Project Design Document

Name of project:	CarbonLog-Connect
Name of quality manager:	CarbonLog
Date of issue:	20.08.2024
Methodology:	Global Artisan C-Sink 2.1A

Project location:	Littoral region of Cameroon, Manjo-Mantem
Project start date:	01.06.2024 *(Date of contract conclusion with Carbon Standards or registration date for the Global Artisan C-Sink service.)*
Project period:	The project has no end date, but it is verified on an annual basis
Project summary:	CarbonLog Partners empower smallholder farmers to convert organic farm waste into valuable solid carbon through pyrolysis, enhancing soil health and promoting sustainable agriculture. By training 1,000 farmers annually in biochar production, we help reduce chemical fertilizer use and improve crop yields, leading to financial stability and rural development. Our mission supports the global Net Zero agenda, aiming for a greener and more resilient future. The project will increase carbon sequestration by working the produced biochar into different matrixes and in this way create a long-term carbon storage with a persistence of up to 1000 years as according to the Global Artisan C-Sink Standard. Without the project, no C-sink would be created since the agricultural waste residues such as bamboo, cocoa pods but also waste debris does not constitute a long-term carbon reservoir. In the initial 5 years of the project we expect carbon sequestration of approximately 47895 CO2eq in total or 8708 CO2eq / year.

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1. Purpose and general description of project

The project CarbonLog-Connect compromises 1000 Artisan Biochar Producers for biochar production from agricultural waste residues such as bamboo, cocoa pods but also waste debris in the Littoral area of Cameroon. Biochar is a hyper versatile material with an increasing number of applications in agriculture, environmental engineering, and basic industry. Biochar applied in a matrix permitted by the Global Artisan C-Sink Standard poses a stable carbon sink (C-sink). Without the project, no C-sink would be created, since prune wood, bamboo and other agricultural waste residues do not constitute a long-term carbon reservoir.

At present, we are using bamboo, that is declared as agricultural waste residues that the farmers have to get rid of. In the future and for scaling purposes, we also plan to switch to other feedstocks. Therefore, we want to implement a decentralized biochar production network throughout the whole operating area.

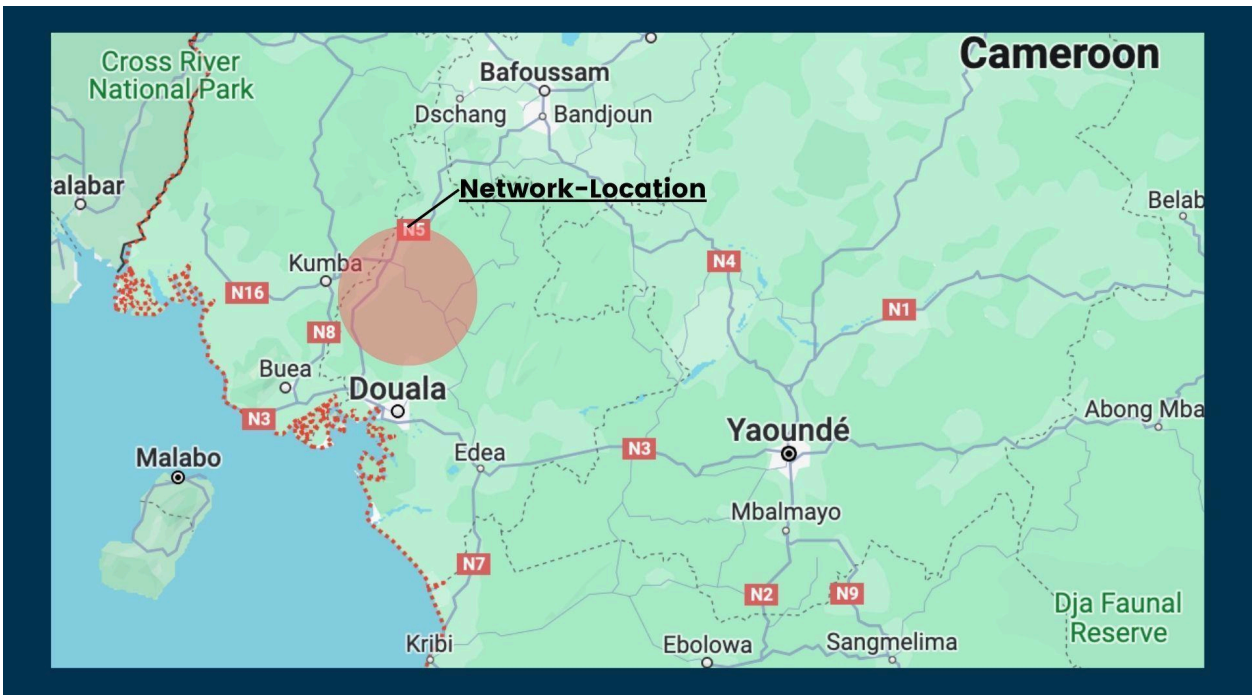
Another objective of the project is to improve the soil quality by giving the farmers the biochar as soil amendment for free. Biochar can improve soil quality significantly because of its impact on the soil pH, its water retention capacity, and its ability to store nutrients.

The monitoring and tracking of this project will be carried out by CarbonConnect GmbH. In the project the digital MRV technology named PlantVillage will be used. This will monitor, report and verify biochar production and carbon sequestration.

