Food and Agriculture Organization
of the United Nations

FUNDING PROPOSAL TO THE GREEN CLIMATE FUND

-IRES-CUBA-
INCREASED CLIMATE RESILIENCE OF RURAL HOUSEHOLDS AND COMMUNITIES THROUGH THE REHABILITATION OF PRODUCTIVE AGROFORESTRY LANDSCAPES IN SELECTED LOCALITIES OF THE REPUBLIC OF CUBA

APPENDIX 2.3 Carbon Estimates

November 2019

Republic of Cuba

Contents

Carbon Estimations

1. Background

1. The objective of the project is to restore critical ecosystem services in productive landscapes and increase climate-resilient, sustainable development in the provinces of Villa Clara, Matanzas and las Tunas encompassing seven highly vulnerable municipalities. This will be accomplished through the promotion of innovative solutions accompany by financial incentives to support protection of soils from salinization and salt-water intrusion in aquifers water tables, regulation of hydrological cycle to prevent run off, soil erosion, improve water absorption and infiltration capacities and enhance ground water recharge. These actions are aimed to increase livelihood resilience and reduce risks to climate change while providing food security to vulnerable rural households. The project will benefit directly and indirectly more than 127,000 people.

2. As outlined in the proposal document, project has 3 components and a dedicated project management unit. Component 1, entitled Green investment and technology, aims to support the application of ecosystem-based adaptation concepts, methodologies and low impact modern technology to restore vital ecosystem services for water regulation and livelihood protection on approximately 35735 ha of productive landscapes. The type of interventions this component will support include: restoration/improvements of ecosystems services, removal of sickle bush encroached rangeland through agroforestry and close to nature planted forest interventions and improved silvopastoral systems in degraded grasslands. Component 2, Building capacity to adapt to climate change, aims to establish a structure to facilitate knowledge transfer and capacity building to promote ecosystem-based adaptation interventions. These include providing technical extension services, preparing extension services technicians in conjunctions with research institutions and training beneficiaries in the implementation of adaptation technologies, as well as strengthening their markets and rural entrepreneurship capacity. Component 3, New Incentives for climate change adaptation support, integrates consideration of climate change adaptations in regional planning as well as in financial incentive mechanisms. Specifically, the component supports interinstitutional dialogue and revision and needs in the legal and regulatory framework to mainstream CC adaptation..

3. Although the project objective is to support national climate change adaptation in agricultural and forestry systems, the typology of ecosystem-based interventions proposed under component 1 have important mitigation co-benefits. In this context, the quantification of GHG emission is an important step to highlight this benefit. It also offers an opportunity to identify how the project actions provide win-win situations in delivering both adaptation and mitigation objectives which are equally important considering the climate change context. Furthermore, considering the Paris commitments, the potential co-benefit from the GHG avoidance impact generated from this project can help Cuba contribute to its NDC, something that should not be overlooked.

2. Methodology

5. GHG accounting has become a common practice for many international financial institutions as part of their project preparation. The Ex-Ante Carbon-balance Tool (Ex-ACT[1]), developed by the Food and Agriculture Organization of the United Nations (FAO) in collaboration with the World Bank is widely used to assess the impact of agricultural and forestry projects on GHG emission and carbon sequestration. Its use includes ex-ante assessments of GEF projects, forestry and agricultural investment projects at the World Bank, African Development Bank among others. Like an economic-financial analysis, Ex-ACT allows the assessment of a project's net carbon-balance, defined as the net balance of CO2 equivalent GHG that were emitted or sequestered because of project implementation actions compared to a without project scenario. This incremental benefit is what truly reflects whether a particular action taken mitigates or generates emission and thus makes the "GHG" bankable per se.

6. Ex-Act is a calculator tool and like all other globally available carbon accounting tools, follows the guidelines, methodologies and calculations formulas issued by the World Reference body on Climate Change, the IPCC[2]. The tool is widely used by World Bank investment projects and has already been used in the preparation of GHG analysis for various green climate fund projects. This analysis is based on the use of the Ex-Act tool. The methodology and calculations used in Ex-Act are well documented and follow the Guidelines for National Greenhouse Gas Inventories generated by the IPCC (2006). The tool provides a set of default coefficients based on global observations. However, users have the oppournity to update coefficients if regional/national (tier 2) are available. The methodology is complemented with additional calculations and emissions coefficients associated with agricultural/forestry production systems, farm operations and inputs which are based on literature reviews acceptable to the scientific community[3]. Default emission coefficient for mitigation options in the agricultural sector are mostly from Smith et al. (2007)[4]. Other coefficients such as embodied GHG emissions for farm operations, inputs, and transportation and irrigation systems implementation are from Lal (2004)[5]. The specific methodologies/calculations used in each of the modules are summarized in page Table 1, page 23 of this publication[6]. The specific technical guidelines describing the methodology and calculations employed by the tool are described in the following publication http://www.fao.org/tc/exact/user-guidelines/en/

7. The Ex-Act tool was designed specifically to support ex ante assessments of agricultural and forestry projects. It is a land-based accounting system which estimates carbons tocks changes as well as emission generated from AFOLU activities. It consists of six topic modules that allow to analyze a range of agricultural and forestry activities including crop production, land rehabilitation, forest management, livestock and grassland production systems among others. The ex-ante evaluation assesses how the impacts of a planned intervention compares to the business as usual scenario. The calculator requires data for 3 specific points in time: initial situation, with project scenario, without project or BAU. In preparing this data a lot of work is required up front to determine the adequate modeling of activities/interventions in the tool. This takes into consideration technical specificities, conversations with

[1] http://www.fao.org/fileadmin/templates/ex_act/pdf/Technical_guidelines/EX-ACT_technicaldescription_EN_v7.pdf

[2] IPCC, 2006. Guidelines for National Greenhouse Gas Inventories, Hayama: IGES.

[3] Carbon Accounting Tools for Sustainable Land Management. Collaboration of FAO/World Bank/GEF http://documents.worldbank.org/curated/en/318251544164909341/Carbon-Accounting-Tools-for-Sustainable-Land-Management

[4] Smith, P. et al., 2007. Agriculture. In: B. Metz, et al. eds. Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the. Cambridge and New York: IPCC, pp. 497-540.

[5] Lal, R., 2004. Carbon Emission from Farm Operations. Environment International, 30(7), pp. 981-990.

[6] http://www.fao.org/fileadmin/templates/ex_act/pdf/Technical_guidelines/EX-ACTUserManuaFinal_WB_FAO_IRD.pdf

national staff to determine current and future projections, literature reviews to assess availability of tier 2 or 3 coefficients to improve the accuracy of the assessment. Once all this information is gather then based on technical expertise a plan on how to best model the intervention in the tool along with the assumptions made is generated. This is a crucial step as this is what really determines the measurement of the impact. All these aspects are discussed below to ensure a clear and transparent understanding of the assessment done for this project.

3. Project Boundaries and Data sources.

8. **Geographical coverage.** Cuba is located in the Central American & Caribbean subregion in the American Continent. The country has a tropical moist climate with a High Activity Clay (HAC) dominant soil type. The IRES project will support the scale up of *six climate resilient land scape production modules* that addressed climate change adaptation and have proven to be technical, financial and social feasible in Cuba. These modules aim to introduce agroforestry systems, sustainable forest plantations, natural reforestation and sustainable silvopastoral systems in 3 provinces in Cuba: Las Villas province in the localities of Corralillo, Quemado de Güines and Santo Domingo; Matanzas province (Central Region) in the locality of Los Arabos; and Las Tunas province (Eastern Region) in the localities of Amancio Rodríguez, Colombia and Jobabo as presented in Figure 2 in the main text of the proposal and summarized below in Table 1. Furthermore, details on the proposed modules are summarized in Table 2.

Table 1: Proposed areas of intervention per locality, province and module in Ha

	Las tunas			Matanzas	Villa Clara			
Module	Amancio	Colombia	Jobabo	Los Arabos	Corralillo	Quemadod de Guines	Santo Domingo	Total per module
CEDPAL	467	61	1053	94	79	0	0	1754
MARREG	0	200	651	724	650	510	360	3095
MARFOM	900	0	0	510	4757	0	2000	8167
FRUAGR	456	59	522	227	515	0	750	2529
SILLEC		1982	5198	490	2465	214	150	10499
SILSOM	2127	0	0	537	4603	210	2214	9691
Total per locality	3950	2302	7424	2582	13069	934	5474	
Total per Province	13676			2582	19477			
TOTAL AREA	35734							

9. Other relevant aspects are:

- **Greenhouse gases considered.** The estimation of emissions for this project considers the sequestration, reduction and or avoidance that result from the implementation of the above six proactive modules. It considers sources and sinks from carbon dioxide (C02), Methane (CH_4) and Nitrous Oxide (N_2O) gases which are presented as CO_2 equivalent. The global warming potential for Methane is 25 and for Nitrous Oxide is 298 CO_2eq.
- **Pools considered:** Assessments of carbon pool changes are based on above- ground biomass, below-ground biomass, soil, deadwood and litter. For livestock enteric and manure management sources and sinks are incorporated.
- **Timeframe:** The EX-ACT differentiates between two time periods. First is the implementation phase, the period during which project activities are carried out and second is the capitalization phase, period where project benefits are still occurring because of the activities performed by the project. Given the typology of activities proposed under this project, the analysis considers a 20-year period, which is in line with IPCC recommendations for considering the timeframe between transition states of natural systems and the period necessary to reach a new equilibrium for carbon stocks. Therefore, the physical implementation of the project consists of 7 years, the

sequestration will continue to capitalize for 13 more years to reach the 20-year period. In the specific case of soil organic carbon, a constant rate over a period of 20 years from the year of planting to reach the new equilibrium is assumed. The analysis further assumes the dynamics of change (from without (BAU) to "with project") to be linear over the duration of the project.

