The EX Ante Carbon-balance Tool

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APPLIED WORK | EASYPol Module 123

Carbon Balance of "Plan Maroc Vert" Roadmap Strategy (2010-2030)

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

Pierre-Luc Sutter[1]

[1] Consulant, Policy Assistance Support Service, FAO

For the
FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS, FAO

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

See EX-ACT website: ***WWW.FAO.ORG/TC/EXACT***

Related resources

- EX-ANTE Carbon-Balance Tool (EX-ACT): (i) TECHNICAL GUIDELINES; (ii) TOOL; (iii) BROCHURE
- See all EX-ACT resources in EASYPol under the Resource package, INVESTMENT PLANNING FOR RURAL DEVELOPMENT, EX-ANTE CARBON-BALANCE APPRAISAL OF INVESTMENT PROJECTS

About EASYPol

EASYPol is a multilingual repository of freely downloadable resources for policy making in agriculture, rural development and food security. The EASYPol home page is available at: *WWW.FAO.ORG/EASYPOL*. These resources focus on policy findings, methodological tools and capacity development. The site is maintained by FAO's POLICY ASSISTANCE SUPPORT SERVICE.

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Abbreviations

ADA	From the French «Agence de développement de l'agriculture» agriculture development agency
AFOLU	Agriculture, Forest and Other Land Use
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 Organisation of the United Nations
GDP	Gross domestic product
GEF	Global Environmental Facility
GHG	Green House Gas
GIS	Geographic Information System
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
MRV	Monitoring, Reporting and Verification
MT	Million tonnes
N_2O	Nitrous Oxide
NAMA	Nationally Appropriate Mitigation Actions
ODA	Official Development Assistance
PICCPMV	From the French: Projet d'Intégration du Changement Climatique dans la mise en œuvre du Plan Maroc Vert
PMV	From the French: Plan Maroc Vert
SCCF	Special Climate Change Fund
SLM	Sustainable Land Management
SNNPR	Southern Nations, Nationalities, and Peoples Region
TCO2-e	Tonnes of CO2 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 increased food security and reductions in rural poverty.

The EX-Ante Carbon-balance Tool (EX-ACT) can estimate the mitigation potential of rural development projects generated from changes in farming systems and land use.

This study presents and discusses the EX-ACT analysis performed on Morocco's Plan Maroc Vert (PMV). The PMV is a strategy of reforms launched by the Moroccan Government aimed at promoting agriculture as a major engine of social and economic development. The projected estimates of the impact of PMV on greenhouse gas emissions and carbon sequestration demonstrate that its implementation should provide additional environmental benefits by contributing to mitigate climate change. Thus it reflects possible synergies between mitigation and rural development goals while developing climate change adaptation approach.

2. INTRODUCTION

Objectives : This paper identifies and interprets the main projected impacts of the PMV on climate change mitigation. The study was commissioned by World Bank. It shows the results issued from a real case project (although simplified), starting with row data collected on the Agricultural Development Agency (Agence de Dévelopment de l'Agriculture, ADA) website. 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 at desk level, it can be used in a training course, where there is no possibility to organize field trips to gather data for a practical applications of the EX-ACT software.

Target audience : This document mainly aims at current or future practitioners working on the formulation and analysis of investment projects, on climate change issues and employees in public administrations, in NGO's, professional organizations or consulting firms. Academics may 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;
- Basic knowledge of the EX-ACT tool;
- Concepts of land use planning and management
- Elements of project economic analysis.

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

3. BACKGROUND

3.1. Project description

Morocco launched its national agricultural strategy, the "Plan Maroc Vert" (PMV), in 2008. The PMV seeks to make agriculture the driving force for economic growth. The PMV 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. The national strategy aims to 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 aims 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). The World Bank is supporting the Government of Morocco in mainstreaming climate change adaptation into the PMV.

The objectives set by the PMV are all the more challenging due to climate change which will increase the variability of agricultural production and decrease the availability of arable land. With 85 percent of the agricultural land without irrigation, farmers are exposed to erratic precipitation and drought, with consequent effects on yields. Annual fluctuation in rainfall explains 75 percent of the year-to-year variability in Moroccan GDP. The drought in 2005 cut 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 a sustainable solution. Water is already exploited beyond renewable limits in many basins, and agriculture, which currently accounts for 87 percent of fresh water use, suffers from increasing competition from urban and industrial demands. In irrigated agriculture, uncertainty about water supply is acute among farmers, and water scarcity is a key factor in lower-than-potential agricultural revenues and in 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).

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

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

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

The objective of the proposed EX-ACT appraisal is to assess whether the PMV can also contribute to reduce the carbon emissions while launching the new agriculture strategy.

3.2. Objectives and structure of the document

Models are being developed to estimate i) the resilience of agricultural systems and the mitigation potential from changes in farming systems, and ii) to support project managers on climate change (CC) mitigation decision making, helping to conduct actions to tackle climate change. EX-ACT (EX-Ante Carbon-balance Tool) is one of these models developed by the Food and Agriculture Organization of the United Nations (FAO) to provide ex-ante estimates of the impact of rural development projects on Greenhouse Gas (GHG) emissions and carbon sequestration, thus estimating the potential contribution of agriculture and forestry sector to CC mitigation. The tool is now going through a testing process: case studies have been selected with the aim of representing a wide range of different ecosystems worldwide, agriculture activities) and geographic coverage.

The objective of this report is to present the results of the EX-ACT test on a World Bank (WB) supported policy, the PMV of the Government of Morocco. It is worth noticing that the results could be subject to change due to possible adjustments regarding data collection, scenarios assumptions and in the methodology adopted in further development of the tool.

The report is organized as follows. The next section provides a brief description of EX-ACT and its methodology. Chapter 4 provides a short description of the proposed PMV while chapter 5 presents the EX-ACT analysis for this specific case study, reporting the main findings in terms of PMV mitigation potential and the results of the sensitivity and economic analysis.

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

EX-ACT is a tool developed by FAO that aims at providing *ex-ante* estimates of the impact of agriculture and forestry development projects on GHG emissions and carbon sequestration, indicating its effects on the C-balance[3] , which is selected as an indicator of the mitigation potential of the project[4]. EX-ACT may be used in the context of *ex-ante* project formulation and 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: a “without project” (i.e. the “Business As Usual” or “Baseline”) and a “with project”. Main output of the tool consists of the C-balance resulting from the difference between these two alternative scenarios (Figure 1).

