Carbon Footprint Report 2021

CI Tequendama SAS

Development Area of New Business

Carbon Footprint Report 2021

Processing plant information: CI Tequendama SAS

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1. Introduction

Internationally, different strategies and treaties have been developed aimed at reducing the negative effects generated by climate change. One of the most important agreements is the Paris Agreement, which sets as one of its objectives the prevention of an increase in the average temperature of the earth by 2 °C with respect to pre-industrial levels. To achieve this goal, several countries and industrial sectors have established specific reduction goals, as well as specific regulations that promote the use of raw materials with a low carbon footprint.

Considering that the use of biofuels is one of the main strategies for the decarbonisation of the transport sector and this is one of the largest contributors to GHG emissions globally, Europe and the United States have defined specific GHG reduction targets for biodiesel (FAME) and advanced biofuels such as renewable diesel and/or bio-jet produced from palm oil.

In the case of bio-jet, the international aviation industry has defined its carbon neutrality strategy and GHG reduction goals through 2050, as well as the actions that airlines must implement to meet the reduction target. According to IATA, the action that contributes most to this goal is the use of Sustainable Aviation Fuels (SAF), which has generated a new market opportunity for oil and residual biomass derived from palm oil cultivation around the world.

Taking into account the above, it is pertinent for the Colombian palm oil sector to determine the carbon footprint of the oil and its derivatives taking into account the specific production conditions of the country. Knowing the carbon footprint of Colombian palm oil will allow us to identify the gap and determine whether the GHG emission levels for the aviation industry and other markets of interest are met.

This report presents the results obtained in the carbon footprint measurement exercise for the oil produced at the CI Tequendama SAS plant in 2021, including the cultivation and processing plant stages.

The quantification of the carbon footprint for Colombian palm oil is a project led by the New Business Development Area of Fedepalma and has the technical guidance of the Biorefinery Area of the Processing Program and the Geomatics Area of Cenipalma.

2. Scope

The scope of the study is defined by the functional unit which relates the system boundaries. For this, the product life cycle, the operation diagrams of each process and the geographical and temporal boundaries from which the information is taken and validated are taken into account. For its part, the reference flow ensures that the comparison of the systems is made on a common basis.

(one tonne of crude palm oil). Table 1 shows the functional unit and reference flow for the main products of each stage of the crude palm oil production chain.

Table 1. Definition of the functional unit and reference flows for the main products in each of the stages of process.

Functional Unit	**Reference flow** 1
Strawberry fruit bunches: raw material for the Extraction of crude palm oil	tonne of fresh fruit bunch (t RFF)
*Crude palm oil: raw material for obtaining other products**	1 tonne of crude palm oil (t APC)
*Palm kernel oil: raw material for obtaining other products**	1 tonne of palm kernel oil (t PKO)
*Palm kernel cake: raw material for obtaining other products**	1 tonne of palm kernel cake (t TAPL)

* Other products such as concentrated animal feed, biofuels, oleochemicals, among others.

3. System limits

a. Cultivation

Palm cultivation, from its establishment to maintenance and harvesting of fresh fruit bunches (FFB), requires certain inputs that must be monitored and controlled due to the greenhouse gas emissions associated with each of them. Some of the most relevant are the following:

- Fossil fuels: used for soil preparation and adaptation activities for sowing, application of fertilizers and pesticides, harvesting and transporting fresh fruit bunches (FFB), through the use of agricultural machinery.

- Fertilizers: required to meet the nutritional needs of the palm and maintain fresh fruit bunch (FFB) production levels.
- Agrochemicals: used to control insects, pests and diseases.

To obtain the FFR, the soil resource is necessary, as well as the use of water, fertilizers, agrochemicals and fuels that will contribute to the balance of greenhouse gas emissions, as described in Figure 1.