Table 2: Selected Intervention Modules

Module	Short description
1. CEDPLA Agroforestry system with cedar / plantain	Planting deciduous, more drought resistant tree species with deep roots and abundant litter production (552 trees/ha) including *Cedrela odorata, Cordia gerascanthus, Caesalpinea violacea*; combined in rows with plantain, *Musa* sp. (625 plants/ha).
2. FRUAGR Agroforestry system with fruit trees, agricultural crops and living fences	Diverse citrus (56 trees/ha) and mango (64 trees/ha) in combination with crop rotation including manioc, sweet potato, maize, beans and various green fence species.
3. MARREG Management of the natural regeneration of native arboreal species	Harvesting thick marabú for charcoal production. Identification and selection of saplings and natural regeneration of native tree species. Further management of the succession towards a natural forest.
4. MARFOM Establishment of planted forests close to nature	Establishment of a Close to Nature Plantation comprasing a mixtures of native and exotic species including *Pinus, Cordia, Lysloma, Colubrina, Caesalpinea and Lysilimasp* on sites were Marabu has been eliminated.
5. SILLEC Silvopastoril system with arbustive leguminous	Establishment of *Guazuma ulmifolia* and *Arachis* applying conservation tillage practices for the progressive introduction of more drought resistant, improved pastures varieties (*Brachiaria B. and Arachis P.*). Contour green fencing with *Lysiloma Bahamensis* trees and internal electric fence to regulate livestock grazing and allow for pasture recovery and soil conservation.
6. SILSOM Silvopasture with shadow trees and protein banks	Introduction of more drought resistant applying conservation tillage to improve pastures varieties *(Brachiaria brizantha*) in combination with 30 shade trees / ha (*Samanea saman*) and contour fencing (*Guazuma, Bursera, Spondias*) and grazing rotation. Establishment of protein (*Morus sp, Moringa sp.)* and energy (*Sacharum*) "banks" on 15% of the area as feed reserves to be cut and harvested in the dry periods.

10. Data. Data used for each module was generated as part of the detailed project technical analysis , as outlined in Appendix 2.6, prepared by national technical forestry and agricultural experts. This information was used to inform the GHG analysis providing some basic data needed to characterize and model the analysis in Ex-Act. Appendix 2.6 and Financial economic Analysis of the project provides all the data on inputs needed as described below:

	With project		Without project	
Module	Fertilizer (ton)	Compost (ton)	Fertilizer (ton)	Compost (ton)
CEDPLA	3781	6556	907	1573
FRUAGR	273	1517	66	364
MARREG	0	0	0	0
MARFOM	0	0	0	0
SILLEC	0	0	0	0
SILSOM	339	0	81	0
Total	4393	8073	1054	1938

	With project		Without project	
Module	Diesel (L/ha)	Gasoline (L/ha)	Diesel (L/ha)	Gasoline (L/ha)
CEDPLA	500	50	120	12
FRUAGR	338	50	81	12
MARREG	250	40	60	10
MARFOM	220	50	53	12
SILLEC	133	50	32	12
SILSOM	367	50	88	12
Total	1808	290	434	70

	With project	Without project
Module	Electricity (kWh/ha)	Electricity (kWh/ha)
CEDPLA	0	0
FRUAGR	65	16
MARREG	0	0
MARFOM	0	0
SILLEC	85	20
SILSOM	65	16
Total	215	52

4. Modeling in Ex-Act tool

11. The first step in the analysis was to identify which Ex-Act module was best fit to evaluate each of the activities proposed under each of the productive modules as well as the emission factors that were going to be used either tier 1 (default) or tier 2. Table 2 summarizes the modelling for each of the module for their accounting in Ex-Act. In the BAU or without project scenario a 24% area of intervention was estimated to be possible based on Cuba's indicative level of past support for implementation of similar projects. This is the baseline and corresponds to a description of expected conditions in the project boundaries in the absence of project activities, which is often referred to the 'without project' scenario.

Furthermore, specific technical conditions *with and without project* are also considered for the project situations. These are discussed in detail in the succeeding sections.

Table 3: Characterization of the analysis in the Ex-Act tool

Module	Area (Ha)	Current land use	Assumptions Without project (BAU)	Assumptions With project	EXACT Module	Reference sources
CEDPLA	1753.58	Marabu- Assume tropical shrubland with tier 2 factors	Only 24% of area will be intervened the rest will remain under Marabu. Treatment to remove marabu is via bulldozing operations Causing substantial soil disruption)	Agroforestry system planted in entire area. No soil disruptions is used, only brush cutter. Treatment of herbicide to control marabou and incorporation of mulch are applied. Improved agronomic practices will be implemented	LUC Deforestation: 2.1 Perennial systems: 3.2 Initial use: set aside tropical shrubland Final use agroforestry system with forest and perennial trees.	IPCC 2006 Volume 4 Chapter 2 Generic Methodology Applicable to Multiple land use categories The difference between initial and final biomass carbon pools is used to calculate carbon stock change from land-use conversion Land Use Category, Chapter 4 Forest land
FRUAGR	2529.36				LUC Deforestation: 2.1 Perennial systems: 3.2 Initial use: set aside tropical shrubland. Final use Agroforestry system mixed with perennial and annual cropping	Annual/perennial systems, Chapter 8 Agriculture of volume in mitigation of the Fourth Assessment Report (Smith et. al 2007) Chapter 2, 11 of IPCC 2006 "Generic Methodology Applicable to Multiple Land-Use Categories" and "N2O emissions from managed soils, and CO2 emissions from lime and urea application" Inputs and Investments Volume 4 (AFOLU) of the IPCC 2006 in Chapter 11 "N2O emissions from managed soils, and CO2 emissions from lime, urea application", and from Lal (2004) for embodied GHG emissions associated with the use of agricultural chemicals in farm operations
MARREG	3094.7	Marabu- Assume tropical shrubland with tier 2 factors	Only 50% of area will be intervened, the rest will remain under Marabu. Marabu removal treatment using bulldozing operations.	Natural Forest regeneration in entire area. No soil disruptions is used, only brush cutter. Treatment of herbicide to control marabou and incorporation of mulch are applied.	LUC 2.2 afforestation/reforestation	
MARFON	8166.52				LUC Deforestation: 2.1 Perennial systems: 3.2 Initial use: set aside tropical shrubland Final use agroforestry system with forest	
SILLEC	10499	Degraded grassland	Only 50% of area will be intervened, the rest will remain under degraded. Operations will use conventional tillage.	Improved through silvopasotril system in entire area. Improved agronomic practices will be implemented	Grassland: 4.1.2 grassland remaining grassland. Livestock:4.2 Initial use: grassland moderately degraded Final use: grassland improved.	Chapter 6 "Grassland" of Volume 4 (AFOLU) of the IPCC 2006, and in Chapter 2 of IPCC 2006 "Generic Methodology Applicable to Multiple Land-Use Categories" Livestock Volume 4 (AFOLU) of the IPCC 2006, Chapter 10 "Emissions from Livestock and Manure Management", and from Chapter 8 of the
SILSOM	9691.2	Degraded grassland				

						Fourth Assessment Report from working group III of IPCC (Smith et al., 2007) for specific technical mitigation options not covered in IPCC 2006. Emissions CH4 enteric fermentation & manure management (10.4), N2O manure management (10.5) and CH4 mitigation potential livestock.

A comparison of proposed areas of intervention under both the baseline vs project scenarios is summarized below.

Summary of Land Use Changes		**Intervention areas**	
Module	**Area**	**Baseline scenario**	**With project**
CEDPLA	1754	421	1754
Share production of Plantain	833	200	833
Share production of Cederela Odorata	833	200	833
Shared Production of Hedgegrow	88	21	88
FRUAGR	2529	607	2529
Share production of fruit trees	1201	288	1201
Share production annual crop	1201	288	1201
Share production hedgegrow	126	30	126
MARREG- all Natural regeneration	3095	743	3095
MARFOM	8167	1960	8167
Share production forest plantations	7758	1862	7758
Share production hedgegrow	408	98	408
SILLEC	10499	2520	10499
Share production silvopastoril	1050	252	1050
Share production better grassland management	8924	2142	8924
Share production hedgegrow	525	126	525
Lievstock feeding improvements		0%	100%
SILSOM	9691	2326	9691
Share production better grassland management	5330	1279	5330
Share of silvopastoril area perennial	2423	581	2423
Share of hedegrow perennial	485	116	485
Livestock feeding improvements	%	0	100%
Share improving grassland protein bank feeding annual	1454	349	1454

Table 4: The main emission factors per pool utilized for the assessment are as follows:

Item	Emission Factor in Tons of C per ha unless otherwise noted.	Sources
Marabu	AGB[7]: 19.6 BGB[8]: 4.4 Soil: 28	Own calculation as explained in the descriptions below from data from Hernandez-Jimenez et al[9] and Appendix 2.6.
Perennial systems including Plantain and Hedgerow	AGB: 2.6 Soil: 0.7 No burning	Default tier 1 coefficients IPCC 2006.
Cedar	AGB: 3.3 BGB: 0.7 Soil:0.7	AGB is default Tier 1 coefficient used in Plantation for tropical moist deciduous forest IPCC 2006. BGB and Soil are default coefficients for perennial crops IPCC 2006
Annual crop systems	Soil: 2.79 Tons of CO2 per ha per year for improved agronomic practices: 0.88 Nutrient mgmt.: 0.55 Tillage/residue mgmt: 0.70.	Default tier 1 coefficients IPCC 2006
Afforestation/reforestation	Growth rate up to 20 years: AGB: 3.29 BGB: 0.66 Growth rate after 20 years: AGB: 0.94 BGB: 0.19 Litter: 3.65 Deadwood: 0 Soil:45.6	Default tier 1 coefficients for AGB, BGB and Litter IPCC 2006 For soil, based on national publication assumed it was " young forest" as per Hernandez-Jimenez et al.
Grasslands state	Soil values for Moderately Degraded 39.0 and 52.3 for improved with inputs.	For soil, based on national publication for good condition grassland then corrected by subtracting 25.44% to represent moderately degraded. The % correction was estimated from comparison of default tier 1 values moderate vs improved values from IPCC 2006.[10]
Livestock	Enteric fermentation in kg CH4 per head per year dairy cattle:63 Calfs for re-stocking have lower rate at 1.412	Dairy cattle default coefficient, IPCC 2006. Calf coefficient, Gonzales and Ruiz.[11]

[7] Above-ground Biomass (AGB)

[8] Below-ground biomass (BGB)

[9] Carbon losses and soil property changes in ferralic Nitisols from Cuba under different covers. Alberto Hernández-Jiménez1, Dania Vargas-Blandino1, José Irán Bojórquez-Serrano2, Juan Diego García-Paredes, Alberto Madueño-Molina2, Marisol Morales-Díaz3. Sci. Agric. v.74, n.4, p.311-316, July/August 2017

[11] González-Avalos E. and L. G. Ruiz-Suárez, 1997. Modeling methane emissions from cattle in Mexico. Sci Total Environ. 1997 Nov 5;206(2-3):177-86. https://doi.org/10.1016/S0048-9697(97)80008-3

5. Assumptions & Details of Modeling of Climate Resilient Landscape Production Modules

5.1 Module 1: CEDPLA- Agroforestry system with cedar / plantain

Objective: The module will establish an agroforestry system with combine wood and plantain plantation.

