Project Design Document

Name of project:	Ghanaian Carboneers
	Carboneers United B.V. ("Carboneers") and Beyond Karbon
Date of issue:	26.08.2024
Methodology:	Global Artisan C-Sink 2.1
Project location:	Upper West and Volta regions, Ghana
Project start date:	06-04-2024
Project period:	The project has no end date, but it is verified on an annual basis
Project summary:	

Carboneers and Beyond Karbon work with smallholder farmers in the Upper West and Volta region of Ghana to produce biochar from agricultural waste using soil pit flame curtain pyrolysis, which is then mixed with compost or manure and applied to the same and neighboring fields. The project, certified under the Global Artisan C-Sink Standard, has the capacity to sequester up to 50.000 tons of CO2 annually, with each ton sequestered generating one carbon credit.

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 corn stalks, sorghum stalks, peanut stalks, millet stalks, cacao pod husks and corn cobs do not constitute a long-term carbon reservoir and is traditionally burned in the field in the baseline scenario (or left to rot in the case of cacao pod husks, creating phytosanitary issues and methane emissions).

In the initial 5 years of the project we expect long term durable carbon sequestration of up to 208.000 tons of CO2eq in total or 41.000 tons CO2eq / year.

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1. Purpose and general description of project

The project Ghanaian Carboneers comprises 128 Artisan Pro Biochar Producers for biochar production from corn stover (corn stalks, leaves and cobs left after harvest), sorghum stalks, peanut stalks, millet stalks, and cacao pod husks*.* Biochar is a hyper versatile material with an increasing number of applications in agriculture, environmental engineering, and basic industry. Biochar applied to 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 corn stover, sorghum stalks, peanut stalks, millet stalks, and cacao pod husks do not constitute a long-term carbon reservoir.

Carboneers' project demonstrates strong additionality by replacing open-field biomass decay or burning with biochar production in areas previously lacking carbon removal practices. This shift not only sequesters carbon but also significantly reduces methane emissions. The project's dual impact of direct carbon removal and emission prevention clearly illustrates its additionality, delivering substantial climate benefits where none existed before.

Another objective of the project is to improve the soil quality in the Volta and Upper West regions of Ghana by marketing biochar as soil amendment. Biochar can improve soil quality significantly because of its impact on the soil pH, its water retention capacity, and its ability to store nutrients.

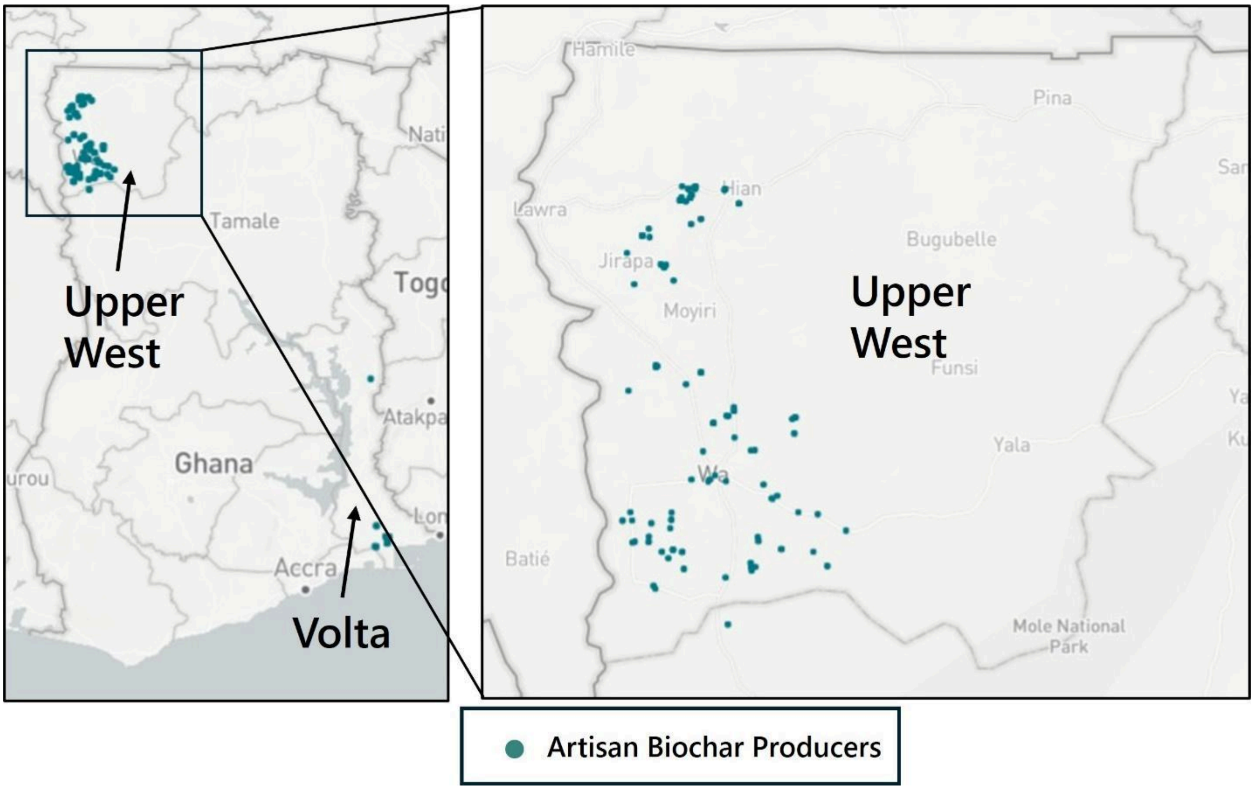
The biochar is then used as an effective C sink, with farmers mixing it 50/50 by volume with cow manure or compost before applying it to their fields, ensuring long-term carbon sequestration in the soil and added soil fertility co benefits.

The monitoring and tracking of this project will be carried out by Carboneers and Beyond Karbon. The project has an internal monitoring mobile app (Biochar+ from Plant Village created by The Pennsylvania State University, USA) that is used by the ground monitoring team consisting of supervisors, managers, and general managers to monitor, report and verify biochar production and carbon sequestration.

1.1. Project location

Volta and Upper West regions of Ghana
The project employs a centralized but distributed approach, utilizing soil pit flame curtain pyrolysis directly in the villages and on farms where agricultural biomass is produced. This method allows farmers to convert their own biomass into biochar on-site, eliminating transportation needs and ensuring efficient resource use as well as local carbon cycles.

The geographical locations of the subsequently installed Biochar Artisan Producers will be documented in the dMRV tool. The geographical locations of the Biochar Artisan Producers are documented in the project’s dMRV system, the Biochar+ app from Plant Village at Penn State.



1.2. Stakeholders and partners involved

To execute a biochar project in the Global South, Carboneers always works together with a local implementation partner. In the case of the Ghanaian Carboneers project, the local implementation partner is Beyond Karbon. A company that has been working with farmers in Ghana and has experience in cookstove projects on the African continent. Alongside each other, Carboneers and Beyond Karbon work with a Canadian NGO, Meda, which has been working with local farming communities in Ghana for over a decade. Carboneers is the C-Sink Manager of the project, a certification that is provided by Carbon Standards International. This means that Carboneers has the final responsibility for sustainable, effective and high quality biochar and carbon credits production. A visual overview of the project structure is presented below.

Carboneers

Carboneers is responsible for:

- Registration of the project

- Contact with all stakeholders

- Writing the project, management plan; training plan

- On ground training of supervisors

- Checking data input from mobile application

- C-Sink registry

- Sales of carbon credit
- Payment of women groups
- Payment of supervisors
- Project supervision

Beyond Karbon

Beyond Karbon is the local implementation partner of the Ghanaian Carboneers project. Beyond Karbon, in

that role, is responsible for:

- Providing farmer and women groups
- Providing educated supervisors
- Providing a project manager that carries out internal control surveys
- First respondents in case of any issue
- Payment of the management team

MEDA

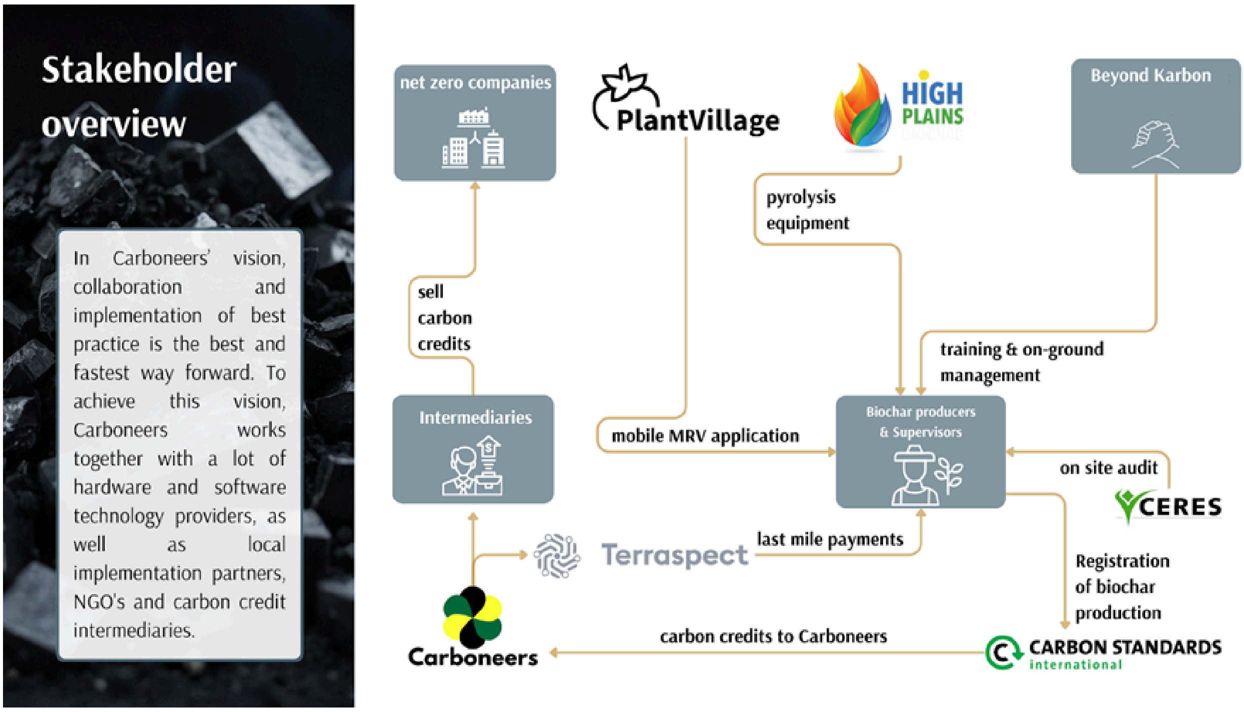
MEDA is a Canadian NGO that has been working with local farming communities in Ghana for over a decade. MEDA plays a crucial role in the project by providing women groups and a field manager, as well as being responsible for checking biomass availability.