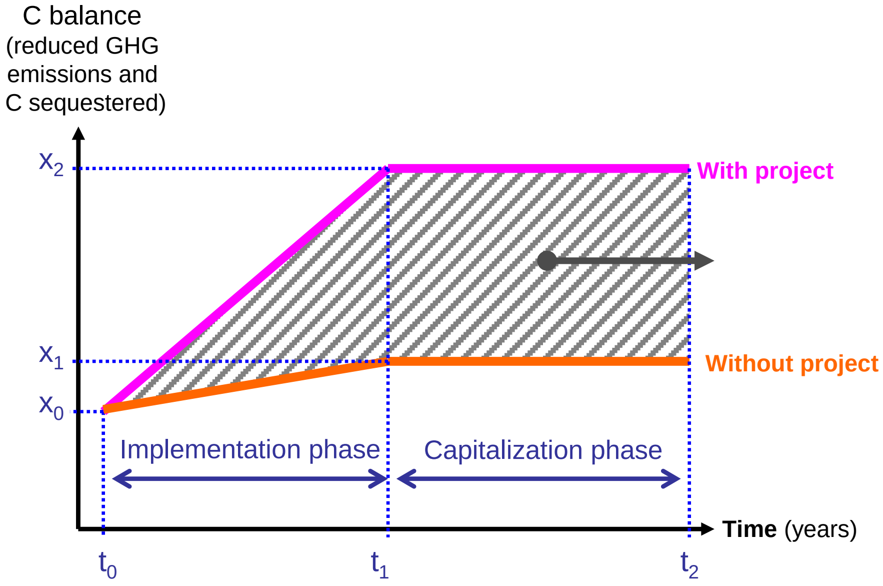
The model takes into account both the implementation phase of the project (i.e. the active phase of the project commonly corresponding to the investment phase where most of the changes will occur), and the so called “capitalization phase” (i.e. a period where project benefits are still occurring as a consequence of the activities performed

[3] C-balance = GHG emissions –carbon sequestered above and below ground.

[4] Bernoux et al. 2010.

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 programme/sector or national level[5].

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



Source: Bernoux et al. 2010b

EX-ACT has been developed mostly using the Guidelines for National Greenhouse Gas Inventories[6] 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[7] with default values 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 or national level) where available, therefore working at Tier 2 level too. EX-ACT measures carbon stocks and stock changes per unit of land, as well as Methane (CH4) and Nitrous Oxide (N2O) emissions expressing its results in tons of Carbon Dioxide equivalent per hectare ($tCO_2e.ha^{-1}$) and in tons of Carbon Dioxide equivalent per year ($tCO_2e.year^{-1}$).

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

[5] Bernoux et al. 2010°.

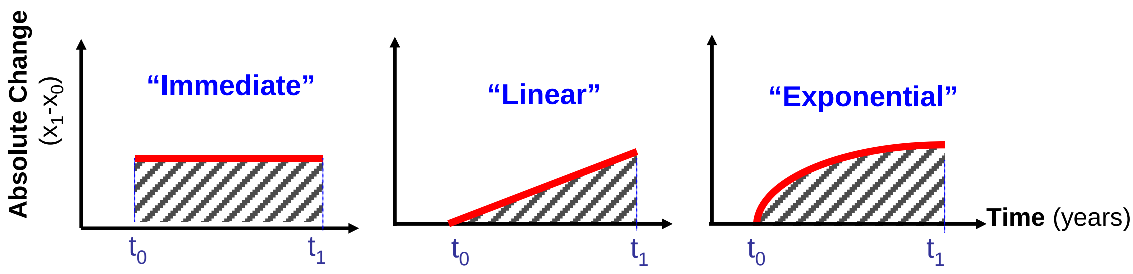
[6] IPCC, 2006.

[7] 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).

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.

The EX-ACT default assumption for the land use and management change is a "linear" function over time, although the software allows for adopting a different dynamic of change, e.g. "immediate" or "exponential" (Figure 2), depending on the characteristics of the specific project activity and on the information available on the adoption rate of the selected practice among project participants. This aspect is often considered in the sensitivity analysis where different rates of adoption are taken into account. In some cases the dynamic observed follow an "S-shaped" curve (commonly abbreviated S-curve). This curve corresponds mathematically to a logistic function or logistic curve, that is the most common sigmoid curve. It can be shown that the total amount of GHG release associated with a S-curve is similar to a linear curve.

Figure 2: Schematic representation of the dynamics of change in the implementation phase



Source: Bernoux et al. 2010b

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[8].

4. Potential impact of project activities

This section describes the analysis of the potential impact of PMV activities on GHG emissions and carbon sequestration. We describe here the methodology followed to take into consideration the different activities and the results obtained from the EX-ACT analysis.

4.1. Structure and basic assumptions of the analysis

4.1.1. Fixed parameters of the carbon appraisal

The analysis takes into account the activities related to the implementation of the PMV. Since the area interested by PMV activities shows significant differences in terms of

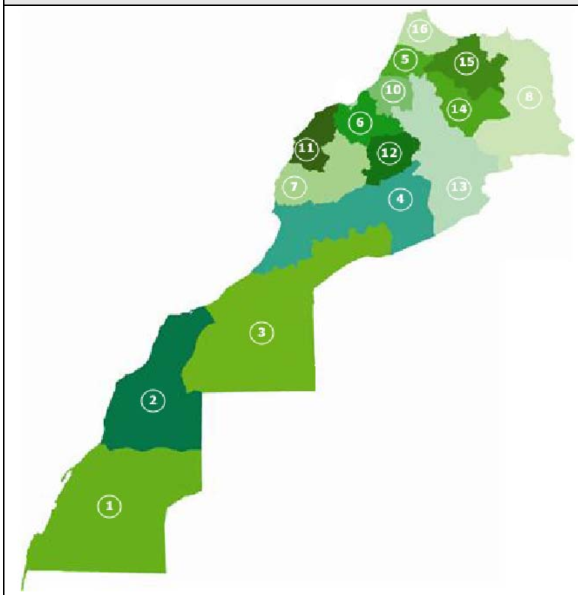
[8] Bernoux et al. 2010°.

climatic conditions, data used to describe climate patterns and soil characteristics cannot take into account the variability of existing soil and climatic conditions and the results of the analysis should therefore be considered only as an average for the whole area. The impact of using average climatic data on the overall carbon balance results is shown in the sensitivity analysis.

As for the soil characteristics – and with reference to the simplified IPCC classification where only six soil categories are listed (Sandy Soils, Spodic Soils, Volcanic Soils, Wetland Soils, High Activity Clay Soils and Low Activity Clay Soils) – PMV 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.

Average climate is considered as **warm temperate** (WT in the following Table 1) and a moisture regime classified as **dry**. These settings correspond to average climate and rainfall for Morocco. Table 1 reflects an average of 471 150 Km^2 under this dominant climate (warm temperate dry) out of the 710850 Km^2 describing the 16 regions where the PMV is implemented. Such information is essential as most coefficients used in the analysis can change drastically according to the climate.