Activities: The specific activities that will be carried out are firstly the removal of marabu (*Dichrostachys cinerea*) shrubbery using tillage. The above ground biomass from the shubbery will be mulch and left in the ground for cover. This will be followed by the establishment of plantation of *Cedrela odorata or cedar*. The plantation rate of the cedar will be 552 trees/ha. These will intertwine rows of plantain, *Musa* sp at a rate of 625 plants/ha. A hedgerow will be installed with local species including Gliricidia sepium/bursera simaruba/Spondias purpurea at rate of 98 pants/ha.

Inputs: Inputs include the use fertilizer 3781 NPK formula 9:13:17; 6556 ton per ha of compost and 500 liters of diesel for machinery and 50 liters of gasoline for chainsaw data comes from Appendix 2.6.

Assumptions: The implementation of the module considers that 24% of the area will dedicated to cedar plantation and 50% to plantain production. The *without project* scenario considers that only 24% of the proposed area could be cover without the additional resources from the GCF. The medium annual increment (MAI) for marabu based on national experts is estimated at 1.3 m3 per ha year and for cedar 11 m3 per ha per year (appendix 2.6). In consultation with national experts, it is concluded that *no fire* will be used for the conversion of marabu to plantain plantation and to forest species.

Modeling details: The activities under this module represent a Land Use (LU) change from shrubbery to establishment of woody plantation/perennial crop planation agroforestry system. For the carbon factors specific tier 2 factors were determined based on information provided by forestry Cuban specialists on marabu and soils from literature review as *explained below.*

Calculations to prepare data for Ex-Act entries:

Calculation on Marabu carbon factors:

- Above ground biomass: Using the marabu IMA of 1.3 m3 with no harvesting was applied to a simple allometric growth equation (initial volume + annual increment-harvesting) over a 20-year period to estimate the total volume. The density of wood 0.5 ton of dry matter per m3 was used to convert this volume to tons (IPCC Table 4.13). Then variables on expansion coefficient of 1 was used to calculate the total above ground biomass (IPCC Table 4.5). We used the conversion coefficient of 0.47 ton of C per tonne of dry matter to calculate the total ton of C in the above (Table 4.3 IPCC Volume 4 p.g 4.48). Finally, we divided by 20 years to obtain the rate of C ton of per ha per year for marabu. The above ground biomass was calculated to be 0.66 ton of C per ha per year. Considering this rate of carbon stock in 30 years of invasion of the species, the *carbon sink is estimated to be 19.6 t of C per ha*.
- Below ground biomass: The below ground biomass was calculated multiplying by the shoot to root ratio of 0.33 low end for shrublands (Table 4.5 IPCC Volume 4, pg. 4.50). This resulted in 0.218 ton of C per ha per year for below ground biomass and a carbon sink of 4.35 ton of C over 20-year period.

- Soil: observations in literature indicate an average accumulation of 14 g C per m2 per year[12] for these types of shrubs. This was converted to tonne per ha using conversion factor of 1 tonne per ha = 100 g per meter square. Furthermore, considering a 20-year period for soil to reach equilibrium a value of 28 ton of C was calculated. These factors were used in the Ex-Act tool as tier 2.

Calculation on Cedar carbon factors: default tier 1 emission factors coefficient were used as provided by Ex-Act in section Plantation for a tropical moist deciduous forest

Plantains: default tier 1 emission factors coefficient were used as provided by Ex-Act.

Hedgerow: for the initial state we used tier 2 coefficient for marabu as calculated above for above ground biomass was 0.66 ton of C per ha per year and for soil 28.0 ton C per ha same as above. For the final use the above ground biomass coefficient tier 1 default of 2.6 ton of C per ha per year was used and for soil tier 2 value of 52.3 was used based on Cuban study on soil measurements in grasslands[13].

Input calculations were carried out to estimate the total active NPK ingredients in agrochemicals as follows:

•For with project the following equations were used to calculate the inputs entries for EX-ACT.

Equation 1 Active ingredient = amount of fertilizer* % of Nitrogen content / years of implementation

3781*.09 % of active N in fertilizer divided by 7 years of implementation = 48.6 tons

P2O5= 3781*.13 / 7 = 70.2 tons

KOH = 3781*.17 / 7 = 91.82 tons

Organic matter in compost was assumed to be 2% N content based on literature[14].

Equation 2: N from organic compost= amount * % nitrogen / years of implementation

Nitrogen in compost= 6556*0.02/7 = 18.7 tons

For diesel and gasoline,

Equation 3: Fuel in m3= Liters per ha * # ha module/ 1000 liters to m3 conversion / years of implementation 7 years.

Diesel m3 = 250 liters per ha * 1754 ha intervention / 1000 /7 = 62.63 m3 per year

Gasoline m3 = 25 liters per ha * 1754 ha intervention / 1000 /7 = 6.263 m3 per year

Note that for CEDPLA the values for gasoline were divided equally between plantain portion and forest portion since these were run in two separate excel files.

•In the case of without project, it is estimated that only 0.24 of the value of inputs and fuel will be used.

Entries in Ex-Act

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12 Woody encroachment reduces nutrient limitation and promotes soil carbon sequestration. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4020701/table/tbl1/

13 Carbon losses and soil property changes in ferralic Nitisols from Cuba under different covers. Alberto Hernández-Jiménez1, Dania Vargas-Blandino1, José Irán Bojórquez-Serrano2, Juan Diego García-Paredes, Alberto Madueño-Molina2, Marisol Morales-Díaz3. Sci. Agric. v.74, n.4, p.311-316, July/August 2017

14 https://umaine.edu/soiltestinglab/wp-content/uploads/sites/227/2016/07/Compost-Report-Interpretation-Guide.pdf

Modeling of the land use changed of the 1753.58 hectares was managed as follows:

(I) *833 ha of Marabu to Perennial/Tree Crop (Plantain plantation*). Without project only 200 ha will be converted to plantain plantation, with project all the 833 ha will be converted after Marabu is removed.

(II) *833 ha of Marabu to Cedrela odorata (common cedar).* Without project only 200 ha will be converted to forest species, with project all the 833 ha will be converted after Marabu is removed.

(III) *88 ha of Hedgerow were included in other land use changes with project and only 21 ha without project*

(IV) Baseline scenario: Without the project, 421 ha will implement the activities in the module while the remaining 1333 hectares will continue to be with Marabu shrubland.

Step by Step Ex-ACT entries:

CEDPLA 1: Marabu to plantain plantation-

1.1 Land use change module

2.1. Deforestation

AEZ map — Zone 1 = Tropical rain forest — Zone 2 = Tropical moist deciduous forest — Zone 3 = Tropical dry forest — Zone 4 = Tropical shrubland

Type of vegetation that will be deforested	HWP# (tDM/ha)	Fire Use? (y/n)	Final use after deforestation	Forested area (ha) Start	Without	*	With	*	Deforested area (ha) Without	With	Total Emissions (tCO2-eq) Without	With	Balance
Forest Zone 4	0	NO	Perennial/Tree Crop	832.9505	633	D	0	D	200	833	15,653	65,206	49,553
Select the vegetation	0	NO	Select Use after deforestation	0	0	D	0	D	0	0	0	0	0
Select the vegetation	0	NO	Select Use after deforestation	0	0	D	0	D	0	0	0	0	0
Select the vegetation	0	NO	Select Use after deforestation	0	0	D	0	D	0	0	0	0	0
Select the vegetation	0	NO	Select Use after deforestation	0	0	D	0	D	0	0	0	0	0
Select the vegetation	0	NO	Select Use after deforestation	0	0	D	0	D	0	0	0	0	0
Select the vegetation	0	NO	Select Use after deforestation	0	0	D	0	D	0	0	0	0	0
Select the vegetation	0	NO	Select Use after deforestation	0	0	D	0	D	0	0	0	0	0
Total Deforestation											15,653	65,206	49,553

#Harvested Wood Products

* Note concerning dynamics of change : "D" corresponds to default/linear, "I" to immediate and "E" to exponential (Please refer to the guidelines)

Tier 2

1.2. Coefficients in the LUC- tier 2 for Marabu based in LUC on calculation explained above.

2.1. Deforestation

AEZ map — Zone 1 = Tropical rain forest — Zone 2 = Tropical moist deciduous forest — Zone 3 = Tropical dry forest — Zone 4 = Tropical shrublan

Back

You have indicated that you are using the following types of vegetation: Forest Zone 4

Use this part only if you want to refine the analysis with Tier 2 coefficients.
(default values are provided for your information only, while EX-ACT will use Tier 2 values automatically wherever specified)

All values are in t of carbon per ha (tC/ha)

Type of vegetation that will be deforested	Above-ground Default	Tier 2	Below-ground Default	Tier 2	Litter Default	Tier 2	Dead wood Default	Tier 2	Soil carbon Default	Tier 2
Forest Zone 1	141.0		52.2		3.7		0.0		65.0	
Forest Zone 2	103.4		24.8		3.7		0.0		65.0	
Forest Zone 3	98.7		27.6		3.7		0.0		65.0	
Forest Zone 4	37.6	19.6	15.0	4.4	3.7	0.0	0.0	0.0	65.0	28.0
Plantation Zone 1	70.5		26.1		3.7		0.0		65.0	
Plantation Zone 2	56.4		11.3		3.7		0.0		65.0	
Plantation Zone 3	28.2		7.9		3.7		0.0		65.0	
Plantation Zone 4	14.1		7.9		3.7		0.0		65.0	
Mangrove	86.6		42.4		0.7		10.7		68.0	

1.3 Crop Production module

3.2.1. Perennial systems from other LU or converted to other LU (please fill step 2.LUC previously)

Description	Residue/ biomass burning	Yield (t/ha/yr)	Area (ha) Start	Without	With	Total Emissions (tCO2-eq) Without	With	Balance
Perennial after Deforestation	NO		0	200	833	-32,809	-136,673	-103,865
Converted to A/R	NO		0	0	0	0	0	0
Perennial after non-forest LU	NO		0	0	0	0	0	0
Converted to OLUC	NO		0	0	0	0	0	0

1.4 Coefficients by default (tier 1) were used for Plantain plantation as follows:

Systems	Above-ground Growth rate (t C/ha/yr) Default	Tier 2	Below-ground Growth rate (t C/ha/yr) Default	Tier 2	Rates of soil C sequestration (t CO2/ha/yr) Default	Tier 2	Burning (quantity of residues and periodicity) Main season crop Default	Tier 2	Periodicity (yr) Default	Tier 2
Perennial systems from (or to) other LU										
Perennial after Deforestation	2.6		0		0.7		10		1	