The project emphasizes gender equality and youth empowerment, with at least 50% of beneficiaries being women and 50% being youth. In the northern part of Ghana, MEDA's focus on women's empowerment in agriculture aligns well with the project's goals.

MEDA's office serves as a central location where Carboneers trains all supervisors provided by Eroceht, along with MEDA's field manager and officers.

In the Upper West region, MEDA organizes women's groups consisting of community representatives who collectively own a financial account for biochar production payments.

These groups democratically decide how to spend their earnings, with many considering investing in groundnut shelling machines, which MEDA would partially fund in collaboration with Carboneers.



1.3. Description of baseline scenario

In the baseline scenario, farmers primarily used to burn the waste biomass in the open field or leave the biomass to decay. This caused significant release of CO2 and other greenhouse gases.

Additionality is a core principle of the project. Prior to our intervention, there were no carbon removal practices in the area. Instead, open-field burning was prevalent, resulting in significant methane emissions.

Upon joining our project, farmers sign a declaration of honour committing to cease open-field burning (Annex 7.3). Non-compliance results in project exclusion and loss of associated financial benefits. However, farmers retain the freedom to continue biochar production independently.

We have carefully assessed and mitigated potential indirect leakage. The biomass stream utilised was not previously employed for essential purposes such as cooking, thereby avoiding the risk of increased deforestation.

Open field burning comes with high emissions, of which methane is an important emission (See section 3.6 of this document and annex 7.2). In our farmer training we emphasise that optimal pyrolysis conditions depend on dry biomass, which farmers have dried out as much as possible with a maximum allowable moisture content of 15%. This should theoretically result in negligible methane emissions due to the gas's high flammability during the pyrolysis process.

While quantifying emissions from biomass decay is more challenging, it is well-established that uncontrolled decomposition leads to significant greenhouse gas emissions.

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 must be accounted and need to be adequately offset by registered carbon sinks.

Scope 1 and Scope 2 emissions as well as transport emissions from Scope 3 in connection with the production, processing and application of biochar for the creation of a C-sink.

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.

1.7. Additionality

Artisanal Biochar Producers do not generate income yet with biochar in most regions, there is no market for biochar-based fertilisers, 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 fertilisers. 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 fertilisers, 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 flame curtain pyrolysis 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.

Not all feedstock types are allowed within the Global Artisan C-Sink Standard. The restriction of eligible biomass for biochar production is explained by the intention to avoid by all means the overexploitation of ecosystems and the impairment of food security for the sake of C-sink maximation.

2. Ex-ante estimate of impact

See Annex 7.7 for detailed calculations.

Year of operation	Amount of feedstock (DM)	Amount of biochar produced (metric tons)	Established temporary C-sinks (tCO_2e)	Established permanent C-sinks (tCO_2e)
1	2352 ton	470.4	299	898
2	29411 ton	5882.2	3745	11235
3	73529 ton	14705.8	9363	28088
4	147058 ton	29411.6	18725	56176
5	294117 ton	58823.4	37451	112353
sum	546467 ton	109293	69583	208750

Temporay tCO2e = DM * (biochar yield ~20%) * (biochar C content ~70%) * (44/12) * (safety maring 98%) * (SPC 25%).

Permanent tCO2e = DM * (biochar yield ~20%) * (biochar C content ~70%) * (44/12) * (safety maring 98%) * (PAC 25%).

3. Technology and business cases

3.1. Artisan Biochar Producer

The C-Sink Farmer is an Artisan Biochar Producer who produces up to 100 m3 of biochar per year from residues of her/his farm and applies this biochar back to his/her soil. Exceptionally, biomass from neighbouring farms or debris can be used, and biochar can be sold to other farmers when correctly tracked. C-Sink Farmers are grouped in Artisan Networks with a maximum of 1000 participating farmers managed by an Artisan C-Sink Manager.

Carboneers is the C-Sink Manager of the project, a certification that is provided by Carbon Standards International. This means that Carboneers has the final responsibility for sustainable, effective and high quality biochar and carbon credits production.

In total there are 128 groups of which 99 are coming from the Upper West region and 29 are coming from the Volta region. All these groups are registered as biochar production locations.

Carboneers and Beyond Karbon will use the C-Sink Farmer framework in which an artisan biochar producer produces up to 100m3 of biochar per year from residues of her/his farm and applies this biochar back to his/her soil. Exceptionally, biomass from neighbouring farms or debris can be used, and biochar can be sold to other farmers when correctly tracked. C-Sink Farmers are grouped in Artisan Networks with a maximum of 1000 participating farmers managed by an Artisan C-Sink Manager.

The contract between the Global Artisan C-Sink Manager and Artisan Biochar Producers was presented to the Certifier.

3.1.1. Training of Artisan Biochar Producer

The Global Artisan C-Sink Manager proves how the Artisan Biochar Producers were qualified to produce high-quality biochar with low emissions. The Artisan Biochar Producer follows a biochar production training given by a qualified trainer and proves 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.

Participant Selection Process

The team structure consists of three tiers: General Managers at the top overseeing regional operations, Supervisors managing district or village-level activities, and Farmers producing biochar at the base. The on ground operation team is selected by both MEDA and Beyond Karbon. All team members undergo comprehensive orientation on operational procedures.

Farmer selection leverages the operations team's expertise, targeting experienced and motivated individuals who can serve as mentors for future participants. The enrollment process is guided by MEDA, Carboneers and Beyond Karbon. This includes a thorough training, project briefing and data collection, with farmers and supervisors signing a contract.

Training Program

The training program encompasses all team members, from General Managers to Farmers. It employs a multi-faceted approach combining classroom sessions and field training. The curriculum focuses on four key areas: biomass preparation, fire management, quality control, and supervision.

In biomass preparation, participants learn proper storage and drying techniques, with a target moisture content below 15%. Fire management training covers controlled pyrolysis techniques and flame curtain maintenance. Quality control education helps team members assess biochar quality and understand factors affecting carbon sink efficiency. Supervision training emphasises constant oversight during production and strict adherence to guidelines.

The program's effectiveness is evaluated through regular knowledge and performance tests, with feedback collected to drive continuous improvement. The underlying philosophy is to empower participants with practical skills that maximise the impact on climate change mitigation.

Monitoring System

Supervisors play a crucial role as internal auditors. They schedule production appointments with farmers, oversee biochar production and application, and handle data entry via the Plant Village mobile app. This approach ensures accurate documentation and prevents conflicts of interest.

General Managers have broader responsibilities, including overall program management, team leadership, and communication. With approval of Carboneers and Beyond Karbon, they have the authority to add or remove team members and farmers, and are responsible for ensuring compliance with Global Artisan C-Sink Guidelines. Their duties also include supervising and supporting supervisors, overseeing operations, resolving issues, and reviewing and approving data submissions.

Data integrity is paramount in this system. Once data is submitted, it cannot be edited. If a batch is incorrect, it can only be deleted, not modified. The review process conducted by General Managers ensures adherence to guidelines and allows for analysis of supervisor performance, contributing to the overall quality and effectiveness of the biochar production program.

3.2. Feedstock

In the project the following feedstocks are corn stover (stalks, cobs and other harvest residues), sorghum stalks, millet stalks, and cacao pod husks are used.

Biomass waste streams that will be used for the production of biochar in the North Western region will initially be corn stover, sorghum stalks and millet stalks. In the Volta region, biochar will be produced with cacao pod husk. All biomass that is being used, is not considered valuable at the point of writing. It is left out for decay or uncontrollably burned to get rid of it. With the entrance of the project, artisans will sign a declaration of honour that declares open field burning will not be performed any longer (Annex 7.3). Appointed internal supervisors visit artisanal farmers regularly to inspect that only sustainably biomass sources are used to create biochar. All biomass is collected by the groups and is processed by the leader of that group, who will be trained to sustainably and correctly convert biomass to biochar with flame curtain pyrolysis.

All biomass does not travel a greater distance than 10 kilometres to the biochar production location. By limiting farmers and villages to produce a maximum of 15 tons of biochar per year it is ensured that only sustainably sourced biomass is used. To increase total project production, the number of farmers is increased, not the production per group. This is a more social and more environmental approach in the eyes of Carboneers. We are planning to establish hulling stations for the smallholder farmers so they don't need to do the hulling by hand. In that case, we will reassess the project and biomass amount per hulling station.
Origin of feedstocks; all feedstocks are derived from their own village and agricultural fields.

Control of Methane emission during storage:

To avoid methane emissions during biomass storage, the following principles must be followed:

1. Use only dry feedstock:
    - Do not use freshly cut biomass or material from rain-exposed piles.
    - Store feedstock in well-ventilated, rain-protected areas.
2. Proper stacking of wet feedstock:
    - If the feedstock is wet, do not pile it higher than one meter.
    - Move the feedstock around every day.
    - This prevents self-heating, oxygen depletion, and anaerobic decomposition that produces significant methane.
3. Handling rain-exposed feedstock:
    - If feedstock gets wet from rain, spread it in thin layers for at least three days of sun drying.
    - Ensure the feedstock doesn't feel damp to the touch before use.
4. Enhanced moisture control measures:
    - Supervisors will use digital hygrometers to accurately check biomass humidity.
    - The target moisture content is below 15% with a maximum admissible moisture reading set at 15%.
    - Take an average of five measurements per cubic meter of feedstock using handheld moisture meters.
5. Benefits of new protocols:
    - Improved quality control and production efficiency.
    - Further reduction in methane emission risks during biochar production.