Table 1: Climate and moisture regime of the regions involved on the PMV



Source: http://www.ada.gov.ma/en/plans_regionaux/plans-regionaux.php

Regions involved		Area (10^3Km^2)	Moisture regime	Climate
1	Oued-ed-Dahab- lagouira	142,9	Dry	WT-S
2	Laayoune-boujdour-sakia El Hamara	139,5	Dry	WT -S
3	Guelmim es-Semara	133,7	Dry	WT -S
4	Souss-Massa-Draa	70,8	Dry	WT
5	Gharb-Chrarda-Bni hseen	8,8	Moist	WT
6	Chaouia Ouardigha	16,7	Dry	WT
7	Marrakech-Tensift-Al Haouz	31,2	Dry	WT
8	L'oriental	82,9	Dry	WT
10	Rabat-Sale-Zemmour-Zaers	9,6	Moist	WT
11	Doukkala-Abda	13,3	Moist	WT
12	Tadla-Azilal	17,1	Dry	WT
13	Meknes-Tafilalt	79,2	Moist	WT
14	Fes-Boulemane	20,3	Dry	WT
15	Taza-Al Hoceima-Taounate	24,1	Dry	WT
16	Tanger-Tetouan	11,5	Moist	WT

The analysis will consider an implementation phase of **nine years (the project life-time)**, followed by a capitalization phase of **eleven years in order to consider a total analysis period of 20 year**. The capitalization phase represents a period where the benefits of the investment are still occurring 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 take place 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[9], 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.

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.

4.1.2. Assumptions for the "without" project scenario

The "without" project situation represents the baseline scenario (also indicated as "business as usual"). The Pillar I projects of the PMV aim at increasing the competitiveness of areas with comparative advantages to produce cereals, milk and meat for the food sovereignty and vegetables for exportation. Without the PMV, the competitiveness of Morocco producers would decrease comparatively to other countries because of lower import taxes. The agriculture sector would thus not be able to attract investment making the improvement of existing crops difficult.

The Pillar II projects of the PMV are especially targeted to fight against poverty and to adapt the population against the climate change impacts. Considering the current level of poverty, no improvement in the agricultural sector would happen, the investments being evaluated as too risky. The perennial cropland could not be improved without setting up the value chain to improve the value added.

It is therefore assumed that there will be no improvements on the existing cropland, no change in the land use and in the use of inputs. According to project experts, the baseline without project would be a non-change scenario, except for the livestock sector. The livestock is indeed expected to change, following the previous trends (1990-2008) and forecasts (2008-2020).

4.1.3. Assumptions for the "with" project scenario

The second part of the analysis concerns the identification of the "with project" scenario. Several assumptions regarding land use, land use changes, use of inputs and other investments are made, as summarized in what follows:

The agriculture sector should be improved following the expectations of the PMV Regional report[10].

[9]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 (whose GWP is by convention equal to 1).

[10] http://www.ada.gov.ma/en/accueil.php

The annual cropland with be intensified with different levels of improvements such as better agronomic practices, conservation agriculture and better irrigation.

Some cropland will be converted to perennial cropland with low density of trees per hectare implying land use changes. The project is also expected to develop forest lands and grassland as well as of livestock management whose impacts will be accounted for in the carbon balance appraisal.

The use of fertilizers and agrochemicals is accounted according difference between actual needs and agronomic recommendation to the expected growth of production.

Table 2: Frame of reference for the appraisal

EX-ACT Modules used	A/Re-forestation	Perennial crop	Land Use change	cropland	Grassland	livestock	Inputs
Methodology	Tier 1	Tier 1 & 2	Tier 1				
Chapter	4.2.1	4.2.2	4.2.3	4.2.4	4.2.5	4.2.6	4.2.7
	Final carbon balance : 4.3						

4.2. The carbon-balance analysis

This section briefly presents the main results linked to the different expected activities in the AFOLU sector under the PMV.

4.2.1. Afforestation and reforestation activities

Only one region is intending a kind of reforestation on the PMV planification. The region of Chaouia Ouardigha is planning to plant forage trees in an area of 3000 Ha. Regarding the local conditions, it is assumed that this reforestation will occur on degraded land. On the "afforestation/reforestation" module of EX-ACT, the forage tree plantations are considered as a plantation "type 3", closed to the subtropical steppe in terms of carbon contents.

Figure 3: Impacts of afforestation according to EX-ACT forestation module

	Ecological Zone	Ecol_Zone
Natural1	Subtropical humid forest	
Natural2	Subtropical dry forest	
Natural3	Subtropical steppe	
Natural4	Subtropical mountains systems	
Plantation1	Subtropical humid forest	
Plantation2	Subtropical dry forest	
Plantation3	Subtropical steppe	
Plantation4	Subtropical mountains systems	

Conversion details (Previous land use, use of fire before afforestation/reforestation,...)								GHG emitted during Burning			Biomass of forests/plantation		
Vegetation Type	Previous use before afforestation/reforestation	Burnt before conversion	Default Biomass (tC/ha)	Specific	Soil k_{soil}	Delta C	tCO2/yr	CH4 kg	N2O kg	Total tCO2 eq	Annual Biomass G <=20yrs	>20yr	Litter+dead wood
Plantation3	Degraded Land	NO	1,0		0,33	25,5	**4,7**	0,00	0,00	**0,0**	3,1	3,1	24,3

	Afforested or reforested Area (ha)					Biomass Gain		Biomass Loss		Soil		Fire		Total Balance		Difference
	Start	Without Project		With Project		Without	With	Without	With	Without	With	Without	With	Without	With	
	t0	End	Rate	End	Rate	tCO2	tCO2	tCO2	tCO2	tCO2	tCO2	tCO2	tCO2	tCO2	tCO2	tCO2
	0	0	*Linear*	4000	*Linear*	0	-1061588	0	14667	0	-289395	0	0	0	-1336317	-1336317
													A/R Total	0	-1336317	-1336317

A total of (-) **1 336 317 TCO_2e** could be mitigated during 30 years thanks to the afforestation. This kind of forestry plantation could have a positive impact regarding the availability of fuel wood for the rural population. This sustainable land management is also sustainable water management when plantations are carried out in accordance with the hydrologic scheme of a watershed.

4.2.2. Improvement of perennial crops

Most of the perennial tree crops are appraised with the Tier 1 approach, by considering an above ground biomass growth of 4.2 t of dry mater (DM) per year and hectare.

The other perennial crops (cactus and grape) could not reasonably be accounted for with the Tier1 approach, because of their smaller biomass.

In *Ecophysiology of Opuntia Ficus-Indica*[11], estimates that the cactus annual above ground biomass growth of 0.52 t of DM.Ha^{-1} (the DM representing 10% of the fresh matter[12]).

The aboveground biomass of grapes and niora crops is assumed to be similar and to reach 0,744 T of DM.$year^{-1}$.Ha^{-1}.

The irrigated area is assumed to show a highest biomass growth. The olive tree being the first tree in terms of area planted, the difference of growth between irrigated and non irrigated area is generalized for the whole tree crops. The carbon stored is growing from 7.02[13] [14] to 10.95[15], [16] $tCO_2e.Ha^{-1}.year^{-1}$. This increase of 155.9% is applied for the tree crops and cactus.

The carbon content is assumed to be 50% of the DM.

Table 3: Compilation of perennial crops

	Improvements	Assumed Rate of biomass growth	Above ground biomass growth (t DM.ha	Carbon stored ($tCO_2e.year^{-1}.ha^{-1}$)	Area (Ha)
Tree crop	Non irrigated	100%	4.20	6.03	358 105
Grapes			0.74	1.31	56 800
Cactus			0.52	0.99	54 700
Tree crop	Irrigated	155.9%		9.56	2 887
Cactus				1.41	7 000

With a conservative approach it is assumed that there is no burning residue practice currently and with the adoption of the PMV.