1.5 Hedgerow reported land uses

2.1. Deforestation													
AEZ map	Zone 1 = Tropical rain forest		Zone 2 = Tropical moist deciduous forest			Zone 3 = Tropical dry forest			Zone 4 = Tropical shrubland				
Type of vegetation that will be deforested	HWP# (tDM/ha)	Fire Use? (y/n)	Final use after deforestation	Forested area (ha) Start	Without	*	With	*	Deforested area (ha) Without	With	Total Emissions (tCO2-eq) Without	With	Balance
Forest Zone 4	0	NO	Perennial/Tree Crop	87.679	67	D	0	D	21	88	1,619	6,864	5,245
Select the vegetation	0	NO	Select Use after deforestation	0	0	D	0	D	0	0	0	0	0
Select the vegetation	0	NO	Select Use after deforestation	0	0	D	0	D	0	0	0	0	0
Select the vegetation	0	NO	Select Use after deforestation	0	0	D	0	D	0	0	0	0	0
Select the vegetation	0	NO	Select Use after deforestation	0	0	D	0	D	0	0	0	0	0
Select the vegetation	0	NO	Select Use after deforestation	0	0	D	0	D	0	0	0	0	0
Select the vegetation	0	NO	Select Use after deforestation	0	0	D	0	D	0	0	0	0	0
Select the vegetation	0	NO	Select Use after deforestation	0	0	D	0	D	0	0	0	0	0
	#Harvested Wood Products		* Note concerning dynamics of change : "D" corresponds to default/linear, "I" to immediate and "E" to exponential (Please refer to the guidelines)										
Tier 2									Total Deforestation		1,619	6,864	5,245

1.6 Coefficients used for hedgerow same as 1.2 diagram.

CEDPLA 2: Marabu to forest species

2.1 Land use change module

2.1. Deforestation													
AEZ map	Zone 1 = Tropical rain forest		Zone 2 = Tropical moist deciduous forest			Zone 3 = Tropical dry forest			Zone 4 = Tropical shrubland				
Type of vegetation that will be deforested	HWP# (tDM/ha)	Fire Use? (y/n)	Final use after deforestation	Forested area (ha) Start	Without	*	With	*	Deforested area (ha) Without	With	Total Emissions (tCO2-eq) Without	With	Balance
Forest Zone 4	0	NO	Perennial/Tree Crop	832.951	633	D	0	D	200	833	15,653	65,206	49,553
Select the vegetation	0	NO	Select Use after deforestation	0	0	D	0	D	0	0	0	0	0
Select the vegetation	0	NO	Select Use after deforestation	0	0	D	0	D	0	0	0	0	0
Select the vegetation	0	NO	Select Use after deforestation	0	0	D	0	D	0	0	0	0	0
Select the vegetation	0	NO	Select Use after deforestation	0	0	D	0	D	0	0	0	0	0
Select the vegetation	0	NO	Select Use after deforestation	0	0	D	0	D	0	0	0	0	0
Select the vegetation	0	NO	Select Use after deforestation	0	0	D	0	D	0	0	0	0	0
Select the vegetation	0	NO	Select Use after deforestation	0	0	D	0	D	0	0	0	0	0
	#Harvested Wood Products		* Note concerning dynamics of change : "D" corresponds to default/linear, "I" to immediate and "E" to exponential (Please refer to the guidelines)										
Tier 2									Total Deforestation		15,653	65,206	49,553

2.2 Coefficients in the LUC- tier 2 for Marabu based on calculation explained above and same as 1.2 diagram.

2.3 *Crop* production module

3.2.1. Perennial systems from other LU or converted to other LU (please fill step 2.LUC previously)								
Description	Residue/ biomass burning	Yield (t/ha/yr)	Area (ha) Start	Without	With	Total Emissions (tCO2-eq) Without	With	Balance
Perennial after Deforestation	NO		0	200	833	-48,645	-202,643	-153,998
Converted to A/R	NO		0	0	0	0	0	0
Perennial after non-forest LU	NO		0	0	0	0	0	0
Converted to OLUC	NO		0	0	0	0	0	0

2.4 Coefficients tier 2 for Cedar for forest species as calculated above were used as follows:

Systems	Above-ground Growth rate (t C/ha/yr)		Below-ground Growth rate (t C/ha/yr)		Rates of soil C sequestration (t CO2/ha/yr)		Burning (quantity of residues and periodicity) Main season crop		Periodicity (yr)	
Perennial systems from (or to) other LU	Default	Tier 2	Default	Tier 2	Default	Tier 2	Default	Tier 2	Default	Tier 2
Perennial after Deforestation	2.6	3.3	0	0.7	0.7		10	0.0	1	
Converted to A/R	0		0		0.7		10		1	
Perennial after non-forest LU	2.6		0		0.7		10		1	
Converted to OLUC	0		0		0.7		10		1	

2.5 RESULTS

	CO2				
CEDPLA per (ha/year) All GHG in Ton CO2 eq	CO2 Biomass	CO2 Soil	Inputs/investments	N2O	CH4
CEDPLA total balance (Ton CO2 eq/year)	**-5105.430**	**-404.250**	**57.127**	**197.733**	**0.000**

CEDPLA Component	**tonnes of CO2eq per year**	**tonnes of CO2eq in 7 years (project implementation)**	**tCO2eq in 20 years ecosystem equilibrium reached.**
Banana plantation	-2251	-15760	-45029
Forest Trees plantation	-5165	-36156	-103302
Hedgerow	-287	-2012	-5749
Total	-7704	-53928	-154081

Altogether the CEDPLA module could sequester carbon at an annual rate of -7704 tCO2-eq or -53928 tCO2eq for the entire duration of the project implementation.

5.2 Module 2: FRUAGR- Agroforestry system with fruit trees, agricultural crops and living fences

Objective: This module will establish agroforestry systems using perennial fruit trees in combination with annual crop rotational crops.

Activities: The specific activities that will be carried out are: firstly, the removal of Marabu (*Dichrostachys cinerea*) shrubbery using tillage and mulching and leaving the above ground biomass from the shubbery as cover. This will be followed by the establishment of plantation of fruit trees at rate of 56 trees/ha citrus and mango 64 trees/ha. The trees will be intercalated with crop rotation of manioc, sweet potato, maize and beans. A hedgerow will be installed surrounding the plots using local species including B*ursera simaruba/Spondias purpurea* covering approximately area of 126.5 ha.

Inputs: Inputs include the use fertilizer 273 tons of NPK formula 9:13:17; 1517 ton per ha of compost and 338 liters of diesel per ha for machinery and 126 liters of gasoline per ha for chainsaw. Electricity consumption is estimated at 65 kWh per ha.

Assumptions: The cultivation arrangement for this system considers that in general 50% of the area will should be dedicated to production of fruit trees and 50% to the production of annual crops. Trees will be intercalated with annual crops. Careful alternation on annual crop rotations will be taken to maximize the benefits of using leguminous to fix nitrogen in soil. Cultivation will be carried out manually respecting appropriate agrotechnical norms for the species. The annual crop production assumes that improved agronomic practices, nutrient management, no till and residue retention, water management and manure application will be applied. No fire will be used in the Land Use conversion.

Modelling details: The activities under this module represent a Land Use change (LU) from shrubs to agroforestry plantation system of perennial fruit trees, annual crop production and trees for hedgerow is contemplated.

Marabu initial status: tier 2 coefficients are used, the same ones as previously calculated in the CEDPAL module. Specifically, the above ground biomass sink is 19.6 tons of C per ha, the below ground biomass estimated at 4.35 ton of C per ha and the soil 28 ton of C per ha.

Citrus and an annual crop: tier 1 or default coefficients are used to calculate the GHG impact.

Hedgerow: for the initial state we used tier 2 coefficient for Marabu as calculated above in CEDPLA, for above ground biomass was 19.6 ton of C per ha per year, for below-ground 4.4 ton of C per ha per year and for soil 28.0 ton C per ha.

Input calculations were carried out to estimate the total active NPK ingredients in agrochemicals as following equations 1, 2, and 3 above.

•For with project the following values were estimated as: 4 tons N; 5.8 tons P2O5 and7.6 tons KCl.

N from organic compost is estimated to be 4.98 tons

Diesel is 122 and gasoline is 18 cubic meters respectively.

Electricity is 164MWh.

•In the case of without project, it is estimated that only 24% of the value of inputs, fuel and electricity will be used.

Entries in Ex-Act

Modeling of the land use changed of 2529.36 hectares will be managed as follows:

(I) 1201 ha of Marabu LUC to Perennial/Tree Crop. Without project only 288 ha will be converted to Perennial/ Tree Crop, with project all the 1201 ha will be converted after Marabu is removed.

(II) 1201 ha of Marabu LUC to annual crops. Without project only 288 ha will be converted to annual crops, with project all the 1201 ha will be converted after Marabu is removed. Croplands will be managed to maintenance soil cover to promote soil moisture retention. Integrated management of crops will include improve timing and placement of fertilizers and improve varieties adapted to climatic conditions.

(III) *126 ha of Marabu to Hedgerow were included.* LUC to Perennial/Tree Crop. Without project only 30 ha will be converted to Perennial/ Tree Crop.

(IV) Baseline scenario: Without the project, 1922 ha of Marabu will remain the same as shrubland and only 607will be intervened.

Step by Step Ex-ACT entries:

3.1 Land use change Marabu to annual and perennial crops

2529 hectares of Marabu will be converted to Annual and Perennial crops.

