GCS Scientific Committee

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Foreword

The Global Carbon Standard was originally created in 2023 by two parties working together to create an improved methodology: Carbify, a carbon offsetting program that utilizes blockchain to tokenize carbon and its assets to increase transparency and reliability, and the founding GCS team members.

Since its creation, these two teams have officially formed two separate entities to ensure impartiality and transparency, seek new opportunities and to make the Global Carbon Standard available for public use.

This methodology can be applied to any carbon project, as it represents a more efficient approach to carbon sequestration accounting. Carbon debits are issued only after the carbon has been absorbed. The use of blockchain technology, while optional, enhances the transparency and credibility of the carbon reduction impact. The Global Carbon Standard includes scenarios and definitions referencing Carbify and its blockchain-based carbon offset program, illustrating how blockchain can complement the carbon market.

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ABBREVIATIONS

Abbreviation	**Meaning**
GCS	Global Carbon Standard
CO2	Carbon Dioxide
GCSD	Global Carbon Standard Database
dApp	Decentralized App (for compensating CO2)
GHG	Greenhouse Gasses
GIS	Geographic Information System
GPS	Global Positioning System
GPX	GPS Exchange Format
KML	Keyhole Markup Language
KP	Kyoto Protocol
NFT	Non-Fungible Token
PA	Paris Agreement
SHP	Shapefile
UNFCCC	United Nations Framework Convention on Climate Change

DEFINITIONS

● *Carbon Debits:* Some companies will want to use tokenized Carbon **Debit** tokens, Ex Post sequestration units which only account for the CO_2 that has already been offset. This means that there is no distribution or assignment of carbon in advance. An immutable blockchain ledger, if available, is the most accurate and fair way to calculate and award projects that offset CO_2 emissions. These companies can provide carbon debit tokens in the form of digital tokens that represent the amount of CO_2 that has been reduced or eliminated through offsetting measures based on the GCS systems.

● *Additionality:* Additionality is the concept of evaluating whether a proposed action or activity will bring about an additional positive outcome in comparison to a predetermined reference point, known as the baseline. Would_this additional benefit have happened without the project existing It is a way to determine if a proposed activity is superior to the baseline scenario [1].

● *Baseline Scenario*: A baseline scenario for CO_2 measurements is a reference point or starting point used to measure the amount of CO_2 emissions from a particular source or activity. It's a prediction of the emissions that would occur in the absence of any interventions, such as new technologies, policies, or regulations. The baseline is used as a comparison point to measure the effectiveness of different strategies or projects that are implemented to reduce CO_2 emissions. A baseline condition assessment is necessary for the approval of a project. These assessments and reports of underlying assumptions will be included with accompanying project documents in the GCS registry.

● To understand the carbon emissions of a company, carbon accounting is employed. This involves using various techniques to calculate the amount of carbon dioxide equivalents emitted by a business, it's Carbon footprint. This is weighed against the value of the Carbon offset on a compensatory ratio. The demand for these debits is high due to the importance of reducing carbon emissions for businesses and consumers.

● A *Carbon Offset*, also known as a tokenized asset representing the actual CO_2 already done in the past, is a type of asset for reducing or eliminating greenhouse gas emissions from the atmosphere. Governments, businesses, or individuals can use this token to offset the emissions they produce in other areas. The Carbon Offset is earned through emission reduction projects.

● The *Compliance Market* operates in a way where government regulations require states and industries to follow specific carbon regulations. This approach is known as a top-down approach. In *Voluntary Carbon Markets* [2], organizations and industries can choose to offset their carbon emissions by investing in projects that remove carbon from the atmosphere. This approach is mostly based on grassroots efforts.

● A project's boundaries [3] determine the scopes, limits, and parameters of the project and the geotagged boundaries of the proposed planting site. It defines what is included in the project and sets clear expectations for what is accomplished within the specified time period and budget. Project boundaries also establish the project's objectives, deliverables, and milestones, and outline the roles and responsibilities of all team members involved. This helps to ensure that everyone involved in the project has a clear understanding of what is expected of them and what the project aims to achieve.

DISCLAIMER

Please note that the present document includes the Global Carbon Standard (GCS) and the applicable Methodology. Through this integration, the GCS is meant to be informative and firmly directed to action.

The GCS (Global Carbon Standard) was created to help offset carbon emissions in the Voluntary Market. We do not work in the Compliance Market, so the GCS cannot be used concerning carbon allowances in any other accounting. The Compliance Market is regulated by each individual state, with strict rules and regulations. It serves regional industries, with each state having its own rules and carbon allowances. It is widely recognized that carbon allowances are not achieving the sustainability goals outlined in the Paris Agreement and Kyoto Protocol, even potentially doing more harm to the environment, contrary to their original purpose of combating climate change and reducing greenhouse gas emissions (GHGs).

The Global Carbon Standard (GCS) works in the voluntary market and focuses on the concept of Additionality. This concept shows how a project can reduce carbon dioxide (CO_2) emissions or absorb and sequester GHGs in a responsible and Pro generative way. Therefore, the GCS aims to measure the amount of carbon absorbed or CO_2 fluxes using the method and standard outlined in this document. Along with sustainable principles outlined within, The benefits of the GCS approach align with the consensus of all users and communities that believe that action can be taken on a small scale, even by individuals, to protect the environment by restoring damaged areas, soils, and ecosystems. By participating in these activities, The GCS seeks to contribute to reduction of CO_2 and GHGs emissions, supporting the removal of CO_2 from the atmosphere through carbon sequestration projects, and aligning with both the Paris Agreement and Kyoto Protocol [4] through a community-wide effort to protect the planet's ecosystem and biodiversity.

Reforestation, Food Security, Habitat Restoration, Biodiversity, Education, it's all worth it.

Disclaimer of Warranty: THE READER IS RESPONSIBLE FOR CARRYING OUT THEIR OWN INDEPENDENT RESEARCH ON THE TOPIC CARBON SEQUESTRATION AND GHGS MITIGATION REGARDLESS OF THE INFORMATION CONTAINED IN THE PRESENT GCS. CARBIFY PRESENTS THE INFORMATION HEREIN ON AN "AS IS" BASIS AND MAKES NO REPRESENTATION OR WARRANTY WHATSOEVER RELATING TO THE COMPLETENESS OR ACCURACY OF SUCH INFORMATION. ANY AND ALL ACTIONS DERIVED OUT OF OR IN CONNECTION WITH THIS DOCUMENT ARE ENTIRELY THE RESPONSIBILITY OF THE READER. CARBIFY IS NOT RESPONSIBLE FOR ANY ACTION OR DECISION UNDERTAKEN BASED ON THIS STANDARD AND OUTSIDE THE CARBIFY PROJECTS UNLESS OTHERWISE AGREED IN WRITING.

DEVELOPMENT TEAM

The Carbify team members that have contributed to the development of the current GCS are the following:

Jaap Harmsma
Co-Founder of Carbify, Initiator of the Global Carbon Standard, serial entrepreneur, former CTO of Vulcan Forged and writer. Environmental enthusiast, who wants to make a real change.

Toby Wagenaar
Co-Founder of Carbify, Initiator of the Global Carbon Standard, and former COO of Vulcan Forged..

William ten Zijthof
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Ecologist,-Degree in Environmental Engineering, an expert in stormwater/Watershed and Environmental Safety and Securities Management.

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Ecologist. Graduated in BCs.Environmental Technology & Engineering, Applied Nanotechnology and Sustainability Development researcher, and expert in the field of Health, Safety, Security, and Environment Management.

EXECUTIVE SUMMARY

The GCS has established guidelines that enrollment projects must follow for reporting requirements or issuing Debits. By adhering to these guidelines, projects can accurately measure the amount of CO2 they sequester and report it to GCS consistently. This document is designed to provide cost-effective and clear information on GCS Standards and Methodology.

