152498	0	12074	0	164571	**164571**
System R4	*0*	*0*	*Linear*	*0*	*Linear*	0	0	0	0	0	0	0	0	**0**
Rice1	*1200*	*1200*	*Linear*	*0*	*Linear*	0	0	0	-163391	8279	1035	8279	-162356	**-170635**
Rice2	*0*	*0*	*Linear*	*1200*	*Linear*	0	0	0	109798	0	7244	0	117043	**117043**
											Total	8279.0	119258.4	**110979.3**

Improved rice cultivation on 2 000 ha have two opposite impacts. On one side, there will be an expansion of rice production implying a source of GHG, reaching 164 571 tonnes of eq-CO_2. However, this expansion has better management through the adoption of intermittent irrigation, which emits less GHG than the continuous irrigation system. On the other side, the rest of the surface will also be improved with the adoption of this management, implying avoided emissions reaching 117042.6-170635= -53592.1 tonnes of eq-CO_2.

The improvements proposed are not sufficient to balance the emissions of CH_4 linked with the rice expansion. The rice activity leads to a source of 110 979.3 tonnes of eq-CO_2.

6.5. **Livestock results**

The livestock project support results mostly in increasing the number of chickens while the goat population remains the same. The equivalent carbon balance is worked out from four main sources: (i) methane emissions from enteric fermentation; (ii) methane emissions from manure management; (iii) nitrous oxide emissions from manure management; and (iv) improved feeding practices. In the set of tables below an aggregated balance of 36 000 tonnes of eq-CO_2 of increased emissions is generated by the project.

Figure 7: Screenshot of the EX-ACT livestock module

Methane emissions from enteric fermentation

Choose Livestocks:	IPCC factor	Specific factor	Default Factor	Head Number: Start t0	Without Project End	Without Project Rate	With Project End	With Project Rate
Dairy cattle	40		YES	0	0	Linear	0	Linear
Other cattle	31		YES	0	0	Linear	0	Linear
Buffalo	55		YES	0	0	Linear	0	Linear
Sheep	5		YES	0	0	Linear	0	Linear
Swine (Market)	1.5		YES	0	0	Linear	0	Linear
Swine (Breeding)	1.5		YES	0	0	Linear	0	Linear
Poultry	0		YES	*700,000*	*700,000*	*Linear*	*1,800,000*	*Linear*
Goats	5		YES	*243,186*	*243,186*	*Linear*	*243,186*	*Linear*
Camels	46		YES	0	0	Linear	0	Linear
User Defined- Specified value --------------->			NO	0	0	Linear	0	Linear
User Defined- Specified value --------------->			NO	0	0	Linear	0	Linear
								Sub-Total I

PLEASE SPECIFY INFORMATION BELOW IF AVAILABLE

Country "Type"	*Developing*	
Mean Annual Temperature (MAT*) in °C	25	**Possible**

Methane emissions from manure management

Livestocks:	IPCC factor	Specific factor	Default Factor	Head Number: Start t0	Without Project End	Without Project Rate	With Project End	With Project Rate
Dairy cattle	1		YES	0	0	Linear	0	Linear
Other cattle	1		YES	0	0	Linear	0	Linear
Buffalo	1		YES	0	0	Linear	0	Linear
Sheep	0.15		YES	0	0	Linear	0	Linear
Swine (Market)	1		YES	0	0	Linear	0	Linear
Swine (Breeding)	1		YES	0	0	Linear	0	Linear
Poultry	0.02		YES	700,000	700,000	Linear	1,800,000	Linear
Goats	0.17		YES	243,186	243,186	Linear	243,186	Linear
Camels	1.92		YES	0	0	Linear	0	Linear
User Defined- Specified value --------------->			NO	0	0	Linear	0	Linear
User Defined- Specified value --------------->			NO	0	0	Linear	0	Linear
								Sub-Total I