2.1. Deforestation

AEZ map | Zone 1 = Tropical rain forest | Zone 2 = Tropical moist deciduous forest | Zone 3 = Tropical dry forest | Zone 4 = Tropical shrubland

Type of vegetation that will be deforested	HWP# (tDM/ha)	Fire Use? (y/n)	Final use after deforestation	Forested area (ha) Start	Forested area (ha) Without	*	With	*	Deforested area (ha) Without	Deforested area (ha) With	Total Emissions (tCO2-eq) Without	Total Emissions (tCO2-eq) With	Balance
Forest Zone 4	0	NO	Annual Crop	1201.45	913	D	0	D	288	1201	32,747	136,670	103,924
Forest Zone 4	0	NO	Perennial/Tree Crop	1201.45	913	D	0	D	288	1201	22,581	94,053	71,473
Forest Zone 4	0	NO	Perennial/Tree Crop	126.468	96	D	0	D	30	126	2,385	9,900	7,515
Select the vegetation	0	NO	Select Use after deforestation	0	0	D	0	D	0	0	0	0	0
Select the vegetation	0	NO	Select Use after deforestation	0	0	D	0	D	0	0	0	0	0
Select the vegetation	0	NO	Select Use after deforestation	0	0	D	0	D	0	0	0	0	0
Select the vegetation	0	NO	Select Use after deforestation	0	0	D	0	D	0	0	0	0	0
Select the vegetation	0	NO	Select Use after deforestation	0	0	D	0	D	0	0	0	0	0
									Total Deforestation		57,712	240,624	182,911

#Harvested Wood Products

* Note concerning dynamics of change : "D" corresponds to default/linear, "I" to immediate and "E" to exponential (Please refer to the guidelines)

Tier 2

3.2 Coefficients in the LUC- tier 2 for Marabu based in LUC on calculation explained above same as diagram 1.2.

3.1 Crop production module

Management of annual crops: selection of improve agronomic, nutrient management, manure application

3.1. Annual systems (to be used also for pluri-annual systems such as cotton or sugarcane)

3.1.1. Annual systems from other LU or converted to other LU (please fill step 2.LUC previously)

Description	Main season crop	Management options: Improved agronomic practices	Nutrient management	No till & residue retention	Water management	Manure application	Residue management	Yield (t/ha/yr)	Area (ha) Start	Without	With	Total Emissions (tCO2-eq) Without	With	Balance
Annual after Deforestation	Default	Yes	Yes	Yes	No	Yes			0	288.446	1201.446	-12,944	-53,916	-40,972
Converted to A/R	Default	?	?	?	?	?	Please select		0	0	0	0	0	0
Annual after non-forest LU	Default	?	?	?	?	?	Please select		0	0	0	0	0	0
Converted to OLUC	Default	?	?	?	?	?	Please select		0	0	0	0	0	0

3.2 Coefficient for annual crops- tier 1 used.

3.1. Annual systems (to be used also for pluri-annual systems such as cotton or sugarcane)

Back

Use this part only if you want to refine the analysis with Tier 2 coefficients.

(default values are provided for your information only, while EX-ACT will use Tier 2 values automatically wherever specified)

Systems	Rates of soil C sequestration (t CO2/ha/yr) Default	Tier 2	Minor season crop/ intercrop: Crop type	Yield (t/ha/yr)	Residue management	Residues/Biomass available f (t Dry Matter per ha) Main season crop Default	Tier 2	Minor season crop/ intercrop Default	Tier 2
Annual systems from (or to) other LU									
Annual after Deforestation	2.79		None		Please select	4.4		#N/A	
Converted to A/R	0		None		Please select	4.4		#N/A	
Annual after non-forest LU	0		Maize		Retained	4.4		3.6	
Converted to OLUC	0		None		Please select	4.4		#N/A	
Annual systems remaining annual systems									
description 1	0		None		Please select	3.6		#N/A	
description 2	0		None		Please select	4.4		#N/A	
description 3	0		None		Please select	4.4		#N/A	
description 4	0		None		Please select	4.4		#N/A	
description 5	0		None		Please select	4.4		#N/A	
description 6	0		None		Please select	4.4		#N/A	
description 7	0		None		Please select	4.4		#N/A	
description 8	0		None		Please select	4.4		#N/A	
description 9	0		None		Please select	4.4		#N/A	
description 10	0		None		Please select	4.4		#N/A	

3.3 Perennial crop

3.2.1. Perennial systems from other LU or converted to other LU (please fill step 2.LUC previously)

Description	Residue/ biomass burning	Yield (t/ha/yr)	Area (ha) Start	Without	With	Total Emissions (tCO2-eq) Without	With	Balance
Perennial after Deforestation	NO		0	319	1,328	-52,328	-217,889	-165,560
Converted to A/R	NO		0	0	0	0	0	0
Perennial after non-forest LU	NO		0	0	0	0	0	0
Converted to OLUC	NO		0	0	0	0	0	0

3.4 Coefficient for perennial crops- tier 1 used.

3.2. Perennial systems (agroforestry, orchards, tree crops...)

Back

Use this part only if you want to refine the analysis with Tier 2 coefficients.

(default values are provided for your information only, while EX-ACT will use Tier 2 values automatically wherever specified)

Systems	Above-ground Growth rate (t C/ha/yr) Default	Tier 2	Below-ground Growth rate (t C/ha/yr) Default	Tier 2	Rates of soil C sequestration (t CO2/ha/yr) Default	Tier 2	Burning (quantity of residues and periodicity) Main season crop Default	Tier 2	Periodicity (yr) Default	Tier 2
Perennial systems from (or to) other LU										
Perennial after Deforestation	2.6		0		0.7		10		1	
Converted to A/R	0		0		0.7		10		1	
Perennial after non-forest LU	2.6		0		0.7		10		1	
Converted to OLUC	0		0		0.7		10		1	

3.5 RESULTS

	CO2				
FRUGAR per (ha/year) All GHG in Ton CO2 eq	CO2 Biomass	CO2 Soil	Inputs/investments	N2O	CH4
FRUGAR total balance (Ton CO2 eq/year)	**-573.998**	**-673.587**	**373.639**	**86.310**	**0.000**

FRUAGR Component	**<u>tonnes of CO2eq per year</u>**	**<u>tonnes of CO2eq in 7 years (project implementation)</u>**	**<u>tCO2eq in 20 years ecosystem equilibrium reached.</u>**
Total	-784	-5491	-15687

The FRUGAR module could sequester <u>approximately - 784 tonnes of CO2eq per year or -5491 tCO2eq for the entire duration of the project implementation.</u>

5.3 Module 3: MARREG- Management of the natural regeneration of native arboreal species

Objective: The module aims to support a natural regeneration of native tree species in areas with marabu.

Activities: The specific activities that will be carried out involved firstly manually and small machinery to harvest the marabu (*Dichrostachys cinerea*) shrubbery for use for charcoal and fuelwood production. Then an inventory and selection of tree species to be regenerated will be identified according to the needs of the areas. Collection of promising saplings of desire species and their growth in nurseries will then take place. Saplings will then be cultivated in open spaces, aiming to a density of 2500 tress per ha to ensure that the trees crowns will impede light to eliminate the marabu.

Inputs: No use of fertilizer or compost is expected. 250 L/ha of diesel for machinery and 40 L/ha of gasoline for chainsaw are expected. Equation 3 was used to calculate inputs into EX-Act.

Assumptions: The medium annual increment (MAI) for marabu based on national experts is estimated at 1.3 m3 per ha year. The MAI for the native regeneration is estimated to be around 8 m3 per ha per year. In the case of without project, it is estimated that only half the value of fuel will be used.

Modeling details: The activities under this module represent a conversion of land through afforestation. Based on the description of the activities as no major soil disturbances are envision, this LUC is determined to take place from set aside/unused lands to afforestation uses. The tier 1 or default coefficients for above ground biomass of 3.29 ton C per ha per year, below ground of 0.66 ton of C per ha per year and litter of .3.65 ton C per ha per year seem to be adequate as there was no available national data. In case of the soil carbon, the values from the soil study referenced in CEDPAL module was used, for young forest this value is 45.6 ton of C per ha.

Entries in Ex-Act

Modeling of the land use change for the 3095 hectares was managed as follows:

(I) 3095 ha of assisted natural regeneration. Without project only 743 ha will be assisted, with project all the 3095 ha will be converted.

(II) Baseline scenario: Without the project, 2352 hectare will remain set aside land.

Step by Step Ex-ACT entries:

4.1 MARREG Land use change:

2.2. Afforestation and Reforestation

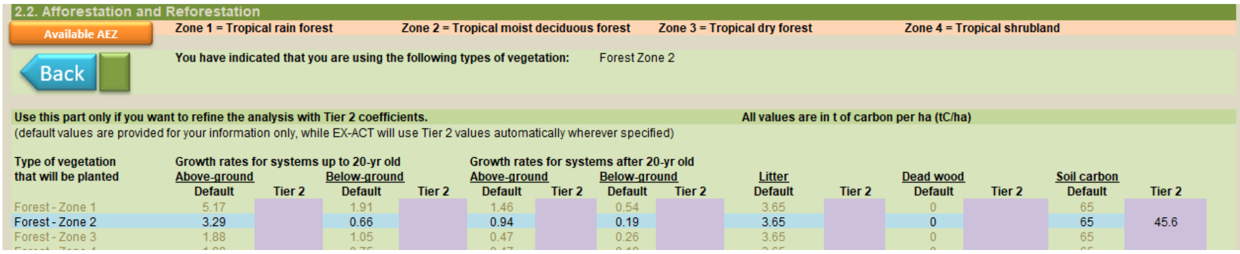
AEZ map | Zone 1 = Tropical rain forest | Zone 2 = Tropical moist deciduous forest | Zone 3 = Tropical dry forest | Zone 4 = Tropical shrubland

Type of vegetation that will be planted	Fire Use? (y/n)	Previous land use	Area that will be afforested/reforested: Without	*	Area that will be afforested/reforested: With	*	Total Emissions (tCO2-eq): Without	Total Emissions (tCO2-eq): With	Balance
Forest Zone 2	NO	Set Aside	742.8	D	3095	D	-192,199	-800,830	-608,631
Select the vegetation	NO	Select previous use	0	D	0	D	0	0	0
Select the vegetation	NO	Select previous use	0	D	0	D	0	0	0
Select the vegetation	NO	Select previous use	0	D	0	D	0	0	0
Select the vegetation	NO	Select previous use	0	D	0	D	0	0	0
Select the vegetation	NO	Select previous use	0	D	0	D	0	0	0
Select the vegetation	NO	Select previous use	0	D	0	D	0	0	0
Select the vegetation	NO	Select previous use	0	D	0	D	0	0	0
Total Af-/Reforestation							-192,199	-800,830	-608,631

* Note concerning dynamics of change : "D" corresponds to default/linear, "I" to immediate and "E" to exponential (Please refer to the guidelines)

Tier 2

4.2 Coefficient selection- default for all except soil where tier 2 was selected.



4.3 RESULTS

	CO_2				
MARREG per (ha/year) All GHG in Ton CO2 eq	CO2 Biomass	CO2 Soil	Inputs/investments	N2O	CH4
MARREG total balance (Ton CO2 eq/year)	**-27509.449**	**-2922.083**	**213.573**	**0.000**	**0.000**

MARREG Component	**tonnes of CO2eq per year**	**tonnes of CO2eq in 7 years (project implementation)**	**tCO2eq in 20 years ecosystem equilibrium reached.**
Total	-30218	-211526	-604359

The regeneration management in 3094.7 ha could sequester -30,218 tCO2eq per year or -211526 tCO2eq for the entire duration of the project implementation.

5.4 Module 4: MARFOM- Establishment of planted forests close to nature

Objective: The module aims to establishment of Close-to-Nature Planted Forests (CTNPF) in areas currently invaded with Marabu.