The Additionality principle is the foundation of the GCS. It refers to any new activities or features that are added to a project to improve its carbon compensation and any pre-existing conditions and activities. These Additional Activities may include tree planting and new agricultural practices that reduce CO_2 emissions. Any activities that increase CO_2 absorption or prevention of release can be considered. Additional Activities may be eligible for CO_2 debits or tokens, as mentioned in the GCS. Examples of Additional Activities include, but are not limited to the following activities:

- The improvement of soil characteristics to enhance CO_2 absorption; such as allowing leaf and woody debris to remain as protective cover for soil, proper non-tilling planting practices, etc.
- The planting of native flora for agroforestry over the pre-existing ground cover to conserve biodiversity and improve CO_2 absorption; or
- The prevention of monoculture to enhance CO_2 absorption, and to benefit the environment.

The Global Carbon Standard science team will calculate the increase or change in CO_2 absorption. The projects with quantifiable and proven additionality that follow the requirements herein set forth may be subject to enrollment. Debits are part of the voluntary market and can be operated, sold, bought or burned within a qualified outlet.

This standard contains specific application methods to collect field data and calculation templates. Continuity is an important variable that contributes to the success of a project. Monitoring and accountability are essential and will be done using GCS development models. It is worth noting that any available remote imagery, usage of GIS data, and other third-party imagery are considered for land mapping, due to advances in technology or industry standards.

One of the aims of the GCS is to provide participants, such as local farmers, indigenous people, and landowners, the opportunity to protect the environment and contribute to

GHG mitigation while tapping into a new source of income that was unavailable to them until now. Showing a more sustainable method of living with their land.

GCS welcomes projects from all over the world and aims to continue the activities past our initial 20-year commitment. To ensure local farmers, indigenous people, and landowners gain knowledge of the GCS, the systems we approve supply a network of farmer unions and farmer cooperatives. In addition, GCS cooperates with other environmental projects and foundations featuring green projects, tree planting, and afforestation, among others.

BACKGROUND INFORMATION

Historical background

The sustainability of our planet is a global concern, often linked to pollution and overuse of natural resources caused by increasing market demands. These issues lead to extreme conditions and biodiversity loss, and the integrity of natural habitats is crucial for maintaining a balanced eco-socio-environmental system and strengthening local ecosystems. Sustainable ecosystems are the foundation of human civilization.

The Paris Agreement and the Kyoto Protocol are two of the most relevant international efforts to tackle the causes and effects of climate change, which have rapidly risen and deteriorated after years of endless exploitation of natural resources. First adopted in 1997, the Kyoto Protocol has established the firm commitment of its signing parties to reduce GHGs emissions. In 2015, the parties to the UNFCCC reached an agreement at COP-21, the Paris Agreement, to further proceed with the appliance of environmental solutions by proposing numerous actions and targets, thus motivating states and industries to reduce GHGs emissions. One of the most notorious resolutions is Article 2 of the Paris Agreement, which aims to limit the current average global temperature to no more than 2 degrees celsius increase from the average global temperatures in the pre-industrial era.

Global Carbon Standard

The Global Carbon Standard team acknowledges that the primary concern for our future generations is our climate. The reduction of waste, reduction of overconsumption and reduction of the impacts of GHG's should be the number one focus. The current model of Carbon Credits has been proven repeatedly to be non-transparent, difficult to track and too easy to abuse via double counting etc. So, we devised this methodology to make it functional. Our Carbon Debit system does not count the carbon until *after* it is sequestered (known as *'ex-post')*. In this way from cradle to grave we can account for the carbon offset and offer a viable alternative to a flawed system. At GCS, we believe in sustainability. Our GCS certified projects will plant trees and help promote eco-friendly, biodiversity focused, and world-healing projects.

Compliance Market vs. Voluntary Market

The carbon market consists of two distinct and separate markets: the Compliance Market and the Voluntary Market. The Compliance Market operates under government regulations, requiring states and industries to adhere to certain carbon emission standards. This often involves the use of quotas and the buying and selling of carbon allowances. The

Voluntary Market, on the other hand, allows organizations and industries to voluntarily offset their carbon emissions through investments in projects that remove carbon from the atmosphere. This is typically represented through carbon compensation units such as carbon credits or offsets. The GCS is specifically designed for the Voluntary Market and aims to introduce a new carbon compensation unit, the CO_2 Debit, that is transparent, accurate, and verifiable. These Debits may also be tokenized using Blockchain technology - we call these tokens 'Carbon Debits'.

Carbon Accounting

Carbon Accounting is the process of measuring how much CO_2 an entity emits or sequesters. In this standard, Carbify has applied a solid methodology (suggested by EPA [6]) enabling us to carry out Carbon Accounting in a relatively simple but conservative manner. Several concepts deeply intertwined with Carbon Accounting must be acknowledged for the interpretation and appliance of the present GCS.

Firstly, carbon is an essential chemical element that forms the base of all life on earth. It is found in all organic materials and living species and in various non-organic forms such as diamonds, limestone, and carbon dioxide (CO_2). Although carbon and CO_2 are often interchangeably used, this is technically incorrect. When carbon is present in organic molecules or biomass, it is often referred to as carbon. When these organic molecules are burnt or decomposed, they react with oxygen to form a molecule named carbon dioxide (CO_2). The mass of one carbon atom is 3.67 times higher when it binds to two oxygen atoms to form CO_2. A tree absorbs CO_2 from the air during photosynthesis, through which CO_2 is turned into biomass containing organic carbon. Once organic carbon is completely stored, the amount of carbon not released into the atmosphere can be quantified by multiplying this amount by 3.67 (a single metric ton of CO_2 equals 3.67 metric tons of carbon). This value is expressed as carbon using CO_2 equivalent.

Carbify has developed a unique model to estimate how much carbon is sequestered by different tree species based on specific factors such as age, height and diameter of trees, and soil characteristics. This model uses a compilation of many different tree species, soil types, and locations to estimate carbon sequestration for species studied in less depth.

This information allows Global Carbon Standard to create and complete its databases.

CARBON STANDARD & METHODOLOGY

1. Introduction

We present our Global Carbon Standard & Methodology aka GCS as a set of standardized scientific methods focusing on accurate carbon accounting and monitoring at minimum cost. The GCS can be applied by small and large projects within their carbon mitigation activities. In the following sections, this document will introduce the reader to the GCS, with a focus on Additionality in reforestation, GHG mitigation through agroforestry projects, biodiversity and food security. To make calculations efficient and effective, Any Debits or potential resulting tokens will be distributed ex-post, or after the CO_2 is absorbed by trees.

The primary GCS methodology for CO_2 absorption calculation considers the tree's above and below-ground biomass dry weight. The GCS calculation method results in very conservative numbers to ensure that CO_2 Debits or tokens are never over representing the actual amount of carbon sequestered; furthermore, this provides a simple yet effective way of reporting, which does not require additional investments from the project owner other than time and the costs of any potential audits.

2. Project Requirements

The Global Carbon Standard methodology uses the Global Warming Potential (GWP) values provided by the latest Intergovernmental Panel on Climate Change (IPCC) report. This ensures we convert various greenhouse gasses (GHGs) into CO2 equivalents accurately and with the latest information.

Under our Global Carbon Standard, projects have a crediting period of 20 years. This duration reflects the time needed for activities like afforestation and reforestation to achieve stable CO2 reductions or removals. Projects can renew this period after reassessing their baseline conditions.

Our approach requires project proponents to evaluate overall uncertainty in emission reductions and removals using an approved method. This involves assessing uncertainties from assumptions, estimation equations, parameters, and measurement methods, ensuring transparent and accurate reporting.

We apply a conservative approach to all quantification methods. By using conservative assumptions and estimates, we ensure the carbon credits issued represent the minimum actual emission reductions or removals, maintaining reliability and preventing over-crediting.

In the Global Carbon Standard, baseline emissions consider existing government policies and legal requirements that might reduce GHG emissions, like carbon taxes, renewable energy standards, and air quality regulations. We also consider the enforceability and grace periods of these policies to ensure a fair and accurate baseline assessment.

Global Carbon Standard accepts and certifies both Project-Based Activities and Programme of Activities (PoA). Below you will find the definition of each.

Project-Based Activities
Definition: Project-based activities are individual, discrete projects that aim to reduce greenhouse gas (GHG) emissions or enhance carbon removals1. Each project is independently designed, implemented, and verified.

