The EX Ante Carbon-balance Tool

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APPLIED WORK EASYPol Module 122

The Carbon Balance of Selected "Plan Maroc Vert" Projects

An Application of the EX-Ante C-balance Tool (EX-ACT version 3)

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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

ADA	From the French «Agence de développement de l'agriculture» agriculture development agency
CC	Climate Change
CCA	Climate Change Assessment
CDM	Clean Development Mechanism
CH_4	Methane
CO_2	Carbon Dioxide
DM	Dry Matter
EX-ACT	EX-Ante Carbon Balance Tool
FAO	Food and Agriculture Organization
GDP	Gross Domestic product
GEF	Global Environmental Facility
GHG	Greenhouse Gas
GWP	Global Warming Potential
HAC	High Activity Clay
IPCC	Intergovernmental Panel on Climate Change
LAC	Low Activity Clay
LUC	Land Use Change
LU	Land Use
LULUCF	Land use, land use change and forestry
Mt	Million tonnes
N_2O	Nitrous Oxide
PICCPMV	From the French « Projet d'Intégration du Changement Climatique dans la mise en œuvre du Plan Maroc Vert », Climate change integration in Moroccan Green Plan implementation Project
PMV	From the French «Plan Maroc Vert» Moroccan Green Plan
SLM	Sustainable Land Management
tCO_2e	Tonnes of CO_2 equivalent
$t\ CO_2e\ .ha^{-1}$	Tonnes of Carbon Dioxide equivalent per hectare
$t\ CO_2e\ .year^{-1}$	Tonnes of Carbon Dioxide equivalent per year
UNFCCC	United Nations Framework Convention on Climate Change
WB	World Bank

1. SUMMARY

Agriculture can play an important role in climate change mitigation while contributing to the rural development goals. The Ex-Ante Carbon-balance Tool (EX-ACT) can estimate the mitigation potential of rural development projects generated from changes in farming systems and land use. The study presents and discusses the EX-ACT analysis performed on selected World Bank and Government of Morocco-supported projects under the Moroccan Green Plan (PMV[1]). The projected estimates of the impact of project activities on greenhouse gas emissions and carbon sequestration demonstrate that the recommended agricultural practices can be twofold with respect to climate change: actions aiming at improving resilience to climate change (adaptation) and actions that have a beneficial impact on carbon sequestration (mitigation).

2. INTRODUCTION

Objectives: This paper identifies and interprets the main project impacts of three PMV projects on climate change mitigation. It shows the results issued from a real case project (although simplified), starting with row data collected by project teams, the carbon balance having been commissioned by World Bank.

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:

- Basic knowledge of the EX-ACT tool;
- Concepts of climate change mitigation and adaptation;
- Concepts of land use planning and management

Readers can follow links included in the text to other EASYPol modules or references[2]. See also the list of EASYPol links included at the end of this module[3].

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[1] Plan Maroc Vert

[2] EASYPol hyperlinks are shown in blue, as follows:

a) training paths are shown in **underlined bold font**
b) other EASYPol modules or complementary EASYPol materials are in ***bold underlined italics***;
c) links to the glossary are in **bold**; and
d) external links are in *italics*.

[3] This module is part of the EASYPol Resource Package: **Investment planning for rural development – Ex-ACT**

3. BACKGROUND

3.1. Description of "Plan Maroc Vert"

In 2008 Morocco launched its new national agricultural strategy, the Plan Maroc Vert (PMV)[4]. . The PMV seeks to make agriculture the driving force for economic growth. It aims to double agriculture's value added within a decade through a comprehensive overhauling of the sector's structure in terms of cropping patterns, land tenure, and agricultural taxation. This national strategy should increase productivity and improve food security by providing a roadmap for investment programmes in the agri-food sector and implementing a series of systemic public sector reforms. The PMV should contribute to transform the currently underperforming agricultural sector into a source of growth for the country, developing high-value and high-performing agriculture (Pillar I), and combating rural poverty by supporting small farmers in marginal areas (Pillar II).

Achieving the objectives set by the PMV is challenged by climate change which could decrease yields of key crops and could increase the volatility of agricultural production. 85 percent of agricultural land does not have irrigation leaving farmers exposed to erratic precipitation and drought, with consequent effects on yields. Annual fluctuation in rainfall explains why there is 75percent of the year-to-year variability in Moroccan GDP. The drought in 2005 cutthe national cereal production by half. Climate change will increase the probability of low harvests or crop failure in rainfed areas, where irrigation is not available to buffer adverse climate conditions. The impact on production is projected to be unevenly distributed across Morocco, with the highest reductions concentrated in some of the driest parts of the country. This will particularly affect the rural poor who depend on rainfed agriculture as their primary source of income and employment. Expansion of irrigated areas is not an adequate solution. Water is already exploited beyond renewable limits in many basins, and agriculture, which currently accounts for 87 percent of water use, suffers from increasing competition from urban and industrial demands. In irrigated agriculture, uncertainty about water supply is acute among farmers. Water scarcity is also a key factor in lower-than-potential agricultural revenues and in leads to increasing disputes about water allocation. Climate change will exacerbate this situation. Reductions in the availability of water will jeopardize the prospects of irrigated agriculture, with a wider gap between water demand (increased by rising temperatures) and supply (reduced by less precipitation).

The proposed project on Integrating Climate Change in the implementation of the Plan Maroc Vert (Projet d'Intégration du Changement Climatique dans la mise en œuvre du Plan Maroc Vert, PICCPMV[5]) will strengthen the capacity of relevant stakeholders on climate change adaptation in agriculture in five Regions of Morocco. The PICCPMV is funded by the Special Climate Change Fund (SCCF) and supervised by the Global Environmental Facility (GEF) Secretariat. It will develop the capacity on climate change adaptation of relevant staff of public and private institutions involved in the

[4] Plan Maroc Vert: http://www.ada.gov.ma/Plan_Maroc_Vert/plan-maroc-vert.php

[5] PICCPMV: http://www.ada.gov.ma/uplds/pars/ECIES_PICCPMV.pdf

planning and implementation of Pillar II projects, with the objective of mainstreaming climate change adaptation in the screening process of future Pillar II projects. At the same time, the PICCPMV will support the dissemination of climate change adaptations among farmers.

The objective of this paper is to assess if Pillar II projects can contribute to climate change mitigation while implementing specific climate change adaptation actions.

Under the Strategic Framework for Development and Climate Change, three out of the ten Pillar II projects will be analyzed to assess their potential mitigation contribution.

3.2. Objectives and structure of the document

Models are being developed to: i) estimate the resilience of agricultural systems and the mitigation potential from changes in farming systems, and ii) support project managers on CC mitigation decision making, helping to conduct actions to tackle climate change. EX-ACT (EX-Ante Carbon-balance Tool[6]) is one such model developed by the Food and Agriculture Organization of the United Nations (FAO) to provide an ex-ante evaluation of the impact of rural development projects on Greenhouse Gas (GHG) emissions and Carbon (C) sequestration, thus estimating the potential contribution of agriculture (and forestry) sector to CC mitigation.

The objective of this report is to present the results of the EX-ACT test on three projects implemented under the PMV Pillar II. It is worth remembering that the results could be subject to change as a result of possible adjustments regarding data collection, scenario building, and in the methodology adopted in further development of the tool.

The report is organized as follows: the next section provides a description of EX-ACT and its methodology. Chapters 4, 5 and 6 present the carbon balance appraisal of the three projects analyzed. Chapter 7 highlights some limits of the appraisal, as well as of some specific perspectives for the three projects appraised.

3.3. The EX-Ante Carbon-balance Tool (EX-ACT)

FAO's EX-ACT tool aims at providing ex-ante estimates of the impact of agriculture and forestry development projects on GHG emissions and C sequestration, indicating its effects on the C-balance[7], which is selected as an indicator of the mitigation potential of the project[8]. It is capable of covering the range of projects relevant for the land use, land use change and forestry (LULUCF) sector. It can compute the C-balance by comparing two scenarios: "without project" (i.e. the "Business As Usual" or "Baseline") and "with project". The main output of the tool consists of the C-balance resulting from the difference between these two alternative scenarios (Figure 1).

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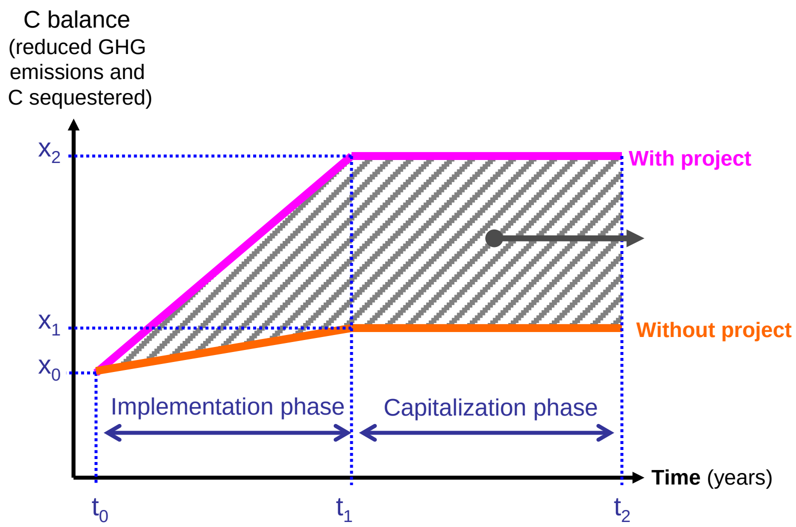
[6] EX-ACT Tool: http://www.fao.org/docs/up/easypol/780/ex-act_version_3-2_april_2011_101en.xls EASYPol Module 101

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

[8] EX-ACT 2010.

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 sum of the implementation and capitalization phases is set at 20 years. EX-ACT was designed to work at a project level but it can easily be up-scaled at program/sector or national level[9].

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



Source: Bernoux et al. 2010b

EX-ACT has been developed using mostly the Guidelines for National Greenhouse Gas Inventories[10] complemented with other methodologies and review of default coefficients for mitigation option as a base. Most calculations in EX-ACT use a Tier 1 approach[11] as default values are proposed for each of the five pools defined by the Intergovernmental Panel on Climate Change (IPCC) guidelines and the United Nations Framework Convention on Climate Change (UNFCCC): above-ground biomass, below-ground biomass, soil, deadwood and litter. It should be highlighted that EX-ACT also allows users to incorporate specific coefficients (e.g. from project area), where available, therefore working at Tier 2 level too. EX-ACT 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 tons of Carbon Dioxide equivalent per hectare (t CO_2e.ha^{-1}) and in tons of Carbon Dioxide equivalent per year (t CO_2e.year^{-1}).

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[9] Bernoux et al. 2010°.

[10] IPCC, 2006.

[11] IPCC Guidelines provide three methodological tiers varying in complexity and uncertainty level: Tier1, simple first order approach which uses 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, which makes reference to higher order methods, detailed modeling and/or inventory measurement systems driven by data at higher resolution and direct measurements (much lower uncertainty).