These rigorous moisture control measures and protocols ensure compliance with established guidelines and minimize the risk of methane emissions throughout the storage and production processes.

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 safety measures, such as marketing and labelling the biochar with the aim of becoming an C-sink we enter into agreements with farmers, committing them not to burn the biochar. Additionally, we provide comprehensive training on proper biochar application techniques, including correct charging and incorporation into their fields, and monitoring all distribution channels 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)

Our biochar production method uses soil pit flame curtain pyrolysis, an efficient and low-cost technique based on the Kon-Tiki method. This process involves creating biochar layer by layer in a pit dug directly into the soil.

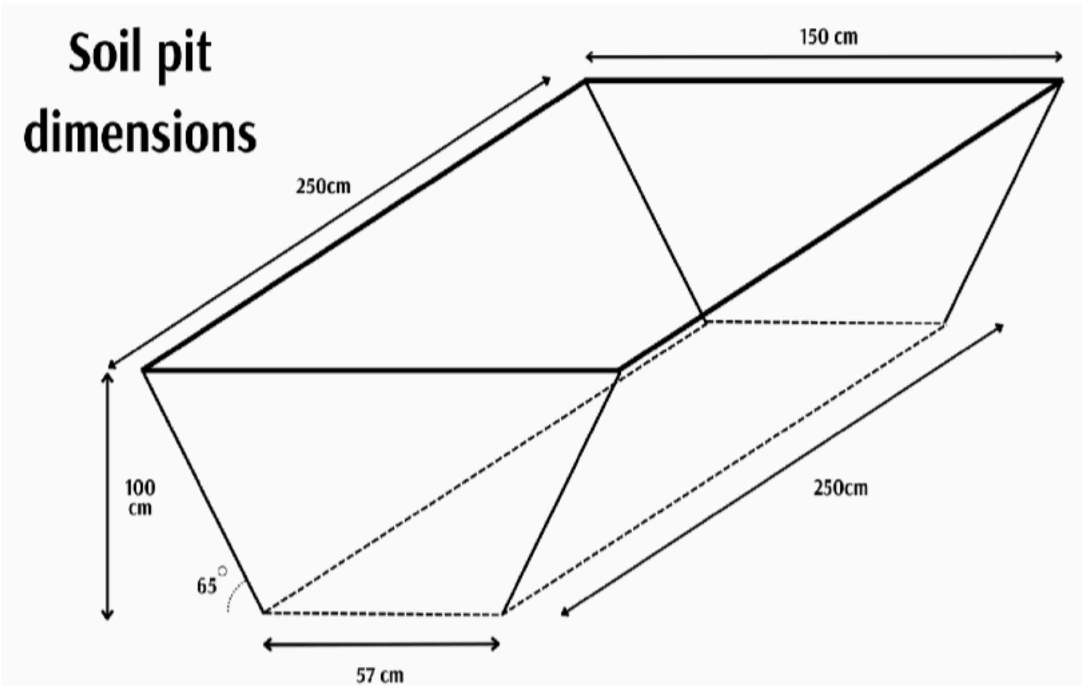
The process begins by igniting a fire at the bottom of the pit. Once embers form a base layer, a thin layer of biomass is added on top. This biomass quickly heats and begins to release pyrolysis gases. These gases are captured by the flame curtain above and combust with air entering from the top of the pit.

As each layer of biomass carbonizes, indicated by ash appearing on its surface, another thin, evenly spread layer of fresh biomass is added on top. This new layer is heated by both the flames above and the hot, pyrolyzing layers below, initiating its own pyrolysis process.

The flame curtain serves two purposes: it shields the underlying biochar from oxygen while also cleanly burning all pyrolysis gases and smoke as they pass through this hot fire front. This layering process continues until the soil pit is filled to the desired level with biochar.

To conclude the process, the biochar is either quenched with water or smothered with a layer of soil to stop the pyrolysis process. This soil pit method aligns with goals of sustainable, low-tech biochar production that can be easily implemented by local farmers with minimal equipment requirements.

The dimensions of the soil pit are important. The angle of the sides allows the biogases to roll upwards and burn above the fire, and the pit's depth ensures minimal wind effect on the fire's steadiness. When the pit is too shallow, wind can disrupt the flame curtain and allow biogases to escape. The pit's length can be extended into a trench shape for larger batches, but the width and depth should remain consistent.



Soil pits create the same pyrolysis environment as Kon-Tiki kilns, using flame curtain pyrolysis. The process begins with a small fire of dried stalks to generate initial heat. Then, thin layers of biomass are systematically and evenly added manually. Gases escaping the biomass due to heat burn over it, protecting it from external oxygen while radiating heat that chars the biomass below. Just before ash forms on the biochar, a new biomass layer is added to protect the earlier material from fully burning out. This new layer provides fresh biogas to maintain a steady, hot, and stable fire.

The fire can be distributed and controlled with a rake or hoe. Artisans are trained to stabilise and control the fire to prevent smoke generation, which indicates unwanted methane emissions. As an additional control measure, each artisan's first batch is recorded and shared with Carbon Standards International and Carboneers for verification of proper pyrolysis.

A supervisor is present for each biochar batch to ensure correct production. During Carboneers' visits to the Upper West and Volta regions, managers, field officers, and producers are trained on smokeless biochar production. Field officers then train one individual per farming group on biomass collection, storage, and biochar production and application.

Soil pit selection criteria include:

- Pits must not be near houses or vegetation.
- Sufficient space around the pit for biomass storage and movement.
- Excavated soil should not be piled next to the pit to prevent tripping hazards.
- The pit must be at least 100 centimetres deep for fire stability and wind protection.

- Three buckets of water or sand (15 liters) must be present before production starts for fire safety. Typically just one 15 liter bucket of water is needed so the extra 2 buckets are there for safety reasons in cases in which the fire spreads (which has not happened yet).




A new decentralised method is also being explored, using a combination of the established soil pit and a stainless steel chamber to enclose the system and provide more control of flue gases and pyrolysis conditions. This aims to increase pyrolysis efficiency and reduce methane emissions, in partnership with High Plains Biochar, an American low and mid-tech biochar equipment manufacturer[1]. If trials prove successful, plans include distributing this equipment to multiple farming communities to maintain a decentralised biochar production system while increasing efficiency, biochar yield, and reducing methane emissions.

3.4. Suitability of Artisan Biochar for Agriculture

Based on the Global Artisan C-Sink standard, Kon-Tiki biochar was extensively analysed 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 soil pit flame curtain

[1] https://www.hpbiochar.com/

pyrolysis. Therefore, biochar produced under the Artisan Standard are suitable for agricultural uses as they fulfil all requirements of WBC-Agro.

The sample plan was presented to Carbon Standards International.

3.5. Application and trade of biochar

Our biochar process is designed to be a closed-loop system within each farm, maximizing efficiency and sustainability. Farmers are responsible for the entire process: biomass collection, biochar production, charging, and application to their own fields.

After production, the biochar is immediately charged using manure or compost available on the farm on a 50/50 ratio by volume. This charging process enhances the biochar's beneficial properties. Once charged, the biochar is applied directly to the fields on the same farm where it was produced.

Throughout this process, our supervisors closely monitor each step using the Plant Village app to collect evidence and data. For every batch, a supervisor oversees the production process, capturing photos of the biomass, the biochar production, the charging process with local organic materials, and the final quantities produced. In a subsequent visit, the supervisor documents the application of the charged biochar to the farm's soil.

All photographic evidence is geotagged and timestamped, allowing us to cross-reference the location with the registered farmer's details. This data is then uploaded to the Plant Village database, where it's accessible to scientists, Plant Village personnel, and other project developers within the ecosystem.

Before the charged biochar is cleared for soil application, we thoroughly verify all collected data and images. Once verified, the supervisor's app is updated, allowing them to oversee and document the final step of applying the farm-specific, charged biochar to the fields.

This integrated, on-farm approach ensures that each batch of biochar is optimized for the specific soil conditions of the farm where it's produced and used, maximizing its benefits for soil health and crop productivity.

The following applications are possible for this project:

- Geological C-sink (biochar applied to soil)

3.6. Methane emissions compensation

Offsetting methane emissions with the SPC-fraction of biochar

The global warming effect of methane emissions caused by a Kon-Tiki or TLUD can at least partly be offset by the global cooling effect of the first 20 years of the SPC fraction. To calculate it correctly, the annual global cooling of the SPC for each of the first 20 years must be summed-up and match the GWP100 of the CH_4 emission to be compensated.

The global warming effect of methane emissions caused by a Kon-Tiki or TLUD can at least partly be offset by the global cooling effect of the first 100 years of the SPC fraction. To calculate it correctly, the annual global warming potential effect has to be calculated for the first 100 years using a factor of 27 (average non fossil methane 100-year global warming potential value from the latest IPCC report)[2] and a 3.6 kg/ton of biochar benchmark for production emissions[3].

GWP100 for 1 ton of biochar = 0.0036 tons CH_4 × 27 CO_2eq/ton CH_4 = 0.097 tons CO_2eq for 1 ton of biochar

However, since only the biochar carbon sink potential beyond 1000 years (75% of the biochar fraction) is traded in the voluntary carbon credit market, we can use the 25% fraction of the biochar that still has a carbon removal potential over the first 100 years.

