

Project Design Document

Name of project: Carbon Sequestration and
Grassland Restoration in India

Name of C-Sink Manager: Varaha ClimateAg Pvt Ltd

Date of issue: 20.08.2024

Version of the PDD: Version 1.0

Methodology: Global Artisan C-Sink 2.1A



Project location: India

Project start date: 21.07.2023

Project period: The project has no end date, but it is verified on an annual basis

Project summary: 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 Prosopis Juliflora does not constitute a long-term carbon reservoir.

In the initial 5 years of the project we expect carbon sequestration of approximately 100,000 CO₂eq in total or 20,000 CO₂eq / year.

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1. Purpose and general description of the project

The project Carbon sequestration and Grassland Restoration in India comprises 50 Artisan Biochar Producers for biochar production from invasive wood of *Prosopis Juliflora*, cotton stalks, tea/coffee residue and crop residue of rice & maize.. Biochar is a versatile material with an increasing number of applications in agriculture, environmental engineering, and basic industry. Biochar applied 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 invasive wood of *Prosopis Juliflora*, cotton stalks, tea/coffee residue and crop residue of rice & maize. does not constitute a long-term carbon reservoir.

In India, invasive plant species tend to proliferate rapidly and in large numbers, disrupting local biodiversity and adversely affecting the local ecosystem. Because these species typically hold little economic value, their removal can contribute to the restoration of native biodiversity and enhance overall land health

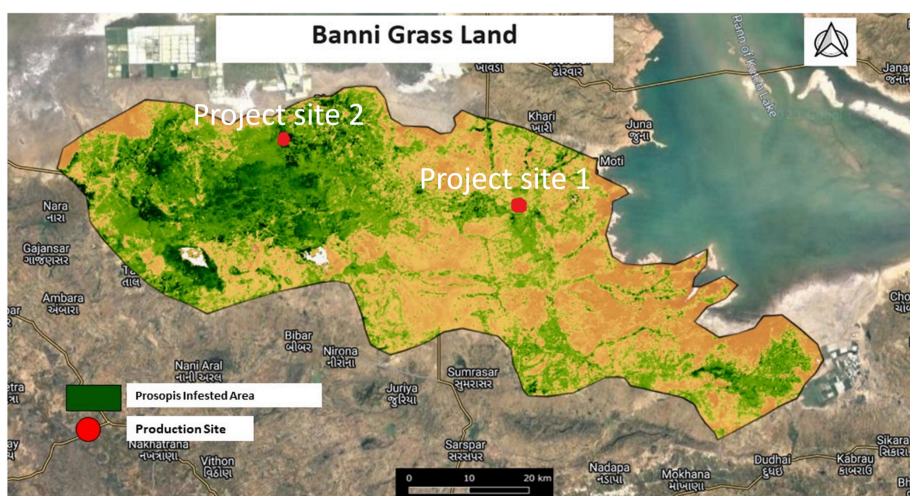
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Another objective of the project is to improve the soil quality in farms by marketing biochar as soil amendment. Biochar can improve soil quality significantly because of its impact on the soil pH, its water retention capacity, and its ability to store nutrients. Furthermore, the biochar may be used as a temporary C-sink.

The monitoring and tracking of this project will be carried out by Varaha ClimateAg Pvt. Ltd. In the project the digital MRV technology named KALKI will be used. This will monitor, report and verify biochar production and carbon sequestration.

1.1. Project location

Banni Grasslands, Gujarat



Banni Landscape: The green color in the figure represents the *Prosopis*-infested area. The project sites are the locations that are heavily infested by *Prosopis*.



Project Site 1: Vagura Village - Excavation of Prosopis & Production of Biochar has already started. The red color boundary is the identified excavation area. The yellow color location pin in the image represents the biochar production site. The production happens in the vicinity of the excavation site only eliminating the need for transportation of feedstock.



Project Site 2: Gorewali Village - Identified site for excavation of Prosopis & Production of Biochar. The red color boundary is the identified excavation area. The yellow color location pin in the image represents the biochar production site. The production happens in the vicinity of the excavation site only eliminating the need for transportation of feedstock.