Activities: The activities that will be carried out are: the removal of Marabu (*Dichrostachys cinerea*) shrubbery using subsoiling and brushcutter. The above ground biomas from the shubbery will be mulch and left in the ground. This will be followed by the establishment of a CTNPF by plantation of mixtures of native and exotic species including *Pinus caribaea*, *Cordia gerascanthus*, *Caesalpinea violácea (yarúa)*, *Colubrina ferruginosa (bijáguara)*, *Lysiloma bahamensis (soplillo)* and *Guazuma ulmifolia (guásima)* sp at a rate of 184 plants/ha on sites were Marabu has been mechanically eliminated. A hedgerow will be installed with local species including Anacardium occidentale (Marañón) at a rate of 64 plants/ha, Mangifera indica (Mango) at a rate of 32 plants/ha and Tamarindus indica (Tamarindo) at a rate of 24 plants/ha.

Inputs: Inputs include the use of 220 L/ha of diesel and 50 L/ha of gasoline.

Assumptions: The implementation of the module considers that 100% of the area will be dedicated to forest plantation. The without project scenario considers that only 24% of the proposed area could be cover without the additional resources from the GCF. In consultation with the project's implementation unit, it is concluded that no fire will be used for the conversion of Marabu to perennial plantation and to forest species.

Modeling details: The activities under this module represent a Land Use (LU) change from shrubbery to an intense forest regeneration.

Calculation on Marabu carbon factors: Tier 2 coefficients are used, the same ones as previously calculated in the CEDPAL module. Specifically, the above ground biomass sink is 19.6 tons of C per ha the below ground biomass estimated at 4.35 ton of C per ha and the soil 28 ton of C per ha.

Calculation on forest trees carbon factors: we used the default tier 1 emission factors coefficients as provided by Ex-Act for forest plantation.

Calculation on Perennial tree crops (fruit trees): we used the default tier 1 emission factors coefficients as provided by Ex-Act.

Calculation of Hedgerow: applies the same tier 2 coefficients for the initial sate for Marabu as calculated in the CEDPLA module.

Input calculations: Using equation 3 the following inputs were calculated 256.66 cubic meters of diesel and 58.322 cubic meters of gasoline.

The modeling of the land use change of the 8166.52 hectares will be managed as follows:

(I) 8167 ha *of Marabu to Perennial/Tree Crop*. Without project only 1862 ha will be converted to forest plantation, with project all the 8167 ha will be converted after Marabu is removed.
(II) Hedgerow in about 5% of total area 408 ha will be installed with project and only 90 ha without project.
(III) Baseline scenario: Without the project, 6207 hectare will remain set aside and 1960 will be intervened.

Step by Step Ex-ACT modelling:

MARFOM 1: Marabu to forest plantation

5.1 Land use change module

AEZ map | Zone 1 = Tropical rain forest | Zone 2 = Tropical moist deciduous forest | Zone 3 = Tropical dry forest | Zone 4 = Tropical shrubland

Type of vegetation that will be deforested	HWP# (tDM/ha)	Fire Use? (y/n)	Final use after deforestation	Forested area (ha) Start	Without	*	With	*	Deforested area (ha) Without	With	Total Emissions (tCO2-eq) Without	With	Balance
Forest Zone 4	0	NO	Perennial/Tree Crop	7758.19	5896.2274	D	0	D	1862	7758	146,102	608,760	462,657
Forest Zone 4	0	NO	Perennial/Tree Crop	408.326	310.32776	D	0	D	98	408	7,690	32,040	24,350
Select the vegetation	0	NO	Select Use after deforestation	0	0	D	0	D	0	0	0	0	0
Select the vegetation	0	NO	Select Use after deforestation	0	0	D	0	D	0	0	0	0	0
Select the vegetation	0	NO	Select Use after deforestation	0	0	D	0	D	0	0	0	0	0
Select the vegetation	0	NO	Select Use after deforestation	0	0	D	0	D	0	0	0	0	0
Select the vegetation	0	NO	Select Use after deforestation	0	0	D	0	D	0	0	0	0	0
Select the vegetation	0	NO	Select Use after deforestation	0	0	D	0	D	0	0	0	0	0
									Total Deforestation		153,792	640,800	487,008

#Harvested Wood Products

* Note concerning dynamics of change : "D" corresponds to default/linear, "I" to immediate and "E" to exponential (Please refer to the guidelines)

Tier 2

5.2. Coefficients in the LUC

All values are in t of carbon per ha (tC/ha)

Type of vegetation that will be deforested	Above-ground Default	Tier 2	Below-ground Default	Tier 2	Litter Default	Tier 2	Dead wood Default	Tier 2	Soil carbon Default	Tier 2
Forest Zone 1	141.0		52.2		3.7		0.0		65.0	
Forest Zone 2	103.4		24.8		3.7		0.0		65.0	
Forest Zone 3	98.7		27.6		3.7		0.0		65.0	
Forest Zone 4	37.6	19.6	15.0	4.4	3.7	0.0	0.0	0.0	65.0	28.0

5.3 Crop Production module

3.2.1. Perennial systems from other LU or converted to other LU (please fill step 2.LUC previously)

Description	Residue/ biomass burning	Yield (t/ha/yr)	Area (ha) Start	Without	With	Total Emissions (tCO2-eq) Without	With	Balance
Perennial after Deforestation	NO		0	1,960	8,167	-413,585	-1,723,272	-1,309,687
Converted to A/R	NO		0	0	0	0	0	0
Perennial after non-forest LU	NO		0	0	0	0	0	0
Converted to OLUC	NO		0	0	0	0	0	0

5.4 Coefficient for perennial

Back

Use this part only if you want to refine the analysis with Tier 2 coefficients.
(default values are provided for your information only, while EX-ACT will use Tier 2 values automatically wherever specified)

Systems	Above-ground Growth rate (t C/ha/yr)		Below-ground Growth rate (t C/ha/yr)		Rates of soil C sequestration (t CO2/ha/yr)		Burning (quantity of residues and periodicity) Main season crop		Periodicity (yr)	
Perennial systems from (or to) other LU	Default	Tier 2	Default	Tier 2	Default	Tier 2	Default	Tier 2	Default	Tier 2
Perennial after Deforestation	2.6	3.4	0		0.7		10		1	
Converted to A/R	0		0		0.7		10		1	
Perennial after non-forest LU	2.6		0		0.7		10		1	
Converted to OLUC	0		0		0.7		10		1	

5.5 RESULTS

MARFOM per (ha/year) All GHG in Ton CO2 eq	CO2: CO2 Biomass	CO2: CO2 Soil	CO2: Inputs/investments	N2O	CH4
MARFOM total balance (Ton CO2 eq/year)	**-37549.659**	**-3584.286**	**527.046**	**0.000**	**0.000**

MARFON Component	**tonnes of CO2eq per year**	**tonnes of CO2eq in 7 years (project implementation)**	**tCO2eq in 20 years ecosystem equilibrium reached.**
Total	-40607	-284248	-812138

The plantation following the removal of marabu in 8167 ha is estimated to be able to sequester -40607 tCO2eq per year or -284248 tCO2eq for the entire duration of the project implementation.

5.5 Module 5: SILLEC- Silvopastoril system with arbustive leguminous

Objective: The establishment of sustainable silvopastoril systems in grassland areas affected by Marabu. The intervention focuses on improve the conditions of the grasslands and improve the cattle's feed availability.

Activities: The specific activities that will be carried out are the establishment of *Leucaena sp* and *Thithonia sp.* in double strips every 3 m. applying conservation tillage practices for the progressive introduction of more drought resistant and improved pastures varieties (*Panicum m., Penisetum purp. and Brachiaria x.).* A hedgerow will be installed with *Glyricidia sepium* trees and internal electric fence to regulate livestock grazing and to allow pasture recovery and soil conservation.

Inputs: Inputs include the use of 85 kWh/ha Electricity, 133 L/ha of diesel and 50 L/ha of gasoline.

Assumptions: The implementation of the module considers that all activities will improve the conditions of grasslands in 100% of the area. The without project scenario considers that conditions in 100% of the area of grasslands will remain moderately degraded. The number of cattle will remain the same: 2 heads/ha, it considers 20% of calves. Improving the cattle's feed availability, improves digestibility which impacts enteric emissions.

Modeling details: The activities under this module represent a grassland system remaining grassland system with the aim of improving the state of the degradation and include sustainable livestock production management.

Calculation on state of grasslands systems carbon factors: we use tier 2 emission factor from a previous soil study in Cuba that evaluates the soil carbon stocks in grasslands under good conditions and then from a base of 52.3 ton C/ha per ha minus 25.44% ton of C per ha impact of soil degradation we use for moderately degraded 38.99 ton C/ha

Calculation on Livestock: the factor emission of calves is 1.4 kg CH_4 per head per year, this was obtained from a study in México.[15]

Calculation of Hedgerow: applies tier 1 coefficient LUC from grassland to perennial.

Input calculations: Based on equation 3 the following inputs for exact were Ex-Act tool were 199.47 cubic meters of diesel and 74.99 cubic meters of gasoline.

The modeling of the state of the grasslands in 10,498.6 hectares was managed as follows:

(I) 8924 ha with better grassland management practices with project situation and only 2142 without project

(II) 524.93 ha of perennial tree stripes will be installed in with project situation and 126 without project situation.

(III) 1050 ha of silvopastoril system (Alley Crooping) will be installed in with project situation and only 252 without project situation.

(IV) The number of cattle will remain the same: 2 heads/ha, that represent 26,247 cows and 5249 calves, assumes 20% for stocking. Feeding practices will be improved 100% with project. Feeding practices will improved by 100% in with project and 24% in without project.

(V) Baseline scenario: Without the project, 6782 ha will remain moderately degraded. No Improve feed production and livestock will remain the same as for the initial situation. No hedgerow will be installed in this area.