Characteristics:

- Specific Goals: Each project has specific, measurable goals and outcomes.
- Independent Verification: Each project undergoes its own verification and validation process to ensure compliance with standards.
- Limited Scope: Projects are usually limited to a specific location, technology, or activity.
- One-Time Registration: Each project must go through the full registration and approval process before implementation.

Programme of Activities (PoA)
Definition: A PoA is a framework that allows for the coordinated implementation of multiple project activities (CPAs) under a single umbrella. It provides a streamlined

approach to registering and managing multiple projects that share common goals and methodologies.

Characteristics:

- Coordinated Implementation: The PoA defines how a policy, measure, or goal leads to emission reductions or removals.
- Multiple CPAs: Once a PoA is registered, an unlimited number of component project activities (CPAs) can be added without undergoing the full project cycle.
- Streamlined Process: The PoA simplifies the registration and approval process for individual CPAs, reducing administrative burden and costs.
- Ongoing Management: The coordinating/managing entity (CME) is responsible for designing, coordinating, and implementing the PoA and its CPAs.

Key Differences

Aspect	Project-Based Activities	Programme of Activities (PoA)
Scope	Limited to one project	Multiple projects under one framework
Verification	Individual verification	Streamlied verification for CPAs
Registration Process	Full registration process	Simplified registration for CPAs
Management	Independent management	Coordinated by a managing entity
Flexibility	Fixed project scope	Flexible addition of CPAs

Project Sectors, Scopes and Geographical Regions

Global carbon standard's agroforestry methodology currently supports projects in the Forestry and Land Use sector. These projects work to prevent deforestation, promote reforestation or enhance forest management with the additional benefit of agroforestry systems and are described as ARR-type (Afforestry, Reforestry and Revegetation) projects.

There are currently no geographic restrictions in place, however each region will be assessed prior to any certification processes begin.

General Eligibility Criteria

Realistic Baseline: Offset credits must be based on a realistic and credible baseline estimation of emissions.

Additionality: Projects must demonstrate that the emission reductions or removals would not have occurred without the offset project.

Permanence: The benefits of the project should be long-lasting, with measures in place to ensure that carbon sequestration is maintained over time.

Leakage: Projects should avoid unintended negative impacts, such as shifting emissions to other areas or sectors.

Verification and Monitoring: Projects must have robust systems for verifying and monitoring GHG reductions or removals.

These criteria help ensure that offset activities contribute to genuine and measurable reductions in GHG emissions, supporting the overall goals of the Global Carbon Standard program.

3. Project damages

As outlined in the Enrollment Agreement, enrolled projects must either plant an additional 10% of each plant species or leave 10% of each plant species un-tokenized as a backup in case any plant damages occur. This will ensure that the debits remain properly linked to real trees and continue to absorb CO_2. If the backup is insufficient to cover the damage, we will agree to work with the project owner in good faith to find a solution. We will be forced to end our contract for those trees however, as the trees are no longer absorbing and/or the backup trees are insufficient to cover loss.

4. Methodology description

Step 1 - Project boundaries

To accurately map a project site, methods such as GPS surveys, drone mapping primarily, and high or medium-resolution satellite imagery may be utilized. GCS have provided project owners descriptions on using smartphones or handheld GPS devices for mapping and some help with necessary measurement tools and guidelines for performing tests, audits, and other related tasks. It is worth noting that all the remote sensing techniques currently are applied only to project mapping, not to biomass estimation which may come later.

Project participants may choose to operate a homogeneous forest plantation (using a single vegetation) with Agroforestry systems surrounding or supporting them, a heterogeneous plantation syntropic Agroforestry System (mixed vegetation), or a combined composting pastoral agroforestry method. They should use the GCS guidelines to consistently map their project sites and indicate which type of project they are enrolling in. If the project involves mixed vegetation or agroforestry, the participants must provide GCS with details such as the number and types of tree species planted or to be planted. For a homogeneous vegetation project, the owner must map the area and provide information on the number of and future disposition of planted trees. GCS typically does not approve projects that involve planting a single type of vegetation (such as orchards and monoculture activities), however, exceptions may be made if the project owner can provide valid justification for why using a homogeneous approach is appropriate and adaptive for the specific location and be open to providing a supportive or syntropic system to share space If the project has not yet begun, the map should show the planned project boundaries.

● To estimate total surface area for each area, either a GPS or a smartphone application can be used (with a provided manual). When calculating the area, use the local projected WGS84 UTM coordinate system and report the result in hectares with at least two digits (e.g., 23.03 ha). More digits are allowed, but not fewer.

● All areas that are mapped should have an official ownership or other long-term rights agreement in place. These agreements should be valid for at least 20 years from the time the Enrollment Agreement is signed.

● Data should be created with a scale of 1:5,000. This is roughly equivalent to a GPS survey for which a waypoint is recorded every 5 (five) meters; and

● Spatial data should be provided in SHP, KML, or GPX format. (manual will be provided).

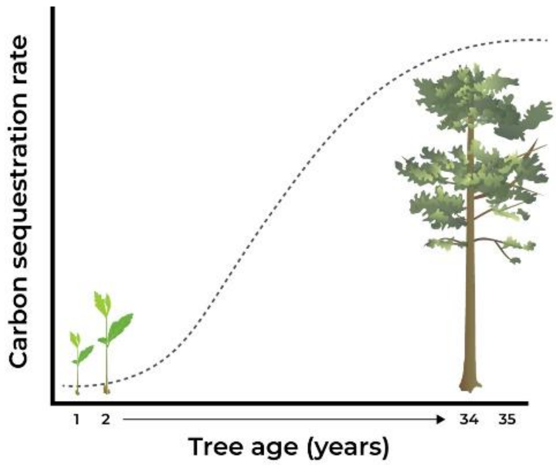
Step 2 - Baseline scenario

The baseline scenario aims to determine the current rate of carbon emission or carbon sequestration, meaning the rate of carbon emission or carbon sequestration before the implementation of any Additional Activities. To do this, we use carbon sequestration rates based on the current vegetation type and age. These rates differ depending on the type of forest or vegetation and agricultural usage. For these estimations, we use carbon emission factors from published literature or local measurements that are in the same region for local conditions or soil. GCS may use historical satellite data, historical data and anecdotal observations from local people to determine the baseline scenario and to ensure the values reported do not overestimate GHG mitigation from any activity.

The baseline for a project can include the current rate of carbon sequestration and the amount of carbon stored in existing vegetation, if tests have been done, including soil samples and lab test results, if available and/or applicable. If the project has already begun before calculating the baseline, the biomass must be estimated using the information and best practices available at the time. **None of the baselines will be considered in accounting other than to show a Zero point for the project start point.**

If a baseline changes after an activity is registered or the activity requests clarification, a program may contact the GCS using established channels of communications to respond or request clarification.

The Global Carbon Standard Database (GCSD)



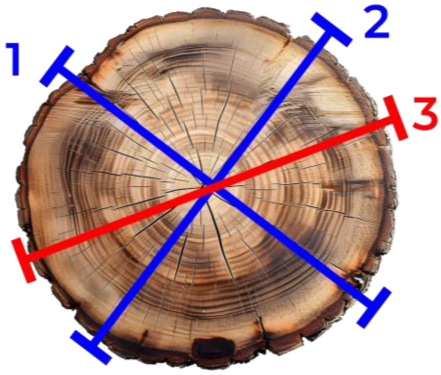
The Carbon Sequestration Factor Database (GCSD) serves as the foundation for GCS' approach, having verified data on many factors, including sequestration curves for specific tree species and forest types, location, planting density, species names, and soil characteristics all within an allometric model based on a 20-year cycle.

The Global Carbon Standard GCSD links the data from models and real-world data to models that can predict the relative rate of carbon sequestration over time for various localities, soil types, and planting densities. This model is based on nonlinear regression techniques and built using data from multiple tree species. The GCSD will provide GCS with sequestration factors for various tree species, forest types, and agroforestry systems, which can vary over time as shown in Figure 1. Therefore, the GCSD database along with the models that consider the age of the tree stand and its corresponding sequestration factor, allows for a standardized, regenerative, cost-effective, and case-specific approach to estimating carbon storage and sequestration.

