

4C CARBON FOOTPRINT CERTIFICATION

System Document

Version 3.0

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Contents

List of Tables III
List of Figures III
List of Equations IV
Abbreviations V
1 Introduction 1
1.1 Background and objectives 3
1.2 Main changes from v2.1 to v3.0 4
1.3 Definitions and applications 7
2 Calculation and reporting methodology 11
2.1 GHG Emissions calculation 11
2.1.1 Scope and system boundaries 11
2.1.2 Data requirements and emission responsibilities 13
2.1.3 Calculation and reporting of GHG emissions and carbon removals 18
2.1.4 Calculation methods by supply chain stage 19
2.2 Carbon Stocks 37
2.2.1 Foundational concepts 38
2.2.2 Carbon stock change due to LUC 41
2.2.3 Carbon removals 45
2.2.4 Permanence of carbon removals 57
2.2.5 Reversals 57
2.3 Accounting framework for emissions and removals 57
3 Improvement plan to reduce GHG emissions 59
3.1 Elements of the Improvement Plan 60
3.1.1 GHG emission baseline 60
3.1.2 GHG emission reduction targets 60
3.1.3 GHG emission reduction measures 61
3.1.4 Monitoring plan 62
3.2 GHG emission reduction and carbon removal measures 62
3.2.1 Cultivation related reduction measures 63
3.2.2 Processing stage mitigation options 63
3.2.3 Transport and logistics-related measures 64
3.2.4 Further action in downstream processing, roasting, and packaging 64
4 Obtaining the 4C CFC 66
4.1 About the Applicability 66
4.2 4C CFC Certification cycle 66
4.2.1 Preparing for certification 68
4.2.2 Getting certified 69
4.2.3 Maintaining the CFC 76
4.3 Inclusion and exclusion of BPs 76
5 Claims and logo use 77
List of References 81
Annexes 82

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List of Tables

Table 1: Summary of changes between v2.1 and v3.0 4
Table 2: Description of the different carbon pools 39
Table 3: Reference to IPCC 2006 Guidelines and 2019 Refinement 43
Table 4: Examples of pre-stratification variables for coffee agroforestry systems 46
Table 5: Example of plots size definition based on to the stem diameter 47
Table 6: Ratio of BGB to ABG 51
Table 7: Accounting approach 58
Table 8: Factors of the square root to be applied for different risk levels 73
Table 9: Requirements for claims 79

List of Figures

Figure 1: Different scope of system boundaries 9
Figure 2: Set-up for GHG emissions calculation for the CFC 10
Figure 3: System boundary 1 showcased as a 4C Unit or CPG 11
Figure 4: System boundary 2 with Intermediary Buyers (IB) 12
Figure 5: System boundary 3 with Final Buyers (FB) 12
Figure 6: Overview of emissions responsibilities 13
Figure 7: Example of a coffee supply chain and transport responsibilities 14
Figure 8: Overview of upstream and operational emission sources in fuel supply chains 32
Figure 9: Example processing unit up- and downstream transportation emissions 32
Figure 10: Example roaster upstream transportation emissions 33
Figure 11: Example of natural coffee - dry processing done on the farm 34
Figure 12: Example of washed coffee - wet processing done on the farm 35
Figure 13: Example of washed coffee - wet processing in central station 35
Figure 14: System boundaries for a roaster 37
Figure 15: Example of sampling design 47
Figure 16: Measuring DBH for trees of different shapes and forms 48
Figure 17: Improvement Plan elements and development process 60
Figure 18: Complete certification cycle of the 4C CFC 66
Figure 19: A complete cycle of 4C CF certification 67
Figure 20: 4C CFC audit combined with 4C core certification audit 68
Figure 21: 4C CFC audit combined with 4C core surveillance audit 68
Figure 22: Application process for 4C CFC certification 71
Figure 23: Risk assessment procedure for existing 4C Unit of coffee production 72
Figure 24: Risk assessment procedure for CPG, 4C CoC Unit and FB 72
Figure 25: 4C Carbon Footprint Certification Logo 78

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List of Equations

Equation 1: Total Emissions (TE) 18
Equation 2: Land Use Change (LUC) 18
Equation 3: Removals (R) 18
Equation 4: Cultivation Emissions 20
Equation 5: Emissions from fertilizer production ($EM_{fertilizer}$) 21
Equation 6: Emissions from synthetic fertilizers with N (EM_{N2O}) 21
Equation 7: N_2O direct emissions (E_{N2O}) 22
Equation 8: N_2O indirect emissions (E_{N2O}) 22
Equation 9: Other -than fertilizers- input emissions (EM_{inputs}) 23
Equation 10: Fuel consumption emissions (EM_{fuel}) 23
Equation 11: Electricity emissions ($EM_{electricity}$) 23
Equation 12: Cultivation waste emissions ($EM_{cultivation\ waste}$) 24
Equation 13: Emissions from Processing (e_p) 25
Equation 14: Electricity emissions 25
Equation 15: Heat emissions (option 1) 25
Equation 16: Heat emissions (option 2) 25
Equation 17: Other inputs emissions EM_{inputs} 28
Equation 18: Wastewater treatment emissions $EM_{wastewater}$ 28
Equation 19: Residue treatment emissions $EM_{residues}$ 28
Equation 20: Transport and distribution emissions e_{td} (option 1) 29
Equation 21: Ship and train transportation formula 30
Equation 22: Total transportation and distribution emissions e_{td} (option 2) 30
Equation 23: Total amount of fuel used and density $TA_{fuel\ used}$ 31
Equation 24: Coffee turnover ratio (TR) 33
Equation 25: The conversion of emissions for cultivation (from cherries to beans) 34
Equation 26: Conversion formula for emissions of coffee beans 36
Equation 27: Carbon stock change 39
Equation 28: Total carbon stock change 40
Equation 29: Carbon Stock difference from LUC 41
Equation 30: LUC calculation 42
Equation 31: CS assessment for LUC 42
Equation 32: SOC calculation 44
Equation 33: AGB estimation 49
Equation 34: Root to shoot ratio for BGB 50
Equation 35: Net Carbon Removals 52
Equation 36: Annual removals calculation 52
Equation 37: SOC removals calculation 53
Equation 38: BP change rate calculation 77

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Abbreviations

Abbreviation	Meaning
AA	Annual Audit
AE	Allometric Equations
AFOLU	Agriculture, Forestry and other Land uses
AGB	Above Ground Biomass
ASA	Annual Surveillance Audit
BGB	Below Ground Biomass
BOC	Biomass Organic Carbon
BP	Business Partner
BPM	Business Partner Map
BPM_CF	Carbon Footprint Certification Business Partner Map
CB	Certification Body
CCF	Coffee Conversion Factor
CF	Carbon Footprint
CFC	Carbon Footprint Certification
CO2eq	Carbon-Dioxide Equivalent
CoC	Chain of Custody
CPG	Coffee Producing Group
CS	Carbon Stocks
DBH	Diameter at breast height
DOM	Dead organic matter
EF	Emission factor
FB	Final Buyer
GBE	Green Beans Equivalent
GHG	Greenhouse gas
GoO	Guarantees of Origin
GRAS	Global Risk Assessment Services
GWP	Global warming potential
H	Tree height
IB	Intermediary buyer
IPCC	Intergovernmental Panel on Climate Change
IP_CF	Carbon Footprint Certification Improvement Plan
ISO	International Organisation for Standardisation
LSRS	GHG Protocol Land Sector Removal Standard
LUC	Land Use-Change
ME	Managing Entity
PAS	Publicly Available Specification
PPA	Power Purchase Agreement

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SBTi	Science Based Targets initiative
SC-Unit	Soil/Climate Homogeneous Unit
SDG	Sustainable Development Goals
SOC	Soil organic carbon
TR	Coffee Turnover Ratio

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1 Introduction

Welcome to the 4C CFC

The 4C Carbon Footprint Certification (4C CFC) 3.0 is an independent certification programme that enables coffee and cocoa supply chain actors to calculate, verify, manage and communicate GHG emissions, reductions and carbon removals within defined system boundaries at different levels of claim. It supports credible climate action in the coffee and cocoa sector by combining robust methodological requirements with independent third-party verification and practical guidance for implementation.

4C CFC within the 4C system

Building on the experience of the former 4C Carbon Footprint Add-On 2.1, the 4C CFC has evolved into a certification programme that can be applied for by existing 4C Units, as well as independent producing groups who do not hold a 4C core certificate, thus, opening the certification to all relevant market participants. While it remains aligned with the broader 4C system and its assurance approach, the 4C CFC does not require 4C core certification as a prerequisite. Accordingly, it also applies to chain of custody actors, such as Intermediary Buyers (IB) and Final Buyers (FB). This allows a broader range of coffee and cocoa sector actors to apply a consistent and independently verifiable carbon accounting methodology.

Improvement of design

In addition to the methodological changes summarised in the table above, the document structure, formatting, and overall design have been revised and enhanced. These improvements were implemented to increase user-friendliness, improve readability, and facilitate a more intuitive application of the methodology. The revisions aim to support users in navigating the document more efficiently and to strengthen the overall usability and accessibility of the certification framework.

Purpose of the document

This document defines the methodological and certification requirements for calculating and verifying GHG emissions, reductions and removals in coffee and cocoa supply chains. It sets out the applicable system boundaries, data requirements, emission responsibilities, calculation methodologies and forwarding rules for GHG values along the physical flow of coffee and cocoa. It also provides guidance on carbon stock changes, land use change, soil organic carbon and biomass carbon accumulation, as well as the requirements for claims under the 4C CFC.

Current methodology applicability

The 4C CFC is intended to cover both coffee and cocoa supply chains. However, key differences in crop characteristics, production systems and agronomic practices require a methodology tailored to each crop. Accordingly, the methodology presented in this version of the document applies exclusively to coffee. A cocoa-specific methodology is currently under development and will be published in a forthcoming update.

Structure of the document

To guide system users, certification bodies and other stakeholders through the 4C CFC, this document is structured into the following main areas:

- **Introduction and applicability:** Outlines the background, objectives and key changes introduced in 4C CFC v3.0. It also identifies eligible certificate applicants and explains the system boundaries and supply-chain applications.
- **Calculation and reporting methodology:** Establishes the requirements for calculating and reporting GHG emissions and carbon stock changes:
    - **GHG emissions:** Covers emissions from cultivation, processing, transport and distribution, including data requirements,

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sampling methods and the forwarding of GHG values along the supply chain.
    - **Carbon stock changes:** Covers relevant carbon pools, land-use change, soil organic carbon and biomass accounting, including the calculation and reporting of emissions and removals and the treatment of permanence and reversals.
- **Improvement planning:** Defines the requirements for establishing baselines and reduction targets, selecting mitigation and removal measures, and monitoring progress throughout the certification period.
- **Certification and assurance:** Describes the application and certification processes, including preparation, risk assessment, audit sampling, certification decisions, annual audits and certificate maintenance for each applicant type.
- **Claims and logo use:** Sets out the requirements for claim levels, communicating verified results, using the 4C CFC logo and applying the required disclaimers.
- **Supporting references and annexes:** Provides terminology and references, guidance on emission factors, examples of reduction and removal measures, sample claims, and logo specifications.

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1.1 Background and objectives

The 4C CFC

The 4C CFC is an independent certification program and enables companies to measure, verify, and manage their GHG emissions, reductions, and removals, contributing to global efforts to combat climate change by supporting climate targets and aligning with the objectives set by the Sustainable Development Goals (SDGs).

Evolution of the 4C CFC

Building on the established 4C Carbon Footprint Add-On, this 4C Carbon Footprint Certification (4C CFC) is now accessible as an independent program, open to all stakeholders without requiring the 4C core certification as a prerequisite. To strengthen the completeness of carbon accounting, this guidance now includes an expanded Carbon Removals section. While the Soil Organic Carbon (SOC) methodology for the estimation of soil carbon accumulation has been adapted, the section also introduces biomass carbon accumulation calculations. The assessment and reporting of carbon removals are voluntary under the 4C CFC; however, where reported, removals shall be calculated in accordance with the methodologies provided in this guidance. This ensures that both emissions and removals are addressed for a more accurate net GHG balance.

Why assess GHG emissions

With increasing awareness of the impact of global climate change, companies face new challenges of understanding the effects of their operations and implementing measures to contribute to successful climate protection. Brand owners worldwide 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. Consumers' interest in becoming informed about the carbon footprint (CF) of the products they buy is growing steadily.

Emission sources

Coffee production shall also contribute to the fight against climate change: Among the main sources of GHG emissions in coffee cultivation are fertilizer and chemical use, energy-consuming machines, land use change, and wastewater. Especially chemical fertilizers and land use change are found to be major sources of emissions. In the supply chain, transport emissions and energy consumption in processing units also contribute to GHG emissions. At the same time, coffee systems can sequester carbon through SOC and biomass, which is now considered in this guidance to reflect removals alongside emissions. On a global level, agriculture contributes significantly to the total GHG emissions – highlighting the need for immediate and comprehensive action.

The 4C CFC

With the 4C CFC, 4C provides a solution for its system users to address the increasing demand for ascertaining and verifying GHG emissions, reductions, and removals in coffee supply chains.

Objectives

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
- provide the methodology for estimations of biomass and soil carbon stored
- describe rules and guidelines for calculating and verifying emissions
- explain the prerequisites and processes for becoming certified under the 4C CFC
- clarify the requirements which shall be fulfilled for the respective claims of "4C Carbon Footprint Certification"

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CF 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 identifying where measures should be targeted. Identifying and implementing GHG emission reduction measures to decrease the CF of coffee cultivation and processing in the long term, for example, through regenerative agriculture, is key to achieving sustainable development in the coffee industry. The focus should always be primarily on reduction measures rather than offsetting emissions.

Recognised standards and initiatives

For the development of the 4C CFC, recognised methodologies, standards, and initiatives were researched and considered, such as ISO 14067:2018[1], GHG Protocol Product Standard[2] , GHG Protocol Land Sector Removal Standard[3] and several IPCC guidelines[4]. The 4C CFC considers the Science Based Target Initiative (SBTi) guide and the Paris Agreement target to limit global warming to 1.5°C[5].

1.2 Main changes from v2.1 to v3.0

The following table is a summary of all changes in the content of this document in comparison to the previous 4C Carbon Footprint Add-On v2.1. Document structure changes made to improve the reader's experience and understanding are not listed in this table. Other changes, such as spelling corrections, are also omitted.

Table 1: Summary of changes between v2.1 and v3.0

4C Carbon Footprint Add-on v2.1	4C Carbon Footprint Certification v3.0	Reasons for change or addition
4C Carbon Footprint Add-on v2.1	4C Carbon Footprint Certification v3.0 See Chapter 1	The former 4C Carbon Footprint (CF) Add-On v2.1 has evolved into the 4C Carbon Footprint Certification (CFC) v3.0. Unlike the previous Add-On approach, which was only available in combination with 4C Core Certification, meanwhile the revised scheme is now accessible to both core-certified and non-certified entities. This broader scope allows a wider range of market participants to assess, report, and communicate their coffee and cocoa supply chain carbon footprint. The transition from an "Add-On" to a standalone "Certification" reflects this expanded applicability and market accessibility.
Emission savings from soil carbon accumulation	Removals from Carbon Stock Changes from Soil Organic Carbon (r_{soc})	Compared to the former 4C CF Add-On v2.1, the approach to accounting for carbon removals has been significantly extended and aligned with the GHG Protocol Land Sector and Removals Guidance (LSRG). While the previous methodology primarily focused on emission savings from soil carbon accumulation

1 The ISO 14067:2018, from the International Organisation for Standardisation, provides guidance for the quantification of greenhouse gases for the development of a carbon footprint of a product.
2 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.
3 . The GHG Protocol Land Sector and Removals Standard provides detail on how to account for and report GHG emissions and CO_2 removals from agricultural land use and emerging CO_2 removal technologies.
4 The 2006 IPCC Guidelines for National Greenhouse Gas Inventories and the 2019 Refinement are a nationally recognised methodology for the development of greenhouse gas inventories.
5 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.

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via improved agricultural Management (es_{SOC})	Biomass Organic Carbon (r_{BOC}) Annualised Emission or Removals from carbon stock changes caused by Land-use change $e(r)_{LUC}$ See Chapter 2	through improved agricultural management (es_{SOC}), the revised 4C CFC v3.0 considers additional carbon pools, including soil organic carbon (SOC), biomass organic carbon (BOC), and, where applicable, Land-Use Change emissions/ removals as $e(r)_{LUC}$. This enhancement ensures that carbon removals are quantified and reported in line with current best practice for agricultural and agroforestry systems, including coffee and cocoa cultivation. The methodological revision also led to a restructuring of the calculation framework. In the former 4C CF Add-On v2.1, emissions and soil carbon savings and Land-use Change were accounted for within a single calculation equation. In contrast, 4C CFC v3.0 treats emissions and removals as separate accounting elements that must be reported independently. Consequently, the former single-equation approach has been replaced by three distinct calculation formulas, improving transparency and consistency with internationally recognised GHG accounting principles.
-	Coffee Producing Group (CPG) See Chapter 1	For independent coffee-producing groups that are not certified under the 4C core certification scheme, the term Coffee Producing Group (CPG) is used. A CPG refers to a group of coffee producers organised and selling coffee to a local trader, cooperative, or company. Unlike the former 4C CF Add-On v2.1, where participation was limited to entities holding a valid 4C core certification, the 4C CFC v3.0 allows CPGs to participate independently and obtain certification without being certified under the core 4C scheme.
Level	System Boundaries See Chapter 1	The former 4C CF Add-On v2.0 was structured around four implementation levels, which defined both the scope of GHG accounting and the associated claims that could be communicated. In the 4C CFC v3.0, this approach has been revised. Rather than using implementation levels to define the extent of the assessment, the revised methodology introduces three clearly defined system boundaries. These system boundaries specify the sections of the coffee supply chain that are covered by the GHG inventory and therefore provide a more transparent and technically robust framework for emission accounting. The transition from implementation levels to system boundaries also improves alignment with internationally recognised accounting frameworks and terminology, including the GHG Protocol. The concept of levels has nevertheless been retained within the 4C CFC v3.0, but for a different purpose. Instead of describing accounting boundaries, levels are now linked to the communication of results and the corresponding claims that can be made under the certification scheme.
-	GWP for N_2O See Section 2.1.4.1	The former 4C CF Add-On v2.1 used a GWP_{100} value of 298 for nitrous oxide (N_2O). To align the methodology with the latest scientific consensus and current greenhouse gas accounting practices, the revised 4C CFC v3.0 applies an updated GWP_{100} value of 273. This revision reflects advances in climate science and the updated characterization factors provided by the IPCC. As a result, N_2O emissions reported under the revised

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		methodology may differ from those calculated under previous versions, despite identical activity data and emission factors.
-	Emissions from cultivation waste ($EM_{cultivation\ waste}$) See Section 2.1.4.1	Compared to the former 4C CF Add-On v2.1, emissions from cultivation waste were introduced as a separate accounting element in 4C CFC v3.0 to clearly distinguish them from crop residues and organic fertilizers applied to the field. This distinction improves transparency, avoids potential double counting with on-field emissions, and ensures a more consistent allocation of emissions across different material flows within the cultivation stage.
Coffee beans	Coffee parchment See Section 2.1.4.2	Another enhancement introduced in 4C CFC v3.0 is the explicit change of the wording coffee beans to coffee parchment in relation to the processing emissions. Unlike the former 4C CF Add-On v2.1, coffee parchment is now recognised as a separate intermediate product resulting from processing activities. This improves the transparency of product flows and GHG emission forwarding throughout the supply chain, while acknowledging that the relevance of this intermediate product may vary depending on the specific coffee processing pathway and supply chain of the customer.
-	Emissions from residues ($EM_{residues}$) See Section 2.1.4.2	Compared to the former 4C CF Add-On v2.1, the drying of co-products and outputs generated during processing has been revised in 4C CFC v3.0. In the previous methodology, drying of co-products and their associated treatment were considered within the processing emission calculation (e_p). In the revised methodology, however, emissions related to residues and cultivation waste are accounted for separately through a dedicated processing residues component. As a result, any allocation of co-products generated during processing, including those that undergo drying, is no longer included within e_p, but is instead reflected through the corresponding residue treatment emissions by $EM_{residues}$. Together with the introduction of a separate cultivation waste category ($EM_{cultivation\ waste}$) at the farm level, these changes establish clearer boundaries between material flows and treatment pathways throughout the coffee supply chain. This approach minimises the risk of double counting, improves the interpretation of the results, and provides a more consistent and transparent accounting framework for emissions associated with cultivation and processing residues.
	Emissions from wastewater ($EM_{wastewater}$) See Section 2.1.4.2	A similar approach as for Emissions from residues ($EM_{residues}$), the emissions from wastewater has been adapted. While wastewater-related emissions were in 4C CF v2.1 integrated differently within the overall processing calculations, 4C CFC v3.0 introduces a dedicated wastewater component that focuses specifically on emissions arising from wastewater treatment. This clear distinction between processing-water inputs and wastewater treatment improves methodological transparency and ensures that each emission source is assigned to the appropriate calculation category.
Feedstock factor (FF)	Coffee -Turnover Ratio (TR)	The Turnover Ratio (TR) represents the relationship between the input and output quantities of coffee products during processing.

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	See Section 2.1.4.4	In 4C CFC v3.0, the former Feedstock Factor (FF) used in the 4C CF Add-On v2.1 was replaced by the TR. This change improves the terminology's relevance to coffee and cocoa supply chains and aligns the methodology with current scientific practices, where conversion factors are commonly used to describe the physical transformation of products along a supply chain.
-	Coffee Producing Groups (CPGs) Certification process See Section 4.1	Under the former 4C CF Add-On v2.1, participation was limited to entities holding a valid 4C Core Certification. The introduction of CPGs under the 4C CFC v3.0 has expanded the scope of the scheme to include entities operating independently of the 4C core system. Consequently, a dedicated certification pathway has been established for CPGs, while 4C Units continue to follow the existing certification and audit procedures. This approach increases the accessibility of the scheme while ensuring equivalent levels of credibility, transparency, and auditability.
4C Climate Friendly & 4C Climate Neutral coffee	Claim levels See Chapter 5	Compared to the former 4C CF Add-On v2.1, the claim framework of the 4C CFC v3.0 has been fundamentally revised. Previous claims such as “Climate Friendly” and “Climate Neutral” are no longer part of the certification scheme. Instead, the revised framework introduces a set of differentiated claim options that reflect the specific scope and level of GHG accounting achieved by the certificate holder. A key enhancement is the explicit recognition of both GHG emissions and carbon removals. While the former Add-On primarily focused on emissions and emission savings, the revised methodology allows carbon removals to be quantified, reported, and communicated as a separate accounting element. As a result, claims may now reflect not only emissions but also verified removals where applicable. Furthermore, claim eligibility is linked to specific certification requirements. In particular, Claim Level 2 requires the development and implementation of an Improvement Plan (IP_CF) for the reduction of emissions and carbon removals, whereas Claim Level 1 does not require an IP_CF. The visual presentation of the claims, including the associated logos, has also been updated to reflect the revised certification structure. Due to these changes, certificate holders are strongly encouraged to consult Chapter 9 and, where necessary, coordinate with 4C before communicating claims externally, in order to ensure compliance with the applicable requirements and communication rules.

1.3 Definitions and applications

Independent use of the certification

As previously stated, this certification scheme can be achieved without the 4C core certification scheme. This means that any independent Coffee Producing Group (CPG) or existing 4C Unit can access this programme within the defined system boundaries. The 4C CFC clearly defines three different kinds of system boundaries where the certification scheme is applicable. In any case, an independent third-party audit shall confirm that the GHG emissions, reductions and removals have been calculated for certified supply chain actors, including independent units at farm or final level, as well as certified coffee-producing 4C units and 4C Chain of Custody-certified IBs and FBs. Depending on the chosen System Boundaries, additional instruments must be set for ensuring the monitoring of developments concerning GHG emissions,

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removals and the commitment to reduce GHG emissions in the future. In these cases, a mandatory improvement plan shall be implemented as part of the certification module.

Methodology for carbon sequestration

The 4C CFC does not only accounts for GHG emissions but also provides clear instructions and a methodology for accounting for the carbon sequestration potential in the form of soil organic carbon accumulation (SOC including, dead organic matter (DOM) and biomass organic carbon (BOC), the last mentioned including both AGB and BGB). SOC refers to the carbon stored in soil as part of organic matter, such as decomposed plants, roots, and microorganisms. It is a key component of soil health and plays an important role in the global carbon cycle because it helps store carbon that would otherwise be in the atmosphere as CO_2. The methodology accounts also for DOM referring to organic material that is no longer living, such as fallen leaves, branches, and plant residues. It is found on the soil surface or within the soil and gradually decomposes, releasing nutrients and sometimes carbon back into the atmosphere.

Carbon removals

On the other hand, BOC is the carbon contained in living plant biomass (trees, crops, shrubs) and sometimes in dead plant material above ground. It represents the carbon stored in vegetation and is an important indicator of how much carbon is captured by plants through photosynthesis. Another potential for carbon sequestration can be Land Use Change (LUC) meaning altering how land is used e.g., converting forests to farmland or vice versa. It is important to highlight that LUC can lead to emissions, when forests are cleared or burned, stored carbon is released into the atmosphere as CO_2. But it can also lead to sequestration as mentioned before, when degraded land is restored (e.g., reforestation), carbon is absorbed and stored in plants and soil. Chapter 2.2 explains how to estimate these removals in more detail.