In terms of dynamics, land use changes associated with the establishment of project activities and the rate of adoption of land management, options occur only in the implementation phase. Therefore, it is assumed that all project activities will be completed in the project timeframe and that no additional change in land use and management will take place in the capitalization phase.

EX-ACT consists of a set of Microsoft Excel sheets in which project designers insert information on dominant soil types and climatic conditions of project area together with basic data on land use, land use change and land management practices foreseen under projects' activities as compared to a business as usual scenario[12].

4. MITIGATION POTENTIAL OF THE FEM 1 SUB-PROJECT

4.1. The project profile

The proposed Pillar II project is located in the provinces of Beni Zrantel, Boukhriss, Beni Batao, Ouled Gouaouech, Rouached, Chougrane, Tachraft, Kaicher, in the region of Chaouia – Ouardigha. It especially aims at supporting the plantation of 1600 ha of olive orchards for the benefit of 940 farmers. The objectives should be reached through the implementation of the following actions (cf. Table 1).

Table 1: Project FEM1 description

Actions planned to reach the target:
• Extension of the orchards on an area of 1600 ha by converting cereals systems. • Valorisation of the olives by the building of 5 oil processing plants with 500 $kg.h^{-1}$ of capacity each. • Organise producers into professional organisations and agricultural extension services before and after the production. • Support to integrated crop management through inputs and training financing, in order to: Improve fertility ; Ensure weed control; Control pests and diseases
Project targets
• Variety : Picholine marocaine (96% of plantations) ; • Density : 100 - 200 trees.ha-1 ; • Crop management: Traditional ; • Expected Yield : 1,2 $T.ha^{-1}$ on rainfed area and 3 $T.ha^{-1}$ on irrigated area ; • Localisation of the plantations : 56% on irrigated areas and 44% on rainfed areas; • Processing: 80% (or 10 300 t of olives per year) of the production will be transformed into oil by 27 traditional maâsra, 36 half-modern and 2 modern processing units.

Source: FICHE SOUS-PROJET FEM N°1: Reconversion des céréales en olivier sur une superficie de 1600 ha dans la région de Chaouia – Ouardigha.

[12] Bernoux et al. 2010°.

4.2. Main assumptions taken to build the carbon balance appraisal

4.2.1. Soil and Climate assumptions

The area interested by project activities does not show significant differences in terms of climatic conditions, but data used to describe soil characteristics cannot take into account the variability of existing soil so the results of the analysis should be considered only as an average for the whole area.

Average climate is considered as **warm temperate** and a moisture regime classified as **dry**. These settings correspond to average climate and rainfall for Morocco. Such information is essential as most coefficients used in the analysis can change drastically according to the climate.

As for the soil characteristics – and with reference to the simplified IPCC classification where only six soil categories[13] are listed– project area is characterized essentially by High Activity Clay (**HAC**) soils which are lightly to moderately weathered soils and dominated by 2:1 silicate clay minerals[14].

4.2.2. Time frame

The analysis will consider an implementation phase of six years (according to the technical implementation planning), followed by a capitalization phase of twenty-four years. The appraisal lasts 30 years and corresponds to the life expectancy of olive tree orchards. The capitalisation phase represents a period where the benefits of the investment still occur and may be attributed to the changes in land use and management induced by the adoption of the project. As concerns the Global Warming Potential (GWP) coefficients[15], the present analysis uses the same values as those adopted within the Clean Development Mechanism (CDM), i.e. 21 for CH_4 and 310 for N_2O.

4.2.3. Assumptions for the baseline "without project" scenario

The analysis is based on the identification of two alternative land use and management scenarios, i.e. "with" and "without" project as explained in what follows. The "without" project situation represents the baseline scenario (also indicated as "business as usual"). That is what the Government or farmers by themselves would implement without taking into consideration any specific climate change adaptation activity.

The project has been defined within the Pillar II of the Plan Maroc Vert, which means that farmers do not have capacities or enough capital to fight poverty and to adapt to climate change. As confirmed by experts working on the project, this area would not be able to cope with climate change without the project implementation. According to

[13] (Sandy Soils, Spodic Soils, Volcanic Soils, Wetland Soils, High Activity Clay Soils and Low Activity Clay Soils)

[14] Bernoux et al. 2010b.

[15] The GWP is a measure of how much a given mass of greenhouse gas is estimated to contribute to global warming. It is a relative scale which compares the gas in question to that of the same mass of carbon dioxide (the GWP of which is by convention equal to 1).

project experts, it has been assumed that the current situation would remain in the near future without project implementation. Indeed the required investment could be evaluated as too risky to be implemented considering the current level of poverty. Without the project, there are no incentives to overcome the barriers. Thus the perennial cropland would not be improved or expanded because the value chain approach promoted with the project is not set up. It is therefore assumed that there will be no additional implementation of perennial crops on existing annual cropland (the overall perennial area equals 0 ha), no increase in input use, and no building of oil processing factory.

4.2.4. Assumptions for the "with project" scenario

The "with project" scenario is built on the basis of project targets. Project interventions focus on the Chaouia and Ouardigha regions and will promote olive plantations as well as the adoption of soil conservation measures to reduce erosion and maintain/restore soil fertility.

The analysis considers that 1600 ha of existing annual cropland in irrigated areas (56%), and in rainfed areas (44%) will be converted to perennial crops (olive trees). Fertilizers, agrochemicals and the building of five agro-processing plants will be accounted for as they may represent a source of GHG.

Within the project, Olive trees are planted with a low density of 150 trees per hectare. Usually, to be considered as perennial in full density, in this kind of zone, density reaches 400 trees per hectare[16]. Consequently it has been considered that the agricultural system of the project is managed as an agroforestry system. At the moment, no specific or accurate emission factors are provided by the IPCC to match this agro forestry management. Consequently, that kind of agrosystem has to be separated in two full densities of perennial and annual cropland. Thus the area of perennials accounted for in EX-ACT corresponds to 1600*150/400=600 ha, and the remaining area of annual cropland is 1600-600=1000ha.

The project involves perennial growth in particular, which aim at storing carbon in soil and biomass. In order to test the sensitivity of the tool, the carbon appraisal carried out on olive orchards will be done in three different ways. The first one will use the Tier1 approach of the EX-ACT tool, the other will use the Tier 2 approach, with different published studies.

The with and without project are summarized on the following Table 2.

[16] Si Bennasseur Alaoui, 2005. Référentiel pour la conduite technique de l'olivier, (olea europea), , IAVH, Rabat, Morocco..

Table 2: Frame of reference for the carbon appraisal

	Land Use change	Olive Orchard	Annual cropland	Input	Oil extraction value chain
With project FEM1	Conversion of 600 ha from annual to perennial	600 ha	1000 ha improved (residue mgmt)	Fertilizer and agrochemicals	5 oil plants Transportation Transformation
Without project	X	X	1600 ha traditional	X	X
Methodology	Tier 1	Tier 1 Tier 2	Tier 1		
Chapter	4.3.1	4.3.2	4.3.3	4.3.4	4.3.5
	Final carbon balance : 4.4				

4.3. Carbon balance appraisal

This section aims at briefly describing the carbon appraisal according to the different project activities accounted for in EX-ACT and the frame of reference provided above (cf. Table 2).

4.3.1. Land use change implied to develop perennials

The project activities refer to the plantation of perennial crops in the irrigated and rainfed area of project sites. Those two activities will imply land use change from annual cropland to olive perennial crops the impact of which is calculated among the "Non forest land use change" module of EX-ACT (cf. figure 2). Without the implementation of the project, it is assumed that no perennial cropland will be developed and that the current annual crops would remain.

Figure 2 : Impacts of planting perennials according to EX-ACT Land Use Change module

Your Name	Description of LUC: Initial Land Use	Final Land Use	Alert	Burnt before conversion	Default C Stocks (tC/ha): Biom. Ini.	Biom. Fin.	Soil Ini.	Soil Fin.
Rainfed olive orchard	Annual Crop	Perennial/Tree Crop		NO	5,0	2,1	30,4	38,0
Irrigated olivie orchard	Annual Crop	Perennial/Tree Crop		NO	5,0	2,1	30,4	38,0
						Default Soil Native (tC/ha)		38

	Area concerned by LUC: Without Project		With Project		Biomass Change		Soil Change		Fire		Total Balance		Difference
	Area	Rate	Area	Rate	Without tCO2	With tCO2	Without tCO2	With tCO2	Without tCO2	With tCO2	Without tCO2	With tCO2	tCO2
Rainfed olive orchard	0	Linear	264	Linear	0	2807	0	-7357	0	0	0	-4550	-4550
Irrigated olivie orchard	0	Linear	336	Linear	0	3573	0	-9363	0	0	0	-5790	-5790
Other LUC total											0	-10340	-10340

A total of (-) **10 340** tCO_2e could be mitigated during the 30 year-period due to the land use change from annual to perennial cropland.

4.3.2. Olive orchard development

The olive orchard is considered in EX-ACT as a perennial crop which stores carbon during its growth period. The impact of olive orchards was calculated in different ways to determine more accurate results depending on the emission factors used:

Tier 1 approach:

- This approach automatically uses the default factors established by the IPCC proposed in EX-ACT according to the climate and moisture regime. It is assumed that the pruning material will not be burnt. The Tier 1 approach forecasts a sink of **(-) 126 390 tCO_2e** during a period of 30 years, considering the whole area as non irrigated.

Tier 2 approach:

- Specific factors were used in the perennial module to reduce the uncertainty of default factors by using a published study[17] carried out in southern Spain where climate and moisture regime could be comparable to the Moroccan situation on **non irrigated area**. This study establishes the division of the biomass on the different carbon pools (Table 3). The growth of biomass of the different pools was accordingly calculated with the above ground biomass growth of $422 g.tree^{-1}.year^{-1}$ The appraisal duration of 30 years (Life expectancy of olive tree orchards) exceeds the 20 years usually accounted for in a carbon balance in cropland. To counteract the accuracy losses, two growth periods where established, up and after 20 year-old, like the methodology proposes for the EX-ACT “afforestation” module (cf. Table 3).

Table 3: Biomass in non irrigated orchard

	Residue/Biomass	Aboveground Biomass	Belowground Biomass
% of Biomass	22	51	27
*t of DM <20 yr	0.74	1.69	0.9
t of DM >20 yr	3.14	1.27	0.67
Mean of DM	1.53	1.55	0.82

**Source: M. J. Mariscal, F. Orgaz and F. J. Villalobos, 1998*

- Other specific amounts of biomass were found in the literature of Adriano Sofo et al, on the “Net storage in Mediterranean olive and peach orchards” study (2005). This study was led in southern Italy where climate and moisture regime could be comparable to the Morocco situation **irrigated areas**.