The geographical locations of the subsequently installed Biochar Artisan Producers will be documented in the spreadsheet (Annex 7.1)

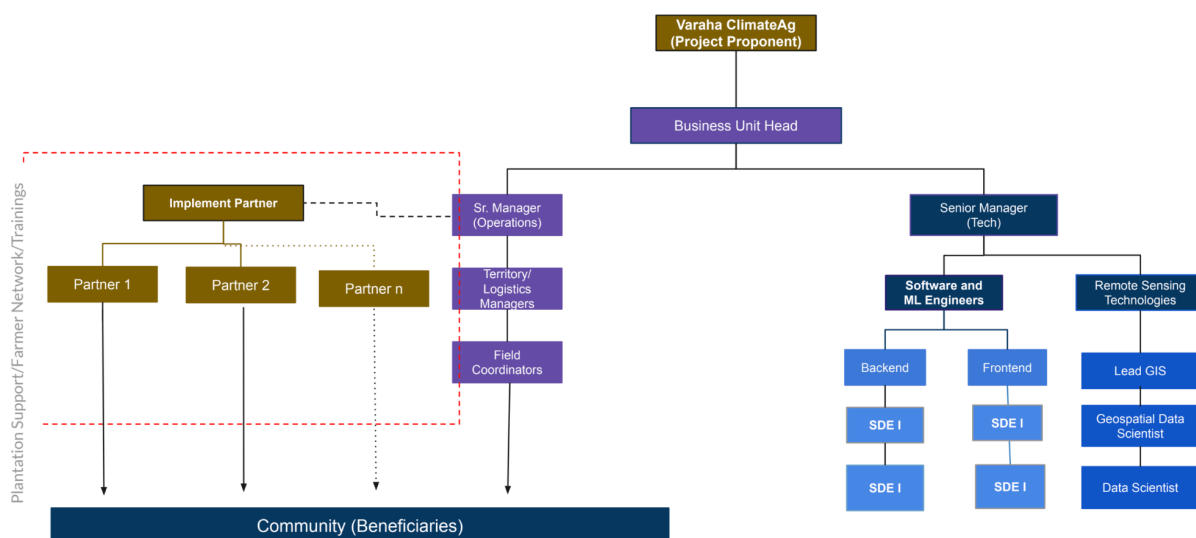
States of India



1.2. Stakeholders and partners involved

There will be various local stakeholders and partners involved with the project, who will play a crucial role in the removal and collection of crop residues and invasive plants. By collaborating with farmers, local communities, and environmental groups, the partners can efficiently ensure a steady supply for biochar production. Additionally, partnerships with local community bodies and NGOs can facilitate training and resource allocation, creating a coordinated effort that maximizes the value-added benefits.

In the project's first instance, Sahjeevan - a pivotal stakeholder in the project, brings 25 years of expertise in revitalizing traditional ecological knowledge, leveraging pertinent technologies, and advocating scientific approaches to empower marginalized communities and preserve ecological resources while enhancing livelihoods. In this instance, Sahjeevan has been assisting the Maldharis, the pastoral community, in the removal of Prosopis, including its root systems from the ground.



1.3. Description of baseline scenario

Before the project's first instance, the invasive *Prosopis juliflora* shrubs were left unchecked, allowing it to expand its territory within the Banni grasslands. This unchecked growth posed a significant threat to the indigenous grass species and local biodiversity, as the invasive species rapidly took over the grassland ecosystem. In response to this threat, the government included *Prosopis Juliflora* removal in the forest management plan¹ in 2004, allowing grassland and biodiversity restoration.

Additionally, the Maldhari community engaged in illegal logging of the wood, which was then sold in the open market for energy purposes, either directly or indirectly. This illicit logging activity created a local economy centered around the harvesting and sale of *Prosopis Juliflora* wood, contributing to the release of greenhouse gas emissions upon its combustion.

The baseline situation thus involved the unchecked proliferation of the invasive bush, leading to its exploitation for illegal logging by various stakeholders. This activity shift towards the utilization of *Prosopis Juliflora* as a feedstock for energy production highlights the importance of addressing the invasive species issue in the Banni grasslands through sustainable management strategies.

