

Annex 22. A. PREFOREST GHG calculation methodology

The calculation methodology of the GHG emission reduction was developed considering different source of information, assumptions and specific formulas taking into consideration PREFOREST's components and characteristic.

Climate additionally of the project:

The emission reductions will not be possible without the support of the GCF as the Government of The Republic of Congo does not have the capacity to allocate the required funding for the project implementation. Similar project have been implemented in the past only with concessional financing¹. The main objective of the Project is climate change mitigation in the form of reduced carbon emissions from land use, land-use change and forestry (LULUCF). The Project activities funded by the GCF will contribute to the reduction of carbon emissions specifically through: (a) The deployment of agroforestry and forestry systems to stabilize slash-and-burn agriculture and reduce pressure on forests and (b) Assisted natural regeneration and protection of forests. These interventions will result in a direct reduction in emissions of approximately 0.84 million tonnes of CO₂ equivalent (t CO₂ eq) per year which is a total of 6.72 million t CO₂ eq over an 8-year period. The Project will assist in establishing low carbon agroforestry and forestry systems over an area of 10,000 ha, as well as assisted natural regeneration and protection in savanna-forest transition areas and more specifically on community land which is subject to severe anthropic pressure from slash-and-burn agriculture.

A. Scope of the carbon accounting considering PREFOREST's components

Project Component	Scope of carbon accounting	
Component 1. Land-use and resources planning and strengthening of land access and security rights		
Output 1.1: Land access and security rights of beneficiaries strengthened and Output 1.2: Other enabling actions in place	Carbon removal	Avoided emissions
Activity 1.2.2. Participatory mapping		
1. Establishment of agroforestry/forestry systems	Carbon sequestered as a result of an increase in forest biomass from the establishment of agroforestry/forestry systems	Emissions avoided as a result of the availability of new source for fuelwood from the establishment of agroforestry/forestry systems, shifting fuelwood collection away from natural forests.

¹ Such as the 65M grant provided by CAFI for forestry activities in Congo

2. Sustainable management of forest land		Emissions avoided as a result of the introduction of sustainable management practices with reduced emissions.
Component 2: Deployment of climate-resilient agroforestry and forestry systems		
Output 2.1. Fast start forestry systems for energy purpose are established	Carbon removal	Avoided emissions
<i>Activity 2.1.1. Provision of technical assistance for the establishment of fast start forestry systems for energy purposes</i>		
1. Establishment of fast-start forestry systems	Carbon sequestered as a result of an increase in forest biomass from the establishment of fast-start forestry systems for energy	Emissions avoided as a result of the availability of new source for fuelwood from the establishment of fast-start forestry systems, shifting fuelwood collection away from natural forest
Output 2.2. Low emission, climate-resilient agroforestry and forestry systems established	Carbon removal	Avoided emissions
<i>Activity 2.2.2. Establishment of agroforestry and forestry systems</i>		
1. Establishment of agroforestry and forestry systems	Carbon sequestered as a result of an increase in forest biomass from the establishment of forestry and agroforestry systems	Emissions avoided as a result of the availability of new source for fuelwood from the establishment of agroforestry/forestry systems, shifting fuelwood collection away from natural forests.
Output 2.3. Nurseries are rehabilitated and forest are restored	Carbon removal	Avoided emissions

Activity 2.3.2. Deployment of Assisted natural regeneration		
1. Restoration of degraded forest land	Carbon sequestered as a result of an increase in forest biomass from tree plantations for the restoration of degraded forest land.	N/A

B. Calculation formula for carbon accounting

Based on areas indicated for conversion in table B and also considering vegetation characteristics and details indicated in other parts, the GHG balance in CO₂-eq is calculated for the biomass and soil pool and emissions from fire consistently with the IPCC 2006 Guidelines for National Greenhouse Gas Inventories (IPCC, 2006) specifically Volume 4 (Agriculture, Forestry and Other Land Use), Chapter 2 (Generic Methodologies Applicable to Multiple Land Use Categories)

$$GHGBalance = \Delta C_G + \Delta C_{soil} + L_{fire}$$

For the biomass pool, we used Equation 2.9

$$\Delta C_G = \sum_k A_k \times G_{TOTAL} \times CF$$

ΔC_G = annual increase in biomass carbon stocks, given vegetation type and climatic zone (tC.yr⁻¹)