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[11] Parks S. Nobel, 2001. Ecophysiology of Opuntia Ficus-Indica, in Cactus (Opuntia spp.) as Forage, *FAO Plant Production and Protection Paper 169,* FAO, Rome, Italy, http://www.fao.org/DOCREP/005/Y2808E/y2808e06.htm

[12] Arba, A. ; El aich, A. ; Sarti, B. Institut Agronomique et Vétérinaire Hassan II

[13] Mariscal et al., 1998.

[15] Sofo et al., 2004.

Figure 4: Impacts of perennial crop according to 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
Reserved syst	From annual cropland to tree	NO	1	10	2.1		0		0.33
Reserved syst	From annual cropland to grapp	NO	1	10	0	0.372	0		0.33
Reserved syst	From degradeds lands to date	NO	1	10	2.1		0		0.33
Reserved syst	From degradeds lands to cactus	NO	1	10	0	0.26	0		0.33
Perennial Syst	**non improved**	NO	1	10	2.1		0		0.33
Perennial Syst	**improvment of existing tree**	NO	1	10	2.1		0		0.33
Perennial Syst	**improvment irrigated tree**	NO	1	10	0	3.276	0		0.33
Perennial Syst	**improvment irrigated cactus**	NO	1	10	0	0.4056	0		0.33
Perennial Syst 5		NO	1	10			0		0.33

Mitigation potential

Vegetation Type	Areas Start t0	Without project End	Without project Rate	With Project End	With Project Rate	CO_2 fluxes from Bioma Without	CO_2 fluxes from Bioma With	CO_2 fluxes from Soil Without	CO_2 fluxes from Soil With	**Difference** tCO2eq
System P1	0	*0*	*Linear*	307300.13	*Linear*	0	-35493164	0	-1571840	**-37065005**
System P2	0	*0*	*Linear*	56800	*Linear*	0	-1200866	0	-290532	**-1491398**
System P3	0	*0*	*Linear*	10534	*Linear*	0	-1216677	0	-53881	**-1270558**
System P4	0	*0*	*Linear*	54700	*Linear*	0	-808284	0	-279791	**-1088074**
Perennial Syst 1	50158.125	50158.125	*Linear*	0	*Linear*	-7724351	-1737979	-331044	-74485	**6242931**
Perennial Syst 2	0	0	*Linear*	40271	*Linear*	0	-4806299	0	-205984	**-5012283**
Perennial Syst 3	0	0	*Linear*	2887.5	*Linear*	0	-537612	0	-14770	**-552382**
Perennial Syst 4	0	0	*Linear*	7000	*Linear*	0	-161361	0	-35805	**-197166**
Perennial Syst 5	0	0	*Linear*	0	*Linear*	0	0	0	0	**0**
Total Syst 1-5	50158.125	50158.125		50158.125						

Agric. Annual - 40,433,935

The different kinds of plantations are storing **(-) 40,433,935 TCO2e** during the 20 year-period. As for the forest plantation, the perennials cropland could positively impact the water management at the watershed scale.

4.2.3. Non forest land use changes

It is expected that southern Morocco regions will plant cactus and palm trees. Considering the adaptation capacity of these plants and the aridity of the implementation area, it was considered that these plantations will be implemented on degraded or marginal lands.

All the other regions are planning to plant perennials, mainly for the pillar two of the PMV. The plantation of those trees will mainly occur on annual cropland. Intending to maximise the productivity of the land, the plantation is included into an agro forestry system, with a low tree plantation density.

A density of 150 trees per ha is assumed for this plantation. Usually, to be considered as perennial in full density, in this kind of zone, the density has to reach 400 trees per hectare[17]. Thus the area of perennials accounted for in EX-ACT corresponds to the PMV planned area multiplied by a ratio of 150/400. Table 4 shows the area accounted for in the carbon balance appraisal.

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[17] Si Bennasseur Alaoui, 2005. *Référentiel pour la conduite technique de l'olivier, (olea europea)* , IAVH, RABAT.

Table 4: Compilation of the PMV data regarding the plantation of perennial crops

		Planed area (Ha) of perennials	Density Ratio (planted/full density)	Area (Ha) of perennials in full density 400 trees.Ha^{-1}
From degraded land to perennial	Palm tree	10 534	400/400	10 534
	Cactus	54 700		54 700
From annual to perennial	Vineyard	5 300		5 300
	Niora	380		380
	Olive tree	676 168	150/400	253 563
	Almond	64 950		24 356
	Orange tree	1 460		5 573
	Apple tree	263		99
	Avocado tree	7 500		2 813
	Medlar	136		51
	Fig tree	22 400		8 400
	Pomegranate	390		146
	Plum tree	600		225
	Argan tree	9 500		3 563
	Carob tree	22 700		8 513

Consequently two main types of land use changes are accounted for in EX-ACT, the annual crops converted to perennial crops, and the degraded lands converted to perennial crops.

Figure 5: Impacts of LUC according to Tier 2 of EX-ACT Non Forest LUC

Name	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.
LUC-1	Tree crop	Annual Crop	Perennial/Tree Crop		NO	5,0	2,1	30,4	38,0
LUC-2	Grap and noria	Annual Crop	Perennial/Tree Crop		NO	5,0	2,1	30,4	38,0
LUC-3	Date	Degraded Land	Perennial/Tree Crop		NO	1,0	2,1	12,5	38,0
LUC-4	Cactus	Degraded Land	Perennial/Tree Crop		NO	1,0	2,1	12,5	38,0
							Default Soil Native (tC		38

GHG emissions														
Vegetation Type		Area concerned by LUC				Biomass Change		Soil Change		Fire		Total Balance		Difference
		Without Project		With Project		Without	With	Without	With	Without	With	Without	With	
		Area	Rate	Area	Rate	tCO2	tCO2	tCO2	tCO2	tCO2	tCO2	tCO2	tCO2	tCO2
LUC-1	Tree crop	0	Linear	307300	Linear	0	3267625	0	-6636658	0	0	0	-3369034	-3369034
LUC-2	Grap and noria	0	Linear	56800	Linear	0	603973	0	-1226691	0	0	0	-622717	-622717
LUC-3	Date	0	Linear	10534	Linear	0	-42487	0	-762123	0	0	0	-804610	-804610
LUC-4	Cactus	0	Linear	54700	Linear	0	-220623	0	-3957481	0	0	0	-4178105	-4178105
									Other LUC total			0	-8974465	-8974465

Land use changes are contributing to climate change mitigation by achieving a carbon sink reaching about **(-) 8 974 465 TCO_2e** over 20 years.

4.2.4. Improvements on cropland

The ambitious objective of yield growth would be reached with the adoption of improved agricultural practices. For the cereal, legume and oleaginous crops, conservation farming intends to reduce the erosion and improve the soil fertility. Moreover the crop residue will be kept on the surface with the no-tillage practice.

The practice inspired by conservative farming is considered in the IPCC category “Adoption of reduced or minimum tillage, with or without mulching”, re-used in the annual module of the EX-ACT tool. The amount of carbon stored by this practice is almost 0.25 $tC.year^{-1}.ha^{-1}$.