Step by Step Ex-ACT modelling:

SILLEC 1: Silvopastoril system with arbustive leguminous *(please referred to the Excel spreadsheet as the constrast of the color in the tool makes it hard to ready the copy*)

6.1 LUC other

2.3. Other Land Use Changes

Fill with your description	Initial land use		Final land use	Message	Fire Use? (y/n)	Area transformed (ha) Without	*	With	*	Total Emissions (tCO2-eq) Without	With	Balance
Cercas Vivas	Grassland	→	Perennial/Tree Crop		NO	126	D	525	D	503	2,095	1,592
Sistemas silvopastoriles	Grassland	→	Perennial/Tree Crop		NO	252	D	1,050	D	-12,287	-51,195	-38,908
	Select Initial Land Use	→	Select Final Land Use	Fill initial LU	NO	0	D	0	D	0	0	0

6.2 Coefficient for LUC

[8]González-Avalos E. and L. G. Ruiz-Suárez, 1997. Modeling methane emissions from cattle in Mexico. Sci Total Environ. 1997 Nov 5;206(2-3):177-86. https://doi.org/10.1016/S0048-9697(97)80008-3

Use this part only if you want to refine the analysis with Tier 2 coefficients. All values are in t of carbon per ha (tC/ha/yr)
(default values are provided for your information only, while EX-ACT will use Tier 2 values automatically wherever specified)

Systems	Initial land use	Biomass Default	Biomass Tier 2	Soil carbon Default	Soil carbon Tier 2	Final land use	Biomass (1st year) Default	Biomass (1st year) Tier 2	Soil carbon Default	Soil carbon Tier 2	Belowground Default	Belowground Tier 2
Cercas Vivas	Grassland	7.6		65.0		Perennial/Tree Crop	0.47		72.2		0.11	
Sistemas silvopastoriles	Grassland	7.6		65.0		Perennial/Tree Crop	2.59		86.5		0.58	

6.3 Grassland and livestock module

Description	Initial State	Final state of the grassland: Without project	Final state of the grassland: With project	Fire use to manage? Periodicity (Without) (y/n)	(year)	Periodicity (With) (y/n)	(year)	Yield (t/ha/yr) Start	Withou	With	Area (ha) Start	Without	With	Total Emissions (tCO2-eq) Without	With	Balance
Grassland after Deforestation	Select state	Select state	Select state	NO	5	NO	5				0	0	0	0	0	0
Converted to A/R	Select state	Select state	Select state	NO	5	NO	5				0	0	0	0	0	0
Grassland after non-forest LU	Select state	Select state	Select state	NO	5	NO	5				0	0	0	0	0	0
Converted to OLUC	Moderately Degraded	Moderately Degraded	Improved with inputs improvement	NO	5	NO	5				1,575	1,197	0	0	-13,440	-13,440

4.1.2. Grassland systems remaining grassland systems (total area must remain contant)

Fill with your description	Initial State	Final state of the grassland: Without project	Final state of the grassland: With project	Fire use to manage? Periodicity (Without) (y/n)	(year)	Periodicity (With) (y/n)	(year)	Yield (t/ha/yr) Start	Withou	With	Area (ha) Start	Without	*	With	*	Total Emissions (tCO2-eq) Without	With	Balance
76%	Moderately Degraded	Moderately Degraded	Improved with inputs improvement	NO	5	NO	5				6,782	6,782	D	6,782	D	0	-272,861	-272,861
24%	Moderately Degraded	Improved with inputs improvement	Improved with inputs improvement	NO	5	NO	5				2,142	2,142	D	2,142	D	-86,167	-86,167	0
	Select state	Select state	Select state	NO	5	NO	5				0	0	D	0	D	0	0	0
	Select state	Select state	Select state	NO	5	NO	5				0	0	D	0	D	0	0	0
	Select state	Select state	Select state	NO	5	NO	5				0	0	D	0	D	0	0	0
	Select state	Select state	Select state	NO	5	NO	5				0	0	D	0	D	0	0	0
	Select state	Select state	Select state	NO	5	NO	5				0	0	D	0	D	0	0	0
	Select state	Select state	Select state	NO	5	NO	5				0	0	D	0	D	0	0	0
	Select state	Select state	Select state	NO	5	NO	5				0	0	D	0	D	0	0	0
	Select state	Select state	Select state	NO	5	NO	5				0	0	D	0	D	0	0	0
Total Grassland Systems																-86,167	-372,467	-286,300

Tier 2

* Note concerning dynamics of change : "D" corresponds to default/linear, "I" to immediate and "E" to exponential (Please refer to the guidelines)

6.4 Coefficients for grasslands state

4.1. Grassland systems

Back

Use this part only if you want to refine the analysis with Tier 2 coefficients.
(default values are provided for your information only, while EX-ACT will use Tier 2 values automatically wherever specified)

Corresponding soil C stocks (tC/ha)	Default	Tier 2
Non degraded	65.0	
Severely Degraded	45.5	
Moderately Degraded	62.4	39.0
Improved without inputs management	75.4	
Improved with inputs improvement	83.7	52.3

	Default	Tier 2
Above-ground: Main season crop (tC/ha)	6.2	
Combustion (%)	77%	

6.5 *The Livestock module*

4.2. Livestock (and manure management)

Livestock categories	Head number (mean per year) Start	Without project	*	With project	*	Feeding practices* Start	Without	With	Specific Agents* Start	Without	With	Breeding* Start	Withou	With	Production (meat, milk, etc) in tonnes of product per year Start	Without	With	Total Emissions (tCO2-eq) Without	With	Balance
Dairy cattle	26,247	26,247	D	26,247	D	0%	24%	100%	0%	0%	0%	0%	0%	0%				3,176,901	3,008,382	-168,518
Other cattle	5,249	5,249	D	5,249	D	0%	0%	0%	0%	0%	0%	0%	0%	0%				48,228	48,228	0
Buffalo	0	0	D	0	D	0%	0%	0%	0%	0%	0%	0%	0%	0%				0	0	0
Sheep	0	0	D	0	D	0%	0%	0%	0%	0%	0%	0%	0%	0%				0	0	0

Technical mitigation option (%)

6.6 Coefficients for livestock

Livestock categories	Enteric fermentation (kg CH4 per head/yr) Default	Tier 2 Start	Tier 2 Without	Tier 2 With	% correspondings to pasture, range and paddock systems Default	Tier 2 Start	Tier 2 Without	Tier 2 With	Methane from manure management (kg CH4 per head/yr) Default	Tier 2 Start	Tier 2 Without	Tier 2 With
Dairy cattle	63				36%				1.00			
Other cattle	56	1.4	1.4	1.4	99%				1.00			

6.7 The perennial module- grass production

3.2.1. Perennial systems from other LU or converted to other LU (please fill step 2.LUC previously)

Description	Residue/ biomass burning	Yield (t/ha/yr)	Area (ha) Start	Without	With	Total Emissions (tCO2-eq) Without	With
Perennial after Deforestation	NO		0	0	0	0	0
Converted to A/R	NO		0	0	0	0	0
Perennial after non-forest LU	NO		0	378	1,575	-50,333	-209,720
Converted to OLUC	NO		0	0	0	0	0

6.8 coefficient perennial production

For perennial system coming from grasslands, croplands, forestry and plantations, the response ratio Flu (dimension less is used). Refer to Cardinael et al 2018 for further details.
For hedgerow, above-ground and below-ground biomass growth rate are given in tC/km/yr

Systems	Above-ground Growth rate (t C/ha/yr)		Below-ground Growth rate (t C/ha/yr)		Rates of soil C sequestration (t CO2/ha/yr)		Burning (quantity of residues and periodicity) Main season crop		Periodicity (yr)	
Perennial systems from (or to) other LU	Default	Tier 2	Default	Tier 2	Default	Tier 2	Default	Tier 2	Default	Tier 2
Perennial after Deforestation					0.70		10.00		1	
Converted to A/R	0.00		0.00		0.70		10.00		1	
Perennial after non-forest LU					0.70		10.00		1	
Converted to OLUC	0.00		0.00		0.70		10.00		1	
Perennial syst. remaining perennial syst.										

6.9 Results

	CO_2				
SILLEC per (ha/year) All GHG in Ton CO2 eq	CO2 Biomass	CO2 Soil	Inputs/investments	N2O	CH4
SILLEC total balance (Ton CO2 eq/year)	**-5969.634**	**-16707.518**	**507.598**	**0.000**	**-777.587**

SILLEC Component	**tonnes of CO2eq per year**	**tonnes of CO2eq in 7 years (project implementation)**	**tCO2eq in 20 years ecosystem equilibrium reached.**
Total	-22947	-160630	-458943

The silvopasture systems 10,499 ha could sequester -22,947 tCO2eq per year or -160630 for the entire duration of the project implementation.

5.6 Module 6: SILSOM- Silvopasture with shadow trees and protein Banks

Objective: The establishment of sustainable silvopastoril systems in grassland areas affected by Marabu. The intervention focuses on improve the conditions of the grasslands, establishing a protein food bank to improve cattle's feed quality and availability and to reduce temperature stress due to the shade provided by the trees in the silvopastoral systems. The grasses can also be harvested for energy if deemed appropriate.

Activities: The activities that will be carried out are the Introduction of more drought resistant varieties (*Panicum m. Brachiaria brizantha*) in combination with 30 shade trees / ha (*Samanea saman*) applying conservation tillage to improve pastures. A contour fencing (*Glyricidia, Bursera, Spondias*), grazing rotation and establishment of a protein (Thitonia, Morera, Moringa sp.) and energy (Pennisetum x., Sacharum) "banks" on 15% of the area as feed reserves to be cut and harvested in the dry periods.

Inputs: Inputs include the use of fertilizers NPK 389.85 ton, electricity65 kWh, diesel 367 L/ha and 50 L/ha gasoline.

Assumptions: The implementation of the module considers that all activities will improve the conditions of grasslands in 100% of the area. The without project scenario considers that conditions in 100% of the area of grasslands will remain moderately degraded. The number of cattle will remain the same: 2 heads/ha, it considers 20% of calves. Improving the cattle's feed availability, improves digestibility and that impact directly in enteric emissions. We assume that the priority use of grasses will be for feed rather than energy consumption.

Modeling details: The activities under this module represent a grassland system remaining grassland system improving the state of the degradation and include livestock management.

Calculation on state of grasslands systems carbon factors: we use tier 2 emission factor from a previous soil study in Cuba that evaluates the soil carbon stocks in grasslands under good conditions and then from a base of 52.3 ton C/ha per ha minus 25.44% ton of C per ha impact of soil degradation we use for moderately degraded 38.99 ton C/ha, as previously referenced.

Calculation on Livestock: the factor emission of calves is 1.4 kg CH4 per head per year, this was obtained from a study in México as previously referenced.

Calculation of Hedgerow: applies tier 1 coefficient LUC from grassland to perennial.

Inputs calculation: Using equation 1,2 and 3 the following are calculated 89.98 MWh for electricity 508.10 cubic meters of diesel and 69.22 cubic meters of gasoline and N 4 tons per year, P2O5 6 tons per year and K2O 8 tons per year.