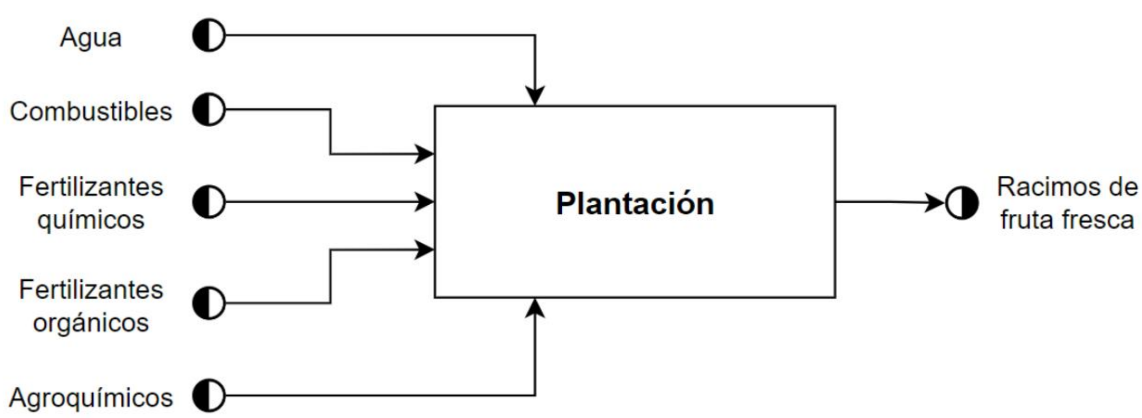

Figure 1. Main inputs and outputs of the cultivation or planting stage.

b. Processing plant

Figure 2 details the main inputs and outputs of material and energy in the processing plant subsystem. Four main products are generated from the oil extraction process (crude palm oil, almond (palm kernel), palm oil, and palm kernel oil).

palm kernel, palm kernel cake) and both solid and liquid biomass (stone, fiber, husk and effluents). Figure 2 also shows the intermediate process flows, service flows such as steam and electricity. The raw material in the processing plant is the FFB produced in the cultivation stage. These bunches go through several stages of the process starting with sterilization, de-fruiting, digestion-pressing, and clarification from which crude palm oil and effluents are obtained. On the other hand, the nuts and fiber generated in the pressing operation are separated in the palm kernel stage. A portion of the fiber produced is used as fuel in a boiler for steam production, while the remaining portion is used in the field as part of the organic fertilization scheme, and the nuts are broken to separate the kernel from the stone.

Part of the core is sent to the boiler to be used as part of the fuel mix, it is also sold to other industries, or it is sent to the field as a road conditioner and for other uses. The kernel, on the other hand, is sold or sent to the stage of extraction of palm kernel oil and palm kernel cake. The husk obtained in the de-fruiting stage is sent directly to the field or to composting systems, or it can enter a press to recover the residual palm oil through a husk press liquor sent to clarification. After pressing, the husk is applied in the field as part of the organic fertilization scheme.

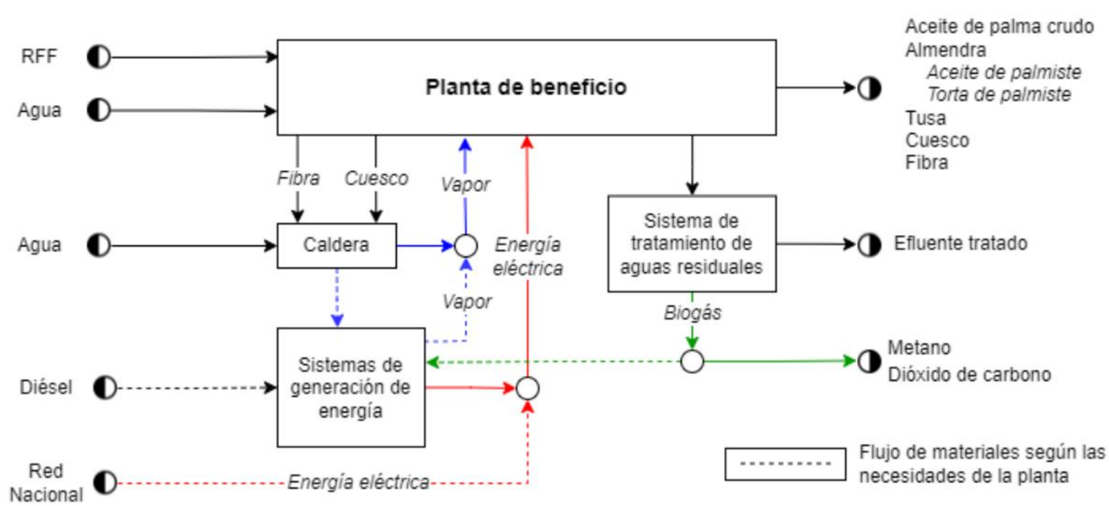

Figure 2. Main inputs and outputs of the processing plant

Figure 2 is a model process schematic for the oil palm fruit processing plant. Therefore, intermittent streams in the line can be omitted depending on the case and needs of each processing plant.