The crop rotations need to be changed to cope with the weed pressure and to improve soil fertility. Improved varieties will be used to guarantee better adaptation to the difficult conditions of biomass growth. These practices are considered in the IPCC category “Improved agronomic practices”, re-used in the annual module of the EX-ACT tool. The amount of carbon stored by this practice is almost 0.28 $tC.year^{-1}.ha^{-1}$.

The above practices are to be implemented on the area specified by the regional reports for cereals, legumes and oleaginous crops on a total of 957 695 ha.

In the new Agro forestry systems implanted by the PMV, it is assumed that the intercrops are also managed under the same practices (Improved agronomic practices and better management of residue), Thus the total area of improved crops reaches a total of 1 469 862 ha.

Sugar beet and vegetable crops could not adopt all conservation farming practices, due to the need to greatly disturb the soil during the harvest. Only the “Improved agronomic practices” category is chosen for this kind of improved area.

The new irrigation scheme and rehabilitation of existing irrigation to a more efficient one covers an area of 395 107 ha. The use of efficient water management is especially mentioned for 60 340 ha on this area. However, regarding the importance of the water on Moroccan agriculture, it is assumed that the whole area will receive improved water management that is reflected in the IPCC category “Water management” reused in the EX-ACT tool. This category corresponds indeed to the implementation of an effective irrigation measure.

Table 5: Compilation of the improved area for annual crop system

Annual crops	Improved practices	Area (ha)
All high value-added	Irrigated area	395 107
Cereals and intercrops	Conservation agriculture and Improved agronomic practices	1 469 862
Sugar bet, potatoes, vegetable crops	Improved agronomic practices	171 850

With a conservative approach it is assumed that there is no burning residue practice currently in these areas. In Morocco, the cereal crop residue and barley crops are indeed the main forage for the ruminant livestock[18]. 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[19].

[18] Tully, 1989; Fenster, 1989.

[19] United Nations Environment Programme, 1977.

Figure 6: Impacts of annual crop according to the EX-ACT “annual” module

	Your description	User-defined practices	Name	Rate in tC/ha/yr	Improved agro-nomic practic	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 decreasi					NO	10
Annual System2	irrigated area	NO			Yes	No	No	Yes	No	NO	10
Annual System3	Conservation agric	NO			Yes	No	Yes	No	No	NO	10
Annual System4	Best practices	NO			Yes	No	No	No	No	NO	10

Mitigation potential												
Vegetation	Areas					Soil CO2 Change		CO2eq emitted from Burning		**Total Balance**		**Difference**
Type	Start	**Without project**		**With Project**		Without	With	Without	With	Without	With	
	t0	End	Rate	End	Rate	tCO2	tCO2	tCO2	tCO2	tCO2	tCO2	tCO2
System A4	364100,125	364100,13	Linear	0	Linear	0	0	0	0	0	0	0
Annual System1	2 036 819	2 036 819	*Linear*	0	*Linear*	0	0	0	0	0	0	0
Annual System2	0	0	*Linear*	395 107	*Linear*	0	-6981541	0	0	0	-6981541	-6981541
Annual System3	0	0	*Linear*	1469862	*Linear*	0	-7518343	0	0	0	-7518343	-7518343
Annual System4	0	0	*Linear*	171850	*Linear*	0	-772466	0	0	0	-772466	-772466
Total Syst 1-10	2036818,875	2036818,9		2036818,875								
Agric. Annual Total										0	-15272350	-15272350

According to the EX-ACT methodology, the representative mitigation potential is determined as the maximum potential of all selected management practices (improved agronomic practices 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 (linked with the adoption of improved practices and residue management). Only the practice with the best storage potential is taken into account which is in this case the better residue management.

The improvement to annual cropland imply a sink of (-) **15 272 350 TCO$_2$e** over a 20 years period for the cropland.

4.2.5. Grassland improvement

The region of Chaouia Ouardigha plans to restore 34 300 ha of pasture. Regarding the regional quality[20] of these public lands, the improvement is assumed to be achieved on moderately degraded grasslands. The “Moderately degraded grassland” category represents overgrazed grassland, with somewhat reduced productivity (relative to the native or nominally managed grassland) and receives no management inputs. The improvement is assumed to sustain the management with moderation of grazing pressure and species’ improvement after tillage.

Figure 7: EX-ACT grassland module screenshot

Initial state	**Final State of the grassland**		Fire used to manage			
	Without Project	**With Project**	**Without project**		**With project**	
			Fire*	Interval (yr)	Fire*	Interval (yr)
Moderately Degraded	Moderately Degraded	Improved with inputs improvement	NO	5	NO	5

* is fire occuring?

Start	**Without project**		**With Project**		Soil C variations (tCO2eq)		Total CO2 eq from fire		Total CO2eq		Difference
t0	End	Rate	End	Rate	Without	With	Without	With	Without	With	tCO2eq
34300	*34300*	*Linear*	*34300*	*Linear*	0	-1507339	0	0	0	-1507339	-1507339
34300	34300		34300								
							Grassland total		0	-1507339	-1507339

[20] Forage and pasture legume biodiversity in the semi-arid areas of West-Central Morocco, E.El Mzouri, I. Thami Alami. Dryland Agricultural Research Program, INRA.2000.

The amount of carbon stored due to the grassland improvement is reaching (-) **1 507 339 TCO_2e** during 20 years.

4.2.6. Livestock Management

The regional plans of the PMV are targeting some livestock's improvements so as to intervene around the milk and meat value chains.

However only the number of improved livestock management is expressed, there is no information provided about the total number of heads and its evolution in the project area. To fill the gap, FAOstat[21] is used as a consensual data base.

Table 6: Forecast on Livestock growth

Animal category	Number of animal	
	2011	2020
Camel	46 640	52 640
Sheep	18 659 207	21 136 323
Goat	5 493 416	5 973 717
Cattle	1 093 276	911 275
Dairy cattle	1 580 000	1 740 000

Source: Linear forecast based on data from FAOstat- 1990-2009

In the EX-ACT Livestock Module, the livestock growth is accounted, as well as of the improvements brought in the livestock management. The number of better bred/fed livestock is gathered from the regional report[22].

The nutrition improvement is generally used when more concentrates and oils or oilseeds are added to the diet. The breeding practices correspond to those which increase the productivity through breeding and better management practices, such as a reduction in the number of replacement heifers.

Table 7: Livestock improvements according to PMV regional plans

	Nutrition improvements	Breeding practices
Camel	66 800	60 860
Sheep	1 953 800	20 700
Goat	928 600	23 900
Cattle	356 250	22 269
Dairy cattle	257 001	20 950

Without any information about the possible use of specific agents and dietary additives (such as ionophores) in order to reduce CH_4 emissions, it is assumed that this practice is not adopted in the PMV.