4C terminology

Before exploring the methodology and its applications in more detail, it's important to understand the 4C terminology used throughout this document for supply chain actors and entities, as well as for the CF certificate. Please see Annex 1 to check the definitions of the most used terms in this document. For additional terminology, refer to the 4C Glossary in the 4C document library.

System boundaries

The methodology described in this document can be adopted in three system boundaries of implementation, making it possible to implement the CFC gradually and in different arrangement levels of the coffee supply chain. The three system boundaries of implementation are listed below and illustrated in Figure 1.

- System Boundary 1: GHG emissions calculation at the farm level (4C Unit and CPG)
- System Boundary 2: GHG emissions calculation at the farm level and IB until point of export
- System Boundary 3: GHG emission calculation of entire supply chain from farm to IB to FB

4C Units and 4C Chain of Custody

Any organisation involved in coffee production, post-harvest processing, trading or roasting can apply for the 4C CFC, even if they don't hold a 4C core certification. This includes producers, processors, traders, roasters and other supply chain actors, as well as FB. Certification can be pursued at various levels, depending on the scope of operations (see Section 2.1.4.5 for further detailed requirements).

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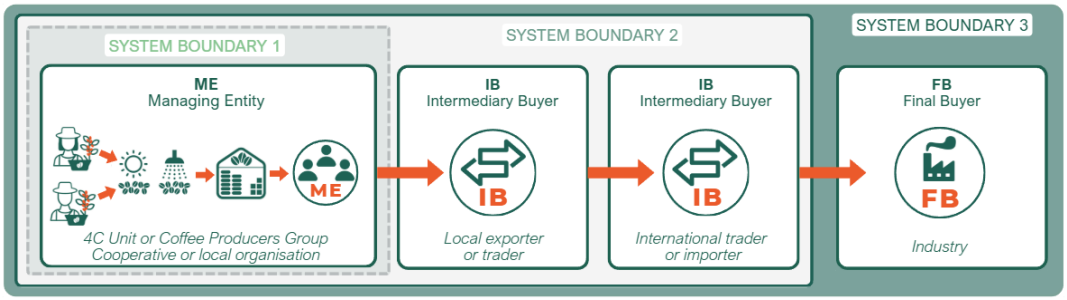


Figure 1: Different scope of system boundaries

Overall set-up

The 4C CFC can either consider the 4C Unit/CPG only or the entire supply chain (see above for system boundaries). However, if the supply chain involves cooperatives or local organisations, these can be considered as independent Managing Entities (MEs) within the supply chain. Figure 2 on next page illustrates an exemplary set-up for the system boundaries as well as the components for the GHG emissions calculation for the 4C CFC.

Certificate and amendment

4C system users can decide freely whether to assess and reduce GHG emissions in their supply chain based on the voluntary market. The 4C CFC is closely aligned and consistent with certification requirements and procedures under the 4C system. The 4C system user has the right to use the respective logos and claims and communicate their efforts to reduce GHG emissions. The 4C team will provide clear instructions and possibilities (see Chapter 5).

Global application

The CFC 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.

Logos and claims

Based on the system boundary and the coffee supply chain steps covered, claims can be made in different ways referring to calculation of GHG emissions, reduction of emissions, and carbon removals. The detailed is explained in see Chapter 5, Logos and Claims.

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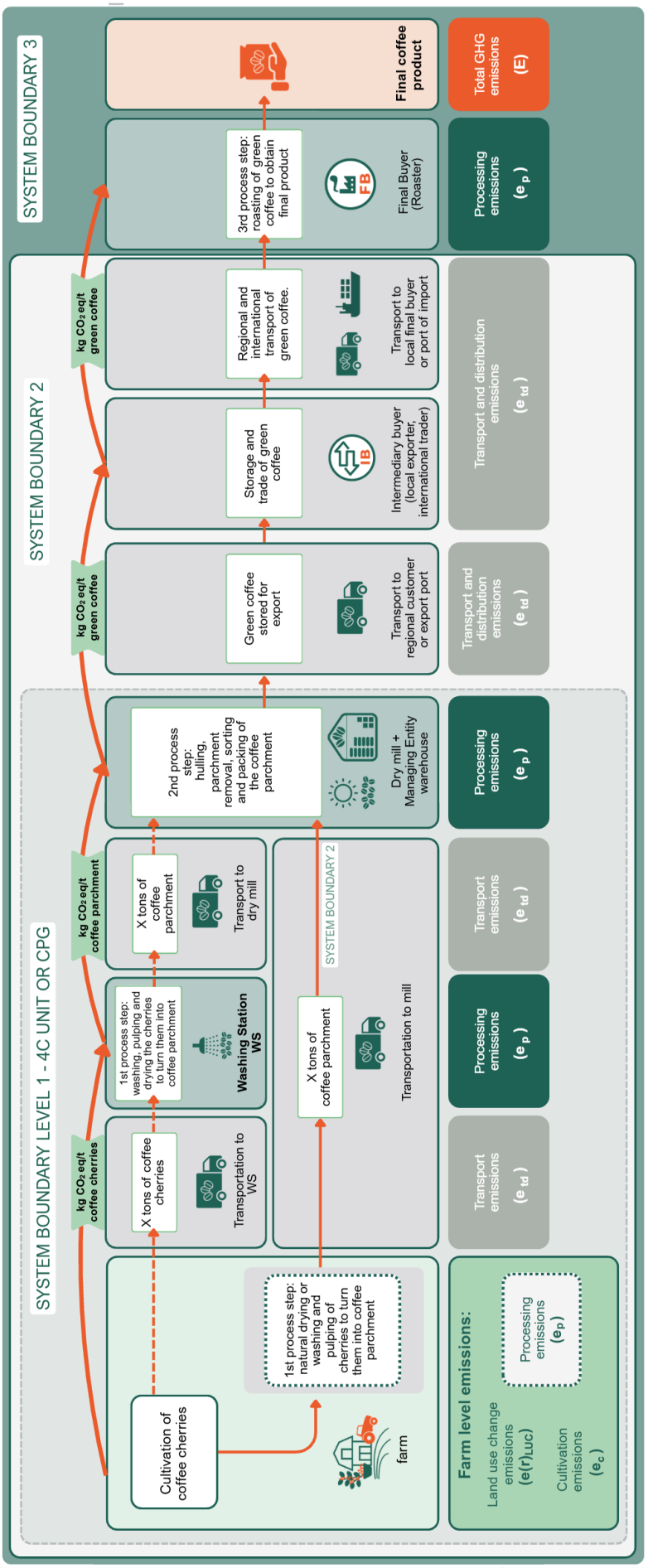


Figure 2: Set-up for GHG emissions calculation for the CFC

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2 Calculation and reporting methodology

Chapter content

This chapter sets out the methodological requirements for calculating GHG emissions and estimating carbon stock changes and the resulting emissions and removals. It also establishes the mandatory reporting framework aligned with the GHG Protocol Land Sector and Removals Standard (LSRS).

2.1 GHG Emissions calculation

Verified calculation

The following chapter outlines the details of the GHG emissions calculation, including its scope, data requirements, and methodological guidelines. It provides guidance for developing the GHG emissions calculation required for CFC. The certification applicant such as the 4C Unit or CPG, an IB or a FB may perform the calculation independently or outsource (i.e., to a consulting company). In all cases, the calculation must be independently verified by an approved Certification Body (CB) cooperating with 4C. Additionally, the GHG emissions and removals calculation will undergo an internal review by an expert team as part of the 4C internal validation process prior to the audit. This validation solely verifies whether the methodological requirements have been correctly applied for auditing by a CB and does not validate any GHG values or provide assurances.

2.1.1 Scope and system boundaries

System boundaries

The GHG emissions calculation can cover each entity of a supply chain, including the activities of agricultural production, post-harvest processing, storage, transportation, and distribution of the final packaged product. In other words, it can cover everything from coffee cherry production to green coffee roasting. All Business Partners (BPs) of a 4C Unit or CPG that are registered in the Business Partner Map (BPM) 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 BPM for the Chain of Custody should be included into the GHG calculation. Section 2.1.2.1 describes the sampling method and the criteria for selecting Business Partners to be included in the GHG emissions.

GHG emissions of 4C Unit

In order to obtain the 4C CFC, the individual GHG emissions of all elements are required to be within the system boundary of the certified 4C Units/CPGs. Figure 3 shows a coffee supply chain with a minimum system boundary illustrating the elements that should be included.

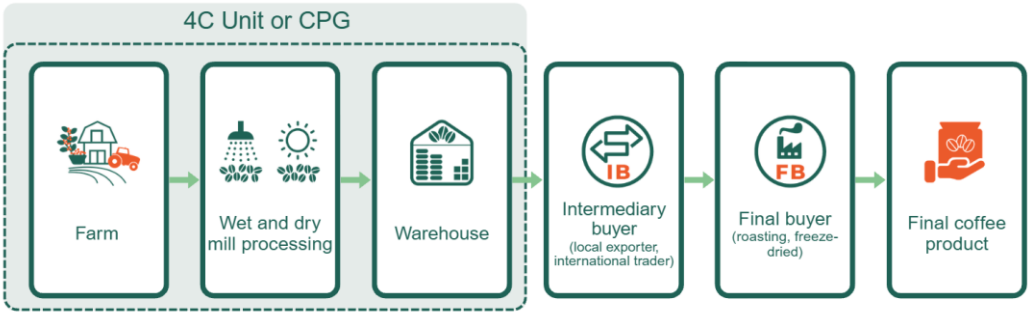


Figure 3: System boundary 1 showcased as a 4C Unit or CPG

Individual calculation required

The 4C Unit or CPG represents the minimum system boundary (1) required for the 4C CFC. This involves considering individual GHG calculations for each element certified under the 4C system. To avoid allocating emissions to potential co-products (i.e., when fertilizer is applied laterally in mixed crop scenarios), the system boundaries

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should be defined in a way that the final coffee product is considered as the system's main and relevant output.

CFC for CoC

The system boundary[6] 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 also need to be covered as transport emissions in the GHG calculation. Retailers and consumers can receive the final coffee product with a calculated GHG value.

Supply chain coverage

If a FB requires the entire upstream supply chain to be 4C Carbon Footprint certified, IBs shall also follow the methodology of the 4C CFC. 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 supply chain including the IBs as system boundary 2.

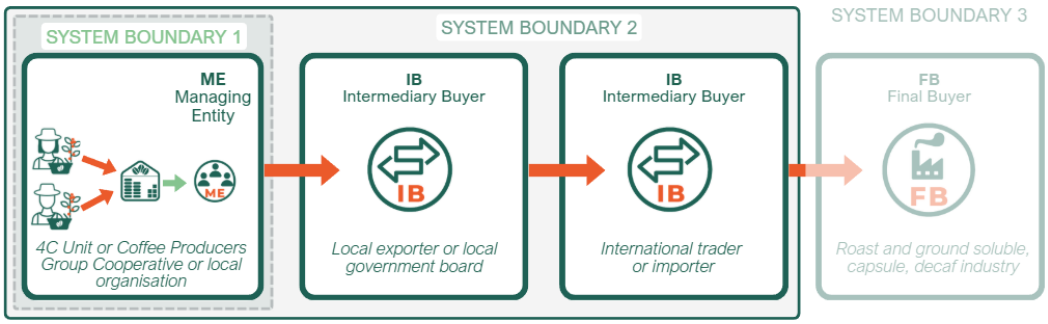


Figure 4: System boundary 2 with Intermediary Buyers (IB)

Final buyer

The FB can be included in the GHG calculation as the last step in the supply chain and will be covered by the 4C CFC at system boundary 3 (see Figure 5). Similar to the IB, FB shall also follow the 4C CFC methodology and include additional elements in the GHG calculation, such as upstream international logistics up to the factory gate.

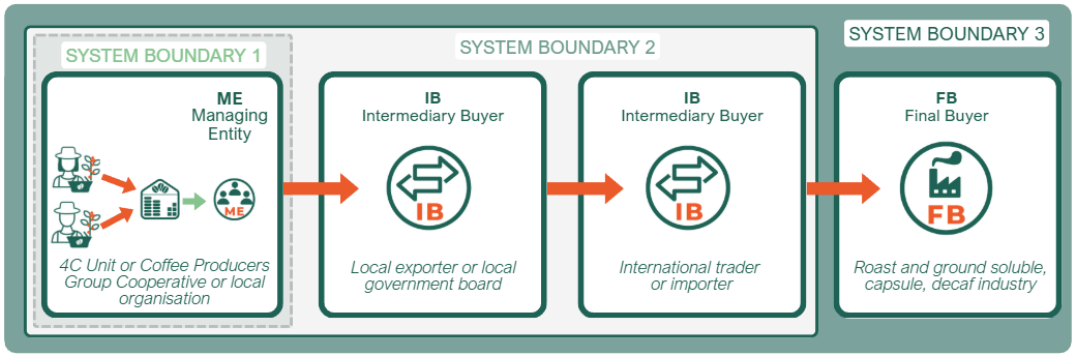


Figure 5: System boundary 3 with Final Buyers (FB)

Claims

It is important to highlight that both on-product and off-product claims shall be consistent with the selected system boundary above, focusing on the committed reduction level. More details about the claims are described in Chapter 5.

6 System boundary refers to all the entities covered or supply chain components that are accounted for calculation.

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2.1.2 Data requirements and emission responsibilities

Actual data

The calculation of GHG emissions for coffee cultivation and processing requires actual data, which shall be up to date. Actual emission values can only be determined at the level at which the individual GHG calculation is performed i.e., at farm or plantation level for the emissions coming from coffee cultivation. For farm groups this responsibility lies with the designated ME. This could be a cooperative or a registered local entity that manages the group of farmers.

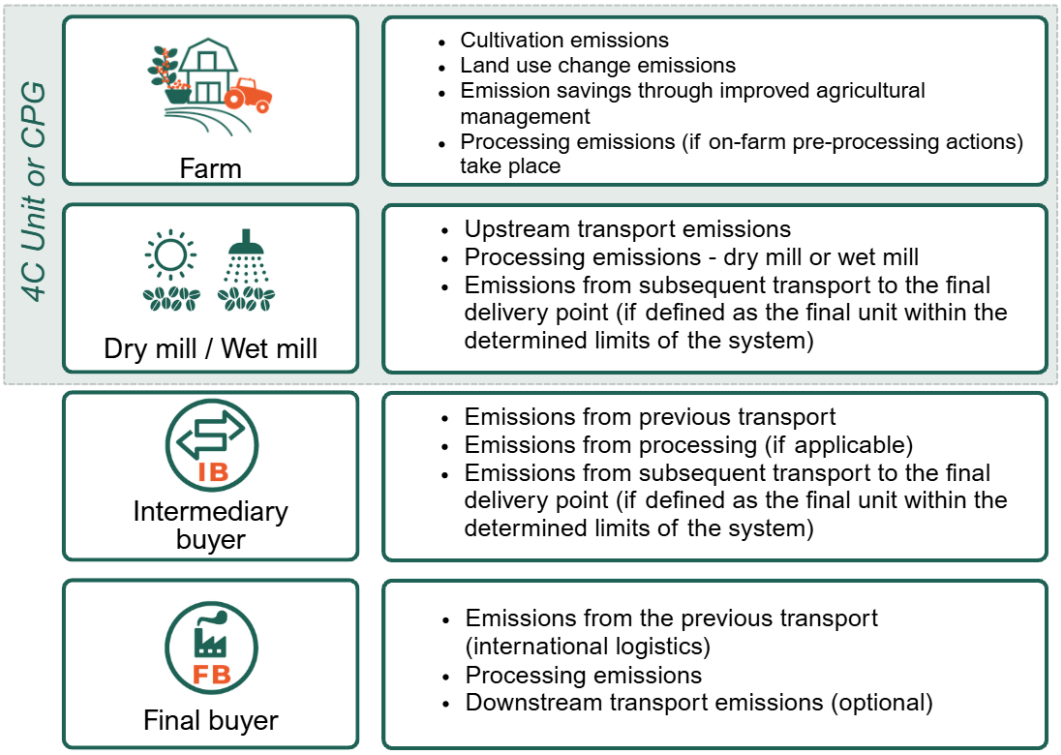


Figure 6: Overview of emissions responsibilities

Coffee cultivation

The **actual emission values at farm level** include the activities of coffee cultivation (e_c) and coffee pre-processing (e_p) that occur at farm and/or plantation level. Farmers or ME of 4C Units or CPG (acting on behalf of their farmers members and belonging to the group) can conduct an individual GHG emission calculation for e_c and e_p. It is important to highlight, that emissions occurring during the pre-processing stage of the coffee production must be reported as e_p even though they occur at farm level. The data for this must be collected by the responsible entity. If farms or plantations belong to a group, they can conduct either an individual GHG emissions calculation for each farmer, or one GHG emissions calculation for the whole group. In the latter case, a sample approach can be used (see Section 2.1.2.1).

Accounting of removals

If LUC ($e(r)_{LUC}$) has occurred, a change in biomass carbon stocks (r_{BOC}) has been reached, or improved agricultural management has been applied, potentially leading to soil carbon accumulation (r_{SOC}), these emissions and/or removals will also need to be calculated and reported separately at this step. Chapter 2.2 will provide detailed information on reporting and calculation of these emissions and removals.

Processing

If there is a **processing facility** (e.g., wet/dry mill or roaster), emissions from processing (e_p) must be calculated. Actual values of these emissions shall include all processing activities directly related to coffee production. This means that all data related to

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processing, (e.g., processing water, wastewater and energy used for processing) must be collected from most recent periods of the calculation year.

Transport and distribution

The actual values of **emissions from transport and distribution** (e_{td}) must be determined and included in the GHG calculation. Any entity in the supply chain receiving physical coffee material shall determine the upstream transport emissions (e_{td}) and transmit these values to the next downstream supply chain entity, together with the physical product. The final unit within the defined system boundary for the individual calculation shall determine the downstream transport emissions to the final delivery point (see Figure 7). This may be a processing facility, warehouse, roaster or a port. Example of a coffee supply chain and transport responsibilities are shown in the figure below.

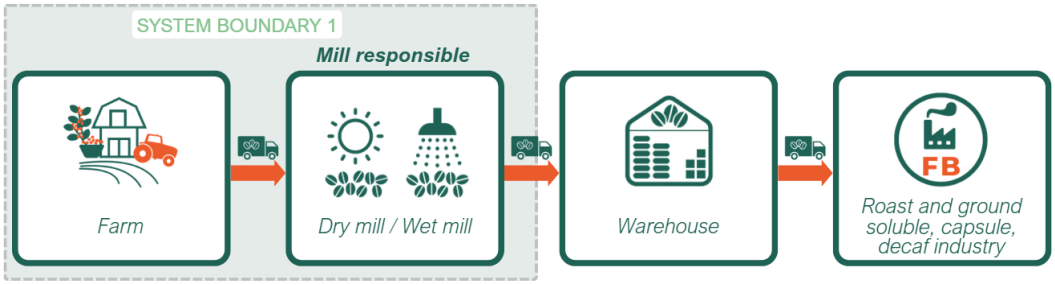


Figure 7: Example of a coffee supply chain and transport responsibilities

Processing emissions for IBs and FBs

If an IB of FB is only engaged in trading and storing coffee, without performing any processing activities, they are required to account solely for transport and distribution emissions and forward the resulting total to the next entity in the supply chain. However, if processing activities fall within their operational scope, they must also include the respective processing emissions in their CF calculation according to Section 2.1.4.2

International transport and export

For export shipments and international transportation, the recipient of the coffee product (e.g., the roaster) is responsible for calculating and including transport and distribution emissions in the GHG inventory. Therefore, the specific point at which these emissions are accounted for, as well as the methodology used, depends on the selected system boundary and the availability of relevant transport data.

Warehouses

Storage facilities, such as **warehouses**, shall be treated separately as their data requirements vary from case to case. If a warehouse belongs to a processing facility, potential emissions shall be included as part of the calculation for the processing unit under (e_p). Warehouses located at the port and belonging to the port infrastructure can be neglected in the GHG calculation as coffee is stored for a short term only before being shipped and in most cases, they are usually due to a lack of data very hard to be identified. Independent warehouses between two processing units also do not need to be considered if they are only responsible for logistic activities. Please ensure that the distance is marginal in comparison to the total travel distances in the entire supply chain.

Warehouse at roastery

In the case of certification, warehouses do not need to be certified separately or provide Sustainability Declarations/Directives, but they will be audited. However, warehouses after the roastery only need to be audited if they belong to the roastery. Warehouses after the roastery can be included voluntarily by the Certificate Holder, e.g., FB.,

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2.1.2.1 Sampling for GHG emissions calculation

4C Unit

For a 4C Unit covering a group of BP Producers and BP Service Providers (post-harvest processors, storage and traders), the data basis for the GHG emissions calculation can be based on a sample of relevant BP Producers and BP Service Providers registered within the 4C Unit, i.e., listed in the BPM for a selected baseline year[7].

CPG

For any other cases, where the CPG or any other independent supply chain is applying for the first time for the 4C CFC, the data basis for the GHG emission calculation should be based on the previous or current harvesting season, as this will be the baseline year. The upcoming section provides a detailed explanation of the sampling method.

Sampling methodology for BP Producers or CPG

Sample size of GHG calculation

The **sampling methodology for BP Producers (4C Units) or any CPG** shall be based on the following steps to calculate the **minimum sample size** for the GHG emissions calculation:

1st Step Identification of homogeneous clusters of producers (for 4C Units, among all BP producers registered in the BPM) according to the following criteria:

- coffee yield range
- farm field size
- coffee varieties
- soil type[8]
- use of irrigation
- organic or conventional farming practices
- 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 washing station with different methods such as honey process, clean parchment, fermentation, etc.

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

Sampling methodology for (BP) Service Providers, IBs and FBs

Grouping methodology

The sampling methodology for BP Service Providers (4C Units), any CPG related processors and service providers, and for Facilities of IBs and FBs shall be based on the following steps:

7 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 the 4C System Regulations and the 4C Glossary.
8 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

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1st Step Identification of homogeneous clusters among all processors/facilities (for 4C Units, registered in the BPM) according to the following criteria:

- For BP Service Providers of a 4C unit or any service providers within the CPG supply chain:
  - type of post-harvest processing, i.e., dry process, wet process, dry and wet process
  - processing capacity range, i.e., the amount of coffee the facility is capable of processing per year
- For Facilities of an IB or an FB:
  - type of facilities, i.e., roastery, roastery with grinding or with warehouse, pure warehouse
  - 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 cluster identified in the 1st step mentioned above, applying the square root of the number of processors/facilities included in each cluster from five onwards. The resulting number should always be rounded up to the nearest integer. If a cluster has fewer than five entries, all processors/facilities need to be considered for the sample and data gathering in the GHG assessment.

Sample increases possible

For both producers and service providers as well as facilities of IB and FB, the methodology described above defines the minimum sample size. The party responsible for calculating GHG emissions may decide to increase the sample size to improve the representativeness of the sample.

GHG values of clusters

If there is more than one sample group representing the clusters, a calculation per cluster should be conducted. For each cluster, the final GHG value can be averaged based on the number of farms in the cluster. The final average values of all clusters 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 beans per cluster on farm level.

Further guidance

For guidance regarding the sample for Annual Audits and recertification audits, please check Chapter 4.

2.1.2.2 Data collection, quality and documentation requirements

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 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 data of current or previous harvest season shall be used to calculate the baseline emissions.

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Use of averaged data

This ensures that emissions are correctly allocated in line with balancing the inputs and outputs of the cultivation activity. If the farmers have data of previous years, an average yield may be applied. This is the case when coffee productivity data (yield) can be calculated as the average of the last two to four years to account for variations between high- and low-productivity years (e.g., due to natural disturbances) and differences between main crops and fly crops within the harvest season. Any use of averaged data must be clearly documented in the calculation and justified during the audit.

Data quality requirements

The time period analysed for the following GHG calculation should cover a full twelve-month period and one full harvesting season of coffee (main crop), 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. This needs to be properly highlighted in the calculation and justified during the audit procedure. The respective period for data gathering and thus for the calculation of GHG emissions shall in general be transparently displayed in the calculation. It should be noted that the focus at the farm level is on collecting primary data. Secondary data sets may only be used when collecting primary data is not feasible or possible due to qualitative justification. Please be aware that if secondary data is used, it will be reviewed by the auditing parties and must be properly documented. If the justification for using secondary data is insufficient, the data may be rejected during the audit process. In such cases, the ME will be informed.

Inputs with little or no effect

If an input has minimal or no impact on generated emissions, it can be excluded from the emissions calculation. Inputs with minimal or no impact are those that have a lower contribution to the overall emissions of the respective calculation formula element (e.g., cultivation (e_c)). In any case, it should be highlighted that the exclusions must be transparently justified and documented, following the GHG Protocol Product Carbon Footprint (PCF) Standard (Greenhouse Gas Protocol, 2026). However, it is recommended to include all inputs in the calculation for the most precise result.