c. Treatment of liquid effluents

The effluent stream has a high amount of high organic matter (COD) and requires adequate treatment. The effluent must be stabilized (temperature decreased from ~65 °C to 40 °C) and subjected to degradation under anaerobic conditions. At this stage, microbial digestion is expected to remove most of the COD (80-90%), producing biogas (methane and carbon dioxide) as a product. After this, the effluent goes to an aerobic or facultative phase where 10 to 15% is removed, with the aim of disposing of the effluent with an organic load of less than 1500 mg/L, either in water bodies or recirculated to the field as fertigation.

d. Geographical boundaries

The production facilities of CI Tequendama SAS are located in the municipality of Aracataca, Magdalena, and the crops that provide the fruit to the processing plant are located in the surrounding municipalities.

e. Time limits

The time horizon considered is the year 2021.

f. Impact category

The impact category being assessed through the product carbon footprint (HCP) indicator is global warming. The carbon footprint is the balance of GHG emissions and removals from each stage of the production chain of the product under study. The impact is expressed in units of carbon dioxide equivalent.

4. Sources of information

The information was collected in the Ecopalma App (a tool for estimating GHG emissions from the palm oil sector) through an interview with the person in charge of each area of CI Tequendama SAS. The data collected was used to generate an inventory of the material and energy balance of the stages of the crude palm oil production chain. The inventory data was compared with scientific publications and Cenipalma databases to analyze the veracity of the information. For the emission factors and to generate the emissions calculations, scientific literature specialized in palm oil, databases from Ecoinvent, the Intergovernmental Panel on Climate Change (IPCC) and Cenipalma were used.

The considerations taken into account for this study are listed below:

- The nursery stage is excluded from the emissions balance, as it is considered insignificant due to its low resource consumption and the duration of this stage [4].
- Biogenic CO_2 emitted by biomass burning is not taken into account in the emissions balance. The neutrality criterion is applied[1] [4].
- Emissions from the transport of raw materials (agrochemicals and fertilizers) are less than 1% of total emissions, and are therefore not significant in the overall balance for calculating the carbon footprint.
- Transport involves the use of diesel to transport bunches of fruit by tractor, both during the harvesting activity and for transporting the fruit by truck to the processing plant.
- Methane and nitrous oxide emissions associated with the combustion of biomass in boilers are taken into account [11].
- Land use change (LUC) was calculated at zonal level taking into account the period from 2007 to 2020, according to the CORSIA standard methodology and the availability of images for each area in this period. That is, plantations in the same area have the same LUC.
- For cases where processing plants have tented anaerobic digestion lagoons, biogas leaks are not considered.

1 Biogenic carbon refers to carbon that is sequestered from the atmosphere during biomass growth and may be released into the atmosphere later due to biomass combustion or decomposition.

5. Life cycle analysis inventory

a. Cultivation

The reported plantations, whether owned or not, represented 45% of the fruit processed at CI Tequendama SAS, while the other suppliers provide 55% of the fruit processed at the processing plant, which is 148,895 tRFF/year. The carbon footprint of the reported fruit was calculated with the information provided by each processing plant. On the other hand, the carbon footprint of the fruit that comes from suppliers (55%) for whom no information is available will be assumed to be that calculated with the information of all the characterized plantations in the Northern Zone, including those of the other nuclei.

This is done to allow the calculation of crude palm oil produced, with the share shown in Figure 3.

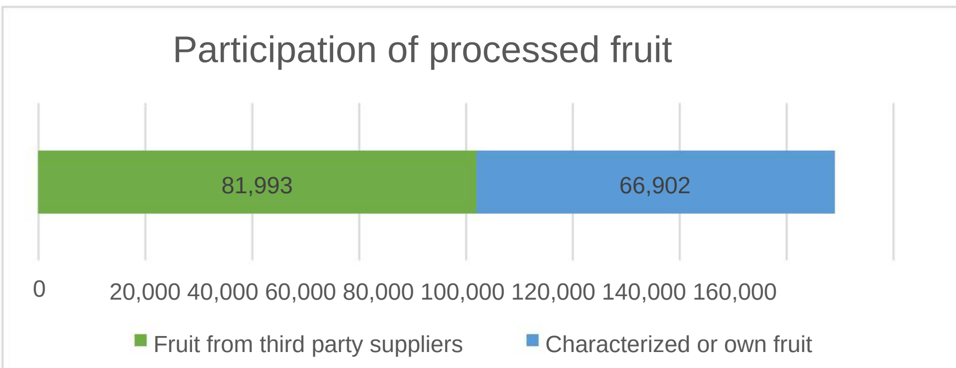

Figure 3. Distribution of reported fruit with respect to that processed by CI Tequendama SAS