For the calculation of Carbon removed by the SPC fraction of the biochar produced we use the following example:

1. 1 ton of biochar (usually around 70-80% Carbon content) ≈ 0,75 tons of carbon

2. CO2 removed = Carbon content × Conversion factor CO2 removed (44/12) = 0,75 × 3,67 = 2,75 tons

3. Therefore, 1 ton of biochar = 2,75 tons of CO2 removed.

And the SPC fraction (25%) of that would be:

4. 1 ton of biochar = 2,75 tons of CO2 removed * 0,25 = 0,68 tons of CO2eq removed

Thus, the SPC fraction of the biochar, stable for at least 100 years but most likely anywhere from 100 to 1000 years outweighs the 100 year global warming potential from the project over the first 100 years (0,68 tons removal > 0,097 tons emitted)

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 contribute to global warming and are harmful for communities around the burn sites. Besides significant emissions of particulate matter that cause smog (the main reason for air pollution in urban centres, methane and carbon monoxide emissions are very high due to the uncontrolled combustion of mostly wet or

[2] Forster, P., T. Storelvmo, K. Armour, W. Collins, J.-L. Dufresne, D. Frame, D.J. Lunt, T. Mauritsen, M.D. Palmer, M. Watanabe, M. Wild, and H. Zhang, 2021: Chapter 7: The Earth's Energy Budget, Climate Feedbacks, and Climate Sensitivity. In https://www.ipcc.ch/report/ar6/wg1/ [Masson-Delmotte, V., P. Zhai, A. Pirani, S.L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M.I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T.K. Maycock, T. Waterfield, O. Yelekçi, R. Yu, and B. Zhou (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 923–1054, doi:10.1017/9781009157896.009.
[3] Gerard Cornelissen, Erlend Sørmo, Ruy Korscha Anaya de la Rosa, Brenton Ladd, Flame curtain kilns produce biochar from dry biomass with minimal methane emissions, Science of The Total Environment, Volume 903, 2023, 166547, ISSN 0048-9697, https://doi.org/10.1016/j.scitotenv.2023.166547.

humid residues. Based on the 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. A declaration of honor was submitted to Carbon Standards and approved. Including a list of which feedstocks are eligible for this option.

Corn Stover

The reference for this project will be corn stover, a combination of the stalk and other residues left behind after harvest, a very common feedstock in the Upper West region:

1. To produce one ton of biochar, 5 tons of feedstock are used (yield of 20%).
   a. 1 / 0,2 = 5 tons of feedstock

2. BURNING[4]: For 5 tons of corn stover, assuming 50% of it is burned (2.5 ton):

   a. **CO2**: Approximately 1756.5 kg of CO2 is released per one tonne of corn stover burned
      i. 1.7565 tons CO2 * 2.5 = 4.391 tons CO2 for 2.5 tons of biomass burned

   b. **CH4**: Approximately 1.75 kg of CH4 is released per one tonne of corn stover burned
      i. GWP100 = 0.00175 * 27 (kg CO2-eq/ton biochar produced) = 0.04 tons CO2eq per 1 ton of burned corn stover.
      ii. 0.04 * 2.5 = 0.1 tons CO2 eq for 2.5 tons of biomass burned

   c. **Nitrous Oxide (N2O)**: Approximately 2.59 kg of N2O are released per one tonne of burned corn stover with a global warming potential factor of 273.
      i. GWP100 = 0.00259 * 273 = 0.707 tons of CO2eq per 1 ton of burned corn stover.
      ii. 0.707 * 2.5 = 1.768 tons CO2 eq for 2.5 tons of biomass burned

   d. **Carbon Monoxide (CO)**: Approximately 54.495 kg of CO are released per one tonne of burned corn stover, with a global warming potential factor of 1.9
      i. GWP100 = 0.054495 * 1.9 = 0.104 tons of CO2eq per 1 ton of burned corn stover.
      ii. 0.104 * 2.5 = 0.260 tons CO2 eq for 2.5 tons of biomass burned.

   e. **TOTAL GWP100 from open field burning:**
      i. 4.391 + 0.1 + 1.768 + 0.260 = 6.52 tons of CO2 eq emitted for business as usual scenario of 2.5 tons burning of corn stover.

Excluding CO2 emissions because these are considered to be biogenic CO2, the final GWP100 for the open field burning of 2.5 tons of corn stover is 2.12 tons CO2 eq (0.1 + 1.768 + 0.260)

[4] Cao, G., Zhang, X., Wang, Y. and Zheng, F., 2008. Estimation of emissions from field burning of crop straw in China. Chinese Science Bulletin, 53, pp.784-790.

3. Comparing with the GWP100 from producing one ton of biochar (from the same 5 tons of corn stover feedstock)[5]

   a. **CO_2**: Approximately 3.6 tons of CO_2 are released per ton of biochar
   b. **CH_4**: Approximately 3.6 kg of CH_4 are released per ton of biochar
      i. GWP100 = 0.0036 * 27 = 0.097 tons CO2eq
   c. **N_2O**: Approximately 0.012 kg of N_2O are released per ton of biochar
      i. GWP100 = 0.000012 * 273 = 0.0003 tons CO2eq
   d. **CO**: Approximately 101 kg of CO are released per ton of biochar
      i. GWP100 = 0.101 * 1.9 = 0.192 CO2eq
   e. **TOTAL CO2eq GWP100 from biochar:**
      i. 3.6 + 0.097 + 0.0003 + 0.192 = 3.9 tons of CO2 eq GWP100 emitted by biochar production.

Excluding biochar production CO2 emissions because these are considered biogenic CO2, the final GWP100 for 1 ton of biochar from 5 tons of corn stover is 0.28 tons CO2 eq

Thus, starting with 5 tonnes of corn stover feedstock, the business-as-usual scenario in which half of the initial feedstock mass (2.5 tons) is burned in the field, the global warming potential over 100 years is 2.159 tonnes of CO2 eq. Meanwhile, using the same 5 tonnes of feedstock for biochar production yields a total GWP100 0.3 tonnes CO2 eq. **The difference between these values (2.12 - 0.28 = 1.84 GWP100 CO2 eq) indicates the project represents a significant reduction in global warming potential emissions** compared to the business-as-usual scenario in which around 50% of the biomass left after harvest is burned. The avoidance of potential emissions is seen by Carboneers as a co-benefit of the project and not valued or used as avoidance/ reduction credits.

Millet Stalks

Another reference feedstock for biochar production in the Upper West is Millet Stalk, commonly burned as well after harvest. Following a similar scenario, we find the emissions can be broken down as such:

1. To produce one ton of biochar, 5 tons of feedstock are used.
   a. 1 / 0.2 = 5 tons of feedstock

2. BURNING[6]: For 5 tons of millet stalks, assuming 50% of it is burned (2.5 ton):
   a. **CO_2**: Approximately 1613 kg of CO_2 is released per one tonne of millet stalks burned
      i. 1.613 tons CO2 * 2.5 = 4.033 tons CO2 for 2.5 tons of biomass burned

   b. **CH_4**: Approximately 2.7 kg of CH_4 is released per one tonne of millet stalks burned

[5] Gerard Cornelissen, Erlend Sørmo, Ruy Korscha Anaya de la Rosa, Brenton Ladd, Flame curtain kilns produce biochar from dry biomass with minimal methane emissions, Science of The Total Environment, Volume 903, 2023, 166547, ISSN 0048-9697, https://doi.org/10.1016/j.scitotenv.2023.166547.
[6] Das, B., Bhave, P.V., Puppala, S.P., Shakya, K., Maharjan, B. and Byanju, R.M., 2020. A model-ready emission inventory for crop residue open burning in the context of Nepal. Environmental Pollution, 266, p.115069.

i. GWP100 = 0.0027 * 27 (kg CO2-eq/ton biochar produced) = 0.07 tons CO2eq per 1 ton of burned millet stalks.
ii. 0.07 * 2.5 = 0.175 tons CO2 eq for 2.5 tons of biomass burned

c. **Nitrous Oxide (N2O)**: Approximately 2.5 kg of N2O are released per one tonne of burned millet stalks with a global warming potential factor of 273.
i. GWP100 = 0.0025 * 273 = 0.683 tons of CO2eq per 1 ton of burned millet stalks.
ii. 0.683 * 2.5 = 1.708 tons CO2 eq for 2.5 tons of biomass burned

d. **Carbon Monoxide (CO)**: Approximately 36.4 kg of CO are released per one tonne of burned millet stalks, with a global warming potential factor of 1.9
i. GWP100 = 0.0364 * 1.9 = 0.069 tons of CO2eq per 1 ton of burned millet stalks.
ii. 0.069 * 2.5 = 0.173 tons CO2 eq for 2.5 tons of biomass burned.

e. **TOTAL GWP100 from open field burning:**
i. 4.033 + 0.175 + 1.708 + 0.173 = 6.09 tons of CO2 eq emitted for business as usual scenario of 2.5 burning of millet stalks

Excluding CO2 emissions because these are considered biogenic CO2, the final GWP100 for millet stalks is 2.05 tons CO2 eq

3. Comparing with the GWP100 from one ton of biochar (from the same 5 tons of millet stalks feedstock)[7]

a. **CO2**: Approximately 3.6 tons of CO2 are released per ton of biochar
b. **CH4**: Approximately 3.6 kg of CH4 are released per ton of biochar
i. GWP100 = 0.0036 * 27 = 0.097 tons CO2eq
c. **N2O**: Approximately 0.012 kg of N2O are released per ton of biochar
i. GWP100 = 0.000012 * 273 = 0.0003 tons CO2eq
d. **CO**: Approximately 101 kg of CO are released per ton of biochar
i. GWP100 = 0.101 * 1.9 = 0.192 CO2eq
e. **TOTAL CO2eq emissions from biochar:**
i. 3.6 + 0.097 + 0.0003 + 0.192 = 3.9 tons of CO2 eq emitted by biochar production.

Excluding CO2 emissions because these are considered biogenic CO2, the final GWP100 for millet stalk 0.28 tons CO2 eq

Thus, starting with 5 tonnes of millet stalks feedstock, the business-as-usual scenario in which half of the initial feedstock mass is burned in the field, the global warming potential over 100 years is 2.05 tonnes of CO2 eq while using those 5 tonnes of feedstock for biochar production yields a total GWP100 0.28 tonnes CO2 eq. **The difference between these values (2.05 - 0.28 = 1.77 tons GWP100 CO2 eq) indicates the project represents a significant reduction in global warming potential emissions compared to the business-as-usual scenario** in which around 50% of the biomass left after harvest is burned.