Emission factors

In addition to the on-site data gathered, literature values play an important role in comprehensive GHG emissions calculations. These include emission factors (EFs), which are used to multiply the respective input and output data in order to estimate the environmental impact. These should be obtained from official and peer-reviewed sources. Different values may be used, but these must be duly justified and flagged in the calculation documentation. Sources of these values can be based on emission factor (EF) databases (e.g., Ecoinvent), the IPCC, individually calculated or measured values, or values from supply partners among others (e.g., PPA). If these values and EFs are not available, other peer-reviewed scientific literature or official statistical data from government bodies can be used instead. All data gathered from databases or literature must be based on the most recent available sources and shall be updated over time.

EF reference

The source and the date of data collection must be documented. EFs chosen or calculated shall also reflect the specific situation and set-up. For example, if a process-specific input was produced in South America, the EF for this input must also reflect the South American situation. Only in cases where specific EF are not available, alternative values from other sources may be used if this has been confirmed by the CB and verified by 4C. In addition, 4C provides system users with an updated list of important EF from public sources. This list can be requested via e-mail to 4C, as system user.

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2.1.3 Calculation and reporting of GHG emissions and carbon removals

Calculating GHG emissions

The following sections describe the methodology for calculating GHG emissions generated at each step of the coffee supply chain included in the certification. Emission data is based on actual and individually calculated values. Currently, there are no recognised default values available for the coffee sector that could be applied to any of the elements described below.

Unit of measurement

The final unit for the total GHG emission value shall be expressed as **kg CO_2eq per ton (t) green coffee or kg CO_2eq per kilogram (kg) of green coffee**. CO_2eq, (carbon dioxide equivalent), is a unit of measurement that represents the 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 requirements related to downstream transportation or distribution of coffee, as well as the conversion of the coffee product, please refer to Sections 2.1.4.3 and Section 2.1.4.4 for specific forwarding guidelines.

Separate GHG calculation

In line with the GHG Protocol Land Sector and Removals Standard (LSRs), emissions and removals must be reported separately and not combined in a single formula. This means that farm emissions, LUC emissions, and removals in soil and biomass carbon stock (CS) (as SOC and BOC respectively) are calculated and disclosed as distinct components before determining the net GHG balance. The 4C CFC follows this approach by quantifying the GHG emissions from the coffee supply chain steps in the following elements:

GHG calculation formula elements

$$Total\ Emissions\ (TE) = e_c + e_p + e_{td}$$

Equation 1: Total Emissions (TE)

$$Land\ Use\ Change\ (LUC) = e(r)_{LUC}$$

Equation 2: Land Use Change (LUC)

$$Removals\ (R) = r_{SOC}\ \&\ r_{BOC}$$

Equation 3: Removals (R)

Where:

TE	Total Emissions from cultivation, processing, and transport/distribution with the supply chain system boundary (kg CO_2eq/t or kg of green coffee)
e_c	emissions from the cultivation of coffee
e_p	emissions from processing (dry milling, wet milling, roasting, etc)
e_{td}	emissions from transport and distribution
$e(r)_{LUC}$	annualised emissions or removals from CS changes caused by LUC
r_{SOC}	removals from permanent soil carbon accumulation via improved agricultural management
r_{BOC}	removals from permanent biomass carbon accumulation (AGB and BGB)

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Machinery and equipment

Emissions from the manufacture of machinery and equipment are not required to be included, also in line with the ISO (ISO, 2018) and Publicly Available Specification (PAS) approach. The same applies to activities that 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 CF of a product. As a result, the methodology for the 4C CFC is aligned with the following standards and methodologies:

- ISO 14067:2018 - CF of products (ISO, 2018)
- GHG Protocol Product Standard (Greenhouse Gas Protocol, 2011)
- GHG Protocol Land Sector and Removals Standard (LSRS) (Greenhouse Gas Protocol, 2026)
- 2006 IPCC Guidelines for National Greenhouse Gas Inventories and 2019 IPCC refinement (IPCC, 2006) and (IPCC, 2019)
- PAS 2050:2011(BSI, 2011)

SBTi

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

Complimentary material

This 4C CFC 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 CFC.

2.1.4 Calculation methods by supply chain stage

GHG emission accounting

The following chapter describes how GHG emissions shall be calculated under the 4C CFC methodology standard. Emissions are generated during coffee cultivation, processing, and transport activities. GHG emissions refer to the release of gases such as carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O), all of which contribute to global warming and climate change. Calculating GHG emissions involves identifying all relevant emission sources, collecting activity data in the coffee production (e.g., fuel use, energy consumption, production volumes), and applying scientifically established EFs. This process allows organisations to quantify their climate impact, track progress over time, and support transparent reporting and the development of emission-reduction strategies.

2.1.4.1 Emissions on farm level (e_c)

Cultivation and post-harvest

The actual values for emissions on the farm level include primarily activities for coffee cultivation (e_c)and in some cases, coffee post-harvest processing (e_p) that occur at the farm and/or plantation level. This chapter is mainly focusing on the coffee cultivation emissions (e_c).

Data requirements

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

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in the calculation. The parameter hectare is of particular importance, as all calculations must be based on a consistent land area. For example, if coffee cultivation covers 5 hectares, the complete cultivated area shall be included in the assessment. Accordingly, all activity data, inputs, and calculations must be reported for and refer to the entire farm area to ensure consistency and comparability of results. All above mentioned data must be collected for the designated reference or baseline year and should not include a mix of information from other years. However, exceptions apply in the case of yield data. If different peak levels or natural disturbances occurred in the past year for the baseline, the yield data input should be averaged over the last two or four years to account for potential variations. This must be clearly documented and made accessible to the CB.

Data collection

The aforementioned data will form the basis for the calculation of GHG emissions for an individual farm or the sampled group in the supply chain. All input values shall be obtained for the same area and time period, e.g., a farm area of one hectare over a time period of one year and harvest season. All farm activities connected to the cultivation of coffee shall 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 also excluded (see Section 2.1.3).

Formula

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

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

Equation 4: Cultivation Emissions

Sum of GHG emissions

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

Different inputs

The EM of the different inputs are calculated by multiplying the input data with the respective EFs. Care shall be taken that every unit of measurement of on-site gathered data and EFs from recognised sources are the same. For each input, a respective EF shall be applied to calculate the GHG emissions.

Post-harvest processing

If post-harvest processing activities of the coffee cherries take place on the farm level (e.g., cleaning, separation of cherries, de-pulping, washing and/or 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 Section 2.1.4.2.

The following section provides a detailed description of the various calculation elements, beginning with the accounting methodology for fertilizers.

Fertilizer emissions

In general, the term “amount of fertilizer used” refers to the total quantity applied to the soil. Producing this fertiliser generates emissions during manufacturing, transportation, and distribution. In addition to emissions associated with fertilizer production, a substantial share of farm-level GHG emissions originates from the fertilizer's active ingredient. Nitrogen is the most relevant nutrient in this regard, as its application to soil triggers microbial processes such as nitrification and denitrification. These processes generate on-field emissions and are therefore a key source of agricultural greenhouse gas emissions. These processes convert nitrogen compounds into nitrous oxide (N_2O), a GHG with a GWP about 273 times higher than

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carbon dioxide (CO_2) over a 100-year period according to the IPCC (Greenhouse Gas Protocol, 2024). The extent of these emissions depends on soil conditions (moisture, temperature, pH) and the timing and amount of fertilizer applied. Consequently, nitrogen fertilizer use is a major source of agricultural emissions in coffee production systems and therefore:

- For synthetic fertilizers, emissions from fertilizer production (***$EM_{fertilizer}$***) shall be considered and specific EFs (***$EF_{production}$***) shall be applied:

Synthetic fertilizers

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

Equation 5: Emissions from fertilizer production ($EM_{fertilizer}$)

- For synthetic fertilizers containing nitrogen, in addition to ***$EM_{fertilizer}$***, N_2O-field emissions from managed soils, ***EM_{N2O}*** shall be calculated by applying specific EFs referring to each different element of N_2O emission, as specified:

Synthetic nitrogen fertilizers

$$EM_{N2O} = \left[E_{N2O-direct}\left[\frac{kg\ N_2O}{ha}\right] + E_{N2O-indirect}\left[\frac{kg\ N_2O}{ha}\right]\right] * 273$$

Equation 6: Emissions from synthetic fertilizers with N (EM_{N2O})

- For ***organic nitrogen fertilizers and crop residues*** applied or left on the field, only N_2O-field emissions from managed soils should be calculated. See below for further details.

Organic fertilizer

IPCC method as reference

The IPCC has defined a methodology to calculate emissions from the application of fertilizers in the field, the so called on-field emissions. 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 accurately accounted for, including both "direct" and "indirect" N_2O emissions resulting from the application of synthetic and organic nitrogen fertilizers and crop residues to managed soils (IPCC,2006, Vol. 4, Ch.11). Direct emissions are those N_2O emissions generated by the soil itself as a result of N input application. Indirect emissions occur through processes such as volatilisation and subsequent redeposition of ammonia (NH_3) and nitrogen oxides (NO_x) to soils and waters, as well as 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 must be calculated and included for both mineral and organic soils (where applicable). The following formulas refer to mineral soils, which cover most cases. For N_2O calculation formulas addressing organic soils, this is described in Volume 4, Chapter 11, Eq.11.1 of 2019 IPCC Refinement (IPCC,2006, Vol. 4, Ch.11).

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

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

Equation 7: N_2O direct emissions (E_{N2O})

Where:

$E_{N_2O-direct}$	Annual direct N_2O–N emissions produced from mineral managed soils, kg N_2O ha-1
I_N	annual synthetic N-fertilizer input, kg N ha^{-1}
F_{ON}	annual organic N-fertilizer input, kg N ha^{-1}
F_{Cr}	annual 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 of IPCC,2006, Vol. 4, Ch.11
F_{SOM}	amount of N in mineral soils that is mineralised, 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:

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

Equation 8: N_2O indirect emissions (E_{N2O})

Where:

$E_{N_2O-indirect}$	annual indirect N_2O–N emissions produced from mineral managed soils, kg N_2O $ha^{-1,}$
$N_2O - N_{ATD}$	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 EFs 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 (4C Unit or CPG) 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. As mentioned previously, when calculating the emissions check if the unit of the EF is corresponding to the input unit.

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

Equation 9: Other -than fertilizers- input emissions (EM_{inputs})

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. Fuel consumption data and respective emissions from irrigation practices or other field activities, should be separately collected and calculated as fuel consumption coming from pre-processing of coffee cherries. If the farmer uses a generator to produce electricity for cultivation activities, include the amount of fuel consumed for energy generation here as well.

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

Equation 10: Fuel consumption emissions (EM_{fuel})

Electricity emissions

If electricity is consumed from the grid, the EF of the national electricity mix ($EF_{electricity}$) shall be used. If electricity from renewable sources is consumed directly from the respective electricity plant, an adapted EF for the type of renewable electricity can be used if provided by the plant. If renewable electricity is purchased from an external provider via the national grid and guarantees of origin (GoO) or a power purchase agreement (PPA) are available, the respective EF provided for this electricity (mix) can be used as an alternative to the regular grid EF.

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

Equation 11: Electricity emissions ($EM_{electricity}$)

Workers and offices

Consumption of fuel for the transport of workers and electricity usage for office buildings **are not to be included in the GHG calculation** as they are not directly related to the production process of coffee and out of the predefined system boundaries.

Cultivation waste emissions

Emission from cultivation waste ($EM_{cultivation\ waste}$) in coffee production refers to all organic material generated during the growing and maintenance of coffee plants on the plantation, before any harvesting or processing takes place. This includes pruning residues (branches and twigs), fallen leaves and weeds. These materials are typically classified as agricultural field residues and are often left on-site, composted, or reused as mulch. In addition, occasionally unharvested or damaged coffee cherries can also be accounted as cultivation waste.

Waste and residues

In general, it is important to distinguish between cultivation waste and the processing residues, which arise after harvest. The broader term “residues” in coffee systems generally refers to all by-products generated during the transformation of coffee cherries into green beans. Within the processing residues, more specific terms such as husk, pulp and parchment describe distinct layers of the coffee fruit that are removed during processing (see for further information Section 2.1.4.2).

Exclusion of cultivation waste

Building on this distinction, the 4C CFC defines cultivation waste in a more simplified way. Due to the high level of complexity and variability involved in quantifying pruning residues, combined with their dispersed nature and biomass flows, the emissions from pruning activities can be excluded from detailed calculation until adequate and reliable data are available to quantify their contribution. Accordingly, the estimation of emissions from cultivation waste focuses primarily on damaged coffee cherries and

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other organic fractions that are collected and subsequently managed through composting or open burning. Alternative waste management pathways (e.g. energy recovery) are not considered within the scope, when their contribution to overall emissions is considered insignificant. Furthermore, the application of organic fractions to the field is not considered in this calculation in order to avoid double counting with fertilizer-related on-field emissions.

Cultivation waste emission

Accordingly, the system boundary is set at the point of composting and no further modelling of emissions associated with subsequent decomposition processes is carried out. This approach ensures consistent and pragmatic treatment of cultivation waste, while limiting the complexity of the overall assessment. The following equation describes the calculation of emissions associated with cultivation waste. If cultivation waste is not included in the calculation, a justification shall be documented, demonstrating that no relevant cultivation waste was generated or that its contribution to overall GHG emissions is considered negligible.

$$EM_{cultivation\ waste} = cultivation\ waste \left[\frac{kg}{ha * yr}\right] * EF_{waste\ compost} \left[\frac{kg\ CO_2eq}{kg}\right]$$

Equation 12: Cultivation waste emissions ($EM_{cultivation\ waste}$)

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 (see Section 2.1.4.4). If post-harvest processing took place on farm level as well, next to emissions from cultivation a final GHG emission value for processing (e_p) shall also be forwarded to the corresponding unit. Accordingly, the final unit for emissions on farm level is $kgCO_2eq/t$ coffee parchment or green coffee.

Emissions from sample

If the calculation is conducted for multiple defined homogeneous sub-group samples of BP producers, the GHG value for cultivation emissions can be averaged (based on guidance in Section 2.1.2.1) and shall be forwarded as $kgCO_2eq/t$ coffee beans or coffee cherries (if no post-harvest processing took place on farm level).

2.1.4.2 Emissions from processing (e_p)

Calculating processing emissions

Emissions from processing (e_p) are emissions generated by the coffee producers if post-harvest processing takes place on farm level and/or at BP Service Providers/facilities, i.e., post-harvest processing facilities, which are registered in the BPM of the 4C Unit/CPG. In CPG supply chains that are not organised as a 4C Unit, each processing entity shall be responsible for quantifying and reporting the GHG emissions associated with its own processing activities before it becomes the final product. On the other hand, 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).

Emission sources to be covered

Emissions from processing (e_p), shall include emissions from the coffee processing itself (washing, hulling, grading, packing), from waste (coffee pulp, coffee husk, wastewater, unsaleable coffee), 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 the manufacture of machinery and equipment are not required to be taken into account, since they are not directly connected to the coffee cultivation, production process or system boundaries.

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The calculation shall be based on the following formula:

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

Equation 13: Emissions from Processing (e_p)

Emissions of different inputs

The emissions of the different processing elements (***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 related to the reporting year. Formula components for calculating ***EM*** are shown below starting with electricity.

Electricity emissions

If electricity is sourced externally from the grid, the EF 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 renewable electricity is purchased from an external provider via GoO or PPA, the respective EF provided for this electricity (mix) can be used as an alternative. The GoO or PPA shall be made available for the audit by the energy provider.

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

Equation 14: Electricity emissions

Office activities

> **Note:** Emissions from office activities are not required to be taken into account.

Heat emissions

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

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

Equation 15: Heat emissions (option 1)

or

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

Equation 16: Heat emissions (option 2)

EFs for heat production

As emission factors (EFs) for heat generation vary depending on the fuel or energy source used and, where applicable, the heating technology, the appropriate EF shall be selected and the corresponding information shall be documented. To calculate EM_{heat}, either the amount of heat consumed, or the quantity of fuel used for heat generation during processing activities shall be determined and multiplied by the respective EF.

Biomass for heat production

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 GHG that can be used to differentiate the emissions

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occurring from biomass burning. The values per GHG need to be converted into CO_2 equivalent values by multiplying with the respective GWP. All relevant GWP are listed in the Annex 1: 4C Terminology

Find below the most commonly used 4C terminology throughout this document. For additional terminology not included in this table, please refer to the 4C Glossary in the 4C document library.

TERM	DEFINITION
4C CoC Unit	An Intermediary Buyer, a Final Buyer, or an entity having facilities that include any type of post-harvest processing activities, storing, or trading 4C coffee that holds a 4C chain of custody certificate.
4C Unit	An entity managed by the ME as a Certificate Holder and subject to 4C certification, bringing together all relevant supply chain actors within the defined certification scope.
Baseline scenario	The projected emissions in the absence of the specified emission reduction measures; it is distinct from the measured inventory for the baseline year.
Baseline year	The reference year or harvest-season period for which the initial GHG inventory is established and against which subsequent emission results are compared.
Business Partner (BP)	Any actor within the 4C Unit or CPG up to the Managing Entity level who has physical contact with coffee cherries, parchments, or coffee beans. Those actors are typically coffee farmers, traders, warehouses, and mills.
BP producer	A farmer or actor recorded in the Business Partner Map (BPM) that owns, leases, or has legal use rights of the fields/plots from which he/she/it grows and sells 4C certified coffee.
BP Service Provider (SP)	A person or company that either handles or that participates in the transformation of coffee cherry, parchment, or green coffee bean at any stage of the supply chain between the BP Producer and the ME. This can be either a BP Trader, BP Storage, or BP Processor.
Certificate applicant	The entity applying for certification and responsible for preparing and submitting the required application documents.
Certificate holder	The entity to which the certificate is issued following a positive certification decision and which is responsible for maintaining compliance throughout the certificate validity period.
Claim level	A category describing the type of verified result communicated under the certification. Claim Level 1 concerns quantified GHG emissions, while Claim Level 2 concerns emission reductions relative to a baseline and requires an Improvement Plan. A system boundary defines the supply-chain activities covered by the assessment, rather than the type of claim.
Coffee cherries	The fruit of the coffee plant containing one or two coffee beans enclosed within outer layers of skin, pulp, mucilage, and parchment. Coffee cherries represent the harvested raw coffee material prior to processing into intermediate products such as parchment coffee or green coffee beans.
Coffee parchment	An intermediate coffee product consisting of coffee beans still enclosed in their parchment layer, before hulling. Parchment as a processing residue

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	refers to the detached layer removed during hulling, not to the intermediate coffee product.
Coffee Producing Group (CPG)	Independent coffee-producing groups that are not certified under the 4C core certification scheme but can apply for the 4C CFC. A CPG refers to a group of coffee producers organised and selling coffee to a local trader, cooperative, or company, managed by a Certificate Holder.
Final Buyer (FB)	The last actor in the supply chain that purchases 4C certified green coffee beans. i.e., an entity that transforms green coffee beans into processed coffee (e.g., roasting, grinding, production of soluble or capsule coffee, decaffeination).
Functional unit	The reference quantity of a coffee product to which all inputs, outputs, greenhouse gas emissions, and carbon removals are related throughout the coffee supply chain. Depending on the assessment scope, the functional unit may be expressed as coffee cherries, parchment coffee, green coffee, green bean equivalent (GBE), or another defined coffee product unit.
Green bean Equivalent (GBE)	The quantity of coffee expressed as an equivalent mass of green, unroasted coffee. Quantities at other processing stages can be converted to this common reference using the applicable coffee turnover ratio (TR) or Coffee Conversion Factor (CCF). For emission-related claims under this certification, the reference unit is one kilogram or one tonne of green coffee equivalent.
Green coffee	Coffee beans obtained after the removal of all outer fruit layers and parchment, but prior to roasting. Green coffee represents the internationally traded coffee commodity and serves as the primary input for roasting and downstream coffee products.
Intermediary Buyer (IB)	Traders, exporters, importers, or any other legal entity which trades 4C certified products, and which is neither the Managing Entity (ME) of the 4C Unit the 4C certified coffee has been purchased from nor the Final Buyer (FB). An IB is not part of a 4C coffee Unit but is operating as a trader outside of the 4C coffee Unit.
Managing Entity (ME)	A legally registered entity, responsible for implementing the 4C System requirements and managing a 4C Unit, as well as monitoring, evaluating, and reporting of the 4C Unit. It's the 4C certificate holder and responsible for trading 4C certified products.
Reporting period	The period covered by the activity data and results of a particular assessment.

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Annex 2 of this document.

External fuel & biogenic CO_2

If such material for heating purposes is coming from an external source, respective upstream emissions shall be accounted for in the calculation by using the aforementioned formulas and reflected in the respective EF. The respective data and information shall be documented in the calculator. Biogenic CO_2 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} 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).

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

Equation 17: Other inputs emissions EM_{inputs}

Wastewater treatment emissions

The $EM_{wastewater}$ applies only to wastewater treatment. It is essential to use an appropriate EF that accurately reflects the treatment process as here, the emissions are estimated, when the specific amount of wastewater undergoes the selected treatment method. All wastewater that is generated during the activities of processing shall be documented and multiplied by the respective EF for the treatment. It is important to highlight that the amount of wastewater and the associated upstream emissions are included as inputs in the input formula above.

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

Equation 18: Wastewater treatment emissions $EM_{wastewater}$

Residue treatment emissions

All product-related residues (e.g., husk, pulp or low-quality cherries) generated during the processing activities shall be documented and multiplied by the respective EF for their treatment as waste. It is important to highlight that the quantity of residues can also include biomass residues generated at the farm level, particularly when processing takes place on-site. These residues shall not be confused with cultivation waste (see Section 2.1.4.1) which mainly covers damaged or unharvested coffee cherries generated during cultivation. Therefore, the formula below can be applied to any type of processing output or processing residue, whereas cultivation waste is accounted for separately. The $EM_{residues}$ applies only to the treatment of output or residue. It is essential to use an appropriate EF that reflects the treatment process as accurately as possible.

$$EM_{residue} = residues\left[\frac{kg}{yr}\right] * EF_{residues\ treatment}\left[\frac{kg\ CO_2eq}{kg}\right]$$

Equation 19: Residue treatment emissions $EM_{residues}$

Inclusion of all emissions

Each processing unit in the supply chain must ensure that all GHG emissions from processing activities, residues and process-specific inputs are included in the emissions calculation.

Minimum requirements

Considerations from GHG emissions from processing

To calculate GHG emissions from processing (e_p), the following data must be determined and collected as a minimum. These quantities should be extracted from

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operating records and verified by the auditors. The following data must refer to the same time period and be gathered on-site:

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

Methane emissions

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

For roasters

> Note: Coffee roasters shall also calculate processing and transport emissions following the general methodology under the requirement described in Section 2.1.4.5

If the calculation is conducted for a sample of supply chain actors (e.g., BP Service Providers or a CPG), the GHG value for processing emissions can be sampled following the same approach as for farm samples in Section 2.1.2.1.

2.1.4.3 Emissions from transport and distribution (e_{td})

Transport and distribution of coffee

Emissions from transport and distribution (e_{td}) shall include all emissions related to the transport of coffee products (e.g., coffee cherries or green coffee) between BP Producers and BP Service Providers, including post-harvest processing and storage facilities. These emissions shall be accounted for from the field to the port of export or the respective local final destination, regardless of whether the involved entities are registered in the BPM of the 4C Unit/CPG or operate independently within the supply chain. In the case of 4C Chain of Custody certification, emissions are included among facilities registered in the corresponding BPM. Independent certificates must be communicated with 4C.

About the roaster

The roaster as final processing unit may as well include the downstream transportation, so local distribution of final coffee product to distribution centres or even the end user. Emissions from the transport or commuting of workers do not need to be included.

Transport emissions calculation

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

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

Equation 20: Transport and distribution emissions e_{td} (option 1)

Where:

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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 is multiplied by the number of times this transport system is being used and the EF of the fuel for a conservative approach.

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 must be considered:

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

Equation 21: Ship and train transportation formula

EF in ton-km

The amount of transported coffee cherries, coffee beans or green coffee is multiplied by the total distance and by an EF 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.

Emission from transport fuel-based

Additionally, when transport distances are unknown, but an accurate calculation is required, transportation standards refer to the following fuel-based formula. In this case, the type of fuel used for transport and the amount consumed must be known. This formula is built on an energy/fuel-based methodology that considers emission drivers from all stages of the transport fuel's life cycle, including combustion during later transportation activities. The essential parameter for this calculation is the well-to-wheel EF. Well-to-wheel EFs consider both well-to-tank and tank-to-wheel emissions. The distinction between the aforementioned two emission types will be explained later.

e_{td} calculation formula

If the total amount and type of fuel used in transportation is known, the following equations can be used to estimate emissions from transportation using a specific fuel, based on the well-to-wheel life cycle.

$$e_{td}\left[\frac{kg\ CO_2eq}{ton}\right] = \frac{\left(TA_{fuel\ used}\left[\frac{kg}{yr}\right] * LHW_{of\ used\ fuel}\left[\frac{MJ}{kg}\right]\right) * WTW_{factor\ for\ the\ fuel}\left[\frac{kg\ CO_2eq}{MJ}\right]}{amount\ transported\ coffee\ in\ transport\ type\ [ton]}$$

Equation 22: Total transportation and distribution emissions e_{td} (option 2)

Where:

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$TA_{fuel\ used}$	total amount of fuel used for transport,
$LHW_{of\ used\ fuel}$	lower heating value of the fuel,
$WTW_{factor\ for\ the\ fuel}$	well-to-wheel emission factor

Energy in fuel used

The formula above multiplies the total amount of fuel used to transport coffee during a production period by the lower calorific value of that specific fuel. This gives the amount of energy contained in the quantity of fuel used. This will be the main factor transformed in the transport activity.

