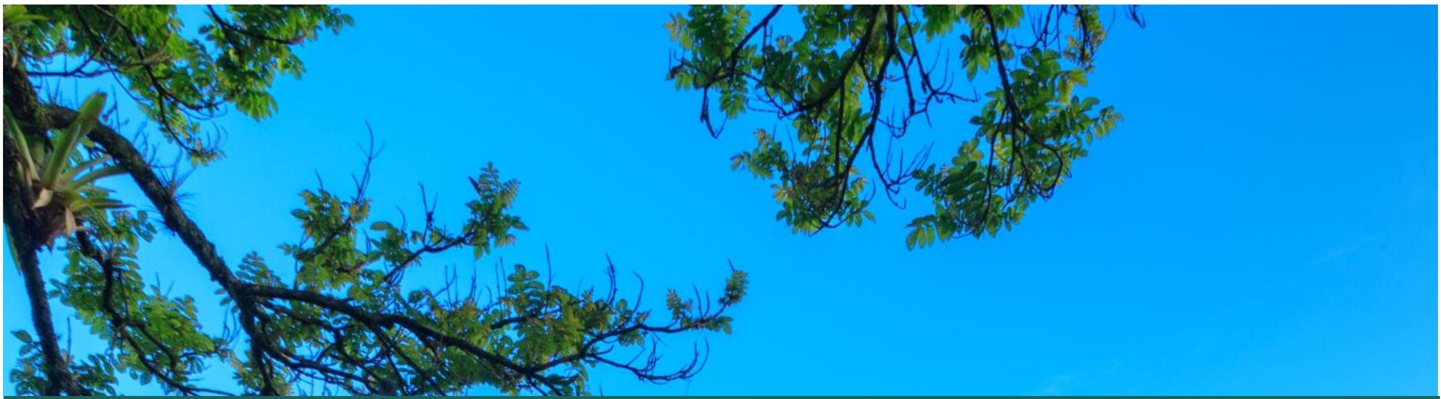

Carbon Footprint – 4C Add-On

Version 1.1

Document Title: Carbon Footprint – 4C Add-On
Version 1.1
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Abbreviations

AU	Annual updates
BP	Business Partner
BPM	Business Partner Map
CB	Certification body
CF	Carbon Footprint
CS	Carbon stock
DOM	Dead organic matter
EC	European Commission
EF	Emission factor
FB	First buyer
FF	Feedstock factor
GHG	Greenhouse gas
GWP	Global warming potential
IB	Intermediary buyer
IPCC	Intergovernmental Panel on Climate Change
IP_CF	Carbon Footprint add-on Improvement Plan
ISO	International Organization for Standardization
ME	Managing entity
PAS	Publicly Available Specification
SBTi	Science Based Targets initiative
SC-Unit	Soil/Climate Homogeneous Unit
SDG	Sustainable Development Goals
SOC	Soil organic carbon

1 Background and Objectives

The 4C certification system

As an independent, stakeholder-driven, internationally recognized certification system for the entire coffee sector, 4C aims at anchoring sustainability in the coffee supply chains across environmental, social, and economic dimensions.[1] 4C strives also to contribute and support companies in combating climate change, reducing greenhouse gas (GHG) emissions, and working towards the objectives set by the Sustainable Development Goals (SDG).

Relevance of assessing GHG emissions

With increasing awareness for the impact of global climate change, companies face new challenges of understanding the impacts of their operations and implementing measures to contribute to successful climate protection. Brand owners around the world have expressed their commitment to combat climate change, either through a strategic net-zero target or other climate strategy announcements. It is also likely that stricter regulations will be developed that respond to consumers' demand for sustainably sourced products. The interest of consumers to become informed about the carbon footprint of the products they buy is growing steadily.

Emission sources

Coffee production shall also contribute to the fight against climate change: GHG are emitted in the cultivation of coffee due to fertilizer and chemicals use, energy-consuming machines, land-use change, and wastewater. Especially chemical fertilizers and land-use change are found to be major sources of emissions. On a global level, agriculture contributes a significant share to the total GHG emissions – highlighting the need for immediate and comprehensive action. In the supply chain, transport emissions and energy consumption in processing units also contribute to GHG emissions.

The Carbon Footprint Add-On

4C provides a solution for its system users to address the increasing demand for and the need to ascertain and verify changes of the GHG emissions in coffee supply chains with the newly developed "**Carbon Footprint – 4C Add-On**".

This document has the following main purposes:

- describe how GHG emissions and their reduction along the coffee supply chain should be assessed
- set the relevant system boundaries
- provide the methodology for GHG calculations
- describe rules and guidelines for calculating and verifying emissions
- explain the prerequisites and processes for becoming certified under the Carbon Footprint Add-On
- outline carbon offsetting options that can be included to compensate unavoidable emissions along the supply chain
- clarify the requirements which shall be fulfilled to make respective claims of "4C Climate Friendly Coffee" or "4C Climate Neutral Coffee" to market participants

Carbon footprint of coffee

Measuring and quantifying GHG emissions is necessary to identify the impact of coffee production on the climate. Assessing GHG emissions is the basis for comprehensively evaluating the potential for reductions and to identify where measures should be targeted. Identifying GHG emission reduction measures to decrease the carbon footprint of coffee cultivation and processing (i.e., carbon insetting) and implementing carbon compensation mechanisms for

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[1] *More information are provided here: https://www.4c-services.org/about/what-is-4c/.*

unavoidable emissions (i.e., carbon offsetting) are key for achieving climate neutrality in the long term.

Recognized standards and initiatives

For the development of the Carbon Footprint Add-On, recognized methodologies, standards, and initiatives were researched and taken into account such as ISO 14067:2018[2], GHG Protocol Product Standard[3], PAS 2050:2011[4], and several IPCC guidelines.[5] The Carbon Footprint Add-On is aligned with the guide from the Science Based Target Initiative (SBTi) and the Paris Agreement target to limit global warming to 1.5°C.[6]

2 Definitions and Applications

Climate Friendly and Climate Neutral Coffee

The Carbon Footprint Add-On distinguishes between Climate Friendly and Climate Neutral Coffee. The latter one represents an optional upgrade within the Carbon Footprint Add-On. **4C Climate Friendly Coffee** refers to the production and processing of coffee and aims to support market participants in contributing to climate change mitigation by calculating, monitoring and reducing GHG emissions. Independent 3rd party audits confirm that GHG emissions have been calculated for certified actors of the supply chain, including the certified 4C Units for agricultural production and the 4C Chain of Custody certified companies. It ensures monitoring of developments with respect to GHG emissions and the commitment to reduce GHG emissions in the future. Therefore, a mandatory improvement plan shall be implemented as part of the application. **4C Climate Neutral Coffee** additionally requires that remaining GHG emissions are offset. Consequently, the upgrade to Climate Neutral is only possible if the Climate Friendly status has been reached. A simultaneous application is possible.

Four levels of implementation

The methodology described in this document can be adopted in four levels of implementation, making it possible to implement the Carbon Footprint Add-On gradually and in different arrangements of the coffee value chain. The four levels of implementation are listed below.

- **Level 1**: GHG emissions calculation at the 4C Unit level
- **Level 2**: GHG emissions calculation at the 4C Unit level and Intermediary Buyers
- **Level 3**: level 1 or 2 including the reduction of the GHG emissions
- **Level 4**: level 3 including carbon compensation

4C Units and 4C Chain of Custody

All operations and facilities responsible for coffee production and post-harvest processing covered by a 4C certificate are eligible for the application of the Add-On. In other words, Managing Entities of the 4C Units and 4C Chain of Custody certified companies can apply and benefit from the 4C Climate Friendly Coffee & Climate Neutral Coffee Add-On. In addition, final buyers such as roasters can also be included at level 2 and become certified to benefit from this Add-On (see chapter 3.3.7 for further requirements).

[2] The ISO 14067:2018, from the International Organization for Standardization, provides guidance for the quantification of greenhouse gases for the development of a carbon footprint of a product.
[3] The Product Life Cycle Accounting and Reporting Standard, from the GHG Protocol, is the guideline document stating the requirements for a Life Cycle Analysis of a product.
[4] The PAS 2050:2011, by BSi British Standards, is the Publicly Available Specification (PAS) for the calculation of the greenhouse gas emissions produced during a product's life cycle.
[5] The 2006 IPCC Guidelines for National Greenhouse Gas Inventories and the 2019 Refinement are a nationally recognize methodology for the development of greenhouse gas inventories.
[6] The 1.5°C ambition scenario was the result of a collaboration including UN agencies, businesses, and industry representatives as a way to call for companies in all sectors to commit and contribute to limiting the largest impacts on climate change.

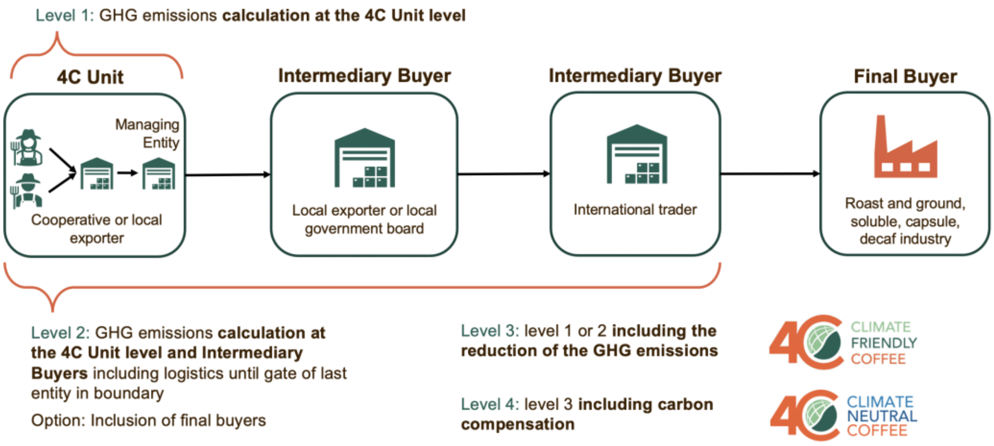

Figure 1: Four levels of implementation

Overall set-up

The Add-On can either consider the 4C Unit only or the entire supply chain (see chapter 3 for system boundaries). Figure 2: Set-up for GHG emissions calculation for the Add-On on the following page illustrates the overall set-up for applying the Carbon Footprint Add-On.

Certificate and amendment

The Add-On is not mandatory – 4C System users can decide freely whether to assess and reduce GHG emissions in their supply chain with the support of 4C. The Carbon Footprint Add-On is closely aligned with existing certification requirements and procedures under the 4C system. Once all requirements for 4C Climate Friendly (or Neutral) Coffee are successfully fulfilled, the existing 4C core certificate receives an amendment confirming the successful application of the Add-On. If the Add-On is used in combination with an initial 4C core certification, the initial certificate issued will already include the Carbon Footprint Add-On amendment. The 4C system user has the right to make use of the respective logos and claims and to communicate their efforts to reduce GHG emissions.

Global application

The Add-On can be applied globally, regardless of the type of coffee produced and the cultivation practices. The latest version of this document is available on the 4C website and shall be applied.

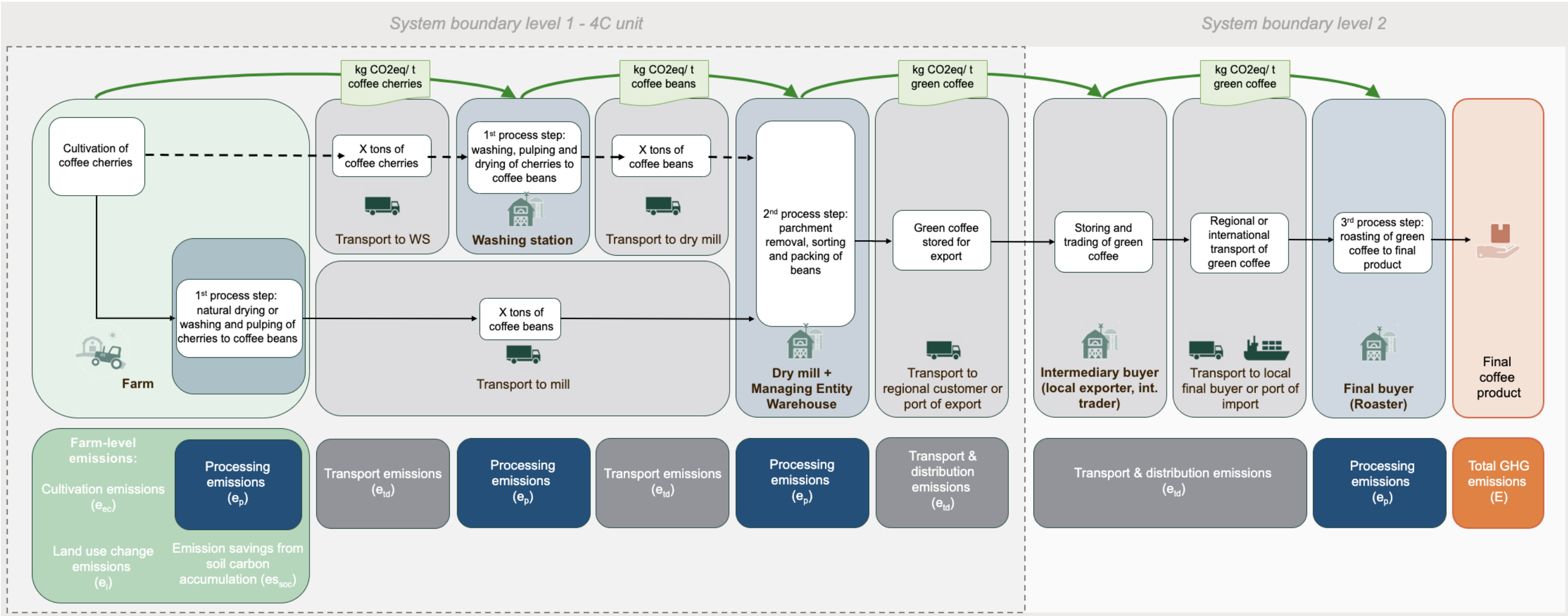

Figure 2: Set-up for GHG emissions calculation for the Add-On

3 GHG Emissions Calculation

Verified calculation

The following chapter describes the details of the GHG calculation covering the scope for the calculation, data and methodology requirements. It provides guidance for the development of the GHG emissions calculation required as part of the Carbon Footprint Add-On. The calculation can be performed by the certification applicant (e.g., Managing Entity (ME) of a 4C Unit, Intermediary or Final Buyer) or outsourced (i.e., consulting company) and must be verified by an approved certification body (CB) cooperating with 4C.

3.1 Scope and System Boundaries

System boundaries

Each entity of the supply chain can be covered in the GHG calculation, including the activities of agricultural production, post-harvest processing, storage, transportation, and distribution of the final packaged product, i.e., from the production of the coffee cherries to the roasting of the green coffee. All Business Partners (BPs) of a 4C Unit registered in the Business Partner Map are subject to the GHG calculation. The same logic applies to 4C Chain of Custody certified IB/FB, i.e., all facilities registered in the Business Partner Map for the Chain of Custody should be subject to the GHG calculation. The sampling method and the criteria for selecting Business Partners to be included in the GHG emissions calculation sample are described in chapter 3.2.1.

GHG emissions of 4C Unit

For the Carbon Footprint Add-On, it is required to calculate the individual GHG emissions of the elements within the system boundary of certified 4C Units. Figure 3 shows a simplified supply chain with the elements which shall be included.

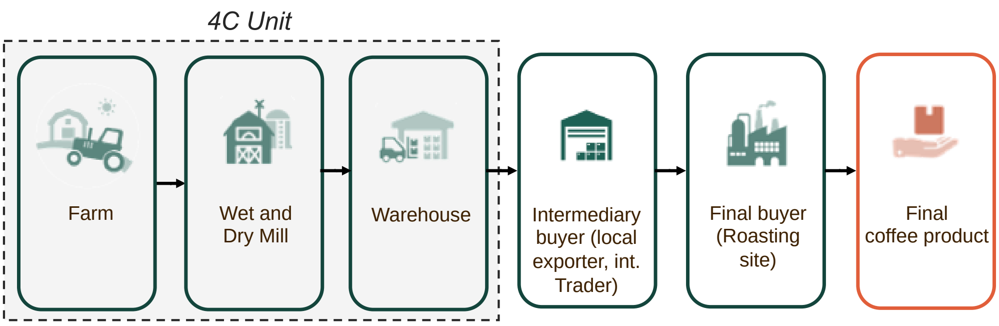

Figure 3: Supply chain steps for GHG calculation

Individual calculation required

The 4C Unit represents the minimum system boundary (level 1) required to be certified under the Carbon Footprint Add-On and where an individual GHG calculation for each element certified under 4C shall be conducted. In order to avoid allocation of emissions to possible co-products (i.e.: for lateral application of fertilizer in mixed crop scenarios), the system boundaries should be defined in a way that the main coffee product should be the main output of the system.[7]

The system boundary for the calculation can be extended to include other elements of the 4C Chain of Custody (see Figure 4 and Figure 5). Logistics between each step in the supply chain need to be covered in the GHG calculation as well. Retailers and consumers can receive the final coffee product with a calculated GHG value.

[7] *Greenhouse Gas Protocol. Product Life Cycle Accounting and Reporting Standard. 2011.*

Supply chain coverage

If a Final Buyer requires the entire upstream supply chain to be 4C Climate Friendly (or Neutral) Coffee certified, Intermediary Buyers shall also follow the methodology of the Carbon Footprint Add-On. In this case, the GHG emissions calculation shall cover additional elements in the supply chain, such as local and/or international logistics and downstream processing activities. Figure 4 illustrates the entire supply chain being 4C Climate Friendly (or Neutral) Coffee certified, including the Intermediary Buyers as system boundary level 2.