The area cultivated with oil palm that CI Tequendama SAS reported is 4,590 hectares planted in 2021, made up of 1 plantation. The productivity of the area reported in 2021 is 14.58 tRFF/ha-year.

i. Chemical fertilization

Table 2 shows the fertilizers applied to the plantation for the year 2021.

Table 2. Use of fertilizers by plantations associated with CI Tequendama SAS

Fertilizer	**Applied quantity [t]**
Potassium sulfate (sop)	112
Borax 48%	46.1

Based on the quantities of fertilizers applied and the compositions of each one, the nutrients that were applied to palm crops through chemical fertilizers in 2021 were determined (Table 4). These compositions were obtained from the technical sheets of the manufacturers or suppliers of the aforementioned commercial products that were applied.

ii. Organic fertilization

The reported plantation uses corn husk and compost. The main nutrients provided by the biomass applied in the field include silicon, calcium, potassium and phosphorus. Table 3 summarizes the application of organic products in the plantations associated with CI Tequendama SAS, and Table 4 shows the nutrient contribution of these products applied in the field.

Table 3. Use of organic fertilizers by plantations associated with CI Tequendama SAS

Organic product	**Applied quantity [t]**
Composting	2.289
Tusa (pressed)	2.031

iii. Consumption of agrochemicals

CI Tequendama SAS did not report information on agrochemicals for the characterized plantations. Therefore, the contribution of agrochemicals observed in section 6.b. Carbon Footprint corresponds to the agrochemicals from third-party plantations (Northern Zone).

iv. Plantation Inventory Summary

Table 4 summarizes the inventory of consumption of the Tequendama plantation. It shows the size of the plantation, chemical and organic fertilization, and the application of agrochemicals.

Table 4. Inventory of key parameters for the production of one ton of fresh fruit bunch.

Parameter			
Production	Unit		
Fresh fruit bunches (FFB) Reported	t	66.902	
area	ha	4.590	
Chemical fertilization		Unit/year	Unit/t RFF
Ammoniacal Nitrogen (NH4 +)	kg	0	0.00
Nitric Nitrogen (NO3 -)	kg	0	0.00
Urea Nitrogen (CH ÿ N ÿ EITHER)	kg	0	0.00
Total phosphorus (P205)	kg	0	0.00
Total Potassium (K2O)	kg	57,263	0.86

Sulfur (S) kg		20,210	0.30
Disodium tetraborate pentahydrate (B2O3) kg		7,006	0.10
Organic fertilization			
Total nitrogen (N)	kg	25,597	0.38
Total phosphorus (P205)	kg	28,157	0.42
Total Potassium (K2O)	kg	24.798	0.37
Calcium (CaO)	kg	30,714	0.46
Magnesium (MgO)	kg	13,711	0.20
Iron (Fe)	kg	18,479	0.28
Silicon (SiO2)		767,692	11.47
Agrochemicals			
No data for reported plantation	g	0	0
Consumption of fossil products			
Diesel	gal	134.983	2.02
Gasoline	gal	31.265	0.47
Lubricants	gal	0	0.00

It can be noted that the distribution of nutritional application is headed by potassium and sulfur. These nutrients, some of which are essential for the benefit of oil palm and for the least impact from environmental changes, are the most applied and are reflected in the indicators per ton of FFB in the last column of Table 4.

b. Land use change (LUC)

Harris et al. (2015) mentioned that land use change (LUC) is one of the main causes of biodiversity degradation, and it also reduces the biological production capacity of the land [5]. The term LUC is used to denote a classification of human activities on a soil surface, or it is used for environmental impacts related to the occupation and physical transformation of areas of interest.