Unit conversion

If you have the total amount of fuel used in the production period ($TA_{fuel\ used}$) in litres, the following formula shall be used to convert it into the corresponding unit of the initial formula, considering the density of the respective fuel.

$$TA_{fuel\ used}\left[\frac{\mathrm{kg}}{yr}\right] = TA_{fuel\ used}\left[\frac{l}{yr}\right] * density_{fuel\ type}\left[\frac{kg}{l}\right]$$

Equation 23: Total amount of fuel used and density $TA_{fuel\ used}$

Where:

$Density_{fuel\ type}$	density of the fuel in kg per litre

WtW EF sources

Once the amount of fuel used has been correctly calculated, it must be multiplied by the relevant well-to-wheel EF. The well-to-wheel EF is based on two main emission sources.

Well-to-tank emissions

The first is energy provision emissions, also known as well-to-tank emissions. These are all the emissions that occur during the production of the fuel before it is made available on the market. These include processing emissions from extraction, refining, storage, production, transport and distribution. For this reason, it is called well-to-tank, as all emissions are factored in until the fuel reaches the tank of the transport medium.

Tank-to-wheel emissions

The second relevant emission source is the operational value for a specific transport, which is known as tank-to-wheel emissions. This indicates the emissions by the amount of energy generated in the operational activity of the fuel, primarily in the combustion chamber, to power the transport medium and transfer kinetic energy to the wheel and the external environment. This depends not only on the type of fuel, but also on the transport mean and the engine efficiency of that vehicle. It should be noted that both emission sources (well-to-tank and tank-to-wheel) in total represent the well-to-wheel EF, which is necessary for the calculation. The relationship between these two sources is illustrated in the following diagram.

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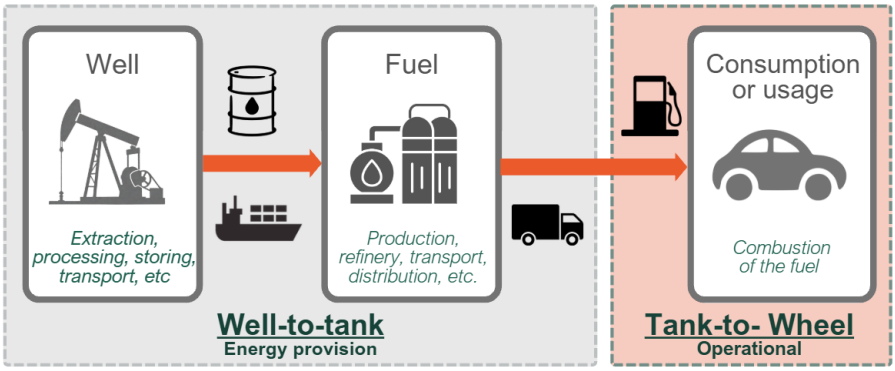


Figure 8: Overview of upstream and operational emission sources in fuel supply chains

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 processing unit is responsible for upstream transport of coffee cherries from farm level
- Processing unit is responsible for upstream transport from previous entity (e.g. farm or intermediate) and if last entity of system boundary is also responsible for downstream transport to next IB or if there is no IB within the supply chain up to the port of export or local destination
- IB is responsible for upstream transport from previous entity (e.g. dry mill or other IB) if not receiving respective values together with green coffee delivery from previous entity
- In general, roaster as final processing unit is responsible for upstream (international) transport from country of origin to roasting site. However, exceptions can change the responsibility for accounting for transport emissions. Further downstream transport by the roaster e.g., to a distribution centre or final consumer can be included on a voluntary base.

Responsible unit for transport

The following figures (Figure 9 and Figure 10) show examples of which supply chain entity is responsible for calculating transport and distribution emissions in the coffee supply chain:

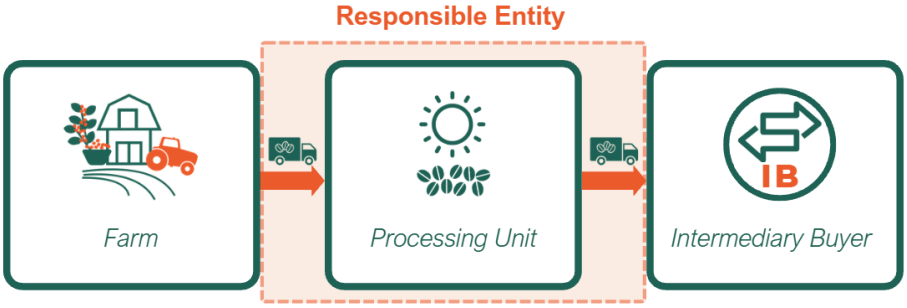


Figure 9: Example processing unit up- and downstream transportation emissions

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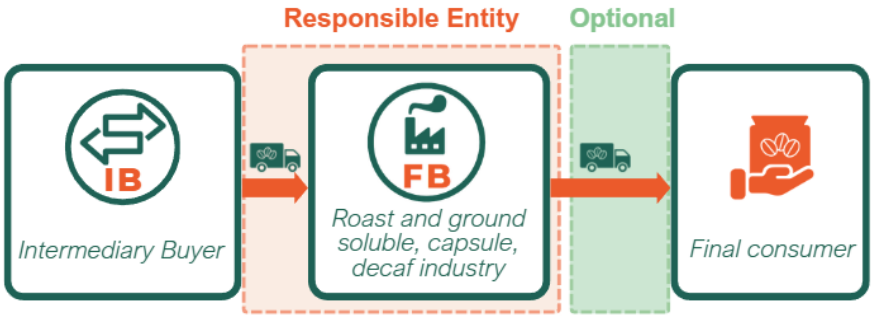


Figure 10: Example roaster upstream transportation emissions

GHG value forward

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

Transport default values

As mentioned, 4C can provide a list of EFs for different transport types by request. If companies already have more efficient logistics or have implemented reduction measures, it will be possible to insert their actual emission value for transport, which will be verified during the audit.

2.1.4.4 Forwarding of 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. It usually starts being applied at the unit which is processing the coffee.

Each entity in the supply chain belonging to the defined system boundary (see Section 2.1.1) 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 or CPG 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 IB or FB.

4C Portal

The 4C Portal has a feature where the 4C Units, CPG and facility of Chain of Custody (CoC) can insert the corresponding emission values of each stage: e_c, e_p, e_{td}. For some GHG values, like processing emissions or transport emissions, actual values need to be added at each step of the CoC by the respective operational unit.

The coffee turnover ratio (TR)

The coffee turnover ratio (TR) can be defined as the ratio between the total amount (mass) of received input of the coffee product and the total amount (mass) of produced output coffee product. It shall be applied for all incoming emissions (e_c, e_p, e_{td}) as they are expressed in terms of the coffee product by the functional unit and need to be converted to the respective outgoing coffee product of the calculating unit's emissions. Since the functional unit of the total emissions ***(TE)*** is defined as green coffee, also expressed as Green Bean Equivalent (GBE) in the claims (see Section 5), this conversion step is mandatory to ensure consistency throughout the calculation. The following formula shall be applied to calculate the factor based on real data values:

$$Coffee\ turnover\ ratio\ (TR) = \frac{Total\ amount\ (mass)\ of\ received\ input\ coffee\ product}{Total\ amount\ (mass)\ of\ produced\ output\ coffee\ product}$$

Equation 24: Coffee turnover ratio (TR)

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Conversion of upstream emissions

Applying the TR is mandatory to ensure that GHG emissions are consistently transferred between coffee products along the supply chain. The formula below illustrates how emissions associated with coffee cherries are converted and forwarded from cultivation to the subsequent processing stage.

$$e_{cb}[(kg\ CO_2eq)/(ton_{cb})] = e_{cc}\left[\frac{kg\ CO_2eq}{ton_{cc}}\right] * TR_{beans}\left[\frac{ton_{cc}}{ton_{cb}}\right]$$

Equation 25: The conversion of emissions for cultivation (from cherries to beans)

Where:

e_{cb}	emissions for cultivation of coffee beans
e_{cc}	emissions for cultivation of coffee cherries
TR_{beans}	coffee turnover ratio for beans
ton_{cc}	ton coffee cherries
ton_{cb}	ton coffee beans

TR for different coffee products

Within the coffee supply chain from farm to dry mill, input products range from coffee cherries to (dry) green coffee, with coffee beans serving as an additional intermediate product for processes such as wet milling or washing. In this example, the TR must be calculated twice:

1. TR for the conversion of coffee cherry to coffee parchment (farm to wet mill)
2. TR for the conversion of coffee parchment to green coffee (wet mill to dry mill)

Forwarding GHG emissions

The following figures (Figure 11, Figure 12, Figure 13) 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 or CPG.

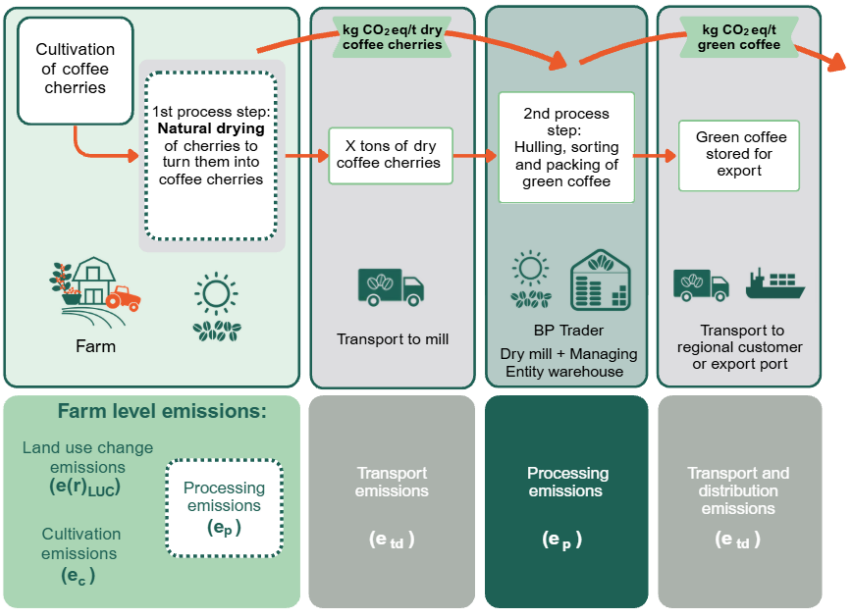


Figure 11: Example of natural coffee - dry processing done on the farm

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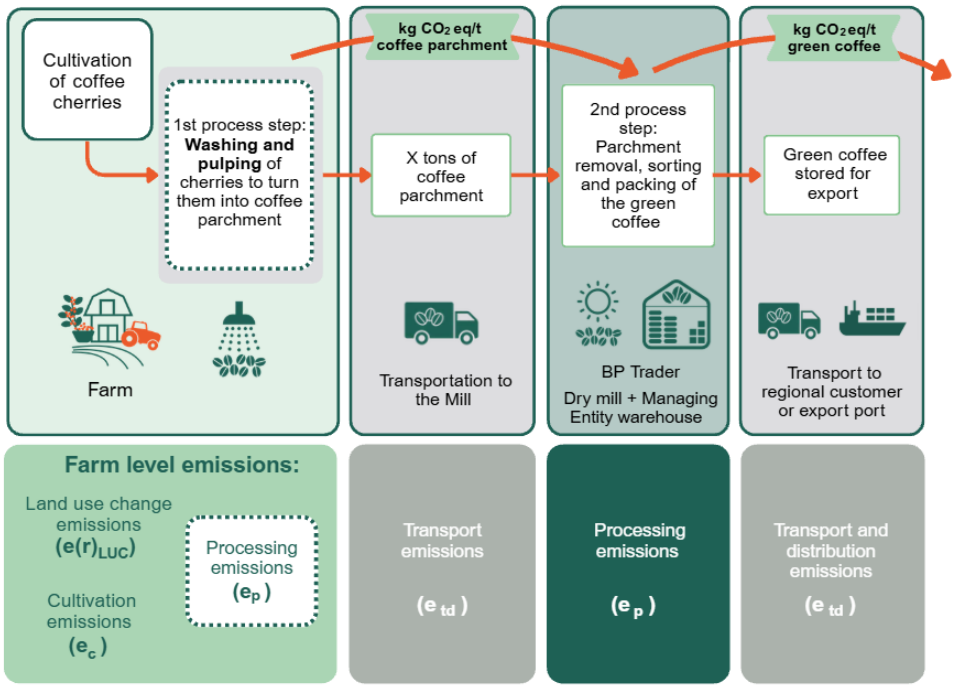


Figure 12: Example of washed coffee - wet processing done on the farm

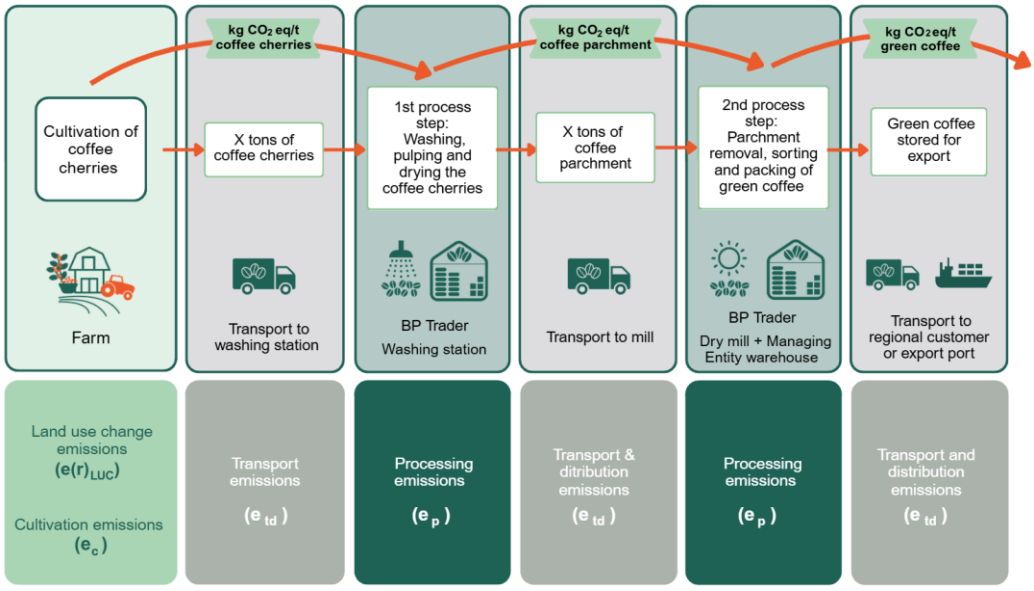


Figure 13: Example of washed coffee - wet processing in central station

Alternative method for forwarding GHG

As an alternative to the TR, a Coffee Conversion Factor (CCF) may be used to consistently convert GHG emissions between distinct coffee processing stages (e.g., from cherries to parchment and then to green beans). A CCF should be sourced from recognised literature or validated empirical datasets by the company and must be up to date as possible, traceable, and well documented. When applying a CCF, total emissions associated with the stage of the supply chain step are multiplied by the factor to express emissions in terms of the target functional unit.

Proper application requires alignment of functional units (e.g., kg CO_2eq per kg of coffee cherries converted to kg CO_2eq per kg of green coffee), product specificity (the CCF must correspond to the exact product transition under study, such as cherries to parchment or parchment to green), and finally consistency in input–output

relationships and measurement units. All assumptions (factor origin, data year, geographical relevance, process boundary, moisture basis) should be documented and disclosed for audit purposes.

General coffee conversion factor (CCF)

The following formula demonstrates how the CCF is applied when a wet mill receives the GHG emission value of cultivated coffee cherries as the incoming product for its processing activities. In addition to this, the same steps as for TR need to be followed when different coffee products form part of the system boundaries.

$$e_{cb}[(kg\ CO_2eq)/(ton_{cb}] = e_{cc}\left[\frac{kg\ CO_2eq}{ton_{cc}}\right] * CCF_{beans}\left[\frac{ton_{cc}}{ton_{cb}}\right]$$

Equation 26: Conversion formula for emissions of coffee beans

Where:

e_{cb}	emissions for cultivation of coffee beans,
e_{cc}	emissions for cultivation of coffee cherries,
TR_{beans}	coffee turnover ratio for beans,
ton_{cb}	ton coffee beans,
ton_{cc}	ton coffee cherries,
CCF_{beans}	coffee conversion factor for beans.

2.1.4.5 Further requirements for producers of final coffee products

There are additional requirements to be considered for the coffee producers.

Roaster GHG emissions

If GHG emissions are also calculated for downstream processing activities after the dry mill and international transport, such as warehousing and roasting, the calculation must follow the same rules as for the upstream production process described in previous Section 2.1.4.2 and Section 2.1.4.3.

The formula elements which shall be covered are:

- Emissions from processing e_p
- Emissions from transport and distribution e_{td}

Upstream GHG emissions

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

Roaster downstream emissions

The next entity in the supply chain, such as the roaster receiving green coffee, must account for emissions from international transportation, from the point of export to the facility gate. Each processing unit is responsible for its upstream transport emissions. The roaster, as the final processing unit, may also include downstream transportation, such as local distribution of the finished coffee product to distribution centres or end users. Additionally, the final entity in the supply chain can voluntarily include emissions from downstream warehouses not located at the processing site.

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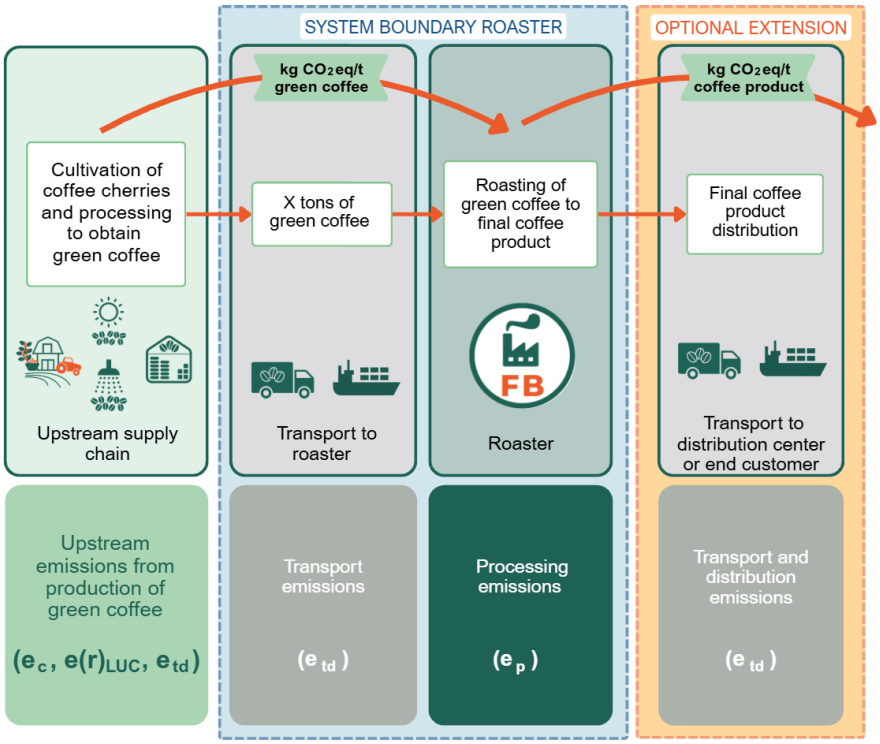


Figure 14: System boundaries for a roaster

The forwarding process should follow the same rules as for all previous supply chain steps described in Section 2.1.4.4 The producer of a final coffee product as well must apply the *TR* to convert the incoming GHG emission value into the respective final unit of the coffee product e.g., roasted coffee beans. Figure 14 gives an overview of the calculation and forwarding activities for roasters as the final unit.

2.2 Carbon Stocks

Methodological approach

The methodology follows the GHG Protocol Land Sector and Removals Guidance (LSRG) and the 2006 IPCC Guidelines for National GHG Inventories, together with the 2019 Refinement, and applies to agroforestry coffee systems. These frameworks are based on a tiered methodological approach, which allows different levels of methodological complexity and data requirements depending on data availability, system characteristics, and the purpose of the assessment.

In accordance with these GHG accounting frameworks, coffee production systems shall clearly distinguish between

- Emissions and removals from LUC
- Carbon removals from biomass and soil
- Reversals of previously accounted removals

As stated previously, the assessment and reporting of carbon removals are voluntary under the 4C CFC. Accordingly, the quantification of SOC and BOC removals is optional. However, where included, they shall be calculated and reported in accordance with this guidance. Accounting guidance is provided in Section 2.3.

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2.2.1 Foundational concepts

LSRG & IPCC frameworks

These subsections establish the core definitions and accounting principles for carbon pools and stock changes under the LSRG and IPCC 2006/2019 frameworks. They provide the basis for applying the tiered methods used to quantify LUC emissions, ongoing removals, and reversals.

2.2.1.1 Tier approaches (IPCC)

Tiered methods (IPCC)

In accordance with the LSRG and the IPCC Guidelines, this methodology follows a tiered approach. The selected Tier depends on data availability, system characteristics, and the purpose of the assessment.

- **Tier 1 methods** use default EFs and simplified assumptions and may be applied where data availability is limited, particularly for screening LUC emissions.
- **Tier 2 and Tier 3 methods** rely on site-specific data, field measurements, or monitoring systems and are encouraged where higher accuracy is required.

For farm-level applications, simplified approaches may be used where appropriate to ensure feasibility. However, higher-tier methods are recommended for estimating carbon stored in plant biomass and soil where direct measurements or robust site-specific data are available.

As a foundational step, CS in AGB, BGB and soil must be defined and quantified, as all LUC emissions, removals, and reversals are derived from changes in these stocks.

2.2.1.2 Definition of carbon pools

Carbon pools

Carbon stored in plant biomass constitutes a major carbon pool in terrestrial ecosystems and is highly sensitive to LUC and management practices. According to the IPCC, a carbon pool is any reservoir with the capacity to accumulate or release carbon, including biomass, soils, dead organic matter, and the atmosphere. In land use systems such as coffee production, carbon can therefore be held in several distinct components: AGB, BGB, Dead Organic Matter (DOM), and Soil Organic Carbon (SOC). Each of these pools responds differently to management, disturbance, and LUC.

Carbon pools in coffee systems

In coffee systems, most carbon is held in AGB and BGB. DOM biomass is typically small and highly variable. Because IPCC Tier 1 methods treat DOM in non-forest land uses as negligible, and higher-tier quantification would require system-specific litterfall and decay data not consistently available across regions, DOM is excluded from carbon stock quantification in this methodology. SOC refers to carbon stored in soils as organic matter, humified material, and stable compounds such as charcoal. SOC is generally assessed for the top 30 cm of soil, consistent with IPCC default methodologies. Further details on how these components are assessed are provided in the following sections.

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A detailed categorisation of the different carbon pools is depicted in Table 2:

Table 2: Description of the different carbon pools

Carbon pools breakdown

Carbon Pools	Description
AGB	Aboveground biomass of trees and vegetation above soil, including branches, bark, and foliage
BGB	Belowground biomass of live roots (excluding fine roots <2 mm)
DOM	Dead Organic Matter, including litter (fallen leaves, small branches, and plant debris) and deadwood (larger fallen branches and tree trunks). DOM composed of litter and deadwood is unlikely to represent a significant carbon pool in agroforestry systems and will therefore be excluded from the quantification.
SOC	Carbon stored in soil, including organic matter, humified material, and stable compounds

Coffee trees biomass exclusion

Biomass of coffee trees is excluded from AGB because, while their carbon sequestration potential is recognised, these trees are regularly harvested and replaced, making long-term CS of this component of the agroforestry system uncertain. According to IPCC guidelines, perennial crops with regular harvesting cycles do not contribute to long-term CS (IPCC,2006).

2.2.1.3 Carbon stock changes estimation

Establishing baseline carbon stock

Under the LSRG and IPCC framework, both LUC and carbon removals are quantified as changes in carbon stock over time within defined inventory boundaries. Carbon stock is the amount of carbon held in a pool at a given moment, as defined by the IPCC. It represents the quantity of carbon stored in biomass or soil (e.g., kgC/ha). To ensure consistent tracking, a baseline year shall be established. The carbon stock measured in the baseline year serves as the reference against which future measurements are compared.

Stock-difference method

Quantifying stock change

Consistent with IPCC guidance, carbon stock change shall be calculated using the Stock-Difference Method, particularly where measurable changes in biomass occur or where field-based inventories are available. This method is especially suitable for coffee agroforestry systems, where tree growth, shade management, or biomass removal can significantly influence the AGB and BGB CS.