Crop residues in fields can cause considerable land management problems as they accumulate. The major crop residues produced in India are straws of paddy, wheat, millet, sorghum, pulses (pigeon pea), oilseed crops (castor, mustard), maize stover and cobs, cotton and jute sticks, sugarcane trash, leaves, fibrous materials, roots, branches and twigs of varying sizes, shapes, forms and densities. Similarly, the agro-industrial residues are rice husk, groundnut shell, cotton waste, coconut shell, coir pith, tamarind shell, mustard husk, coffee husk, cassava peels etc. Some of the common agricultural by-products available in large quantities include bagasse, rice husk, groundnut shell, tea-coffee waste, casuarina leaf

¹ <https://www.downtoearth.org.in/news/environment/ngt-upholds-rights-of-pastoralists-in-banni-grasslands-wants-encroachments-removed-77075>

litter, silk cotton shell, cotton waste, oil palm fibre and shells, cashew nut shell, coconut shell, coir pith etc.².

Among the cereal residues, rice and wheat straws are the dominant and the easiest way to clear the field is burning these in the field itself. For example, 23% of rice straw residue produced is surplus and is either left in the field as uncollected or to a large extent open-field burnt. In Punjab alone, some 70 to 80 million tons of rice and wheat straw are burned annually³, releasing approximately 140 million tons of CO₂ to the atmosphere, in addition to methane, nitrous oxide and air pollutants. About three- fourths of greenhouse gas (GHG) emissions from agro-residues burning were CH₄ and the remaining one-fourth was N₂O. Burning of wheat and paddy straws alone contributes to about 42% of GHGs.⁴

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.

$$C - \text{sink}(\text{Baseline}) = 0 \text{ tCO}_2\text{e}$$

1.4. Biochar carbon sinks

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

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

1.5. Project Boundary

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

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.

A margin of security of 3% is accounted for in the calculations.

² Sugumaran, P. and Sheshadri, S. 2009. Evaluation of selected biomass for charcoal production. Journal of Scientific & Industrial Research, 68: 719-723.

³ Punia, M, Prasad, N.V. and Yogesh, Y. 2008. Identifying biomass burned patches of agriculture residue using satellite remote sensing data. Current Science, 94 (9): 1185-1190.

⁴ Murali S, Shrivastava R, Saxena M. Green house gas emissions from open field burning of agricultural residues in India. J Environ Sci Eng. 2010 Oct;52(4):277-84. PMID: 22312795.

1.6. Eligibility

S. No.	Eligibility	Rationale
1	Production of biochar according to Global Artisan C-Sink conditions.	Our artisanal biochar project adheres to the Global Artisan C-Sink (GACS) conditions for several compelling reasons: • Sustainability: The GACS framework prioritizes the use of biomass feedstocks that wouldn't otherwise be utilized. This prevents competition with food production and discourages unsustainable land-use changes. • Community Benefits: By focusing on small-scale production and local feedstocks, our project empowers local communities. GACS principles encourage the creation of new income streams for farmers and rural populations. • Carbon Sequestration: The GACS methodology emphasizes practices that maximize carbon capture and storage in the produced biochar. This ensures the long-term effectiveness of our project in mitigating climate change. • Transparency: GACS promotes robust monitoring, reporting, and verification (MRV) procedures. This transparency fosters trust with stakeholders and allows for an accurate assessment of the project's carbon removal potential. • Scalability: The artisanal approach championed by GACS allows for a distributed production model. This enables us to replicate the project across various regions with minimal infrastructure requirements. • Alignment with Carbon Standard International (CSI): Following GACS guidelines ensures our project aligns with the high standards set by CSI. This facilitates verification and allows us to generate tradable carbon credits, further incentivizing project sustainability. In conclusion, adhering to GACS conditions positions our artisanal biochar project for long-term success. It fosters environmental and social responsibility while contributing significantly to carbon sequestration efforts, all within the framework of a recognized and respected carbon standard.
2	Farmers and Artisan Biochar Producers are not certified under any other methodology for nature-based climate service (i.e. biomass production and	Artisan biochar producers under our project are not certified under any other methodology for nature-based climate services. This ensures, • Preventing Double Counting • Maintaining Additionality • Streamlining Verification • Focus on Biochar Expertise