Nitrous Oxide emissions from manure management

Livestocks:	IPCC factor	Specific factor	Default Factor	Annual amount of N manure* (t N per year): Start t0	Without Project End	Without Project Rate	With Project End	With Project Rate
Dairy cattle	0.01		YES	0	0	Linear	0	Linear
Other cattle	0.01		YES	0	0	Linear	0	Linear
Buffalo	0.01		YES	0	0	Linear	0	Linear
Sheep	0.01		YES	0	0	Linear	0	Linear
Swine (Market)	0.01		YES	0	0	Linear	0	Linear
Swine (Breeding)	0.01		YES	0	0	Linear	0	Linear
Poultry	0.01		YES	210	210	Linear	539	Linear
Goats	0.01		YES	3,648	3,648	Linear	3,648	Linear
Camels	0.01		YES	0	0	Linear	0	Linear
User Defined- Specified value --------------->			NO			Linear		Linear
User Defined- Specified value --------------->			NO			Linear		Linear
see equation 10.30								Sub-Total I

With the current assumptions, the project activities on goats are not impacting the final carbon results as the size of the herd is not expected to change. The growth of poultry implies a small source of GHG reaching 36.152 tonnes of eq-CO_2 during 20 years.

6.6. Investment results linked to the second component of the ARRSP

The rice improvements lead to the installation of 2 000 ha of irrigation system (center-pivot sprinkle) generating 0.1 tonne of eq-CO_2 per hectare, hence a project source of 158.4 tonnes of eq-CO_2.

Moreover, the ARRSP foresees opening a total length of 2 500 km of roads. It was assumed that the roads would be 3m large, hence a total surface of 2 500*1 000*3=7 500 000 m^2. This activity generates 550 000 tonnes of eq-CO_2.

Figure 8: Screenshot of the EX-ACT other investment module

Released GHG associated with installation of irrigation systems

Installation of irrigation system	surface (ha)	Type of irrigation syste	Associated tCO2eq
Without Project	0	Hand moved sprinkle	0.0
With Project	2000	Center-pivot sprinkle	158.4
			Difference 158.4

IRSS = Irrigation runoff return system

Released GHG associated with building of infrastructure

Type of construction or infrastructure	Default value t CO2 /m2	Specific Value	Default Factor	surface (m2) Without	surface (m2) With	Emission (t CO2eq) Without	Emission (t CO2eq) With
Road for medium trafic (asphalt)	0.073		YES		7500000	0.0	550000.0
Agricultural Buildings (metal)	0.220		YES			0.0	0.0
Agricultural Buildings (metal)	0.220		YES			0.0	0.0
Agricultural Buildings (metal)	0.220		YES			0.0	0.0
Industrial Buildings (concrete)	0.825		YES			0.0	0.0
Road for medium trafic (concrete)	0.319		YES			0.0	0.0
Road for medium trafic (asphalt)	0.073		YES			0.0	0.0
			Subtotal	0.0	550000.0	Difference	550000.0

SUB-TOTAL FOR INVESTMENT	Without	0	With	550158	Difference	550158

6.7. Global results of the initial scenario

The overall C balance of the project is computed as the difference between C sinks and sources over 20 years (five years for the implementation phase and 15 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).

Figure 9: Global carbon appraisal results

Project Summary	
Name	Ag Rehab and Recov. Supp. (ARRSP) DRC
Continent	Africa
Climate	Tropical Moist
Dominante Soil	LAC Soils

Area (Initial state in ha)		
Forest/Plantation		21630
Cropland	Annual	133900
	Perennial	0
	Rice	1200
Grassland		0
Other Land	Degraded	0
	Other	9270

Duration of the Project (years)	
Implementat	5
Capitalisatic	15
Total	20
Total Area	**166000**