The estimation of GHG emissions associated with land use change are considered when the natural or semi-natural cover has been changed to perform some agricultural activity, in the last 20 years [5]. The changes in GHG are related to the amount of carbon contained in the soil covers (example: pastures, forests, food crops, shrubs, etc.). When there is a change from one cover to another, a change is generated in the carbon absorption capacity (by photosynthesis) by the vegetation associated with these covers.

To better understand this concept, the following are proposed.

- A hectare that was naturally covered with grass 20 years ago had a lower capacity to store carbon compared to today when it is cultivated with oil palm, which has a greater plant growth than from atmospheric CO2. As a result of land use change, there are now more GHG absorptions, rather than emissions.

- On the other hand, a hectare that was native forest 20 years ago and is now used to grow corn means that the capacity to absorb CO2 has been lost due to the density of the original vegetation that was removed. Therefore, the change in land use will reflect a generation of emissions into the atmosphere.

According to IPCC guidelines, calculations of emissions from CUS change are made from data on the occupation of the areas of interest. To perform these calculations of GHG emissions associated with CUS, the identification of vegetation cover through images obtained with free satellites (LandSat) and the carbon accumulation factors *(carbon stock)* of said vegetation that covers and/or covered said area, reported in scientific literature derived from real studies or estimated calculations, are taken into account.

For the purpose of this study, Cenipalma's Geomatics area collected the images for the North zone and identified the types of coverage corresponding to the period between 2007 and 2020, whose area corresponds to 117,336 ha. According to the carbon accumulation factors of these vegetation covers, the emissions/absorptions derived from the CUS at the zone level were estimated.

For the purposes of this study, it is assumed that the plantations reported by C.
I. Tequendama SAS suffered the same Land Use Change behavior that the Northern Zone had for the period from 2008 to 2020. The coverage legend was made by applying the Corine Land Cover legend adapted for Colombia by IDEAM.

As can be seen in Table 5, the areas devoted to oil palm cultivation between 2007 and 2020 in the Northern Zone increased by around 39,622 ha, going from occupying 66.23% of the area in 2007 to a total of 117,336 ha in 2020. The land covers that experienced the greatest change were: pastures with a modified area of 16,248 ha and shrublands with 11,611 ha.

Table 5. Historical change in land cover and use.

Period 2007 to 2020	**Classification Corine Land Cover**	**Areas [Ha]**	**% change in land use**
Northern Zone	Oil palm	77,714	33.12%
	Shrubs	11,611	4.95%
	Pastures	16,248	6.92%
	Secondary forest	4,984	2.12%
	Other areas without vegetation	6.779	2.89%
	Area in palm for the year 2020	**117.336**	

c. Processing plant

The main input to the palm oil extraction process is the fresh fruit bunch from the plantations. To obtain one tonne of crude palm oil, 4.99 tonnes of FBO must be processed (oil extraction rate of 20.05%). The inventory of crude palm oil production and the values related to 1 t of CPO are shown in Table 6.

Table 6. Inventory of key parameters for crude palm oil production.

Parameter				
Production	Unit			
Actual operating capacity	tRFF/h		21.61	
Hours of operation	h/year		6.889	
Processed fruit	tRFF/year		148,895	
Steam turbine	-		No	
Biodigester	-		Yeah	
Industrial services	Unit	Unit/year	Unit/tRFF	Unit/tAPC
Steam available from biomass burning	kg	99.313.240	667.00	3.326,30
Steam available from biogas burning	kg	N/A	0.00	0.00
Electrical energy				
Cogeneration with biomass	kWh	N/A	0.00	0.00
Biogas burning	kWh	4.166.205	27.98	139.54
National Network	kWh	N/A	0.00	0.00
Diesel plant	kWh	14.880	0.10	0.50
Use of fossil fuels				
Diesel for power generation	gal	986	0.01	0.03
Diesel other activities	gal	1.473	0.01	0.05
Consumption of industrial services				
Process water	m3	61,689	0.41	2.07
Steam for APC extraction	kg	78.457.460	526.93	2,627.77
Steam for APL extraction	kg	20,855,781	140.07	698.52
Energy for APC extraction	kWh	2,608,107	17.52	87.35
Energy for APL extraction	kWh	1,450,410	9.74	48.58
Products				
Palm oil	t	29.857	0.20	1.00
Almond	t	0	0.00	0.00
Palm kernel oil	t	4.443	0.03	0.15
Palm kernel cake	t	5.597	0.04	0.19
By-products				
Pressed corncob	t	19,773	0.13	0.662
Fiber	t	19.103	0.13	0.640