Table 4: Biomass in irrigated orchard

	Residue/Biomass	Aboveground Biomass	Belowground Biomass
t of DM <20 yr *	1	2.31	1,23
t of DM >20 yr	4.3*	1.74	0.92
Mean of DM	2.10	2.12	1.13

* Data concerning mature orchard, in Adriano Sofo et al, 2005

[17] M. J. Mariscal, F. Orgaz and F. J. Villalobos . 1998. *Radiation-Use Efficiency and Dry Matter Partitioning of a Young Olive (Olea europaea) Orchard, Heron Publishing..* *http://treephys.oxfordjournals.org/content/20/1/65.full.pdf*

There is a lack of data concerning the ad-hoc soil carbon content. Thus, the EX-ACT default value was used (-0.33 $tCO_2e.year^{-1}$). Finally the Tier 2 should be filled out as follows:

Table 5: Irrigated and Non Irrigated Coefficients used in Tier 2 approach

	Residue/Biomass (t of Carbon.$ha^{-1}.year^{-1}$)	Aboveground Biomass (t of Carbon.$ha^{-1}.year^{-1}$)	Belowground Biomass (t of Carbon.$ha^{-1}.year^{-1}$)	Soil Effect (tCO2e.$ha^{-1}.year^{-1}$)
Irrigated Area	2,10	2,12	1,13	0,33
Non Irrigated Area	1,53	1,55	0,82	0,33

The sink of carbon forecast with the Tier 2 is about **(-) 172 893 tCO_2e** over a period of 30 years.

Regarding the different results provided by using the different methodologies, there is no significant difference between the tier 1 and 2 approaches for the non irrigated area.

Table 6: Result discrepancy

	Tier 1	Tier 2	
		Non irrigated	Irrigated
Area concerned (in ha)	600	336	264
Mitigation potential (in $tCO_2e.ha^{-1}year^{-1}$)	-7,3	-7.9	-10.9
References	IPCC	Mariscal el al, 1998 Sofo et al. 2005	

With a conservative approach, Tier 1 coefficients will be used on non irrigated orchards and Tier 2 on the irrigated ones.

Figure 3: Impacts of perennial crops according to EX-ACT perennial module

Your description	Residue/Biomass Burning	Residue/Biomass Interval (yr)	Residue/Biomass Tons dm/ha	Aboveground Biomass Growth rate (tC/ha) Default	Aboveground Biomass Growth rate (tC/ha) Specific	Belowground Biomass Growth rate (tC/ha) Default	Belowground Biomass Growth rate (tC/ha) Specific	Soil Effect Default t CO2/ha/yr	User default available	User default available tCO2/ha/yr	CH4 kg	N2O kg	CO2eq t
OLUC to Perennial Defaul	NO	1	10	2.1		0		0.33	NO		0	0	0.0
OLUC to Perennial Irrigate	NO	1	2.10	0	2.12	0	1.13	0.33	NO	0.00	0	0	0.0

Areas Start t0	Vithout project End	Vithout project Rate	Vith Project End	Vith Project Rate	CO_2 fluxes from Biomass Without	CO_2 fluxes from Biomass With	CO_2 fluxes from Soil Without	CO_2 fluxes from Soil With	CO_2eq emitted from Burnir Without	CO_2eq emitted from Burnir With	Total Balance Without tCO_2	Total Balance With tCO_2	Difference tCO2eq
0	0	Linear	263	Linear	0	-53665	0	-1736	0	0	0	-55401	- 55,401
0	0	Linear	336	Linear	0	-108108	0	-2218	0	0	0	-110326	-110326
													-165727

The sink of carbon accounted for with the Tier 1 (non irrigated orchards) and Tier 2 approach (irrigated orchards) is about **-165 727 tCO_2e** during 30 years (cf. Figure 3).

4.3.3. Changes in crop management

The area cropped under the lines of olive trees will be improved with the project. By reducing the erosion and improving the soil fertility, the crop residue will be kept on the surface. This practice, inspired by the conservative farming, is considered in the IPCC category and re-used in EX-ACT called "Adoption of reduced or minimum tillage, with or without mulching", in the "annual" module of the EX-ACT tool (cf. Figure 4).

With a conservative approach it is assumed that there is no burning residue practice.

Figure 4: Impacts of annual crop according to EX-ACT annual module

	Your description	User-defined practices	Name	Rate in tC/ha/yr	Improved agro-nomic practice	Nutrient management	NoTillage/residu management	Water management	Manure application	Residue/Biomass Burning	t dm/ha
Reserved system	Converted to OLUC	NO			?	?	?	?	?	NO	10
Annual System1	Current system *	YES	Equilibrium	0	conservative approach is to consider this system at equilibrium or decreas					NO	10
Annual System2	improved weat	NO			?	?	Yes	?	?	NO	10

Mitigation potential												
Vegetation	Areas					Soil CO2 Change		CO2eq emitted from Burning		**Total Balance**		**Difference**
Type	Start t0	**Without project** End	Rate	**With Project** End	Rate	Without tCO2	With tCO2	Without tCO2	With tCO2	Without tCO2	With tCO2	tCO2
System A4	600	600	Linear	0	Linear	0	0	0	0	0	0	0
Annual System1	1 000	1 000	*Linear*	-	*Linear*	0	0	0	0	0	0	0
Annual System2	0	0	*Linear*	1 000	*Linear*	0	-6600	0	0	0	-6600	-6600
Total Syst 1-10	1000	1000		1000								
						Agric. Annual Total				**0**	**-6600**	**-6600**

The new management of residue leads to store (-) **6 600 tCO_2e** in the cropland over a 30 year-period.

4.3.4. Use of inputs

The use of fertilizers is expected to be adjusted with soil analysis. The total use could be close to the agronomic recommendations (Table 7), following the exportation of mineral mater[18]. The total production planned is about 12 875 $T.year^{-1}$, corresponding to a production of 53 $kg.tree^{-1}$.

Table 7: NPK recommendations for Olive trees the production of which is superior to 50 kg of olive per tree.

	N	P2O5	K2O
kg of fertilizer.$Tree^{-1}.year^{-1}$	1	0,5	1
Ton of fertilizer.$year^{-1}$	240	120	240

Source: Guide pratique de la fertilisation raisonnée des principales cultures au Maroc

The use of massive quantity of fertilizers is acceptable in the case of agroforestry, because of the increasing competition between annual crops and olive trees. The efficiency of the use of fertilizer is increased, taking advantage of both crops the excess fertilizer for one crop is absorbed by the other. The use of agrochemicals 3 years after the plantation could be carried out accordingly to the recommendations summarized in the following table.

[18] De la Vega de Luque 1969.

Table 8: Recommendations on agro-chemicals use

Type of Pesticide	Active Ingredient	Dose	Source	Total
Herbicide	Flazasulfuron	0,2 kg.ha^{-1}	Gratraud C., Le Verge S., 2006. Bonnes pratiques culturales en vergers d'oliviers. Ed FIDOL.	5,7 kg.ha^{-1}
	Fluazifop-p-butyl	1 l.ha^{-1}		
	Glyphosate	4.5 l.ha^{-1}		
Insecticide	Organophosphates	0.075 kg.ha^{-1}	AFIDOL Bulletin n°1	4,935 kg.ha^{-1}
	Pyrethroids	3*0.02 l.ha^{-1}		
	Spinosoïdes	4* 1.2 l.ha^{-1}		
Fungicide	Cooper	0,4 kg.ha^{-1}	AFIDOL Bulletin n°6	0,7 kg.ha^{-1}
	Krésoxim-méthyl	0,3 L.ha^{-1}		

The amount of agrochemicals included in the EX-ACT Input module generates a source of **63 074 tCO_2e** over 30 years (cf. Figure 5).

Figure 5: EX-ACT Input module screenshot

Carbon dioxide emissions from Urea application

Amount of Urea in tonnes per year; Emission (t CO2eq) per year; Total Emission (tCO2eq)

	IPCC factor	Specific factor	Default Factor	Start t0	Without Project End	Without Project Rate	With Project End	With Project Rate	Emission Start	End Without	End With	Total Without	Total With	Difference
Urea	0,2		YES			Linear	514,00	Linear	0	0	102,8	0	2 776	2776
								Sub-Total I-2	0	0	102,8	0	2776	2776

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

Amount of N Applied (t per year); Emission (t CO2eq) per year; Total Emission (tCO2eq)

Type of input	IPCC factor	Specific factor	Default Factor	Start t0	Without Project End	Without Project Rate	With Project 0	With Project Rate	Emission Start	End Without	End With	Total Without	Total With	Difference
Urea	0,01		YES	0	0	Linear	240	Linear	0,0	0,0	743,6	0	20 077	20077
*N fertilizer from upland rice should be included above (N fertilizer)								Sub-Total I-3	0,0	0,0	743,6	0	20077	20077

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

Amount in tonnes of product (active ingrediente for Pesticides)

Type of input**	Default factor*	Specific factor	Default Factor	Start t0	Without Project End	Without Project Rate	With Project End	With Project Rate	Start	End Without	End With	Total Emission Without	Total Emission With	Difference
Urea	4,8		YES	0	0	Linear	240	Linear	0,0	0,0	1143,4	0	30 871	30871
Phosphorus synthetic fertilizer	0,7		YES			Linear	120	Linear	0,0	0,0	88,0	0	2 376	2376
Potassium synthetic fertilizer	0,6		YES			Linear	240	Linear	0,0	0,0	132,0	0	3 564	3564
Herbicides (Pesticides)	23,1		YES			Linear	3,1	Linear	0,0	0,0	71,1	0	1 920	1920
Insecticides (Pesticides)	18,7		YES			Linear	2,7	Linear	0,0	0,0	49,8	0	1 346	1346
Fungicides (Pesticides)	14,3		YES			Linear	0,4	Linear	0,0	0,0	5,4	0	146	146
								Sub-Total I-4	0,0	0,0	1489,7	0	40222	40222
									Total "Inputs"			0	63074	63074

* from Lal (2004) Table 5 - central value -tCO2/t product
** tonnes of N, P2O5, K2O and CaCO3

4.3.5. Other investments

The construction of infrastructures and the operational consumption of fuel due to project implementation is also included in the carbon balance appraisal.

- **Investments directly linked with the Project implementation**

Building five olive oil processing plants could be included in the projected carbon balance. The processing plants could be integrated as industrial concrete buildings each[19] of 160 m^2.