1.1. Project location

The project will take place in the Littoral region of Cameroon. The region is located in the southwestern part of the country, bordering the Atlantic Ocean.
We establish a farmer network and track each onboarded location in the dMRV tool. This project's headquarters will be in Manjo.

The geographical locations (4.83202,9.77857) of the subsequently installed Biochar Artisan Producers will be documented in the dMRV tool from PlantVillage.



The Littoral region of Cameroon, located along the southwestern coast, is rich in fertile soils and a favorable climate, making it a key area for agricultural production. The region's agriculture is diverse, with crops like oil palm, cocoa, and bananas thriving due to the abundant rainfall and warm temperatures. So far we have 200 farmers onboarded in the marked location, and we are working with around 50 bigger soil pits, that the farmers share for biochar production. Currently, we are using bamboo as a feedstock, that is left behind for decomposition or can also be categorized as waste debris, in case of blocking riverbeds.

1.2. Stakeholders and partners involved

CarbonConnect GmbH (C-Sink Manager) is a start-up from Hamburg, Germany, founded in April 2021, focusing on the development and management of Biochar Carbon Removal projects. The founders Nando Knodel and Tim Künzel have developed with a lot of research and practical evaluation a circular and for all stakeholders' profitable economic model with positive ecosystem and climate performance to drive the decarbonization of the agricultural sector and contribute to a climate resilient agriculture as a whole. Through participation in the Social Impact Lab Incubator Hamburg & Stuttgart, the Hafven Impact Accelerator Hannover, the Farm Food Climate Challenge of Project Together, and the remove Accelerator for Carbon Dioxide Removal, the young company has received a lot of support and network to acquire excellent expertise in the field of climate resilient agriculture. Competencies include extensive knowledge of agronomy and cultivation, its life cycle assessment, calculations of greenhouse gas emissions along the agricultural supply chain, processing of agricultural residues and its use for pyrolysis, digital agriculture, and precision technology, and most importantly, knowledge of Carbon Removal & Carbon Credits. A first Artisan pro network in Zimbabwe is up and running. A 3-rd party audit by Ceres already successfully took place. CarbonConnect's goal is to enable climate-positive value creation, calculate, and sell the surplus of climate performance, the net sequestration of CO_2, as certificates, creating additional revenue for project actors.

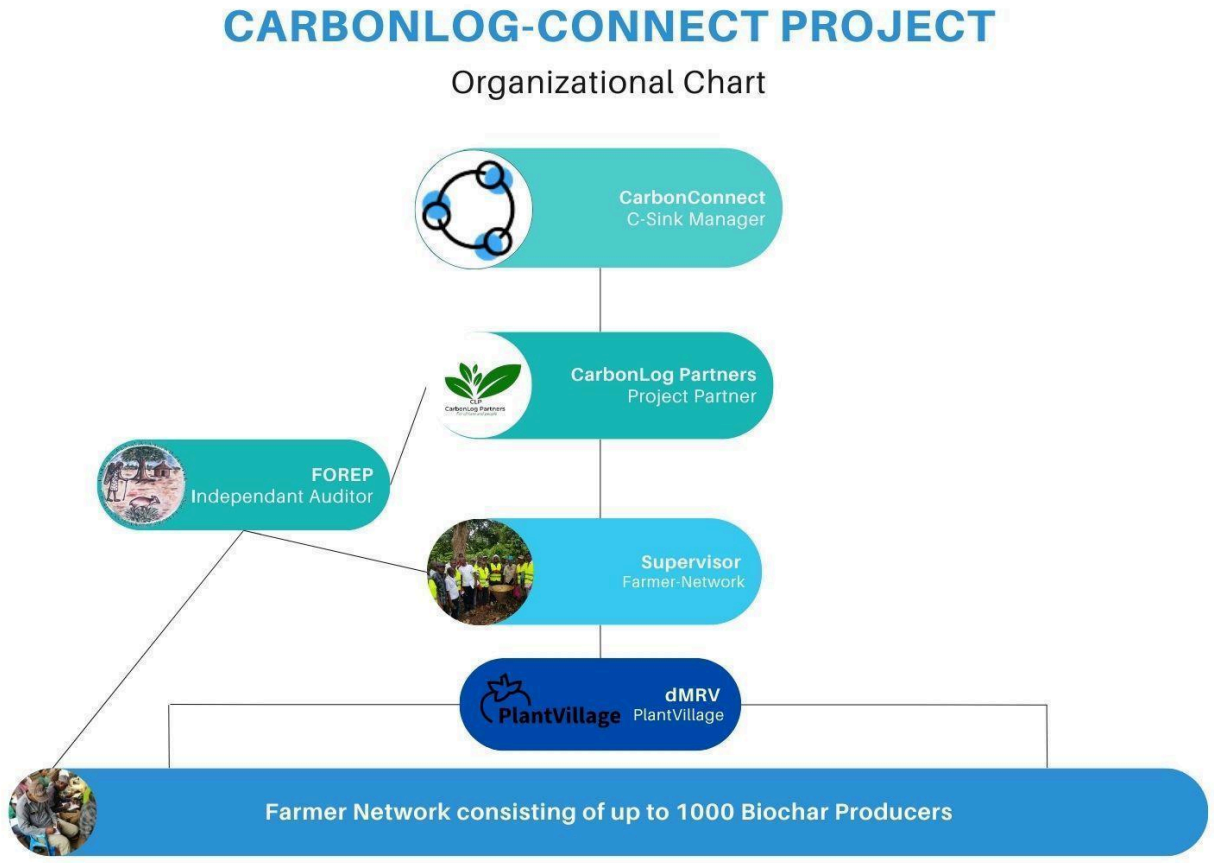
CarbonLog Partners (Project Partner) was created in 2024 by Ambe Pascal. The NGO is Empowering Farmers to implement sustainable agricultural practices. This includes equipping them with essential skills and knowledge, boosting productivity and resilience, generating additional income through biochar production and high yields, and fostering community development by providing resources, training, and support. The initiative also promotes gender equality, self-employment, and contributes to rural development and poverty reduction.