A_k = area of land converted following the index k (ha)

G_{TOTAL} = mean annual biomass growth (tDM.ha⁻¹.yr⁻¹)

CF = carbon fraction of dry matter (tC.tDM⁻¹)

For the soil pool, we used Equation 2.25

$$\Delta C_{soil} = \frac{(SOC_0 - SOC_{0-T})}{D}$$

SOC_0 = soil organic carbon stock in the last year of the project, tC

$SOC_{(0-T)}$ = soil organic carbon stock at the beginning of the project, tC

SOC_0 and $SOC_{(0-T)}$ are calculated using the SOC equation in the box where the reference carbon stocks and stock change factors are assigned according to the land-use and management activities and corresponding areas at each of the points in time (time = 0 and time = 0-T)

T = number of years of the project (yr)

D = Time dependence of stock change factors which is the default time period for transition between equilibrium SOC values (yr). Default 20 yr

c = represents the climate zones, s the soil types, and i the set of management systems that are present in a country.

SOC_{REF} = the reference carbon stock, tC.ha⁻¹ (default values)

FLU = stock change factor for land-use systems or sub-system for a particular land-use, dimensionless

FMG = stock change factor for management regime, dimensionless

FI = stock change factor for input of organic matter, dimensionless

A = land area of the stratum being estimated (ha).

For the emission from fire, we used Equation 2.27

$$L_{fire} = A \times M_B \times C_f \times G_{ef} \times 10^{-3}$$

L_{fire} = amount of greenhouse gas emissions from fire, tonnes of each GHG e.g., CH₄, N₂O.

A = area burnt (ha)

M_B = mass of fuel available for combustion (t.ha⁻¹)

C_f = combustion factor, dimensionless (default values)

G_{ef} = emission factor, g.kg⁻¹ dry matter burnt (default values)

Project Component	Calculation formula for carbon accounting	
Component 1. Land-use and resources planning and strengthening of land access and security rights		
Output 1.1: Land access and security rights of beneficiaries strengthened and Output 1.2: Other enabling actions in place	Carbon removal	Avoided emissions
Activity 1.2.2. Participatory mapping		
1. Establishment of agroforestry/forestry systems	<ul style="list-style-type: none">• Area of annual crop and grassland converted to forest plantation with project interventions;• Area of annual crop and grassland converted to perennial/tree crop;• Area of non-forest land use converted to perennial (agroforestry, tree crops, etc.);• Area of other land use converted to annual systems after deforestation or to afforestation/reforestation or to other land use.	Area of forest non converted into annual crops with project interventions.
2. Sustainable management of forest land		Area of degraded forest land managed/restored.
Component 2: Deployment of low-emission climate-resilient agroforestry and forestry systems		
Output 2.1. Fast start forestry systems for energy purpose are established	Carbon removal	Avoided emissions

Activity 2.1.1. Provision of technical assistance for the establishment of fast start forestry systems for energy purposes		
1. Establishment of fast-start forestry systems	<ul style="list-style-type: none"> • Area of annual crop and grassland converted to forestry systems with project interventions; • Area of annual crop and grassland converted to perennial/tree crop; • Area of non-forest land use converted to perennial (agroforestry, tree crops, etc.); • Area of other land use converted to annual systems after deforestation or to afforestation/reforestation or to other land use. 	Area of forest non-converted into annual crops with project interventions.
Output 2.2. Low emission, climate-resilient agroforestry and forestry systems established	Carbon removal	Avoided emissions
Activity 2.2.2. Establishment of agroforestry and forestry systems		
1. Establishment of agroforestry and forestry systems	<ul style="list-style-type: none"> • Area of annual crop and grassland converted to forest plantation with project interventions; • Area of annual crop and grassland converted to perennial/tree crop; • Area of non-forest land use converted to perennial (agroforestry, tree crops, etc.); 	Area of forest non-converted into annual crops with project interventions.