[21] *FAOStat: http://faostat.fao.org/*

[22] *http://www.ada.gov.ma/plans_regionaux/plans-regionaux.php*

There is a discrepancy between the FAO data forecast and the PMV objectives dealing with the camel number of heads. In fact, the improved number is superior to the existing one. The total number of heads was assumed to be the one from the regional report (66 800 heads) for the “with project” resulting from the PMV incentive. For the ‘’without project’’ the FAO trend indicating 52 640 heads is used.

Table 8: Rate of livestock improvement

	Nutrition improvements	Breeding practices
Camel	100%	78.8%
Sheep	9.2%	0.1%
Goat	15.5%	0.4%
Cattle	39.1%	2.4%
Dairy cattle	14.8%	1.2%

The EX-ACT Livestock module accounts for the improved practices only for four types of livestock (dairy cattle, cattle, sheep and buffalo). However the goats were considered as sheep. They indeed have similar emission factor than the sheep for the methane emissions coming from enteric fermentation (see Table 9).

Table 9: Converging IPCC for Sheep and Goat

	Sheep	Goat
Methane emissions from enteric fermentation	5	5
Methane emissions from manure management	0.15	0.17
Nitrous Oxide emissions from manure management	0.1	0.1

Due to the similitude between sheep and goat emissions, the percentage of improved goat management will be added to the improved sheep management, as shown in Table 10.

Table 10: Goat considering

	Nutrition improv.	Breding practices
Sheep	9.24%	0.10%
Goat	15.54%	0.40%
Sheep (+ Goat)	13.64%	0.21%

In literature, there are no specific coefficients for camels regarding any possible improvement. However it has been assumed that better nutrition and breeding practices will also impact methane emissions from camels. Thus it has been conservatively assumed to use the emission factors for the dairy cattle, which are the lowest ones.

Figure 8: EX-ACT Livestock module screenshot

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	Difference
Dairy cattle	40		YES	1580000	1740000	*Linear*	1740000	*Linear*	0
Other cattle	31		YES	1093276	911275	*Linear*	911275	*Linear*	0
Camels	46		YES	46,640	52,640	*Linear*	52,640	*Linear*	0
Sheep	5		YES	18659207	21136323	*Linear*	21136323	*Linear*	0
Goats	5		YES	5493416	5973717	Linear	5973717	*Linear*	0
								Sub-Total L-	0

PLEASE SPECIFY INFORMATION BELOW IF AVAILABLE

Country "Type"	*Developing*	
Mean Annual Temperature (MAT*) in °C	17.3	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	Difference
Dairy cattle	1		YES	1,580,000	1,740,000	Linear	1,740,000	Linear	0
Other cattle	1		YES	1,093,276	911,275	Linear	911,275	Linear	0
Camels	1.92		YES	46,640	52,640	Linear	52,640	Linear	0
Sheep	0.15		YES	18,659,207	21,136,323	Linear	21,136,323	Linear	0
Goats	0.17		YES	5,493,416	5,973,717	Linear	5,973,717	Linear	0
								Sub-Total L-	0

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	Difference
Dairy cattle	0.01		YES	95,156	104,792	Linear	104,792	Linear	0
Other cattle	0.01		YES	43,492	36,252	Linear	36,252	Linear	0
Camels	0.01		YES	2,070	2,336	Linear	2,336	Linear	0
Sheep	0.01		YES	223,116	252,735	Linear	252,735	Linear	0
Goats	0.01		YES	82,409	89,615	Linear	89,615	Linear	0
see equation 10.30								Sub-Total L-	0

Additional Technical Mitigation (See IPCC TAR Vol 3 Chapter 8)

Livestocks	Dominant Practice*	Factor	Percent of head with practices (0% =none;100%=all): Start t0	Without Project: End	Without Project: Rate	With Project: End	With Project: Rate	Difference
Dairy cattle	Feeding practices	0.010	0%	0%	Linear	15%	Linear	-33529
	Specific Agents	0.003	0%	0%	Linear	0%	Linear	0
	Management-Breed	0.004	0%	0%	Linear	1%	Linear	-1,087
	No Option	0.000	100%	100%	Linear	84%	Linear	0
Other cattle	Feeding practices	0.010	0%	0%	Linear	39%	Linear	-35,953
	Specific Agents	0.004	0%	0%	Linear	0%	Linear	0
	Management-Breed	0.006	0%	0%	Linear	0%	Linear	-110
	No Option	0.000	100%	100%	Linear	61%	Linear	0
Camel	Feeding practices	0.010	0%	0%	Linear	100%	Linear	-7,882
	Specific Agents	0.003	0%	0%	Linear	0%	Linear	0
	Management-Breed	0.004	0%	0%	Linear	100%	Linear	-3,153
	No Option	0.000	100%	100%	Linear	-100%	Linear	0
Sheep & Goat	Feeding practices	0.010	0%	0%	Linear	14%	Linear	-46,921
	Specific Agents	0.000	0%	0%	Linear	0%	Linear	0
	Management-Breed	0.006	0%	0%	Linear	0%	Linear	-433
	No Option	0.000	100%	100%	Linear	86%	Linear	0
							Sub-Total L-	-129,069

Feeding practices: e;g. more concentrates, adding certian oils or oilseeds to the diet, improving pasture quality,…
Specific agents: specific agents and dietary additives to reduces CH4 emisisons (Ionophores, vaccines, bST…)

-129,069

Finally, the livestock is generating a sink of **(-) 129,069 TCO2e** over a 20 year period, the best feeding and breeding practices being insufficient to compensate the emissions due to the camel growth.

4.2.7. Use of inputs and Implementation of new irrigation schemes

To reach the targets in terms of expected yield growth, a more intensive use of fertilizers and agrochemicals is needed. The fertilizer use is expected to be adjusted with soil analysis. The total use could be close to the agronomic recommendations, following the exportation of mineral mater[23]. Following the recommendation rates, the needs of each element is calculated with the formula ∑ (crop area * kg of fertilizer recommended for the crop). The total area concerned is the 8 282 000 ha[24] existing on the Moroccan scale.

The current rate of input use at the national level is estimated with the FAOSTAT data concerning the use of input and area cropped in Morocco. The improved area corresponds to 0.257 time the whole arable land in Morocco.

Table 11: Current use and recommendation on fertilizer (t.year^{-1}) to be applied

Element	Total needs (t.year^{-1}) (1)	Total used (t.year^{-1}) (2)	Use Increase (3) = (1) - (2)	Accounted = (3) * 0.257
N	171 420	74 279	97 141	24 979
P	77 244	38 095	39 149	10 061
K	80 281	17 405	62 876	16 159

Because of data gaps, availability and discrepancy, the increased use of agrochemical is accounted for the PMV improved area has been assumed as follows:

Table 12: Increased use of pesticide assumed for the whole PMV area

Kind of pesticide	Increased Dose (kg .Ha^{-1}.year^{-1})	% Active Matter	Total increased consumption (t.year^{-1})
Herbicide	2	30%	4472
Fungicide	1	10%	223.6
Insecticide	2	10%	447.2

[23] Guide pratique pour la fertilisation raisonnée des principales cultures au Maroc, Si Bennasseur Alaoui et Ajiro Yasuehi.