	soil organic carbon)	
3	Social Impact: Involved parties have to be compensated fairly and transparent	Our artisanal biochar project is committed to promoting social equity and poverty reduction through fair and transparent compensation practices. This extends to all involved parties, including our valued implementation partners, Sajeevan and Sahjeevan, who play a critical role in feedstock collection. We have meticulously ensured that all personnel engaged in on-ground operations receive fair compensation, adhering strictly to the established regional and national labor laws. This commitment to transparency fosters trust with our partners and local communities, while also guaranteeing compliance with ethical sourcing standards. By prioritizing fair treatment and economic opportunity, we empower those involved and contribute to the long-term sustainability of the project. We pay for all the costs associated with biomass excavation, biochar production, and biochar application. This includes the cost of the Kon Tikki fabrication, Prosopis excavation, salaries of all the ground personnel involved in the project, and transportation costs for biochar application. We conduct regular audits to ensure that all the local labor laws related to the work environment and compensation are followed at each production site. Moreover, we are also providing the majority of the biochar produced in the project for free to the farmers.
4	Project location: Project is located in a low- or middle-income country according to the World Bank classification.	Our project is located in India. As per World Bank classification, India is a low-income country.
5	Biochar production does not exceed 100m ³ /year for a single C-Sink Farmer or 1500m ³ /year for a single Artisan Pro and is done with a	We ensure our biochar production using low-tech production unit don't exceed 1500m ³ /year for a single Artisan Pro.

	low-tech production unit.	
6	The C-sinks issued in this project are not claimed in any other Carbon Crediting Scheme.	The C-sinks generated in this project are exclusively issued and are not claimed under any other Carbon Crediting Scheme.

1.7. Additionality

Artisanal Biochar Producers do not generate income yet with biochar in most regions, there is no market for biochar-based fertilizers, and the production costs are higher than the expected agronomic benefit, or tropical smallholder farmers do not have the financial resources to pay biochar-based fertilizers. Farmers could produce their biochar from their feedstock to improve their yields, but without the training provided by Varaha ClimateAg Pvt. Ltd, 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. Varaha ClimateAg Pvt. Ltd will provide not only training on biochar production but also on the preparation and application of biochar-based fertilizers, which (a) will enable most farmers to establish this practice and (b) will avoid the adoption of unsustainable biochar production practices which could result in pollution and GHG-emissions. Moreover, methane compensation, as introduced by the Global Artisan C-sink is a key element to achieving net negative emissions with Kon-Tiki 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.

The Carbon Sequestration and Grassland Restoration in India project demonstrably achieves additionality by proactively addressing the historical constraints that have impeded artisanal biochar production in India. These constraints can be categorized into four key areas: technological limitations, financial barriers, knowledge gaps, and socio-cultural considerations.

Technological Innovation: Previously, the absence of readily available and user-friendly biochar production technologies posed a significant challenge. This project bridges this gap by introducing the Kon-Tiki technology. Kon-Tiki's efficiency and low emissions make it particularly well-suited for the project's goals, enabling local communities to adopt biochar production without extensive prior expertise.

Financial Sustainability: High upfront costs have historically stifled the development of artisanal biochar production. The project directly addresses this by creating a dedicated

market for the biochar produced by participating communities. This market mechanism provides a crucial financial incentive, ensuring the project's long-term economic viability. Furthermore, the project eliminates the financial burden on farmers by not requiring them to purchase biochar-based fertilizers.

Knowledge Transfer: The project acknowledges the historical lack of readily available training programs on biochar production. To bridge this knowledge gap, the project leverages the expertise of the Global Artisan C-Sink Manager. The Manager delivers comprehensive training programs specifically tailored to the needs of artisanal biochar producers. These targeted training sessions equip 50 individuals with the skills and expertise necessary to become proficient in sustainable biochar production practices.

Community Engagement: Limited awareness regarding the environmental and economic benefits of biochar could have led to resistance from local communities. The project proactively addresses this by prioritizing community engagement. Effective communication and education initiatives foster an understanding of the project's goals and the advantages of biochar. This cultivation of community buy-in ensures long-term project success and a sense of shared ownership in this transformative initiative.