CarbonLog aims to train and support more than 1,000 farmers annually in biochar production, reducing the need for chemical fertilizers and enabling farmers to generate additional income through biochar sales and carbon sink credits. The vision is to empower smallholder farmers to contribute to the NetZero mission, fostering a sustainable and green future by 2050.

Currently, there are already supervisor, employed by CarbonLog, working in this project: ASSAMBA ACHILLE ARTHUR, SOH LOYICK GHISLAIN, EDOU VANINA, FEDJIEU TIGNE LOIC.

Forest Resources and People (FOREP) Cameroon is a multidisciplinary association dedicated to sustainable forest resource management and community development. They conduct research, implement conservation strategies, negotiate funding, and train local populations on environmental issues. FOREP also supports forest-dependent communities in optimizing resource benefits while ensuring ecological sustainability, social equity, and economic viability. Additionally, they facilitate partnerships, raise awareness, and help young Cameroonians develop skills in research, natural resource management, and environmental protection. They will do on site audits to verify and measure project development.

Organigram:



1.3. Description of baseline scenario

The situation prior to the production of biochar is that some organic material or feedstock was used for farm activities, such as composting and often getting burned.

At present, most of the agricultural waste residues such as bamboo, cocoa pods but also waste debris remain as waste and are left to decay. Therefore, we want to implement a decentralized biochar production network throughout the whole operating area.

The network also includes a lot of Bamboo-residues from dedicated biomass production.

We already started implementing the network in May 2024 and started training the first farmers. We already onboarded our partner organisation with all 4 supervisors in PlantVillage and already successfully produced biochar, did mixing and also created the first usage surveys. Most of the surveys are already confirmed by PlantVillage.

The baseline scenario for carbon removal accounting is the "business as usual", in which no permanent biochar-based carbon sink is generated and is considered as zero. The fact that biomass could have been used differently in the baseline scenario, has no impact on the consideration of the baseline as zero.

$$C - sink\,(Baseline) = 0\,tCO2e$$

1.4. Biochar carbon sinks

When plant biomass is burnt or decomposed, the assimilated carbon is released again in the form of CO2. However, if the plant biomass is pyrolyzed, about half of the plant carbon is transformed into a mixture of predominantly very persistent carbon compounds that form a solid material known as biochar. While in the environment, any carbon compound is subject to degradation; for most components of biochar, this process is extremely slow, and mostly even so slow, that it is hard to measure for thousands of years. Provided that the biochar is not burned, the biochar carbon remains as a C-sink in the terrestrial system.

If biochar with an H to Corg ratio < 0.40 is applied to soil, a major part of its carbon is considered Persistent Aromatic Carbon (PAC, the portion of biochar carbon bound in clusters of more than seven aromatic rings as analyzed by the hydro pyrolysis method) and will constitute a carbon sink for several millennia. A minor though relevant part of the biochar-carbon is less persistent (semi persistent carbon, SPC) and likely to be microbially degraded within decades to centuries, presenting a mean residence time of 50 years. The biochar carbon that may be decomposed within the first 1000 years after the application to soil is called Semi-Persistent Carbon (SPC) and constitutes a temporary C-sink. For biochars presenting an H to Corg ratio < 0.4, the PAC fraction is conservatively fixed by the standard at 75% and the SPC fraction at 25%.

1.5. Project Boundary

All emissions occurring due to biomass sourcing, biochar production and application are accounted for and will be adequately offset by registered carbon sinks.

In this project, the boundary includes the following aspects:

- Biomass sourcing: Harvesting, Collecting
- Pyrolysis: Open field pyrolysis in Soil-Pits
- Biochar processing: Biochar is collected in bags and then mixed by hand with compost
- A margin of security

Since this is a Farmer network in rural areas, all biochar production related activities, such as collecting feedstock or mixing, are done by hand.

1.6. Eligibility

- ☑ Production of biochar according to Global Artisan C-Sink conditions.
- ☑ Farmers and Artisan Biochar Producer are not certified under any other methodology for nature-based climate service (i.e. biomass production and soil organic carbon).
- ☑ Social Impact: Involved parties have to be compensated fairly and transparent.
- ☑ Project location: Project is located in low- or middle-income country according to the World Bank classification.
- ☑ Biochar production does not exceed 100m3/year for a single C-Sink Farmer or 1500m3/year for a single Artisan Pro and is done with a low-tech production unit.
- ☑ The C-sinks issued in this project are not claimed in any other Carbon Crediting Scheme.