Components of the Project	Balance (Project - Baseline) All GHG in tCO2eq		CO2 Biomass	CO2 Soil	N2O	CH4	Per phase of the project Implement.	Capital.	Mean per year Total	Implement.	Capital.
Deforestation	**-15419847**	**this is a sink**	-13074254	-2345593	0	0	-13409338	-2010509	-770992	-2681868	-134034
Afforestation and Reforestation	**0**		0	0	0	0	0	0	0	0	0
Non Forest Land Use Change	**-579606**	**this is a sink**	0	-559709	-15776	-4122	-99856	-479750	-28980	-19971	-31983
Agriculture											
Annual Crops	**-2213268**	**this is a sink**	0	-1602783	-168974	-441512	-316181	-1897087	-110663	-63236	-126472
Agroforestry/Perennial Crops	**0**		0	0	0	0	0	0	0	0	0
Rice	**110979**	**this is a source**	0	0	3342	107638	15854	95125	5549	3171	6342
Grassland	**0**		0	0	0	0	0	0	0	0	0
Other GHG Emissions			CO2 (other)								
Livestock	**36152**	**this is a source**	---		28067	8085	5165	30987	1808	1033	2066
Inputs	**0**		0		0	---	0	0	0	0	0
Other Investment	**550158**	**this is a source**	550158		---	---	550158	0	27508	110032	0
Final Balance	**-17515432**	**It is a sink**	**-12524095**	**-4508085**	**-153341**	**-329911**	**-13254199**	**-4261233**	**-875772**	**-2650840**	**-284082**
Result per ha	**-105.5**		**-75.4**	**-27.2**	**-0.9**	**-2.0**	**-79.8**	**-25.7**	**-5.3**	**-16.0**	**-1.7**

Table 3: Contribution of the different activities on carbon appraisal

EX-ACT modules	t of eq-CO2 over 20 years	% of total GHG mitigated	% of total GHG emitted
Deforestation	-15709328.25	85	
Non Forest Land Use Change	-579606.4983	3	
Annual Crops	-2213268.12	12	
total GHG mitigated	-18502202.87	100	
Rice	110979.316		16
Livestock	36151.8575		5
Other Investment	550158.4		79
total GHG emitted	697289.5735		100
Carbon balance	-17804913.29		

DOMINATED BY IMPACT OF AVOIDED DEFORESTATION
(85 percent)

7. RESULTS FROM A BROADER SCENARIO WITH AN EMPHASIS ON DEFORESTATION

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

(i) it expands the project to 145 000 households in Equateur (target provided in PAD by 2020), with a project duration of 10 years;

(ii) it emphasizes the negative effects of slash and burn practices in conventional cropping, which means that 1 ha cropped is left aside and replaced through land use change every 14-15 years (7 percent per year of renewed annuals 50 percent from tropical shrub lands and 50 percent from set aside lands) just to maintain a fixed cropped area;

(iii) the agriculture area expansion is not stopped but reduced in the with project situation (0.6 percent increase instead of 0 percent with the project and 2.1 percent per year on 10 years without the project).

Table 4: Comparison between the two simulated carbon balance appraisals

	Carbon appraisal	
	Initial *(cf.part 5)*	**Reviewed** *(cf.part 6)*
Implementation phase	5 years	10 years
Households concerned	103 000	145 000
Emphasize S&B	no	yes
With project annual crop expansion	Stopped (0%)	Reduced (0.6%)

7.1. How to better integrate the impact of slash and burn practices in the scenario

Slash-and-burn (or shifting cultivation), the traditional farming system for centuries over large areas of the humid tropics, still remains the dominant land-use practice in about 30 percent of the arable soils of the world[11].

Concerned farmers have cleared forests for crop production, but not for continuing agricultural use. They cut and burn relatively small forest plots, and produce crops in the burned-over area, taking advantage of the nutrients in the ashes from the burned plants. After 2-3 years, the nutrients are depleted and weeds become a problem so the farmers abandon the plot for 10-20 years, permitting the regrowth of forest species.

[11] Source: ICRAF. 1999. Disponible sur http://www.worldagroforestrycentre.org/Sea/Publications/files/report/RP0007-04/RP0007-04-1.PDF

They move on to another forested plot, which they slash-and-bum and then crop for 2-3 years before this plot is abandoned as before. A farmer may shift to five to ten such small plots before returning to clear and burn trees on the first one left idle (fallowed) 10-20 years previously. The steps are then repeated until another cycle is completed[12][13].