- **Investments directly linked to the continuous project cycle**

Olive processing and transportation need energy. The distance between the processing plant and the orchards is expected to be around 20 km. The return route is not accounted

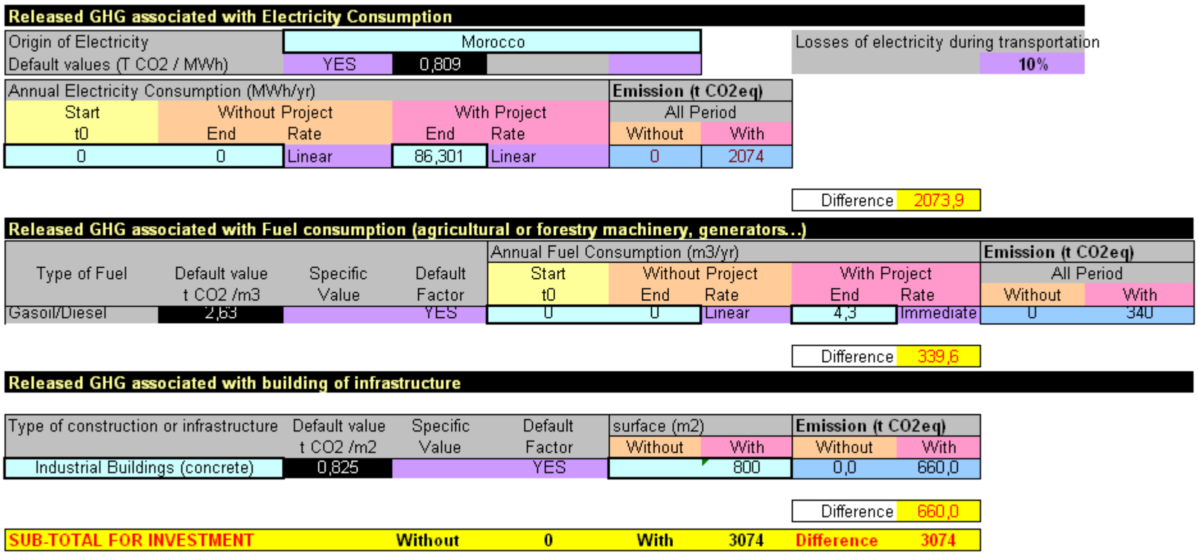
19 Fiche sous-project FEM N°1: Reconversion des céréales en olivier sur une superficie de 1600 Ha dans la région de Chaouia - Ouardigha

for, as it is supposed that a truck will come back full of other products. It is also assumed that trucks do not return empty. Transport trucks have a 12 t capacity. Transportation energy consumed is about 25 L of diesel per 100km. The total consumption reaches (10300/12)*20 *25/100 = 4,3m^3 of diesel per year.

The new plants' capacity is about 3600 t of olive out of the 10900 t produced per year (0,5 $t.h^{-1}$ * 5 Unit * $12h.days^{-1}$ * 120 days = 3 600t). The remaining 7 300 t of olive is treated on traditional maâsra. On traditional maâsra, only renewable animal energy is used. The energy spent for processing the olive oil in modern units is about 15 20 $kW.h^{-1}$ (17,5 accounted for) for the line of machinery with a capacity of 625-835 kg $olive.h^{-1}$ (730 accounted for) [20]. The total consumption of electricity is estimate to be about 86,301 $MW.year^{-1}$ (3600/0,73 * 0,0175).

The amount of energy spent to build the units, transport and transform the olive is a source of **3 074 tCO_2e** over 30 years (Figure 6).

Figure 6: EX-ACT Other Investment module screenshot



4.4. Results of the carbon balance appraisal

Table 9 summarizes the overall C balance of the project, computed as the difference between C sinks and sources over 30 years, i.e a 4-year implementation phase and a 26-year capitalization phase. The project is in fact able to sequester 182 667 tCO_2e while emitting 66 648 tCO_2e so that the net effect of project activities is to create a sink of -**119 226** tCO_2e over 30 years.

[20] Tunis Medindustrie : http://www.made-in-tunisia.net/data/art_recherche.php?id_ps=260889&mode_recherche_art=ps

Table 9: C-balance of the Project 1

C-balance elements	tCO_2e over 30 years
Total GHG mitigated	-182 667
Total GHG emitted	66 648
C-balance	- 119 226

Source: our calculations using EX-ACT (2011)

Table 10 shows the mitigation potential of the project by category of land use change (corresponding to the EX-ACT modules). The mitigation potential calculated is three times higher than emissions, the overall impact being a sink in comparison with the without project scenario.

Table 10: Mitigation potential of the sub project FEM1, by EX-ACT module

EX-ACT modules	tCO_2e over 30 years	% of total GHG mitigated	% of total GHG emitted
Perennial crops	-165 727	90	
Annual crop	-6 600	3.5	
Non forest land use changes	-10340	6.5	
Total GHG mitigated	- 182 667	**100**	
Inputs	63 074		95
Other Invest. Project	660		1
Other Invest. Value Chain	2414		4
Total GHG emitted	66 648		**100**
C-balance	**- 119 226**		

Source: our calculations using EX-ACT (2010)

5. Mitigation potential of the FEM 3 Sub-project

5.1. Project profile

This Pillar II project is located in the regions of Rabat, Salé, Zemmour, Zaër. The sub-project FEM 3 especially supports the improvement of 1000 ha of cereal crops for the benefit of 350 farmers. The objectives should be reached through the implementation of the following actions (Table 11).

Table 11: Sub project FEM 3 description

Project targets
• Increasing wheat yield by 40%, from 1,2 $t.ha^{-1}$ to 2 $t.ha^{-1}$. • Increasing the farmers' income. • Adopting of good practices for cereals production. • Valorising the production by the adoption of a mass approach for the collect and commercialisation of the cereals.

Source: Fiche sous-projet Fem N°3: Intensification des céréales (blé tendre) dans la région de Rabat – Salé – Zemmour – Zaër

5.2. Main assumptions taken to build the carbon balance appraisal

5.2.1. Soil and climate assumptions

As per project FEM 1, the area interested by project activities does not show significant differences in terms of climatic conditions, but data used to describe soil characteristics cannot take into account the variability of existing soil and the results of the analysis should therefore be considered only as an average for the whole area.

Average climate is considered as a **warm temperate** and a moisture regime classified as **moist**. These settings correspond to average climate and rainfall for Morocco regions where project FEM 3 will be implemented.

As for the soil characteristics the project area is characterized essentially by **High Activity Clay** (HAC) soils which are lightly to moderately weathered soils and dominated by 2:1 silicate clay minerals[21].

5.2.2. Time frame

The analysis considers an implementation phase of six years, followed by a capitalization phase of fourteen years, which represents a period where the benefits of the investment still occur and may be attributed to the changes in land use and management induced by the adoption of the project. In the analysis it is assumed that the implementation phase will happen according a linear dynamic of change as no specific information is available about the adoption rate of the project activities among project participants.

As concerns the Global Warming Potential (GWP) coefficients, the present analysis uses the same values as those adopted within the Clean Development Mechanism (CDM), i.e. 21 for CH_4 and 310 for N_2O.

5.2.3. Assumptions for the baseline "without project" scenario

The analysis is based on the identification of two alternative land use and management scenarios, i.e. "with" and "without" project as explained in what follows.

[21] Bernoux et al. 2010b

The "without" project situation represents the baseline scenario (also indicated as "business as usual"). That is what the Government or farmers by themselves would implement without taking into consideration any climate change adaptation.

The proposed project is also part of the Pillar II projects, meaning that the current level of poverty does not allow for changing the current agriculture situation. Once again, it has been considered that the current initial situation would remain in the future appraised years without any supported project. Therefore it is assumed that there will be no improvements on existing annual cropland, no increase of inputs use.

5.2.4. Assumptions for the "with project" scenario

The "with project" scenario is built on the basis project's targets. Project interventions focus on the region of Rabat, Salé, Zemmour, Zaër and will promote soil conservation measures to reduce erosion and maintain/restore soil fertility and good agronomic practises to enhance the yields. The area concerned by these improvements reaches 1000 ha. The use of inputs should grow. The commercialisation of the produced cereal with a mass approach needs the development of a warehouse to store and pack the wheat.

Table 12: Frame of reference for the carbon appraisal

	Annual cropland	Input	Other Investments
With project	1000 ha improved - Residue management - Best Agricultural practices	Incremental use of fertilizer and agrochemicals	- Packaging plan - Transportation of wheat
Without project	1000 ha traditional	X	X
Methodology	Tier 1 Tier 2	Tier 1	
Chapter	5.3.1	5.3.2	5.3.3
	Final carbon balance : 5.4		

5.3. Carbon balance appraisal

This section aims at describing briefly the carbon appraisal according to the different project activities accounted for in EX-ACT and the frame of reference provided above (cf. table 2).

5.3.1. Changes in cropland management

The project area will be improved with the adoption of conservation farming. Intending to reduce the erosion and improve the soil fertility, the crop residue will be kept on surface with the no-tillage practice.

Two approaches can be used to determine the impact of this management change. First the impacts could be calculated within the Tier 1 approach, then within a Tier 2 approach.

Tier 1 Approach

- The practice inspired by the conservative farming is considered in the IPCC category called "Adoption of reduced or minimum tillage, with or without mulching", also integrated in the annual module of the EX-ACT tool. The corresponding amount of carbon stored by this practice is almost 0.6 $t.year^{-1}.ha^{-1}$
- Crop rotations need to be changed to i) ensure yield enhancement, ii) manage weed pressure and iii) improve the soil fertility. The varieties cropped are also improved ones to be more adapted to the difficult conditions of growth. These practices are considered in the IPCC category called "Improved agronomic practices" also integrated in the "annual" module of the EX-ACT tool. The amount of carbon stored by this practice is almost 0.75 $t.year^{-1}.ha^{-1}$.

- With a conservative approach it is assumed that there is no burning residue practice currently. In Morocco, the cereal crop residue and barley crops are the main forage for the ruminant livestock[22]. Once the residue has been harvested for winter feeding, the ruminants are allowed to graze the remaining stubble. 99% of the residues are used for fodder[23].
- To follow the EX-ACT methodology, the representative mitigation potential is determined as the maximum potential of all selected management practices (improved agronomic practises and residue management). This approach is very conservative and supposed to be the best choice because there is evidence in the literature that some measures are not additive when applied simultaneously. Thus, the final carbon balance is not the addition of the two previous potentials. Only the practice with the best storage is taken into account. In this case the practice of improved agronomic practices leads to store (-) **14 960 tCO_2e** on a 20 year period in the cropland.

Tier 2 Approach

Specific factors could be used in the annual module to reduce the uncertainty of default emission factors used in EX-ACT and coming from the IPCC.

- Two published studies have been used [24], which were carried out in Tunisia, with a similar crop system, climate and dominant soil type. The conservation agriculture is supposed to store up to 0.9 $tCO_2e.ha^{-1}.year^{-1}$.
- Another Study[25] produced in the same conditions, but at a larger scale, demonstrates an increase of 0.2 to 0.3 $tCO_2e.ha^{-1}.year^{-1}$ under conservation agriculture. In this case, the rate is less in accordance to the tier 1 rate (0.6 $tCO_2e.ha^{-1}.year^{-1}$)

[22] Tully, 1989; Fenster, 1989.

[23] United Nations Environment Programme, 1977.

[24] Brahim et al., 2009 and 2010.

[25] Ben Moussa-Machraoui et al., 2009.

The main difference between the two previous main studies is the quantity of biomass returning to the soil. In the first one, all the biomass (straw and intercrop) is returning to the soil (closed system). In the second one managed as an open system, most of the straw is exported and grassed by the sheep.

Comparison and choice
The difference between the two approaches is summarised on the next Table 5.3.