[24] FAO stat : Resources, Resources STAT, Land

The two previous Tables 11 and 12 allow users to fill the EX-ACT Input module as follows.

Figure 9: EX-ACT Input module screenshot

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	Emission (t CO2eq) per year: Start	End: Without	End: With	Total Emission (tCO2eq): Without	Total Emission (tCO2eq): With	Difference
N Fertiliser (other than Urea)	0.01	24979	Linear	0.0	0.0	77434.9	0	1,200,241	1200241
*N fertilizer from upland rice should be included above (N			Sub-Total I-3	0.0	0.0	77434.9	0	1200241	1200241

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

Type of input**	Default factor*	With Project End	With Project Rate	Start	End: Without	End: With	Total Emission: Without	Total Emission: With	Difference
N Fertiliser (other than Urea)	4.8	24979	Linear	0.0	0.0	119066.6	0	1,845,532	1845532
Phosphorus synthetic fertilizer	0.7	10,061	Linear	0.0	0.0	7378.1	0	114,360	114360
Potassium synthetic fertilizer	0.6	16,159	Linear	0.0	0.0	8887.5	0	137,755	137755
Herbicides (Pesticides)	23.1	1342	Linear	0.0	0.0	30992.1	0	480,377	480377
Insecticides (Pesticides)	18.7	224	Linear	0.0	0.0	4181.5	0	64,813	64813
Fungicides (Pesticides)	14.3	447	Linear	0.0	0.0	6395.2	0	99,125	99125
* from Lal (2004) Table 5 - central value -tCO2/t product			Sub-Total I-4	0.0	0.0	176900.8	0	2741963	2741963
** tonnes of N, P2O5, K2O and CaCO3									
				Total "Inputs"			0	3942204	3,942,204

The amount of agrochemicals accounted in the Input module of EX-ACT is generating a source of **3,942,204 TCO2e** during 20 years.

4.2.8. Implementation of new irrigation schemes

The implementation of a new irrigation scheme is accounted for in the other investment EX-ACT module described as permanent sprinkler. It implies a source of **52 717 TCO2-e** over the 20 years period.

Figure 10: Irrigation scheme

Released GHG associated with installation of irrigation systems

Installation of irrigation system	surface (ha)	Type of irrigation systei	Associated tCO2eq
Without Project		Please select	0.0
With Project	404,995	Permanent sprinkle	52716.8
		Difference	52,717

4.3. The "Plan Maroc Vert" mitigation potential

Table 13 summarizes the overall carbon balance of the "Plan Maroc Vert", computed as the difference between carbon sinks and sources over 20 years (9 years implementation phase and 11 years capitalization phase). The project is in actual fact able to sequester (-) 70 421 546 TCO_2e while emitting 17 001 305 TCO_2e so that the net effect of project activities is to create a sink of (-) 53 420 241 TCO_2e during 20 years.

Table 13: C-balance of the PMV

C-balance elements	TCO_2e over 20 years
Total GHG mitigated	-69 570 296
Total GHG emitted	6 591 245
C-balance	-62 979 051

Source: our calculations using EX-ACT (2011)

Table 14 shows the mitigation potential of the project by category of land use (corresponding to the EX-ACT modules). Mitigation potential is especially linked to the activities of perennial crops plantation.

Table 14: Mitigation potential of the PMV

EX-ACT modules	TCO_2e over 20 years	% of total GHG mitigated	% of total GHG emitted
Reforestation	-1 336 317	2	
Non forest land use changes	-8 974 465	13	
Annual crop	-15 272 350	61.5	
Perennial crops	- 40 433 935	20.5	
Grassland	-1 507 339	2	
Livestock	-129 069	0	0.6
Total GHG mitigated	**- 67,653,474**	**100**	
Inputs	3 942 204		99
Irrigation	52 717		1
Total GHG emitted	**3 994 291**		**100**
C-balance	**- 63 658 554**		

Source: our calculations using EX-ACT (2011)

4.4. Sensitivity analysis

The carbon-balance analysis was carried out at the national level. Since the area interested by PMV activities shows significant differences in terms of climatic conditions (see Table 1), data used to describe climate patterns and soil characteristics cannot take into account the considerable variability of existing soil and climatic conditions in all project sites and the results of the analysis should be considered only as an average for the whole area.

A sensitivity analysis has therefore been conducted in order to estimate the impact of using other possible average climatic and soil data on the overall carbon-balance results. Four combinations were tested by changing the average possible climate and type of soil. Instead of choosing a warm temperate dry climate, the same carbon balance appraisal was conducted by choosing a warm temperate moist climate, either with a dominant HAC or LAC soil.

Results show that in all alternative scenarios the project always has a net carbon sink, as in the base scenario. Nevertheless, the quantity of carbon sequestered increases when wetter moisture regime is considered (warm temperate, tropical), and decreases when LAC soil category is taken into account as the dominant type of soil (see Table 15).

Table 15: Sensitivity analysis for a Warm temperate climate

Scenarios	Moisture regime	Soil	Carbon balance TCO_2e sequestered over 20 years	Difference %
Base scenario	Dry	HAC	- 63 658 554	-
Alternative 1	Moist	HAC	- 113 992 082	+80
Alternative 2	Dry	LAC	- 56,681,145	-11
Alternative 3	Moist	LAC	- 102,026,026	+61

Finally, the appraisal was carried out by choosing a dry moisture regime and HAC soils which seems to be the most likely and realistic assumption for a conservative approach, so as not to over-evaluate the carbon sinks.

4.5. Some economic aspects

A quick economic analysis could be carried out using the carbon estimates provided by EX-ACT and applying a FAO methodology[25].

Mitigation public and private financing for agriculture can play two important roles: providing increased investment flows to the agricultural sector of developing countries, and/or providing increased incomes to farmers in the form of carbon payments. Mitigation finance could be either public or market-based and integrated with existing official development assistance (ODA). Rural development projects involving the implementation of sustainable land management practices could therefore obtain funds from carbon finance related to mitigation benefits[26].

It is possible to classify projects which are of interest for agricultural development in four categories depending on their mitigation potential. Type 0 projects have no mitigation potential (e.g. they are a net source of GHG emissions) and they cannot benefit from any additional financing from the carbon sector. Type 1 projects have a low mitigation potential so that the mitigation benefits are smaller than the costs for monitoring, reporting and verification (MRV) carbon mitigation activities, so that there would be no space for additional project financing from carbon mitigation sources (ODA public funds remain the main financing source for this category of projects). For Type 2 projects the benefits of pursuing low-carbon agricultural strategies may be greater than the costs associated with adoption of basic MRV for public implementation. In this case, public funding may be a possible financing source which