By systematically dismantling these historical barriers, the Carbon Sequestration and Grassland Restoration in India project establishes itself as a truly additional carbon sequestration initiative. The project's multifaceted approach provides the necessary technological tools, financial incentives, and targeted knowledge transfer. Additionally, it fosters community understanding, paving the way for a future where artisanal biochar production thrives. This project demonstrably generates a new and permanent carbon sink through sustainable biochar production practices, leaving a lasting positive impact on the farmers' croplands, grasslands and its inhabitants.

2. Ex-ante estimate of impact

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

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

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

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

Yield factor (feedstock to biochar) : 0.25 t biochar (DM)/t feedstock (DM)

Ccontent of biochar: 84% (based on preliminary analysis)

Year of operation	Amount of feedstock (t DM)	Amount of biochar produced (t DM)	Established temporary C-sinks (tCO ₂ e)	Established permanent C-sinks (tCO ₂ e)
1	20,000	5,000	4,000	12,000
2	25,000	6,250	5,000	15,000
3	25,000	6,250	5,000	15,000

4	25,000	6,250	5,000	15,000
5	30,000	7,500	6,000	18,000
sum	125,000	31,250	25,000	75,000

3. Technology and business cases

3.1. Artisan Biochar Producer

An Artisan Pro is a registered company or part of a registered company. An Artisan Pro may have several production units and artisans that run these. Artisan Pro biochar is professionally produced by a company, an association, or an individual using all sorts of eligible biomass found within a radius of 10 km from the production site. Artisan Pro biochar is not necessarily applied back to the fields where the biomass was grown but is mostly traded to other farms and industries. Artisan Pro biochar is produced at a registered production site with registered production equipment. It can be produced by several trained Artisan Biochar Producers (i.e., employees of the certified company), though they work at the same site with the same equipment. The maximum annual biochar production is 1500 m³ per year.

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

3.1.1. Training of Artisan Biochar Producer

In this project, Varaha Climate Ag Pvt Ltd ensures that the Artisan Biochar Producers are qualified to produce high-quality biochar with low emissions through an internal training protocol. The Artisan Biochar Producer follows a biochar production training given by a qualified trainer and 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.

The details of content, duration and learning goals (internal training protocol) were presented to Carbon Standards and the Certifier (Annex 7.2).

3.2. Feedstock

The Global Artisan C-Sink Managers ensures that the biochar is made from biomass feedstock that originated invasive wood of Prosopis Juliflora, cotton stalks, tea/coffee residue and crop residue of rice & maize

In the project the following feedstocks are used which is eligible with the sustainability criteria:

- **Air Quality Improvement:** Biochar production eliminates the need for open burning of crop residues, significantly reducing air pollution and associated health risks.
- **Soil Health Enhancement:** Biochar application improves soil structure, enhances nutrient retention, and supports microbial activity, reversing the negative effects of burning and soil degradation.
- **Biodiversity Restoration:** Removing invasive plants and converting them to biochar helps restore native ecosystems, allowing local flora and fauna to recover and thrive.
- **Economic Benefits:** The biochar production process can create new economic opportunities for farmers and local communities, transforming agricultural waste into a valuable resource and providing additional income streams.
- **Climate Change Mitigation:** Biochar sequesters carbon, reducing greenhouse gas emissions and contributing to climate change mitigation efforts. This aligns with broader environmental sustainability goals and carbon offset initiatives.

3.2.1. Origin of feedstocks:

1. Cotton Stalks :

- **Geographic Regions :** Cotton is predominantly grown in the states of Maharashtra, Gujarat, Andhra Pradesh, Telangana, Punjab, and Haryana.
- **Agricultural Context :** India is one of the largest producers of cotton globally. After the cotton is harvested, significant amounts of stalks remain as residue in the fields.
- **Challenges :** Traditionally, these stalks are either burned or left to decay, posing environmental and agricultural challenges. Utilizing cotton stalks for biochar production offers a sustainable alternative.