1.7. Additionality

Artisanal Biochar Producers do not generate income yet with biochar in most regions, there is no market for biochar-based fertilizers, and the production costs are higher than the expected agronomic benefit, or tropical smallholder farmers do not have the financial resources to pay biochar-based fertilizers. Farmers could produce their biochar from their feedstock to improve their yields, but without the training provided by the Global Artisan C-Sink Manager, they would hardly acquire the craft to do so. The Community Service Activity is a central aspect of the project.

The Global Artisan C-sink will, thus, be the decisive monetary incentive and knowledge transfer to produce climate positive biochar and thus carbon sinks. The Global Artisan C-Sink Manager will provide not only training on biochar production but also on the preparation and application of biochar-based fertilizers, which (a) will enable most farmers to establish this practice and (b) will avoid the adoption of unsustainable biochar production practices which could result in pollution and GHG-emissions. Moreover, methane compensation, as introduced by the Global Artisan C-sink is a key element to achieving net negative emissions with Kon-Tiki Soilpit based biochar C-sinks.

Global Artisan C-sink assures the adoption of low-emission technology, methane compensation, and the use of sustainably sourced biomass. Without those boundary conditions, biochar production in countries with low purchasing power and limited financial and technical possibilities would hardly result in net negative emissions. Hence, additionality of any C-sink certificates issued under this standard is guaranteed.

2. Ex-ante estimate of impact

The estimations are based on the dry matter amounts of biomass and the resulting biochar. The C-sink is calculated as the expected amounts of biochar multiplied by the expected carbon content.

The established temporary C-sinks are based on the SPC fraction (25%) of the biochar or the lifetime of the products where the biochar is applied to temporary matrixes (e.g. cement/concrete in buildings).

The established permanent C-sinks are based on the PAC fraction of the biochar (75%), when the biochar is applied to soils and has a H/C ratio below 0.4.

The ex-ante estimate is based on the following values:

Yield factor (feedstock to biochar): 0,169 t biochar (DM)/t feedstock (DM)

C-content of biochar: 0,78 (based on preliminary analysis/ literature)

Year of operation	Amount of feedstock (t DM)	Amount of biochar produced (t DM)	Established temporary C-sinks (tC)	Established permanent C-sinks (tCO_2eq)
1	12000t	2028t	1465	4354
2	24000t	4056t	2930	8708
3	24000t	4056t	2930	8708
4	24000t	4056t	2930	8708
5	48000t	8112t	5860	17416
sum	132000t	22308t	16114	47895

3. Technology and business cases

3.1. Artisan Biochar Producer

The Carbon Removal Biochar project will implement a decentralized biochar production system involving multiple Artisan Biochar Producers across the Littoral region in Cameroon. Each cluster has a supervisor who is registered in the dMRV app and takes care of the operations. Accordingly, the definition of "farmer" is also referred to below as "Artisan Biochar Producer".
Each Artisan Biochar Producer will utilize pyrolysis units to convert the agricultural waste residues within their specific area into biochar within the 100 m3 of biochar per year. This process will capture and stabilize the carbon content of the biomass, preventing its release into the atmosphere. The resulting biochar will be incorporated into the soil during reforestation activities and farming operations, enhancing soil fertility and structure for newly planted trees. The system will be coordinated by CarbonLog, which will oversee the production and ensure quality control. This approach not only promotes sustainable waste management and reforestation but also provides Artisan Biochar Producer with an additional revenue stream from carbon credits.

The (Sample) contract between the Global Artisan C-Sink Manager and Artisan Biochar Producers (C-Sink Farmers, C-Sink Cooks, as well as Artisan Pro) was presented to the Certifier.

3.1.1. Training of Artisan Biochar Producer

In this project, Global Artisan C-Sink Manager ensures that the Artisan Biochar Producers are qualified to produce high-quality biochar with low emissions through an internal training protocol. The Artisan Biochar Producer follows a biochar production training given by a qualified trainer and prove their proficiency in an exam. The training includes principles of feedstock selection and biomass drying, the biochar kiln operation principles, the volume measurement of the produced biochar, a biochar sampling procedure, and the proficient use of the Artisan smartphone app.

The details of content, duration and learning goals (internal training protocol) were presented to Carbon Standards and the Certifier (Annex 7.3).

3.2. Feedstock

The Global Artisan C-Sink Managers ensures that the biochar is made from biomass feedstock that originated from the artisan's farm.

3.2.1. Origin of feedstocks:

Feedstock often comes in the form of waste residue from each of the farmers own agricultural operations. A lot of feedstock is also created by big biomass production operations of bamboo in that area. For now we are only using Bamboo that is left behind to decompose from agricultural operations. Often times it also gets burned. In the future we also plan to use corn stalks, cocoa pods, palm fronds, and cocoa tree prunings were previously left to decompose on farms or burned openly to clear land for farming. Before CarbonLog Partners' activities, these disposal methods led to widespread wildfires, greenhouse gas emissions, and severe environmental consequences. During heavy rains, non-compostable feedstock was often washed away, clogging drainage systems, polluting rivers, and causing floods that damaged crops and property.

A small structure with a roof and floor will be built to store the biomass. The logs will not be in contact with the ground and will be protected from rain so that they lose moisture as soon as possible. Feedstock will be able to be stored in such a way that the sides do not touch each other, allowing good ventilation between them. If needed, the sides need to be covered, so rain cannot enter.