	<ul style="list-style-type: none"> Area of other land use converted to annual systems after deforestation or to afforestation/reforestation or to other land use. 	
Output 2.3. Nurseries are rehabilitated and forest are restored	Carbon removal	Avoided emissions
Activity 2.3.2. Deployment of Assisted natural regeneration		
1. Restoration of degraded forest land	<ul style="list-style-type: none"> Area of annual crop and grassland converted to forest plantation with project interventions; Area of annual crop and grassland converted to perennial/tree crop; Area of non-forest land use converted to perennial (agroforestry, tree crops, etc.); Area of other land use converted to annual systems after deforestation or to afforestation/reforestation or to other land use. 	N/A

C. Assumptions for estimating emissions removal and avoided

C.1 General Assumptions

Parameters	Value	Source	Note
Implementation phase	8 years	Assumption	
Capitalization phase	12 years	Assumption	
Duration of accounting	20 years	Assumption	

Total project area	50,992 ha (~ 4% forest area in the 13 target districts)	GIS estimate	4,148 ha of avoided deforestation 55,431 ha of reduced degradation 10,900 ha of Mampu system 1,900 ha of Cocoa 1,700 ha of Avocado/Orange
Average area of deforestation in the project area per year	1,037 ha (8,296 ha for 8 years)	CNIAF	
Area of forest (Forest zone 1: Tropical rain forest) converted to annual crop deforestation with the project – slash and burn during conversion	4,148 ha	Assumption	
Area of forest (Forest zone 1: Tropical rain forest) converted to annual crop deforestation without the project	8,296 ha	Assumption	
Improvement of canopy from assisted natural regeneration (5,000 ha) in remaining forest area	9%	Assumption	
Area of annual crop converted to plantation zone 1	5,450 ha	Assumption	
Area of grassland converted to plantation zone 1	5,450 ha	Assumption	
Area of annual crop converted to perennial/tree crop	566 ha	Assumption	
Area of degraded land converted to perennial/tree crop	566 ha	Assumption	
Area of grassland converted to perennial/tree crop	566 ha	Assumption	
Forest zone 1 above-ground biomass	101.7 tC/ha	We used the national averaged ecosystem carbon stock provided by the Forest Reference	Ex-Act Tier 2
Forest zone 1 below-ground biomass	37.6 tC/ha		Ex-Act Tier 2
Forest zone 1 deadwood	0.4 tC/ha		Ex-Act Tier 2

		Emissions Level (FREL) ² , referenced in Table 9	
Area of annual system after deforestation with residue burned without the project	8,296 ha	Assumption	
Area of annual system after deforestation with residue burned with the project	4,148 ha	Assumption	
Area of annual system converted to A/R with residue burned at the start of the project	5,450 ha	CNIAF	
Area of annual system converted to A/R with residue burned without the project	5,450 ha	Assumption	
Area of annual system converted to A/R with residue burned with the project	0 ha	Assumption	
Area of perennial systems after non-forest land use without the project	0 ha	CNIAF	
Area of perennial systems after non-forest land use with the project	1,700 ha	Assumption	
Area of perennial systems remaining perennial systems – old cocoa plantations – at the start of project	1,900 ha	CNIAF	
Area of perennial systems remaining perennial systems – old cocoa plantations – without the project	1,900 ha	CNIAF	
Area of perennial systems remaining perennial systems – renewal of old cocoa plantations – with the project	1,900 ha	We assume new plantations growing two times faster than old plantations	Cardinael et al., 2018
Above-ground growth rate for old cocoa plantations	0.9 tC/ha/year	We use the growth rate provided by the FREL	Ex-Act Tier 2
Below-ground growth rate for old cocoa plantations	0.2 tC/ha/year		Ex-Act Tier 2
Rate of soil carbon sequestration	0.4 tC/ha/year		Ex-Act Tier 2
Area of Forest zone 1 vegetation type degraded without the project	55,431 ha	We assume large level of degradation	

² FREL for Republic of Congo, 2017.