Cuesco	t	3.023	0.02	0.101
Ashes	t	819	0.006	0.027
Effluents	m3	81.892	0.55	2,743

By 2021, the electric power at the CI Tequendama SAS plant
It comes mainly from the burning of biogas, with a contribution of 99.64%.

d. Solid and liquid waste treatment system

The liquid effluent from the process enters the wastewater treatment system, where the organic load is removed by microbial oxidation, within a configuration of equalization, anaerobic and aerobic/facultative lagoons. The final discharge with a low concentration of organic matter is disposed of in a nearby surface water body. The removal process through the lagoon system occurs as follows. The raw effluent contains a
COD of 90,680 mg/l O2, after anaerobic treatment the COD composition of the treated effluent decreases to 3,627 mg/l O2, achieving an approximate removal of the organic load of 96%. After this initial treatment, the effluent enters the aerobic/facultative lagoon system where the COD composition is reduced to 2,480 mg/l O2, thus achieving an overall removal of the organic load of approximately 97%.

Table 7 and Table 8 show the data on organic matter from each step of the effluent treatment and the uses given to the biomass generated in the oil extraction process, respectively.

Table 7. Wastewater treatment system.

	Effluent	**Anaerobic output**	**Dumping**
COD (mg/ l)	90.680	3.627	2.480

Table 8. By-product inventory and distribution of uses.

Uses of biomass	**Field**	**Boiler**	**Compost**	**Other**
Pressed corncob	0%	0%	100%	0%
Fiber	0%	90%	10%	0%
Cuesco	0%	50%	0%	50%
Ashes	0%	0%	100%	0%
Treated effluents	70%	0%	30%	0%

The CI Tequendama SAS processing plant disposes of biomass as follows:
Table 8 shows that the pressed husk is disposed of entirely through the composting system, which also consumes 10% of the fibre generated, the ashes from the boiler, and 30% of the treated effluent to moisten the degrading substrate. On the other hand, the boiler consumes 90% of the fibre and 50% of the husk as fuel.

6. Life cycle impact assessment

The use of carbon footprint estimation tools is common, as they allow for comparisons of different systems, in addition to the use of various analysis methods depending on the objective and scope of the study. Specifically for this study, the "Ecopalma" carbon footprint estimation tool was used, which was developed by Cenipalma. This calculator is adjusted to the specific conditions of the palm oil sector. Likewise, Ecopalma is harmonized with the ISO 14067 methodology, which establishes the requirements for calculating the carbon footprint of products and their Life Cycle Analysis. In addition, it uses the Ecoinvent database as a source of information, which has information on different production processes worldwide. At the date of delivery of this report, Ecopalma has the Icontec certification and will be launched for use by the entire Colombian palm oil sector.

This section presents the results obtained from the tool for calculating Cenipalma's carbon footprint.

a. Impact category

The methodology used is based on the characterization of gaseous emissions based on their global warming potential (GWP) and the aggregation of different emissions in the impact category "Climate Change" is one of the most widely used methods in life cycle impact analysis. The calculations used to calculate emissions were based on the IPCC guidelines (2006) for national greenhouse gas inventories, bibliographic resources and information from Cenipalma.

b. Carbon footprint

The carbon footprint of Colombian palm oil was estimated by taking into account the consumption of materials and energy during the cultivation stages of oil palm and the extraction of crude palm oil.

One of the most significant components of the footprint in the APC value chain is the consumption of fertilizers, an essential component for the nutrition of the palm and for the adequate yield of fruit in the crop. Some of the nitrogen fertilizers applied in the plantation are lost through volatilization and transformation into nitrogen oxides, which are one of the main sources of GHG in this stage of the production chain [6]. Other emissions come from the burning of fossil fuels due to the use of machinery, vehicles, and the burning of biomass. In addition, there are indirect emissions from the manufacturing and transportation of raw materials.

Table 10 and Table 11 provide a summary of the main GHG emissions at the cultivation and processing plant stages, as well as the carbon footprint for the fruit and palm oil, respectively.

Table 9. GHG emissions by component at the oil palm cultivation stage for the bunch carbon footprint of fresh fruit in plantations associated with CI Tequendama SAS, in 2021.