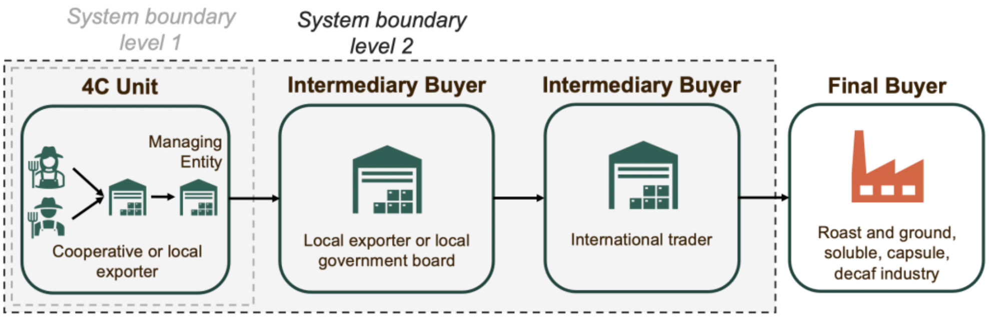

Figure 4: Entire supply chain Add-On certified, including IBs

Final buyer

Optionally, the Final Buyer can also be added to level 2 of the GHG calculation as the last step in the supply chain and thereof be covered by the Carbon Footprint Add-On (see Figure 5). Similar to the Intermediary Buyers, Final Buyers shall also follow the methodology of the Add-On and include additional elements in the GHG calculation such as upstream international logistics until factory gate.

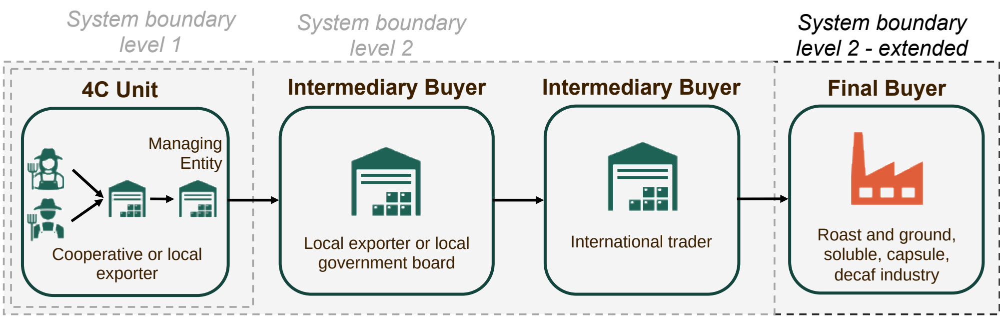

Figure 5: System boundary 2 including final buyer

Claims

On-product and off-product claims shall be consistent with both options mentioned above, i.e. 4C Climate Friendly (or Neutral) Coffee, focusing on agricultural production or covering the entire supply chain. More details about the claims are described in chapter 7.

3.2 Data Requirements

Actual data

For the calculation of GHG emissions for coffee cultivation and processing actual data is required. Actual values of emissions can only be determined at the unit that does the individual GHG calculation i.e., on the farm/ plantation level for the emissions from coffee cultivation. For farm groups this can be taken over by the responsible ME.

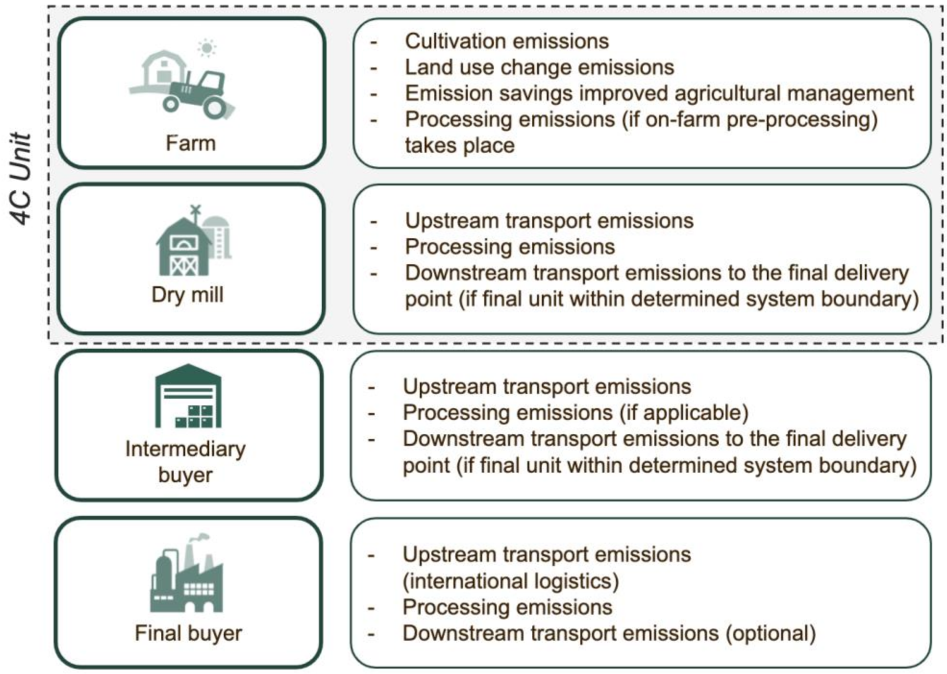

Figure 6: Overview of emissions responsibilities

Coffee cultivation

The **actual values for emissions on farm level** include activities for coffee cultivation (e_c) and coffee pre-processing (e_p) that occur at the farm and/or plantation level. Farmers or Managing Entities of 4C Units (on behalf of the farmers belonging to the group) can conduct an individual GHG emission calculation for e_c and e_p. If, additionally, land-use change (e_l) has occurred or improved agricultural management potentially leading to soil carbon accumulation (es_{soc}) is applied, these emissions (or savings in the case of (es_{soc})) also need to be calculated at this step. If farms or plantations belong to a group, they can either conduct an individual GHG emissions calculation for each farmer or one GHG emission calculation for the whole group. In the second case, a sample approach can be used (see chapter 3.2.1).

Processing

If the operator is a **processing facility** (i.e., wet/dry mill, roaster) registered in a certified 4C Unit or in a 4C Chain of Custody certificate, the emissions from processing (e_p) shall be calculated. Actual values of emissions from processing shall include all processing activities directly related to the production of coffee.

Transport and distribution

Actual values of **emissions from transport and distribution** (e_{td}) shall be determined and included in the GHG calculation. Any recipient of physical material shall determine the upstream transport emissions (e_{td}) and transmit these values to the next downstream supply chain entity. The final unit within the determined system boundary for the individual calculation shall determine the downstream transport emissions to the final delivery point, whether this is a processing facility, a warehouse, a roaster, or a port in the case of cargo shipments destined for export.

Figure 7: Calculating transport emissions – Example farm to dry mill

3.2.1 Sampling

4C Unit

For a 4C Unit covering a group of BP producers, post-harvest processors and traders, the data basis for the GHG emissions calculation can be based on a sample of relevant BP Producers and BP Processors registered within the 4C Unit, i.e., listed in the Business Partner Map (BPM).[8]

Sample size

The **sampling methodology for BP Producers** shall be based on the following steps in order to calculate the minimum sample size for the GHG emissions calculation:

1st Step: Identification of homogeneous sub-groups of producers among all BP producers registered in the BPM according to the following criteria:

- coffee yield range
- farm field size
- coffee varieties
- soil type[9]
- use of irrigation
- organic or conventional farming
- post-harvest processes that take place inside the farm
    - coffee cherries, i.e., the producer does not carry out any post-harvest processing
    - natural coffee beans, i.e., sun-drying process
    - washed coffee beans, i.e., wet process including wet process through a washing station including the different methods such as honey process, clean parchment, fermentation, etc.

2nd Step: Calculation of the sample size for each homogeneous sub-group identified in the 1st step mentioned above, applying the square root of the number of producers included in each sub-group. The resulting number should always be rounded up to the nearest whole number.

Sampling of BP Processors

The **sampling methodology for BP Processors** shall be based on the following steps:

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[8] *Further details on the composition of a 4C Unit, including a description of the different types of business partners and the Business Partner Map (BPM) are available in chapter 4 of the 4C System Regulations and the 4C Glossary.*

[9] *See COMMISSION DECISION of 10 June 2010 on guidelines for the calculation of land carbon stocks for the purpose of Annex V to Directive 2009/28/EC*

1st Step: Identification of homogeneous sub-groups of processors among all BP Processors registered in the BPM according to the following criteria:

- type of post-harvest processing, i.e., dry process and wet process
- processing capacity range, i.e., the amount of coffee the facility is capable of processing per year

2nd Step: Calculation of the sample size for each homogeneous sub-group identified in the 1st step mentioned above, applying the square root of the number of processors included in each sub-group. The resulting number should always be rounded up to the nearest whole number.

Sample increase possible

For both producers and processors, the methodology described above defines the minimum sample size. The party responsible for calculating GHG emissions may decide to increase the sample size in order to improve the representativeness of the sample.

GHG values of sub-groups

If there is more than one sample group defined due to different criteria, a calculation per sub-group should be conducted. For each sub-group the final GHG value can be averaged based on the number of farms in the sub-group. The final average values of all sub-groups then need to be weighted to receive one GHG value that can be forwarded in the supply chain to the next entity. The weighting should be based on the produced output of the production stage e.g., the amount of coffee cherries cultivated per sub-group on farm level.

Certifying part of a 4C Unit

It is possible for 4C Units to start with only a part of the producers belonging to the 4C Unit. If this approach is taken, only the coffee produced by this group of farmers can be sold with the specific GHG value. This must be properly accounted for by the 4C Unit in its traceability documentation. The corresponding bookkeeping will be verified in the 4C audits.

For guidance regarding the sample for annual updates and recertification audits, please check chapter 5.3.

3.2.2 Data Gathering

Information sources

Data gathering refers to the process of collecting all the information required for the calculation of GHG emissions. On-site data gathering is relevant for actual input and output data, e.g., electricity or diesel consumption, application of pesticides or fertilizers and for output data like wastewater production and treatment. Data obtained on-site shall be recorded and provided to the auditor for verification. This can include field record systems, production and harvest reports, production information systems, delivery notes, weighbridge records, contracts, invoices and others. For the initial GHG calculation, the coffee productivity data (yield) should be the average of the last three years to account for low and high productivity years. The time period analyzed for the following GHG calculation should cover a full twelve month period and one full harvesting season, but not necessarily one calendar year. The chosen time period and respective data gathered should be as up to date as possible. In cases of exceptional maintenance measures and unstable production conditions a shorter or more distant period (for inputs and respective outputs) may be considered if it better reflects the relevant timeframe. The respective period for data gathering and thus for the calculation of GHG emissions shall be transparently displayed in the calculation.

Inputs with little or no effect

If an input has little or no effect on generated emissions, it can be excluded from the emission calculation. Inputs with little or no effect are those that have an impact on the overall emissions of the respective calculation formula element (e.g., cultivation e_c) lower than 5%. This threshold for relevancy can be determined through a preliminary estimation using other disaggregation criteria. For example, using the volumes of processing inputs consumed to determine if a specific input is consumed in very low quantities (lower than 5% of all processing inputs) and therefore does not contribute significantly to the overall GHG emissions calculated. However, it is recommended to include all inputs in the calculation for the most precise result.

Emission factors

In addition to the data gathered on-site at farm or company level, literature data needs to be collected for a proper GHG emissions calculation. This includes the emission factors (EF) by which the respective input and output data are multiplied. These should be gathered from official and peer-reviewed sources. Different values may be used but shall be duly justified and flagged in the calculation documentation. They can be based on e.g., Ecoinvent, IPCC, or individually calculated or measured. If not available, other scientifically peer-reviewed literature or official statistical data from government bodies can be used. All data gathered from databases or literature shall be based on the most recent available sources and shall be updated over time. The source and the date of data collection shall be documented. Emission factors chosen or calculated shall also reflect the specific situation and set-up, e.g., if a process-specific input was produced in South America, then the emission factor for this input shall also reflect the South American situation. Only in cases where specific EF are not available, alternative values from other sources can be used if this has been confirmed by the CB.

3.3 GHG Methodology

Emission value for green coffee

The following chapters describe the methodology to calculate the GHG emissions generated from each coffee supply chain step included in the certification. Information on GHG emissions is provided by using actual and individually calculated values. For the time being there are no recognized default values available for the coffee sector which could be used.

Unit of measurement

The **final unit** for the total GHG emission value shall be **kg CO_2eq/t of green coffee**. CO_2eq or carbon dioxide equivalent refers to the unit of measurement representing the level of global warming potential (GWP) of other greenhouse gases (e.g., CH_4, N_2O), expressed in terms of the GWP of one unit of carbon dioxide. For downstream conversion and transportation/distribution of coffee please see chapter 3.3.6 for specific requirements.

GHG calculation formula elements

The quantification of GHG emissions from the coffee supply chain steps shall contain the following elements:

$$E = e_c + e_l + e_p + e_{td} - es_{soc}$$

Where:

E *total emissions from the coffee supply chain (kg CO_2eq/t of green coffee),*

e_c *emissions from the cultivation of coffee,*

e_l *annualized emissions from carbon stock changes caused by land-use change,*

e_p *emissions from processing (dry milling, wet milling, roasting, etc),*

e_{td} *emissions from transport and distribution,*

es_{soc} *emission savings from soil carbon accumulation via improved agricultural management.*

Machinery and equipment

Emissions from the manufacture of machinery and equipment are not required to be included, in line with the ISO and PAS approach.[10] The same applies for activities which are not directly connected to the coffee cultivation or production process e.g., transport of workers and office activities.

Aligned approach

GHG calculations need to be in line with the methodological requirements of this document. The GHG emission calculation methodology presented in this document is aligned with international standards and protocols. The most known and widespread standards and methodologies were compared and benchmarked to identify similarities and differences, focusing on the calculation requirements and scope of the carbon footprint of a product. As a result, the methodology for the Carbon Footprint Add-on is aligned with the following standards and methodologies:

- ISO 14067:2018 - Carbon footprint of products[11]
- GHG Protocol Product Standard[12]
- PAS 2050:2011[13]
- 2006 IPCC Guidelines for National Greenhouse Gas Inventories and 2019 IPCC refinement[14]

SBTi

In addition to the previously mentioned standards and methodologies, the Carbon Footprint Add-on is also aligned with the 1.5°C ambition scenario from the Science Based Targets initiative (SBTi). The specific scenario and its target are applicable to the emission reduction activities that can be implemented. Further information on this can be consulted in chapter 4. With this, 4C seeks to join the global commitments and contributions to limiting the largest impacts on climate change.

Complimentary material

This Carbon Footprint Add-On document sets the methodological requirements for a GHG emissions calculation. All requirements of this document shall be covered and all criteria shall be fulfilled to receive the Carbon Footprint Add-On certification.

3.3.1 Emissions on Farm Level

Cultivation and post-harvest

The actual values for emissions on farm level include activities for coffee cultivation (e_c) and coffee post-harvest processing (e_p) that occur at the farm and/or plantation level.

Calculation

The calculation can be conducted by either the farmer themself or by the ME of the 4C Unit. All necessary data shall be gathered including yield, inputs (seeds, fertilizers, plant protection products), crop residues, water usage, electricity and fuel consumption. In the case where further inputs are used during cultivation, the relevant amounts per hectare and time period shall be

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[10] *ISO 14067:2018 Section 6.3.2 System boundary, 6.3.4.1 General. PAS 2050:2011 Section 6.4.4 Capital goods.*
[14] *International Standard ISO 14067:2018. Greenhouse gases — Carbon footprint of products — Requirements and guidelines for quantification.*
[12] *Greenhouse Gas Protocol. Product Life Cycle Accounting and Reporting Standard. 2011.*
[13] *PAS 2050:2011. Specification for the assessment of the life cycle greenhouse gas emissions of goods and services*
[14] *2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories.*

documented and included in the calculation. For the yield only, the data input shall be averaged over the last three years to account for potential variations in yield.

Data requirements

This data will form the basis for the calculation of GHG emissions for an individual farm. All input values shall be obtained for the same area and time period, e.g., farm area of one hectare over a time period of one year and season. All farm activities connected to the cultivation of coffee have to be taken into consideration for data gathering, e.g., soil preparation, seedling planting, irrigation, pruning, harvesting and storage. Domestic use of e.g., energy and water for housing or offices are excluded. The uptake of CO_2 by the coffee plant is excluded.

Calculation formula

The calculation formula for cultivation emissions shall contain the following elements:

$$e_c\left[\frac{kg\ CO_2eq}{ton}\right] = \frac{\left(EM_{fertiliser} + EM_{N2O} + EM_{inputs} + EM_{fuel} + EM_{electricity}\right)\left[\frac{kg\ CO_2eq}{ha * yr}\right]}{yield\ coffee\ cherries\ \left[\frac{tons}{ha * yr}\right]}$$

Sum of GHG emissions

The sum of GHG emissions from all inputs including fertilizers, plant protection products, seedlings, fuel and electricity (EM, here in kg CO_2eq per ha and year) is divided by the yield of coffee cherries in tons per ha and year in order to receive the specific GHG emissions per ton of coffee cherries.

Different inputs

The emissions of the different inputs (EM) are calculated by multiplying the input data with the respective emission factors. Care shall be taken that every unit of measurement of on-site gathered data and emission factors from recognized sources are the same. For each input a respective emission factor shall be applied to calculate the GHG emissions (see Annex I for a list of typical emission factors).

Post-harvest processing

If post-harvest processing activities of the coffee cherries take place on farm-level (e.g., cleaning, separation of cherries, de-pulping, washing, mechanical drying) respective emissions shall be stated as processing emissions (e_p) and accounted for in the calculation on farm level. For the calculation of processing emissions see chapter 3.3.5.

In the following, the different calculation elements are described in more detail.

Fertilizer emissions

The amount of fertilizer used always refers to the main nutrient/active ingredient (e.g., nitrogen).

- For *synthetic fertilizers* (e.g., N, P_2O_5, K_2O, CaO) emissions from fertilizer production, $EM_{fertilizer}$, shall be considered and specific emission factors, $EF_{production}$, shall be applied.

$$EM_{fertiliser} = fertiliser\ input\ \left[\frac{kg\ nutrient}{ha * yr}\right] * EF_{production}\left[\frac{kg\ CO_2eq}{kg\ nutrient}\right]$$

- For *synthetic nitrogen fertilizers*, in addition to $EF_{production}$, N_2O-field emissions from managed soils, EM_{N2O} shall be calculated, by applying specific emission factors referring to each different element of N_2O emission, as specified below.

$$EM_{N2O} = \left[E_{N2O-direct}\left[\frac{kg\ N_2O}{ha}\right] + E_{N2O-indirect}\left[\frac{kg\ N_2O}{ha}\right]\right] * 296$$

Organic fertilizer

- For *organic nitrogen fertilizers* and *crop residues* left on the field only N_2O-field emissions from managed soil shall be calculated. See below for further details.