Area of Forest zone 1 vegetation type degraded with the project	55,431 ha	We assume low level of degradation	
Forest zone 1 above-ground degradation	101.7 tC/ha	We used degradation rate provided by the FREL	Ex-Act Tier 2
Forest zone 1 below-ground degradation	37.6 tC/ha		Ex-Act Tier 2
Forest zone 1 deadwood	0.4 tC/ha		Ex-Act Tier 2
Quantity of limes applied without the project	0 t/year	Assumption	
Quantity of limes applied with project	200 t/year	Assumption	
Quantity of fertilizers (NPK 15, 15, 15) applied without the project	0 t/year	Assumption	
Quantity of fertilizers (NPK 15, 15, 15) applied with project	54 t/year	Assumption	
Quantity of pesticides (fungicide and insecticide) applied without the project	0 t/year	Assumption	
Quantity of pesticides (fungicide and insecticide) applied with the project	4 t/year	Assumption	
Quantity of energy (gasoil, diesel) consumed without the project	0 m³/year		
Quantity of energy (gasoil, diesel) consumed with the project	15 m³/year	Assumption	
Quantity of wood (dry matter) consumed without the project	0 t/year	Assumption	
Quantity of wood (dry matter) consumed with the project	75,379 t/year	We assume that approximately 45 t/ha of wood (from acacia, eucalyptus, and cassia) will be removed from year 7 and after end of project capitalization.	

C.2 Emission factors for estimating avoided emissions

Component 1. Land-use and resources planning and strengthening of land access and security rights	Avoided emissions from deforestation - without project	Avoided emissions from deforestation - with project situation	Source
	tCO ₂ /ha	tCO ₂ /ha	
Output 1.1: Land access and security rights of beneficiaries strengthened and Output 1.2: Other enabling actions in place			Forest Reference Emissions Level (FREL) ³ , referenced in Tables 9 & 10
Activity 1.2.2. Participatory mapping	N/A	139.6	
1. Establishment of agroforestry and forestry systems	N/A	139.6	
2. Sustainable management of forest land	N/A	N/A	

Component 2: Deployment of climate-resilient agroforestry and forestry systems	Avoided emissions from deforestation - without project	Avoided emissions from deforestation - with project situation	Source
	tCO ₂ /ha	tCO ₂ /ha	
Output 2.1. Fast start forestry systems for energy purpose are established			Forest Reference Emissions Level (FREL) ⁴ , referenced in Tables 9 & 10
Activity 2.1.1. Provision of technical assistance for the establishment of fast start forestry systems for energy purposes	N/A	139.6	
1. Establishment of fast-start forestry systems	N/A	139.6	
Output 2.2. Low carbon, climate-resilient agroforestry and			

³ FREL for Republic of Congo, 2017.

⁴ FREL for Republic of Congo, 2017

forestry systems are established and operationalized			
Activity 2.2.3. Establishment of agroforestry and forestry systems	N/A	139.6	
1. Establishment of agroforestry and forestry systems	N/A	139.6	

D. Emission factors for estimating carbon removal

	Without project situation	With project situation	Source
	tCO ₂ /ha/yr	tCO ₂ /ha/yr	
Component 1. Land-use and resources planning and strengthening of land access and security rights			
Output 1.1: Land access and security rights of beneficiaries strengthened and Output 1.2: Other enabling actions in place			
Activity 1.2.2. Participatory mapping			
1. Establishment of agroforestry and forestry systems	27.6	53.48	IPCC, 2006
2. Sustainable management of forest land	27.6	53.48	

	Without project situation	With project situation	Source
	tCO ₂ /ha/yr	tCO ₂ /ha/yr	
Component 2. Deployment of low-emission climate-resilient agroforestry and forestry systems			
Output 2.1. Fast start forestry systems for energy purpose are established			
Activity 2.1.1. Provision of technical assistance for the establishment of fast start forestry systems for energy purposes			
1. Establishment of fast-start forestry systems	27.6	53.48	IPCC, 2006
Output 2.2. Climate-resilient agroforestry and forestry systems are established and operationalized			