[7] Gerard Cornelissen, Erlend Sørmo, Ruy Korscha Anaya de la Rosa, Brenton Ladd, Flame curtain kilns produce biochar from dry biomass with minimal methane emissions, Science of The Total Environment, Volume 903, 2023, 166547, ISSN 0048-9697, https://doi.org/10.1016/j.scitotenv.2023.166547.

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. 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.

In the Volta region, The growing production of cocoa has led to a significant waste management challenge, particularly concerning cocoa pod husks and tree trimings. If these are evenly distributed in the fields, not close to cocoa tree roots, these can be beneficial to the cocoa trees, adding organic matter to the soil. However, when not properly treated and left to decompose in piles, this waste becomes a substantial source of methane, a potent greenhouse gas that contributes to climate change[8] (methane's greenhouse effect is 80 times more potent over the first 20 years than carbon dioxide).

For every ton of dry beans produced, approximately 10 tons of wet cacao pod husk are generated, often left to decompose on the ground[9]. Cocoa pod waste in Ghana has been responsible for an average annual greenhouse gas emission of approximately 10.4 million tonnes of carbon dioxide equivalent, with projections suggesting that this figure could potentially increase twofold, reaching around 19.5 million tonnes of carbon dioxide equivalent by the year 2030[10].

This practice can also lead to the leaching of highly bioavailable heavy metals like cadmium into the topsoil where most of the roots are located[11]. Likewise, leaving cocoa pod husk to decompose in the field also creates ideal conditions for the proliferation of fungi and potential pathogens[12]

Emissions reductions of cocoa production

Residue decomposition contributes 25% of the cocoa carbon footprint in Ghana, the second contributor after land use change emissions[13]. By managing residues, the footprint can be significantly reduced. Though not accurate methane emissions have been reported

[8] Antwi, E., Engler, N., Narra, S., Schüch, A. and Nelles, M. (2019). Environmental effect of cocoa pods disposal in 3 West African Countries. In *13th Rostock Bioenergy Forum Proceedings; Rostock University: Rostock, Germany*

[9] de Souza Vandenberghe, L.P., Valladares-Diestra, K.K., Bittencourt, G.A., de Mello, A.F.M., Vásquez, Z.S., de Oliveira, P.Z., de Melo Pereira, G.V. and Soccol, C.R., 2022. Added-value biomolecules' production from cocoa pod husks: A review. *Bioresource Technology*, *344*, p.126252.

[10] Antwi, E., Engler, N., Narra, S., Schüch, A. and Nelles, M. (2019). Environmental effect of cocoa pods disposal in 3 West African Countries. In *13th Rostock Bioenergy Forum Proceedings; Rostock University: Rostock, Germany*

[11] Guarín, D., Martín-López, J. M., Libohova, Z., Benavides-Bolaños, J., Maximova, S. N., Guiltinan, M. J., ... & Drohan, P. (2024). Accumulation of cadmium in soils, litter and leaves in cacao farms in the North Sierra Nevada de Santa Marta, Colombia. *Geoderma Regional*, 36, e00762.

[12] Arthur, R., Baidoo, M. F., & Antwi, E. (2011). Biogas as a potential renewable energy source: A Ghanaian case study. Renewable energy, 36(5), 1510-1516.

[13] WFLDB (3.7.1) country-specific emission factors (EFs)

for the decomposition of cocoa pod husks left in the field, some estimations can be made based on existing literature.

Estimations from published scientific literature

In the baseline scenario where some cacao pod husks are left to decompose in the field, the following greenhouse gases (GHGs) and associated emissions are considered (these values are estimations based on soil temperature, lignin, cellulose and hemicellulose contents and decomposition rates as no emissions have been reported in the literature as of 2024):

Carbon Dioxide (CO2)

Released as microorganisms break down the organic matter in cacao pod husks.

1. Cacao pod husk composition[14]:
Cellulose: 41%
Hemicellulose: 14%
Lignin: 33%
Other contents: 12%
Total easily decomposable material: 55%

2. Theoretical maximum CO2 emissions:
1 ton cacao pod husks = 410 kg cellulose + hemicellulose
If fully decomposed: ~600 kg CO2

3. Actual decomposition rate:
67% decomposition in 12 months[15]

Assuming a 67% decomposition in the first year, that equals **402 kg CO2 per ton of cacao pod husks (even though this would be considered biogenic CO2).**

Adjusting for real-world conditions, considering incomplete decomposition and soil incorporation of labile Carbon, we estimate emissions of 350-450 kg CO2 per ton in the first year of cacao pod husks left in the field to decompose.

Methane (CH4)

Once again, considering reported values of cacao pod husk composition: Cellulose: 41% Hemicellulose: 14% Total easily decomposable material: 55%

Methane production potential: Methane is produced under anaerobic conditions. Assuming 1-5% of decomposed carbon becomes methane (conservative estimate based on typical soil conditions)

[14] Hozman-Manrique, Ana Sofia, Andres J. Garcia-Brand, María Hernández-Carrión, and Alicia Porras. 2023. "Isolation and Characterization of Cellulose Microfibers from Colombian Cocoa Pod Husk via Chemical Treatment with Pressure Effects" *Polymers* 15, no. 3: 664. https://doi.org/10.3390/polym15030664
[15] Hougni, D.G.J., Schut, A.G., Woittiez, L.S., Vanlauwe, B. and Giller, K.E., 2021. How nutrient rich are decaying cocoa pod husks? The kinetics of nutrient leaching. *Plant and Soil*, *463*, pp.155-170.

Carbon content estimation: Assuming ~45% carbon in cellulose and hemicellulose 1 ton cacao pod husks = 410 kg cellulose + hemicellulose

Carbon available = 410 kg × 45% = 184.5 kg

First-year decomposition: 67% decomposition in first year (from previous estimate) Carbon decomposed = 184.5 kg × 67% = 123.6 kg

Methane production estimate: 1-5% of decomposed carbon becomes methane

Methane carbon = 123.6 kg × (1% to 5%) = 1.24 to 6.18 kg

Converting carbon to methane mass: Molecular weight ratio of CH_4 to C is 16:12

Methane produced = (1.24 to 6.18 kg) × (16/12) = 1.65 to 8.24 kg CH_4 per ton of cacao pod husks

The 100 years GWP of these emissions would be

GWP100 = [0.0012 to 0.0062] * 27 (kg CO_2-eq/ton biochar produced) = 0.032 to 0.167 tons CO_2eq for one ton of cacao pod husks left to decompose.

Nitrous Oxide (N_2O): Released during the decomposition of nitrogen-containing compounds in the cacao pod husks Has a high global warming potential

By converting cacao pod husks to biochar instead of allowing them to decompose, the project activity would potentially reduce these baseline GHG emissions. Biochar production would stabilize a significant portion of the carbon in the cacao pod husks, preventing its release as CO_2 during decomposition. Additionally, it would likely reduce CH_4 and N_2O emissions that occur during natural decomposition processes.

Furthermore, the application of biochar to soil will have an additional GHG mitigation effect. Biochar in the soil can prevent the leaching of plant available nutrients and release of GHGs (including inorganic-N leaching, N_2O emissions, and ammonia volatilization) from the decomposition of organic material already present in the soil at the moment of application[16].

Thus, biochar application not only removes carbon from the cacao pod husks but also helps to stabilize existing soil organic matter, providing a dual benefit in terms of GHG emission reduction.

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.

The production of biochar is monitored using the PlantVillage mobile application, developed by Penn State University under the leadership of David Hughes. (For a comprehensive

[16] Singh, B.P.; Hatton, B.J.; Singh, B.; Cowie, A.L.; Kathuria, A. Influence of biochars on nitrous oxide emission and nitrogen leaching from two contrasting soils. J. Environ. Qual. 2010, 39,1224–1235.

explanation of how the PlantVillage app works, you can watch David's video presentation https://www.youtube.com/watch?v=lmYSJC2-Urk&t=475s)

We have implemented a system involving managers, supervisors, and biochar-producing farmers. Farmers are responsible for biomass collection, biochar production, and soil application.

Supervisors oversee every step of the process using the PlantVillage app to collect evidence and data. For each batch, a supervisor visits the site to monitor the production process. They photograph the biomass, the production process, the quantity of biochar produced, and later, the application of biochar to the soil. Each photo is timestamped, dated, and geotagged.

The GPS location is cross-checked against the farmer's registered location. In the backend, we can see how far the photo was taken from the expected biochar production site.

Once the supervisor uploads the data to the PlantVillage database, we can check the status of biochar production and application. This data is accessible to all members of the PlantVillage ecosystem, including scientists, PlantVillage personnel, and other project developers.

Before the biochar is cleared for soil application, we verify the photos and data. Once verified, the information becomes available in the supervisors' app, allowing them to proceed with the final application step.

3.8. Planned business development

In 2024, the Carboneers Indian projects are expected to produce 45000 carbon credits. Introducing this new project in Ghana, with the key partnerships with local NGO's we have an ambitious goal to be able to grow to 1 million tons of durable CDR by 2026. To achieve this goal, we would have to develop 35 more projects in the coming two and a half years as each project is roughly limited to 25.000 tons of CDR annually. We are currently already making preparations for 3 more projects in India, 2 more in Ghana and one in Suriname. From start till end, with the right preparations, it takes roughly 3 months to set up an entirely new project. When we create new projects adjacent to our current projects in India and Ghana, this can be done within a month and with multiple projects in the same timeframe.

In Ghana, our projects are expanding rapidly, particularly in the cocoa sector. We are finalising partnerships with major chocolate companies this year, which will:

- Give us access to an extensive network of farmers
- Generate revenue to support and develop our projects

These successful collaborations are key to our growth and impact in the region.