Also, will leave a space to store tools, supplies, etc., that are used in the process.

3.2.2. Leakage

The specific feedstock used by CarbonLog at the moment is not suitable for cooking or other traditional uses due to its non-combustible nature without further drying and processing. Moreover, farmers have alternative sources of firewood for household and other purposes.

"In Cameroon's Littoral region, firewood is a primary energy source for many households. The area is rich in diverse tree species that serve as common sources of firewood. Some notable examples include:

- **Anigre (Aningeria spp.)**: This hardwood is prevalent in the region and is commonly used for firewood due to its availability.
  en.wikipedia.org
- **Pycnanthus angolensis**: Known locally as "ilomba," this species is also utilized as a firewood source.
  en.wikipedia.org"

We make sure, that none of the wood above is currently used.

3.2.3. Methane emission during storage of biomass

To avoid methane emissions during storage of biomass the following measures are taken:

- The feedstock must not be used freshly cut or from a feedstock pile where it rained upon.
- Feedstock needs to be stored airy and protected from rain.
- To avoid methane emissions from feedstock storage, wet feedstock must not be piled higher than a meter. Otherwise, the humid feedstock will self-heat, consume the oxygen inside the pile and decompose anaerobically, which produces significant amounts of methane.

- When feedstock got exposed again to rain, a new period of at least three days of thinly layered sun drying has to start.
- Touching the feedstock must not feel humid.
- The water content of feedstock should be below 25% when used in the Kon-Tiki or TLUD. Simple, low-cost digital devices exist to measure feedstock humidity, which must be used at the biochar trainings so that Artisan Biochar Producer get the experience of how to test the feedstock for humidity even without digital devices. Producers of more than 100 m^3 biochar per year are required to measure the feedstock humidity with an appropriate device and record it in the production protocols. Here, the average humidity is recorded using five measurements with the handhold device per m^3 of feedstock.
- Both, feedstock drying and correct bulkiness of the feedstock blend, is an essential part of the initial Artisan Biochar Producer and C-Sink Cook training.

3.3. Production unit

Biochar is produced via pyrolysis technology. Pyrolysis means the thermo-chemical decomposition of the feedstock under the exclusion of oxygen.

By converting sustainable biomass into biochar by pyrolysis, a long-term carbon reservoir is created. The produced biochar poses a potential of C-sink (C-sink potential). It could still be burned. By intense training and monitoring in a digital Measurement, Reporting and Verification tool (dMRV), it is ensured in the best possible way, that the biochar is used to form a C-sink. C-sink certificates are only issued for those parts of the biochar for which it can be proven that they have been put in a matrix. Without the project, no C-sink would be created, as non-pyrolytic biomass does not ensure persistent carbon storage.

The produced biochar is certified under the Global Artisan C-Sink standard, what guarantees that the biomass feedstock is sustainably procured and produced, biochar fulfils the analytical threshold values, so no damage is caused to the environment, emissions limits of the pyrolysis unit are adhered to, and storage procedures are environmentally sound.

The biochar production follows the Global Artisan C-Sink standard, which ensures:

- Only trained Artisan Biochar Producer are allowed to produce biochar
- Minimization of risks on human health, social and environmental impacts
- No forest wood and slash of forest trees are permitted as feedstock

Flame Curtain Pyrolysis (the Kon-Tiki method)

The principle of flame curtain pyrolysis consists of pyrolyzing biomass layer by layer in a soil kiln.
A fire is started in the pit, and the embers spread to form a first layer on the bottom of the pit. A thin layer of biomass is then added on top of the embers, heats quickly and starts outgassing. The rising pyrolysis gas is caught in the flame curtain and reacts with combustion air entering the kiln from the top. When ash appears on the outside of the carbonizing biomass, the next layer of biomass is homogeneously spread on top. Convective and radiant energy from the flames above and from the hot pyrolyzing layers below heat up the fresh biomass layer, which starts to pyrolyze.
The biochar below the upper pyrolysis layer is shielded from oxygen access by the fire curtain itself. The combustion zone thus creates a flame curtain that protects the underlying biochar from oxidizing, and cleanly burns all pyrolysis smoke and gases as