IPCC method as reference

The Intergovernmental Panel on Climate Change (IPCC) has defined a methodology to calculate emissions from the application of fertilizers on the field. This is described in Volume 4, Chapter 11 of 2019 IPCC Refinement which constitutes the reference here. All three IPCC Tiers can be used by BP Producers.

Direct and indirect emissions

The IPCC methodology ensures that N_2O emissions from soils are properly accounted for, including both "direct" and "indirect" N_2O emissions from the application of synthetic and organic nitrogen fertilizers and crop residues to managed soil.[15] Direct emissions are those N_2O emissions directly generated by the soil, because of N input application. Indirect emissions are originated by volatilization and subsequent redeposition to soils and waters of ammonia (NH_3) and nitrogen oxides (NO_x), generated by managed soils, fossil fuel combustion and biomass burning. Indirect emissions also include emissions generated after leaching and runoff of N, mainly as NO_3^-, from managed soils.

N_2O emissions for mineral soils

N_2O emissions shall be calculated and included for both mineral and organic soils (if any). The following formulas refer to mineral soils, which cover most cases. For N_2O calculation formulas addressing organic soils, please refer to IPCC 2019 Refinement (Chapter 11, Equation 11.1).

N_2O direct emissions

For the calculation of N_2O direct emission the following formula shall apply:

$$E_{N_2O-direct} = \left[I_N\left(\frac{kg\mathrm{N}}{ha}\right) + F_{ON}\left(\frac{kg\mathrm{N}}{ha}\right) + F_{Cr}\left(\frac{kg\mathrm{N}}{ha}\right) + F_{SOM}\left(\frac{kg\mathrm{N}}{ha}\right)\right] * EF_1\left(\frac{kg\ N_2O-\mathrm{N}}{kg\ N}\right) * 44/28$$

Where:

$E_{N_2O-direct}$	Annual direct N_2O–N emissions produced from mineral managed soils, kg N_2O ha^{-1}
I_N	Total synthetic N-fertilizer input, kg N ha^{-1}
F_{ON}	Total organic N-fertilizer input, kg N ha^{-1}
F_{Cr}	Total crop residues N-input, kg N ha^{-1}
EF_1	Emission factor for N_2O emissions from N inputs, kg N_2O-N kg N^{-1}. Aggregated default value is equal to 0.01. For further details please refer to Table 11.1 (Updated) of 2019 IPCC Refinement Chapter 11.
F_{SOM}	Amount of N in mineral soils that is mineralized, due to loss of soil C from soil organic matter as a result of changes to land use or management, kg N ha^{-1}.
$44/28$	Conversion factor to convert N_2O-N to N_2O.

N_2O indirect emissions

The calculation of N_2O indirect emissions shall rely on the following formula:

$$E_{N2O-indirect} = \left[N_2O - N_{ATD}\left(\frac{kg\ N_2O-\mathrm{N}}{ha}\right) + N2O - N_L\left(\frac{kg\ \mathrm{N}}{ha}\right)\right] * 44/28$$

Where:

$E_{N2O-indirect}$	Annual indirect N_2O–N emissions produced from mineral managed soils, kg N_2O ha^{-1}

[15] *IPCC guidelines for National Greenhouse Gas Inventories, Volume 4, Chapter 11, http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/4_Volume4/V4_11_Ch11_N2O&CO2.pdf and "2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories"*

$N_2O - N_{ATD}$	N_2O emissions produced from atmospheric deposition of ammonia (NH_3) and nitrogen oxides (NO_x), kg N_2O-N ha^{-1}
$N_2O - N_L$	N_2O emissions generated from leaching and runoff of N.
$44/28$	Conversion factor to convert N_2O-N to N_2O.

IPCC detailed formulas

Detailed formulas and specific emission factors to be used in the calculation of every single element contributing to N_2O emissions can be found on the IPCC reference document.

Replanting activities

When calculating GHG emissions at cultivation level, emissions from (re-) planting activities and from activities on immature areas shall also be considered.

Other input emissions

EM_{input} refers to cultivation inputs other than fertilizers e.g., seedlings or plant protection products. For seedlings raised in nursery owned by the BP Producer with seeds coming from the producer's fields, the emission value can be set to 0. In the case of plant protection products, the unit for EM_{input} is always kg active ingredient.

$$EM_{inputs} = input \left[\frac{kg}{ha * yr}\right] * EF_{input} \left[\frac{kg\ CO_2eq}{kg}\right]$$

Fuel emissions

For calculating EM_{fuel}, the fuel consumption (e.g., petrol, diesel) of all activities during field-preparation, cultivation, irrigation, harvest, or further post-harvest processing of the coffee cherries shall be determined and multiplied with the emission factor (EF) for the respective fuel used.

$$EM_{fuel} = fuel\ consumption \left[\frac{l}{ha * yr}\right] * EF_{fuel} \left[\frac{kg\ CO_2eq}{l}\right]$$

Electricity emissions

If electricity is consumed from the grid, the emission factor of the national electricity mix ($EF_{electricity}$) shall be used. If electricity from renewable energies is directly consumed (i.e., not supplied from the grid), an adapted EF for the type of renewable electricity may be used if that plant is not connected to the electricity grid.

$$EM_{electricity} = electricity\ consumption \left[\frac{kWh}{ha * yr}\right] * EF_{electricity} \left[\frac{kg\ CO_2eq}{kWh}\right]$$

Workers and offices

Consumption of fuel for the transport of workers and electricity usage for office buildings are not to be included

Forwarding GHG values

A final GHG emission value for cultivation e_c in kgCO_2eq/t coffee cherries shall be forwarded to the next supply chain entity together with the coffee cherries.

If post-harvest processing took place on farm level as well, next to emissions from cultivation also a final GHG emission value for processing e_p shall be forwarded. The final unit for emissions on farm level is kgCO_2eq/t coffee beans accordingly.

Emissions from sample

If the calculation is conducted for a sample of BP producers, the GHG value for cultivation emissions can be averaged and shall be forwarded as kgCO_2eq/t coffee beans or coffee cherries (if no post-harvest processing took place on farm level) following the defined homogeneous sub-groups of the sample.

3.3.2 Emissions from Land-Use Change (e_l)

LUC emissions

The calculation of potential land-use change emissions is mandatory if a change in the use of land took place for the establishment of coffee cultivation and shall be based on the IPCC methodology as a relevant standard (see 3.3.2.1).

IPCC land categories

Land-use change is meant as a change from one of the following IPCC land cover categories: forest land, grassland, wetlands, settlements, or other land, to coffee cultivation. Coffee is classified as a perennial crop[16] under IPCC cropland, both when grown as monocultural plantations and as agroforestry system with shaded coffee trees.[17] Land-use change that can occur for coffee is mainly a conversion from Forest Land or Grassland to Cropland. However, the GHG emissions from land-use change (e_l) of any of the five land categories defined by IPCC to coffee cultivation after the cut-off date of 1 January 2006[18] (same cut-off date as 4C core certification) shall be included.

Structure and practices

A change in cropland structure, management activities, tillage practices, or manure input practices is not considered as land-use change and shall fall rather under es_{soc} (chapter 3.3.3).

e_l formula

For calculating emissions (in kg CO_2eq/ton of coffee cherries), the change in carbon stocks shall be considered. In the below formula, the carbon stock of the actual land use (CS_A) is subtracted from the carbon stock of the reference land use (prior to the land-use change) (CS_R), to get the change in carbon stock due to the occurred land use change. The result is divided by the yield of coffee beans and annualized over 20 years. To convert the carbon (C) to CO_{2eq}-emissions, the conversion factor of 3.664 shall be applied. The following formula needs to be used:

$$e_l\left[\frac{kg\ CO_2eq}{ton\ coffee\ cherries}\right] = \left(\frac{CS_R\left[\frac{kg\ C}{ha}\right] - CS_A\left[\frac{kg\ C}{ha}\right]}{yield\ coffee\ cherries\left[\frac{ton}{ha * yr}\right] * 20\ [yr]} * 3.664\right)$$

Where:

e_l annualized GHG emissions caused by land use change.

CS_R carbon stock per unit area associated with the reference land use (land carbon stock before conversion into agricultural land) measured as mass (kg) of carbon per unit area, including both soil and vegetation. The reference land use shall be the land use in January 2006 (cut-off date) or 20 years before coffee was harvested, whichever is more recent.

CS_A carbon stock per unit area associated with the actual land use (carbon stock per unit of land after conversion into agricultural land) measured as mass (kg) of carbon per unit area, including both soil and vegetation. In cases where the carbon stock accumulates over more than one year, the value attributed to CS_A shall be the estimated stock per unit area after 20 years or when coffee tree reaches maturity, whichever is earlier.

[16] *Perennial crops are defined as multi-annual crops, the stem of which is usually not annually harvested such as short rotation coppice and oil palm.*
[17] *"Cropland includes arable and tillable land, rice fields, and agroforestry systems where the vegetation structure falls below the thresholds used for the Forest Land category and is not expected to exceed those thresholds at a later time. Cropland includes all annual and perennial crops as well as temporary fallow land (i.e., land set at rest for one or several years before being cultivated again). Annual crops include cereals, oils seeds, vegetables, root crops and forages. Perennial crops include trees and shrubs, in combination with herbaceous crops (e.g., agroforestry) or as orchards, vineyards and plantations such as cocoa, coffee, tea, oil palm, coconut, rubber trees, and bananas, except where these lands meet the criteria for categorization as Forest Land. Arable land which is normally used for cultivation of annual crops, but which is temporarily used for forage crops or grazing as part of an annual crop-pasture rotation (mixed system) is included under cropland." IPCC 2006, Vol 4, Chapter 5.*
[18] *Different cut off dates, specifically defined by brand owners or companies willing to apply 4C Add-On, may be applied provided that this is clearly communicated to 4C and in B2B and/or B2C communication.*

3.664 Conversion factor from C to CO_2.

IPCC Tier approach

Tier 1, 2 or 3 approach can be used. Tier 1 offers the possibility to use default values provided in the IPCC documents, while Tier 2 and 3 require increasing detail and resources. Tier 3 can imply the use of modelling and geo-referenced datasets, and field measurements. The choice of the most appropriate depends on the scale and data availability.

Forwarding respective value

Together with the batch of coffee beans (or coffee cherries if no post-harvest processing took place on farm level), the farmer forwards to the next supply chain entity inside of the system boundaries the actual GHG value for land-use change e_l in kg CO_2eq/ton coffee beans respective coffee cherries.

3.3.2.1 Calculate Change in Carbon Stock Linked to Land Use Change

Elements of carbon stock

To apply e_l formula, carbon stock in reference land use (CS_R) and in the actual land use (CS_A) shall be calculated. The carbon stock is defined by the mass of carbon in the soil and in the vegetation, including dead organic matter, per unit of land subject to conversion:

$$CS_i\left[\frac{kg\ C}{ha}\right] = (C_{veg} + DOM + \mathrm{SOC}) * A$$

Where:

CS_i carbon stock per unit area associated with land use i (reference or actual) measured as mass of carbon per unit area,

C_{veg} carbon stock in above and below ground biomass,

DOM carbon stock in dead matter,

SOC carbon stock in soil,

A converted area (is 1 if whole area is subject to conversion).

IPCC 2006 and 2019 Refinement

IPCC 2006 Guidelines for National Green House Inventories[19] constitutes the base reference, together with the *2019 Refinement*[20] for the calculation of change in carbon stocks associated with land use change. The two are complementary and shall be used together. IPCC 2019 in fact refines only some parts of IPCC 2006 guidelines, referring for the rest to IPCC 2006. Volume 4 is the one addressing "Agriculture, Forest and Land Use" to be referred as guidelines for the calculation of e_l and es_{SOC} (chapter 3.3.3) for coffee. Chapters 3.3.2 and 3.3.3 are mostly based on chapter 2 "Generic methodologies applicable to multiple land-use categories"[21] and chapter 5 "Cropland"[22] with some additions from chapter 4 "Forest" (IPCC chapter 4). Table 1 shows the main references used in this chapter to provide relevant information, with the objective of supporting the calculation of change in

[19] *2006 IPCC Guidelines for National Greenhouse Gas Inventories. Available at: https://www.ipcc-nggip.iges.or.jp/public/2006gl/*
[20] *IPCC 2019 refinement to 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 4 – Agriculture, Forestry and Oher Land Use. Available at: https://www.ipcc.ch/report/2019-refinement-to-the-2006-ipcc-guidelines-for-national-greenhouse-gas-inventories/*
[21] *Chapter 2: Generic methodologies applicable to multiple land-use categories, Vol. 4. IPCC 2006 and 2019 Refinement. Available respectively at: https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/4_Volume4/V4_02_Ch2_Generic.pdf ; https://www.ipcc-nggip.iges.or.jp/public/2019rf/pdf/4_Volume4/19R_V4_Ch02_Generic%20Methods.pdf*
[22] *Chapter 5: Cropland, Vol.4 IPCC 2006 and 2019 Refinement. Available respectively at: https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/4_Volume4/V4_05_Ch5_Cropland.pdf ; https://www.ipcc-nggip.iges.or.jp/public/2019rf/pdf/4_Volume4/19R_V4_Ch05_Cropland.pdf*

carbon stocks driven by land use change. For a thorough calculation it is highly recommended to follow the procedure described in the relevant sections of the IPCC documents.

Reference to IPCC documents

Table 1: Reference to IPCC 2006 Guidelines and 2019 Refinement

Element	General methods (Chapter 2)	Cropland (Chapter 5)	Relevant tables	Tier choice
Above and below ground biomass	Equation 2.15 - 2.16 [a] Equation 2.11 - 2.14 [a]	Chapter 5.3.1 [b]	Table 5.3 Table 5.8 Table 5.9 Table 4.12	Figure. 2.2
Dead organic matter	Equation 2.23 [b]	Chapter 5.3.2 [b]	Table 2.2	Figure. 2.2.3
Soil carbon	Equation 2.24 [b] Equation 2.25 [b] Equation 2.26 [b]	Chapter 2.5 [b] Chapter 5.3.3 [b]	Table 2.3 Table 5.10	Figure. 2.4 Figure. 2.5 Figure. 2.6

Note: [a] IPCC 2006, [b] 2019 Refinement.

Carbon Stock in Above and Below Ground Biomass

Biomass carbon stock

Plant biomass constitutes a significant carbon stock in many ecosystems, and coffee is not an exception here. Biomass is present in both aboveground and belowground parts of coffee plants. Possible land-use changes in the coffee sector include conversion from Forest Land to Cropland. This often result in substantial loss of carbon from the biomass pool, biomass stocks of forest land generally being the largest among land use categories.

Change in biomass carbon stock

The IPCC provides methods for calculating carbon stock change in biomass due to the conversion of land from Forest and other uses to Cropland, including deforestation and conversion of pasture and grazing lands to Cropland. The methods require estimates of carbon in biomass stocks prior to and following conversion, based on estimates of the areas of land converted. The difference between initial and final biomass carbon pools is used to calculate carbon stock change from land-use conversion.

Biomass stock change formula

Equation 2.15 in IPCC chapter 2 summarizes the major elements of a first-order estimation of carbon stock change from land use conversion to Cropland and shall be used as reference, for land use change to coffee cultivation. The same equation is used to calculate in Tiers 1, 2 and 3 with some key distinctions for each Tier.

$$\Delta C_B = \Delta C_G + \Delta C_{CONVERSION} - \Delta C_L$$

Where:

ΔC_B	annual change in carbon stocks in biomass on land converted to other land-use category, in tons C yr^{-1}
ΔC_G	annual increase in carbon stocks in biomass due to growth on land converted to another land-use category, in tons C yr^{-1}
$\Delta C_{CONVERSION}$	initial change in carbon stocks in biomass on land converted to other land-use category, in tons C yr^{-1}
ΔC_L	annual decrease in biomass carbon stocks due to losses from harvesting, fuel wood gathering and disturbances on land converted to other land-use category, in tons C yr^{-1}

Conversion to Cropland may be associated with a change in biomass stocks, e.g., part of the biomass may be withdrawn through land clearing, restocking or other human-induced activities. These initial changes in carbon stocks in biomass ($\Delta C_{CONVERSION}$) are calculated with the Equation 2.16 from IPCC chapter 2 below:

$$\Delta C_{CONVERSION} = \sum_i \{(B_{AFTER_i} - B_{BEFORE_i}) * \Delta A_{TO\_THERS_i}\} * CF$$

Where:

$\Delta C_{CONVERSION}$ initial change in biomass carbon stocks on land converted to another land category, tons C yr^{-1}

B_{AFTER_i} biomass stocks on land type i immediately after the conversion, tons d.m. ha-1

B_{BEFORE_i} biomass stocks on land type i before the conversion, tons d.m. ha^{-1}

$\Delta A_{TO\_THERS_i}$ area of land use i converted to another land-use category in a certain year, ha yr^{-1}

CF carbon fraction of dry matter, ton C $(\text{ton d.m.})^{-1}$

i type of land use converted to another land-use category.

IPCC Tier

The Tier 1 method follows the approach in IPCC chapter 4 (Forest Land) where the amount of biomass that is cleared for the conversion to Cropland is estimated by multiplying the area converted in one year by the average carbon stock in biomass in the Forest Land prior to conversion.

Default parameters

Default parameters to support estimation of emissions under a Tier 1 approach are given in Table 4.12 (Updated) in chapter 4 of the 2019 IPCC Guidelines for National Greenhouse Gas Inventories. For monoculture perennial croplands, since there is no parameter defined for coffee, the default parameters of tea or orchard can be used to represent coffee. The default parameters for monoculture perennial croplands are given in Table 5.3 (Updated) in chapter 5 of the 2019 IPCC Guidelines for National Greenhouse Gas Inventories.

Carbon Stock in Dead Organic Matter

DOM carbon stock

Forest Land, Grassland, Settlements, and other land-use categories could be potentially converted to Cropland which, in general will have little or no dead organic matter (DOM), in the form of dead wood or litter (DOM pools), except for agroforestry systems.[23]

DOM stock change formula

Equation 2.23 in the IPCC chapter 2 2019 provides the formula for the application of Tier 1 for the estimate of annual change in carbon stock in deadwood and litter, due to land conversion:

$$AC_{DOM} = \left(\frac{(C_n - C_o) * A_{on}}{T_{on}}\right)$$

[23] *Agroforestry systems which may be accounted either under Cropland or Forest Land, depending upon definitions adopted by countries for reporting. IPCC 2006, Vol.4, Chapter 5.*

Where:

AC_{DOM} changes in carbon stocks in dead wood or litter, tons C yr^{-1}

C_o dead wood/litter stock, under the reference land-use category (before land use change occurs), tons C yr^{-1}

C_n dead wood/litter stock, under the actual land-use category (after land use occurs), tons C yr^{-1}

A_{on} area undergoing conversion, ha

T_{on} time period for transition from reference to the actual land use, yr. The Tier 1 default is 20 years for carbon stock increases and 1 year for carbon losses

Decay rates of DOM pools

Change in carbon stocks in dead organic matter, associated with land conversion depends on the decay rates of DOM pools, which highly differ between regions.