Activity 2.2.4. Provision of technical assistance for the establishment of agroforestry and forestry systems			
1. Establishment of agroforestry and forestry systems	27.6	53.48	IPCC, 2006
Output 2.3. Nurseries are rehabilitated and forest are restored			
Activity 2.3.2. Deployment of Assisted natural regeneration			
1. Restoration of degraded forest land	27.6	53.48	IPCC, 2006

E. Summary: Aggregated calculation methodology

Component	Current situation	Area (ha)/#	Without project	With project	Quantification/ Assumptions	Reference
Component 1: Land-use and resources planning and strengthening of land access and security rights	Lack of land use and resource use planning	55,431 ha	Lack of resource use planning result into unsustainable use in ad hoc basis	The development and implementation of participatory mapping contribute to resource use planning and sustainable forest management	a) Calculations were done considering a scenario without and with the project b) Establishment of agroforestry and forestry systems will generate direct and indirect GHG impact	a) IPCC 2006 Guidelines for National Greenhouse Gas Inventories (IPCC, 2006) b) Forest Reference Emission Level (FREL, 2017)
			0 ha	Establishment of agroforestry systems and sustainable management of forest resources	Main assumptions: a) Direct impact around the project intervention area due to carbon removal from increasing forest biomass as a result of new agroforestry	

				<p>over an area of at least 1000 ha of community forests managed under participatory mapping</p>	<p>systems established and sustainable forest management.</p> <p>b) Indirect impact around the project area due to avoided emissions resulting from sustainable forest management practices and the availability of new source of fuelwood from forest plantations, shifting away from natural forests</p> <p>c) Carbon removal and avoided GHG emissions are estimated based on IPCC 2006 Guidelines for National Greenhouse Gas Inventories (IPCC, 2006) and Forest Reference Emission Level (FREL, 2017) for the Republic of Congo.</p> <ul style="list-style-type: none"> • Emission factor for carbon removal (Tier 1): 27.6 tCO₂/ha/yr (without the project); 53.48 tCO₂/ha/yr (with the project) • Emission factor for avoided emission (Tier 2): 139.6 tCO₂/ha/yr with the project. 	
--	--	--	--	--	--	--

Component 2: Deployment climate-resilient agroforestry and forestry systems	Limited awareness, lack of skills and experience in low emission agroforestry and forestry practices	14,500 ha	Lack of skills and resources for low emissions agroforestry and forestry practices result into carbon intensive agricultural practices	Technical and financial support to beneficiaries to establish low emission agroforestry and forestry systems help shift agricultural practices toward low carbon footprint	<ul style="list-style-type: none"> a) Calculations were done considering a scenario without and with the project b) Establishment of agroforestry and forestry systems will generate direct and indirect GHG impact 	<ul style="list-style-type: none"> a) IPCC 2006 Guidelines for National Greenhouse Gas Inventories (IPCC, 2006) b) Forest Reference Emission Level (FREL, 2017)
				<ul style="list-style-type: none"> a) ~ 2,700 ha of fast-start tree plantations for fuelwood established b) ~ 11,800 ha of agroforestry and forestry systems established 	<p>Main Assumptions:</p> <ul style="list-style-type: none"> a) Direct impacts around the project intervention area due to carbon removal from increasing forest biomass as a result of new agroforestry systems established b) The indirect impacts around the project area due to avoided emissions resulting from the availability of new source of fuelwood from forest plantations, shifting fuelwood collection away from natural forests c) Carbon removal and avoided GHG emissions are estimated based on IPCC 2006 Guidelines for National Greenhouse Gas Inventories (IPCC, 2006) and Forest Reference Emission Level (FREL, 2017) for the Republic of Congo 	