Error Propagation in Measurements: How We Reduce Uncertainty

Regarding diameter at breast height (DBH), most tree trunks are not completely round, and the measurements are done manually. So we will apply several methods and procedures to provide the most accurate measurement and minimize potential error. In cases of smaller diameter trees, we rely on a standard Vernier caliper measurement, which requires 2 calipers both properly maintained to eliminate systematic error. We will take a total of 3 measurements, including 2 measurements at right angles, and a third using another caliper to get a proper representation of the tree's diameter. This will establish standard deviation, and reduce errors by using the third measurement (Lindberg, 2000 [7]).

Due to the varied terrain and locales, we will primarily rely on a D-tape for tree diameters that exceed the calipers range. A D-tape is a string or flexible tape measure (like a tailor's tape, to measure around the trunk, the D=diameter tape. We will apply the same method of 3 measurements to reduce standard error in calculation. The variance is within proper limits (<0.1cm). [8]

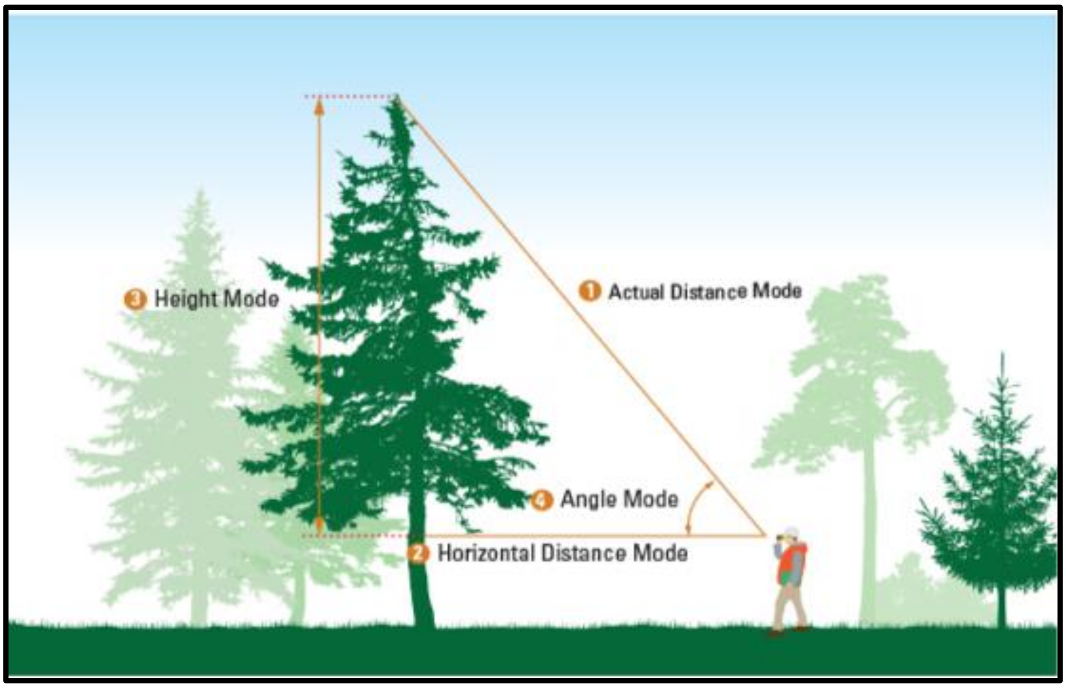


2 notes to DBH measurement at height of 1.3 meters.

a. Slope: ground level is on uphill side of tree

b. Deformity at 1.3m: shift to nearest normal position on tree; if shift is >15cm we will avg 2 series of measures, above and below.

Measurement of tree height: primarily we will use an electronic hypsometer, or laser rangefinder with a clinometer to determine height. Either an ultrasonic hypsometer [9], or laser rangefinder [10] (see figure below), or the combined height systems of both [11], for redundancy and error minimization. (Each manufacturer supplies the range of error, generally to within several decimal points), however we will verify these measurements with a secondary method, tape to measure distance from base, and forestry grade hypsometer.



Where applicable we will also use clinometer [12], relaskop [13], and basic trigonometry [14] to confirm results. We believe all issues of error can be addressed and minimized through a combined process of redundancy, proper training, and using multiple measurements as well as applying multi-method of measurements.

Step 3 - Additionality demonstration

As the core of the GCS, Additionality is the added carbon benefits that result specifically from the project activities. Each project must demonstrate Additionality. Otherwise, the project does not qualify for enrollment. To prove Additionality, projects must show Additional Activities initiated to reduce GHGs by either sequestration or emission reduction. These extra activities include, without limitation, tree planting, improving soil characteristics, enhancing biodiversity through agroforestry methods, and avoiding monoculture for the well-being of the environment, aerobic compost of post-consumer degradable waste among others, to the extent these activities increase the amount of sequestered carbon.

Additionality is required to ensure that the activities increase carbon sequestration or emission reduction compared to the baseline scenario. This increase is what can be used for offsetting. Additionality will be assessed and documented, alongside other requirements, during validation or verification processes conducted by qualified independent entities.

Some illustrative scenarios are provided hereinafter to help the reader understand the concept of Additionality:

Illustrative example:

Oby says that she planted a few trees on her property to capture carbon dioxide from the atmosphere. She hopes to earn CO_2 for this, which can be used for offsetting emissions and generating income. Although planting trees is generally a good idea, it may not always be considered Additional in the context of the Carbify program. The following scenarios illustrate what Additionality means in this context:

- Scenario A. Oby says that the government has implemented a policy that requires her to plant a certain number of trees each year on her property. In this case, all the trees planted according to the mandate are not considered offsetting, because the carbon compensation associated with them is already accounted for by the government. Therefore, such activities would lack additionality, as they are already part of the government's requirements.

- Scenario B. Before planting her trees, Oby cut down a few native fruit trees that were good for the environment. In this case, Oby's trees are not considered Additional because she simply replaced one type of tree with another, without actually increasing the total number of trees on her property.

- Scenario C. Oby owns an old apple orchard with 1,000 trees. She knows her trees capture carbon dioxide from the atmosphere, so she wants to monetize this carbon. She does not do anything different than what she has been doing for the last 10 years. In this case, there is no additional carbon captured in comparison to the baseline.

- Scenario D. Oby's parents owned farmland that was covered in forest 10 years ago. Oby has bought the land and decides to plant fruit trees on it in order to earn GCS Debits and income from her fruits. In this case, Obys activities really increase carbon sequestration and emission reduction, something that would not have happened without her intervention. Therefore, there is Additionality in this case.

- Scenario E. Oby learns that her new land requires soil improvement in order to enhance the carbon sequestration of each tree (at least 25 kg/ha), so she needs to consider the below-ground carbon and soil characteristics. In this case, Oby's activities really increase carbon sequestration and emission reduction, which would not have happened without her intervention. Therefore, it is called Additionality in this case.

- Scenario F. Oby learns that planting hardwood trees between the existing fruit trees increases the health for all vegetation, and will increase the fruit yields. Monoculture trees do not have competition from other trees. By adding other types of trees the overall efficiency, health and success of the fruit bearing trees will significantly increase. Therefore, there is Additionality in this case.

To demonstrate Additionality, projects should provide detailed information about the Additional Activities they are carrying out or planning to carry out. This includes explaining how these activities differ from what has been previously done on the land. Additionally, projects should provide evidence of whether there has been any deforestation on the land in the past five years, using historical satellite imagery.

Step 4 - Project scenario-A

Carbon reduction or emission is estimated after having implemented the project activities (Step 3). For afforestation, reforestation, and agroforestry projects, GCS considers the tree's above-ground and below-ground biomass, and dry weight, also the related soil characteristics in which the Additional Activities are carried out, including any added regrowth or increases in local vegetation. The methodology for the project scenario is like that of the baseline scenario. Project activities need to be converted to carbon sequestration. The future tree densities, age, and the area size of the planned vegetation need to be considered in relation to carbon sequestration. Using the GCSD, these values will be used to initially estimate the annual carbon yield for the next 20 years. If the project has already started, the data can be based on randomly selected sample plots.