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 the dMRV System Plant Village. The dMRV system is either provided by Carbon Standards or by an external MRV system provider. External MRV systems and tools must be endorsed by Carbon Standards annually. The data will be monitored as mentioned below.

Data required for C-sink calculations is entered into a dMRV (digital Measurement, Reporting, and Verification) system provided by PlantVillage from Penn State University.

Biochar Production Process:

1. Locally trained supervisors oversee each batch of biochar production.
2. Supervisors are present before, during, and after production.
3. Supervisors have exclusive access to the mobile application for registering soil pits and artisanal farmers.

Post-Production Handling:

1. Biochar is stored in Plant Village conformant standardized 20-liter bags that are distributed to participating farms. We record the number of bags delivered, as well as number of bags used vs unused.
2. Weight is determined based on the biomass source and previously analyzed bulk density of the corresponding biochar and the volume of the standardized bags.

Data Collection and Verification:

1. Supervisors provide production data and photographic evidence through the mobile application.
2. Each entry includes a time and geographic stamp.
3. Data is checked weekly by Carboneers via the application's backend.
4. Carboneers verifies that uploaded photos align with the volumes claimed by farmers and supervisors.

C-sink Calculation and Reporting:

1. Carboneers calculates the C-sink using data and formulas from the Global Artisan C-Sink guidelines.
2. After verification and calculation, biochar production and carbon sequestration potential data are shared monthly with Carbon Standards International.
3. Carbon Standards International maintains a C-Sink registry to prevent double counting.

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 Carboneers documentation and Plant Village App data logs and documentation
Proof of successful participation in an artisan biochar workshop	per year	Internal Carboneers documentation
Producers list	per year	Internal Carboneers documentation and Plant Village App data logs and 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 Carboneers documentation and Plant Village App data logs and documentation
Feedstock preparation	per feedstock type	Internal Carboneers documentation and Plant Village App data logs and documentation
Documentation of technology used	per Artisan Biochar Producer	Internal Carboneers documentation and Plant Village App data logs and documentation
Volume measuring device	per Artisan Biochar Producer	Internal Carboneers documentation and Plant Village App data logs and documentation
Definition of a production load	per production unit type	Internal Carboneers documentation and Plant Village App data logs and documentation

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 Carboneers documentation and Plant Village App data logs and documentation
GPS data of cultivated land	continuous	Internal Carboneers documentation and Plant Village App data logs and documentation
Crop rotation, harvest data, harvest amount	continuous	Internal Carboneers documentation and Plant Village App data logs and documentation
Total amount of feedstock (dry matter) used for the load	per load	Internal Carboneers documentation and Plant Village App data logs and documentation
Feedstock type	per load	Internal Carboneers documentation and Plant Village App data logs and documentation
Documentation of biochar making	per load	Internal Carboneers documentation and Plant Village App data logs and documentation
Amount of biochar produced	per load	Internal Carboneers documentation and Plant Village App data logs and documentation
Documentation of biochar mixing to matrix	per load	Internal Carboneers documentation and Plant Village App data logs and documentation
Amount of volume applied to each matrix	per load	Internal Carboneers documentation and Plant Village App data logs and documentation
Registration of biochar amount, date and location applied	per load	Internal Carboneers documentation and Plant Village App data logs and documentation
Receiver address/location when biochar (mix) is sold	per trade	Biochar is not sold by Carboneers or Beyond Karbon or is part of the project.

Other parameters that you measure	x	Carboneers will start measuring soil health benefits from biochar production. These include but are not limited to soil hydraulic conductivity, soil organic carbon, aggregate stability, and concentration of plant available nutrients (P, K, Mg, S), soil organic matter, soil particle size distribution and soil pH. Carboneers will also start conducting social impact surveys in which we will track the co benefits under the SDGs framework. The survey will track the benefits of participation in the carbon markets on gender equity, financial empowerment, access to technological and educational resources, better nutrition, and access to partnerships with global north stakeholders, among others.

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 realised with the registered permanent biochar C-sink whose production had caused the emission.

Parameter	**Monitoring frequency**	**Source of data**
Proof of compensation	annually	Internal Carboneers documentation

4.1.4. Production unit

☐	The production unit used in the project has a system certification, see system certification.
	The Kontiki/Soil pit is accredited by Carbon Standards. The mean methane emission for Kontiki/Soil pit is known to be 3.6 kg CH_4/t DM biochar produced[17].

[17] Gerard Cornelissen, Erlend Sørmo, Ruy Korscha Anaya de la Rosa, Brenton Ladd, Flame curtain kilns produce biochar from dry biomass with minimal methane emissions, Science of The Total Environment, Volume 903, 2023, 166547, ISSN 0048-9697, https://doi.org/10.1016/j.scitotenv.2023.166547.

	In a recent article by Cornelissen et al 2023, authors state that methane emissions from biochar production using biomass under 15% moisture content are much lower, at 0-3.6 grams of methane per kilogram of biochar[18]. Further readings of the moisture content of our feedstock will help refine the estimated methane emissions produced by our projects. Given the current Artisan Standard uses a 30kg CH4/ton of biochar produced reference, we will consider that as the project emissions reference, keeping in mind that this value is probably going to be much lower given our feedstock moisture measurements not surpassing 15%.

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	Gerard Cornelissen et al 2016

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	Carboneers Emission portfolio

4.1.6. Leakage emissions

The Global C-Sink Standard prohibits non-sustainable biomass cultivation, land use change and soil organic carbon depletion - thus, leakage in sense of carbon expenditure outside of the project boundaries is avoided as much as possible. It is assumed that activity shifts to biochar production causes only minimal leakage emissions.
For the Global Artisan C-Sink, the emissions from Scope 1 and 2 are fully recorded. As per project boundary, from Scope 3, only the emissions from biochar transport are directly quantified if the distance is more than 100 km. Other indirect emissions from Scope 3 are not recorded individually due to their comparatively low volume but are instead included in the calculation with a security margin.

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

To keep the certification procedures reasonably lean, Artisan Biochar Producers

[18] IBID.

are not required to provide a detailed account of these potential emissions, but a margin of security of 20 kg CO2e per ton of biochar (DM) is levied.

$$[security\ margin] = [produced\ biochar\ (t)] * \ 0.02\ (t\ CO2e\ per\ t\ biochar)$$

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 for methane emissions, the GWP100 of the emitted amount of non fossil methane is calculated using the factor 27 kg CO2eq per kg CH_4[19] . 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 = 27 CO_2eq[20]

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:

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

[19] Forster, P., T. Storelvmo, K. Armour, W. Collins, J.-L. Dufresne, D. Frame, D.J. Lunt, T. Mauritsen, M.D. Palmer, M. Watanabe, M. Wild, and H. Zhang, 2021: [Chapter 7: The Earth's Energy Budget, Climate Feedbacks, and Climate Sensitivity](). In https://www.ipcc.ch/report/ar6/wg1/ [Masson-Delmotte, V., P. Zhai, A. Pirani, S.L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M.I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T.K. Maycock, T. Waterfield, O. Yelekçi, R. Yu, and B. Zhou (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 923–1054, doi:10.1017/9781009157896.009.
[20] IBID

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

4.2. 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:

$$[C(year = 0)] = [dry\ mass\ of\ biochar\ applied] * [C\ content] * \frac{44}{12} - [security\ margin]$$

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.

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

4.2.1. Geological C-sink

According to the Global Artisan C-Sink standard, Biochar made in a soil pit flame curtain pyrolysis Kon-Tiki 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:

$[remaining\ C\ (year)] = [dry\ mass\ of\ biochar\ applied\ ]/1000 * Ccontent * (750 + 45 * e^{-0.5232 * year} + 205 * e^{-0.009966 * year})$

When C-sinks are sold to offset CO2 emissions only the PAC fraction must be used.
The SPC-fraction of biochar can be used for methane emission offsets.

No other matrixes other than soil are used

5. 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 Lab results

Lab results from biochar produced from cacao pod husk, corn cobs, sorghum, soy bean stalks and millet stalks in the Volta region of Ghana:

Ruhr Lab

Report

Customer:
Dutch Carboneers
Europaplein 83-4b
1078 GX, Amsterdam
The Netherlands

Ruhr Lab GmbH
Glückaufstraße 56
D-45896 Gelsenkirchen
Tel.: +49-152 310 685 19
info@ruhr-lab.de

Date 05.01.2024

Sample no.	**340119**	Reception	**02.01.2024**
Sample type	**Solid fuel**	Completion	**05.01.2024**
Description	**CACAO**		

	Place	Time	Standard
Sampling by customer			

Preparation	Date	Standard
Sample Preparation	**04.01.2024**	DIN 51701-3 (2006-09)

Standard Tests	Unit	ar	ad	d	daf	Standard
Total moisture	wt-%	**62,92**				DIN 51718 (2002-06)
Inherent Moisture	wt-%		**7,09**			DIN 51718 (2002-06)
Carbon (C)	wt-%	**22,01**	**55,14**	**59,35**		DIN 51732 (2014-07)
Hydrogen (H)	wt-%	**0,51**	**1,28**	**1,38**		DIN 51732 (2014-07)

Special Tests	Unit	Value	Standard
Bulk Density	kg/m^3	**400**	DIN EN ISO 17828 (2016-05)

CARBON STANDARDS international

ARTISAN C-SINK

Ruhr Lab

Report

DAkkS Deutsche Akkreditierungsstelle D-PL-21007-01-00

Ruhr Lab GmbH
Glückaufstraße 56
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Tel.: +49-152 310 685 19
info@ruhr-lab.de

Date 03.04.2024

Customer:
Dutch Carboneers
Europaplein 83-4b
1078 GX, Amsterdam
The Netherlands

Sample no.	**341862**	Reception	**27.03.2024**
Sample type	**Solid fuel**	Completion	**03.04.2024**
Description	**SOYA BEAN**		

	Place	Time	Standard
Sampling by customer			

Preparation	Date	Standard
Sample Preparation	**28.03.2024**	DIN 51701-3 (2006-09)

Standard Tests	Unit	ar	ad	d	daf	Standard
Total moisture	wt-%	**52,56**				DIN 51718 (2002-06)
Inherent Moisture	wt-%		**3,42**			DIN 51718 (2002-06)
Carbon (C)	wt-%	**24,15**	**49,17**	**50,91**		DIN 51732 (2014-07)
Hydrogen (H)	wt-%	**0,57**	**1,16**	**1,20**		DIN 51732 (2014-07)

Special Tests	Unit	Value	Standard
Bulk Density	kg/m^3	**360**	DIN EN ISO 17828 (2016-05)

The results refer exclusively to the examined test items, as received.
The use of the analysis report results in extracts is only permitted with the written permission of Ruhr Lab GmbH.