					<ul style="list-style-type: none"> Emission factor for carbon removal (Tier 1): 27.6 tCO₂/ha/yr (without the project); 53.48 tCO₂/ha/yr (with the project) Emission factor for avoided emission (Tier 2): 139.6 tCO₂/ha/yr with the project. 	
	Lack of skills and resources for land restoration	5,000 ha	Lack of skills and resources for land restoration result in high level vegetation degradation	<p>Technical and financial support for land restoration result in low level vegetation degradation</p> <p>5,000 ha of degraded vegetation restored</p>	<p>a) Calculations were done considering a scenario without and with the project</p> <p>b) Restoration of degraded vegetation will generate direct GHG impact</p> <p>Main Assumptions:</p> <p>a) Direct impacts around the project intervention area due to carbon removal from increasing forest biomass from restored vegetation</p> <p>b) Carbon removal is estimated based on IPCC 2006 Guidelines for National Greenhouse Gas Inventories (IPCC, 2006).</p> <ul style="list-style-type: none"> Emission factors for carbon removal (Tier 1): 27.6 tCO₂/ha/yr (without the project); 	a) IPCC 2006 Guidelines for National Greenhouse Gas Inventories

					53.48 tCO ₂ /ha/yr (with the project)	
--	--	--	--	--	--	--

Ex-Act Module 2.1. Deforestation

It is assumed that 8,296 ha will be deforested without the project and 4,148 ha with the project, and corresponding to avoided emissions of 2,406.54 tCO₂eq

Ex-Act module 2.2. Afforestation and reforestation

It is assumed no afforestation and reforestation without the project. With the project 5,450 ha of annual crop and 5,450 ha of grassland will be converted to plantations (agroforestry/forestry systems), corresponding to a carbon removal of 3,451,881 tCO₂eq and 3,009,870 tCO₂eq respectively.

Ex-Act module 2.3. Other land use changes

It is assumed that with the project, 566 ha each for annual crop, grassland and degraded land will be converted to perennial/tree crop with carbon removal of 43,023 tCO₂eq, 5,836 tCO₂eq, and 58,606 tCO₂eq respectively. There is no conversion without the project.

Ex-Act module 3.1.1. Annual systems from other land use

It is assumed that 8,296 ha will be converted to annual systems after deforestation without the project, and only 4,148 ha with the project corresponding to avoided emissions of 11,000 tCO₂eq. It is assumed that 5,450 ha of land converted to afforestation/reforestation will not be converted to annual systems with the project, corresponding to a sequestration of 14,453 tCO₂eq. It is also assumed that 566 ha of existing annual systems will not be converted to other land use with the project, corresponding to a sequestration of 1,503 tCO₂eq.

Ex-Act module 3.2.1. Perennial systems from other land use or converted to other land use

It is assumed that with the project, 1,700 ha will be converted to perennial after non-forest land use, corresponding to a sequestration of 363,828 tCO₂eq.

Ex-Act module 3.2.2. Perennial systems remaining perennial systems

It is assumed that with the project, 1,900 ha of new cocoa plantations will be established, corresponding to an overall sequestration of 273,195 tCO₂eq

Ex-Act module 5.1. Forest degradation and management

It is assumed that degradation level of the vegetation will be large on a forest area of 50,982 ha without the project, but low within the same area with the project. Carbon sequestration will be 7,546,958 tCO₂eq with the project.

Ex-Act module 7.1. Inputs

It is assumed that 190 ton of limestones will be used per year with the project corresponding total emissions of 3,901 tCO₂eq. It is assumed that 57 ton of fertilizers NPK will be used per year with the project, corresponding to total emissions of 4,071 tCO₂eq. It is assumed that 4 ton of pesticides will be use per year, corresponding to total emissions of 1,329 tCO₂eq.

Ex-Act module 7.2. Energy

It is assumed that 15 m³ of gasoline per year will be used, corresponding to total emissions of 779 tCO₂eq. It is assumed that 75,379 ton of solid dry matter per year will be used, corresponding to total emissions of 271,087 tCO₂eq.