Step 4 - Project scenario - B composting

Carbon reduction or emission is estimated after having implemented activities or processes related to Composting, Repurposing, or continued carbon retention, (gaseous or solid). The intention is that once the carbon is captured it continues to remain sequestered.

Step 5 - Leakage

Leakage is when the carbon-reducing activities lead to an increase in carbon emissions elsewhere. For example, Oby owns a farm and grows potatoes on it. He decided to plant trees on half of the land to earn carbon Debits or tokens, while another half was still used for potato farming. After a year, Oby realized that the yield of potatoes decreased because he only used half of the land. As a result, he intensified the farming practices by using extra fertilizers and pesticides to increase the yield, which eventually resulted in higher carbon emissions. This should be accounted for in the carbon-benefit model by deducting the emissions from the benefits achieved from planting trees. Not every project causes leakage, but it is important to consider whether a project may cause any significant leakage and, if it does, to include it in the carbon-benefit model step 6. Projects need to describe the aspects below:

1. Is there any leakage expected?

2. In case there is leakage, what does this constitute, and what is the expected carbon emission from this?

If any of the leakages, as mentioned above [6], occur within our project boundaries, the calculation of that leakage would be taken into account to the carbon benefits.

To mitigate most potential negative leakages, our guidelines require that no unnatural or synthesized fertilizer, herbicide, chemicals, insecticides, or any other additives are used in the projects. This requirement limits the potential negative leakages within the project boundaries to footprints of harvesting or planting machinery (if used), which can be identified and quantified by using available methods,[15]as seen in this standard's related references. In contrast, the nature of our project can promote certain positive leakages to the surrounding areas, such as the natural activities of pollinators that will increase yield, and the use of reserve trees in case of die off or loss, which are paired with repopulation of vegetation to otherwise barren or denuded areas. [16] (see Appendix).

The procedure of estimating leakages and emissions is described in those steps below:

1. Identify sources of leakage from areas near or surrounding our plots. In general there are two main categories of leakage sources:

- Leakage inside the project: we assume that this leakage is from agricultural activities. In most cases, the agriculture leakage within the project boundaries is calculated as below:

$$C_{project\ leakage} = \text{Annual fruit yield [kgfruit/yr]} * C_{average\ leakage}\ [kgCO_2/kgfruit]$$

- Leakage from nearby sources, such as industrial or chemical manufacturing, agricultural practices, environmental runoff, etc. (see Appendixes)

2. Employ appropriate quantification, calculations, and mitigative practices specific to the sources of leakage, regardless of where they occur.

a. GCS makes a commitment to apply established methods that are already in place. Although it is not possible to address all potential sources of leakage in one paper, methods to identify and accurately account for such leakages are readily available.

b. Emissions or leakages can impact the assigned area in various vectors. For instance, if the area is situated at a lower gradient of elevation, we may use methods depending on the location, as scenario examples below:

I. A physical buffer zone is established between the boundaries using natural features or earthworks to redirect leachate from external agricultural runoff away from the plots in the form of mounding or culvert, depending on the situation.

II. A greenspace buffer zone or wetland area is set up to minimize negative fertilizer leachate or eutrophication caused by nutrient intrusion or runoff while simultaneously positive impact to the surrounding area.

c. If leakage or emission intrusion is unavoidable, we will use the appropriate formulas to deal with it by first identifying the sources. Below are some sources that provide the appropriate methods for some of these possible eventualities, including how to identify and common methods of calculation and/or remediation.

In the case of significant negative leakages arising out of the analysis here concerning initial project site assessment, GCS will not be considering those leakages into the calculation of the carbon benefit per the present GCS, as it is considered that any potential leakages are mitigated by either or both of the following:

● The carbon absorbed by the 10% of backup plants that are not calculated or tokenized; and

● The carbon that will be absorbed by the plant is subject to enrollment after the period of 20 years, as this is the term of the contract. Thereafter, the plants will continue absorbing carbon, and such carbon will no longer be counted.

According to Schwarze *et al.*, (2002) [16], to properly identify and quantify leakages, first we should recognise two principal avenues that may cause unintended GHG emissions globally:

○ Activity shifting: the project can displace an activity or alter the nature of such activity outside the project's boundaries. For example, if a plantation project displaces farmers and leads them to clear adjacent forests, it will cause a negative activity-shifting leakage.

○ Market effects: A project can alter supply, demand, and equilibrium price of goods and services, meaning that it increases or decreases the emissions elsewhere. An example of the market-related leakage would be a forest conservation project reduces the local timber supply, thus leading to the unmet demand along with rising prices and pressures on forests elsewhere.

In the case of reforestation projects, Schwarze *et al.* [16] suggested that activity shifting does not necessarily mitigate market leakage as for the conservation projects. Commercial reforestation projects could simultaneously displace baseline agricultural activities into other forest areas (activity-shifting leakage) and depress investments by increasing supply (market leakage). Therefore, it required to make the sum of both leakages in order to quantify the total leakage outside a reforestation project:

$$C_{leakage\ (total)} = (L_{AS} + L_M) * GPB$$

For:

L_{AS}: activity-shifting leakage (%)
L_M: marketing leakage (%)
GPB : gross project benefits (tC or tCO_2)

Step 6 - Carbon definitions and benefit

Our program clearly defines and ensures the underlying attributes of a carbon debit unit through the following measures:

1. **Definition of Carbon Debits**: Each carbon debit represents one metric tonne of CO2 equivalent (CO2e) of greenhouse gas emissions that have been reduced or removed. This definition ensures that all carbon debits issued are based on measurable and verifiable emission reductions.
2. **Verification of Attributes**: All carbon debits are subjected to rigorous validation and verification processes. This includes assessments of the methodologies used for carbon accounting, ensuring they adhere to our established standards and accurately reflect the emissions reductions achieved.
3. **Transparency**: Our program maintains transparency in how carbon debits are calculated, including the methods and data used. This information is readily available to stakeholders and project developers, enhancing trust in the integrity of the carbon debits issued.
4. **Monitoring and Reporting**: Ongoing monitoring and reporting requirements are in place to track the effectiveness of mitigation activities over time. This ensures that the underlying attributes of each carbon debit are continuously upheld throughout the crediting period.
5. **Compliance with Standards**: Our program aligns with recognized carbon standards, which outline the essential attributes that each carbon debit must meet. This compliance further guarantees that the debits issued are credible and reliable.
6. **Addressing Non-Permanence Risks**: We incorporate measures to address non-permanence risks, ensuring that the carbon debits remain valid and that any potential reversals in emissions reductions are accounted for.

Through these mechanisms, our program ensures that the underlying attributes of each carbon debit are well-defined, verified, and maintained, thus promoting the overall integrity of the carbon accounting process.

Carbon benefits are the total amounts of carbon reduced or stored. This is calculated initially using the equation below. Projects will receive the result of the calculation herein in the Enrollment Report issued by Global Carbon Standard after signing the Enrollment Agreement.

Estimation of carbon absorbed/sequestrated:

$$C_B = C_{project} - C_{base} - C_{leak}$$

Where

C_B : carbon benefits
C_{proj}: carbon stock or sequestration rate in the project scenario
C_{base}: carbon stock or sequestration rate in the baseline scenario
C_{leak}: carbon emission caused by leakage

Step 7 - Estimation of CO_2 Debits

The estimation of CO2 debits being issued will be a direct result of the previous Step 6, in which the carbon absorbed/ sequestrated is converted to a base unit over time, considering the change in sequestration rate due to aging vegetation. These numbers are automatically calculated using the GCSD. The unit can then be used for tokenization, where applicable, or certificate.

Our methodology uses the global warming potential (GWP) values published by the Intergovernmental Panel on Climate Change (IPCC) in its most recent assessment report. This ensures accurate and up-to-date conversion of various greenhouse gasses (GHGs) into CO2 equivalent based on their relative impact on global warming.

The crediting period for projects under our Global Carbon Standard is set at **20 years**. This period reflects the estimated time over which carbon sequestration activities, such as afforestation and reforestation, will achieve stable CO2 reductions or removals. Projects may be eligible for renewal of the crediting period after reassessment of their baseline conditions.