CS change is calculated as:

$$\Delta CS = \frac{CS_{t2} - CS_{t1}}{t_2 - t_1}$$

Equation 27: Carbon stock change

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Where,

ΔCS	annual carbon stock change in the respective pool, in tonnes of C per hectare
CS_{t1}	carbon stock in the pool at time t_1 in the respective pool, in kg of C per hectare
CS_{t2}	carbon stock in the pool at time t_2 in the respective pool, in kg of C per hectare

> **Note:** Although carbon stock change is calculated using the IPCC Stock Difference Method, for reporting we present the change as ($t_1 - t_2$) (not $t_2 - t_1$). This aligns results with the accounting approach applied in this guidance, ensuring that reported values show positive values as emissions and negative values as removals (carbon sequestration). Further detail is provided in the Accounting Interpretation section.

Carbon stock change estimation

Total change for a land use category equals the sum of changes across relevant carbon pools:

$$\Delta C_{LU_i} = \Delta CS_{AGB} + \Delta CS_{BGB} + \Delta CS_{SOC}$$

Equation 28: Total carbon stock change

Where,

ΔCS_{LU_i}	total annual carbon stock change for land use category (kg C ha^{-1} yr^{-1}),
ΔCS_{AGB}	change in AGB carbon (kg C ha^{-1} yr^{-1}),
ΔCS_{BGB}	change in BGB carbon (kg C ha^{-1} yr^{-1}),
ΔCS_{SOC}	change in SOC (kg C ha^{-1} yr^{-1})

After understanding how changes in CS can be estimated, the next chapter outlines the methods and workflow to estimate CS at a specific point in time.

2.2.1.4 Accounting interpretation

Accounting carbon stock change

For consistency across all accounting methods, CS before land use or management change are referred to as the reference (CS_R) or pre-conversion stock level (equivalent to t_1 in the Stock-Difference Method). Carbon stock after land use or management change is referred to as the actual (CS_A) or post-conversion stock level (equivalent to t_2 when using the Stock-Difference Method).

The accounting classification depends on both the direction of stock change and the cause of that change:

- **Increase in carbon stock ($CS_{post\text{-}conversion} > CS_{pre\text{-}conversion}$):** Accounted as carbon removals, including removals resulting from LUC (e.g., Cropland → Agroforestry or Forest Land).
- **Decrease in carbon stock ($CS_{post\text{-}conversion} < CS_{pre\text{-}conversion}$):** Accounted as emissions, including emissions resulting from LUC (e.g., Forest Land → Cropland).
- **Decrease of previously credited removals:** Accounted as reversals.

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For LUC, the impact is calculated as:

Accounting LUC

$$LUC\ Impact = CS_{pre-conversion} - CS_{post-conversion}$$

Equation 29: Carbon Stock difference from LUC

- If the result is negative: LUC removals
- If the result is positive: LUC emissions

📌 Note: A change in managing practices is not LUC

2.2.2 Carbon stock change due to LUC

Mandatory LUC

The LUC calculation 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.

Reference regarding LUC

This guidance follows IPCC approaches because they provide a clear, well-established, and widely applied scientific approach for quantifying changes in CS in biomass and soils when land use changes. While the GHG Protocol LSRG builds on the IPCC framework, its full implementation can be complex for project and farm level applications. Using IPCC methods ensures that LUC related CS changes are transparent, consistent, and feasible to apply, while remaining aligned with the scientific basis of the LSRG.

Cut-off date to define LUC

LUC is meant as a change from one of the following IPCC land cover categories: forest land, grassland, wetlands, settlements, or other lands, to coffee cultivation. Coffee is classified as a perennial crop[9] under IPCC cropland, both when grown in monocultural plantations and in an agroforestry system with shaded coffee trees. LUC that can occur for coffee is mainly a conversion from Forest Land or Grassland to Cropland. However, the CS changes associated with LUC from any of the five land categories defined by IPCC to coffee cultivation must be accounted for if the conversion occurred after the cut-off date of 1 January 2008[10].

Non-LUC practices

A change in cropland structure, management activities, tillage practices, or manure input practices is not considered as LUC and shall fall rather under improved agricultural practices that can lead to soil CS increase.

The annualised change in CS, expressed in kg CO_2eq per hectare per year, is calculated by comparing CS before and after land-use change. In the below formula, the CS of the actual land use (CS_A) are subtracted from the CS of the reference land use (prior to the LUC) (CS_R), to get the change in CS due to the occurred LUC. The result is annualised over 20 years. To convert the carbon (C) to CO_2eq-emissions, the conversion factor of 3.664 shall be applied.

To calculate LUC the following formula needs to be used:

9 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.

10 Different cut off dates, specifically defined by brand owners or companies willing to apply 4C CFC, may be applied provided that this is clearly communicated to 4C and in B2B and/or B2C communication.

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$$e(r)_{LUC}\left[\frac{kg\ CO_2eq}{ha * yr}\right] = \left(\frac{CS_R\left[\frac{kg\ C}{ha}\right] - CS_A\left[\frac{kg\ C}{ha}\right]}{20\ [yr]} * 3.664\right)$$

Equation 30: LUC calculation

Where:

$e(r)_{LUC}$	annualised land use related change in CS expressed in CO_2eq units per hectare per year.
CS_R	CS per hectare of the reference land use before conversion (including soil and vegetation). The reference land use corresponds to that in January 2008 or 20 years prior to coffee harvest, whichever is more recent.
CS_A	CS per hectare of the actual land use conversion (including soil and vegetation). In cases where the CS accumulate over more than one year, CS_A represents the estimated stock after 20 years or when coffee tree reaches maturity, whichever occurs earlier.
3.664	conversion factor from C to CO_2eq.

Forwarding respective LUC value

If the LUC result represents a release of carbon to the atmosphere, meaning emissions (i.e., a positive value), it shall be allocated to the batch and forwarded to the next supply-chain entity expressed per ton of coffee beans or per ton of coffee cherries, as applicable. If the LUC result represents an increase in CS, meaning removals (i.e., a negative value), it shall be reported separately and not forwarded with the batch. The allocation procedure for positive values is described in Section 2.3 Accounting Framework for Emissions and Removals.

Quantifying CS changes due to LUC

Elements of LUC CS

To apply the LUC formula, CS in reference land use (CS_R) and in the actual land use (CS_A) shall be calculated. The CS are defined by the mass of carbon in the soil and in the vegetation, including DOM, per unit of land subject to conversion:

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

Equation 31: CS assessment for LUC

Where:

$CS_{R/A}$	CS per unit area associated with land use (R: reference or A: actual) measured as mass of carbon per unit area,
C_{veg}	CS in AGB and BGB,
DOM	carbon stock in dead matter,
SOC	carbon stock in soil,
A	converted area (is 1 if whole area is subject to conversion).

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IPCC constitutes the base reference, together with the 2019 Refinement for the calculation of CS changes associated with LUC. The two are complementary and shall be used together. IPCC 2019, in fact, refines only some parts of the 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 LUC and SOC.

Reference to IPCC documents

For LUC assessment, this guidance is mostly based on the IPCC volumes, specifically chapter 2 "Generic methodologies applicable to multiple land use categories" (IPCC, 2019, Vol. 4, Ch. 2) and chapter 5 "Cropland" with some additions from chapter 4 "Forest" (IPCC, 2019, Vol. 4, Ch. 5) (IPCC, 2019, Vol. 4, Ch. 4).

Table 3 shows the main references used in this section to provide relevant information, with the objective of supporting the calculation of CS changes driven by LUC. For a thorough calculation it is highly recommended to follow the procedure described in the relevant sections of the IPCC documents.

Table 3: Reference to IPCC 2006 Guidelines and 2019 Refinement

Element	**General methods** *(Chapter 2)*	**Cropland** *(Chapter 5)*	**Relevant tables**	**Tier choice**
C_{veg}: AGB & BGB	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
DOM	Equation 2.23 [b]	Chapter 5.3.2 [b]	Table 2.2	Figure. 2.2.3
SOC	Equation 2.24 [b] Equation 2.25 [b] Equation 2.26 [b]	6 2.5 [b] Chapter 5.3.3 [b]	Table 2.3 Table 5.10	Figure. 2.4 Figure. 2.5 Figure. 2.6

2.2.2.1 CS in ABG & BGB (C_{veg})

Meaning of Cveg

Cveg represents the carbon stored in living vegetation, including both AGB, such as stems, branches, and leaves, and BGB, such as roots, as mentioned in Section 2.2.3 In LUC accounting, *Cveg* is a core carbon pool defined by the IPCC because conversions from one land use category to another (e.g., forest, grassland, or pasture to cropland for coffee) typically result in significant changes in vegetation biomass.

The IPCC 2006 Guidelines and the 2019 Refinement provide the methodological basis for quantifying biomass CS in different land use categories. IPCC (IPCC, 2019, Vol. 4, Ch. 5) provides additional guidance for Cropland, including perennial systems.

Default parameters for Cveg

Default parameters to support estimation under a Tier 1 approach are given in Table 4.12 (Updated) in chapter 4 of the IPCC (IPCC, 2019, Vol. 4, Ch. 4). 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 IPCC (IPCC, 2019, Vol. 4, Ch. 5).

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2.2.2.2 CS in dead organic matter

DOM considerations

In cropland systems, and typically also in agroforestry systems, DOM stocks are generally very low and not considered a significant carbon pool. This is consistent with the IPCC Tier 1 assumption that DOM pool in non-forest land uses is negligible and that biomass removed during land use conversion is immediately oxidised rather than transferred into deadwood or litter pools.

While some agroforestry systems may accumulate non zero quantities of litter and deadwood, reliable quantification would require Tier 2 or Tier 3 system specific data (e.g., litterfall rates, deadwood turnover, climate dependent decay factors), which are not consistently available across regions. To ensure methodological consistency with IPCC Tier 1 and to avoid introducing high uncertainty, DOM is therefore excluded from carbon stock quantification in this methodology.

2.2.2.3 Carbon stock in soil

Mineral and organic soils

Soil carbon dynamics under LUC focus on variations in SOC that arise from changes in land use, management practices, and underlying soil conditions. These changes are assessed separately for mineral and organic soils. Mineral soils contain relatively low levels of soil organic matter (SOM) and are dominated by mineral particles such as sand, silt, and clay, while organic soils are characterised by substantially higher SOM content. These distinctions are important because SOC dynamics and management responses differ significantly between mineral and organic soils.

The change in SOC stock is calculated as the difference between the SOC associated with the reference land use (before land-use change) and the SOC associated with the actual land use (after land-use change). This corresponds to the Tier 1 method presented in Equation 2.25 of IPCC Chapter 2, which forms the basis for estimating SOC changes in mineral soils (IPCC, 2019, Vol. 4, Ch. 2).

SOC elements

SOC consists of four factors, which depend on climate, soil type, management practice, and C-input practice: the standard SOC in the 0-30 cm topsoil layer (SOC), the land use factor (FLU), the management factor (FMG) and the input factor (Fi), as specified in the formula below:

$$SOC_{R/A} = (SOC * F_{LU} * F_{MG} * F_I) * A$$

Equation 32: SOC calculation

Where:

$SOC_{R/A}$	soil organic C stock, associated with land use (R: reference or A: actual), measured as mass of carbon
SOC	soil organic C stock for mineral soil in the reference or actual 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).

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📌 Note: The whole area should have common biophysical conditions.

IPCC default values for SOC

Reference and actual soil organic C stocks ($SOC_{R/A}$) 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 CS values for mineral soils, to be used in Tier 1(IPCC, 2019, Vol. 4, Ch. 2). 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 (IPCC, 2019, Vol. 4, Ch. 5).

IPCC Tiers for SOC

Tier 2 is an extension of the Tier 1 approach that allows to incorporate country-specific data and to better specifies 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 or Tier 3 methods) of IPCC chapter 2 for additional details on Tier 3 methods.

Methodology choice

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.

2.2.3 Carbon removals

Definition of carbon removal

Carbon removals occur when carbon is taken from the atmosphere and stored in long-lasting carbon pools within the farm system. In this inventory, removals are only accounted for when CS increase relative to the baseline year. Carbon stored in coffee trees themselves is not included in the accounting.

Practices

Most removals arise when agroforestry systems are introduced or strengthened. Agroforestry, understood as a land management approach in which woody perennials such as trees or shrubs are intentionally combined with crops and/or livestock in a spatial or temporal arrangement that creates ecological and socio-economic interactions (FAO, 2026) . In coffee systems, this means cultivating coffee alongside additional local species, usually woody perennials that provide multiple benefits, including shade, microclimate regulation, soil and water conservation, biodiversity enhancement, reduced climate and market risks, and diversified income through fruit, timber, or other products. As these trees grow, they increase the AGB and BGB CS, and these gains are accounted as carbon removals.

Other removals

Removals may also occur through increases in SOC when improved management practices enhance soil carbon inputs or reduce losses. Practices such as mulching, residue retention, the use of organic amendments, or reduced soil disturbance can raise SOC levels over time. When a measurable SOC increase is observed relative to the baseline, the associated change is accounted for as a carbon removal.

2.2.3.1 AGB accounting

Assessment elements of AGB

AGB is estimated primarily through direct field measurements of tree parameters such as diameter at breast height (DBH) and, where applicable, tree height (H). These measurements are then applied to allometric equations (AE), which are mathematical models derived from empirical data that relate tree dimensions to biomass.

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2.2.3.1.1 Stratification and plot definition

Stratification options

To improve accuracy and cost-effectiveness, the project area may be divided into strata (relatively homogeneous units) based on variables such as agroforestry system type, tree species composition, tree age, or biomass density. Table 4 provides insight into variables that can be considered for stratification of the agroforestry system. If stratification brings minimal benefits, direct sampling without stratification can be applied.

Table 4: Examples of pre-stratification variables for coffee agroforestry systems

Variables of stratification

Variable	Basis for stratification	Recommendations
Agroforestry configuration type	• Simple shade • Multistrata • Fruit/timber coffee combinations	• Estimating each area to the corresponding configuration strata. • If more than one system coexists, the dominant system should determine the strata.
Tree species composition	• Based on predominant species	• In mixed-species systems, the dominant species determined by basal area, canopy cover, or number of individuals should define the stratum. • Where no clear dominance exists, creating multiple strata is recommended.
Tree age	• Based on predominant tree age if there is a clear difference	• When clear differences exist (e.g., newly planted trees vs. mature systems), separate strata should be created for each group.
Biomass volume or tree density	• Based on volume or density of biomass	• Areas with contrasting shade tree density or overall biomass should be stratified accordingly. This helps reflect differences in CS capacity and improves estimation accuracy.

Note The purpose of stratification should be to partition natural variation in non-homogeneous systems to reduce monitoring costs and should reflect actual variability in field conditions and management practices. If stratification leads to no or minimal benefits in terms of costs, then it should not be undertaken, and instead direct plots can be used to estimate trees' AGB.

Tree size and variability

Once strata are defined, sampling plots are established. Plot size and number depend on tree size and variability, an example of how the numbers of plots can be calculated can be seen in Table 5.

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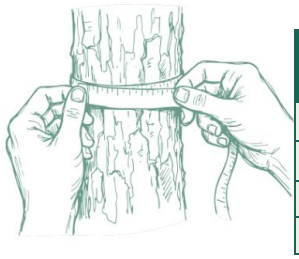


Table 5: Example of plots size definition based on to the stem diameter

Stem diameter (DBH, cm)	Square plot (m)
< 5	2 * 2
5–20	7 * 7
21–50	25 * 25
> 50	35 * 35

Plots allocation

Plots can be located randomly or systematically (e.g., along transects), but their coordinates must be recorded (e.g., GPS) for future monitoring. An example of selection of plots within the area is depicted in Figure 15. GIS tools can be used to lay out systematic transect lines across the project area-for example, every 100 meters. A random selection of transects can then be made, and sampling points marked at fixed intervals (e.g., every 50 meters) along each selected line. At these points, circular or rectangular plots (e.g., 20 m * 25 m) can be established for tree measurement.

This spatially structured design improves representativeness and efficiency, (especially in heterogeneous coffee landscapes). GIS can also be used to export GPS coordinates for field teams and track data collection.

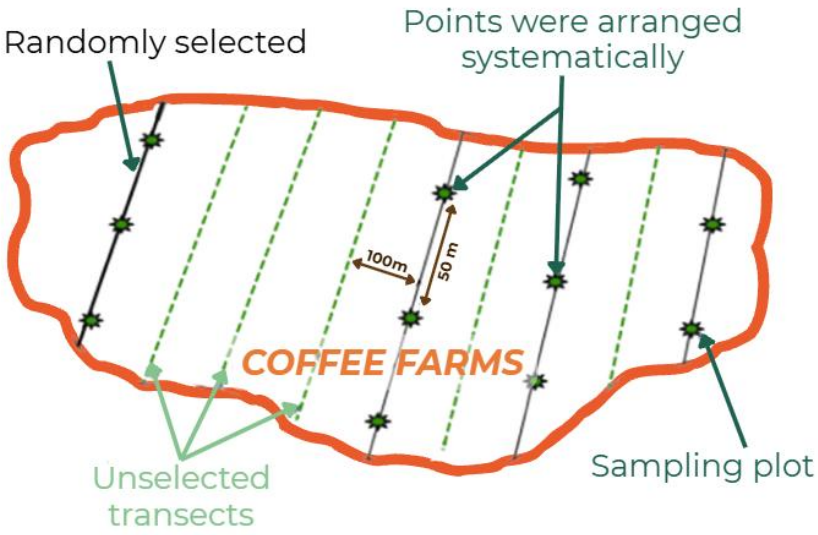


Figure 15: Example of sampling design

2.2.3.1.2 Raw data collection

Tree measurement elements

Accurate measurement of DBH and tree height (H) is essential for estimating AGB and CS in coffee agroforestry systems. In addition, recording tree status, regeneration, species composition, and health provide a complete view of the system.

DBH assessment

Tree diameter classes

DBH is typically measured at 1.3 meters above the ground using a DBH tape. For trees with irregular trunks or those growing on slopes, follow the indications depicted in Figure 16. DBH is a key parameter for estimating AGB and is independent of tree height.

Trees are typically categorised into three DBH classes for measurement:

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- Large/Mature Trees: DBH > 30 cm
- Medium Trees: DBH between 10-30 cm
- Young/Regenerating Trees: DBH < 10 cm

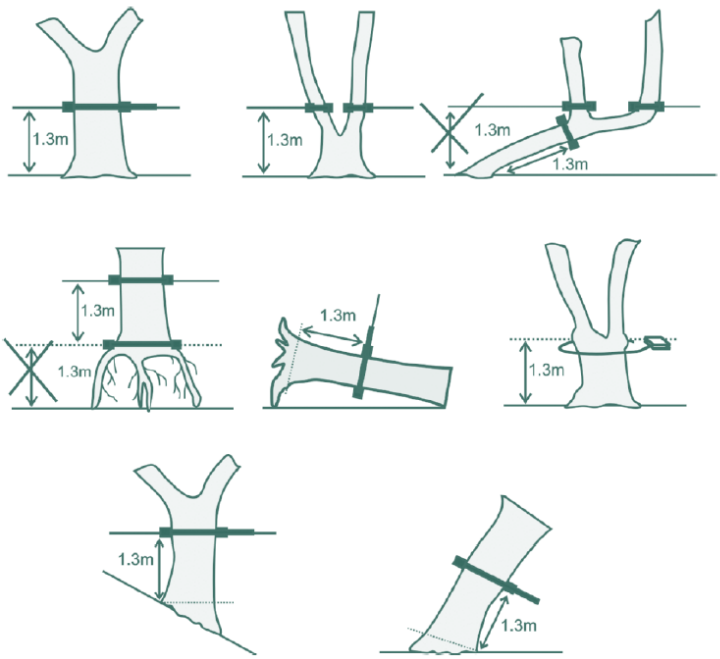


Figure 16: Measuring DBH for trees of different shapes and forms[11]

Tree height (H)

Tree height measurement

Tree height is measured using a clinometer together with a measuring tape.

Steps to determine tree height:

a) Stand at a known distance from the tree (e.g., 15–25 m) where both base and crown are visible.

b) Take an angle reading to the top of the tree with the clinometer at eye level.

c) Take a second reading to the base of the tree.

d) Combine these readings with the measured distance to calculate the height above eye level.

e) Add your eye height to get the total tree height.

Example

Example: Tree height measurement

Standing 20 m from a tree, the angle to the top is 40° and to the base is –5°. Height above eye level = 18.52 m. Adding an eye height of 1.6 m gives a total height of 20.12 m.

During fieldwork, also record tree status, regeneration, species composition, and health indicators (e.g., crown damage, standing/fallen).

[11] Source of figure (Ravindranath & Ostwald, 2008).

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2.2.3.1.3 Estimating AGB using AE

AE for AGB

The collected data is used in the respective AE derived from literature to estimate the biomass of trees. The AE allow to estimate the AGB in kg of biomass per tree.

Biomass estimation

These equations are developed through extensive field measurements and statistical analysis, where data on tree attributes and corresponding measurements are collected from various trees of different species, ages, and conditions. A range of species-specific and generic biomass estimation equations are available in published works and databases[12]. AE can be found across diverse literature sources and should be selected carefully to ensure they are robust and appropriate for the regional conditions, forest structure, and species composition of the assessment area.

Default AE

Alternatively, an illustrative example in Table 6 using the allometric model developed by Chave et al. (2014), which provides a generalised equation for estimating AGB of tropical trees based on tree diameter, tree height, and wood density:

$$AGB = 0.0673 * (\rho * D^2 * H)^{0.976}$$

Equation 33: AGB estimation

Where:

ρ	wood density,
D	DBH in cm,
H	tree height in m

Step-by-step AGB estimation

AGB process estimation

- Choose the appropriate species specific or generic AE from literature. The selected equation must match the ecological zone, forest type, and available field measurements (e.g., DBH only, DBH and height, or DBH/height/wood density).
- Optional integration of remote sensing data to complement and validate field observations.
- Optional: Integrate remote sensing data to validate field data.
- Apply AE: Insert the measured DBH (and height/wood density where applicable) into the selected equation to calculate AGB per tree (kg/tree).
- Carbon conversion: AGB is converted to carbon using the IPCC default carbon fraction of 0.5, which assumes that dry biomass is 50% carbon
- Scale up: Multiply by tree density (number of trees) to estimate per-plot, per-hectare, and project-level CS. This provides AGB and carbon estimates at the scale required for reporting and monitoring.
- Uncertainty shall be quantified based on sampling error, model error, and measurement error, and incorporated into confidence interval calculations.

12 E.g., GlobalAllomeTree

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Example: Process of AGB estimation

Example

To illustrate the application of AE, using as example the AE from Moist Forest Equation from Chave et al. (2014). AE estimate biomass per individual tree, therefore the output is expressed in kg/tree:

$$AGB = 0.0673 * (\rho * D^2 * H)^{0.976}$$

Using a representative tree with:

- Wood density (ρ) = 0.60 g cm^{-3}
- Diameter at breast height (D) = 15 cm
- Total height (H) = 12 m

The estimated AGB is:

$$AGB = 0.0673 * (0.60 * 15^2 * 12)^{0.976}$$

$$AGB = 0.0673 * (1620)^{0.976}$$

$$AGB = 90.9\ kg/tree$$

If 30 trees per hectare occur in this DBH class, the per tree biomass is scaled up to a per area value. Multiplying kg/tree by trees/ha results in kg/ha:

$$90.9 \frac{kg}{tree} * 30\ \frac{trees}{ha} = 2.727 \text{ kg biomass /ha}$$

Applying the IPCC (2006) default carbon fraction of 0.5, the corresponding CS is:

$$2.727 \frac{kg\ biomass}{ha} * 0.5 = 1.363 \text{ kg biomass /ha}$$ [13]

This process is repeated for all DBH classes to obtain total plot or hectare-level biomass and CS.

2.2.3.2 BGB accounting

BGB Estimation

BGB can be estimated as a proportion of the AGB estimated previously (kg biomass/tree). Directly measuring BGB is generally not feasible due to the complexity and high costs associated with the methods.

Root to shoot ratio for BGB

Default and global BGB factors

a) Generic root-to-shoot ratios

A general root to shoot ratio can be used where no species or region specific information is available:

$$BGB = 0.26 * AGB$$

Equation 34: Root to shoot ratio for BGB

This IPCC ratio is commonly applied in global biomass studies where local ecological data are limited.

b) Geography-Specific Root-to-Shoot Ratios (IPCC, 2006)

13 In this example, units remain kgC/ha because the calculation is applied to hectare-level biomass

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For more contextual accuracy, IPCC guidance and literature (e.g., Mokany et al., 2006) provide root-to-shoot ratios tailored by forest type and geographic conditions (Table 6):

Table 6: Ratio of BGB to ABG [14]

Geography	Condition	BGB = Ratio * AGB
Tropical/Sub-Tropical Moist Forest/ Plantation	AGB > 62.5 t C/ha	0.235 *AGB
	AGB ≤ 62.5 t C/ha	0.205* AGB
Tropical/Sub-Tropical Dry Forest/ Plantation	AGB > 20 t C/ha	0.275 * AGB
	AGB ≤ 20 t C/ha	0.563 * AGB

2.2.3.3 Carbon removals from agroforestry biomass

BOC removals quantification

To quantify carbon removals from agroforestry systems, tree biomass must be estimated and converted into carbon and CO_2eq following IPCC guidelines. The carbon stored in AGB and BGB is referred to as Biomass Organic Carbon (BOC). As BOC covers atmospheric CO_2 taken up and stored in tree biomass, it is accounted for as carbon removal from BOC (r_{BOC}), which provides the basis for calculating biomass CS and net removals compared to the baseline.