1 = not accredited, **2** = external outsourcing, **3** = Results from the customer
ar: as received, **ad**: as determined, **d**: dry, **daf**: dry and ash free

Daniel Haxter (Managing Director)

CARBON STANDARDS international

ARTISAN C-SINK

Ruhr Lab

Report

Customer:
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info@ruhr-lab.de
Date 03.04.2024

Sample no.	**341863**	Reception	**27.03.2024**
Sample type	**Solid fuel**	Completion	**03.04.2024**
Description	**SORGHUM**		

	Place	Time	Standard
Sampling by customer			

Preparation	Date	Standard
Sample Preparation	**28.03.2024**	DIN 51701-3 (2006-09)

Standard Tests	Unit	ar	ad	d	daf	Standard
Total moisture	wt-%	**6,54**				DIN 51718 (2002-06)
Inherent Moisture	wt-%		**3,98**			DIN 51718 (2002-06)
Carbon (C)	wt-%	**53,85**	**55,33**	**57,62**		DIN 51732 (2014-07)
Hydrogen (H)	wt-%	**0,28**	**0,29**	**0,30**		DIN 51732 (2014-07)

Special Tests	Unit	Value	Standard
Bulk Density	kg/m^3	**115**	DIN EN ISO 17828 (2016-05)

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ar: as received, **ad**: as determined, **d**: dry, **daf**: dry and ash free

Daniel Haxter (Managing Director)

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info@ruhr-lab.de
Date 05.01.2024

Sample no.	**340120**	Reception	**02.01.2024**
Sample type	**Solid fuel**	Completion	**05.01.2024**
Description	**MILLET STALKS**		

	Place	Time	Standard
Sampling by customer			

Preparation	Date	Standard
Sample Preparation	**04.01.2024**	DIN 51701-3 (2006-09)

Standard Tests	Unit	ar	ad	d	daf	Standard
Total moisture	wt-%	**72,72**				DIN 51718 (2002-06)
Inherent Moisture	wt-%		**7,44**			DIN 51718 (2002-06)
Carbon (C)	wt-%	**19,43**	**65,92**	**71,22**		DIN 51732 (2014-07)
Hydrogen (H)	wt-%	**0,69**	**2,33**	**2,52**		DIN 51732 (2014-07)

Special Tests	Unit	Value	Standard
Bulk Density	kg/m³	**150**	DIN EN ISO 17828 (2016-05)

The results refer exclusively to the examined test items, as received.
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1 = not accredited, **2** = external outsourcing, **3** = Results from the customer
ar: as received, **ad**: as determined, **d**: dry, **daf**: dry and ash free

Daniel Haxter (Managing Director)

Ruhr Lab

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Customer:
Dutch Carboneers
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1078 GX, Amsterdam
The Netherlands

Date 05.01.2024

Sample no.	**340118**	Reception	**02.01.2024**
Sample type	**Solid fuel**	Completion	**05.01.2024**
Description	**CORN STALKS**		

	Place	Time	Standard
Sampling by customer			

Preparation	Date	Standard
Sample Preparation	**04.01.2024**	DIN 51701-3 (2006-09)

Standard Tests	Unit	ar	ad	d	daf	Standard
Total moisture	wt-%	**67,55**				DIN 51718 (2002-06)
Inherent Moisture	wt-%		**8,54**			DIN 51718 (2002-06)
Carbon (C)	wt-%	**21,41**	**60,33**	**65,96**		DIN 51732 (2014-07)
Hydrogen (H)	wt-%	**0,57**	**1,60**	**1,75**		DIN 51732 (2014-07)

Special Tests	Unit	Value	Standard
Bulk Density	kg/m³	**110**	DIN EN ISO 17828 (2016-05)

The results refer exclusively to the examined test items, as received.
The use of the analysis report results in extracts is only permitted with the written permission of Ruhr Lab GmbH.

1 = not accredited, **2** = external outsourcing, **3** = Results from the customer
ar: as received, **ad**: as determined, **d**: dry, **daf**: dry and ash free

Daniel Haxter (Managing Director)

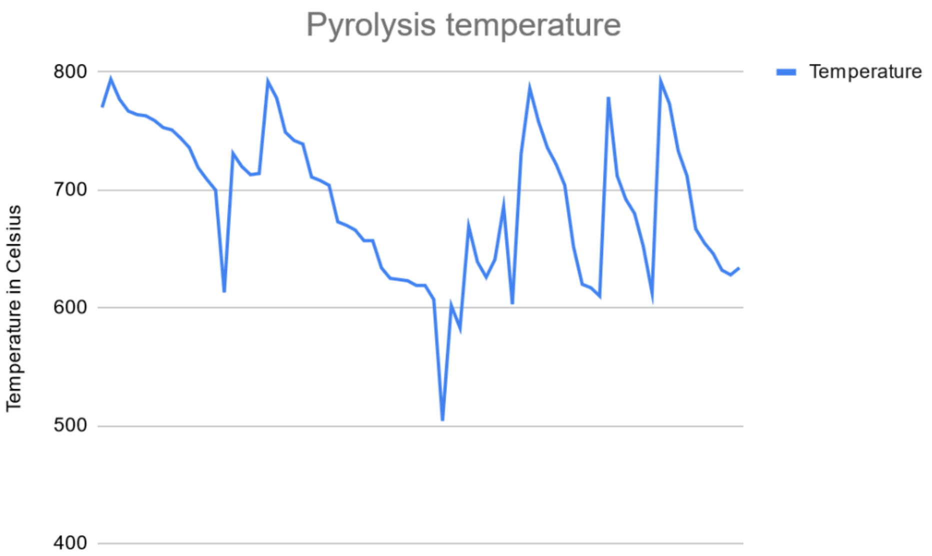
7.2 Pyrolysis Temperatures

Biochar production temperatures across 74 random measurements in different batches and different farms:

Measurement	Temperature °C	# of measurments	Average
1	770	74	690,3108108
2	794		
3	777		
4	767		
5	764		
6	763		
7	759		
8	753		
9	751		
10	744		
11	736		
12	719		
13	709		
14	700		
15	613		
16	731		
17	720		
18	713		
19	714		
20	792		
21	778		
22	749		
23	742		
24	739		
25	711		
26	708		
27	704		
28	673		
29	670		
30	666		
31	657		
32	657		
33	634		

34	625		
35	624		
36	623		
37	619		
38	619		
39	607		
40	504		
41	602		
42	583		
43	669		
44	639		
45	626		
46	641		
47	686		
48	603		
49	731		
50	786		
51	758		
52	736		
53	722		
54	704		
55	652		
56	620		
57	617		
58	610		
59	779		
60	712		
61	692		
62	680		
63	652		
64	613		
65	792		
66	773		
67	733		
68	712		
69	667		
70	655		
71	646		
72	632		
73	628		

74	634		



7.3 Biochar application guidelines

Biochar application guidelines

Biochar closely resembles charcoal in appearance and combustion properties, and is commonly used for cooking in many countries. This similarity poses a challenge: ensuring biochar is utilized as a carbon sink rather than as fuel. Our project implements several methods to guarantee proper usage, each requiring photographic evidence uploaded via a mobile application.

Preferred methods of application:

1. Mixing with manure (primary recommendation):
   - Reduces burning potential
   - Creates an effective carbon sink
   - Immediately enriches biochar with nutrients
2. Co-composting:
   - Decreases combustion risk
   - Enhances nutrient content
3. Direct soil application:

- Note: Initially, untreated biochar may temporarily absorb soil nutrients before releasing them later

We currently favor the manure-mixing method due to its simplicity and the region's abundant manure supply. However, we also accept direct field application and co-composting.

To promote adoption, we educate farming communities on biochar's benefits, including improved soil water retention and nutrient availability. This approach not only enhances agricultural productivity but also reduces the likelihood of biochar misuse as fuel.

7.4 Training Protocol

Training manuals

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 Plant Village+ smartphone app.

Participant Selection Process

The team structure consists of three tiers: General Managers at the top overseeing regional operations, Supervisors managing district or village-level activities, and Farmers producing biochar at the base. The on ground operation team is selected by both MEDA and Beyond Karbon. All team members undergo comprehensive orientation on operational procedures.

Farmer selection leverages the operations team's expertise, targeting experienced and motivated individuals who can serve as mentors for future participants. The enrollment process is guided by MEDA, Carboneers and Beyond Karbon. This includes a thorough training, project briefing and data collection, with farmers and supervisors signing a contract.

Training Program

The training program encompasses all team members, from General Managers to Farmers. It employs a multi-faceted approach combining classroom sessions and field training. The curriculum focuses on four key areas: biomass preparation, fire management, quality control, and supervision.

In biomass preparation, participants learn proper storage and drying techniques, with a target moisture content below 15%. Fire management training covers controlled pyrolysis techniques and flame curtain maintenance. Quality control education helps team members assess biochar quality and understand factors affecting carbon sink efficiency. Supervision training emphasises constant oversight during production and strict adherence to guidelines.

The program's effectiveness is evaluated through regular knowledge and performance tests, with feedback collected to drive continuous improvement. The underlying philosophy is to empower participants with practical skills that maximise the impact on climate change mitigation.

Monitoring System

Supervisors play a crucial role as internal auditors. They schedule production appointments with farmers, oversee biochar production and application, and handle data entry via the Plant Village mobile app. This approach ensures accurate documentation and prevents conflicts of interest.