Renewal of the crediting period involves a full reassessment of the baseline scenario to verify whether the original conditions and barriers at the start of the project still exist. The project proponent must provide updated data on the key parameters used for calculating emissions reductions and removals, and the baseline must be adjusted to reflect current conditions. All steps are outlined in our project documentation and require thorough review before a new *debiting/*crediting period can be approved.

Our methodology requires that the project proponent assess the overall uncertainty in emissions reductions and removals using an approved methodology. This includes evaluating uncertainties arising from assumptions (e.g., baseline scenario), estimation equations, parameters, and measurement methods. The total uncertainty is calculated as a combination of these factors to ensure transparency and accuracy in reporting.

A conservative approach is applied to all quantification methodologies used in our system. By taking conservative assumptions and estimates into account, we ensure that the carbon debits issued represent the minimum actual emissions reductions or removals. This ensures reliability and avoids over-debiting.

In the Global Carbon Standard, baseline emissions must take into account existing government policies and legal requirements that may lower GHG emissions, such as carbon taxes, renewable energy standards, and air quality regulations. The enforceability and grace periods of such policies are also considered to ensure an accurate and fair baseline assessment.

Step 8 – Verification, Validation and Monitoring

In order to adhere to regulatory guidelines and frameworks, projects undergo Verfication and Validation periods prior to being registered. These processes are conducted by qualified, neutral third-parties called **Verification and Validation Bodies** (VVBs).. These are independent organizations responsible for assessing and ensuring the credibility and accuracy of carbon offset projects.

Verification involves confirming that the project's reported emission reductions or removals are accurate and comply with established standards. This typically includes onsite inspections, data analysis, and documentation review.

Validation occurs before the project starts, verifying that the project design, methodology, and projected outcomes meet the necessary criteria and standards for generating carbon credits.

In essence, VVBs act as a third-party watchdog, ensuring that carbon offset projects are legitimate, measurable, and truly beneficial for the environment. Their work is critical for maintaining trust and integrity within the carbon market. VVBs play a crucial role in ensuring the integrity and credibility of carbon offset projects.

Below is an overview of their importance and responsibilities:

Importance of VVBs

Ensuring Accuracy: VVBs verify the accuracy of the data and methodologies used in carbon offset projects. This ensures that the reported emission reductions or removals are genuine and reliable.

Maintaining Standards: They ensure that projects adhere to established standards and methodologies, which are essential for generating credible carbon debits.

Building Trust: By providing independent verification, VVBs help build trust among stakeholders, including project developers, investors, and buyers of carbon debits.

Facilitating Market Growth: Reliable verification and validation processes are essential for the growth and stability of the voluntary carbon market, attracting more participants and investments.

Role of VVBs

Project Validation: Before a project begins, VVBs validate the project's design and documentation to ensure it meets the criteria for generating carbon debits.

Ongoing Verification: Once the project is operational, VVBs conduct regular audits to verify that the project continues to meet the standards and accurately reports its emission reductions or removals

Certification: After successful verification, VVBs issue certifications that confirm the project's compliance with relevant standards, allowing the project to generate carbon credits.

Monitoring and Reporting: VVBs monitor the project's progress and ensure that all reporting is accurate and transparent

Addressing Non-Compliance: If a project fails to meet the standards, VVBs can take corrective actions, which may include revoking certifications or requiring remedial measures.

In addition to independent verification processes, the GCS Team will conduct annual to bi-annual monitoring of enrollment projects to ensure compliance with the requirements of this agreement for a 20-year term. This monitoring will be carried out with the help of the certified program and their data, using various methods such as regular measurement and growth data, images and other technologies to ensure accuracy and reliability.

Step 9 - Coaching and Educational Pillar
We at GCS regard coaching and education as key to ensuring the success of its projects.

Primarily from learning from our farmers and passing along what is learned to benefit the scientific community. Also, By providing access to information on key concepts like "Additionality," carbon sequestration, and GHG mitigation. The GCS aims to foster a deeper understanding of sustainability and low-carbon economic development. Throughout a project, we are available to participants and will be available to answer any questions or concerns related to its work and vision.

5. Compatibility & Regulations

The Compliance Market and Voluntary Market are discussed in the Background Information provided. As such, GCS operates in the Voluntary Market, which means that it does not guarantee any specific value or function for its Debits within any regulatory framework. It is recommended for all projects to investigate the potential uses, functions, and value of GCS Debits in their specific location.

6. Independent Partners' roles

Auditing partners who engage in the CO_2 Token activities are crucial in maintaining the integrity and independence of the process and assessment, avoiding any conflicts of interest. You can find information about Global Carbon Standard’s independent partners on the website.

7. Methodology-associated projects

Global Carbon Standard’s focus is reforestation initiatives that involve planting tree seeds, seedlings, sprouted trees and plants promoting native plant species propagation, and supporting biodiversity through the cultivation of symbiotic species above and below ground, including microorganisms and companion species. These projects also include educational efforts for local and indigenous communities, where knowledge is shared and exchanged. At GCS, there is no restriction on minimum or maximum size of project-onboarded land, even though the GCS mainly works with small-scale farmers, indigenous people, and landowners in partnership with government agencies.

8. Funding

The development of the Global Carbon Standard was completed internally by the dedicated staff. No funding was received or accepted during the entire life of preparing the standard.

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Additional Guidance

Global Carbon Standard (GCS) and Agroforestry Methods

The **Global Carbon Standard (GCS)** provides a comprehensive framework for carbon offset projects, ensuring that they adhere to rigorous environmental, social, and sustainability criteria. A key strength of the GCS is its flexibility, allowing various agroforestry methods, including **Syntropic Agroforestry**, **The Miyawaki Method**, **Alley Cropping**, **Silvopasture**, and **Forest Farming**, to align with its core requirements. If implemented to the guidelines of the GCS each of these systems aims to achieve common objectives: biodiversity enhancement, carbon sequestration, reforestation, and food security.

Agroforestry Systems Overview

1. **Syntropic Agroforestry (Ernst Götsch)**

- **Description:** Developed by Ernst Götsch, syntropic agroforestry mimics natural ecosystems by incorporating diverse plant species arranged in layers. It emphasizes **succession**, where fast-growing pioneer species provide shade and support for slower-growing trees. Regular pruning (chop-and-drop) generates organic matter, enhances soil health, and promotes biodiversity.
- **Core Features:** Dense planting, diverse species, ongoing pruning, and a focus on soil health.

2. **The Miyawaki Method**

- **Description:** Created by Japanese botanist Akira Miyawaki, this method involves dense planting of native species to establish fast-growing forests. The goal is to restore local ecosystems quickly, improve biodiversity, and enhance carbon uptake. By using a multi-layered forest structure, the Miyawaki method fosters wildlife habitats and supports community well-being.
- **Core Features:** Rapid establishment of native species, dense planting, and biodiversity enhancement.

3. **Alley Cropping**

- **Description:** Alley cropping combines rows of trees or shrubs with crops grown in the alleys between them. This system provides multiple benefits, such as shade for crops, reduced soil erosion, and enhanced nutrient cycling. The trees can also provide timber, fruit, or fodder while improving overall farm productivity.

- **Core Features:** Complementary crops, resource-efficient space use, and reduced erosion.

4. **Silvopasture**

- **Description:** Silvopasture integrates trees, pasture, and livestock in a single system. This approach improves land productivity while enhancing animal welfare and providing shade and shelter for livestock. It helps sequester carbon, improve soil health, and increase biodiversity by creating diverse habitats.

- **Core Features:** Integration of trees with livestock grazing, improved animal welfare, and carbon sequestration.

5. **Forest Farming**

- **Description:** This method involves cultivating high-value crops under the protection of a forest canopy. Forest farming allows farmers to grow medicinal herbs, mushrooms, or other specialty crops while leveraging the benefits of the forest ecosystem, such as shade and humidity, leading to improved yields and sustainability.
- **Core Features:** Sustainable crop production under forest canopies, biodiversity enhancement, and soil health improvement.

Alignment with Global Carbon Standard (GCS)

The GCS takes the best parts of each of these methods to generate a flexible and robust framework to achieve our goals throughout the world.