BOC assessment guidance

The steps below describe the calculation pathway from biomass estimation to comparison with baseline measurements.

Step-by-step r_{BOC} estimation

- **Step 1: Estimate AGB**

  Calculate AGB for each tree (kg/tree) using the species-specific AE provided in the previous section.

- **Step 2: Estimate BGB**

  Apply the appropriate root to shoot ratio from Table 6 to estimate BGB (kg/tree).

- **Step 3: Calculate total biomass**

  Total Biomass (kg/tree) = AGB + BGB

- **Step 4: Convert biomass to carbon**

  Carbon (kg/tree) = Total Biomass * 0.5[15]

  This carbon represents BOC and is used to derive r_{BOC}, consistent with the definition provided in the introduction to this section

- **Step 5: Convert carbon to CO_2 equivalent**

  Express carbon in kg C/ha, then convert to CO_2eq using the molecular weight ratio:

  CO_2 (hg/ha) = C (kg/ha) * 3.664

- **Step 6: Compare with baseline to quantify removals**

14 Source of table: Mokany, K.et al., 2006
15 Using the IPCC default carbon fraction of 0.5

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Net carbon removals are determined by comparing the biomass carbon stock measured in the reporting monitoring year (CS_R) with the biomass carbon stock measured in the baseline or previous assessment year (CS_A). The difference represents the net change in BOC (ΔBOC) over the monitoring interval.

$$\text{Net Removals} = CS_R - CS_A$$

Equation 35: Net Carbon Removals

- To report annualised removals, the total change is divided by the length of the monitoring interval:

$$\text{Annual Removals} = \frac{CS_R - CS_A}{i}$$

Equation 36: Annual removals calculation

Where:

CS_R	Carbon stock in the reporting (current) monitoring year (kg C/ha or t C/ha
CS_A	Carbon stock in the baseline or previous monitoring year (kg C/ha or t C/ha
i	Number of years in the monitoring interval (typically 3–5 years)

About the monitoring interval

The monitoring interval (i) represents the number of years between two successive biomass carbon assessments. Conceptually, CS_A corresponds to CS_{t-1}, while CS_R corresponds to CS_t, but the notation CS_{t-1} is used only to explain the temporal sequence of monitoring events, not in the calculation formulas.

Disturbances consideration

This comparison ensures that reported removals reflect actual sequestration relative to the defined baseline, in line with IPCC and Verra AFOLU guidance.

Example: Calculating removals after biomass conversion to CO_2

Example

- Baseline measurement (Year 0):
  CS_{t1} = 20 t C/ha
- Converted to CO_2:
  CO_{2t1} = 20 * 3.664 = 73.28 t CO_2/ha
- Second measurement (Year 5):
  CS_{t2} = 28 t C/ha
- Converted to CO_2:
  CO_{2t2} = 28 * 3.664 = 102.59 t CO_2/ha
- Removals over the period:
  $\Delta CO_2 = CO_{2t2} - CO_{2t1}$ = 102.59 – 73.28 = 29.31 t CO_2/ha
- Annualised removals:
  29.31 ÷ 5 = 5.86 t CO_2/ha per year

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Monitoring and claiming removals

Monitoring frequency

Monitoring shall be repeated every three years. No carbon removals are claimed during the first 3 years after project implementation, as trees require time to establish measurable increases in biomass. Beginning at the third monitoring event (post year 3), annualised removals can be claimed if CS have increased relative to the baseline.

Disturbance and loss accounting

Registering biomass change

Any biomass loss occurring between monitoring events such as from cutting, burning, storms, pests, or disease is inherently captured through the field-measured carbon stock at monitoring year t. Losses are quantified using the stock-difference approach by comparing measured CS between consecutive monitoring events.

If the measured carbon stock at time t (CS_t) is lower than the stock at the previous monitoring event (CS_{t-1}), this decrease represents a loss of previously stored carbon. In such cases:

- If $CS_t < CS_{t-1}$, net carbon removals for the monitoring period may be reduced to zero or become negative.
- No removals may be claimed for carbon that has been lost.
- Decreases in CS shall be transparently reported as carbon stock losses (i.e. resulting emissions), consistent with the stock-difference method.

This approach ensures that all disturbances and reversals are automatically reflected through repeated carbon stock measurements, without the need for separate disturbance-specific calculations.

2.2.3.4 Carbon removals from SOC (r_{soc})

Understanding r_{soc}

Improved agricultural management in coffee systems can lead to measurable increases in SOC, contributing to soil carbon accumulation, finally resulting in carbon removals.

This chapter provides guidance to account for removals due to soil carbon accumulation. The r_{soc} element refers to the increase in soil CS which might occur due to improved agricultural management, such as:

- Improved cropping systems including cover crops, intercropping especially with perennials, agroforestry, and a combination with nitrogen-fixing crops.
- Improved crop residue management (e.g., leaves and pruning residues left on the field).
- Improved fertilizers or manure management (e.g., use of organic fertilizers).
- Use of soil improvers (e.g., compost, manure fermentation digestates, biochar).

2.2.3.4.1 Equation for r_{soc}

r_{soc} assessment

Removals from r_{soc} shall be calculated as follows:

$$r_{soc}\left[\frac{kg\ CO_2eq}{ha * year}\right] = \frac{CS_R\left[\frac{kg\ C}{ha}\right] - CS_A\left[\frac{kg\ C}{ha}\right]}{yn\ [yr]} * 3.664$$

Equation 37: SOC removals calculation

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Where:

r_{soc}	annualised change in soil carbon stock due to improved agricultural management practices,
CS_R	carbon stock associated with the reference crop management practice (i.e. before applying improved management)
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

2.2.3.4.2 Methodological requirements

The following methodological elements apply to r_{soc} calculations:

IPCC considerations

- **IPCC Framework (conceptual basis only).** CS change associated with Improved agricultural management practices, shall be addressed under the IPCC "cropland remaining cropland" only accounting for changes in SOC[16], Hence, reference and actual CS (CS_R and CS_A) are expressed as reference and actual SOC respectively. *Bases of the methodology*
- The use of Tier 3 is mandatory under the LSRG guidance when estimating soil carbon dynamics. Tier 3 provides the highest level of detail compared to Tier 1 and Tier 2, incorporating site-specific data and models to account for soil conditions and management practices, ensuring the most accurate results. *Tier approach*
- While soil models are recognised in the broader literature, this guidance does not apply modelling due to complexity, calibration needs, and data demands. r_{soc} calculations are therefore based solely on field measurements (supported by LSRG and IPCC concepts). *Soil models*

General requirements for claiming r_{soc}

General provisions shall be considered for either option applied:

- Removals from improved agricultural management must be taken into account if evidence is provided that the above-mentioned practices were adopted after January 2008. *Eligibility and implementation*
- Solid and verifiable evidence for each individual farm which claims r_{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 scheme may reject practices without clear long-term SOC benefit. *SOC Improvement*
- The actual values for r_{soc} shall be calculated at individual farm level or agroforestry area level. In case of non-homogenous soil, climate or management practice(s), SOC values shall be estimated for each single field the farm owns or rents, and r_{soc} shall be calculated at farm level. This can result in different r_{soc} values per farm. *Level of SOC calculation*

16 In case specific improved agricultural practices imply huge changes in AGB and BGB, the inclusion of this component might be considered and discussed with 4C

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- 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 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. *GHG impact of inputs*
- The improved agricultural management practices shall be applied continuously for at least three years successively if the BP Producer would like to account for r_{soc}. This means that it is not allowed to switch management practices every year when r_{soc} is claimed. *Continuous practice requirement*
- When the r_{soc} improved agricultural management has been applied for three years continuously, the r_{soc}, should be calculated and can be claimed. Such r_{soc} value will be valid until a new measurement (i.e., a new r_{soc} value) is available. *SOC claim validation*
- In agroforestry systems where trees and crops occupy the same land area within the same year, r_{soc} shall be allocated proportionally to the agroforestry components contributing to the SOC change. *Agroforestry allocation rule*
- Averaging of emission values from farms applying $r_{soc}$and farmers not applying r_{soc} is not allowed, and only those farmers who apply r_{soc} measures are allowed to forward respective values together with the batch of sustainable material, i.e., green coffee. *Emissions considerations*
- r_{soc} shall be monitored and verified before the improved agriculture management starts. In absence of that, changes in SOC (and their magnitude) cannot be detected. *Baseline SOC*
- For field measurements, the first measurement defines SOC_R; SOC_A is measured periodically thereafter to confirm changes. Measurements shall occur at intervals not exceeding five years and follow the same sampling points and field conditions as SOC_R. *SOC monitoring*
- 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. *Carbon permanence*

2.2.3.4.3 Farm-level accounting requirements

Field measurements of the SOC content shall include the following steps and both sampling and lab analysis shall follow internationally recognised methodologies[17]:

Sampling design and sampling procedure

17 e.g., in Europe sampling based on LUCAS approach and laboratory measurements according to DIN-norms

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About sampling

- 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 approach.
  - Farmers may use SOC values from the SC-Unit for fields located within the unit, provided that the same r_{soc} measure is implemented in all sample pool fields.

Sampling density

- At least 1-3 grab samples of 15 well distributed sub samples per five hectares or per SC-Unit, whichever 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.

Sampling timing

- Sampling shall be carried out 2 months before or after fertilization and harvesting and only in fields that have already started production.
- Direct measurements of SOC changes in the first 30 cm of the soil.
- The points of the initial sampling to measure SOC_R under identical field conditions (especially soil moisture) shall be used.

Consistent sampling points

- Sampling protocol shall be documented in a sampling report including identification of the farms, geo-coordinates, timing, sample coding system used and related details.

Laboratory analysis of SOC

Conditions of samples

- Soil samples must be dried, sieved, and if necessary, ground.
- In case the combustion method is used, inorganic carbon shall be excluded.

Determination of dry bulk density

Considerations

- Changes of bulk density over time shall be considered.
- Bulk density should be measured using the tapping method, i.e., by mechanically tapping a cylinder into the soil, which greatly reduces the error associated with bulk density measurement.
- 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.
- Samples should be oven-dried prior to weighing.

Measurement frequency and updates

Sampling frequency

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

Management updates

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

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SOC increase curve

New measurements

A measurement-based SOC increase curve could be developed to show SOC increase starting from r_{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.

2.2.4 Permanence of carbon removals

Long-term carbon storage

Permanence refers to the extent to which carbon removals are maintained over a long period of time. It is ensured through the continued maintenance of CS via the sustained application of the land-based practice over the defined activity period (e.g., continuous implementation of SOC practices or long-term maintenance of trees or perennial vegetation). The activity period represents the timeframe during which the practice is actively applied and monitored to deliver and maintain carbon benefits. Its length depends on the production system and management context, but it must cover the full duration over which carbon removals are claimed. Under this approach, permanence is addressed through ongoing monitoring of CS. CS are re-measured at each monitoring event, and any decreases are reflected as a loss of previously claimed removals. Therefore, permanence does not require a separate calculation; it is ensured through continuous practice implementation and repeated stock measurements over time.

2.2.5 Reversals

Carbon losses

A reversal occurs when previously claimed carbon removals are partially or fully lost. This can happen due to land use change, changes in agricultural management practices, stopping improved SOC practices, or disturbances such as storms, pests, fire, harvesting, or clearing. Decreases in CS must be considered as reversals and reported as GHG emissions. The occurrence of any reversal or reversal risk shall be communicated to 4C, which will provide further guidance on calculating the respective emissions using the stock-difference method.

2.3 Accounting framework for emissions and removals

Reporting structure

This chapter describes how all previously quantified GHG components are classified and reported under the 4C CFC. All methodological steps (activity data, EFs, biomass carbon, SOC, and LUC calculations) are presented in earlier chapters.

The purpose here is to define the reporting logic, how each result is interpreted, how it is assigned to the correct category, and how it is handled within the product CF level.

Reporting principles

According to established good practices for GHG reporting:

- Each GHG component must be reported individually.
- Components must not be combined or netted during reporting.
- Emission values are reported in CO_2 equivalent per ton or per kilogram of green coffee, while removal values are reported per ton of CO_2 removed.
- Emission values are forwarded with the batch of coffee because they represent GHG releases attributable to producing and moving that specific volume of coffee and therefore form part of the product level footprint.

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- Removal values are not forwarded, as removals represent increases in ecosystem CS rather than emissions embedded in the product.

Results classification

For all land-based components, results are determined by comparing the reference carbon stock (CS_R) with the actual carbon stock (CS_A) measured after the land use or management change.

A simple rule applies:

- $CS_A > CS_R$ = carbon removals
- $CS_A < CS_R$ = emissions
- $CS_A < CS_R$ after removals were claimed= reversal

The classification outcomes are shown in the Table 7 below:

Table 7: Accounting approach

Component	Basis of assessment	Direction of stock change (CS_A vs CS_R)	Accounting outcome	Forwarded with batch
Cultivation Emissions (e_c)	Activity data *EF	n/a	Positive Emissions	Yes
Processing Emissions (e_p)	Activity data *EF	n/a	Positive Emissions	Yes
Transport/ Distribution Emissions (e_{td})	Activity data *EF	n/a	Positive Emissions	Yes
LUC Emissions	CS_R vs CS_A	$CS_A < CS_R$	LUC Positive Emissions	Yes
LUC Removals	CS_R vs CS_A	$CS_A > CS_R$	LUC Negative Removals	No
BOC (AGB +BGB) Removals	CS_R vs CS_A	$CS_A > CS_R$	BOC Negative Removals	No
SOC Emissions	CS_R vs CS_A	$CS_A < CS_R$	SOC Positive Emissions	Yes
SOC Removals	CS_R vs CS_A	$CS_A > CS_R$	SOC Negative Removals	No
Reversals	CS_R vs CS_A (after removals were credited)	$CS_A < CS_R$	Positive Emissions from reversals	No

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Reporting integrity rules

Accounting rules and principles

To preserve methodological consistency across all lifecycle stages, this framework applies a set of integrity rules that govern the treatment of emissions, removals, and LUC outcomes. These rules ensure that accounting remains transparent, traceable, and fully aligned with the system boundaries defined in this chapter. All data reported under this framework must adhere to the following principles:

Sign convention

- In this reporting framework, all emissions are expressed as positive values (>0), while all removals are expressed as negative values (<0) to ensure consistent interpretation of CS changes across components.

No cross mixing

- Do not embed removals or reversals into cultivation *(e_c)*, processing *(e_p)*, or transport/distribution *(e_{td})* emissions; these remain strictly positive emission categories.

> 📌 Exception: If LUC is positive (emissions), it must be allocated to the batch and forwarded to the next entity in the respective unit. If LUC is negative (removals), it must be reported separately (in tCO2 removed) and not forwarded.

Traceability

- Maintain separate ledgers for GHG emissions, GHG removals, LUC results, and reversals to avoid double counting and to preserve system boundary clarity.

3 Improvement plan to reduce GHG emissions

Setting up improvements

Following the calculation and accounting of GHG emissions along the supply chain, a logical subsequent step is the systematic reduction of these emissions. CPGs or 4C Units that do not aim only to measure their emissions, but also to reduce them over a defined period and based on clear targets, should develop an Improvement Plan as the next step. This improvement plan (IP_CF) serves as a structured monitoring tool that supports planning reliability, transparency and traceability of the defined reduction objectives. In addition, the IP_CF is a mandatory prerequisite for achieving Claim Level 2 (see Chapter 5).

Purpose of the IP_CF

Consequently, an IP_CF is required only for entities aiming to achieve Claim Level 2. To meet this requirement, the CPG or 4C Unit must develop an IP_CF that clearly outlines how GHG emissions will be managed and reduced over time. The IP_CF functions as a structured planning and monitoring tool, enabling the systematic maintenance or reduction of emissions relative to the established baseline calculation.

Effect of emission reduction

The baseline GHG calculation for the coffee supply can be used and analysed 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 multiple parts of the supply chain, but should mainly focus on emission reduction or maintenance, considering the lastly mentioned only valid for IB and FB.

Exceptions at reduction

Final reduction or (maintenance for IB/FB) of emissions needs to be presented during Annual Audits as well as at the end of the certification period, reflecting improvement activities from all parts of the certified unit. It is possible that e.g. at farm level there is an increase of emissions due to a measure but a decrease at wet mill level due to

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another measure. As long as the final GHG value for the certified unit is decreased, the certification is valid.

3.1 Elements of the Improvement Plan

Requirements

The objective of the IP_CF is to provide sufficient information regarding the GHG emission reduction and maintenance activities (lastly mentioned only for IB/FB), planned or already implemented, in the coffee supply chain. The timeframe for the implementation of certain measures depends on type and scope and should be documented.

Main aspects

The certification under the CFC claiming the reduction of emissions, requires the completion and update of the Improvement Plan, a separate applicable template is available and named as 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.

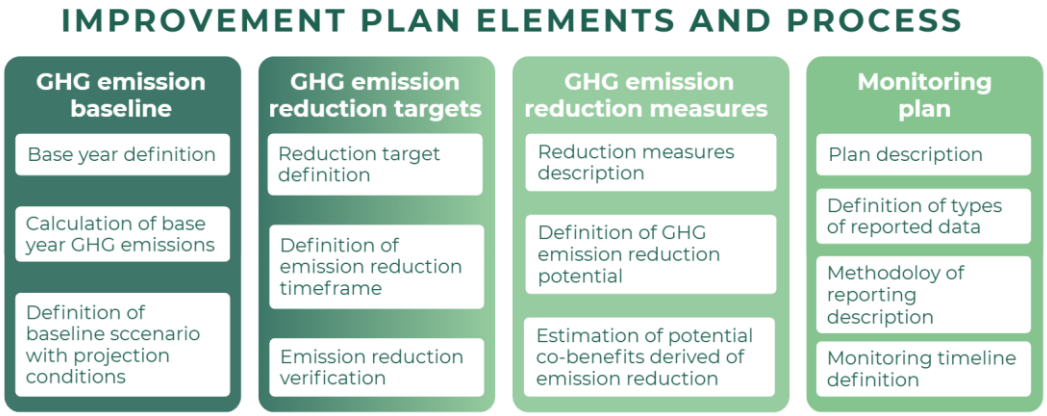


Figure 17: Improvement Plan elements and development process

3.1.1 GHG emission baseline

Baseline checkpoints

The following points should be considered when calculating the GHG emission baseline:

a. **Base year definition:** A specific year to which future GHG emissions are to be compared in order to monitor the emission reductions achieved. The base year shall be the initial year for which GHG emissions were calculated under the 4C CFC. An earlier base year can be accepted if it was set according to the guidelines from the SBTi.

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 or kg green bean equivalent (GBE).

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, EFs and assumptions.

3.1.2 GHG emission reduction targets

Reduction target setting

The IP_CF for the 4C Unit and CPG (including proposed measures and/or report of emission reduction at BP Producers, Coffee producers and processors, and any involved transportation activities managed by third parties or MEs) needs to include at least a total emission reduction target for the whole certification period (meaning the whole validity period of the CF certificate issued), preferable interpreted in a

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specific annual reduction target, based on the calculated GHG emissions of the defined baseline year. This reduction target can be set by the 4C Unit or CPG depending on the baseline scenarios and practical feasibility. The 4C CFC is flexible in terms of reaching an annual reduction target for entities as long as the emissions occurring from green coffee production are reduced in the long term. An increase of the CF at any stage in the production process and during the certification period is not allowed. This is corresponding to the ambition level of the annual linear reduction rate according to the near as well as long-term temperature goal of below 1.5°C.

SBTi agreement

These targets can be set according to any commercial projections or sustainability strategies the company may have, or previous commitments with the SBTi. As the SBTi clearly highlights, reduction requirements vary dependent on sector-specific and commodity specific pathways, the minimum reduction target according to 4C CFC are well adhered to coffee sector as well as practical reductions envisaged based on research and practical experience.

Certification scope

If the IB and/or FB want to be certified or are part of the certification process, the IP_CF that proved the GHG emission reduction becomes also mandatory for them. In some cases, maintenance of emissions for IB and/or FB will be allowed. The IP_CF is therefore a mandatory requirement for all 4C CFC Holders within the supply chain, including the ME, that aim to reduce the overall GHG emissions of the supply chain as part of achieving Claim Level 2. A flexible target can be made as long as the level of emissions is maintained, and feasible measures are applied and monitored regularly. The respective measures have to be documented in the IP_CF for verification during the Annual Audits (AA) of the CFC. Therefore, ME, IB and FB also commit to not increase GHG emissions in the production of a final coffee product. A specified IP_CF must be developed for the FB as following:

Monitoring period

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

b. **Emission reduction verification:** The achieved GHG emission reductions for BP Producers and BP Service Providers and/or transportation of a 4C Unit and CPG, as well as the at least maintenance of the CF of the final coffee product for IB and FB are verified by the CB and validated by 4C during the annual CF audits.

3.1.3 GHG emission reduction measures

Emission reduction activities

c. **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.

d. **GHG emission reduction potential:** Information on emission reductions that could be achieved by implementing the measures. The potential needs to be fully described and included in the report with data sources, EFs and assumptions.

e. **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.

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3.1.4 Monitoring plan

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.

Types of reported data

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 (m3/week), fertilizer consumption (kg/month), etc.

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, how close they are to the real scenario, 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.

Reporting methodology

It is also necessary to include a description on how the emission reduction reporting will be done, including information about the responsible party and data management strategy for data collection. 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.

Monitoring timeline

A clear timeline needs to be presented on the frequency and planned dates for data reporting deadlines. Data reporting can be done at 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 4C CFC.

3.2 GHG emission reduction and carbon removal measures

Emission reduction examples

As part of the IP_CF, information on implemented GHG emission reduction measures should be included. Emission reduction measures can be implemented in any element of the supply chain. Measures focused on soil carbon accumulation in coffee are included in the examples provided in Annex 3. The emission reduction measures can include measures from cultivation, processing, transport, distribution, roasting, and final packaging stages. Some of the measures include but are not limited to, the reduction of fertilizer and pesticides, SOC accumulation, use of renewable energy in processing, use of energy-efficient machinery, logistic management, packaging, etc. Detailed examples of measures are listed in Annex 3.

Methodological Integrity

Beyond listing individual emission reduction measures, it is crucial to understand how these interventions operate across the different stages of the coffee supply chain, as well as the methodological considerations that must be applied when implementing and reporting them. Emission reduction and carbon removal measures can affect multiple operational levels, and as outlined above, they differ substantially in terms of their effectiveness, measurability, and verification requirements. For this reason, transparent documentation, methodological consistency, and full traceability are essential to ensure that all reported reductions are credible, reproducible, and auditable.

Baseline requirements

These requirements must be fully met within the IP_CF. Before establishing the baseline year, preliminary calculations and documentation are needed to pre-assess the potential effectiveness of the proposed emission reduction or removal measures.

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This preparatory step must occur prior to implementation, ensuring that the expected impact is realistic, scientifically grounded, and that the rationale behind each measure has been sufficiently evaluated.

Practical application

The following paragraphs provide an overview of various GHG emission reduction and carbon removal measures in practical terms, highlighting how they can be applied within different stages of the coffee supply chain and what methodological aspects must be taken into account to ensure robust and verifiable reporting.

3.2.1 Cultivation related reduction measures

Cultivation intervention

At the farm level, a broad range of mitigation practices can reduce both direct and indirect GHG emissions. These include measures such as optimising fertilizer application, through reduced use of nitrogen-based fertilizers, applying precision fertilization techniques or incorporating slow-release soil amendments, integrated pest management, and the adoption of agroforestry systems that enhance soil organic CS or increase AGB and BGB. The latter category is classified as a carbon removal measure, as it contributes to the long-term storage of atmospheric carbon within biomass and soils.

Data requirements

When implementing such measures, it is essential to document baseline practices, input quantities, and application frequencies in a transparent and consistent manner. For example, reductions in fertilizer use can only be considered a valid mitigation outcome if they are supported by quantifiable activity data and if the EFs applied reflect both the specific nitrogen compound used and the local soil conditions. Within the IP_CF, these data points are required to calculate, document, and report the estimated mitigation impact of each measure, expressed in kg CO_2eq or in the functional unit of the respective product.

Accounting for removals

Similarly, soil carbon enhancement measures, such as mulching, compost integration, intercropping, or the application of biochar must follow standardised quantification methodologies to ensure the accuracy and comparability of reported removals. In practice, this requires the use of established approaches such as the IPCC Stock Difference Method when assessing changes in SOC over time. Importantly, removals from such interventions must be reported separately from emission reductions or GHG inventories to avoid double counting but should still be listed together with all other implemented measures within the IP_CP in order to provide a comprehensive overview of mitigation actions across the supply chain.