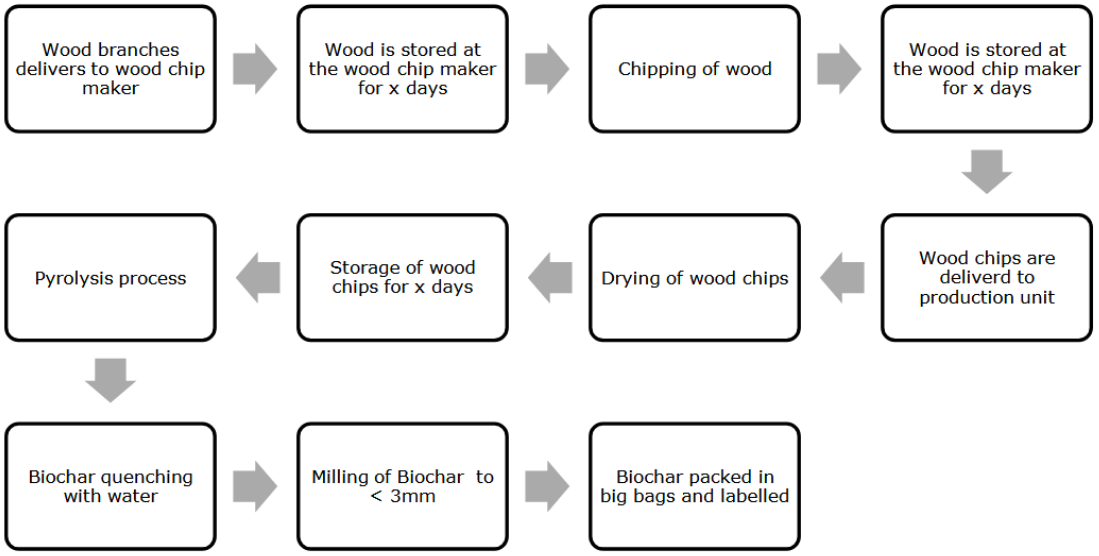
they pass through this hot fire front. The manual layering of biomass is repeated until the metal kiln or soil pit is filled.
The pyrolysis process is then actively ended by quenching with water, or at later stages also by snuffing with a layer of soil.
Below, pictures of one of the soil pits and the biomass we use can be seen.







Annex 1: Example company flowchart



The biochar will then be composted and used on the farmers farm.

3.4. Suitability of Artisan Biochar for Agriculture

Based on the Global Artisan C-Sink standard, Kon-Tiki and TLUD biochar was extensively analyzed following the EBC and WBC analytical requirements. All biochar that was produced from eligible feedstock with the Artisan endorsed technologies fulfilled all requirements of EBC and WBC certification. PAHs and other potential contaminants were found with generally low contents that allowed in all cases the certification as WBC-Agro. As PAH contents of biochar are mainly technology dependent and generally low in Kon-Tiki and TLUD biochars, the Global Artisan C-Sink standard does not require its regular analysis. Meeting the PAH thresholds is covered by the pyrolysis-type accreditation of the Kon-Tiki. Therefore, biochar produced under the Artisan Standard are suitable for agricultural uses as they fulfill all requirements of WBC-Agro.

The sample plan was presented to Carbon Standards International.

3.5. Application and trade of biochar

The following applications are possible for this project:

- Geological C-sink (biochar applied to soil)

3.6. Methane emissions compensation

Compensation of methane emissions by avoiding GHG-emissions from burning crop residues

In many tropical countries, crop residues are burnt directly in the fields. While it has some positive effects on farming (ash fertilization, some pyrogenic carbon, elimination of pests), emissions of such practices are massive. Besides significant emissions of particulate matter that cause smog (the main reason for air pollution methane and carbon monoxide emissions are very high due to the uncontrolled combustion of mostly wet or humid residues. Based on Global Artisan C-Sink standard, it is assumed that the overall climate impact of pyrolysis within Global Artisan C-sink is in any case not worse than direct burning of crop residues in the field. Therefore, abandoning crop residue burning can be accounted as an offset for emissions of Kon-Tiki pyrolysis.

Compensation of methane emissions by avoiding GHG-emissions from biomass decomposition

When biomass is pyrolyzed that otherwise would decompose uncontrolled, the avoided emissions from biomass decomposition can equally be used to compensate for CH_4 emissions of the Kon-Tiki. Examples are cocoa pods, sawdust from sawmills, pulp from coffee, oil palm residues, and sugar cane filter cake. Uncontrolled decomposition, especially in the humid tropics, can cause significant methane emissions in the same or higher range than CH_4 emissions during Kon-Tiki pyrolysis.
A detailed description and flow chart with the current practices was submitted to Carbon Standards and approved.
Prune wood, Cocoa waste as well as other farm residues like corn stalk, combs and also bamboo.





3.7. digital Monitoring, Reporting and Verification (dMRV)

Technically, the C-Sink Artisan certification procedure is based on a digital monitoring, reporting, and verification (dMRV) tool, which is usually a dedicated smartphone application.

In this project the dMRV system of PlantVillage, which is endorsed by Carbon Standards will be used to fulfil the requirements of the Global Artisan C-Sink Standard.

3.8. Planned business development

Our artisanal biochar project in Cameroon focuses on sustainable production, fair distribution, and scalable impact. By partnering with local communities, we ensure consistent biochar supply while providing training and financial incentives for farmers. Sustainability is maintained through efficient low-tech production, revenue from carbon credits, and reinvestment in community development. To scale, we have developed training programs, forged strategic partnerships, and utilize digital payment systems for transparent farmer compensation, ensuring long-term viability and growth.
We have a signed Pre-Sale agreement with a company from France.

3.9. Internal Control System

A blueprint of an Internal Control System (ICS) was presented to the Certifier.

The template for the "internal inspection report" was presented to the Certifier.

4. Determination of C-sink

4.1. Monitoring

All data which is required to calculate the C-sink is entered into a dMRV System. The dMRV system used in this project is provided by PlantVillage.
The data will be monitored as mentioned below.