The modeling of the state of the grasslands in 9,691.2 hectares will be managed as follows:

(VI) Planting forest trees (Silvopastures) on 25% of 9,691.2 ha= 2422.8ha, hedgerow on 5% of 9691.2 ha=485 ha. The project focuses on improving the conditions for the cattle's and soil, reduced temperature stress due to the shade provided by the trees in the silvopastoral systems with 30 shades trees/ha. The number of cattle will remain the same: 2 heads/ha

(VII) Protein/energy banks on 15% of 9,691.2 ha= 1454 ha, this bank will improve the conditions of the soil (level of degradation) and the cattle´s feed availability.

(VIII) Baseline scenario: Without the project, 4,051 ha will remain moderately degraded. No grassland management and feeding practices will be improved and the number of livestock will remain the same as for the initial situation. There will be no protein/energy banks.

Step by Step Ex-ACT modelling:

SILSOM 1: Silvopasture with shadow trees and protein Banks

SILSOM 1: Silvopasture

7.1 Land use change

2.3. Other Land Use Changes

Fill with your description	Initial land use		Final land use	Message	Fire Use? (y/n)	Area transformed (ha) Without	*	With	*	Total Emissions (tCO2-eq) Without	With	Balance
Silvopastoril	Grassland	⟶	Perennial/Tree Crop		NO	581	D	2,423	D	-13,049	-54,372	-41,323
Hedgegrow	Grassland	⟶	Perennial/Tree Crop		NO	116	D	485	D	1,105	4,606	3,501
Protein bank	Degraded Land	⟶	Annual Crop		NO	349	D	1,454	D	-12,783	-53,262	-40,479
	Select Initial Land Use	⟶	Select Final Land Use	Fill initial LU	NO	0	D	0	D	0	0	0

7.2 Coefficients Land use changes

Use this part only if you want to refine the analysis with Tier 2 coefficients. **All values are in t of carbon per ha (tC/ha/yr)**

(default values are provided for your information only, while EX-ACT will use Tier 2 values automatically wherever specified)

Systems	Initial land use	Biomass Default	Biomass Tier 2	Soil carbon Default	Soil carbon Tier 2	Final land use	Biomass (1st year) Default	Biomass (1st year) Tier 2	Soil carbon Default	Soil carbon Tier 2	Belowground Default	Belowground Tier 2
Silvopastoril	Grassland	7.6		47.0		Perennial/Tree Crop	2.91		58.8		0.79	
Hedgegrow	Grassland	7.6		47.0		Perennial/Tree Crop	0.47		52.2		0.11	
Protein bank	Degraded Land	1.0		15.5		Annual Crop	5.00		22.6		0.00	

7.3 Grassland and livestock module

4.1.1. Grassland systems from other LU or converted to other LU (please fill step 2.LUC previously)

Description	Initial State	Final state of the grassland: Without project	Final state of the grassland: With project	Fire use to manage? Periodicity (Without) (y/n)	Periodicity (Without) (year)	Periodicity (With) (y/n)	Periodicity (With) (year)	Yield (t/ha/yr) Start	Yield Withou	Yield With	Area (ha) Start	Area Without	Area With	Total Emissions (tCO2-eq) Without	Total Emissions With	Balance
Grassland after Deforestation	Select state	Select state	Select state	NO	5	NO	5				0	0	0	0	0	0
Converted to A/R	Select state	Select state	Select state	NO	5	NO	5				0	0	0	0	0	0
Grassland after non-forest LU	Select state	Select state	Select state	NO	5	NO	5				0	0	0	0	0	0
Converted to OLUC	Moderately Degraded	Moderately Degraded	Improved with inputs improvement	NO	5	NO	5				2,907	2,210	0	0	-21,203	-21,203

4.1.2. Grassland systems remaining grassland systems (total area must remain contant)

Fill with your description	Initial State	Final state of the grassland: Without project	Final state of the grassland: With project	Fire use to manage? Periodicity (Without) (y/n)	Periodicity (Without) (year)	Periodicity (With) (y/n)	Periodicity (With) (year)	Yield (t/ha/yr) Start	Yield Withou	Yield With	Area (ha) Start	Area Without	Area With	Total Emissions (tCO2-eq) Without	Total Emissions With	Balance
76 Intervention project	Moderately Degraded	Moderately Degraded	Improved with inputs improvement	NO	5	NO	5				4,051	4,051 D	4,051 D	0	-167,412	-167,412
24% intervention without proj	Moderately Degraded	Improved with inputs improvement	Improved with inputs improvement	NO	5	NO	5				1,279	1,279 D	1,279 D	-52,867	-52,867	0

7.4. Coefficients for grasslands state

4.1. Grassland systems

Back

Use this part only if you want to refine the analysis with Tier 2 coefficients.
(default values are provided for your information only, while EX-ACT will use Tier 2 values automatically wherever specified)

Corresponding soil C stocks (tC/ha)	Default	Tier 2
Non degraded	65.0	
Severely Degraded	45.5	
Moderately Degraded	62.4	39.0
Improved without inputs management	75.4	
Improved with inputs improvement	83.7	52.3

Above-ground	**Main season crop** Default	Tier 2
(tC/ha)	6.2	

Combustion	% Default	Tier 2
	77%	

7.5 *The Livestock module*

4.2. Livestock (and manure management)

Livestock categories	Head number (mean per year) Start	Without project		With project		Feeding practices* Start	Feeding Without	Feeding With	Specific Agents* Start	Specific Without	Specific With	Breeding* Start	Breeding Withou	Breeding With	Production (meat, milk, etc) in tonnes of product per year Start	Production Without	Production With	Total Emissions (tCO2-eq) Without	Total Emissions With	Balance
Dairy cattle	19,382	19,382	D	19,382	D	0%	24%	100%	0%	0%	0%	0%	0%	0%				789,514	777,682	-11,832
Other cattle	3,876	3,876	D	3,876	D	0%	0%	0%	0%	0%	0%	0%	0%	0%				139,435	139,435	0
Buffalo	0	0	D	0	D	0%	0%	0%	0%	0%	0%	0%	0%	0%				0	0	0

Technical mitigation option (%)

7.6 coefficient for livestock

Livestock categories	Enteric fermentation (kg CH4 per head/yr) Default	Tier 2 Start	Tier 2 Without	Tier 2 With	% correspondings to pasture, range and paddock systems Default	Tier 2 Start	Tier 2 Without	Tier 2 With	Methane from manure management (kg CH4 per head/yr) Default	Tier 2 Start	Tier 2 Without	Tier 2 With
Dairy cattle	63				36%				1.00			
Other cattle	56	1.4	1.4	1.4	99%				1.00			

7.7. The land use change grassland to perennial and annual module

3.1.1. Annual systems from other LU or converted to other LU (please fill step 2.LUC previously)

Description	Main season crop	Management options: Improved agronomic practices	Nutrient management	No till & residue retention	Water management	Manure application	Residue management	Yield (t/ha/yr)	Area (ha) Start	Area Without	Area With	Total Emissions (tCO2-eq) Without	Total Emissions With
Annual after Deforestation	Default	?	?	?	?	?	Please select		0	0	0	0	0
Converted to A/R	Default	?	?	?	?	?	Please select		0	0	0	0	0
Annual after non-forest LU	Default	Yes	Yes	?	?	?	Please select		0	349	1,454	-5,219	-21,747
Converted to OLUC	Default	?	?	?	?	?	Please select		0	0	0	0	0

Definitions? Yield?

3.2.1. Perennial systems from other LU or converted to other LU (please fill step 2.LUC previously)

Description	Residue/ biomass burning	Yield (t/ha/yr)	Area (ha) Start	Area Without	Area With	Total Emissions (tCO2-eq) Without	Total Emissions With
Perennial after Deforestation	NO		0	0	0	0	0
Converted to A/R	NO		0	0	0	0	0
Perennial after non-forest LU	NO		0	698	2,907	-105,678	-440,325
Converted to OLUC	NO		0	0	0	0	0

7.8 RESULTS

SILSOM- Silvopasture with shadow trees and protein Banks_Results

	CO_2				
SILSOM per (ha/year) All GHG in Ton CO2 eq	CO2 Biomass	CO2 Soil	Inputs/investments	N2O	CH4
SILSOM total balance (Ton CO2 eq/year)	**-15258.336**	**-16716.498**	**1010.323**	**12.797**	**-574.218**

SILLOM Component	tonnes of CO2eq per year	tonnes of CO2eq in 7 years (project implementation)	tCO2eq in 20 years ecosystem equilibrium reached.
Total	-31526	-220682	-630519

The 9,691.2 ha of silvopature with shade trees could sequester -31, 526 tCO2eq per year or -220682 tCO2eq for the entire duration of the project implementation.

6. Results

12. **Net carbon balance.** The net carbon balance quantifies GHGs emitted or sequestered resulting from the project compared to the "without project" (BAU) scenario. In this case results indicate that the project constitutes a carbon sink of -2,675,726.65 million tCO2-eq in 20 years. Without the project Cuba will be limited to intervene only in 24% of the area proposed based on previous budget support in of similar projects, thus reducing the scalability of the interventions. This indicates that the project can also have an important contribution in mitigation which complements the adaptation and resilience objectives sought by the project.

Table 5. Summary of Results Mitigation Impact per module

Module	tonnes of CO2eq per year	tonnes of CO2eq in 7 years (project implementation)	tCO2eq in 20 years ecosystem equilibrium reached.
CEDPLA	-7704	-53928	-154081
FRUAGR	-784	-284248	-15687
MARFON	-40607	-284248	-812138
MARREG	-30218	-211526	-604359
SILLEC	-22947	-160630	-458943
SILLOM	-31526	-220682	-630519
TOTAL			**(2,675,726.65)**

13. According to table 6, the sinks from CO2 absorption from biomass, and soil have a significant contribution. Improvements in feeding practices help generate an absorption from enteric methane.

Table 6: Summary of GHG contribution.

Green house gases according to sources in Ton CO2 equivalent per ha per year					
	CO_2			N2O	CH4
Module	CO2 Biomass	CO2 Soil	Inputs/investments		
CEDPLA total balance (Ton CO2 eq/year)	-5105	-404	57	198	0
FRUGAR total balance (Ton CO2 eq/year)	-574	-674	374	86	0
MARREG total balance (Ton CO2 eq/year)	-27509	-2922	214	0	0
MARFOM total balance (Ton CO2 eq/year)	-37550	-3584	527	0	0
SILLEC total balance (Ton CO2 eq/year)	-5970	-16708	508	0	-778
SILSOM total balance (Ton CO2 eq/year)	-15258	-16716	1010	13	-574
Totales	**-91966.5**	**-41008.2**	**2689.3**	**296.8**	**-1351.8**

14. Sensitivity analysis. This is an ex ante analysis and was done under very conservative assumptions to minimize the overestimation of benefits. It will be important to closely monitor the assumptions made during project implementation to truly assess the impact of the project on the ground.