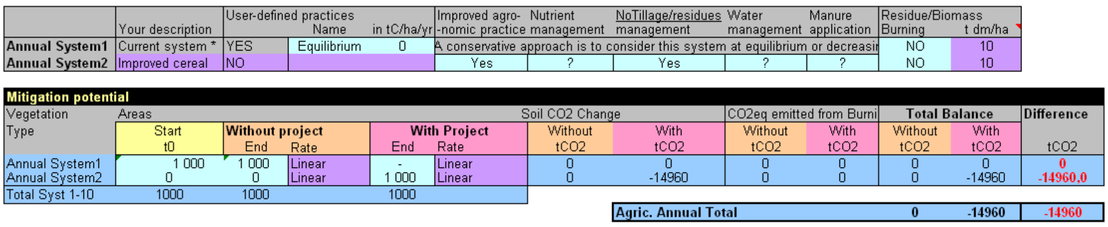
Table 13: Carbon storage discrepancy for conservation farming practices

	Tier 1	Tier 2	
		Open system	Closed system
Carbon storage (in $tCO_2e.ha^{-1}year^{-1}$)	-0.6	-0.25	-0.9

Regarding the conditions of implementation of this improvement in Morocco, it is realistic to assume an open system. In this case, without significant differences between Tier 1 and 2, Tier1 is accounted for, using only the IPCC references with the climate and moisture regime predefined. As explained on the upper section, the "improved agronomic" practices realize the maximal potential of carbon storage. Thus, because of the non-additionality of carbon potential, the carbon storage is limited to 0.75 $tCO_2e.ha^{-1}.year^{-1}$.

The sink generated by the improvement of the agronomic practices is about (-) **14 960 tCO_2e** during 20 years (Figure 7).

Figure 7: Result of the EX-ACT annual module screenshot



5.3.2. Use of inputs

The use of fertilizers is expected to be adjusted with soil analysis. The total use could be close to the agronomic recommendations (Table 4), following the increasing exportation of mineral mater. The production is expected to increase by 0.8 $t.ha^{-1}$.

Table 14: NPK recommendations for an increased production of wheat (+0,8t)

	N	P_2O_5	K_2O
Incremental fertilizer in $kg.ha^{-1}.year^{-1}$	15	7.2	4
Total of incremental fertilizer applied in $t.year^{-1}$	15	7.2	4

Source: Guide pratique de la fertilisation raisonnée des principales cultures au Maroc

The use of agrochemical begins three years after the plantation according to the recommendations summarized in the following tables:

Table 15: Recommendations regarding use of pesticides

Type of pesticide	Active Ingredient	Dose of Active Matter	Source	Total (kg.ha^{-1})
Herbicide	glyphosate	2*0.3*1.26 l.ha^{-1}	Les bonnes pratiques d'utilisation du glyphosate, mars 2009 ARVALIS	0.8
Fungicide	X	1*0,5 kg.ha^{-1}	FICHE SOUS-PROJET FEM N°3: Intensification des céréales (blé tendre) dans la région de Rabat – Salé – Zemmour - Zaër	0,5

The amount of agrochemicals accounted for in the Input module of EX-ACT generates a source of **2 697** tCO_2e.ha^{-1} over 20 years (Figure 8).

Figure 8: EX-ACT Input module screenshot

Carbon dioxide emissions from Urea application

	IPCC factor	With Project End	With Project Rate	End With	With	Difference
Urea	0.2	32.15	Linear	6.43	109	109
			Sub-Total I-2	6.43	109	109

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

Type of input	IPCC factor	With Project 0	With Project Rate	End With	With	Difference
Urea	0.01	15	Linear	46.5	791	791
*N fertilizer from upland rice should be included above (N fertil			Sub-Total I-3	46.5	791	791

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

Type of input**	Default factor*	With Project End	With Project Rate	End With	Total Emission With	Difference
Urea	4.8	15	Linear	71.5	1,216	1216
Phosphorus synthetic fertilizer	0.7	7	Linear	5.3	90	90
Potassium synthetic fertilizer	0.6	4	Linear	2.2	37	37
Herbicides (Pesticides)	23.1	0.8	Linear	19.6	332	332
Insecticides (Pesticides)	18.7	0.0	Linear	0.0	0	0
Fungicides (Pesticides)	14.3	0.5	Linear	7.2	122	122
			Sub-Total I-4	105.7	1797	1797
					2697	2697

* from Lal (2004) Table 5 - central value -tCO2/t product
** tonnes of N, P2O5, K2O and CaCO3

5.3.3. Other investments

Investments directly linked to the Project implementation

The building of a warehouse and packaging plant could be accounted for in the carbon balance of the project. The building could be integrated as metallic industrial buildings of 300 m^2.

Investments directly linked to the continuous project cycle

The 800 t (0,8*1000) of additional wheat produced will be transported to be commercialised. The transportation with 12t capacity truck between the fields to the warehouse is assumed to be a mean average of 100 km. The energy spent in the transportation is about 25 l of diesel per 100km. the total consumption is reaching (800/12)*100 *25/100 = 1,66m^3 of diesel.year^{-1} (Figure 9).

The amount of energy spent to build the units and transport the wheat is a source of **157 tCO_2e** over 30 years.

Figure 9: EX-ACT Other investment module screenshot

Released GHG associated with Fuel consumption (agricultural or forestry machinery, generators…)

Type of Fuel	Default value t CO2 /m3	Specific Value	Default Factor	Annual Fuel Consumption (m3/yr) Start t0	Without Project End	Without Project Rate	With Project End	With Project Rate	Emission (t CO2eq) All Period Without	Emission (t CO2eq) All Period With
Gasoil/Diesel	2,63		YES	0	0	Linear	1,66	Linear	0	74

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
Industrial Buildings (metal)	0,275		YES		300	0,0	82,5
			Subtotal	0,0	82,5	*Difference*	82,5
SUB-TOTAL FOR INVESTMENT		**Without**	**0**	**With**	**157**	**Difference**	**157**

5.4. Results

Table 6 summarizes the overall C balance of the project FEM 3, computed as the difference between C sinks and sources over 20 years (4 years of implementation phase and 16 years of capitalization phase). The project is in fact able to sequester (-) 14 960 tCO_2e while emitting 2 854 tCO_2e so that the net effect of project activities is to create a sink of (-) **12 106 tCO_2e**.

Table 16: C-balance of the Project FEM 3

C-balance elements	tCO_2e over 20 years
Total GHG mitigated	-14 960
Total GHG emitted	2 854
C-balance	-12 106

Source: our calculations using EX-ACT (2011)

The mitigation potential of the project by category of land use change (corresponding to the EX-ACT modules) is presented in the Table 7.

Table 17: Mitigation potential of the sub project FEM 3, by EX-ACT module

EX-ACT modules	tCO_2e over 20 years	% of total GHG mitigated	% of total GHG emitted
Annual crop	- 14 960	100	
Total GHG mitigated	- 14 960	**100**	
Inputs	2 697		94.5
Other Invest. Project	82.5		3
Other Invest. Value chain	74.5		2.5
Total GHG emitted	**2 854**		**100**
C-balance	**- 12 106**		

Source: our calculations using EX-ACT (2010)

6. MITIGATION POTENTIAL OF THE FEM 4 SUB PROJECT

6.1. The project profile

This Pillar II sub-project FEM 4 is located in the region of Rabat – Salé – Zemmour - Zaër. It especially supports the plantation of 8000 ha of olive orchards by the private sector for the benefit of 400 farmers. The objectives should be reached through the implementation of the following actions (Table 6.1).

Table 18: Sub project FEM 4 description

Actions planned to reach the target:
• Extension of the orchards by converting cereals systems on an area of 2 000 ha during the year 2011, with the final objective of 8000 ha totally. • Increase the farmer's incomes and poverty reduction. • Soil conservation measures. • Processing: 80% of the production.
Project targets:
• Variety: Picholine marocaine (96% of plantations). • Density: 100 - 200 trees.ha^{-1}. • Crop management: Traditional. • Expected Yield: 2,7 T.ha^{-1}. • Processing: 80% (or 10 300 Tons of olives per year) of the production will be transformed in morocco.

Source: FICHE SOUS-PROJET FEM N°4: Reconversion des céréales en olivier sur une superficie de 8000 ha dans la région de Rabat – Salé – Zemmour - Zaër

6.2. Main assumptions taken to build the carbon balance appraisal

6.2.1. Soil and climate assumptions

The assumptions taken for this FEM 4 project are exactly the same than the ones taken for the FEM 1 project, for the same reasons (cf. Section 4.2.1): **warm temperate** climate under **moist** moisture regime.

6.2.2. Time frame

The assumptions taken for this FEM 4 project are exactly the same than the ones taken for the FEM 1 project, for the same reasons (cf. Section 4.2): six years of implementation and twenty-four years of capitalization.

6.2.3. Assumptions for the baseline “Without project” scenario

The analysis is based on the identification of two alternative land use and management scenarios, i.e. “with” and “without” project as explained in what follows. The “without” project situation represents the baseline scenario (also indicated as “business as usual”).

That is what the Government or farmers by themselves would implement without taking into consideration any specific climate change adaptation.

The project belongs to the Pillar II of the PMV, especially implemented to fight poverty and adapt the population against climate change impacts. Considering poverty, no change in the agricultural sector would happen, the investment being evaluated as too risky. The perennial cropland could not be improved without the value chain set up, and the value chain could not be implemented without olive tree area extension. Therefore it is assumed that there will be no additional perennial crops on existing annual cropland, no increase of inputs use in the baseline scenario.

6.2.4. Assumptions for the “with project” scenario

The “with project” scenario is built on the basis of project’s targets. Project interventions will promote olive plantations, as well as the adoption of soil conservation measures to reduce erosion and maintain/restore soil fertility.

Therefore the analysis considers in the “with project” scenario that 200 ha of existing annual cropland in rainfed area will be converted to perennial (olive trees). Orchards will be planted with a density of 150 trees per ha. Fertilizers, agrochemicals and the building of irrigation schemes will be accounted for as they may represent a source of GHG.

Within the project, olive trees are planted with a low density of 150 trees per hectare. Usually, in this kind of zone, to be considered as perennial in full density, the density has to reaches 400 trees per hectare[26]. Thus, it has been considered that the agricultural system followed in the project is an agroforestry system. At the moment no specific accurate emission factors are provided by the IPCC to correspond to this agro forestry management. Consequently, this kind of agrosystem has to be separated in two full density of perennial and annual cropland. Thus the area of perennials accounted for in EX-ACT corresponds to 2000*150/400=750 ha, and the remaining area of annual cropland is 2000-750=1250 ha.

The project concerns especially perennial growth that is aimed to store carbon in soil and biomass. In order to test the sensitivity of the tool, the carbon appraisal led on olive orchard will be done in three different ways. The first one will use the Tier1 approach of the EX-ACT tool, the other will use the tier 2 approach using data fromdifferent published studies.

[26] Référentiel pour la conduite technique de l’olivier, (olea europea) Si Bennasseur Alaoui, IAVH, RABAT, 2005

Table 19: Frame of reference for the carbon appraisal

	Land Use change	Olive Orchard	Annual cropland	Input	Irrigation	Oil extraction
With project	Conversion of 750 ha from annual to perennial	750 ha	1250 ha improved (residue managment)	Fertilizer and agrochemicals	Transport of water	Transport of olive
Without project	X	X	2000 ha traditional	X	X	X
Methodology	Tier 1	Tier 1 Tier 2	Tier 1			
Chapter	6.3.1	6.3.2	6.3.3	6.3.4	6.3.5	
	Final carbon balance : 6.4					

6.3. Carbon-balance appraisal

This section aims at briefly describing the carbon appraisal according to the different project activities accounted for in EX-ACT and the frame of reference provided above (cf. Table 9).