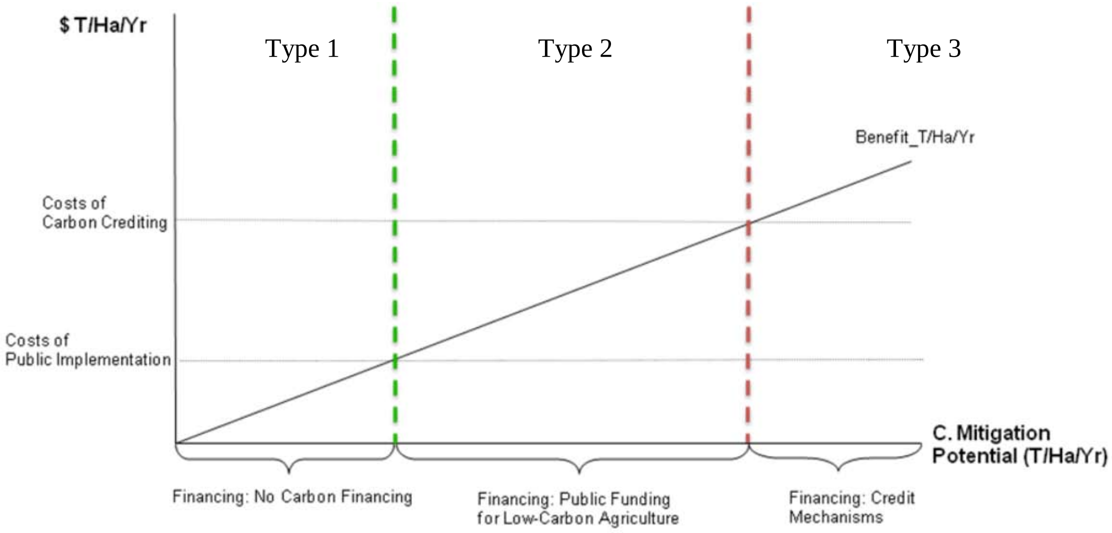
[25] FAO. 2009. Food Security and Agricultural Mitigation in Developing Countries: Options for Capturing Synergies.

[26] Branca, 2010.

could integrate ODA funds, as project offsets are considered as public goods and therefore purchased by a public institution. For Type 3 projects, mitigation benefits are greater than the costs of adopting and meeting carbon crediting MRV requirements (presumably higher than MRV for public sector options) so that carbon crediting mechanisms are a suitable source of financing for this category of projects. This is the case, for example, of projects aimed at producing carbon credits from agriculture in developed countries to be sold on the (voluntary or mandatory) carbon markets (see Figure 3).

It is not easy to estimate the transaction costs related to the considering of carbon activities at public or market level, given the lack of information and the fact that data available are not in standard format to allow accurate comparison. Therefore more research is needed on this topic. Nevertheless, for the purpose of this note, it is assumed that the transaction costs for public implementation are equal to 4 US$.Ha^{-1} (per year) which is an arbitrary but plausible value based on some literature available[27]. The transaction costs for selling carbon credits on the market will be obviously higher, given the number and type of requirements, e.g. establish baseline and carbon flows of the project, design monitoring plan, establish permanent sampling plots, prepare project design document, design individual farm plans, monitor carbon stocks reported by farmers, verification and certification[28].

Figure 11: Financing options for agriculture development and mitigation projects



Source: adapted from FAO 2009.

Using the preliminary estimates from EX-ACT shown above, users can see that the average mitigation potential of the PMV is equal to 1.45 $tCO_2e.ha^{-1}.year^{-1}$. This result could be valued using a price of 3 US$.$tCO_2e^{-1}$, which is the average carbon price for

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

[28] Cacho and Lipper 2006.

agricultural soil carbon at retail level on the voluntary carbon market in 2008 [29]. Therefore, the value of the average mitigation potential of the PMV amounts to about 4.35 $US\$.ha^{-1}$. Since this value is close (<10%) to the level of transaction costs for public implementation 4 $US\$.ha^{-1}$, the PMV could be classified between Type 1 and 2.

However the PMV is made of a set of different improvements. Some of them present low density sinks and other high density sinks. Distinguishing the two should allow users to define options with an upper potential. Regarding the options set, the plantation of perennials tree and the irrigation of them present a higher mitigation potential per hectare than the cropland improvements. The perennials should be mainly planted with a low density in agroforestry systems. The sink is reaching a mean of 2.42 $tCO_2e.ha^{-1}.year^{-1}$. The plantations of perennial crop are mainly planned in the PICCPMV sub-projects aimed to support the dissemination of climate change adaptations among farmers. The appraisal thus highlights the strong link between adaptation and mitigation.

The value of this sequestrated carbon would be about 7.62 $US\$.ha^{-1}$.Since this value is well higher than the level of transaction costs of 4 $US\$.ha^{-1}$, those options could be undoubtedly classified as Type 2 project and would be suitable for being financed on the public carbon sector. The source of value could be a way to finance the second pillar of the PMV combating rural poverty by supporting small farmers in marginal areas.

5. Conclusions

The paper describes the ex-ante carbon-balance analysis performed for the PMV strategy of the Government of Morocco using the EX-ACT methodology.

Preliminary results show that overall the net effect of PMV is to create a carbon sink of **63.5 Million tCO_2e** over 20 years, which represents the balance between the GHG emitted (mainly as a consequence of the use of agro-chemicals) and carbon sequestered (essentially through the adoption of improved agronomic practices on agricultural areas). The project is therefore shown to deliver environmental co-benefits in terms of climate change mitigation. PMV has a relevant unitary mitigation potential (1.44 $tCO_2e.ha^{-1}.year^{-1}$) which is reasonable taking into account the type of activities implemented and in line with similar cases.

The PMV approach should optimize land use and management, promoting activities aimed at restoring soil fertility. Once the soil fertility is recovered the use of inputs could be planned to be reduced progressively. This may have a positive effect on the carbon balance as GHG emissions from input use are expected to be reduced in the future, and the mitigation potential could further increase. The PMV should also sustain water use and management through better implementation of water saving systems at watershed level. Further studies could link improved management with the microclimate establishment as well as of the potential increase of climate change resilience in targeted areas.

[29] Hamilton et al. 2009.

The Moroccan NAMA's is targeting a sink of 2.025 million tCO_2-e yearly due to the possible improvement of agricultural soils[30]. The appraisal carried out shows that the PMV contributes to this target forecasting a sink of 0.76 million tCO_2-e yearly considering only the annual cropland included in the PMV (2.07 million ha out of the 8.05 million ha nationally).

The PMV in its whole could prevent agriculture abandonment and improve natural resource management while developing economic and social aspects in interested areas.

The sensitivity analysis shows that in all alternative scenarios the project would represent a carbon sink as in the base scenario, but confirms that carbon-balance results are quite sensitive to changes in the moisture regime. The analysis could therefore be repeated at the project site level, as achieved for three subprojects in **another case study**[31], in order to take into account the different environmental characteristics of targeted areas, and to allow a more accurate carbon balance.

Nevertheless, the results presented here 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.

6. 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*
- *The Carbon Balance of Selected "Plan Maroc Vert" projects: An Application of the EX-Ante C-balance Tool (EX-ACT version 3),* EASYPol Module 122
- 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**

[30] Appendix II - Nationally appropriate mitigation actions of developing country Parties available on: http://unfccc.int/files/meetings/cop_15/copenhagen_accord/application/pdf/moroccocphaccord_app2.pdf

[31] The Carbon balance of some Moroccan Green Plan Projects.

7. Further readings

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