General Managers have broader responsibilities, including overall program management, team leadership, and communication. With approval of Carboneers and Beyond Karbon, they have the authority to add or remove team members and farmers, and are responsible for ensuring compliance with Global Artisan C-Sink Guidelines. Their duties also include supervising and supporting supervisors, overseeing operations, resolving issues, and reviewing and approving data submissions.

Data integrity is paramount in this system. Once data is submitted, it cannot be edited. If a batch is incorrect, it can only be deleted, not modified. The review process conducted by General Managers ensures adherence to guidelines and allows for analysis of supervisor performance, contributing to the overall quality and effectiveness of the biochar production program.

Internal Control of Supervisors

To ensure supervisors are performing their tasks correctly, Carboneers checks all data incoming through the application. This is done in collaboration with Plant Village staff, and the information is accessible to anyone in the Plant Village ecosystem, allowing peers such as other project developers using Plant Village+, such as Biochar Life, to verify the data's accuracy.

In addition to online checks, on-site managers in both project areas conduct internal inspections. The objectives are to:

1. Ensure only correct biomass is used
2. Assess the skill of biochar producers
3. Check supervisors' data entry skills
4. Verify correct application of biochar to soils

Managers are equipped with moisture and temperature meters to test biomass dryness and monitor pyrolysis temperatures, ensuring high-quality biochar production and sustainable carbon sinks without unwanted methane emissions.

Conflict of Interest Avoidance

Supervisors and biochar producers are compensated differently to avoid conflicts of interest. As explained in the financial section, supervisors receive a monthly wage, while biochar producers are paid per ton of biochar produced. The manager, a key staff member of Beyond Karbon, doesn't receive additional funding for the project. It's the manager's responsibility to produce internal inspection reports and identify potential conflicts of interest between supervisors and producers.

Internal Control System

Internal inspection reports will reveal errors, especially in the early stages, which need to be addressed. Errors are categorized as either human errors or intentional errors. The manual will further explain how managers should respond to these errors.

The purpose of internal inspection reports is to detect errors and train individuals to improve. However, when fraud is detected, serious measures will be taken, and the offending women's group will be suspended from the system. The severity of the fraud will determine the length of the suspension.

Participating Villages

The entire system, including managers, supervisors, internal control, and the mobile application, applies to all farmers. The social structure is consistent across all villages, allowing for uniform implementation of the system. Participating villages were pre-selected based on feasibility for proper inspection by the team. Some villages are only accessible by motorcycle or on foot, not by car.

Internal Inspection Report

Our internal inspection report includes all key factors relevant to our conditions, in compliance with the Global Artisan C-Sink Standard. The mobile application forms the basis of the inspection report. As the application was developed internally, it's easy to control data input. If changes are needed to enhance security and transparency, they can be easily implemented. The goal is to develop a system with minimal human intervention and automatic data control.

In addition to data from the mobile application, managers continuously inspect various farmers and supervisors. Results from these inspections are shared monthly with Carboneers and Beyond Karbon. An annual inspection report detailing all system abnormalities will be produced and made available upon request.

Quality of Internal Inspection Reports

A strict manual guides managers in controlling supervisors and artisanal farmers. Standardizing checklists and internal reports ensures no aspect of the system is overlooked during inspections or communications with Carboneers and Beyond Karbon. As a control measure, managers' internal reports are cross-referenced with data from the mobile application. Any abnormal data from the application should be noted by managers in the weekly internal inspection report.

Follow-up on Internal Inspections, Corrective Actions, and Sanctions

Evaluation of Internal Reports and Non-Conformities

Data analysis generates error reports, which managers regularly monitor to initiate corrective actions. Errors are categorized into two types:

1. System errors (e.g., internet unavailability) and understandable human errors

2. Intentional errors

Intentional errors are taken seriously, with the specific individual flagged in the weekly internal report. After one year, the flag can be removed if managers deem the individual trustworthy.

Monthly internal reports are reviewed separately by Beyond Karbon and Carboneers. Subsequently, they meet to discuss the report's content and, if necessary, determine corrective measures to be executed by Beyond Karbon.

For human errors, strict repercussions aren't necessary after a single occurrence. However, the individual is flagged and monitored for three months. If no further incidents occur, the flag is removed. If another flag arises, a manager assesses whether the individual is suitable for the biochar production project. If not, the individual is removed from the program.

For intentional errors, the individual receives a personal warning from the manager. A period of stringent monitoring follows, and if another issue arises, the individual is removed from the program.

To streamline internal inspections, corrective actions, and sanctions, an annual meeting is held between managers, Beyond Karbon, and Carboneers.

Implementation of Sanctions

Sanctioned individuals are restricted from participation in two ways:

1. Technically: Their profile is blocked in the mobile application, preventing data input and rewards for biochar production.
2. Physically: The responsible manager personally meets with the individual to remove them from the program.

Handling of Complaints

Artisanal farmers can file complaints with their supervisor. To address potential complaints about supervisors, regular supervisor rotation is implemented. Complaints are forwarded to managers and incorporated into the monthly internal report. Supervisors can also file complaints with managers, which are likewise incorporated into the monthly internal report. All complaints are addressed and noted in person by the senior team involved in program implementation.

7.5 Farmer Contract and Declaration

Biochar production contract template between farmers and partners (Beyond Karbon and Carboneers)

Contract Agreement between Biochar Producer and Carboneers & Beyond Karbon

This contract is entered into between ...., hereinafter referred to as "Producer," and Carboneers and Beyond Karbon, collectively referred to as "Parties."

The purpose of this Contract is to establish an agreement outlining the responsibilities and commitments of the Producer in the sustainable acquisition, production, and application of biochar, as well as the Parties' mutual objectives regarding the utilization of biochar.

Responsibilities of the Producer:
The Producer acknowledges and agrees to:

- **Sustainable Biomass Acquisition**: Only agricultural biomass waste or trimmings can and shall be used by the biochar producer.
- **Biomass Drying Procedures**: Implement appropriate techniques for biomass drying to optimize biochar production efficiency and quality while minimizing environmental impact.
- **Biochar Production**: Utilize environmentally responsible methods for the production of biochar, according to training and documentation received.
- **Biochar Application**: Apply biochar to the soil following the recommended mixture with either manure or compost to maximize its beneficial impact on soil health.
- **Training Certification**: Confirm that the Producer has received adequate training and possesses the necessary expertise to fulfill the obligations outlined in this Contract.
- **Prevention of Uncontrolled Burning**: Commit to avoiding uncontrolled burning of agricultural biomass waste streams, prioritizing sustainable and controlled methods for biomass and biochar management.
- **Transfer of Rights**: The producer agrees to transfer the carbon rights to the Parties listed above.

Rights and Obligations of Carboneers & Beyond Karbon:
Carboneers & Beyond Karbon agree to:

- **Support and Collaboration**: Provide necessary training, tools, technology, support, resources, and collaboration to ensure the successful implementation of sustainable biochar production and application.
- **Monitor and Evaluation**: Conduct periodic evaluations and monitoring of the Producer's activities to verify compliance with the terms of this Contract.
- **Payment**: provide payment to the Producer for the production of biochar, measured in quantity of number 5 bags, with the rate of 72 cedi per number 5 bag once the biochar has been applied to the soil.

Biochar Producer	Field Manager	on behalf of Beyond Karbon & Carboneers
name:	name:	name: Berend de Haas
signature:	signature:	signature:

date:

7.6 Biochar Sampling Plan

Objective: To ensure consistent monitoring and quality control of biochar produced from different biomass species by systematically collecting and analyzing samples.

Sampling Procedure:

1. **Sampling Frequency:**
    - A sample of 500 milliliters of biochar will be collected every month
2. **Sampling Responsibility:**
    - The sampling will be conducted by all the designated supervisors overseeing the biochar production.
3. **Sampling Process:**
    - **Selection of the Batch:**
      Each month, the supervisor will select a production batch to take a sample from, the sample is randomly taken from the produced biochar.
    - **Collection of the Sample:**
      The supervisor will take a 500 milliliter sample of biochar from the selected batch. Care should be taken to ensure that the sample is representative of the entire batch.
4. **Labelling of Samples:**
    - Each sample must be labeled immediately after collection with the following information:
        - **Date of Sampling:** The exact date when the sample was taken.
        - **Biomass Source:** The specific biomass species from which the biochar was produced (e.g., rice straw, cotton stalks, corn cobs, cocoa pods).
5. **Sample Storage and Documentation:**
    - The collected sample should be stored in a clean, dry container that is sealed to prevent contamination, which in this case is a 500 milliliter drinking bottle.
    - The supervisor must document the sampling process, including the date, biomass source
    - The supervisor will send or deliver the sample with the manager.
6. **Sample preparations:**
    - The manager will mix all the samples that are derived from the same biomass species and take another 1 liter sample of the mixed pile. This is done for all biochars. The 1 liter samples are labeled and sent to an accredited laboratory

This plan ensures that biochar samples are collected consistently and systematically across different biomass sources, enabling accurate monitoring of biochar quality and adherence to project standards.

7.7 Ex Ante Calculations

Dry mass = tons of feedstock * 0.2

C content = Biochar weight * 0.7

Tons CO_2 eq = C content * (44/12)

Accounting for safety margin = Tons CO_2 eq * 0.98

SPC = Accounting for safety margin * 0.25

PAC = Accounting for safety margin * 0.75

Year	Tons Feedstock	Dry Mass of Biochar (tons)	C Content (tons)	tons CO2eq	Accounting for Safety Margin	SPC (tons CO2 eq)	PAC (tons CO2 eq)
1	2352	470.4	329	1207	1198	299	898
2	29411	5882.2	4118	15098	14980	3745	11235
3	73529	14705.8	10294	37745	37451	9363	28088
4	147058	29411.6	20588	75490	74902	18725	56176
5	294117	58823.4	41176	150980	149804	37451	112353
SUM	546467	109293	76505	280520	278334	69583	208750
							41750