4.1.1 General data

The following general data will be monitored:

Parameter	Monitoring frequency	Source of data
Artisan Biochar Producer Registration	per year	Internal documentation
Proof of successful participation in an artisan biochar workshop	per year	Internal documentation
Producers list	per year	Internal documentation
H/Corg ratio	per feedstock type	laboratories endorsed by Carbon Standards, see https://www.carbon-standards.com/en/standards/service-505~global-artisan-c-sink.html section Laboratories
C-content of biochar	per feedstock type	laboratories endorsed by Carbon Standards, see https://www.carbon-standards.com/en/standards/service-505~global-artisan-c-sink.html section Laboratories
Bulk density of biochar	per feedstock type	Internal documentation, dMRV
Feedstock preparation	per feedstock type	production protocols, dMRV
Documentation of technology used	per Artisan Biochar Producer	Internal documentation, dMRV

Volume measuring device	per Artisan Biochar Producer	Internal documentation, dMRV
Definition of a production load	per production unit type	Internal documentation, dMRV

The following general conversion rates are fixed ex-ante:

Parameter	**Ex-ante definition; value**	**Source of data**
CO_2 emissions from diesel	3.2 kg CO_2eq / l diesel	Methodology, Juhrich, 2016
CO_2 emissions from heavy fuel	65 t CO_2eq / TJ	Methodology, Juhrich, 2016

4.1.2. Artisan Biochar Production

C-Sink farmer & Artisan Network

For each C-Sink Farmer the following parameters will be monitored for each Artisan Biochar Producer:

Parameter	Monitoring frequency	Source of data
Annual on-site visit	per year	Internal documentation, dMRV
GPS data of cultivated land	continuous	dMRV
Crop rotation, harvest data, harvest amount	continuous	dMRV
Total amount of feedstock (dry matter) used for the load	per load	dMRV
Feedstock type	per load	dMRV
Documentation of biochar making	per load	dMRV
Amount of biochar produced	per load	dMRV
Documentation of biochar mixing to matrix	per load	dMRV
Amount of volume applied to each matrix	per load	dMRV
Registration of biochar amount, date and location applied	per load	dMRV

4.1.3. Compensation of Fossil Emissions

All fossil CO_2 emissions, must be offset by long-term carbon sinks before the registration of a biochar C-sink can be validated in the Global C-Sink Registry.
CO_2 must only be offset with geological C-sinks, such as the persistent aromatic carbon (PAC) fraction of soil-applied biochar, that are registered in the Global C-Sink Registry.
The emission offsets can be realized with the registered permanent biochar C-sink whose production had caused the emission.

Parameter	Monitoring frequency	Source of data
Proof of compensation	annually	Global C-Sink registry

4.1.4. Production unit

x □	The production unit used in the project has a system certification, see system certification.
	Pyrolysis system Kontiki/Soil pit is accredited by Carbon Standards. The mean methane emission for Kontiki/Soil pit is known to be 30 kg CH_4/t DM biochar produced.

Accordingly, ex-ante definition of the following parameter:

Parameter	Ex-ante definition; value	Source of data
[CH_4_emissions_pyrolysis]	30 kg CH_4/t DM biochar	Methodology

4.1.5. Compensation of CH4 Emissions

Methane compensation is defined as creating a carbon sink for 20 years that has a climate cooling effect equal to the climate warming effect of a methane emission over 100 years after the emission occurred. Thus, the total climate forcing of a methane emission must be compensated within 20 years after the initial emission.

Parameter	Monitoring frequency	Source of data
Proof of compensation	per C-Sink Unit	Global C-Sink registry

4.1.6. Margin of Security

For this project, the emissions based on the system boundaries are accounted for.
To also address GHG emissions caused by activities not tracked in detail, a *Margin of Security* is applied.

This includes, for example, the emissions caused by:

- the fuel for transportation of the biomass feedstock to the kiln,
- or the transportation of the biochar to the field (up to 100 km),
- the displacement of the kiln
- a pump for quenching water
- fuel for a chain saw for pruning, milling, and blending of the biochar

$$[Margin\ of\ Security] = [produced\ biochar\ (t)] * 0.02\ (t\ CO2e\ per\ ton\ of\ biochar)$$

4.1.7. Methane emissions

During the pyrolysis process methane emissions are produced. They are calculated according to the following formula:

$$[Total\ methane\ emissions] = [CH4\ emissions\ from\ pyrolysis\ unit\ per\ ton\ of\ biochar] * [amount\ of\ biochar\ produced]$$

4.1.7.1. CH4 Emissions from Production unit

Emissions are calculated in **kgCH_4.**

$$[CH4\ emissions\ from\ production\ unit\ per\ load] = [CH4_{emissions_{pyrolysis}}] * [amount\ of\ biomass\ dry\ matter\ (batch)]$$

4.1.7.2. Compensation of CH_4 Emissions

To compensate methane emissions, the GWP100 of the emitted amount of methane is calculated using the factor 25 kg CO2eq per kg CH_4. We then calculate the absolute global warming potential (AGWP) over 100 years using Jeltsch-Thömmes & Joos (2019). The AGWP must then be compensated by a same-sized absolute global cooling potential (AGCP) over a maximum of 20 years. The compensating global cooling must start in the same year as the CH_4 emission occurred, provide annual global cooling in every following year, and finalize the compensation latest 20 years after the methane emission.

$$[CO2e\ of\ CH4\ emissions\ per\ load] = [Total\ methane\ emissions] *\ GWP100_CH4$$

With GWP100_CH4 = 25 CO_2eq

Greenhouse gases decay in the atmosphere. The quantities of CO_2 still present in the atmosphere each year are added up over the 100 years, resulting in the absolute global warming potential (AGWP) over 100 years.