Slash-and-burn agriculture was traditionally practiced on a small or local scale by many farming societies, with long fallow periods and hence a relatively large area of undisturbed forest. It was then a fully sustainable system, with no net input of CO_2 or significant input of other GHGs to the atmosphere. The dramatic change in recent decades has been the intensity and extent to which slash-and-burn of forests is practiced worldwide. Increasing pressure on the land gradually reduces the fallow period until only scrub woodland regenerates, yields are reduced and the average biomass on the land is greatly reduced[14][15].

In other terms the critical point is the duration of the cycle which is the determinant in the degree of regeneration of forest coverage after slash and burn areas are left aside. In terms of above ground biomass, in tropical climates, 13-30 years may allow for a full reforestation, while 6-12 years allow for a partial reforestation (shrub land) and 4-5 years a land set aside. In terms of soil organic content (SOC), soil regeneration is much slower if the cropping duration is longer (over five years).

Table 5: Tentative modeling of impacts of slash and burn (S&B) over time

S&B implemented in **Tropical Wet climate**	Results after 4-5 years of fallow	Results after 6-12 years of fallow	Results after 13-30 years of fallow
on 1-3 years of cropping	set aside land 5 t C U-G biomass	**Tropical shrub land 33 t C U-G biomass**	Tropical deciduous forest plant 56 t C U-G biomass
over 3 years of cropping	Degraded land	set aside land 5 t C U-G biomass	tropical shrub land 33 t C U-G biomass

In the DRC's Equateur Province, which has relatively low pressure in terms of population density, forestry experts consulted have proposed having a one to three-year cropping period in slash and burn followed by a fallow period of 10 or more years.

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12 ***Brady N,*** *Alternatives to slash-and-burn: a global imperative, ELSEVIER Agriculture, Ecosystems and Environment* 58 (1996) 3-11, 1996

13 Brady, 1996.

14 **Tinker B et Al**, *Effects of slash-and-burn agriculture and deforestation on climate change,* ELSEVIER Agriculture, Ecosystems and Environment 58, 1996

15 Tinker et al 1996.

7.2. Scenario changes in land use areas

Table 6: Evolution of agriculture areas (per farmer and aggregate)

		Growth / year	2010	2015	2020
	HH beneficiaries		*145 000*	*145 000*	*145 000*
Without project	area/ farmer	2.1%	1.30	1.44	1.60
	total area		**188 500**	**209 141**	**232 043**
With project	area / farmer	0.6%	1.30	1.34	1.38
	total area		**188 500**	**194 223**	**200 120**

Contrary to the first scenario, the project is not going to stop agriculture expansion but to reduce it. Instead of expanding the agriculture areas by 232 043-188 500 = 43 543 ha, the adoption of the project will lead to expanding agricultural areas by 200 120-188 500 = 11 620 ha.

Table 7: Evolution of type of management in agriculture areas (per farmer and aggregate)

	2010	2020	
	Start	Without project	With project
Traditionally cropped	188 500	188 500	75 400
Improved			113 100
Extension of traditional crop		43 543	11 620

The agriculture expansion in the without project scenario is going to be managed as traditional crops, without improved management practices regarding climate change mitigation.
In the project situation, the intensification is going to abandon progressively the traditional management: instead of 188 500 + 43 543= 232 043ha of traditional crop management in the without project situation, 75 400 + 11 620 = 87 020ha will be traditionally cropped and 113 100 ha will use improved practices.

Table 8: Land use change linked with agriculture area expansion

Agriculture area expansion	2020	
	Without project	With project
Total area expansion	43543	11620
from deforestation (70%)	30480	8134
from set aside (30%)	9144	2440

The land use change to expand agriculture areas will be in the two situations (without and with project) done from deforestation (70 percent) as well as from the conversion of set aside lands (30 percent).