6.3.1. Land use change implied to develop perennial crops

The project activities refer to the plantation of perennial crops in the irrigated and rainfed area of project sites. Those two activities will imply land use change from annual cropland to olive perennial crops whose impacts are calculated among the “Non forest land use change” module of EX-ACT (Figure 10). Without the implementation of the project, it is assumed that no perennial cropland will be developed, and that the current annual crops would remain.

The EX-ACT perennial module is forecasting a sink of (-) **12 925 tCO_2e** over a period of 30 years.

Figure 10: Impacts of planting perennials according to EX-ACT Land Use Change module

Your Name	Description of LUC: Initial Land Use	Final Land Use	Alert	Burnt before conversion	Default C Stocks (tC/ha): Biom. Ini.	Biom. Fin.	Soil Ini.	Soil Fin.
Negarim olive orchard	Annual Crop	Perennial/Tree Crop		NO	5,0	2,1	60,7	88,0

	Area concerned by LUC: Without Project		With Project		Biomass Change		Soil Change		Fire		Total Balance		Difference
	Area	Rate	Area	Rate	Without tCO2	With tCO2	Without tCO2	With tCO2	Without tCO2	With tCO2	Without tCO2	With tCO2	tCO2
Negarim olive orchard	0	Linear	750	Linear	0	7975	0	-75020	0	0	0	-67045	-67045
Other LUC total											0	-67045	-67045

6.3.2. Olive orchard development

As per FEM 1 project, different ways of accounting the impact of olive orchard development were tested.

Tier 1 Approach

- The perennials are storing carbon during their growing period. The Tier 1 approach of the perennial module is using a default IPCC factor provided according to the climate and moisture regime. It is assumed that the pruning material will not be burnt. The Tier 1 approach forecasts a sink of (-) **160 875 tCO_2e** over 30 years.

Tier 2 Approach

- Without any information about the Negarims impact on the orchards' biomass production, estimates have been built to distinguish this improved system with irrigated or non irrigated orchards. For the sake of simplicity it is considered that Negarims are actually between the non irrigated and irrigiated orchards in terms of biomass growth (Table 20). The rain harvested by the Negarims[27] will allow to increase the biomass production of the olive tree comparatively to the trees that are growing without Negarims (on rainfed orchards). However the increase in biomass growth is not as high as the biomass growth observed for the olive trees growing in irrigated orchards.

  It is assumed that the trees growing with Negarims will have 20% of the biomass growth between non irrigated orchards and irrigated ones. The following table shows the Tier 2 coefficients for the orchards with Negarims.

Table 20: Biomass in orchards with Negarims

	Residue/ Biomass	Aboveground Biomass	Belowground Biomass
(1) t of DM in irrigated orchard	2,1	2,12	1,13
(2) t of DM rainfed orchard	1,53	1,55	0,82
(3) Additional t of DM= *(1)-(2)*	0,57	0,57	0,31
Assumption	% of Additional DM for Negarim **: 20%**		
(4) Additional t of DM= *0.2*(3)*	0,114	0,114	0,062
t of DM Negarim orchard *= (2)+(4)*	1,644	1,664	0,882

The EX-ACT default value proposed for the soil carbon content is used (-0,33 $tCO_2e.year^{-1}$).

Comparison and choice

The following carbon results reflect the different water irrigation management in the olive orchards.

[27] The negarims are small scale rain harvest system, build with an earth dig (from 15 to 25 cm high) which capture the rainwater and infiltrate it directly on the tree roots area, avoiding the runoff.

Table 21: Result discrepancy

	Tier 1	Tier 2		
		Non irrigated	Negarim	Irrigated
Carbon storage (in $tCO_2e.ha^{-1}year^{-1}$)	-7,3	-7.9	-8.46	-10.9

With a realistic approach, orchards with negarims will be described with Tier 2 coefficients.

The sink of carbon forecast with the Tier 2 approach is about **(-) 196 040** tCO_2e over 30 years (cf. Figure 11).

Figure 11: Impacts of planting perennials according to Tier 2 of EX-ACT Perennial module

Your description	Residue/Biomass Burning	Interval (yr)	Tons dm/ha	Aboveground Biomass Growth rate (tC/ha) Default	Aboveground Biomass Growth rate (tC/ha) Specific	Belowground Biomass Growth rate (tC/ha) Default	Belowground Biomass Growth rate (tC/ha) Specific	Soil Effect Default t CO2/ha/yr	User default available	tCO2/ha/y	CH4 kg	N2O kg	CO2eq t
OLUC to Perennia	NO	1	1,64	2,1	1,66	0	0,88	0,7	NO		0	0	0,0

The default (tiers 1 assumption) is that if the systen is in equilibrium therefore default growth rate is 0

Positive value= gain for soil

Only System P1 and P3 are considered by default not in equilibrium

Areas Start t0	Without project End	Without project Rate	With Project End	With Project Rate	CO_2 fluxes from Biomass Without	CO_2 fluxes from Biomass With	CO_2 fluxes from Soil Without	CO_2 fluxes from Soil With	CO_2eq emitted from B Without	CO_2eq emitted from B With	Total Balance Without tCO_2	Total Balance With tCO_2	Difference tCO2eq
0	0	Linear	750	Linear	0	-185540	0	-10500	0	0	0	-196040	- 196 040
0	0		0										
									Agric. Annual Total		0	-359577	- 196 040

6.3.3. Crop management changes

The area cropped under the lines of olive trees will be improved with the project. Intending to reduce the erosion and improve the soil fertility, crop residue will be kept on surface. This practice inspired by the conservative farming is considered in the IPCC category "Adoption of reduced or minimum tillage, with or without mulching", also integrated in the "annual" module of the EX-ACT tool (cf. Figure 12). With a conservative approach it is assumed that there is currently no burning residue practice .

The new management of residue leads to store (-) **17 500** tCO_2e over 30 years in the cropland.

Figure 12: Impacts of annual crop according to EX-ACT annual module

	Your description	User-defined practices	Name	e in tC/ha/yr	Improved agro-nomic practice	Nutrient management	NoTillage/residues management	Water management	Manure application	Residue/Biomass Burning	t dm/ha
Reserved system	Converted to OLUC	NO			?	?	?	?	?	NO	10
Annual System1	Current system *	YES	Equilibrium	0	* A conservative approach is to consider this system at equilibrium or decreasing					NO	10
Annual System2	Improved wheat	NO			?	?	Yes	?	?	NO	10

Mitigation potential

Vegetation Type	Areas Start t0	Without project End	Without project Rate	With Project End	With Project Rate	Soil CO2 Change Without tCO2	Soil CO2 Change With tCO2	CO2eq emitted from Burning Without tCO2	CO2eq emitted from Burning With tCO2	Total Balance Without tCO2	Total Balance With tCO2	Difference tCO2
System A4	750	750	Linear	0	Linear	0	0	0	0	0	0	0
Annual System1	1 250	1 250	*Linear*	-	*Linear*	0	0	0	0	0	0	0
Annual System2	0	0	*Linear*	1 250	*Linear*	0	-17500	0	0	0	-17500	-17500
Total Syst 1-10	1250	1250		1250								
							Agric. Annual Total			0	-17500	-17500

6.3.4. Use of inputs

The use of fertilizers is expected to be adjusted with soil analysis. The total use could be close to the agronomic recommendations, following the exportation of mineral mater[28]. The total production planed is about 2,7 $T.ha^{-1}$, corresponding to a production of 18 kg per tree.

Table 22: NPK recommendations to increase the olive production by 15-30 kg per tree

	N	P_2O_5	K_2O
Additional quantity of fertilizer to be applied (in kg of fertilizer.$Tree^{-1}$.$year^{-1}$)	0.6	0.3	0.6
Total of incremental fertilizer (in t.$year^{-1}$)	180	90	180

Source: Guide pratique de la fertilisation raisonnée des principales cultures au Maroc.

The use of massive quantities of fertilizer is acceptable in the case of agroforestry, because of the increasing concurrence between annual crops and olive trees. In this case, the efficiency of the use of fertilizer is increased, taking advantage of both crops. The use of agrochemicals three years after the plantation could follow the recommendations summarized in the following table:

Table 23: Recommendations on the use of pesticides

Type of pesticide	Active Ingredient	Dose	Source	Total
Herbicide	Flazasulfuron	0,2 $kg.ha^{-1}$	Gratraud C., Le Verge S., 2006. Bonnes pratiques culturales en vergers d'oliviers. Ed AFIDOL. 52 p.	5,7 $kg.ha^{-1}$
	Fluazifop-p-butyl	1 $l.ha^{-1}$		
	Glyphosate	4,5 $l.ha^{-1}$		
Insecticide	Organophosphates	0,075 $kg.ha^{-1}$	AFIDOL Bulletin n°1	4,935 $kg.ha^{-1}$
	Pyrethroids	3*0,02 $l.ha^{-1}$		
	Spinosoïdes	4* 1,2 $l.ha^{-1}$		
Fungicide	Cooper	0,4 $kg.ha^{-1}$	AFIDOL Bulletin n°6	0,7 $kg.ha^{-1}$
	Krésoxim-méthyl	0,3 $l.ha^{-1}$		

The amount of agrochemicals accounted for in the "Input" module of EX-ACT generates a source of **87 296 tCO_2e** over 30 years (Figure 13).

28 De la Vega de Luque 1969.

Figure 13: EX-ACT Input module screenshot

Carbon dioxide emissions from Urea application

	IPCC factor	Amount of Urea in tonnes per year: Start					Emission (t CO2eq) per year: Start	End		Total Emission (tCO2eq)		Difference
		t0	Without Project: End	Without Project: Rate	With Project: End	With Project: Rate		Without	With	Without	With	
Urea	0,2			Linear	386,00	Linear	0	0	77,2	0	2 084	2084
					Sub-Total I-2		0	0	77,2	0	2084	2084

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

Type of input	IPCC factor	Amount of N Applied (t per year): Start					Emission (t CO2eq) per year: Start	End		Total Emission (tCO2eq)		Difference
		t0	Without Project: End	Without Project: Rate	With Project: 0	With Project: Rate		Without	With	Without	With	
Urea	0,01	0	0	Linear	180	Linear	0,0	0,0	558,4	0	15 077	15077
*N fertilizer from upland rice should be included above (N fertilizer)					Sub-Total I-3		0,0	0,0	1116,4	0	30143	30143

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

Type of input**	Default factor*	Amount in tonnes of product (active ingrediente for Pesticides): Start					Start	End		Total Emission		Difference
		t0	Without Project: End	Without Project: Rate	With Project: End	With Project: Rate		Without	With	Without	With	
Urea	4,8	0	0	Linear	180	Linear	0,0	0,0	858,6	0	23 183	23183
N Fertiliser (other than Urea)	4,8	0	0	Linear	180	Linear	0,0	0,0	858,0	0	23 166	23166
Phosphorus synthetic fertilizer	0,7			Linear	90	Linear	0,0	0,0	66,0	0	1 782	1782
Potassium synthetic fertilizer	0,6			Linear	180	Linear	0,0	0,0	99,0	0	2 673	2673
Herbicides (Pesticides)	23,1			Linear	3,8	Linear	0,0	0,0	88,9	0	2 400	2400
Insecticides (Pesticides)	18,7			Linear	3,3	Linear	0,0	0,0	62,3	0	1 682	1682
Fungicides (Pesticides)	14,3			Linear	0,5	Linear	0,0	0,0	6,8	0	182	182
					Sub-Total I-4		0,0	0,0	2039,6	0	55068	55068
								Total "Inputs"		0	87296	87296

6.3.5. Other investments

Investments to irrigate young olive trees

The young olive trees need 500 l per tree on the third and fourth year following the plantation. The total volume of water needed is reaching (750 ha *400 tree *0,5 m^3 *2 years) = 300 000 m^3.