3.2.2 Processing stage mitigation options

Processing improvements

Within the processing stage of the coffee supply chain, both energy and wastewater related interventions can significantly reduce GHG emissions. The integration of renewable energy sources, such as solar dryers, biogas systems, or renewable electricity contracts, as well as the use of energy efficient equipment, including modern pulpers or mechanical dryers with improved combustion performance, can substantially decrease Scope 1 and Scope 2 emissions at the corporate CF level. These measures also have a relevant influence on product level accounting (at the PCF), as reductions in process energy translate directly into lower GHG intensities of the processed coffee product.

Methane reduction

Similarly, the treatment of wastewater through anaerobic digestion systems can effectively reduce methane emissions, which would otherwise occur from uncontrolled anaerobic decomposition in conventional wastewater handling. The implementation of such technologies requires comprehensive documentation, including energy consumption data before and after the intervention, specifications

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on the type and capacity of installed equipment, and performance monitoring records. When biogas is captured and used as a fuel source, any avoided methane emissions must be quantified using established IPCC methodologies. At the same time, combustion emissions resulting from the use of biogas or any other energy carrier, must continue to be reported as positive values, as they represent actual GHG releases to the atmosphere and cannot be netted out through avoided emission accounting.

3.2.3 Transport and logistics-related measures

Transport efficiency

In the transport stage, GHG emissions can be reduced through a range of logistical and technological measures. These include improving transport efficiency, for example by optimising routing as well as switching to lower emission fuels such as biodiesel or even using more energy efficient vehicles. When applying such measures, it is essential that EFs accurately reflect the specific fuel type and the efficiency improvements achieved.

Evidence requirements

Although alternative fuels generally have a lower carbon intensity, they still generate combustion emissions, which must always be reported as positive values within the GHG inventory (see Section 2.1.4.3). Any reduction claims must be supported by verifiable evidence, such as fuel consumption records, transport distance data, or documentation of fuel types used. If different or supplier-specific EFs are applied, these deviations must be transparently justified and applied consistently to ensure methodological integrity. These measures shall also be pre assessed, so that the potential effectiveness of the proposed emission reduction is clear, as in some cases reduction measures related to transport and logistics can require high financial investments by the owning company.

3.2.4 Further action in downstream processing, roasting, and packaging

Downstream mitigation measurement

At the roasting stage, various measures can contribute to reducing GHG emissions, although the range of options is comparatively limited, meaning that reduction or maintenance measures are most commonly implemented. These include switching to, or maintaining the use of renewable energy sources, improving heat recovery systems, and increasing the thermal efficiency of roasting equipment. Packaging related interventions, such as reducing material use, adopting recyclable packaging, or selecting materials with lower embedded emissions, can also support emission reductions, provided that these improvements are substantiated with life cycle data and appropriate supplier documentation. It also becomes evident at this stage that pre assessments are particularly important, as some measures may require financial investments that must be evaluated in advance.

Emission categorization

In addition, it is essential to clearly distinguish between upstream emissions embedded in packaging materials and operational emissions generated during roasting or packaging activities, as these categories are subject to different accounting rules and verification requirements. Ensuring this separation allows for transparent reporting and prevents methodological inconsistencies within the overall GHG inventory.

Reporting integrity

In summary, the implementation and reporting of GHG emission reduction and carbon removal measures require careful methodological planning and thorough documentation in the IP_CF. To ensure that mitigation outcomes are credible, consistent, and verifiable, several key aspects must be considered before a measure is introduced and throughout its implementation, including the application of a

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scientific approach and the calculation of its reduction potential. These considerations help avoid methodological inconsistencies, prevent double counting, and ensure that all reported reductions or removals withstand audit and verification requirements. The following points highlight the most important elements that must be taken into account when designing, implementing, and documenting improvement measures within the 4C CFC framework and the IP_CF:

IP_CF Considerations

a. **Baseline definition:** A clearly defined, consistent baseline is essential for calculating reductions. The baseline must be supported by reduction potential calculation, which estimates roughly the impact of applying the measure and the overall carbon reduction. This calculation must be scientifically based and can be undertaken in a conservative approach.

b. **Activity data quality:** All measures must be backed by quantifiable, verifiable activity data (e.g., fuel logs, fertilizer invoices, electricity bills).

c. **Avoiding double counting with clear reports:** Emissions and removals must remain separate when reported in the GHG inventory and in the IP_CF each measure shall be documented separately. A reduction does not negate the underlying emission source.

d. **Permanence and leakage:** In the case of carbon removal measures, documentation should address stability of sequestration (e.g., soil carbon permanence) and potential leakage effects (e.g., shifting emissions to another location) with scientific methods.

e. **Transparency and audit readiness:** All assumptions, methodologies, and data sources must be documented and made available for verification. This ensures that reductions claimed under the 4C CFC methodology withstand audit scrutiny.

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4 Obtaining the 4C CFC

This chapter explains the 4C CFC certification process, including its main features and the steps required to prepare for audits, obtain certification and maintain the certificate over time. It also clarifies the audit types and the requirements applicable to each type of Certificate applicant.

Overview of the 4C CFC

4.1 About the Applicability

For existing and new 4C Units, the audit and certification process for the 4C core certification as described in the current valid 4C System Regulations serves as the basis for the 4C CFC, with relevant additional information outlined in this chapter that must be followed as well.

Process for 4C Units

For independent CPGs the general procedure in this chapter applies, except whenever specified otherwise.

Process for CPGs

For an existing 4C CoC group the 4C core CoC certification is a prerequisite and the formation of sub-groups is not possible, meaning that all facilities need to be considered as part of the certification.

4C CoC

The auditing and certification procedures described in the following sub-chapters shall be applied for any of the System Boundaries implemented. All System Updates shall also be complied with as a general requirement relevant to the audit and certification process in 4C System.

Scope of application

4.2 4C CFC Certification cycle

The complete certification cycle of the 4C CFC comprises three different parts with specific steps as detailed in the figure below:

Certification steps

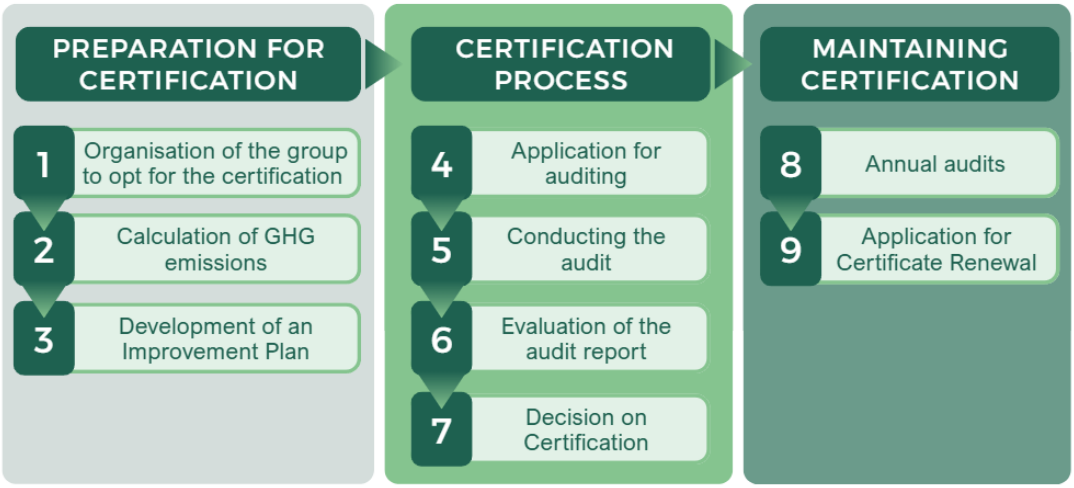


Figure 18: Complete certification cycle of the 4C CFC

A 4C CFC is valid for three years, provided that Annual Audits are successfully carried out and validated, and all 4C CFC requirements are continuously met. The baseline may only be recalculated in cases of significant restructuring taking place before the recertification. See Section 4.2.2.1 for more details.

Audit requirements

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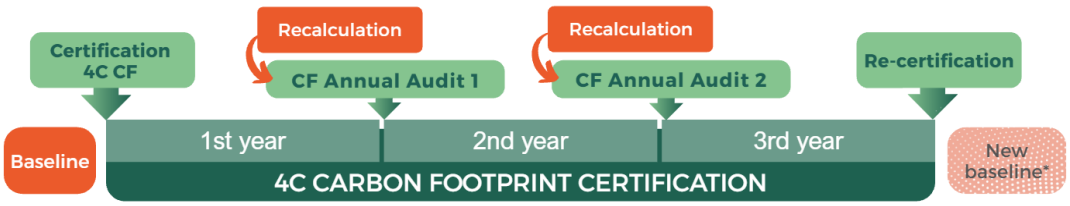


Figure 19: A complete cycle of 4C CF certification

Audit types

There are different possibilities for the conduction of CFC audits by the CB, which can be independent audits or combined with 4C core certification audits (in the case of 4C Units). They are described as follows:

Certification audit

- **CF (re)certification audit:** During the (re)certification audit, all necessary evidence is gathered to verify compliance with the requirements described in this document, as well as any future System Updates that support the CFC decision. The first certification audit is referred to as the "Initial 4C CFC audit" (4C CFC initial audit), while subsequent audits conducted for the purpose of renewing the CFCs are referred to as "recertification audits" (4C CF recertification audit).

Audit combination

- **Combined audits:** For 4C Units, the 4C CFC audits can be combined with the 4C core certification audits, meaning that the CB may conduct both audits simultaneously provided that the requirements for both scopes are fulfilled. For 4C Units holding or applying for the 4C core certification, there are four possible options for the 4C CFC initial certification audit:
  - Combined with the 4C core certification or recertification audit conducted during the harvest season
  - Combined with the 4C core initial certification audit during the off-harvest season, according to the exception rule described in the 4C System Regulations
  - Combined with the 4C core surveillance audit or ASA
  - Conducted independently from 4C audits

> **Note** A 4C CFC cannot be combined with the 4C core addendum audit, as the sampling rules of the two scopes are incompatible. This restriction applies only to 4C Units. For CPGs, no CFC addendum audit is required, as explained in Section 4.3.

Re-certification audits

For 4C Units, the 4C CF recertification audits may be combined with the 4C core certification audits, allowing both certifications to be renewed at the same time. Before applying for recertification, the updated GHG calculation (as described in this document) must be made available. In addition, for those 4C Units or CPGs that target system boundaries 2 and 3, the updated IP_CF, including the description of the reduction measures must be provided.

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Figure 20: 4C CFC audit combined with 4C core certification audit

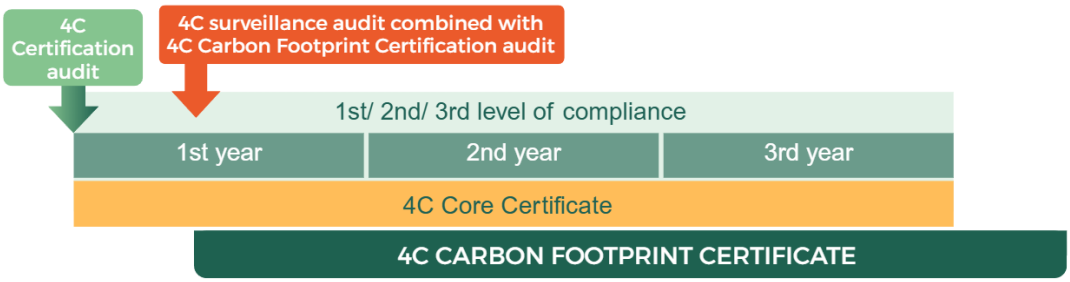


Figure 21: 4C CFC audit combined with 4C core surveillance audit

4C CFC for CoC

For a 4C CoC certification the following three options exist for the 4C CFC initial audit:

- Combined with the 4C CoC core certification or recertification audit
- Combined with the 4C CoC core Annual Surveillance Audit (ASA) (mandatory every year for CoC)
- Conduct independently from 4C CoC core audits

4.2.1 Preparing for certification

Eligibility for 4C CFC

The first step to apply for the 4C CFC is to organise the group that will apply the certification. Any existing 4C Unit (including both coffee production or CoC Unit), CPG, or FB managed by a Certificate Applicant can apply for the 4C CFC.

Certificate Applicant tasks

The following tasks are required from the Certificate Applicant to organise and prepare the 4C Unit or CPG for certification:

- Take responsibility for the 4C Unit or CPG.
- Identify the coffee producers that will join the 4C System as BP Producers, who agree to join the 4C CFC as part of the 4C Unit or CPG and accept the calculations and improvement actions.
- Identify all other elements of the supply chain (BP Service Providers or facilities) that will be handling the coffee cherries and coffee beans originating from the identified BP Producers.
- Obtain the acceptance of participation in the 4C Unit or CPG by all BPs/facilities. A written agreement should be evidenced. The written agreement is required once when a BP/facility is joining the 4C Unit or CPG.
- Fill in and update the BPM.
- Document all records related to the calculation of GHG emissions, as well as the documents used to develop the Improvement Plan for reducing these GHG emissions.
- Contract one of the CBs cooperating with 4C who is approved to perform 4C CFC audits to organise the initial audit and to issue the certificate upon a positive audit result, as well as to undertake Annual Audits as required to maintain the certificate.

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Conditions for 4C CFC CBs and auditors

After organising the 4C Unit or CPG, the Certificate Applicant can apply for a 4C CF audit via a 4C cooperating CB. Only CBs cooperating with 4C and that have been formally approved to conduct CFC audits may perform the respective audits. The list of CBs cooperating with 4C and that are authorised to conduct CFC audits is published on the official 4C website. 4C accredited CBs and their auditors are required to complete the CF training and other related requirements for a CB to perform CFC audits as stated in the current valid 4C Certification Body Regulations, in order to be approved for this scope.

Additional application documents

During the preparation phase of the certification process, it is necessary to calculate the GHG emissions in accordance with the methodology outlined in the previous chapters. In addition to that, users who are interested in applying for the certification under System Boundaries 2 and 3, must develop the corresponding IP_CF before applying for the certification. Users who prefer to begin with the System Boundary 1 may also calculate their emissions under this boundary and prepare an IP_CF to systematically track their emission performance over time.

Exclusive application to coffee

The scope of the 4C CFC document is strictly limited to coffee cultivation and the GHG emissions associated with coffee production, harvesting, and processing. Accordingly, the requirements outlined in this document do not apply to other crops or land uses that may also co-exist on the same farm, as these are addressed separately.

Requirements for audit preparation

Regarding the documentation required for the 4C CFC audit, all records related to the calculation of GHG emissions, as well as the documents used to develop the IP for reducing these GHG emissions, must also be made available. This includes all underlying data, records, reports, scientific articles, procedures and any other supporting documentation described in Chapters 1.2 and 2 of this document. All such materials must be accessible for verification during the audit. This requirement applies to all system boundaries and all actors involved.

4.2.2 Getting certified

4.2.2.1 CFC audit application and audit plan

Application document requirements

For the CFC audit of 4C Units and CPGs, the baseline GHG emissions calculation, conducted according to the methodology described in this document, must be completed and available before submitting the audit application. The same requirement applies to the IP_CF when Level 2 Claim is adopted, as this claim includes emission reduction measures.

Accessible calculator

The GHG emissions calculation document(s) must be submitted as an open, non-protected (e.g., Excel) file. All production steps and formula elements must be separated and clearly displayed. The final GHG emission value and important information on the calculation must be summarised and displayed in an overview sheet within the calculator file. All calculations must be linked directly to respective data cells in the file to ensure full transparency and traceability during the audit.

4C CFC procedure

Exclusively for 4C Units, the procedure and requirements described in the current valid 4C System Regulations must be observed. In this document, however, more detailed rules on how to apply for and plan the 4C CFC audit are described.

For 4C Units and CPGs, the following procedure applies:

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a. The CB shall register an audit application in the 4C Portal, which must then be validated by 4C and then confirmed by the Certificate Applicant. For the initial audit, the CPG or 4C Unit will receive a unique registration number which will be communicated to the Certificate Applicant. The registration number will be included on the CFC certificate at a later stage and remain valid as long as the CPG exists in the 4C System. *Register audit application*

b. The Certificate Applicant needs to complete the application documents and send them to the selected CB. The application documents consist of: *Application documents*

- Updated Business Partner Map (BPM)
- GHG Calculations document(s)
- Improvement Plan (IP_CFC) (only mandatory when applying for Level 2 Claim)
- Document on sampling process and clusters

In case of initial certification, no IP needs to be provided during the application process.

c. The CB must check the application documents concerning the correct versions used and the correct and complete filling out of the documents. The application documents can only be approved when 100% of mandatory required information e.g., Legal name of BPs, national IDs, or (point) geolocation data are provided. After a positive evaluation, the CB approves the application documents and registers the audit application in the 4C Portal. *Documents checked by CB*

d. In steps 2 and 3, both Certificate Applicant and CB must use the automatised pre-check of the BPM (BPM Upload and Analysis Tool) to see if all data was filled in correctly and completely by the Certificate Applicant. This includes but is not limited to the correctness of the format of national IDs and the plausibility of the geolocation data. *BPM Upload tool*

e. The Certificate Applicant needs to accept via the 4C Portal the latest version of the 4C Agreement (if applicable) and the Terms of Use of the 4C Portal (4C ToU). Furthermore, they need to confirm that an application for an audit was indeed requested via the selected CB and confirm the correctness of the data inserted. *Acceptance of ToU in the 4C Portal*

f. 4C validates the audit application in the 4C Portal. *4C Validation*

g. The CB is required to conduct a risk assessment (see Section 4.2.2.2). *Risk*

h. The CB is required to register the audit plan in the 4C Portal, including relevant information on identified risk levels, sample sizes, and audit dates, and upload the required documents: BPM, GHG calculations documents, GRAS risk assessment report(s) (only in case of existing 4C Unit) and sample size determination. If CBs need more relevant information other than the ones supplied in the application documents, they are responsible for contacting the Certificate Applicant and request relevant information. This is to make sure that the CB request will be relevant and realistic in terms of time and resources needed for an adequate audit. *Audit Plan registration*

i. The audit plan must be submitted at least seven (7) calendar days before the audit start date. In that period, 4C will conduct a pre-check of the GHG calculations and in cooperation with CB to request the Certificate Applicant initial corrections where needed. *Audit plan submission period*

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j. 4C checks the audit plan for correct specifications of the audit, e.g., on/off-site, in/out of harvest season, risk levels and sample sizes, and for the correctly provided documents. Upon positive evaluation, 4C approves the audit plan. Starting the audit without approval of the audit plan by 4C is considered an infringement of 4C requirements for the CB.

Audit Plan approval by 4C

All the previously described steps are summarised in the following diagram (Figure 22):

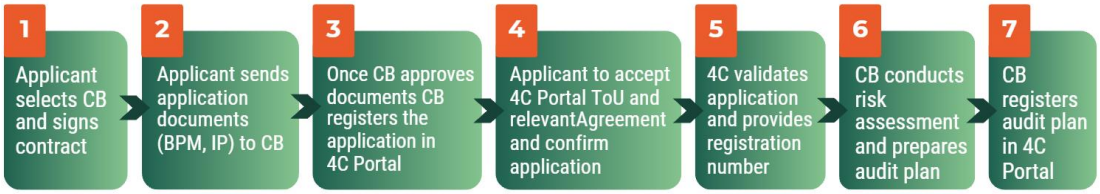


Figure 22: Application process for 4C CFC certification

The CFC audit must be conducted no later than six (6) months after the date of validation of the audit application by 4C. Otherwise, 4C is authorised to annul the process line. In case this occurs and the applicant is still interested in becoming 4C CFC certified, the application process must be started again. Exceptions may only be granted on a case-by-case basis by 4C, provided that adequate evidence can be given in written format by the Certificate Applicant or CB, at least seven (7) calendar days before the due date. 4C holds the rights to evaluate the evidence and grant the exception.

Deadlines for audit conduction

4.2.2.2 Risk assessment

For both 4C Units and CPGs it is important to note that the audit sample differs from the GHG calculation sample. The calculation sample is established by the Certificate Applicant and serves to ensure robust and representative results for calculating the CF of a given 4C Unit or CPG, as explained in Section 2.1.2.1. While in contrast, the purpose of the audit sample identified by the CB is to verify whether BP Producers and BP Service Providers/facilities correctly implement procedures for data collection and data recording, and whether the actions defined in the IP_CF are being properly applied in practice. Requirements of audit sample determination are provided in this chapter.

Audit sample size

The individual steps of the risk assessment and sample size calculation differ for both scopes (coffee production and CoC) in the sense that the risk assessment for coffee production for existing 4C Units involves an additional step, which includes using remote sensing technology to analyse land-use change, biodiversity and carbon stock. For this, the CB must make use of the risk assessment reports that can be generated by the GRAS Tool+ of the Global Risk Assessment Services (GRAS) in the 4C core audit for existing 4C Units.

Difference in risk assessments

Risk assessment for existing 4C Unit

Figure 23 displays the different steps of the procedure to be followed to obtain the two samples for the 4C CFC audit (one sample for BP Producers, one sample for BP Service Providers) of an existing 4C Unit of coffee production.

Risk assessment procedure

In a combined audit, the process starts with identifying the GRAS risk index for each cluster of BP Producers, which determines the minimum risk level for BP Producers. In a separated CFC audit, the CB makes use of the GRAS report and GRAS index of

Combined audit

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the last core audit. Based on the further analysis of specific risk indicators, two final risk levels will be defined, which lead to two minimum sample sizes (one for BP Producers and one for BP Service Providers). These steps are further described in chapter 7 of the current valid version of the 4C System Regulations. Final risk levels that are defined for core audit will be used in the 4C CFC audit to calculate the minimum audit sample size as described Section 4.2.2.3.

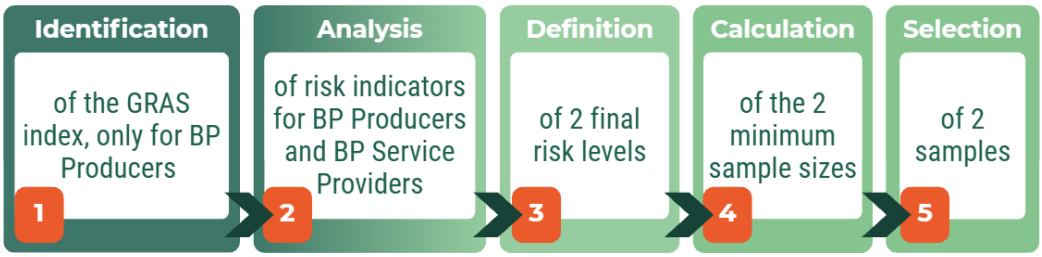


Figure 23: Risk assessment procedure for existing 4C Unit of coffee production

Risk assessment for CPG, 4C CoC Unit, or FB

Assessment for non-4C coffee production

Figure 24 outlines the steps of the risk assessment process for CPG, 4C CoC Unit, or FB, that leads to the sample of BP Producers, BP Service Providers/facilities to be audited. The procedure starts with the analysis of the risk indicators for the BP Producers, BP Service Providers/facilities, leading to the definition of the final risk level for each type of actors, and the minimum sample size to be applied.



Figure 24: Risk assessment procedure for CPG, 4C CoC Unit and FB

Risk indicators

The following risk indicators must always be evaluated for BP Producers and Service Providers and for facilities in CoC in order to determine the final risk levels:

a. **Quality of the Certificate Applicant's Internal Management System (IMS):** Self-assessments of the 4C Unit or CPG on risk/needs, BPM data quality, robustness of training plans and Improvement Plans where applicable, etc.

b. Presence of BPs or of the Certificate Applicant itself in national government ban lists on any of the topics relating coffee production and processing.

c. **History of the 4C CoC Unit or of the CPG:** Past suspended certificates, non-conformities identified in previous audits, indication of possible non-conformities due to public statements or reports/press releases made by the media, watchdog organizations, stakeholders, etc.

d. **Volumes handled by BP Service Providers/facilities of the 4C CoC Unit or CPG:** Analysis of the 4C Unit's commercial and physical coffee flow charts and of the respective volumes handled by each BP Service Provider/facilities.

Risks are typically classified into three levels based on their likelihood and impact across the dimensions of compliance, continuity, and credibility.

- **Low risk level** refers to situations where the chance of occurrence is minimal and the impact is minor, meaning the organization and operation of a 4C CoC

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Unit or CPG is unlikely to experience low disruption or damage. These risks of not complying with CFC requirements are usually well-managed with existing controls and only require periodic monitoring.

- **Medium risk level** describes scenarios where the likelihood or impact is moderate, and there is a possibility that one or more of the CFC requirements-areas (such as on calculating emissions from each source) could be affected if no action is taken. In such cases, controls may exist but are not fully effective, so mitigation measures and closer monitoring are needed to prevent escalation.
- **High risk level** involves a high probability of occurrence and/or severe consequences, potentially causing legal issues, operational disruption, or reputational harm (such as selection of EFs, wrong definition of the system boundary). These risks often indicate weak or missing controls and require immediate attention, escalation to management, and corrective actions to reduce or eliminate the threat.

Risk of not complying with CFC requirements can be but not limited to the following:

a. Completeness and reliability of data (e.g., factors a) and d))
b. Correctness of the system boundary definition (e.g., change of the farmers group organisation relating to factors a), b) and c))
c. Complexity of the group organisation, flows of coffee (e.g., factors a), c) and d))
d. Consistency of the methodology applied, including justification and selection of EFs (e.g., factors a), and c))

The final risk level defined from this step will be used to calculate the minimum audit sample size as detailed in the following Section 4.2.2.3.