CO_2 decay is described by:

$$\mathrm{IRF}(\mathrm{CO}_{2,a}(t)) = a_0 + \sum_{i=1}^{5} a_i \cdot exp\left(\frac{-t}{\tau_i}\right)\ for\ t \geq 0$$

With the values

i	ai	ti
0	0.008	
1	0.044	68521
2	0.112	5312
3	0.224	362
4	0.31	47
5	0.297	6

$$AGWP_CH4(100) = \sum_{y=0}^{100} (IRF(CO2, a(y)) *\ [CO2e\ of\ CH4\ emissions\ per\ load])$$

If SPC fraction of biochar is used for compensation AGCP(20) is calculated as the cumulated sum of:

$$AGCP = \sum_{y=0}^{20} (Sf\ *\ exp(-\ kf\ *\ y)\ +\ Ss\ *\ exp(-\ ks\ *\ y)\ +\ P))$$

with

Sf	0.045341876
kf	0.5134
Ss	0.212136124
ks	0.009451
P	-0.007478

In order to claim that methane emissions where compensated it must be proven that $AGCP(20) \geq AGWP_CH4(100)$.

5. Registration of C-sink

Biochar carbon sinks must be registered with the geo-localized area where the biochar or its derived products have been applied. This encompasses scenarios where biochar serves as a soil amendment or finds application in various contexts, such as construction for residential, infrastructural, or road-related purposes.
In certain specific instances where marginal quantities of biochar are applied or utilized in products, the registration of so-called diffuse carbon sinks (i.e., non-geo-localized) is permitted.

The following information are registered for biochar carbon sink:

1 Feedstock of biochar production
2 Technology of production
3 Date or period of production
4 C-content and H/C ratio of biochar (measured or taken from the Ithaka database)
5 Matrix into which the biochar was mixed (compost, manure, feed, cement etc.)
6 Location of the C-sink (vector file of field location; for fields < than 1000 m2 one GPS point per field is sufficient, for C-Sink Networks and C-Sink Villages only the vector file of the network and village, respectively, is needed)
7 Amount of biochar applied in tons (dry matter tons)
8 Date of application
9 Owner of the C-sink site (name, address, birth date – not necessary for C-Sink Network and C-Sink Village)
10 C-sink project design document
11 Validation report of the validation body
12 Verification report of the verification body
13 Monitoring plan of the operation
14 Confirmation of the compensation of the emission portfolio of the biochar

5.1. Calculation of C -sink

The C-sink is registered in the Global C-sink Registry.

Based on the Global Artisan C-Sink standard, the calculation of the C-sink at day of application is:

$$[C(year\ =\ 0)] = [dry\ mass\ of\ biochar\ applied] * [C\ content] - [security\ margin]$$

However, every biochar C-sink underlies a time-dependent evolution, and the C-sink is a measure of the mass of carbon that is physically present in the C-sink matrix at any given moment in time since the establishment of the C-sink. The size of a biochar C-sink is, thus, a function of the type of biochar determining its specific persistence in a specific C-sink matrix and the time since the application to the C-sink matrix.

$$C\ -\ sink(year) =\ C\ -\ sink(year\ =\ 0)\ *\ specific\ persistence\ (year)$$

5.1.1. Geological C-sink

According to the Global Artisan C-Sink standard, Biochar made in a Kon-Tiki or TLUD reach highest treatment temperatures above 650°C and present an H/Corg ratio well below 0.4,

indicating a PAC fraction of at least 75% when applied to soil. Certified artisan biochar is, therefore, registered with a PAC-fraction of 75% and SPC fraction of 25% in the Global C-Sink Registry.

The remaining carbon for soil-applied biochar is calculated with the following conservative approximation:

$$C_{remain}(years) = \frac{M_{BC} * C_{Content}}{1000} * \left(750 + 45 * e^{-0.5232 * years\ of\ decay} + 205 * years\ of\ decay\right)$$

For the compensation of the GHG emissions within the system boundaries, only the PAC fraction is used.

6. Public consultation

During public consultation the following comments were raised:

Comment	Was comment taken into account (Yes/ No)?	Explanation/ justification (Why? How?)
xx	xx	xx
xx	xx	xx

7. Annexes

7.1. Producer lists and GPS coordinates *)
7.2. Sample contract between Artisan C-Sink Manager and Artisan Biochar Producer (Make sure to add the clause of the ownership/ transfer of the C-Sink)
7.3. Internal training protocol
7.4. Sampling Plan (Refer to section 15 of the standard)
7.5. Additional information on methane compensation through growing additional biomass/ Certificate as Tree C-Sink Manager.
7.6. Screenshot of SPC online calculator with description and explanation.
7.7. Acceptance letter from Carbon Standards International and Example of Declaration of honour for cease open field burning *)
7.8. Acceptance letter from Carbon Standards International and flow chart of current practices for methane compensation through avoiding GHG-emissions from biomass decomposition *)
7.9. Blueprint of the Internal Control System (ICS) *)
7.10. Template Internal Inspection Report
7.11. Social responsibility declaration *)