Tier 1 method assumptions

Tier 1 method assumes that all carbon contained in biomass destroyed during a land-use conversion event is emitted directly to the atmosphere and none is added to dead wood and litter pools. The Tier 1 method also assumes that dead wood and litter pool carbon losses occur entirely in the year of the transition. Lastly, litter and dead wood pools are assumed to be zero in all non-forest categories and therefore transitions between non-forest categories involve no carbon stock changes in these two pools. More details for the application of the Tier 1 approach are provided in IPCC 2019 chapter 2. It is highly recommended to follow the detailed application of the IPCC Tiers (as provided in IPCC 2019 chapter 2 and chapter 5, section 5.3.2). The default carbon stock estimates for litter and dead wood (when available) are provided by Table 2.2 of IPCC 2019 chapter 2. Tier 1 methodology only requires the estimates in Table 2.2 for lands converted from Forest Land to any other land-use category.

Higher Tier estimation methods

Higher Tier estimation methods can be used for non-zero estimates of litter and dead wood pools in agroforestry. The application requires a two-phase approach. During the first phase, there is often an abrupt change in DOM due to land preparation operations (e.g., clearing and burning). The second phase accounts for decay and accumulation processes during a transition period to a new steady-state system. Higher Tier methods may also estimate the details of dead organic matter inputs and outputs associated with the land-use change.

Soil Carbon Stock

SOC elements

The changes in soil carbon stocks includes estimates of soil organic C stock changes for mineral soils and CO_2 emissions from organic soils, due to drainage and associated management activities. In addition, C stock change for soil inorganic C pools (e.g., calcareous grasslands that become acidified over time) included, provided that sufficient information is available (Tier 3). The reference formula is given in Equation 2.24, of IPCC chapter 2 (Tier 1).

SOC in mineral soils

For mineral soils the change in soil carbon stock is provided by the difference between soil organic carbon content associated with the reference land use (before land use change) and the one associated with the actual land use (after land use change) (reference formula in Equation 2.25, IPCC chapter 2).

SOC formula

The soil organic carbon (SOC) consists of four factors, which depend on climate, soil type, management practice and C-input practice: the standard soil organic carbon in the 0-30 cm topsoil layer (SOC_{ST}), the land use factor (F_{LU}), the management factor (F_{MG}) and the input factor (F_i), as specified in the formula below:

$$SOCmineral_i = (SOC_{ref} * F_{LU} * F_{MG} * F_I) * A$$

Where:

$SOCmineral_i$	mineral soil organic C stock, associated with land use i (reference or actual) measured as mass of carbon
$\mathrm{SOC_{ref}}$	soil organic C stock for mineral soil in the reference conditions, measured in ton C ha^{-1},
F_{LU}	stock change factor for mineral soil organic C land-use systems or sub-systems for a particular land-use, dimensionless,
F_{MG}	stock change factor for mineral soil organic C for management regime, dimensionless,
F_I	stock change factor for mineral soil organic C for the input of organic amendments, dimensionless,
A	converted area (is 1 if whole area is subject to conversion).

Note that the whole area should have common biophysical conditions.

IPCC Tiers

Reference soil organic C stocks (SOC_{REF}) and stock change factors (e.g., F_{LU}, F_{MG} etc) are based on a 30 cm depth. Table 2.3 of IPCC chapter 2 provides default reference condition soil organic carbon stock values for mineral soils, to be used in Tier 1. Table 5.10, IPCC chapter 5 provides soil stock change factors for land use conversion to cropland to be applied in land-use changes towards coffee cultivation.

Tier 2 approach

Tier 2 is an extension of the Tier 1 approach that allows to incorporate country-specific data and to better specify certain components of the Tier 1 method (e.g., defining country specific stock change factors or finer disaggregation of default conditions). For the application of Tier 2 the reader should refer to the IPCC chapter 2. Lastly, the approaches in Tier 3 for soil C involve the development of a detailed estimation system based on more advanced models than the methods of Tiers 1 and 2, and/or on the development of a measurement-based data collection with a monitoring network. See section 2.5 (Generic Guidance for Tier 3 methods) of IPCC chapter 2 for additional details on Tier 3 methods.

Basic methodology

The basic methodology for estimating CO_2 emissions from drainage and management activities of organic soils, is to assign an annual emission factor estimating C losses following drainage. Specifically, the area of drained and managed organic soils under each climate type is multiplied by the associated emission factor to derive an estimate of annual CO_2 emissions (source), as presented in Equation 2.26, IPCC chapter 2 (Tier 1). In addition, a specific reference addressing CO_2 emissions from organic soil can be found in the 2013 Wetland Supplement[24] by the IPCC. As for mineral soils, Tier 2 and Tier 3 approaches allow for better specification of certain components of the Tier 1 method.

Decision trees

[24] 2013 Supplement to 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands. Available at: https://www.ipcc.ch/site/assets/uploads/2018/03/Wetlands_Supplement_Entire_Report.pdf

The Generic decision trees in Figures 2.5 and 2.6 IPCC chapter 2 and Figure 5.6, IPCC chapter 5 support the identification of the appropriate Tier to be used.

3.3.3 Emission Savings from Soil Carbon Accumulation (es_{soc})

Crop management and carbon stock

Improved agricultural management modifies soil C stocks to varying degrees, depending on how specific practices influence C input and output from the soil system (Paustian et al., 1997a; Bruce et al., 1999; Ogle et al., 2005). The main management practices that affect soil C stocks in Croplands, including perennials like coffee, are the type of residue management, field management practiced, fertilizer management (both mineral fertilizers and organic amendments), choice of varieties and intensity of cropping management, irrigation management, and mixed systems with cropping and forestry (agroforestry). In addition, drainage and cultivation of organic soils reduces soil C stocks (Armentano and Menges, 1986).

Improved agricultural management

The Carbon Footprint Add-On allows the use of emissions savings, es_{soc}, due to carbon accumulation in soil driven by the adoption of improved agricultural management. This refers to practices that may increase carbon content in soil, such as:

> Improved cropping systems including cover crops, intercropping especially with perennials, agroforestry, and combination with nitrogen-fixing crops.

> Improved crop residues management (e.g., leaves, straws and pruning residues left on the field).

> Improved fertilizers or manure management (e.g., use of organic fertilizers).

> Use of soil improver (e.g., compost, manure fermentation digestate).

If a coffee plantation is established on degraded land[25], es_{soc} should be calculated. Respective GHG emission savings should be claimed as a consequence of restored soil fertility and of the increase in soil carbon content.

es_{soc} formula

Emission savings from es_{soc} shall be calculated with the same formula described for e_l, modified as follows:

$$es_{soc}\left[\frac{kg\ CO_2eq}{ton\ coffee\ cherries}\right] = \frac{CS_R\left[\frac{kg\ C}{ha}\right] - CS_A\left[\frac{kg\ C}{ha}\right]}{yield\ coffee\ cherries\ \left[\frac{ton}{ha * yr}\right] * \mathrm{n}\ [yr]} * 3.664$$

Where:

es_{soc} annualized GHG emissions savings from carbon accumulation via improved agricultural management practices,

CS_R carbon stock associated with the reference crop management practice (i.e. before applying improved management)

[25] *Degraded land, according to the United Nations Convention to Combat Desertification (UNCCD) is a land characterized by a reduction or loss "of the biological or economic productivity and complexity of rainfed cropland, irrigated cropland, or range, pasture, forest and woodlands resulting from land uses or from a process or combination of processes, including processes arising from human activities and habitation patterns, such as: (i) soil erosion caused by wind and/or water; (ii) deterioration of the physical, chemical and biological or economic properties of soil; and (iii) long-term loss of natural vegetation".*

CS_A carbon stock associated with the actual crop management practice (i.e. improved agricultural management in place),

3.664 conversion factor from C to CO_2

n cultivation period of raw material (in years),

The result is divided by the yield of coffee cherries and annualized over the period of cultivation (n).

Options for es_{soc} calculation

The two following options can be applied for the calculation:

- **IPCC methodology**, as defined in the 2006 Guidelines and refined in the “2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories”. The adoption of improved agricultural management practices does not constitute a land use change (chapter 3.3.2). Carbon stock change associated with that, shall be addressed under the IPCC “cropland remaining cropland” only accounting for changes in soil organic carbon[26,] Hence, reference and actual carbon stocks (CS_R and CS_A) are expressed as reference and actual soil organic carbon, SOC_R and SOC_A respectively. Therefore, CS_i and SOC_i are used synonymously in this chapter.

  The application of Tier 2, with country-specific factors, or of Tier 3, when specific factors for coffee varieties are available, is recommended, to duly consider soil specific conditions affecting soil carbon dynamics[27]. For further support on which Tier to apply, the reader can consult IPCC Chapter 2 (Figure 2.5 and 2.6) and Chapter 5 (Figure 2.6).
- **Field measurements**. Under this option the SOC content and SOC change is measured at farm scale following the recommendations provided in the next chapter.

General provisions shall be considered for either option applied:

- Emission savings from the application of improved agricultural management can be taken into account if evidence is provided that the above-mentioned practices were adopted **after January 2006**.
- **Solid and verifiable evidence for each individual farm which claims es_{soc}** shall be provided, showing that soil carbon has increased or that improved agricultural management practices are implemented in best practice so that an increase in soil carbon can be expected over the period in which coffee is cultivated.
- **The actual values for es_{soc}** shall be calculated at individual farm level. In case of non-homogenous soil, climate or management practice(s), soil organic carbon values shall be estimated for each single field the farm owns or rents, and es_{soc} shall be calculated at farm level. This can result **in different es_{soc} values per farm.**
- **Increased use of agrochemicals for pest control (e.g., herbicides), due to the application of improved agricultural practices shall be considered** in terms of overall GHG emissions from cultivation. For example, leaving crop residue in the field, without

[26] In case specific improved agricultural practices imply huge changes in above and below ground, the inclusion of this component might be considered and discussed with 4C

post-harvest incorporation in soil, may significantly increase the risk of spreading plant diseases within the plantation. To avoid such problems, an increase in agro-chemicals input may be required and duly considered in GHG accounting. Additionally, in the case of organic fertilizer use, N_2O emissions shall be calculated.

> The improved agricultural management practices shall be applied **continuously** for at least three years successively if the BP Producer would like to account for es_{soc}. This means that it is not allowed to switch management practices every year when es_{soc} is claimed.

> When the es_{soc} improved agricultural management has been applied for three years continuously, the es_{soc} savings, calculated through the formula described at page 25, can be claimed. Such es_{soc} value will be valid until a new measurement (i.e., a new es_{soc} value) is available.

> If two or more crops are grown in the same field over the same year/agricultural season (i.e., multi-crops system), es_{soc} savings shall be divided among all crops within the same year/agricultural season. This applies also in case of agroforestry.

> **Averaging** of emission values from farms applying es_{soc} and farmers not applying es_{soc} is **not allowed**, and only those farmers who apply es_{soc} measures are allowed to forward respective values together with the batch of sustainable material, i.e., green coffee.

> SOC_R **shall be monitored and verified** before the improved agriculture management starts. **In absence of that, changes in soil organic carbon (and their magnitude) cannot be detected.**

> In the case of the IPCC method, SOC_R and SOC_A are defined by the standard values. For field measurements, the first field measurement defines SOC_R, then SOC_A is measured periodically.

> In contrast to a direct avoidance of GHG emissions, the increase of SOC as a climate protection measure is only effective if carbon storage is long-term and thus the corresponding amount of CO_2 is removed from the atmosphere for the foreseeable future. Changes in agricultural practices can completely reverse the positive effect of the SOC build-up. Hence, **a long-term commitment from the farmer is required** and adequate proof shall be provided to 4C. 4C reserves the right to reject certain improved agricultural practices if scientific evidence shows that these practices will not sequester the SOC in the long run.

Together with the batch of coffee beans (or coffee cherries if no post-harvest processing took place on farm level), the farmer forwards the actual GHG value for soil carbon accumulation via improved agricultural management es_{soc} in kg CO_2eq/ton coffee beans (or coffee cherries) to the next supply chain entity inside the system boundaries.

3.3.3.1 Recommendation on Field Measurements

How to measure es_{soc}

The approach for field measurements of the SOC content shall include the following steps and both sampling and lab analysis shall follow internationally recognized methodologies[28]:

1. **Representative sampling method**
    a. Sampling is necessary for each plot or field. To simplify measurement procedures, 4C recommends to group fields (from any number of farmers) into Soil/Climate Homogenous Units (SC-Unit). These units could be developed by combining the following two maps:
        - **Soil/Climate Homogeneous Unit (SC-Unit) map of the climate regions**. 4C recommends the use of the IPCC climate region map or any map obtained with a similar methodology,
        - **Map of soil units**. 4C recommends the use of a soil subclasses map, while ensuring homogeneity of soil conditions. An example of an acceptable map is any map produced using the SOTER[29] approach.
        - Farmers may use SOC values from the SC-Unit for fields located within the unit, provided that the same es_{soc} measure is implemented in all sample pool fields.
    b. At least 1-3 grab samples of 15 well distributed sub samples per five hectares or per SC-Unit, whatever is smaller (considering the heterogeneity of carbon content of the plot) should be taken. The number of grab samples could be increased or decreased in subsequent years based on the heterogeneity of the first SOC measurements.
    c. Sampling shall be carried out 2 months before or after fertilization and harvesting and only in fields that have already started production.
    d. Direct measurements of SOC changes in the first 30 cm of the soil.
    e. The points of the initial sampling to measure SOC_R under identical field conditions (especially soil moisture) shall be used.
    f. Sampling protocol shall be documented in a sampling report including identification of the farms, geo-coordinates, timing, sample coding system used and related details.
2. **Measurement of the SOC content**
    a. Soil samples must be dried, sieved, and if necessary, ground.
    b. In case the combustion method is used, inorganic carbon shall be excluded.
3. **Determination of dry bulk density**
    a. Changes of bulk density over time shall be taken into account.
    b. Bulk density should be measured using the tapping method, i.e., by mechanically tapping a cylinder into the soil, which

[28] *e.g., in Europe sampling based on LUCAS approach and laboratory measurements according to DIN-norms*
[29] *van Engelen, V. W. P., & Wen, T. T. (1992). The SOTER Manual: Procedures for Small Scale Digital Map and Database Compilation of Soil and Terrain Conditions, 5th ed. (draft). ISRIC. https://edepot.wur.nl/29970*

greatly reduces the error associated with bulk density measurement.

c. If tapping method is not possible, especially in case of sandy soils, another reliable method shall be used instead and documented in the sampling report.

d. Samples should be oven-dried prior to weighing.

Repetition of analysis

Sampling and lab analysis shall be repeated every two years in the first four years, then every three years after that.

Updates

In case this approach is applied, the element n in the formula for es_{soc} represents the number of years the improved agricultural management is implemented. SOC_A (CS_A) should be updated with every new measurement.

SOC increase curve

A measurement-based SOC increase curve could be developed to show SOC increase starting from es_{soc} measure implementation. This could be used for farmers starting in later years. However, the newly added fields shall be included into the regular measurements to ensure the increase SOC follows the presumed curve within the SC-Unit within reasonable limits.

Restrictions on the use of es_{soc}

3.3.4 Emissions from Transport and Distribution (e_{td})

Transport and distribution of coffee

Emissions from transport and distribution (e_{td}) between BP Producers and BP Service Providers, i.e. post-harvest processing and storage facilities registered in the BPM of the 4C Unit, shall include emissions from the transport of the material (e.g., coffee cherries, green coffee) from the field all the way to the port of export or (local) final destination. In the case of 4C Chain of Custody certification, emissions are included among BP Service Providers registered in the corresponding BPM. The roaster as final processing unit may as well include the downstream transportation, so local distribution of final coffee product to distribution centers or even the end user. Emissions from the transport or commuting of workers do not need to be included.

Upstream

GHG emissions from transport of coffee cherries, coffee beans or green coffee at any supply chain step can be calculated based on the following formula:

$$e_{td}\left[\frac{kg\ CO_2eq}{ton}\right] = \frac{T_{needed} * \left(d_{loaded}[km] * K_{loaded}\left[\frac{l}{km}\right] + d_{empty}[km] * K_{empty}\left[\frac{l}{km}\right]\right) * EF_{fuel}\left[\frac{kg\ CO_2eq}{l}\right]}{amount\ transported\ coffee\ in\ transport\ type\ [ton]}$$

Where:

T_{needed} *transport trips needed,*

d_{loaded} *transport distance loaded,*

d_{empty} *transport distance empty,*

K_{loaded} *fuel usage loaded,*

K_{empty} *fuel usage empty*

Transport type and trips

In order to find out how often a transport type was used for the transported amount, T_{needed} shall be calculated. If ,e.g., amount is received in ton, this value is calculated by dividing the amount of transported goods by the loading weight of the transport system used, e.g., if 100 tons of input material is transported by trucks which can carry 20 tons, 5 trucks ($T_{needed} = 5$) would be needed to transport all the coffee beans or green coffee. The sum of the fuel consumption of loaded transport and empty transport (if applicable) is multiplied with the number of times this transport system is being used and the emission factor of the fuel.

Ship and train transport

As an alternative, the methodology for ton-km may also be used. This formula is especially relevant for ship and train transport and distribution, where no empty return transport has to be considered:

$$e_{td}\left[\frac{kg\ CO_2eq}{ton}\right] = \frac{(amount_{coffee\ in\ transport\ type}[ton] * distance_{transported}[km]) * EF_{transport\ type}\left[\frac{kg\ CO_2eq}{tkm}\right]}{amount\ transported\ coffee\ in\ transport\ type\ [ton]}$$

Emission factor in ton-km

The amount of transported coffee cherries, coffee beans or green coffee is multiplied by the total distance and by an emission factor in ton-km for the transport type. This approach needs to be repeated for each amount of material transferred via a different transport type. If all the material is transported via only one transport type, this calculation only needs to be done once.