Table 9: Tentative simulation of S&B dynamics during project duration (10 years) with a cropping cycle of 4 years

Land use change generated by S&B		2010	2020	
		Start	Without project	With project
% of S&B in traditional crops		60%	60%	60%
Average S&B area			126 163	82 656
Total land in S&B cycle (25% **S&B** area renewed yearly)[16]			*315 407*	*206640*
IN	*from set aside to annual*	0%	-	-
	from tropical shrub land to annuals	100%	*315407*	*206640*
OUT	*areas of tropical shrub land natural*	100%	*315407*	*206640*

The assumption has been made that the cropping cycle lasts three years. About 60 percent of traditional crops undergo S&B practices, hence 126 163 ha in the without project situation and 82 656 ha in the with project situation. Thirty-three percent of these average S&B areas are renewed yearly to keep the productive potential. That means additional land use changes that have to be accounted. The total of the 33 percent area comes from the deforestation of tropical shrub land. When farmers leave S&B areas to settle new areas, the land will be converted into tropical shrub land.

7.3. Carbon balance results

Project Summary	
Name	Ag Rehab and Recov. Supp. (ARRSP) DRC
Continent	Africa
Climate	Tropical Moist
Dominante Soil	LAC Soils

Area (Initial state in ha)		
Forest/Plantation		451023
Cropland	Annual	609043
	Perennial	0
	Rice	1200
Grassland		0
Other Land	Degraded	0
	Other	9144

Duration of the Project (years)	
Implementat	10
Capitalisatic	10
Total	20
Total Area	**1070410**

Components of the Project	Balance (Project - Baseline) All GHG in tCO2eq		CO2 Biomass	CO2 Soil	N2O	CH4	Per phase of the project Implement.	Capital.
Deforestation	**-48000484**	**this is a sink**	-36436586	-9746996	-550039	-1266863	-41502487	-6497997
Afforestation and Reforestation	**11390904**	**this is a source**	1643908	9746996	0	0	3318392	8072512
Non Forest Land Use Change	**-399341**	**this is a sink**	0	-380171	-15199	-3971	-145894	-253447
Agriculture								
Annual Crops	**-4106534**	**this is a sink**	0	-1934010	-601323	-1571200	-1368845	-2737689
Agroforestry/Perennial Crops	**0**		0	0	0	0	0	0
Rice	**95125**	**this is a source**	0	0	2864	92261	31708	63417
Grassland	**0**		0	0	0	0	0	0
Other GHG Emissions			CO2 (other)					
Livestock	**30987**	**this is a source**	---		24057	6930	10329	20658
Inputs	**0**		0		0	---	0	0
Other Investment	**550158**	**this is a source**	550158		---	---	550158	0
Final Balance	**-40439183**	**It is a sink**	**-34242519**	**-2314181**	**-1139639**	**-2742844**	**-39106637**	**-1332547**
Result per ha	**-37.8**		**-32.0**	**-2.2**	**-1.1**	**-2.6**	**-36.5**	**-1.2**

[16] *Total land = (annual crop / number of years cropped) x nb of years of fallow*

The project now works on 965 274 ha (including set aside areas and newly cleared areas over 10 years). The overall implementation of the project should be able to create a sink of 40.4 million T of eq-CO_2 during 20 years. This figure seems very high compared to the previous scenario but once the result is affected per hectare, the potential is equal to about 1.9 tonnes of GHG avoided/sequestrated per hectare per year or 37.8 tonnes of eq-CO_2 on 20 years.

Including the slash and burn practices and consequences in terms of land use changes strengthen the mitigation potential of the project, which is especially reflected within the avoided deforestation. The figure for the activity of afforestation doesn't mean that the activity is a net emitter. It corresponds to the fact that the project limits the agricultural expansion, hence reducing the slash and burn practice. Thus there will be less "afforestation" (slash and burn crop -> set-aside -> shrub land) compared to the situation without the project.

Table 10: Contribution of the different activities on carbon appraisal

EX-ACT modules	t of eq-CO2 over 20 years	% of total GHG mitigated	% of total GHG emitted
Deforestation	-46462384	92	
Non Forest Land Use Change	-399341	1	
Annual Crops	-3765437	7	
total GHG mitigated	-50 627 162	100	
Afforestation	8543158		92.7
Rice	95125		1
Livestock	30987		0.3
Other Investment	550158		6
total GHG emitted	9 219 428		100
Carbon balance	-41 407 734		

This scenario appears more realistic in terms of the carbon impact of the project toward mitigation. However, the carbon appraisal is a partial indicator of the slash and burn practices; it does not take into account, for example, the question of availability, and tenure of the land included in the rotation.