Emission component	**Emission or Absorption**	**Units**	**Contribution to total emissions**
Agrochemicals	0.14 kgCO2eq/tRFF		0.15%
Chemical fertilizers	16 kgCO2eq/tRFF		17.39%
Direct NÿO emission	58 kgCO2eq/tRFF		63.04%
Indirect NÿO emission	14 kgCO2eq/tRFF		15.22%
Fossil fuels in plantation	3.05 kgCO2eq/tRFF -		3.32%
Direct Land Use Change	277 kgCO2eq/tRFF		N/A
Carbon footprint of palm fruit	**- 185 *kgCO2eq/ tRFF***		**N/A**

Table 10. GHG emissions by component in the production of crude palm oil from CI Tequendama SAS, in the year 2021.

	Emission component	**Emission or Absorption**	**Units**	**Contribution to total emissions**
	Agrochemicals	0 kgCO2eq/tAPC 8		0.00%
	Chemical fertilizers	kgCO2eq/tAPC 205		2.58%
	Direct NÿO emission	kgCO2eq/tAPC 47		66.13%
Crop	Indirect NÿO emission	kgCO2eq/tAPC 17.32		15.16%
	Fossil fuels in plantation	kgCO2eq/tAPC - 1,287		5.59%
	Direct Land Use Change	kgCO2eq/tAPC 0 kgCO2eq/		N/A
	Methane from effluent digestion	tAPC 10 kgCO2eq/		0.00%
	Biomass combustion	tAPC 22.5 kgCO2eq/		3.23%
	Compost production	tAPC 0 tAPC		7.26%
	Electricity from the national grid			0.00%
Plabenefit	Fossil fuels in processing plant	0 kgCO2eq/tAPC		0.00%
	Application in fertigation	0.04 kgCO2eq/tAPC -		0.01%
	Carbon Footprint	**977 kgCO2eq/tAPC**		**N/A**

Carbon footprint estimation for the CI Tequendama SAS core reported a value of - 977 kg CO2eq/t APC. That is, for each ton of APC produced, 977 kg CO2eq equivalent is being captured. The most significant factor in this footprint is the absorption due to the direct change in land use and the storage of CO2 by photosynthesis of the crop, with a contribution of 1,287 kg CO2eq, which offsets the rest of the emissions and allows a negative net sum. Emissions are distributed from highest to lowest in this order; the use of fertilizers chemicals and their emissions in the field due to the volatilization and leaching of nitrogen compounds (88.73%), the emission associated with the composting process, the consumption of fossil fuels and the emission due to the combustion of biomass in a boiler (Figure 4).