Data gathering requirements

For the calculation of e_{td}, the necessary information and data need to be provided through on-site data gathering. All input values shall be obtained for the same time period.

Transport emissions responsibility

The responsibility of calculating transport emissions per supply chain step is as follows:

- Farm is not responsible for transport calculations
- Intermediate entity between farm and dry mill is responsible for upstream transport of coffee cherries from farm level
- Dry mill is responsible for upstream transport from previous entity (e.g. farm or intermediate) AND if last entity of 4C unit system boundary is also responsible for downstream transport to next intermediary buyer OR if there is no intermediary buyer within the supply chain up to the port of export or local destination
- Intermediary buyer is responsible for upstream transport from previous entity (e.g. dry mill or other intermediary buyer) if not receiving respective values together with green coffee beans delivery from previous entity
- Roaster as final processing unit is responsible for upstream (international) transport from country of origin to roaster. Further downstream transport can be included on a voluntary base.

The following figures (Figure 8, Figure 9) show examples of which supply chain entity is responsible for calculating transport and distribution emissions in the coffee supply chain:

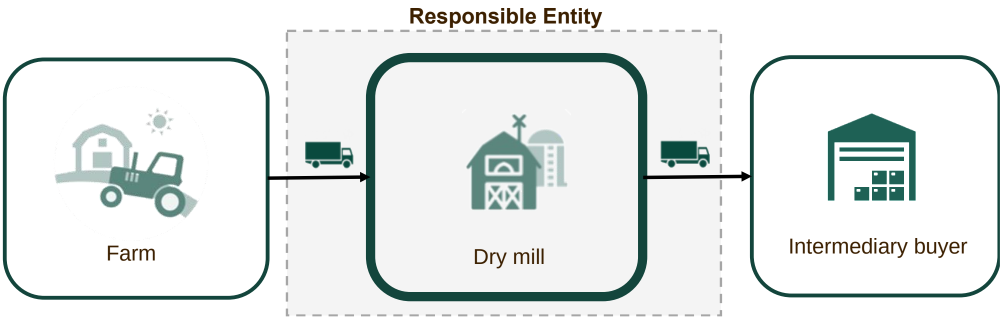

Figure 8: Example dry mill up- and downstream transportation emissions

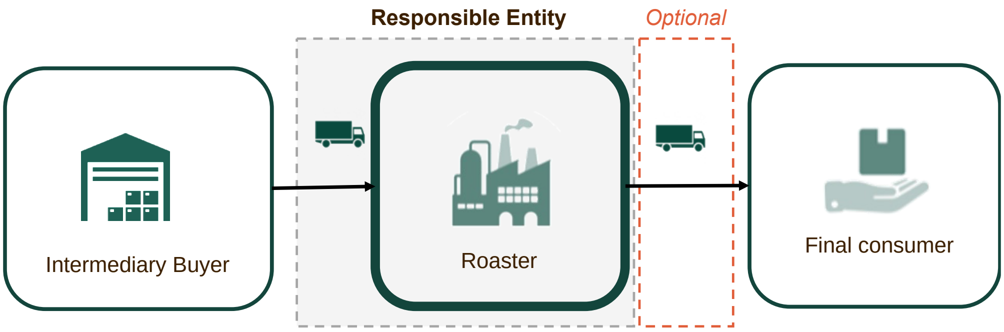

Figure 9: Example roaster upstream transportation emissions

Together with the batch of coffee cherries, beans or green coffee the supplier forwards the actual GHG value for transport e_{td} in kg CO_2eq/ton coffee beans or respective output to the recipient.

3.3.5 Emissions from Processing (e_p)

Calculating processing emissions

Emissions from processing are emissions generated by the BP Producers if post-harvest processing takes place on farm level and BP Service Providers, i.e., post-harvest processing facilities are registered in the BPM of the 4C Unit. In the case of 4C Chain of Custody certification, this applies to post-harvest processing facilities registered in the corresponding BPM (e.g. post-harvest processing facilities used by traders, roasting plants used by the brand owners).

Roaster

Coffee roasters shall also calculate processing and transport emissions following the methodology described in chapters 3.3.4 and 3.3.5. As the final processing unit, they shall also consider the information in chapters 3.3.6 and 3.3.7.

Emission sources to be covered

Emissions from processing, e_p, shall include emissions from the processing itself (washing, hulling, grading, packing), from waste and leakages and from the production of additives or products used in processing, including the CO_2 emissions corresponding to the carbon content of fossil inputs, whether or not actually combusted in the process. Emissions from processing shall include emissions from drying of co-products and materials where relevant. Emissions from the manufacture of machinery and equipment are not required to be taken into account, since they are not directly connected to the coffee cultivation or production process.

Calculation formula

The calculation shall be based on the following formula:

$$e_p \left[\frac{kg\ CO_2eq}{ton}\right] = \frac{\left(EM_{electricity} + EM_{heat} + EM_{inputs} + EM_{wastewater}\right)\left[\frac{kg\ CO_2eq}{yr}\right]}{processed\ coffee\ beans\ or\ green\ coffee\left[\frac{ton}{yr}\right]}$$

Emissions of different inputs

The emissions of the different inputs (EM) shall be calculated according to the formulas below and divided by the yield of coffee beans or green coffee depending on the processing stage.

Formula components for calculating EM are:

Energy emissions

$$EM_{electricity} = electricity\ consumption\left[\frac{kWh}{yr}\right] * EF_{regional\ electricity\ mix}\left[\frac{kg\ CO_2eq}{kWh}\right]$$

Electricity

If electricity is sourced externally from the grid, the emission factor for electricity from the regional electricity mix shall be used (average emission intensity for a defined region, $EF_{regional\ electricity\ mix}$). If electricity from renewable energies is directly consumed (i.e., not supplied from the grid), an adapted EF for the type of renewable electricity may be used if that plant is not connected to the electricity grid. If renewable electricity is purchased from an external provider via guarantees of origin (GoO) the respective EF provided for this electricity (mix) can be used as an alternative. The GoO shall be made available for audit purposes.

Office activities

Emissions from office activities are not required to be taken into account.

Heat

For calculating the emissions from heat production, two different formulas can be used, based on the available units of the provided heat:

$$EM_{heat} = fuel\ consumption\left[\frac{kg\ or\ l}{yr}\right] * EF_{fuel/heat\ system}\left[\frac{kg\ CO_2eq}{kg\ or\ l}\right]$$

or

$$EM_{heat} = heat\ produced\ from\ fuel\left[\frac{MJ}{yr}\right] * EF_{fuel/heat\ system}\left[\frac{kg\ CO_2eq}{MJ}\right]$$

Emission factors for heat production

As the emission factors for heat production differ for the fuel and the heating system, both data shall be documented. For calculating EM_{heat} the consumed heat or the fuel consumption for producing the heat for all activities during processing shall be determined and multiplied with the respective emission factor. If coffee husks or other residues from coffee cultivation, e.g., wood from pruning or renovation of the coffee plantation, are used for heat production on the farm or processing unit, upstream emissions can be set as zero. Biogenic CO_2 emissions from burning can be excluded from the calculation. However, resulting N_2O and CH_4 emissions shall be accounted for and included in the GHG calculation. IPCC provides separate emission values per greenhouse gas that can be used to differentiate the emissions occurring from biomass burning[30]. The values per greenhouse gas need to be converted into CO_2 equivalent values by multiplying with the respective GWP and both can be found in the Annex of this document. If such material for heating purposes is coming from an external source, respective upstream emissions shall be accounted for in the calculation and reflected in the respective emission factor.

[30] *IPCC 2006 Guidelines for National Greenhouse Gas Inventories, http://www.ipcc-nggip.iges.or.jp/public/2006gl/vol2.html*

The respective data and information shall be documented in the calculator. Biogenic CO2 emissions have to be documented as well but separately from the GHG calculation for example as an extra table next to the GHG results overview.

Other inputs emissions

$$EM_{inputs} = inputs\ consumption\ \left[\frac{kg\ or\ l}{yr}\right] * EF_{inputs}\left[\frac{kg\ CO_2eq}{kg\ or\ l}\right]$$

EM_{inputs} refers to all other types of inputs required as e.g., additives, fresh/process water, diesel or other fuel used in the production process (e.g., natural gas).

Wastewater emissions

$$EM_{wastewater} = wastewater\ \left[\frac{cbm}{yr}\right] * EF_{wastewater}\left[\frac{kg\ CO_2eq}{cbm}\right]$$

All wastewater that is generated during the activities of processing shall be documented and multiplied with the respective emission factor.

Inclusion of all emissions

Every processing unit in the supply chain shall ensure that all GHG emissions from processing, GHG emissions from wastes and from process-specific inputs are included in the emissions calculation.

Minimum requirements

For the calculation of GHG emissions from processing (e_p), the following data shall be determined as a minimum, i.e., the respective quantities shall be extracted from respective operating documents and must be verified by the auditors. The following data for the calculation of GHG emissions shall be gathered on-site. All input values shall be gathered for the same time period.

- Amount of main product in tons per year converted to coffee beans or green coffee
- Amount of process-specific inputs used (e.g., chemicals, process water, diesel or other fuel, packaging material) in kg per year or liters per year
- Electricity consumption in kWh/yr and source of electricity (e.g., grid)
- Heat consumption in MJ/yr, fuel or energy source for heat production (e.g., natural gas, wood) and type of heating system (e.g., boiler)
- Amount of waste (e.g., leaves, husks, shells, pulp) in kg per year and wastewater in m^3/yr

Methane emissions

When calculating emissions from wet processing of coffee or intermediate products, potential methane emissions from wastewater treatment and pulp decomposing shall be considered and calculated as well. Normally, methane emissions could occur during wet processing of coffee or intermediate products when the cherry beans are de-pulped with or without mucilage and/or hulled before drying.

If the calculation is conducted for a sample of BP processors, the GHG value for processing emissions can be averaged following the same approach as for farm samples in 3.2.1.

3.3.6 Forwarding GHG Emission Values in the Supply Chain

Forwarding of GHG values

GHG values shall be forwarded along the supply chain according to the physical flow of the coffee.

Each entity in the supply chain belonging to the defined system boundary (see chapter 3.1) shall forward the individually calculated GHG emission value of their production process together with the amount of coffee to the next downstream entity. For example, a 4C Unit shall calculate the emissions of the coffee produced and processed within its facilities, as detailed in the previous chapters, and declare those values when forwarding the coffee to the next entity in the supply chain, for instance, an intermediary buyer.

4C Portal

The 4C Portal has a feature where the 4C Units and Chain of Custody members can insert the correspondent emission values of each stage: e_c, e_p, e_l, es_{soc}, e_{td}. For some GHG values, like processing emissions or transport emissions, actual values need to be added at each step of the chain of custody by the respective operational unit.

Transport default values

4C will provide a calculator with standard values for different modes of transport as a reference, that intermediary and final buyers can adopt. If companies already have more efficient logistics or have implemented reduction measures, it will be possible to insert their actual emissions, which will be verified during the audit.

GHG unit

The GHG emission value shall be forwarded in the correct unit of kg CO_2eq/t coffee beans or respective output to the recipient. For the final processing unit in level 2 of the certification, e.g., the dry mill, the respective unit shall be kg CO_2eq/t green coffee. For further information on producers of final coffee products please see chapter 3.3.7.

Feedstock factor application

Incoming GHG emission values need to be adjusted from kg CO_2eq/t coffee cherries to kg CO_2eq/ton coffee beans and from coffee beans to green coffee. In order to do so, total emissions of incoming coffee beans are multiplied by a **feedstock factor (FF).** The feedstock factor can be defined as the ratio between the total amount (mass) of feedstock and the total amount (mass) of produced main output. It shall be applied for all incoming emissions (e_c, es_{soc}, e_l, e_p, e_{td}) as they are expressed in terms of the feedstock and need to be converted to the respective outgoing product of the unit calculating emissions. The following formula shall be applied:

$$Feedstock\ Factor\ (FF) = \frac{Total\ amount\ (mass)\ of\ feedstock}{Total\ amount\ (mass)\ of\ produced\ main\ output}$$

Conversion of upstream emissions

The calculation and application of this FF is mandatory to carry over the emissions of feedstock to the produced main output. The formula below shows an example how the feedstock factor shall be applied when a wet mill has received a GHG value for emissions from cultivation for coffee cherries as feedstock for its processing activities.

$$Emissions\ coffee\ beans\ (ec)\ \left[\frac{kg\ CO2eq}{ton\ coffee\ beans}\right] = Emissions\ for\ cultivation\ of\ coffee\ cherries\ (ec)\ \left[\frac{kg\ CO2eq}{ton\ coffee\ cherries}\right] * FF$$

FF for different coffee products

Within the coffee supply chain from farm to dry mill, the input products vary from coffee cherry to dry green coffee, with coffee beans as an additional intermediate main product for intermediate processes e.g. at a wet mill or washing station. In this situation, FF shall be calculated twice:

1. FF for the conversion of coffee cherry to coffee beans (farm to wet mill)

2. FF for the conversion of coffee beans to green coffee (wet mill to dry mill)

Forwarding GHG emissions

The following figures (Figure 1010, Figure 1111, Figure 1212) illustrate some examples of post-harvest processing and physical flows of coffee along the supply chain. This same rationale shall be applied on a case-by-case basis, according to the specifics of the supply chains registered within each 4C Unit.

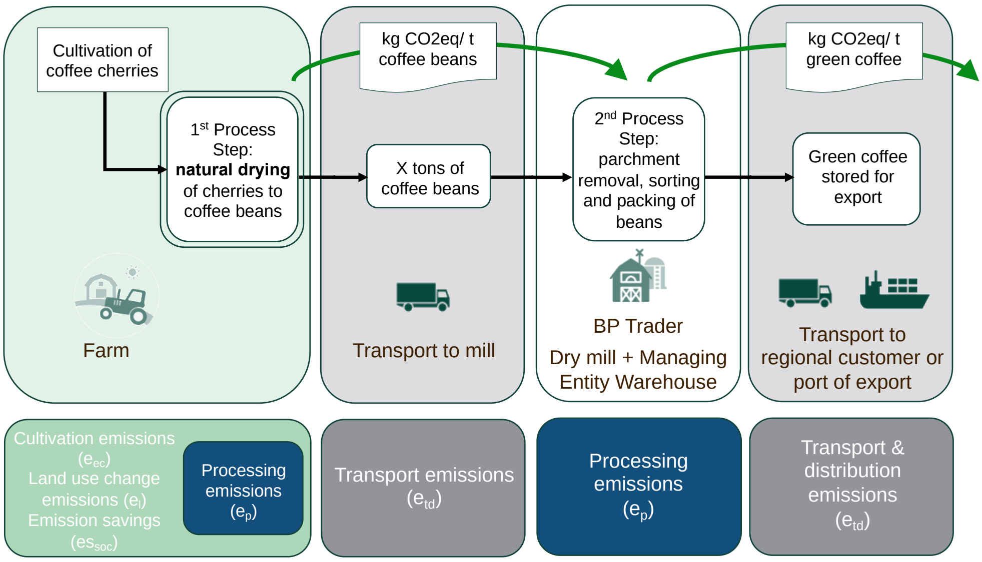

Figure 10: Example of natural coffee - dry processing done on the farm

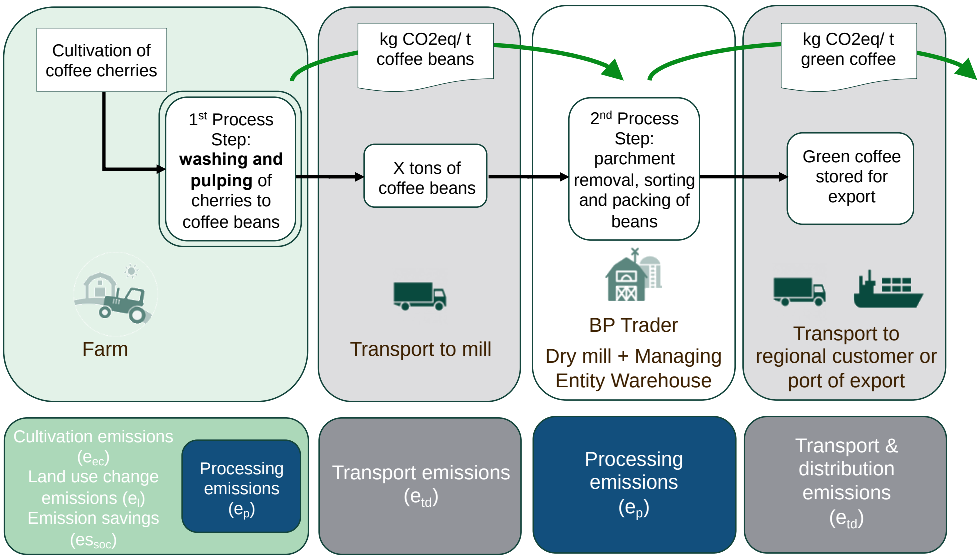

Figure 11: Example of washed coffee - wet processing done on the farm

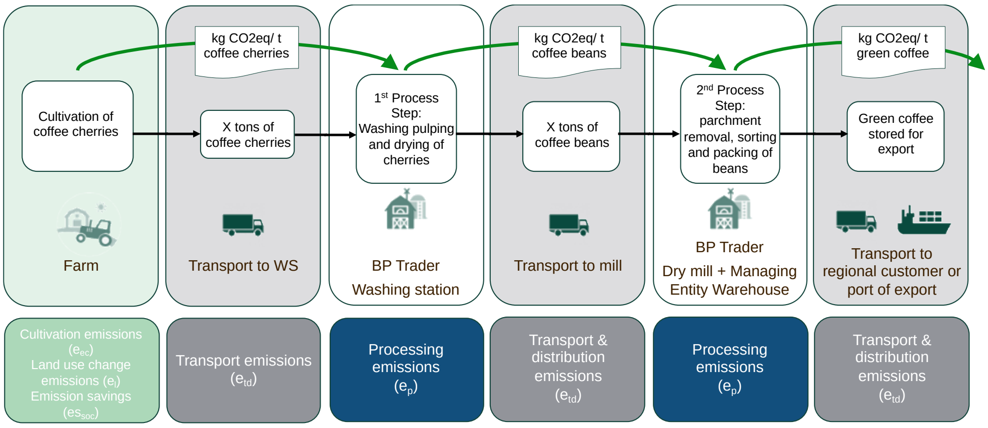

Figure 12: Example of washed coffee - wet processing in central station

3.3.7 Further Requirements for Producers of Final Coffee Products

Roaster GHG emissions

If GHG emissions shall also be calculated for downstream processing activities after dry mill and international transport i.e. warehousing and roasting, the calculation shall follow the same rules as for the upstream production process described in chapters 3.3.4. and 3.3.5.