8. REMAINING QUESTIONS TO DISCUSS IN FIELD MISSION

Agriculture fields:

- There is a discrepancy between the PAD document and the livestock document regarding data on rainfed crops areas (in this draft, data provided by the PAD is used), for example area cultivated by household) as well on targeted households.
- What would happen in the future without the project intervention on irrigated rice? Is expansion expected?

- What are the different crop systems (rotations, association, slash and burn…)? According to the livestock document « The main crops are cassava, maize, soft potato, banana plantain, palm oil, coffee plantation and cacao (PACT-Congo, 2008) ».
- Is there residue burning on traditional crops?
- What are the improvements proposed within the project for the different crop systems?
- What are the amendments brought in traditional and improved irrigated rice?
- What is the input consumption (urea, other fertilizers…) without and with project?
- What are the current characteristics of slash and burn agriculture in the project area (Equateur): part of annual crops in slash and burn, average fallow duration, number of years of cropping before land is left as fallow...
- How far should we integrate the slash and burn practice in the baseline without project scenario?

Livestock fields:

- There is little information about goats and sheep management (what is traditional management?) Are genetic improvements expected to increase the animal weight and food intake?
- Do genetic improvements reduce mortality, and indirectly impact the growth of the herd?
- Is the project changing the food system of goats and sheep?
- What is the percentage of herd receiving improvements?
- The poultry population is only provided for the Equateur Province and not for the other districts. Should we work on this small population or with an aggregated population for the different districts?
- The death rate of poultry seems to be very high according to the livestock document. Should we work with an average poultry population?
- How do we build the without project situation? growth of herd?

Other investments:

- What are the different storage facilities foreseen with the project (size, building material)?
- Same question for the small number of wholesale and retail markets foreseen with the implementation of the project, how much, size and in which building material?

9. CONCLUSIONS

The ARRSP was designed to increase agricultural productivity and improve the marketing of crops and animal products by smallholder farmers in targeted areas. Although it did not integrate climate change dimensions, the project, if implemented according to design, could potentially mitigate climate change while improving land and water management.

The paper describes the ex-ante C-balance analysis performed for the ARRSP in the DRC. The results show that overall the net effect of ARRSP is to create a C sink ranging from 1.9 to 5.3 tonnes of eq-CO_2/ha/year over 20 years, according to assumptions taken regarding land use, land use changes and main practices that will affect GHG flows. The previous figure represents the balance between: (i) the GHG emitted, mainly as a consequence of the increased infrastructure building (irrigation systems, roads), livestock expansion and irrigated rice cultivation; and (ii) carbon sequestered essentially through the scaling up of best practices in annual cropland and avoided deforestation. Regarding the wide range of mitigation potential, the effective result would essentially depend on the capacity to strongly reduce annual cropland expansion to the advantage of annual intensification, as well as the capacity to reduce slash and burn practices.

The issue of traditional slash and burn practices is raised in the carbon balance appraisal. Such practices imply some land use changes upon time, thus leading to GHG sources and sinks, depending on demographic pressure, crop types and final land use changes. Land closest to villages is more intensely cultivated over a long period of time, until it becomes depleted, because there is a lack of arable land. On the contrary, due to the distances and availability of arable land after clearing, land farther away from villages is less cultivated and also fallowed as part of the crop system.

Finally, the produced carbon balance could be considered a proxy for reducing land degradation risks and monitoring the delivering of global environmental benefits.

At this stage of the project appraisal, it is worth noting that the results presented here are only preliminary estimates based on available information (or derived on the basis of working hypotheses). Consolidated information will be available during the implementation of the project. Thus further verification of assumptions would be suitable for adapting the carbon balance appraisal to what is actually happening at field level. The uncertainty in the data availability and the significant number of assumptions made are inevitably reflected in the results discussed.

10. 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**

11. FURTHER READINGS

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