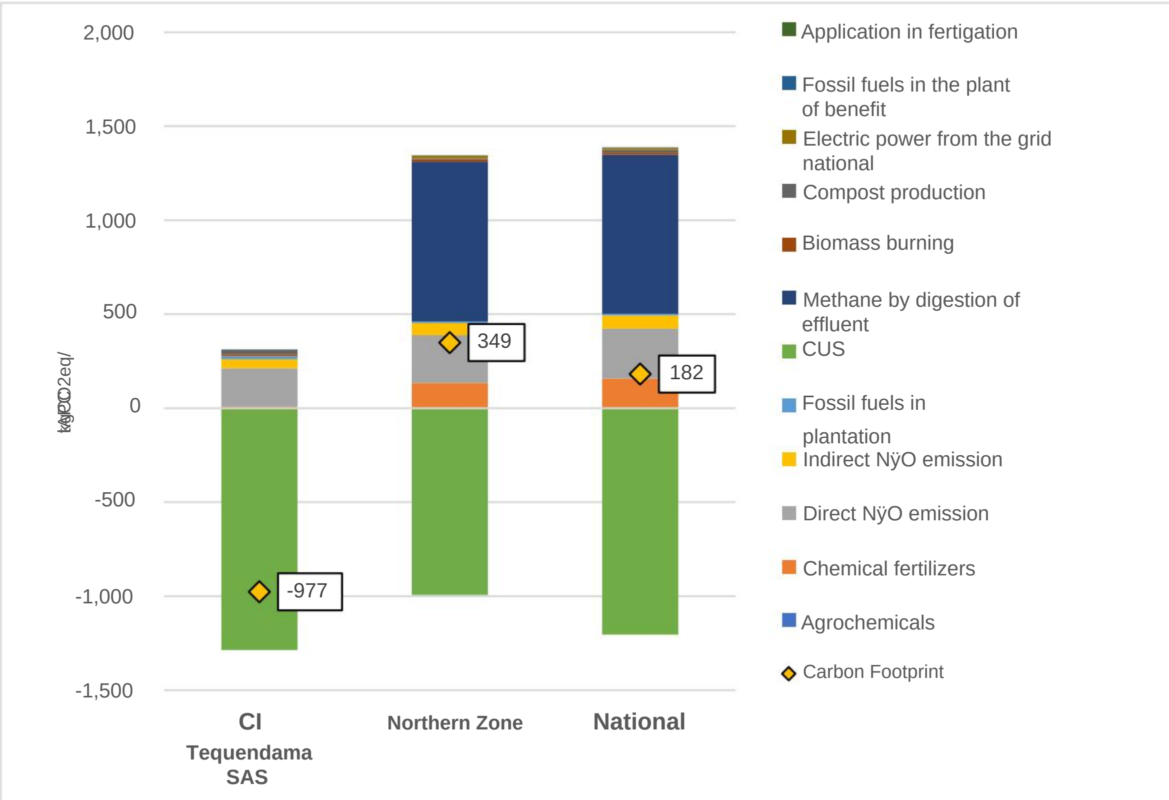

Figure 4. Carbon footprint of CI Tequendama SAS crude palm oil compared to the Northern Zone and the National stage.

CI Tequendama SAS presented a favorable situation compared to the accumulated behavior of the Northern Zone, since its footprint is more negative (- 977 kgCO2eq/ tAPC) than said reference (349 kgCO2eq/tAPC). The main difference is that the contribution of methane in Tequendama does not exist, giving it a negative scenario. In addition, the emissions of chemical fertilizers for CI Tequendama SAS are noticeably lower than those of the zone, however, they do not contribute to the footprint in a significant way as does the CUS component, which directs the net sum towards the negative scenario.

7. Conclusions

Based on the guidelines of the IS0 14067 standard, using the Ecopalma App calculator, the carbon footprint for Fresh Fruit Bunches (FFB) and Crude Palm Oil (CPO) produced at CI Tequendama SAS was estimated for the year 2021. The result was a value of - 185 kg CO2eq/tFFB and - 977 kg CO2eq/tCPO. This study made it possible to translate material and energy consumption into GHG emissions at the most relevant stages of the CPO production chain.

Considering the carbon footprint of the operation for 2021, the extraction plant can formulate well-founded decarbonization strategies to reduce emissions in the coming years and move closer to carbon neutrality.

The stages that most affect the carbon footprint of the production chain
palm oil in CI Tequendama SAS are those associated with the application of nitrogen fertilizers with their direct and indirect emissions (which add up to 88.73%). Therefore, to significantly reduce the carbon intensity it is necessary to rethink these two stages of the process. The covering of the lagoons is the practice that would mitigate this emission of methane into the environment. This would allow reducing the carbon footprint and taking advantage of the biogas produced.

This study assumed that the carbon footprint of the fruit processed by CI Tequendama SAS is the weighted average between the footprint of the reported plantations and those of suppliers in the Northern Zone (- 185 kgCO2eq/tRFF). Therefore, the carbon footprint estimate can be corrected in a subsequent assessment, by raising the real GHG inventories of all the fruit suppliers of the processing plant.

At the plantation stage, significant emissions from the application of nitrogen fertilizers and their direct and indirect nitrous oxide emissions can be reduced through a fertilization plan based on foliar and soil studies, which allow the application of the appropriate dose, at the appropriate application site and at the appropriate time of year. This would allow for optimization of plantation nutrition, contributing to the efficient use of resources for the reduction of GHG emissions per tonne of FFB.

The land use change (LUC) component allows for CO2 absorption
in palm oil production. Therefore, it is important to note that oil palm plantations should be established in areas where previous covers do not have high indicators of biodiversity and organic carbon. This will result in the CUS being an absorption and not an emission of GHG as a result of planting oil palm and therefore a better carbon footprint.

For the estimation of the carbon footprint of CI Tequendama SAS, the CUS was calculated taking into account the changes in the coverage of the Northern Zone from 2007 to 2020, but not the individual coverage of actual supplier plantations. Therefore, this component can also be recalculated. The zonal approximation is a good estimate to take into account in the carbon footprint of the fruit that enters the processing plant.

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