Formula elements which shall be covered are

- emissions from *processing* e_p

  and

- emissions from *transport and distribution* e_{td}.

Upstream GHG emissions

GHG emissions from all *upstream activities* (incl. cultivation, pre-processing, national transport) shall be included by using the GHG emission value forwarded together with the amount of green coffee as incoming value from the last upstream entity.

Roaster Downstream emissions

The next entity in the supply chain e.g. the roaster receiving green coffee has to account for the emissions from these transportation activities from point of export to the gate of the respective facility. Each processing unit shall account for its upstream transport emissions. The roaster as final processing unit may as well include the downstream transportation, so local distribution of final coffee product to distribution centers or even the end user.

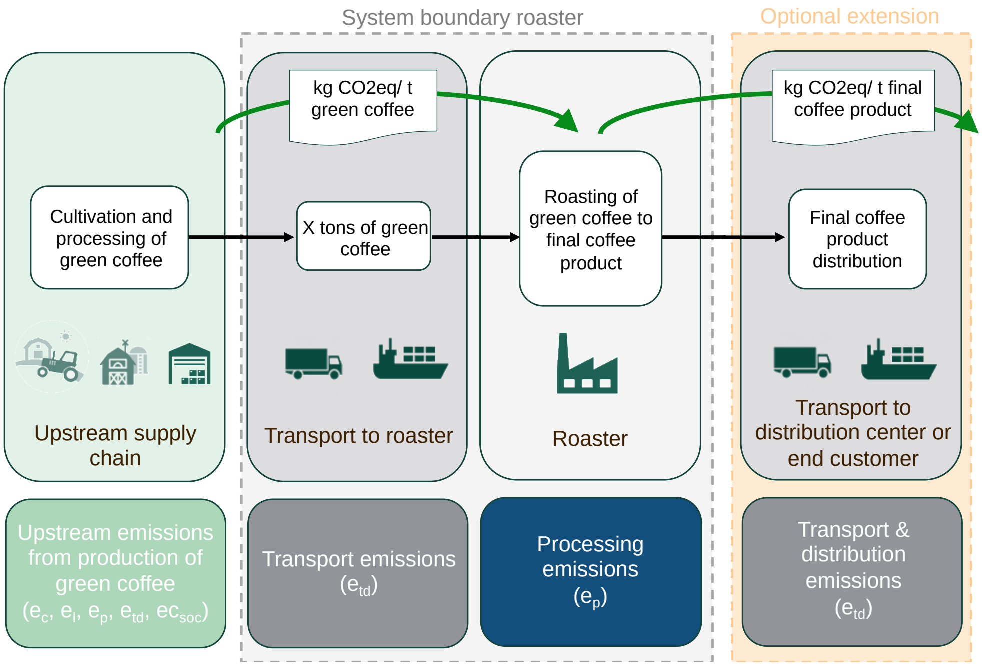

Figure 13 System boundaries for a roaster

The forwarding process should follow the same rules as for all previous supply chain steps described in chapter 3.3.6. The producer of a final coffee product as well has to apply the FF to convert the incoming GHG emission value into the respective final unit of the coffee product e.g., roasted coffee beans. Figure 13 gives an overview of the calculation and forwarding activities for roasters as final unit.

4 Improvement Plan to Reduce GHG Emissions

Setting up improvements

At Level 3 of the certification, when emission reduction actions are implemented, an improvement plan (IP_CF) shall be developed and implemented that demonstrates how emission reductions will be achieved. The initial GHG calculation for the coffee supply can be used and analyzed with respect to the identification of the most relevant emission sources. The effectiveness of the measures should be demonstrated by a GHG emission reduction that can be attributed to the respective measure within one year after the baseline GHG calculation was conducted. The measures can include one or multiply parts of the supply chain.

4.1 Elements of the Improvement Plan

Improvement Plan requirements

The objective of the IP_CF is to provide sufficient information regarding the GHG emission reduction activities, planned or already implemented, in the coffee supply chain. This IP_CF should have a minimum requirement for emission reductions of 4.2%[31] annual reductions of total emissions from the base year. The timeframe for the implementation of certain measures depends on type and scope but should be at least one year. The development, update, and submission to the CBs of the IP_CF regarding GHG emissions reduction measures shall follow the requirements and steps described in chapter 4.3.3 of the 4C System Regulations for certified 4C Units. The

[31] *4.2% annual linear reduction rate over target period from the ambition range corresponding to the long-term temperature goal below 1.5°C from the Science Based Targets initiative (SBTi).*

certification under the Carbon Footprint Add-On requires the completion and update of an improvement plan, a separate applicable template is available and named IP_CF. For this document, the following points shall be included along with any additional information and documentation that is considered to be of relevance.

4.1.1 Baseline

GHG emission baseline

a) Base year definition: A specific year to which future GHG emissions are to be compared to in order to monitor the emission reductions achieved. The base year shall be the initial year for which GHG emissions were calculated under the Carbon Footprint Add-On. An earlier base year can be accepted if it was set according to the guidelines from the Science Based Targets initiative.

b) Base year GHG emissions: Summary of GHG emissions in the selected base year including the final value for GHG emissions in kg CO_2eq/t green coffee.

c) Baseline scenario: Information on the projected emissions in a scenario with no emission reduction measures. The projections need to be fully described and include the report on data sources, emission factors and assumptions.

4.1.2 GHG Emission Reduction Targets

GHG emission reduction target

d) Emission reduction target definition: The IP_CF needs to include at least a total emission reduction target based on the calculated GHG emissions of the defined base year. As part of the system requirements, the minimum target is set at 4.2% annual reduction of total emissions in reference to the base year. This target is in line with the guidelines from the Science Based Targets initiative (SBTi), corresponding to the ambition level of annual linear reduction rate according to the long-term temperature goal of below 1.5°C.[32] These targets can be set according to any commercial projections or sustainability strategies the company may have, or previous commitments with the SBTi.

e) Emission reduction target timeframe: For every target presented in the IP_CF, a specific deadline needs to be defined. This deadline can be set in a short-, mid-, or long-term timeline and need to be monitored and further reported with subsequent recertifications.

4.1.3 GHG Emission Reduction Measures

Emission reduction activities

f) Reduction measures description: Brief report of the activities included in the emission reduction measure. This description needs to include specific information on the size of the project, location, technology requirements, parties involved in the implementation and planned operation starting date.

g) GHG emission reduction potential: Information on the projected emissions avoided through the implementation of the measure. The

[32] *Science Based Targets initiative. Target Validation Protocol. TWG-PRO-002 | version 2. April 2020. Table 3. Minimum ambition thresholds*

projections need to be fully described and include the report on data sources, emission factors and assumptions.

h) Co-benefits: If applicable, mention all additional rewards or secondary effects resulting from the implementation of the emission reduction measure. These can include additional improvements in areas such as energy security, climate change adaptation, poverty reduction, gender equality, among other social benefits.

4.1.4 Monitoring Plan

Monitoring emission reductions

i) Plan description: Overall description of the monitoring activities to keep track of the progress of each of the emission reduction measures. This section needs to include monitoring procedures, involved parties in the monitoring process, and data collection systems used.

j) Description of types of data and information reported: Full list of which data will be collected for monitoring purposes. The type of data will depend on the characteristics of the measure and shall represent a key indicator of the performance of the reduction measure. Examples of these indicators are monthly electricity consumption (kWh/month), weekly water consumption (m^3/week), fertilizer consumption (kg/month), etc.

k) Data quality: Clarification of all data sources where information for the defined indicators is to be collected. This section shall indicate if assumptions and estimations have been made, as well as provide any supporting information sources for default values or proxy data. If there are any data gaps present, information needs to be provided on how they have been addressed.

l) Reporting methodology: It is also necessary to include a description on how the reporting will be done, including information about the responsible party and data management. This includes a clarification if the reporting will be made through on-site surveys, self-reporting on paper, digital tools or mobile applications; as well as who will be collecting/storing the final data.

m) Monitoring timeline: A clear timeline needs to be presented on the frequency and planned dates for data reporting deadlines. Data reporting can be done in different frequencies depending on the characteristics of each measure, but a total amount for 12 months should be collected as part of the monitoring activities for the Carbon Footprint Add-On certification.

4.2 GHG Emission Reduction Measures

Emission reduction examples

As part of the IP_CF, information about currently implemented GHG emission reduction measures should be included. Emission reduction measures can be implemented in any of the supply chain elements. Measures focusing on carbon accumulation in coffee are included in the examples below under the agriculture category. The emission reduction measures can include, but are not limited to, the following examples:

a) Cultivation
    a. Fertilizer reduction

b. Pesticide reduction
c. Reduction of energy consumption
d. Soil carbon accumulation via improved agricultural management
e. Soil fertility restoration and use of degraded land
f. Soil health improvement
g. Soil acidity remediation
h. Soil erosion reduction
i. Methane capture from agricultural activities
j. Agroforestry
k. Increasing shade/coffee tree density
l. Addition of nitrogen fixing plants
m. Reduction of erosion risk with terracing or pits for retention of organic material
n. Methane avoidance from biomass decay
o. Methane avoidance through composting

b) Processing

a. Fuel switch to less carbon intense fuels (e.g., biofuels)
b. Energy efficient water pumps
c. Renewable energy production
d. Installation of solar water heaters
e. Lighting retrofitting
f. Methane avoidance through waste separation
g. Methane recovery in wastewater treatment

c) Transport and distribution

a. Fuel switch from fossil to biofuels or e-fuels
b. Transition to electric vehicle use
c. Transportation fleet retrofitting
d. Improvements in organization and logistics (e.g., less empty running)

5 Carbon Footprint Add-On Certification Process

Options for system users

The audit and certification process for the core 4C certification as described in chapters 5, 6 and 7 of the 4C System Regulations shall be carried out for the Carbon Footprint Add-On certification. The term Carbon Footprint Add-On certification applies to the 4 implementation levels, as listed below.

CF Add-on levels

- **Level 1**: GHG emissions calculation at the 4C Unit level
- **Level 2**: GHG emissions calculation at the 4C Unit level and Intermediary Buyers

- **Level 3**: level 1 or 2 including the reduction of the GHG emissions
- **Level 4**: level 3 including carbon compensation

Therefore, the auditing and certification procedures described in the following chapters should be applied for any of the implementation levels mentioned above. All 4C System Updates should also be considered as a general requirement relevant to the audit and certification process.

Complete certification process

The complete certification process of the Carbon Footprint Add-on comprises three different steps: preparation for certification, certification process and maintenance of the certificate. The steps are detailed in the picture below:

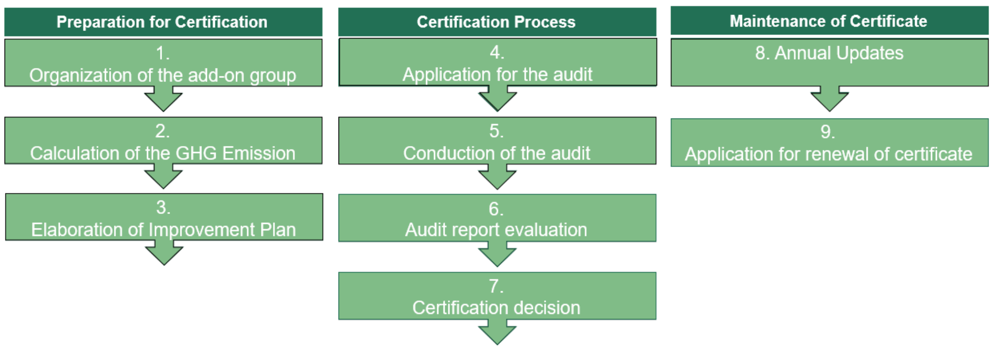

Figure 14 Complete Certification process of the Carbon Footprint Add-On

5.1 Preparation for Certification

Organizing the Add-on group for 4C Units

The first step to apply for the 4C Carbon Footprint Add-On is to organize the group that will apply the Add-On. The core 4C certification is a pre-requisite for the Add-On, and the Managing Entity can decide if it wants to pursue the Carbon Footprint Add-On certification for a whole 4C Unit or for a sub-unit of the 4C Unit. The BPM of the core 4C certification will have an extra column where it will be possible to signal which BPs are under the Add-On.

Adding new BPs to the CF 4C Unit

To add new BPs in an existing 4C Unit certified under the Carbon Footprint Add-On, the MEs need to calculate the footprint of the new BPs before including them in the Unit. The ME needs to observe that including new BPs could increase their carbon footprint, instead of reducing it. That is why it is recommended to only include new BPs that are already working on reducing their emissions. It is also important to note that the resulting CF Improvement Plan needs to be cumulative and that 4C has the right to request detailed information about the added BPs, including to which sub-group they will belong.

Removing BPs from the CF 4C Unit

To remove BPs from an existing CF 4C Unit, MEs also need to observe that, between certification audits, when performing the Annual Updates 1 and 2, the baseline will not change, and the monitoring of progress will consider as if the removed BPs are still there. In the recertification audit, it will be possible to create a new baseline, removing the BPs that have left. In this case, 4C also has the right to request detailed information about the BPs that left the Unit or sub-unit, including to which sub-group they belonged

Organizing the Add-on group for CoC

In the case of Chain of Custody, the core 4C certification is also a pre-requisite and the formation of sub-units is not possible, meaning that all facilities need to be considered as part of the Add-On. If a certain Intermediary of Final Buyer is only trading and storing coffee, not performing any processing activities, then they should only add transport and distribution emissions and forward the sum to the next supply chain entity. In case processing is involved in their scope, they also need to include the respective processing emissions

Additional documents for preparation phase

While still in the preparation phase of the certification process, it is necessary to calculate the GHG emissions according to the methodology described in the previous chapters. In addition to that, for the 4C users interested in getting the certification on levels 2 and 3, it is necessary to elaborate the improvement plan before applying for the certification.

5.2 Certification Process

In addition to the procedures and requirements described in chapters 5.2.2, 5.2.3 and 5.2.4 of the core 4C System Regulations, all requirements listed in this section shall be met.

Add-On scope

The scope of the Add-On audit is focused on coffee cultivation areas. Therefore, it does not apply to other crops and land uses that may eventually occur on the same farm as required by the core 4C certification.

Documents for audit

Apart from the documentation that shall be available for the core 4C certification audit, there shall also be documentation available related to the calculation of GHG emissions and other documents used to support the elaboration of the Improvement Plan to reduce the GHG emissions. The same rule applies to documentation related to carbon offsetting. This means that the data, records, reports, scientific articles, procedures and other related documents as detailed in chapters 3 and 4 of this document must be available for verification during the audit. This rule applies to all 4 implementation levels.

Conditions for CBs and auditors

The list of CBs cooperating with 4C and authorized to conduct the Carbon Footprint Add-On audit is available on the 4C website. Currently 4C accredited CBs and its auditors need to participate on the Carbon Footprint Add-On training to be approved for this scope. There are no further requirements.

5.2.1 Audit Types

The following audits can be conducted by the CB:

Add-On certification audit

Add-On certification audit: during the certification audit, the necessary evidence is gathered to verify compliance with the requirements described in this document and future system updates which support the Carbon Footprint Add-On certification decision. The first certification audit is called initial Add-On audit and the following audits to be conducted with the purpose of renewing the Carbon Footprint Add-On certifications are called recertification Add-On audits.

The Add-On certification audits can be combined with the core 4C certification audits, i.e., the CB can conduct both audits simultaneously provided that the requirements for both audits are met.

Audit combination

Therefore, in the case of 4C certification for producing groups (4C Units) there are three options for the initial Add-On audit as follows:

(1) Combined with the core 4C certification audit during the harvest season.

(2) Combined with the core 4C certification audit during the off-harvest season, according to the exception rule described in chapter 6 of the 4C System Regulations.

(3) Combined with the core 4C surveillance audit (if required based on 4C core certification).

(4) Independent from other types of 4C audits, i.e., on another date. But always after an initial core 4C certification audit.

Combination with addendum

It is not possible to conduct Add-On certification audits combined with the core 4C addendum audit due to the impossibility of matching the sampling rules for both scopes.

Re-certification audits

The recertification Add-On audits should be combined with the 4C core certification audits aiming to renew both certifications at the same time. The updated GHG calculation as described in this document and the updated IP_CF describing the reduction measures shall be available before submitting an application for the 4C Climate Friendly Coffee recertification audit.

Independent audits

In case there is the need to conduct a recertification Add-On audit independent from the core 4C certification audit, the issuance of the Carbon Footprint Add-On amendment is conditioned to the core 4C certification decision.

CoC Add-On audit

For 4C Chain of Custody certification there are three options for the initial Add-On audit as follows:

(1) Combined with the core 4C certification audit

(2) Combined with the core 4C surveillance audit (mandatory every year for CoC)

(3) Independent from other types of 4C audits, i.e., on another date. But always after an initial core 4C certification audit.

Examples of audit combination

The following figures (Figure 15 and Figure 16) show the combination of the core 4C certification and the Carbon Footprint Add-On certification.