1. **Biodiversity Enhancement:**

- **GCS Embrace:** All the aforementioned agroforestry methods prioritize biodiversity, which is essential for creating resilient ecosystems. Increased species diversity enhances ecosystem stability and adaptability to climate change.
- **Implementation:** Agroforestry designs can be tailored to local ecosystems, promoting rich habitats that meet GCS biodiversity criteria.

2. **Carbon Sequestration:**

- **GCS Embrace:** The GCS encourages practices that effectively sequester carbon. Syntropic agroforestry and the Miyawaki method achieve this through plant succession and density, while alley cropping, silvopasture, and forest farming contribute to carbon uptake through their integration of trees and crops.
- **Implementation:** Designs can be adapted to maximize biomass production and carbon storage based on regional conditions, such as soil type and climate.

3. **Reforestation Efforts:**

- **GCS Embrace:** The GCS supports projects that restore degraded lands through reforestation. Syntropic, Miyawaki, alley cropping, silvopasture, and forest farming methods provide effective means to enhance ecosystems and improve land productivity.
- **Implementation:** Depending on regional factors, the choice of native species and planting density can be adjusted while adhering to GCS requirements for successful reforestation.

4. **Food Security:**

- **GCS Embrace:** Integrating food production within agroforestry systems aligns with GCS goals for sustainable development. These methods enable the cultivation of crops alongside ecological benefits, enhancing food security for local communities.

- **Implementation:** Agroforestry designs can vary to include staple crops, fruits, and vegetables suited to local diets, ensuring food security while contributing to carbon offset goals.

5. **Adaptive Design Based on Regional Context:**

- **GCS Embrace:** The GCS recognizes that effective carbon offset projects must be adaptable to local environmental, social, and climatic contexts. This adaptability is crucial for the success of agroforestry systems.

- **Implementation:** Depending on specific regional conditions, agroforestry systems can differ in species composition, planting density, and management practices, yet all aim to achieve the same objectives of biodiversity, carbon sequestration, reforestation, and food security.

Conclusion

The Global Carbon Standard provides a flexible framework with rigid standards that accommodates diverse agroforestry practices, including syntropic agroforestry, the Miyawaki method, alley cropping, silvopasture, and forest farming, and combinations of these in a less formal arrangement, as long as the core GCS requirements are met. By allowing for designs that reflect regional conditions and community needs, the GCS enables a range of agroforestry systems to achieve overarching goals: enhancing biodiversity, effectively sequestering carbon, restoring ecosystems, and improving food security. This inclusive approach fosters sustainable land management practices that contribute to climate change mitigation and ecological restoration on a global scale.

Sample Syntropic System

The following information provides a detailed example of a Syntropic System Plan and should be used for informational purposes only. Tree species used in these systems will vary based on region, focusing on native species.

This is a generalized system plan, to provide a suitable example of what a system may look like on a 4 hectare plot. The species used in the example may or may not be applicable to your zone. The number of trees, crops or native flora can be substituted and adapted.

Syntropic Agroforestry System Plan for a 4-Hectare Plot (Simultaneous Planting with Species Timing)

This syntropic agroforestry plan follows the principle of stratified planting with simultaneous establishment of fast- and slow-growing species. The system focuses on maximizing carbon sequestration, food security, biodiversity, and soil health by leveraging species that provide early benefits (e.g., shade and biomass) while allowing slower-growing species to develop over time. Fast-growing pioneer trees initially provide shade and protection for slower-growing species, which will eventually outpace them, creating a dynamic and self-sustaining ecosystem.

Plot Overview

- Total Area: 4 hectares (40,000 m²)
- Row Width: 10 meters
- Tree Spacing: Based on canopy layer and species (see below)
- Total Number of Rows: 40 rows, each 100 meters long, spaced 10 meters apart

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Site Preparation

1. Clearing & Contour Mapping:
    - Remove invasive species and retain organic matter for mulching.
    - Map the site based on contour lines for water retention and soil stabilization.
2. Soil Preparation:
    - Apply compost, mulch, and microbial inoculants to enrich soil health.
    - Install a temporary irrigation system to support early-stage plant establishment.
3. Simultaneous Planting:
   All layers (canopy, mid-canopy, low-canopy, and ground cover) are planted simultaneously, with careful timing to allow fast-growing species to create a microclimate for slower-growing plants.

Simultaneous Planting Layout (Mixed Species Rows)

Rows 1-8: Carbon Sequestration & Habitat Creation

- Canopy Layer (Fast-Growing Pioneers, 8-10m Spacing):
  Early pioneers like Paulownia, Eucalyptus, and Albizia are spaced 8-10 meters apart. These species will grow quickly, providing early shade and protection.
- Mid-Canopy (Hardwoods, 5-6m Spacing):
  Slower-growing hardwoods such as Mahogany and Teak are interplanted. They will benefit from the shade of the pioneers in the first few years and eventually overtake them.
- Low Canopy (2-3m Spacing):
  Fast-producing plants like Banana, Papaya, and Mexican Sunflower are added for food, early-stage biomass, and mulching.
- Ground Cover (Inter-row):
  Vetiver grass is planted along contours at 1-meter intervals to stabilize soil and prevent erosion.

Rows 9-16: Food Production & Soil Improvement

- Canopy Layer (Nitrogen-Fixing Pioneers, 8m Spacing):
  Nitrogen-fixing trees like Albizia and Acacia are planted 8 meters apart to enrich the soil.
- Mid-Canopy (Fruit Trees, 5-6m Spacing):
  Fruit-bearing species such as Mango, Avocado, and Jackfruit are planted between the canopy trees, benefiting from early shade and soil enhancement.
- Low Canopy (Shrubs, 2-3m Spacing):
  Crops like Coffee, Cacao, and Inga fill the lower layers, thriving in the early-stage shade provided by pioneers.
- Ground Cover (Inter-row):
  Mexican Sunflower provides constant biomass for mulching and soil enrichment, with Vetiver along the contour for erosion control.

Rows 17-24: Timber Production & High-Value Economic Trees

- Canopy Layer (10m Spacing):
  Timber species such as Leucaena, Grevillea, and Gmelina are spaced 10 meters apart for long-term yield.
- Mid-Canopy (6m Spacing):
  High-value economic trees like Cashew and Coconut are planted between timber species, allowing them to develop under the initial shade.
- Low Canopy (2-3m Spacing):
  Shade-tolerant crops such as Vanilla and Pineapple will fill the low canopy, providing additional yields.
- Ground Cover (Inter-row):
  Vetiver and Mexican Sunflower for mulching and erosion control.

Rows 25-32: Biomass and Soil Enrichment

- Canopy Layer (6-8m Spacing):
  Fast-growing pioneers like Eucalyptus and Albizia provide biomass and fast shading.
- Low Canopy (1-2m Spacing):
  Dense planting of Banana and Mexican Sunflower for rapid organic matter accumulation and early food yields.
- Ground Cover (Inter-row):
  Cowpea and Mucuna as nitrogen-fixing ground cover crops to build soil fertility.

Rows 33-40: Root Crops and Tuber Production

- Low Canopy (2-3m Spacing):
  Tuber crops like Cassava, Yam, and Sweet Potato are planted in rotation for yield diversity.
- Ground Cover (Inter-row):
  Vetiver grass stabilizes soil, while Mexican Sunflower is pruned regularly for mulching and nutrient recycling.

Species Timing and Growth Dynamics

1. Fast-Growing Pioneers (Years 1-3):
    - Paulownia, Eucalyptus, and Albizia will dominate the canopy quickly (within 1-3 years), providing shade and microclimatic conditions for slower-growing species.
    - These species are pruned regularly to produce biomass that will improve soil fertility and allow mid-canopy species to access light as they mature.
2. Slow-Growing Hardwood Species (Years 3-5 and Beyond):
    - Hardwood trees such as Mahogany and Teak will take longer to establish but will eventually surpass the pioneers. By the time they mature, they will benefit from the rich soil structure created by the fast-growing trees and biomass-producing plants.
3. Fruit Trees and Economic Crops (Years 2-5):
    - Mango, Avocado, Cashew, and other fruit-bearing trees will start producing within 3-5 years. Early shading by pioneers will protect them from excessive sunlight and drought stress during the establishment phase.
4. Biomass Crops (Continuous):
    - Mexican Sunflower and Banana will be pruned regularly to provide mulch, maintaining a constant cycle of organic matter, enriching the soil for slower-growing species.
5. Ground Cover and Root Crops (Continuous):
    - Vetiver and ground cover crops like Mucuna will control erosion, manage water retention, and continuously build soil health. Cassava, Yam, and other tubers will be rotated to ensure steady yields and nutrient cycling.