4.2.2.3 Sample size calculation and selection

Sample size calculation

Final risk level

After defining the final risk levels of BP Producers and BP Service Providers in the 4C Unit, CPG, or, respectively, the final risk level for the facilities of a CoC Unit/ FB, the minimum sample size must be calculated separately for each, using the factors shown in the table below.

Rounding up

The result of each calculation must be rounded up to the nearest whole number.

Table 8: Factors of the square root to be applied for different risk levels

Risk levels	Factors square root
Low	minimum 0.5 times the square root
Medium	minimum 1.0 times the square root
High	minimum 1.5 times the square root

Certificate applicant in sample

The Certificate Applicant always needs to be audited and therefore is not counted in the sample size defined above.

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Sample selection

Sample composition

The selection of the components of both samples, one for BP Producers and one for BP Service Providers/facilities, is up to the judgement of the auditor, as long as the following conditions are met:

- **For CFC certification audits**, the samples must contain BPs audited from the last audit and BPs who have not been audited yet, both in the sample of BP Producers and in the sample of BP Service Providers/facilities (that requirement is not applicable for 4C CFC initial certification audit). The CB and the auditor must ensure at least one BP Producer to be sampled for each cluster in case there are more than one clusters, and at least one BP Service Provider for each type of BP SP. In addition, the BPs audited in the CFC initial certification audit should be part of the original calculation sample (the sample selected by the Certificate Applicant during the audit preparation step). Therefore, if required, the CB and auditor can increase the sample size to comply with the representative requirement of sample selection mentioned.
- **For CFC annual audits**, the samples must contain BPs who were not audited for BP Producers and for BP Service Providers. It is not mandatory to include the BPs who were already audited during the last audits in the audit sample.

Audit scope for certificate applicant

When auditing the Certificate Applicant, the CB is responsible for verifying whether the calculation methodology has been correctly applied, whether the formulas used are consistent, whether the IP_CF has been properly developed, and whether the Certificate Applicant has an appropriate management plan in place to ensure the effective implementation of the CFC. Specific checkpoints related to the Certificate Applicant apply, and the review of calculations may be conducted remotely.

Increase of minimum sample

Auditors and CBs have the right to increase the sample size of the audit if they observe high risk situations or have difficulties in covering both scopes only by adopting the minimum sample size.

Sample selection for combined audit

For CFC audit combining with 4C Units' core audit, in addition to the procedures and requirements described in the current valid 4C System Regulations regarding risk assessment, sample size calculation and selection, the following specific requirements shall be complied with. The auditor shall select the sample of BP producers and BP Service Providers/facilities in a way that ensures both audit scopes are adequately covered in the final sample. In that case, **the minimum sample size calculated for 4C core certification is the minimum sample size for the combined audit.**

4.2.2.4 Conduction of the audit

4C CFC checklists

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

Levels of claim

4C CFC audit checklists are available for producing groups (4C Units and CPGs) and Chain of Custody Unit or FB who wants to apply for 4C CFC and contain levels of claim in line with the different possibilities to implement the 4C CFC.

4C CFC procedures

The remaining procedures related to the completion of the checklists, their evaluation by the CB 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 CFC.

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4.2.2.5 Audit report evaluation and certification decision

Possible certification decisions

In the case of combined audits for 4C Units, the CFC certification decision is independent from the 4C core certification decision. The following outcomes are possible for existing 4C units applying for 4C CFC:

- **Possibility 1:** Positive 4C core certificate + Positive 4C CFC (Existing 4C Unit): The Certificate Applicant will get two independent certificates.
- **Possibility 2:** Positive 4C core certificate + Negative 4C CFC (Existing 4C Unit): The Certificate Applicant will get only 4C core certificate.
- **Possibility 3:** Negative 4C core certificate + Positive 4C CFC (Existing 4C Unit): The Certificate Applicant will get only 4C CFC certificate.

Decision deadline

The CB has sixty (60) calendar days to make a decision on the 4C CFC. This deadline is counted from the last audit date.

Reassessment by CB and 4C

As to ensure high quality and reliability of calculations and results and that the individual GHG calculations are done correctly by following the described methodology, all GHG calculations must be forwarded to 4C for an additional assessment after verification by the CB/auditor. The CB can only make the certification decision after getting the final confirmation from 4C. The reassessment of 4C is mandatory and is included in the deadline period of sixty (60) calendar days as stated above. Therefore, the Certificate Applicant must make the corrections on GHG calculations required by the CB and the CB is required to inform and share with 4C all related documents up to fifteen (15) calendar days after the last audit date for 4C to have time for the reassessment.

CF certificate validity

The validity of the 4C CF certificate is 3 years. This way, it is not possible to extend or backdate the CF certificate.

4C validation

The validation of the certification documents uploaded by the CB follows the same rule as those stated in the current valid 4C System regulations. This means that 4C internally validates the certification documents uploaded by the CB and might come back to the CB and/or CPG for clarifications in case of doubts within sixty (60) calendar days from the date the CB closes the audit as indicated in the 4C System (via 4C Portal).

Change of responsible CB

The CB who has issued the 4C CFC certificate is responsible for the compliance of the 4C Unit, or CPG with 4C requirements during the validity period of the certificate. In case the CPG or 4C Unit decides to change the CB within the three-year validity period of a certificate e.g. conducting Annual Audits, the Certificate Holder should inform 4C beforehand in written, provided that its decision and justification for a CB change are reasonable and a new certificate would need to be issued by the newly contracted CB after the audit or evaluation has taken place. The new CB is now responsible for the conformity of the 4C Unit's or CPG's compliance with the 4C requirements. The newly contracted CB needs to receive the former audit documents. Therefore, in case of doubt, the newly contracted CB can conduct a surveillance audit to support the CB to come to a positive certification decision and issue a new certificate.

In case of integrity audits

If an integrity assessment is conducted, the CB takes responsibility for any non-conformities identified that should have been already detected by the integrity auditor during the certification or annual audits whichever comes first.

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Change of CB and certificate validity

A change of CB during an audit process (after the audit application and before the certification decision) is not possible. The validity period of the certificate remains the same, despite a new certificate having been issued.

4.2.3 Maintaining the CFC

Mandatory annual audits

After the first year of successfully obtaining the CF certification, the Certificate Holder must undergo a CFC Annual Audit. This means that during the 3-year CF certification cycle, there will be two Annual Audits, where the Certificate Holder will submit an updated set of documents to its contracted CB. These documents include, but are not limited to, the updated BPM_CF, GHG recalculations and IP_CF.

Scope of annual audits

As part of the Annual Audits, the CB then evaluates the Certificate Holder by checking if all documents have been handed in correctly and filled in completely and visiting the 4C Units or CPGs on site to ensure the implementation of and compliance with the 4C CFC requirements. A remote audit is possible provided that the CB can attest compliance with the submitted documents.

4C core ASA

For 4C Units, the CFC Annual Audits can be combined with ASAs of the 4C core certification.

Sample for recalculation

To update the calculations, the Certificate Holder needs to apply the sample requirements to the calculation. That means that the Certificate Holder selects the sample and recalculates the emissions. Half (50%) of the sample for the recalculation shall include BPs that were part of the original calculation, while the other half (50%) shall be composed of new BPs.

Non-combined audits

For 4C Units, in case of an independent CF certification (not coinciding with 4C core certification), for the Annual Audit, an entire 12-month period is required to reflect the data collection and GHG emission recalculation requirements. Therefore, after every 12 months of the certification issuance date, an Annual Audit is required, and it is not needed to coincide with the 4C core ASA deadlines.

Baseline recalculation conditions

For the CFC recertification audit, the baseline will be referred to the one calculated during the initial CFC certification. During any interruption of the 3-year cycle of the CF certification, the baseline of initial certification will still be accounted. This implies that no 4C Units or CPGs are allowed to use more inputs (synthetic fertilizers, pesticides etc.) during the interruption period or conducting any activities to increase the emission and calculate a new baseline based on those inputs. This is to ensure that increasing emissions are no longer allowed.

4.3 Inclusion and exclusion of BPs

Adding new BPs

To add new BP Producers or Service Providers to an existing 4C Unit or CPG certified under the 4C CFC, the Certificate Holder must calculate the carbon footprint of the new BPs before they can be included in the 4C Unit or CPG. In general, it is recommended to add only new BPs that are already actively working to reduce their emissions and are able to demonstrate progress towards the agreed reduction targets.

Contribution of newly added BPs

Newly added BPs play a particularly important role, as their performance directly influences the overall ambition and credibility of the ME carbon-reduction pathway. It is also important to note that the resulting CF_IP must remain cumulative, meaning that new BPs must contribute to, rather than dilute, the Certificate Holder's long-term mitigation goals. Furthermore, 4C reserves the right to request detailed information about any added BPs, including clarification of the sub-group to which they will belong, to ensure full transparency and alignment with the established climate strategy.

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Addition of new BPs

To add new BPs, the Certificate Holder must consider the appropriate moment when they will be included in the BPM_CF. No CFC addendum audits are required for new BPs entering the group. Rather, BPs should only be included during recalculation periods (Annual Audits 1 and 2 or CFC recertification), when the updated documents are submitted and the audits are successfully conducted. For existing 4C Units, for new BPs being added to the 4C core unit as a whole, the conditions and procedure of addendum of 4C core certification, as outlined in the most updated valid 4C System Regulations, still apply.

Removing BPs

When removing BPs from an existing 4C Unit or a CPG, Certificate Holders must consider that, within a CFC 3-year cycle, the baseline cannot be adjusted. During the Annual Audits, progress monitoring will therefore continue as if the removed BPs were still part of the 4C Unit or CPG. This approach ensures methodological consistency and prevents unintended changes in the farmer groups calculated reduction trajectory.

Baseline recalculation

The baseline shall be recalculated during CF recertification in case of significant restructuring, understood as changes are equal to or more than 10% of BP producers, within the 4C Unit or CPG within 3-year cycle, or SPs, or facilities in case of CoC Unit. This means a BP change rate of over 10% for addition and/or exclusion of BPs/facilities. The BP change rate is calculated separately per type of BP/facility and is rounded up to the nearest whole number:

$$BP\ change\ rate\ [\%] = \left[\left(\frac{BP_{included}}{BP_{current}}\right) + \left(\frac{BP_{excluded}}{BP_{previous}}\right)\right] * 100$$

Equation 38: BP change rate calculation

Further information requirement

In all cases, 4C reserves the right to request detailed information about any BPs that were added or removed to ensure transparency and to assess the potential impact of their addition or removal on the unit's overall climate performance. The BPM_CF and 4C CFC certificate will only be valid after the validation/confirmation of the responsible CB and 4C regarding the addition or removal of BPs during the Annual Audit.

Level 2 claim not possible

If a baseline is recalculated during CF recertification, then the 4C Unit or CPG cannot make a level 2 claim for GHG emissions reduction for that CF certificate obtained with a new baseline. Similarly, if the recalculation of emissions in the Annual Audit or Recertification results in higher emissions than the baseline value (including the recalculation of emissions due to the inclusion of new BPs), then the 4C Unit or CPG also cannot make a level 2 claim for GHG emissions reduction.

5 Claims and logo use

Marketing claims

The use of the 4C CFC 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 4C CFC 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 CF certificate amendment substantiated by the respective level of implementation is the prerequisite for the on-product and off-product use of the 4C CFC 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 with respective system boundaries, which can be communicated by Certificate Holders using the term "4C Certified GHG emissions" or similar claims, as long as they clearly indicate the system boundary of the calculation.

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GBE in claims

To ensure consistency and comparability across supply chain actors, product forms, and system boundaries, all emission-related claims shall be reported in Green Bean Equivalent (GBE). The use of a harmonised functional unit enables a standardised interpretation of carbon footprint results throughout the coffee supply chain. This requirement equally applies to the communication of emission reductions against the baseline when making Claim Level 2 claims.

Logo usage by stakeholders

Other 4C users, such as CB and other stakeholders as referred to in Table 9 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 4C Logos and Claims Guideline v1.0 shall also be complied with for the 4C CFC for the existing 4C Units and recertification under core and 4C CFC. The 4C Carbon Footprint Certified logo (Figure 25) holds copyright protection and is a registered trademark.



Figure 25: 4C Carbon Footprint Certification Logo

Claims requirements

General sustainability-related claims that do not directly reference “4C Carbon Footprint Certified’’ 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 to or references “4C Carbon Footprint Certified” or verified GHG emissions with 4C methodology.

Receiving the logo

To obtain approval by 4C and to receive the logo file, interested parties should send a request to 4C via the general 4C contact email 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. This may include, for example, a certification number, or other contextual information relevant to the intended use. 4C is also happy to further support individual requests.

Unauthorised claims

Any direct claim, statement or reference made to the terms “4C Carbon Footprint Certified Coffee” that is not in line with the respective rules outlined in this chapter will be regarded as “unauthorised”.

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 chapter 10 of the 4C Logos and Claims Guideline v1.0 must be complied with. In addition to the requirements described in the 4C System Regulations, the following table (Table 9) shall be used as a guideline for off-product claims.

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Table 9: Requirements for claims

	Interest group	Requirements on claims
1	CPGs or Managing Entities of 4C Units (Agricultural Production Certificate Holders)	Claim shall refer to the 4C CFC according to the corresponding level of implementation. The MEs or CPGs can trade the coffee with verified GHG emissions. Examples: • Level 1 Claim: *"Based on 4C methodology, the green beans equivalent has X kg CO_2eq / kg GHG emissions"* • Level 2 Claim: *"Based on 4C methodology, the GHG emissions of the green beans equivalent (GBE) have been reduced by X% compared to the baseline."* (optional) and *"with carbon removal of X kg CO_2eq."*
2	Intermediary or Final Buyers (Chain of Custody Certificate Holders)	Claim shall refer to the 4C CFC according to the corresponding system boundary, e.g.: *"The green coffee bean has an emission value of X kg CO_2 eq / kg GBE calculated with 4C methodology."* or *"The emissions of green coffee beans have reduced by X% compared to a baseline year 20XX."*

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3	**Certification Bodies**	Claim shall refer to the cooperation, e.g.: *"4C Carbon Footprint Certification cooperating Certification Body."*
4	**Other stakeholders** (e.g., project-related partner)	Claim shall refer to a partnership or relationship with 4C, e.g.: *"GHG calculation project was conducted together with 4C."*

Logo colours

The Level 1 claims will be maintained with a generic green colour of the 4C CFC logo. Level 2 claims will be designated with an orange colour.

Product claims

Product-level claims should be demonstrated with a clear expression of the system boundary, resulting emissions, and the reduction percentage compared to a specific baseline year. The 4C on-pack seal system allows FB and Licensees to communicate their commitment to sustainable sourcing. 4C Logos and Claims Guideline v1.0 can be referred for on-pack claims.

Disclaimer: Logo use and claims

Disclaimer

4C is committed to align with evolving global sustainability regulations and directives, including the forthcoming EU Empowering Consumers Directive. As such, the logo and claims section of this document will be regularly reviewed and updated if necessary. 4C will ensure that all its system users are informed of any changes in a timely manner. It is strongly recommended to consult with 4C for any logo use and claims.

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Annexes

Annex 1: 4C Terminology 83
Annex 2: Emission Factors 85
Annex 3: GHG reduction and carbon removal measures 86
Annex 4: Examples of text claims and disclaimers 88
Annex 5: 4C Logo colour guide 88

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Annex 1: 4C Terminology

Find below the most commonly used 4C terminology throughout this document. For additional terminology not included in this table, please refer to the 4C Glossary in the 4C document library.

TERM	DEFINITION
4C CoC Unit	An Intermediary Buyer, a Final Buyer, or an entity having facilities that include any type of post-harvest processing activities, storing, or trading 4C coffee that holds a 4C chain of custody certificate.
4C Unit	An entity managed by the ME as a Certificate Holder and subject to 4C certification, bringing together all relevant supply chain actors within the defined certification scope.
Baseline scenario	The projected emissions in the absence of the specified emission reduction measures; it is distinct from the measured inventory for the baseline year.
Baseline year	The reference year or harvest-season period for which the initial GHG inventory is established and against which subsequent emission results are compared.
Business Partner (BP)	Any actor within the 4C Unit or CPG up to the Managing Entity level who has physical contact with coffee cherries, parchments, or coffee beans. Those actors are typically coffee farmers, traders, warehouses, and mills.
BP producer	A farmer or actor recorded in the Business Partner Map (BPM) that owns, leases, or has legal use rights of the fields/plots from which he/she/it grows and sells 4C certified coffee.
BP Service Provider (SP)	A person or company that either handles or that participates in the transformation of coffee cherry, parchment, or green coffee bean at any stage of the supply chain between the BP Producer and the ME. This can be either a BP Trader, BP Storage, or BP Processor.
Certificate applicant	The entity applying for certification and responsible for preparing and submitting the required application documents.
Certificate holder	The entity to which the certificate is issued following a positive certification decision and which is responsible for maintaining compliance throughout the certificate validity period.
Claim level	A category describing the type of verified result communicated under the certification. Claim Level 1 concerns quantified GHG emissions, while Claim Level 2 concerns emission reductions relative to a baseline and requires an Improvement Plan. A system boundary defines the supply-chain activities covered by the assessment, rather than the type of claim.
Coffee cherries	The fruit of the coffee plant containing one or two coffee beans enclosed within outer layers of skin, pulp, mucilage, and parchment. Coffee cherries represent the harvested raw coffee material prior to processing into intermediate products such as parchment coffee or green coffee beans.
Coffee parchment	An intermediate coffee product consisting of coffee beans still enclosed in their parchment layer, before hulling. Parchment as a processing residue

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	refers to the detached layer removed during hulling, not to the intermediate coffee product.
Coffee Producing Group (CPG)	Independent coffee-producing groups that are not certified under the 4C core certification scheme but can apply for the 4C CFC. A CPG refers to a group of coffee producers organised and selling coffee to a local trader, cooperative, or company, managed by a Certificate Holder.
Final Buyer (FB)	The last actor in the supply chain that purchases 4C certified green coffee beans. i.e., an entity that transforms green coffee beans into processed coffee (e.g., roasting, grinding, production of soluble or capsule coffee, decaffeination).
Functional unit	The reference quantity of a coffee product to which all inputs, outputs, greenhouse gas emissions, and carbon removals are related throughout the coffee supply chain. Depending on the assessment scope, the functional unit may be expressed as coffee cherries, parchment coffee, green coffee, green bean equivalent (GBE), or another defined coffee product unit.
Green bean Equivalent (GBE)	The quantity of coffee expressed as an equivalent mass of green, unroasted coffee. Quantities at other processing stages can be converted to this common reference using the applicable coffee turnover ratio (TR) or Coffee Conversion Factor (CCF). For emission-related claims under this certification, the reference unit is one kilogram or one tonne of green coffee equivalent.
Green coffee	Coffee beans obtained after the removal of all outer fruit layers and parchment, but prior to roasting. Green coffee represents the internationally traded coffee commodity and serves as the primary input for roasting and downstream coffee products.
Intermediary Buyer (IB)	Traders, exporters, importers, or any other legal entity which trades 4C certified products, and which is neither the Managing Entity (ME) of the 4C Unit the 4C certified coffee has been purchased from nor the Final Buyer (FB). An IB is not part of a 4C coffee Unit but is operating as a trader outside of the 4C coffee Unit.
Managing Entity (ME)	A legally registered entity, responsible for implementing the 4C System requirements and managing a 4C Unit, as well as monitoring, evaluating, and reporting of the 4C Unit. It's the 4C certificate holder and responsible for trading 4C certified products.
Reporting period	The period covered by the activity data and results of a particular assessment.

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Annex 2: Emission Factors

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

Relevant parts of EFs

EFs describe the relationship between the amount of released GHG emissions and the amount of input material. They are needed in order to calculate the CO2eq emissions related to a specific input material. EFs 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 EF used.

Possible sources

The variability of individual EFs may be large and for some inputs EFs might not be available or just an approximation can be used. EFs can be used as long as they are taken from an officially recognised or credible source that can be verified by the auditor.

The greenhouse gases considered for all GHG calculations shall be CO2, N2O and CH4. For the purposes of calculating CO2 equivalence, those gases shall be valued with their GWPs as follows[18]:

- CO_2 1
- CH_4-Fossil 29.8
- CH_4-non-Fossil 27
- N_2O 273

A detailed list of EFs for reference is available under request.

18 IPCC (2021): The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate. https://www.ipcc.ch/report/ar6/wg3/downloads/report/IPCC_AR6_WGIII_SPM.pdf

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Annex 3: GHG reduction and carbon removal measures

Stage	Measure example	Measure type	
		GHG Reduction	Carbon Removal
CULTIVATION – ON FARM	Fertilizer reduction	X	
	Pesticide reduction	X	
	Reduction of energy consumption	X	
	Soil carbon accumulation via improved agricultural management	X	
	Soil fertility restoration and use of degraded land	X	
	Soil health improvement	X	
	Soil acidity remediation	X	
	Soil erosion reduction	X	
	Methane capture from agricultural activities	X	
	Agroforestry	X	
	Increasing shade/coffee tree density	X	
	Addition of nitrogen fixing plants	X	
	Integrated water management	X	
	Reduction of erosion risk with terracing or pits for retention of organic material	X	
	Methane avoidance from biomass decay	X	
	Methane avoidance through composting	X	
	Methane recovery in wastewater treatment	X	
	Reduced deforestation and forest degradation		X
	Increased SOC content		X
	Reduced post-harvest losses		X
	Agroforestry		X
	Agricultural diversification		X
	Increasing shade/coffee tree density		X
	Soil carbon accumulation via improved agricultural management		X
	Soil fertility restoration and use of degraded land		X
	Soil health improvement		X
	Methane capture using carbon capture or carbon storage practices		X
	Addition of nitrogen fixing plants		X
	Regenerating natural shade canopy		X
	Mulching with pruned biomass or coffee pulp		X
	Deep-rooted perennial cover plants		X
	Transition from open-sun to shaded coffee		X
	Biochar from coffee residues		X
	Natural shade canopy regeneration		X
	Contour hedgerows with perennial shrubs/trees		X
	Establishing biodiversity corridors		X
	Restoration of riparian and buffer zones		X
	Rehabilitation of degraded coffee plots		X
	Conservation tillage / zero tillage		X

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Stage	Measure example	Measure type	
		GHG Reduction	Carbon Removal
PROCESSSING	Fuel switch to less carbon intense fuels (e.g., biofuels)	X	
	Energy efficient water pumps	X	
	Renewable energy production	X	
	Installation of solar water heaters	X	
	Light retrofitting	X	
	Methane avoidance through waste separation	X	
	Methane recovery in wastewater treatment	X	
TRANSPORT AND DISTRIBUTION	Fuel switch from fossil to biofuels	X	
	Transition to electric vehicle use with right mix of renewable energy	X	
	Transportation fleet retrofitting	X	
	Improvements in logistics (e.g., less empty running)	X	
	Effective transport strategies and routes with fewer emissions	X	
	Roasting and final distribution of coffee	X	
	Use of renewable or green electricity or in operations and processing	X	
	Use of innovative or environmentally friendly technologies e.g., economisers	X	
	Sustainable packaging i.e., replacing single use plastic in packages, recyclable or compostable packaging wherever possible etc.	X	

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Annex 4: Examples of text claims and disclaimers

Examples of claims for products containing 100% of segregated 4C Carbon Footprint certified coffee

- *Contains 100% 4C Carbon Footprint Certified Coffee*
- *Made from coffee beans certified according to 4C Carbon Footprint Certification requirements*
- *Made from 4C Carbon Footprint certified coffee beans*
- *This 4C certified coffee reduces carbon emissions by X% compared to baseline year 20XX*

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

- *Contains at least 75% 4C Carbon Footprint certified coffee*
- *30% certified 4C Carbon Footprint coffee*
- *50% 4C Carbon Footprint certified*

Annex 5: 4C Logo colour guide

The 4C logo is available in different digital formats and in RGB, CMYK, positive and negative colour 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.

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)

Black version (100%)



White version (inverse)



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4C Carbon Footprint Certified logo (Level 1 Claim)



a. Dark green (CMYK: 80 29 57 42; RGB: 30 97 85; Hex: #1e6155)
b. Dusty green (CMYK: 42 0 15 47; RGB: 80 135 118; Hex: #508776)
c. Light green (CMYK: 53 0 55 0; RGB: 133 196 143; Hex: #85c48f)
d. Pale green (CMYK: 6 0 4 5; RGB: 226 241 231; Hex: #e2f1e7)

4C Carbon Footprint Certified logo (Level 2 Claim)



a. Orange (CMYK: 0 75 86 0; RGB: 235 90 43; Hex: #eb5a2b)
b. Dusty orange (CMYK: 0 36 47 11; RGB: 227 146 120; Hex: #e39278)
c. Light orange (CMYK: 0 20 26 7; RGB: 237 190 176; Hex: #edbeb0)
d. Pale orange (CMYK: 0 4 5 2; RGB: 250 241 237; Hex: #faf1ed)

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