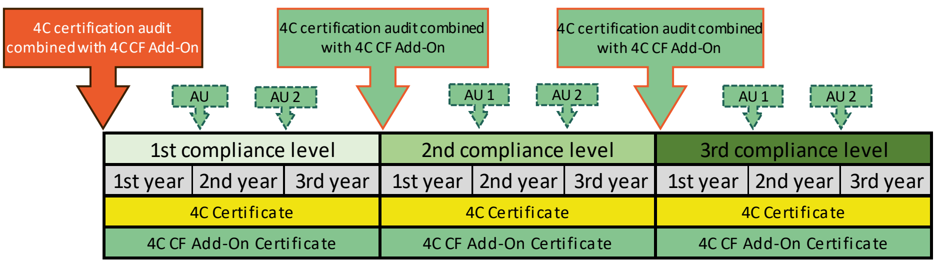

Figure 15: Add-On audit combined with initial core 4C certification

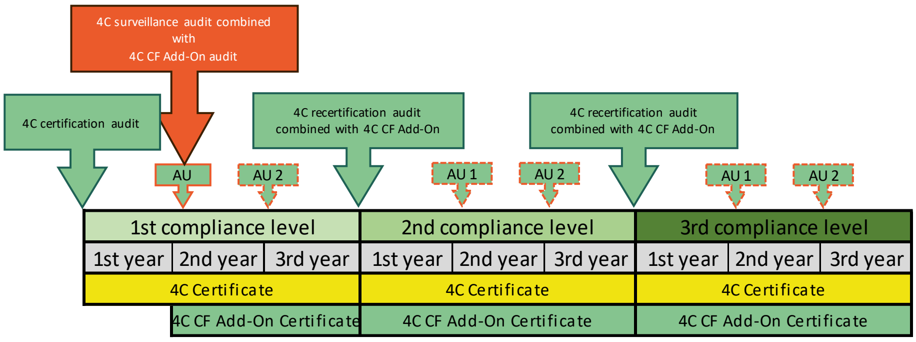

Figure 16: Add-On audit combined with 4C surveillance audit (if required based on 4C core certification)

Figure 17 shows the application of the Carbon Footprint Add-On complementing the 4C chain of custody certification.

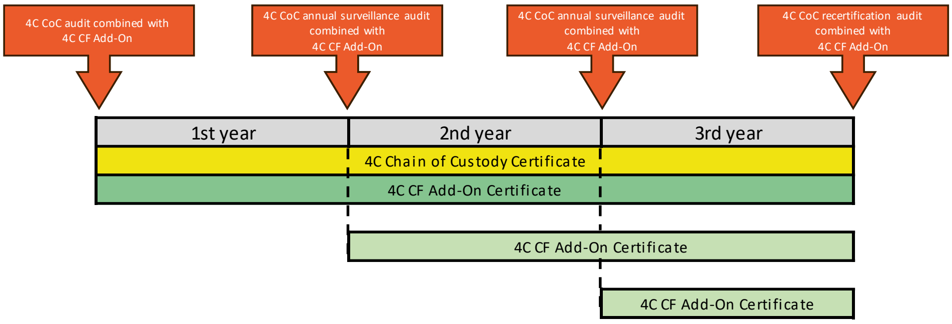

Figure 17: Add-On audit combined with 4C CoC audit certification

5.2.2 Application for Carbon Footprint Add-On Audit

Core 4C certification procedures apply

The procedures and requirements described in the core 4C System Regulations[33] shall be observed as they provide detailed rules on how to apply and plan the 4C audit for the core 4C certification. In general terms, the CB shall register an audit application in the 4C Portal, which needs to be validated by 4C. If the audit is an initial one, the CB and the ME will also receive an unique registration number for the ME. To prepare for the audit, the CB shall perform a risk assessment using GRAS (Global Risk Assessment Services) and other tools and send the audit plan to the 4C staff through the 4C Portal, including dates, times, activities, duration, locations, risk levels, sample size and other relevant information. We recommend the readers of this guide to go through the 4C Systems Regulations document if they are not already familiar with the 4C System requirements.

Additional requirements

In addition to the 4C System Requirements, the following requirements shall be complied with for a Carbon Footprint Add-on audit:

The baseline GHG calculation conducted according to the requirements described in this document shall be available before submitting an application for the Carbon Footprint Add-On certification. The same procedure applies for the improvement plan when the implementation levels 3 and 4 are adopted, as these levels include the emission reduction measures.

[33] *For more detailed information please refer to chapters 5.2.1 and 6.4 of the 4C System Regulations.*

Certification Bodies

Only CBs cooperating with 4C and being approved to conduct the Carbon Footprint Add-On audits and certification process shall conduct respective audits.

Application documents

The application documents must be filled in by the applicant and sent to the selected CB. The table below summarizes the corresponding application documents:

Table 2: Application documents

Level	Scope	Type of certificate	Type of documents needed
Level 1	4C Unit	Verification of Carbon Footprint	BPM+ Calculations
Level 2	4C Unit + IBs + FBs	Verification of Carbon Footprint	BPM + Calculations
Level 3	4C Unit + IBs + FBs	Certification of Climate Friendly Coffee	BPM + Calculations + IP_CF
Level 4	4C Unit + IBs + FBs	Certification of Climate Neutral Coffee	BPM + Calculations + IP_CF + Carbon Credits

Format of the calculation report

The GHG emissions calculation report shall be delivered as an Excel file, in open format (not protected). All production steps and formula elements should be separated and clearly displayed. The final GHG emission value and important information on the calculation should be summarized and displayed in an overview sheet in the Excel file. Calculations should be directly connected to respective data cells in the file to ensure transparency and traceability in the audit.

Next steps

The information provided through these documents will be checked by the CB before conducting the next steps, i.e., risk assessment, preparation and registration of the audit plan on the 4C Portal as described for the core 4C certification.

5.2.3 Risk Assessment, Sample Size Calculation and Selection

Specific requirements

In addition to the procedures and requirements described in chapter 5.2.3 of the core 4C System Regulations regarding Risk Assessment, sample size calculation and selection, the following specific requirements shall be complied with.

Sample selection

As a general rule, the Carbon Footprint Add-On audit is combined with the 4C core certification audit. In order to combine both audits, the sample of BP producers and BP processors to be audited should be selected by the auditor in such a way that both scopes are covered in the final sample.

Audit sample size

It is important to observe that the sample for the audit differs from the calculation sample. The calculation sample is something that should be observed by the Managing Entity to get solid results on the calculations of the CF of a certain 4C Unit. On the other hand, the audit sample aims to verify if the procedures for data registration and collection are being correctly executed by BP Producers and BP processors, and if they are implementing correctly the actions planned in the IP_CF.

Sample includes ME

As per the requirements of the core 4C certification, the Managing Entity always need to be audited. When auditing the ME, the CB will have the responsibility to check if the methodology of the calculations was correctly applied and the formulas are consistent, if the IP_CF is correctly developed and if the ME has a management plan to guarantee the CF Add-on implementation. Many checkpoints related to the ME and the calculations could be audited remotely.

Minimum sample size calculation

To select the sample for the audit, CBs need to apply the current requirements on risk assessment for the core 4C certification audit to determine the final risk levels for BP_Producers and BP_Service Providers. The sample size for the core 4C certification for BP Producers and BP Service Providers varies according to the final risk levels, as stated in the core 4C regulations. **The minimum sample size calculated for core 4C certification is the minimum sample size for the combined audit.**

Combined sample selection

If the whole 4C unit applies for the CF Add-On, at least one BP audited in the first combined audit shall be part of the original calculation sample. In case a sub-unit of the 4C Unit applies for the CF Add-On, the combined audit sample must include:

- BPs outside the scope of the CF Add-On, in order to cover the requirements for the 4C risk assessment and sample selection
- At least one BP part of the CF add-on original calculation sample

Possible to increase minimum sample

As per the core 4C certification regulations, auditors and CBs have the right to increase the sample of the audit if they observe high risk situations or have difficulties in covering both scopes only by adopting the minimum sample size.

5.2.4 Conduction of the Audit

Checklists to verify compliance

In line with the procedures applicable for the 4C core certification, 4C prescribes additional checklists to CBs which shall be used during the Add-On certification audits to verify the compliance with the Carbon Footprint Add-On requirements. Carbon Footprint Add-On audit checklists are working documents containing specific checkpoints and verification guidance.

Checklists according to the levels

Carbon Footprint Add-On audit checklists are available for producing groups (4C Units) and Chain of Custody and contain levels of compliance in line with the different possibilities to implement the Add-On:

Unit Level

Carbon Footprint verification (level 1): GHG emissions calculation at the 4C Unit level. In this case, only the checkpoints related to the GHG emissions calculation are relevant.

Unity Level and Intermediary Buyers

Carbon Footprint verification (level 2): GHG emissions calculation at the 4C Unit level and Intermediary Buyers. Similar to level 1, it includes the checkpoints related to the GHG emissions calculation covering the entire supply chain. The audit checklists for 4C Units and Chain of Custody are two different documents, with different checkpoints, according to the respective scopes.

Reduction of GHG emissions

Climate Friendly Coffee certification (level 3): Includes the reduction of the GHG emissions. For this situation, in addition to checkpoints described in the previous items, there are checkpoints related to the reduction of the GHG emissions.

Carbon compensation

Climate Neutral Coffee certification (level 4): Includes carbon compensation. At this level of implementation, the checklist provides additional checkpoints related to the compensation measures of own emissions by purchasing carbon credits from certified offsetting projects.

4C procedures apply to the Add-On

The remaining procedures related to the completion of the checklists, their evaluation by the CBS evaluators, the treatment of non-conformities, uploading to the 4C Portal and other details as described in the 4C System Regulations are also applicable for the 4C Climate Friendly Coffee certification.

5.2.5 Audit Report Evaluation and Certification Decision

Possible certification decisions

As stated before, a positive certification decision for the Carbon Footprint Add-On can only happen after a positive certification decision about the core 4C certification. The following outcomes are possible:

- Possibility 1: Positive 4C core certificate + Positive 4C CF Add-On certificate
- Possibility 2: Positive 4C core certificate + Negative 4C CF Add-On certificate

A negative decision on the add-on certification does not interfere in the certification decision of the core 4C certification.

Deadlines to certificate decision

The CB has 60 days to make a decision on the Add-On certification and the validity of the add-on certificate follows the same rule of the core 4C certification. This way, it is not possible to extend and backdate the Add-On certificate.

5.3 Maintenance of the Carbon Footprint Add-On Certification

Annual Updates and surveillance audits

In addition to the procedures and requirements described in chapter 5.3 of the core 4C System Regulations, the following requirements shall be complied with. As for the core 4C certification of producing groups (4C Units), the annual update procedure is also mandatory to maintain the Carbon Footprint Add-On certification.

Annual Updates are mandatory

After the first and second year of the Carbon Footprint Add-On certification, the ME must submit an updated set of documents respectively called AU1 and AU2 to its contracted CB, which includes the BPM, updated calculations, and IP_CF. The IP_CF document is not applicable for implementation levels 1 and 2 as already outlined in the previous chapters of this document. The content of the IP_CF is detailed in chapter 4 of this document.

Approval of Annual Updates

The CB then evaluates and approves the AU1 and AU2, by checking if all documents have been handed in correctly and filled in completely. In case of doubts, a surveillance audit may follow to ensure the implementation of the 4C Add-On requirements. Approved AU documents must be uploaded to the 4C portal by the CB.

Chain of Custody

In the case of 4C Chain of Custody certification, verification of the updated BPM, calculations, and IP_CF is done during surveillance audits

Sample for recalculation

To update the calculations, the ME or the CoC applicant needs to apply the same sample requirements for the calculation of the sample size, such as the first calculation, select the sample and recalculate the emission. Half of the sample for the recalculation shall include BPs that were part of the original calculation, while the other half shall be composed of new BPs.

Non-combined audits

In case the Add-On initial audit is not conducted in combination with the core 4C certification audit, i.e., during the first year of validity of the core 4C certificate the AU1 is not required. For that case only AU2 is required and must follow the same due date required for the core 4C certification.

6 4C Climate Neutral Coffee Certification

The purpose of 4C Climate Neutral Coffee

4C Climate Friendly Coffee can optionally be upgraded to 4C Climate Neutral Coffee, reaching the highest level of the Carbon Footprint Add-On certification process, as described in chapters 2 and 4. The purpose of this upgraded certification is to certify that all unavoidable emissions occurring in the coffee production process have been compensated, and that the coffee achieved carbon neutrality. The 4C Climate Neutral coffee certificate will show the carbon neutrality achieved through the combination of GHG reduction measures and the compensation of remaining emissions, by purchasing high-quality carbon credits from certified offsetting projects.
This chapter provides a general overview on carbon compensation (or offsetting) mechanism to introduce the basics, together with the requirements to be met to receive the 4C Climate Neutral Coffee certification.

6.1 Carbon Compensation Mechanism

Carbon compensation as policy instrument

Carbon compensation (or offsetting) is a policy instrument to enhance sustainability through the reduction of GHG emissions. It is an instrument that allows companies to reach climate neutrality in the short term, by offsetting unavoidable GHG emissions. Offsetting carbon emissions means buying carbon credits from certified GHG emissions reduction/avoidance projects (i.e., carbon offsetting projects) in one location, in order to compensate an equivalent amount of emissions occurring in another location. In other words, when a company wants to offset GHG emissions that could not be reduced directly, it can economically contribute to a project aimed at reducing GHG emissions in a different location, that generates carbon credits. One carbon credit represents one ton of equivalent avoided CO_2 emission due to the project activities. The company receives carbon credits for its contribution to the emission reduction project in a proportional amount to the money invested and uses these to compensate its unavoidable emissions.

Requirements of offsetting project

Offsetting projects may address different sectors (e.g., agriculture, forestry, renewable energy, energy efficiency, methane capture, etc.). To generate carbon credits, an offsetting project needs to meet specific requirements (e.g., generate GHG emission reductions that are additional to the business-as-usual status, ensure permanence over time and avoidance of GHG emission reductions), apply approved methodologies, and successfully pass third-party verification.

Carbon credits purchase and retirement

Once the credits are issued, they are stored in the registries owned by certification standards, and they are retired when a company purchase them (to avoid they are sold twice). A certificate certifying the purchase and the retirement of the credits from the respective registry is released as proof of carbon compensation. This certificate can be used by the company to demonstrate carbon offsetting and to allow the credits to be considered in the GHG emission calculation and to appreciate the effect of carbon offsetting in terms of emission reduction.

6.1.1 General Requirements

Climate Neutral Coffee Requirements

The general requirements applying for 4C Climate Friendly Coffee apply also for 4C Climate Neutral Coffee. In addition, the specific requirements listed in chapter 6.1.2 shall also apply.

6.1.2 Specific Requirements

GHG emission reduction must be demonstrated

For this level of certification, it is a prerequisite that after at least one year the implemented IP_CF has led to verified GHG emission reductions, as for the requirements outlined in chapter 5. This reduction can be demonstrated in an updated version of the baseline GHG calculation. The expected GHG emission reductions set in chapter 5 shall be demonstrated every year, to keep the 4C Climate Neutral Coffee certification. This is to ensure a continuous GHG emission reduction pathway and the integration with carbon compensation in a proper proportion. As a result, with the improvement in GHG emissions, the carbon credits needed for carbon compensation and 4C Climate Neutral Coffee certification will proportionally decrease overtime.

Compensation with high-quality credits

Additionally, unavoidable GHG emissions, such as the remaining emissions after the application of GHG emission reduction measures, must be offset. This must be done by purchasing an equal amount of carbon credits by a certified carbon offsetting project. 4C Climate Neutral Coffee certification shall only accept high-quality certified credits, ensuring environmental (e.g., biodiversity loss reduction, ecosystem services provision) and social (e.g., improve livelihood of local communities) co-benefits, beyond the GHG emission reduction. Ideally, the carbon credits must be purchased from ex-post offsetting projects, ensuring the reliability and permanence of GHG emission reduction, However, ex-ante credits, can be accepted, in case suitable projects (i.e., meeting all the previously mentioned requirements) are identified. The use of ex-ante carbon credits is only allowed if 4C is duly informed about the project characteristics and gives the approval for the use of ex-ante carbon credits before the purchase for compensation purposes takes place.

Approval of carbon credits

All the information on carbon credits used to compensate GHG emissions, shall be forwarded to 4C for approval. 4C may also support the selection of high-quality carbon credits and reliable offsetting projects suitable for compensation purposes.

6.2 Verification of Compensation

Compensation proof

After purchasing carbon credits, these must be retired from the respective registry on behalf and with the name of the compensating company, to which a compensation proof (usually known as certificate of compensation) is released. This proof needs to be provided to 4C for check and validation.

6.3 Accounting of Carbon Compensation

Compensation is reported separately

Unavoidable GHG emissions, compensated by the purchase of high-quality carbon credits (offsetting), and certified under 4C Climate Neutral Coffee will remain separated and cannot be directly accounted for in the general formula. Offset GHG emissions are required to be reported independently from the main calculation and the IP_CF.

7 Claims and Logo Use

Marketing claims

The use of the 4C Climate Friendly Coffee logo and 4C Climate Neutral Coffee logo is meant to allow users of the 4C System to communicate and signify their achievements regarding implementing measures to contribute to climate protection in the coffee sector.

Compliance and Claims

Compliance with the Carbon Footprint Add-On requirements is the basis for possible on-product claims on final products (e.g., on-pack labels) and off-product claims (e.g., website, social media, etc). Therefore, a valid Carbon Footprint Add-On amendment substantiated by the respective level of implementation is the prerequisite for the on-product and off-product use of the 4C Climate Friendly Coffee and/or 4C Climate Neutral Coffee logos and related text claims by all 4C certificate holders.

Claims per level of implementation

Companies can start to promote their efforts to mitigate climate change from levels of implementation 1 and 2, which can be communicated by certificate holders using the term "4C Verified GHG emissions" or similar claims, as long as they do not convey the message of GHG emission reduction or neutrality. The use of the 4C Climate Friendly Coffee logo is possible for certificate holders that have chosen level of implementation 3 and the use of the 4C Climate Neutral Coffee logo is possible for companies that have chosen level of implementation 4.

Logo usage by stakeholders

Other 4C users such as Certification Bodies and other stakeholders as referred in Table 2 can also use the logos and claims referred to in this chapter, as long as the conditions described within this document are met.

Logo usage

The general requirements regarding the core 4C logo use and claims described in chapter 10 of the 4C System Regulations shall also be complied with for the 4C Climate Friendly Coffee and 4C Climate Neutral Coffee logos. The 4C Climate Friendly Coffee logo (Figure 18) and the 4C Climate Neutral Coffee logo (Figure 19) holds copyright protection and is a registered trademark.

Figure 18: 4C Climate Friendly Coffee logo

Figure 19: 4C Climate Neutral Coffee logo

Claims requirements

General sustainability-related claims which do not directly reference “4C Climate Friendly Coffee” and/or “4C Climate Neutral Coffee” (e.g., “climate friendly coffee or product”, “climate neutral coffee or product”, etc.) are not subject to approval by 4C. As no "official approval" of such general claims by 4C is required, companies can freely decide to use such claims. When making such general claims, it shall be avoided that third parties are given the impression that the claim directly relates or references to “4C Climate Friendly Coffee” and/or “4C Climate Neutral Coffee”.