Detailed Planting Strategy

- Canopy Layer:
    - Fast-Growing Trees (8-10m Spacing):
      Pioneers like Paulownia, Eucalyptus, and Albizia will establish quickly to provide shade and organic matter. These trees will be pruned for biomass over time.
    - Hardwood Trees (Planted between pioneers):
      Mahogany, Teak, and other slow-growing species will be planted in the same rows. They will take over once the fast-growing pioneers are pruned back or harvested.
- Mid-Canopy:
    - Spacing (5-6m):
      Mango, Avocado, Jackfruit, and economic trees like Cashew and Coconut will be interspersed between canopy species. They will benefit from early shade, thriving as the system matures.
- Low Canopy:
    - Spacing (2-3m):
      Shrubs and smaller crops like Banana, Papaya, Coffee, Cacao, and biomass crops like Mexican Sunflower will rapidly provide food and mulch during early years.
- Ground Cover:
    - Spacing (1m):
      Vetiver planted along contours for erosion control, water retention, and

nutrient cycling. Mexican Sunflower is used for biomass production and mulching to maintain soil fertility.

Summary of Benefits

This 4-hectare syntropic agroforestry system integrates species that grow at different rates to provide continuous canopy cover, soil enrichment, and yield. Fast-growing pioneers create shade and soil benefits for slow-growing hardwoods and fruit trees, which will gradually dominate as the pioneers are pruned. Ground cover plants like Vetiver and biomass producers like Mexican Sunflower are crucial for soil stability and nutrient cycling, ensuring long-term ecosystem health and resilience.

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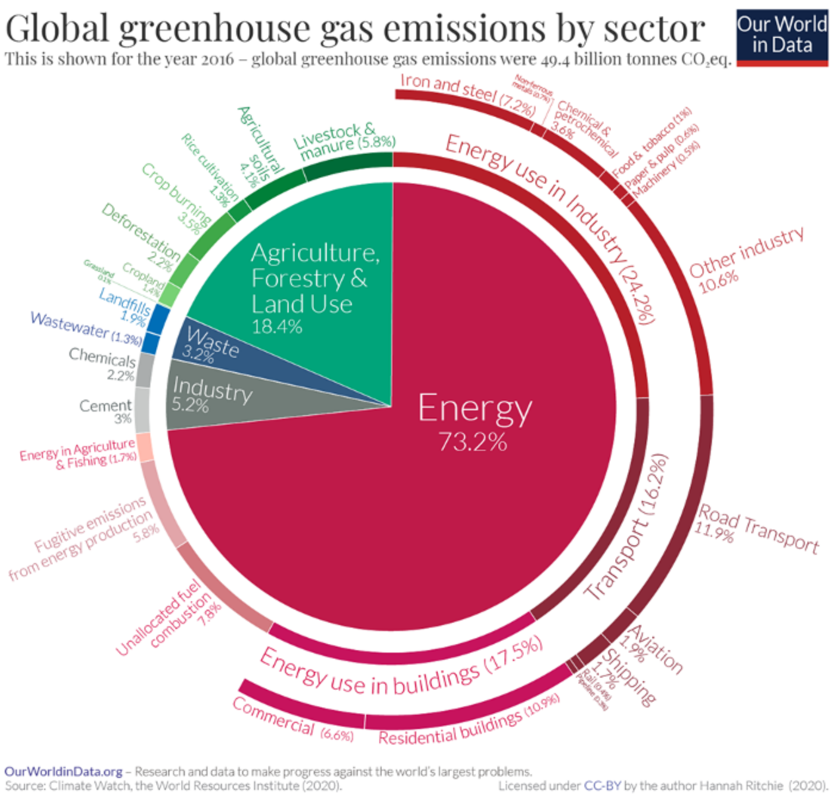
APPENDIXES

A.1. Methods to identify and accurately estimate potential leakage from external sources



Based on the figure above, agricultural activities typically contribute 18.4% of total GHGs emissions around the world. Since we assume that total leakages are proportional to agricultural leakage

$$C_{total\ leakage} = \frac{100 * C_{agriculture\ leakage}}{18.4}$$

(our field of expertise), so total leakages (by all sectors) surrounding the projects would be calculated as [7]:

- Identification and quantification of potential positive and negative leakages in by types of projects [16]

Project Type	Type of activity	Drivers of leakage[3]	Leakage mechanisms	Leakage Scale	Positive (+) negative (-) neutral (N);
Conservation[1]	Replace or prevent subsistence agriculture	Subsistence needs (+ or -)	Activity shift	Local	-/N/+
			Ecological	Local	+
			Market	Local	-/N/+
	Replace or prevent commercial agriculture	Cash crop markets (-)	Activity shift	Local/Global	-/N/+
			Ecological	Local	+
			Market	Local/Global	-/N/+
	Stop commercial logging	Timber markets (-)	Activity shift	Local/Global	-
			Ecological	Local	+
			Market	Local	-
	Stop forest products harvest for local needs	Subsistence needs (-)	Activity shift	Local	-
			Ecological	Local	+
			Market	Local	-
	Reduced impact logging, enhanced forest mgmt.	Technology transfer (+)	Activity shift	Local	+
			Ecological	Local	+
			Market	Local/Global	N
Reforestation & afforestation[2]	Ecosystem restoration	Resource and land availability (+ or -)	Activity shift	Local	+/N/-
			Ecological	Local	+
			Market	Local	+/N/-
	Small-scale reforestation for local needs	Land avail-ability (-) timber supply (+)	Activity shift	Local	N/-
			Ecological	Local	+
			Market	Local	N
	Commercial plantations	Timber markets (+ or -), land availability (-)	Activity shift	Local	+/N/-
			Ecological	Local	+/N/-
			Market	Local/Global	+/N/-

1) Excluded from the Clean Development Mechanism for first commitment period (2008-2012) of the Kyoto Protocol in negotiations as of November 2001.
2) Allowed in the Clean Development Mechanism with limitations.
3) Considering only socio-economic drivers of leakage, not ecological leakage drivers. A (+) sign refers to a driving factor for positive leakage and a (-) sign refers to a driver of negative leakage.

CDM Activity	*Study*	*Study Method*	*Study Period*	*Leakage Potential*	*Driving factors*
Plantations	Sohngen/ Sedjo 2000	Top-down	100 years[6]	50%	Increased timber supply, adverse changes in age classes of trees and forest management intensity
Plantations	Alig/Adams/McCarl/ Callaway/Winnett 1997	Top-down	50 years	100%	Rising agricultural land rents
Plantations	Perez-Garcia 1994	Top-down	50 years	Regionally high, but no global impact	Increased timber supply
Plantations	Kadekodi/Ravindranath 1997	Top-down	50 years	Non negligible	Increased timber supply
Averted deforestation	Sohngen/Mendelsohn/ Sedjo 1999	Top-down	125 years	Little or no perceivable impact	Intensification of existing forest management & additional plantations in subtropics
Reduced Impact Logging	Brown/Cabarele/ Livernash, 1997	Bottom-Up	1 year	60%	*Maximum* leakage potential based on a complete substitution of decreased timber production

VERSION HISTORY

Row #	Document & Version	Revision Date	Revision Description
1	*Global Carbon Standard v3*	*01/13/2023*	*Final checks for Earthood*
2	*Global Carbon Standard v3.1*	*05/27/2024*	*Clarity of GCS role in optional blockchain use, minor spelling/grammar changes*
3	*Global Carbon Standard v3.2*	*10/16/2024*	*Additional Guidance section included*