The transportation of the water from the Oued Beht to the orchard is assumed to be carried out by tank trucks of 12 m^3 (12T) on a mean average distance of 20 km. Energy spent in the transportation is about 25 L of diesel per 100km. The total consumption reaches (300 000/12)*20 *25/100 = 125m^3 of diesel over two years.

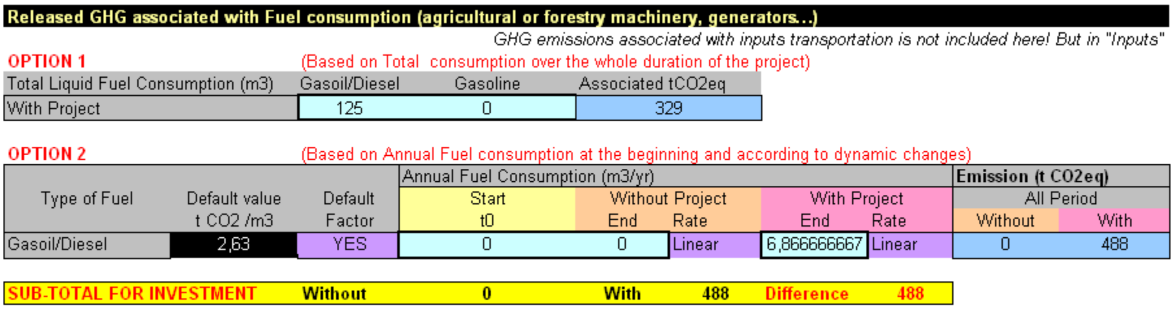
Value chain accounting

The olive transportation implies fuel consumption. The transportation in 12t capacity truck between the orchards to the processing plan is assumed to be a mean average of 30 km. The energy spent in the transportation is about 25 l of diesel per 100km, the total consumption reaches (4320/12)*30 *25/100 = 2,7m^3 of diesel/$year^{-1}$.

About 80 % of olives produced have to be processed. It is assumed that the oil is extracted on traditional maâsra, using exclusively animal energy. So the impact in term of GHG emissions is negligible.

The other investisment needed to transport and process olive is creating a source of **488 tCO_2e** over 30 years (Figure 14).

Figure 14: EX-ACT Other Investment module screenshot



Released GHG associated with Fuel consumption (agricultural or forestry machinery, generators...)

GHG emissions associated with inputs transportation is not included here! But in "Inputs"

OPTION 1 (Based on Total consumption over the whole duration of the project)

Total Liquid Fuel Consumption (m3)	Gasoil/Diesel	Gasoline	Associated tCO2eq
With Project	125	0	329

OPTION 2 (Based on Annual Fuel consumption at the beginning and according to dynamic changes)

Type of Fuel	Default value t CO2 /m3	Default Factor	Annual Fuel Consumption (m3/yr) Start t0	Without Project End	Without Project Rate	With Project End	With Project Rate	Emission (t CO2eq) All Period Without	With
Gasoil/Diesel	2,63	YES	0	0	Linear	6,866666667	Linear	0	488

SUB-TOTAL FOR INVESTMENT Without 0 With 488 Difference 488

6.4. Results

Table 24 summarizes the overall C balance of the project FEM 4, computed as the difference between C sinks and sources over 30 years (4 years of implementation phase and 26 years of capitalization phase). The project is in fact able to sequester (-) 182 801 tCO_2e while emitting 87 784 tCO_2e so that the net effect of project activities is to create a sink of (-)**280 585** tCO_2e over 30 years.

Table 24: C-balance of FEM4 Project

C-balance elements	tCO_2e over 30 years
Total GHG mitigated	- 280 585
Total GHG emitted	87 784
C-balance	- 182 801

Source: our calculations using EX-ACT (2011)

The mitigation potential of the project by category of land use change (corresponding to the EX-ACT modules) is presented in Table 25. Mitigation potential is especially linked with the plantation of perennial crops.

Table 25: Mitigation potential of the FEM4 project, by EX-ACT module

EX-ACT modules	tCO_2e over 30 years	% of total GHG mitigated	% of total GHG emitted
Perennial crops	-196 040	70	
Annual crop	-17 500	6	
Non forest land use changes	-67 045	23	
Total GHG mitigated	**- 280 585**	**100**	
Inputs	87 296		99.5
Other Invest. Project	296		0.3
Other Invest. Value chain	192		0.2
Total GHG emitted	**87 784**		**100**
C-balance	**-182 801**		

Source: our calculations using EX-ACT (2010)

7. DISCUSSIONS

7.1. Limits of carbon balance appraisals

7.1.1. Choice of basic assumptions

The climate is impacting the carbon balance, especially for annual crops. The sensitivity has been tested for example on the project FEM3 (Table 26).

Table 26: Project FEM3 sensitivity according to the moisture regime

Moisture regime	Total C-Balance	Ratio
Moist	-12 106	**-77%**
Dry	-2 756	

Table 26 shows the importance of the backbone data for that kind of appraisal: climate and moisture regime. If the climate is relatively stable, the moisture regime could be very variable on the same project area, depending o Morocco’s high variability of topologies. So the predominant moisture regime has to be assessed. If the share is too difficult, it is safer to divide the appraisal in two, one for each moisture regime.

The soil also has an impact on the carbon balance, especially for perennial crops. For example, the sensitivity of the project FEM3 reflects the impact of selecting different kinds of dominant soils (Table 27).

Table 27: Project FEM1 sensitivity according to soil type

Type of soil	Total C-Balance	Ratio
HAC soil	-119 226	**-14%**
LAC soil	-113 106	
Other	-102 546	

The above types of soil have a lower impact on the final carbon balance compared to the moisture regime. However, to be as precise as possible, it is important to asses clearly the predominant soil type.

7.1.2. Tier 2 coefficients recourse

The biomass and carbon contents were estimated with tier1 and also ad hoc coefficients. The ad hoc coefficients were found for countries with similar climatic and agronomic conditions. They do not show significant differences with the tier 1 approach for basic improvements. This therefore shows the robustness of the IPCC coefficients used by the tool in this particular case.

For specific improvements (irrigated orchard or closed system of conservation agriculture) the literature is relevant for the Maghreb. Therefore, field measurements of carbon content and carbon sequestration are not a high priority.

Specific coefficients for less studied practices such as the building of Negarims and other rain harvest systems are missing. A fast data collection about the above ground biomass growth (the below one could be deducted) of this kind of orchard could be launched. With this data available the calculation could be carried out more precisely, otherwise the coefficient of an assumed 20% has to be endorsed by local arboriculture specialists.

7.1.3. Adoption rate of proposed activities

The carbon-balance results may vary greatly depending on the adoption rate of practices, as well as of the consumption of inputs. For example, if the irrigation is not applied on olive trees, but applied to annual crop (because of the opportunity cost), the carbon sink will decrease by 1.86 $tCO_2e.ha^{-1}year^{-1}$.

For orchard projects the olive tree survival is the weakest point of the appraisal, because of the prevalence (70 to 88%) of the perennial on the composition of the carbon sink. The decreasing density of the tree crop will directly impact the sink generated.

7.1.4. Uncertainty linked with the baseline scenario

The assumption that the without project situation remains the same as the starting point is in actual fact an optimistic assumption, in reality the situation would probably deteriorate.

Agriculture is a sector that constantly changes. Indeed if agriculture is not improved, what is a realistic assumption? and if the competitiveness of agriculture in Morocco as well as of farmers' income does not improve, then cropland could be abandoned to fallow land and be set aside.

The final land use of fallow land is deeply linked to the livestock pressure and the localisation on the topography (plain, piedmont or mountain field). The following table gathers the carbon sinks created by different initial land uses that will be converted into possible new land uses if there is agricultural decline and abandonment.

Table 28: Probable land use change if agricultural abandonment (under moist temperate warm climate, and HAC soil)

Initial land use	Topography	Final land use (Subtropical system)	Realism according to livestock pressure		Change $tCO_2e.ha^{-1}.year^{-1}$
			high	low	
Perennial / Tree Crop	plain	Humid forest	--	-	-5,2
		Dry forest	+	+	-2,3
		Steppe	-	--	0,5
	mountain	Mountains forest	-	+	-3,2
Annual Crop	plain	Humid forest	--	-	-13,7
		Dry forest	-	+	-10,9
		Steppe	+	++	-8,1
		Fallow	++	-	-1,6
	mountain	Mountains forest	-	+	-11,8
Grassland	plain	Humid forest	--	-	-10
		Dry forest	-	+	-7,1
		Steppe	++	++	-4,7
	mountain	Mountains forest	-	+	-7,9635

That kind of land use change could also be probable and taken to build the baseline scenario instead of considering an optimistic without project scenario where nothing changes. It could highly impact the final result, especially for projects FEM 3 and 4. The sensitivity was tested for those two projects FEM 3 and 4, comparing the carbon balance obtained with the current chosen baseline and the one obtained with a more pessimistic baseline in which it was considered that half of the cropped lands are abandoned to fallow land (Table 29).

Table 29: project FEM3 and FEM4 sensitivity: without project

	Project FEM3		Project FEM4	
	Total C-Balance	Ratio	Total C-Balance	Ratio
Baseline "Non change"	**-11 449**	**-221%**	**-192 801**	**-9%**
Baseline "Agric. Abandonment"	**13 858**		**-177 071**	

The project FEM3 is very sensitive to the baseline integrating the agricultural abandonment. Indeed the adoption of the project is leading to a relatively small amount of carbon stored per hectare. Thus the conversion from half of the cropland to fallow in the baseline integrating agricultural abandonment is creating a bigger sink than the crop improvements on the total area proposed by the adoption of the project activities. Thus the carbon balance between the new baseline and the project reflects an emission.

The project FEM4 is less sensitive to the baseline integrating crop abandonment. The abandonment is also creating a sink but smaller than the one implied by the project activities. Half the land converted to fallow stores less than the plantation of olive trees (even with a smaller density of 150 trees.ha-1). Thus the final carbon balance is still a sink.