Receiving the logo

To obtain approval by 4C and to receive the logo file, interested parties should send a request to 4C via the official 4C e-mail address (info@4c-services.org). It should be clearly stated in the request for which use or application the logo and claims are intended and where they will be placed. 4C is also happy to further support on individual requests.

Unauthorized claims

Any direct claim, statement or reference made to the terms “4C Climate Friendly Coffee” and/or “4C Climate Neutral Coffee” that is not in line with the respective rules outlined in this chapter will be regarded as “unauthorized”.

Guideline for off-product claims

On the quantity/volume of certified coffee purchased and/or packaged by a given coffee brand, the same conditions described in the 4C System Regulations (chapter 10.5) must be complied with. In addition to the requirements described in the 4C System Regulations, the following table (Table 3) shall be used as a guideline for off-product claims.

Table 3: Requirements for off-product claims

Interest group		Requirements on claims
1.	Managing Entities of 4C Units (agricultural production certificate holders)	Claim shall refer to the Carbon Footprint Add-On certification according to the corresponding level of implementation. Examples: Level 1 and 2: "4C Verified GHG emissions", “Green Coffee 4C Verified GHG emissions” Level 3: “4C Climate Friendly Coffee”, “Green Coffee 4C Climate Friendly Coffee” Level 4: “4C Climate Neutral Coffee”. “Green Coffee 4C Climate Neutral Coffee”
2.	Intermediary or Final Buyers (chain of custody certificate holders)	Claim shall refer to the Carbon Footprint Add-On certification according to the corresponding level of implementation. Examples: Level 1 and 2: "4C Verified GHG emissions" Level 3: “4C Climate Friendly Coffee”, “Company trades 4C Climate Friendly Coffee”, “Roast & Ground 4C Climate Friendly Coffee” Level 4: “4C Climate Neutral Coffee”, “Company trades 4C Climate Neutral Coffee”, “Roast & Ground 4C Climate Neutral Coffee”
3.	Certification Bodies	Claim shall refer to the cooperation, e.g., “Carbon Footprint Add-On cooperating Certification Body”

4.	Other stakeholders (e.g., project-related partner)	Claim shall refer to partnership or relationship with 4C, e.g., "GHG project was conducted together with 4C"

Annex I: Emission Factors

The choice of emission factors has an impact on the results of the GHG emissions calculation.

Relevant parts of emission factors

Emission factors describe the relationship between the amount of released GHG emissions and the amount of input material. They are needed in order to calculate the CO_2eq emissions related to a specific input material. Emission factors for energy supply shall include direct and indirect effects. Direct effects are air emissions from combustion, waste, effluents and electricity use. Indirect effects are the upstream emissions of a material. They include, e.g., emissions from processing steps. Both factors – direct and indirect – shall be considered in the emission factor used.

Possible sources

The variability of individual emission factors may be large and for some inputs emission factors might not be available or just an approximation can be used. However, to avoid cherry picking and to support objective, transparent and verifiable Individual calculations and audits, 4C has developed a list of frequently used emission factors. The list is mainly based on the list of standard calculation values published on the European Commission website, Biograce, national/country reports and Ecoinvent (version 3.7, Allocation cut-off; IPCC 2013; GWP 100a). Alternative values are allowed only if they belong to a scientific and peer-reviewed sources or official national sources (e.g., government ministry publications, National Inventory Report).

Frequently used emission factors

The following overview (**Error! Reference source not found.**3) will be updated by 4C on a continuous base as soon as databases (e.g., Ecoinvent) provide new published values. This list should serve as an overview of some of the most frequently used emission factors relevant for the coffee supply chain without any guarantee for completeness. Alternative factors can be used as long as they are taken from an officially recognized or credible source that can be verified by the auditor.

Factor specifics

The emission factors RER (Rest of Europe) can be used for European countries, the emission factors RoW (Rest of the World) for all other countries Emission factors listed as GLO (Global) can be used for any country. If there are specific emission factors for individual countries, they are listed and highlighted separately.

The greenhouse gases taken into account for all GHG calculations shall be CO_2, N_2O and CH_4. For the purposes of calculating CO2 equivalence, those gases shall be valued as follows[34]:

CO_2 : 1

CH_4 : 34

N_2O : 298

Table 4: List of frequently used emission factors and their respective sources

Input	Unit	Standard factor	Source, description
A) Emission factors for cultivation			
Fertilizers			

[34] *IPCC(2018). Antropogenic and natural radiative forcing. https://www.ipcc.ch/site/assets/uploads/2018/02/WG1AR5_Chapter08_FINAL.pdf*

Input	Unit	Standard factor	Source, description
CaO-fertilizer	kg CO_2eq/kg CaO	0.13	European Commission: Standard values for emission factors, v 1.0. 2015
Calcium ammonium nitrate	kg CO_2eq/kg CaN	3.67	European Commission: Standard values for emission factors, v 1.0. 2015
Diammonium phosphate (DAP)	kg CO_2eq/kg DAP	1.64	Ecoinvent v. 3.8 (2021), diammonium phosphate production, RoW
K_2O-fertilizer	kg CO_2eq/kg K_2O	0.576	European Commission: Standard values for emission factors, v 1.0. 2015
Limestone (CaCO3)	kg CO_2eq/kg CaCO3	0.41149	Ecoinvent v.3.8 (2021), market for calcium carbonate, precipitated, RoW
Magnesium oxide	kg CO_2eq/kg MgO	1.18	Ecoinvent v.3.8 (2021), market for magnesium oxide, GLO
Muriate of potash (Potassium chloride)	kg CO_2eq/kg K2O	0.58	European Commission: Standard values for emission factors, v 1.0. 2015
Monoammonium phosphate	kg CO_2eq/kg N	0.91328	Ecoinvent v.3.8 (2021), monoammonium phosphate production, RoW
N-fertilizer	kg CO_2eq/kg N[35]	5.881	European Commission: Standard values for emission factors, v 1.0. 2015
NPK fertilizer (15-15-15)	kg CO_2eq/kg N	1.3785	Ecoinvent v.3.8 (2021), market for NPK (15-15-15) fertilizer, RoW
NPK fertilizer (26-15-15)	kg CO_2eq/kg N	2.2688	Ecoinvent v.3.8 (2021), market for NPK (26-15-15) fertilizer, RoW
P_2O_5-fertilizer	kg CO_2eq/kg P_2O_5	1.011	European Commission: Standard values for emission factors, v 1.0. 2015
Urea	kg CO_2eq/kg N	1.92	Biograce v 4d, 2014
Pesticides			
Chlorothalonil	kg CO_2eq/kg	4.22	Ecoinvent v. 3.8 (2021), chlorothalonil production, RoW
Glyphosate	kg CO_2eq/kg	11.63	Ecoinvent v. 3.8 (2021), glyphosate production, RoW

[35] *For all N-fertilizers the emission factor refers to the amount of nitrogen in the fertilizer.*

Input	Unit	Standard factor	Source, description
Mancozeb	kg CO_2eq/kg	5.83	Ecoinvent v. 3.8 (2021), mancozeb production, RoW
Pesticides (general value)	kg CO_2eq/kg a.i.[36]	10.97	European Commission: Standard values for emission factors, v 1.0. 2015
Seedlings			
Coffee seedlings (with roots, externally bought)	kg CO_2eq/kg	1.2154	Ecoinvent v.3.8 (2021), fruit tree seedling production, for planting, RoW
B) Emission factors for processing			
Process inputs			
Process water	kg CO_2eq/kg	Europe without CH: 0.00032956 RoW: 0.0010424	Ecoinvent v. 3.8 (2021), market for tap water
Packaging material (jute)	kg CO_2eq/kg	2.3127	Ecoinvent v. 3.8 (2021), market for textile, jute, GLO
Packaging material (plastic)	kg CO_2eq/kg	3.105	Ecoinvent v. 3.8 (2021), market for packaging film, low density polyethylene, GLO
Packaging material (paper)	kg CO_2eq/kg	0.70356	Ecoinvent v. 3.8 (2021), kraft paper production, RoW
Electricity consumption from grid (electricity mix)			
EU	kg CO_2eq/kWh$_{el}$	0.46	Biograce v 4d, 2014
Brazil	kg CO_2eq/kWh$_{el}$	0.11	Biograce v 4d, 2014
China	kg CO_2eq/kWh$_{el}$	0.55	Climate Transparency. Country Profile China 2019.
Colombia	kg CO_2eq/kWh$_{el}$	0.21	Factores De Emisión Del Sistema Interconectado Nacional Colombia-Sin (2017)

[36] *Active ingredient*

Input	Unit	Standard factor	Source, description
Honduras	kg CO_2eq/kWh_{el}	0.61	CDM Standardized baseline "Honduran Grid Emission Factor Version 01.0 (ASB0042-2019)
India	kg CO_2eq/kWh_{el}	0.68	Climate Transparency. Country Profile India 2020.
Indonesia	kg CO_2eq/kWh_{el}	1.05	Biograce v 4d, 2014
Kenya	kg CO_2eq/kWh_{el}	0.408	CDM Standardized baseline "Grid Emission Factor for the Republic of Kenya" version 01.0 (ASB0050-2020)
Malaysia	kg CO_2eq/kWh_{el}	0.88	Biograce v 4d, 2014
Mexico	kg CO_2eq/kWh_{el}	0.49	Aviso Factor de Emisión del Sistema Eléctrico Nacional 2020 (2021)
Philippines	kg CO_2eq/kWh_{el}	0.69	Department of Energy, the Philippines 2015-2017 National Grid Emission Factor (NGEF)
Rwanda	kg CO_2eq/kWh_{el}	0.537	National Inventory Report Rwanda September 2018
Tanzania	kg CO_2eq/kWh_{el}	0.5081	IGES List of Grid Emission Factors V10.11 (2021)
Thailand	kg CO_2eq/kWh_{el}	0.56	Thailand Grid Emission Factor for GHG Reduction Project/Activity (2016)
Uganda	kg CO_2eq/kWh_{el}	0.51	CDM Standardized baseline: "Grid emission factor for the national power grid of Uganda version 01.0" (ASB0006) (2013)
Vietnam	kg CO_2eq/kWh_{el}	0.149	EC Standard Values v1.0, Electric emission coefficients Vietnam
Energy consumption from internal production			
Diesel	kg CO_2eq/kg	0.56787	Ecoinvent v. 3.8 (2021), market for diesel, low-sulfur, RoW
Petrol	kg CO_2eq/L	3.18	Eggleston & Walsh (2000) Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories

Input	Unit	Standard factor	Source, description
Heat from boiler (NG)	kg CO_2eq/MJ_{th}	Europe without CH: 0.070261 RoW: 0.069896	Ecoinvent v. 3.8 (2021), heat production, natural gas, at industrial furnace >100kW
Natural gas	kg CO_2eq/MJ	4000 km, Russian quality: 0.066 4000 km, EU Mix quality: 0.0676	European Commission: Standard values for emission factors, v 1.0. 2015
Solar electricity	kg CO_2eq/kWh_{el}	0.082623	Ecoinvent v. 3.8 (2021): electricity production, photovoltaic, 3kWp flat-roof installation, single-Si, RoW
Waste wood (external, upstream emissions)	kg CO_2eq/kg	0.045053	Ecoinvent v. 3.8 (2021), treatment of waste wood, post-consumer, sorting and shredding, RoW
Waste wood – CO_2 combustion emissions	kg CO_2/kg	1.61	IPCC 2006 Guidelines for National Greenhouse Gas Inventories, http://www.ipcc-nggip.iges.or.jp/public/2006gl/vol2.html
Waste wood – CH_4 combustion emissions	kg CH_4/kg	0.00432	IPCC 2006 Guidelines for National Greenhouse Gas Inventories, http://www.ipcc-nggip.iges.or.jp/public/2006gl/vol2.html
Waste wood – N_2O combustion emissions	kg N_2O/kg	0,0000576	IPCC 2006 Guidelines for National Greenhouse Gas Inventories, http://www.ipcc-nggip.iges.or.jp/public/2006gl/vol2.html
Wind electricity	kg CO_2eq/kWh_{el}	0.014482	Ecoinvent v. 3.8 (2021), Electricity production, wind, 1-3MW turbine, onshore, RoW
Waste treatment			

Input	Unit	Standard factor	Source, description
Wastewater treatment (externally)	kg CO_2eq/cbm	Europe without CH: 0.4862 RoW: 0.55418	Ecoinvent v. 3.8 (2021), market for wastewater, average
Coffee wastewater methane emissions (on-site)	t CO2/ m3 wastewater	0.0104	Gold Standard & CDM UNFCCC https://registry.goldstandard.org /projects/details/1253
Coffee wastewater methane emissions (on-site)	t CO2/ m3 wastewater	0.014	Federación Nacional de Cafeteros de Colombia Centro Nacional de Investigaciones de Café Cenicafé, Environmental Footprint of Coffee in Colombia - Guidance Document ; Page 47
Composting of residues	kg CO_2eq/kg	0.015667	Ecoinvent v. 3.8 (2021), treatment of garden biowaste, home composting in heaps, RoW
Pulp treatment (decomposition of pulp)	kg CH4/t green coffee	6.22	Federación Nacional de Cafeteros de Colombia Centro Nacional de Investigaciones de Café Cenicafé, Environmental Footprint of Coffee in Colombia - Guidance Document ; Page 48
C) Emission factors for transport & distribution			
Car	kg CO_2eq/ton-km	1.97	Ecoinvent v. 3.8 (2021), transport, freight, light commercial vehicle, RoW
Diesel	kg CO_2eq/liter	3.14	Biograce v 4d, 2014
Diesel consumption truck (loaded)	liter/km	0.49	BLE, 2010, Guideline Sustainable Biomass Production
Diesel consumption: truck (unloaded)	liter/km	0.25	BLE, 2010, Guideline Sustainable Biomass Production
Electricity consumption train (electricity)	kWh/ton-km	0.06	Biograce v 4d, 2014. Conversion factor 1 MJ = 0.28 kWh

Input	Unit	Standard factor	Source, description
Freight, lorry	kg CO_2eq/ton-km	RER: 0.13122 RoW: 0.13803	Ecoinvent v. 3.8 (2021), market for transport, freight, lorry, unspecified
Motorbike	kg CO_2eq/person*km	0.16019	Ecoinvent v. 3.8 (2021): market for transport, passenger, motor scooter, GLO
Truck 3.5-7.5t	kg CO_2eq/ton-km	0.55	EcoInvent v3.8 (2021), market for transport, freight, lorry 3.5-7.5 metric ton, EURO3, RoW
Truck 7.5-16t	kg CO_2eq/ton-km	0.22608	EcoInvent v. 3.8 (2021), market for transport, freight, lorry 7.5-16 metric ton, EURO3, RoW
Truck 16-32t	kg CO_2eq/ton-km	0.17342	EcoInvent v. 3.8 (2021), market for transport, freight, lorry 16-32 metric ton, EURO3, RoW
Truck >32t	kg CO_2eq/ton-km	0.094508	EcoInvent v3.8 (2021), market for transport, freight, lorry > 32 metric ton, EURO3, RoW
Freight train	kg CO_2eq/ton-km	Europe without CH: 0.045838 RoW: 0.048581	Ecoinvent v. 3.8 (2021), market for transport, freight train
Heavy fuel oil (HFO)	kg CO_2eq/liter kg CO_2eq/MJ	3.42 0.085	Biograce v 4d, 2014 European Commission: Standard values for emission factors
HFO for maritime transport	kg CO_2eq/MJ	0.087	European Commission: Standard values for emission factors, v 1.0. 2015
Barge tanker	kg CO_2eq/ton-km	RER: 0.043677 RoW: 0.044584	Ecoinvent v. 3.8 (2021), market for transport, freight, inland waterways, barge tanker

Input	Unit	Standard factor	Source, description
Transoceanic tanker	kg CO_2eq/ton-km	0.009405	Ecoinvent v. 3.8 (2021), market for transport, freight, sea, container ship, GLO

Annex II: Examples of Text Claims and Disclaimers

Examples of claims for products containing 100% of segregated 4C Climate Friendly Coffee or 4C Climate Neutral Coffee:

- Contains 100% 4C Climate Friendly Coffee or 4C Climate Neutral Coffee
- Certified 4C Climate Friendly Coffee or Certified 4C Climate Neutral Coffee
- Sustainable coffee certified based on 4C Climate Friendly Coffee or 4C Climate Neutral Coffee sustainability requirements
- Made from 4C Climate Friendly Coffee or 4C Climate Neutral Coffee beans
- Made from coffee beans certified according to Carbon Footprint Add-On requirements
- Coffee is made from Carbon Footprint Add-On certified coffee beans.
- Coffee produced under climate protection practices
- The coffee in this package originates from climate friendly/neutral sources
- This product originates from a climate friendly/neutral supply chain
- This 4C certified coffee reduces carbon emissions by…
- This 4C certified coffee comes from low carbon/carbon neutral coffee farms

Examples of disclaimers for products containing less than 90% (but a minimum of 30%) of segregated 4C certified coffee:

- Contains over 75% 4C Climate Friendly Coffee or 4C Climate Neutral Coffee certified coffee
- 30% certified 4C Climate Friendly Coffee or 4C Climate Neutral Coffee
- 45% sustainable coffee meeting Carbon Footprint Add-On requirements
- With currently 50% certified 4C Climate Friendly Coffee or 4C Climate Neutral Coffee, we're working towards using 100% 4C certified coffee by (year)
- We are committed to reach 100% certified 4C Climate Friendly Coffee or 4C Climate Neutral Coffee, currently using 80%
- Product contains 4C Climate Friendly Coffee or 4C Climate Neutral Coffee

Annex III: Logo Colour Guide

The 4C logo is available in different digital formats and in RGB, CMYK, positive and negative color schemes. The logos should preferably be used in the colour version. If this is not possible due to optical or graphical reasons, the black or white version can be used. Proposals to use the logo in any other colours should first be approved by 4C.

1. Colour-version
    a. Orange (CMYK: 0 75 86 0; RGB: 235 90 43; Hex: #eb5a2b)
    b. Light green (CMYK: 53 0 55 0; RGB: 133 196 143; Hex: #85c48f)
    c. Dark green (CMYK: 80 29 57 42; RGB: 30 97 85; Hex: #1e6155)
    d. Light blue (CMYK: 100 32 0 28; RGB: 0 125 183; Hex: #007db7)
    e. Dark blue (CMYK: 100 42 0 43; RGB: 0 85 146; Hex: #005592)
2. Black-version (100%)
3. White-version (invers)