This new simulation of baseline scenario is quite pessimistic regarding the social and economic situation in the project area, even if it would be to the advantage of the carbon indicator. Another simulation, less realistic regarding the current situation but more pessimistic in terms of carbon emissions, would be to declare that the current state of degradation will be even more degraded, thus amplifying the mitigation potential of the project.

7.2. Further steps: carbon balance improvements and project viability

7.2.1. Value chain approach

The whole value chain promoted encourages farmers to plant trees, taking advantage of the market outlet, as well as of the availability of good quality plants and adapted technology. This positive carbon externality of the projects could not have been accounted for ex-ante.

7.2.2. Energy

Morocco is showing a high demand concerning fuel wood on rural areas. The valorisation of the other orchard resources, such as pruning material, is a good source of energy (high density wood, under 0.8-1 t/m^3) and furthermore the improvement of stoves could permit households to reduce the wood consumption and also substitute the wood to other fossil fuel.

After the olive oil extraction the pits oil could be promoted. But that is not the best valorisation regarding the pits oil quality. The olive pits are a good source of energy for area close to the oil processing units.

7.2.3. Agronomy

Regarding the previous limits of the appraisal, the rate of tree survival is especially important. Therefore, for the rainfed area, the options of building Negarims and irrigating during the two first years of plantation seem to be very important. The protection device against the livestock grass is also important to ensure the density of plantations.

The orchard economic viability is especially important to ensure tree survival. Therefore, options allowing for sharing the cost of maintenance (as weed control and preparation of the olive harvest) have to be promoted. The agro-forestry systems meet this advantage and also improve the fertilizer efficiency. For mature orchards, silvopastoralism could be a better way to increase the labour efficiency.

To ensure the improved yield on cropland due to a best management of residue, the straw has to return to the soil. However, the livestock is wildly grazing the crop residue, limiting the quantity of restitution. Without changing the open system to an enclosed one it is difficult to enhance the soil carbon pool.

The use of fertilizer could be a way to produce more biomass (residue and intercrop) on cropland. After three years of intense biomass incorporation, the carbon pool of the soil is growing, increasing the water storage (climate change adaptation) and fertilizer efficiency. This practice requires a high investment on fertilizers which is too risky for farmers, thus it should be supported by public policy.

8. SOME ECONOMIC ASPECTS

A quick economic analysis could be done using the carbon estimates provided by EX-ACT and applying a FAO methodology[29]. The average of carbon stored, shown on the Table 30, is valued using a carbon a price of 3 US$.$tCO_2e^{-1}$, which is the average carbon price for agricultural soil carbon at retail level on the voluntary carbon market in 2008[30]. The following table could be set, valuing the carbon stored by the project.

Table 30: Valuating carbon balance.

Project	*Total project sink $tCO_2e.ha^{-1}.year^{-1}$*	*$.ha^{-1}.year^{-1}$ (3US$.$T^{-1}$)*	*Cropland sink $tCO_2e.ha^{-1}.year^{-1}$*	*$.ha^{-1}.year^{-1}$ (3US$.$T^{-1}$)*
FEM 1	**- 2.48**	**7.44**	**- 3.81**	**11.43**
FEM 3	- 0.57	1.71	- 0.75	2.25
FEM 4	**- 2.74**	**9.12**	**- 3.53**	**10.59**

For the purpose of this paper, it is assumed that the transaction costs for taking into account carbon at public or market levels are equal to 4 US$.$ha^{-1}$ (per year) which is an arbitrary but plausible value based on available literature[31].

Since the value of project FEM 1 and 4 are higher than the level of transaction costs for public implementation, they would probably be suitable for being financed on the public carbon sector.

Since the carbon prices remain low and the transaction cost is not efficient enough, the FEM 3 project is not yet suitable for being financed on public carbon sector.

However, if the three projects are aggregated they could be suitable for carbon financing (average of 9.6 $.$ha^{-1}.year^{-1}$). The three projects indeed may have the same global targets, presenting a spatial coherence and common economic impacts, thus allowing for aggregation.

[29] FAO. 2009. Food Security and Agricultural Mitigation in Developing Countries: Options for Capturing Synergies.

[30] Hamilton et al. 2009.

[31] Cacho et al. 2005; Lipper at al. 2010; Mooney et al. 2004.

9. Conclusions

This paper describes the ex-ante C-balance analysis performed for three projects integrated to the Plan Maroc Vert. The results show that overall the net effect of the projects is to create carbon sinks of (-) **313 476 tCO_2e**, which represents the balance between the GHG emitted (mainly as a consequence of the increased use in agro-chemicals) and carbon sequestered (essentially through scaling up the orchard plantation).

The most important sinks are due to the orchard plantations that store carbon into the live biomass and the soil.

The project FEM 1 reflects how water management is a key factor for the orchard biomass growth. The project FEM 4 shows that punctual irrigation and small rain-harvest Negarims could allow to increase the rainfed orchard viability, protecting the watershed and improving the carbon storage. The practice is thrifty regarding water use, which is particularly interesting as water is a limited and limiting resource in Morocco. That is a good example of potential synergy between sustainable land and water management and climate change mitigation.

Considering the warm and dry climate, the FEM 3 project dealing with cropland improvements show lower carbon sinks compared to previous projects, the cereals straw being grazed or burned. The carbon balance for cropland improvement is indeed strongly linked to the rate of biomass returning to the soil. Without an important change in the management between crops and livestock, the sink is restrained.

Nevertheless, the results presented are only preliminary estimates based on information available (or derived on the basis of working hypotheses) at this stage of project appraisal. The uncertainty in the data availability and the significant number of assumptions made is inevitably reflected in the results discussed. Moreover, the agreed non change baseline scenario is less pessimistic than considering further degradation in the project area, making the final result of the carbon balance less optimistic. Further verification of assumptions taken would be suitable to adapt the carbon balance appraisal accordingly to what still really pragmatically happens on field work. Thus it could be interesting to rerun the carbon appraisal in some years to check and monitor what is realistically happening at the project level.

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*
- *Carbon Balance of "Plan Maroc Vert" Roadmap Strategy (2010-2030): Application of the EX-Ante C-balance Tool (EX-ACT Version 3),* EASYPol Module 123

- EX-ACT policy briefs, available on the EX-ACT website

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 READING / REFERENCES

EX-ACT tool

Bernoux, M., Branca, G., Carro, A., Lipper, l., Smith, G., Bockel, l., 2010. Ex-ante Greenhouse Gas Balance of Agriculture and Forestry Development Programs. *Scientia Agricola 67: 31-40*, http://www.scielo.br/scielo.php?pid=S0103-90162010000100005&script=sci_arttext

Bernoux, M., Bockel, l., Branca, G., Tinlot, M., 2010. EX-Ante Carbon-balance Tool (EX-ACT) Technical Guidelines, version may 2010, *EASYPol Module 101*, FAO, Rome, 79 p. Available at: http://www.fao.org/docs/up/easypol/780/ex-act-tech-guidelines_101en.pdf [Accessed July 20, 2010]

Branca, G., Lipper, l., Bockel, l., 2010. *Potential Use of the EX-Ante C-balance Tool (EX-ACT) in the Economic and Financial Analysis of Agriculture and Mitigation Projects*. Working paper. FAO. Rome.

Burney, J.A., Davisc, J.S., Lobella, B.D., 2010. *Greenhouse Gas Mitigation by Agricultural Intensification.* PNAS, June 29, 2010, vol. 107, no.26, pp. 12052–12057. Available at : www.pnas.org/cgi/doi/10.1073/pnas.0914216107 [Accessed September 29, 2010]

FAO , 2010. The EX-Ante Carbon-balance Tool, EASYPol Module 101, available at http://www.fao.org/docs/up/easypol/780/ex-act_version_3-2_april_2011_101en.xls

Eggleston. H., Buendia. l., Miwa. K., Ngara. T., Tanabe. K., 2006. *IPCC Guidelines for National Greenhouse Gas Inventories, The National Greenhouse Gas Inventories Programme*, Intergovernmental Panel on Climate Change.

Building Project scenarios

Word Bank, 2010. Fiche sous-projet FEM N°1: *Reconversion des céréales en olivier sur une superficie de 1600 ha dans la région de Chaouia – Ouardigha*.

Word Bank, 2010. Fiche sous-projetFEM N°3: *Intensification des céréales (blé tendre) dans la région de Rabat – Salé – Zemmour – Zaër*

Word Bank, 2010. Fiche sous-projetFEM N°4: *Reconversion des céréales en olivier sur une superficie de 8000 ha dans la région de Rabat – Salé – Zemmour - Zaër*

Olive trees resources

Mariscal, M. J., Orgaz, F. and Villalobos, F. J. 1998. *Radiation-Use Efficiency and Dry Matter Partitioning of a Young Olive (Olea europaea) orchard, 67-70.*

Alaoui, S.B., 2005. *Référentiel pour la conduite technique de l'olivier*, (olea europea), IAVH,RABAT.

Sofo, A. et al, 2005. *Net CO_2Storage in Mediterranean Olive and Peach Orchards, 18-22. See:* http://www.unibas.it/utenti/dichio/028.pdf

Alaoui, S. B., Yasuehi A. , 2005. G*uide pratique pour la fertilisation raisonnée des principales cultures au Maroc*, 36.

Gratraud C., Le Verge S., 2006. *Bonnes pratiques culturales en vergers d'oliviers*. Ed AFIDOL.

Sbitri. M.O., Serafini. F., 2007. *Techniques de production en oléiculture*, Conseil oléicole international.

Gratraud, C., Leverge, S., Pinatel, C., Argenson. C., Petit. C., 2007. *Un point sur la réglementation des produits phytosanitaires et les bonnes pratiques agricoles*. AFIDOL.

Gratraud, C., Leverge, S., Pinatel, C., Argenson. C., (2009), *L'entretien du sol en vergers d'oliviers* AFIDOL.

FAO, 2011. , *Water Harvesting Techniques*, Natural Resources Management and Environment Department, available at http://www.fao.org/docrep/u3160e/u3160e07.htm

Conservation agriculture resources

Brahim N., Gallali T., Bernoux M., 2009. *Effects of Agronomic Practices on the Soil Carbon Storage Potential in Northern Tunisia*, Journal of Agronomic Research. See: http://scialert.net/qredirect.php?doi=ajar.2009.55.66&linkid=pdf

Brahim N., Bernoux M., Blavet D., Gallali T., 2009. *Tunisian Soil Organic Carbon Stocks*. International Journal of Soil Science. Available at: http://scialert.net/abstract/?doi=ijss.2010.34.40

Ben Moussa-Machraoui S., Errouissi F., Ben-Hammouda M., and Nouira S.,et al., 2010. *Comparative Effects of Conventional and No-Tillage Management on Some Soil Properties Under Mediterranean Semi-Arid Conditions in Northwestern Tunisia* . Soil and Tillage Research, 247-253

De la Vega de Luque 1969. Guide pratique de la fertilisation raisonnée des principales cultures *au Maroc.*