2. Tea and Coffee Twigs and Stems :

- **Geographic Regions :**
 - **Tea :** Tea plantations are primarily found in Assam, West Bengal (Darjeeling), Tamil Nadu (Nilgiris), and Kerala.
 - **Coffee :** Coffee plantations are concentrated in Karnataka, Kerala, and Tamil Nadu.
- **Agricultural Context :** Tea and coffee plants require regular pruning to maintain productivity. This results in significant quantities of twigs and stems as by-products.
- **Challenges :** These residues are often underutilized, leading to waste disposal issues. Converting them into biochar can help manage this biomass effectively and improve soil health in plantations.

3. Rice Crop Residues :

- **Geographic Regions :** Major rice-producing states include West Bengal, Uttar Pradesh, Punjab, Bihar, Andhra Pradesh, Tamil Nadu, and Odisha.
- **Agricultural Context :** India is a leading rice producer. Post-harvest, large amounts of rice straw and husks remain as residues.

- Challenges : Farmers commonly burn rice straw to clear fields quickly, contributing to severe air pollution and soil degradation. Utilizing rice residues for biochar production can mitigate these issues and enhance soil fertility.

4. Maize Crop Residues :

- Geographic Regions : Key maize-producing states are Karnataka, Madhya Pradesh, Bihar, Tamil Nadu, and Andhra Pradesh.
- Agricultural Context : Maize is grown across diverse agro-climatic zones in India, providing substantial quantities of stover and cobs as residues after harvest.
- Challenges : Similar to rice, maize residues are often burned or left to rot, leading to environmental and agricultural problems. Biochar production from maize residues offers a way to manage this biomass sustainably and improve soil properties.

Prosopis Juliflora is an invasive species destroying the Banni Grassland ecosystem

Before biochar production started in the project's first instance, the invasive bush, *Prosopis juliflora*, was left unchecked in the Banni grasslands, allowing it to expand its territory rapidly. The feedstock for biochar production primarily consisted of this invasive species. However, before the project, Prosopis Juliflora was not utilized sustainably. Instead, it posed a significant threat to the local ecosystem as it overtook indigenous grass species and disrupted biodiversity.

3.2.2. Leakage

With the increasing adoption of LPG and improved cook stoves, communities are becoming less dependent on Prosopis juliflora as a primary source of fuel. This shift reduces the likelihood of leakage, as the diversion of this biomass for biochar production does not significantly disrupt its traditional use for cooking. Consequently, the risk of leakage from our project is minimal.

3.2.3. Methane emission during storage of biomass

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

S. No.	Condition	Rationale
1	The feedstock must not be used from freshly cut or from a feedstock pile where it rained upon.	Completely dried feedstock is used for Biochar production and to ensure that moisture meter is also kept at the production site which helps to decide feedstock moisture level.

		
2	Feedstock needs to be stored airy and protected from rain.	While storing the feedstock, precautions are taken such as the storage place should be airy and the feedstock should not get exposed to the rain in case it occurs.
3	To avoid methane emissions from feedstock storage, wet feedstock must not be piled higher than a meter. Otherwise, the humid feedstock will self-heat, consume the oxygen inside the pile and decompose anaerobically, which produces significant amounts of methane.	To avoid methane emissions from feedstock storage, it is dried on the land where it was uprooted and left to dry until wood moisture gets below 25%. It helps to avoid methane emissions from storage. While piling up the feedstock, it is not piled higher than one meter to ensure air circulation and avoid anaerobic conditions which can produce methane potentially. 

4.	When feedstock gets exposed again to rain, a new period of at least three days of thinly layered sun drying has to start.	In case Feedstock gets exposed to rain, as per SOP set at Artisan Producers level, it is sundried for at least three days to cut down moisture trapped in feedstock and it is used for processing only after checking the moisture of feedstock with Moisture meter
5	Humidity and Moisture level in the Feedstock	The water content of feedstock should be below 25% when used in the Kon-Tiki. Simple, low-cost digital devices exist to measure feedstock humidity, which must be used at the biochar training so that Artisan Biochar Producers get the experience of how to test the feedstock for humidity even without digital devices. Producers of more than 100 m3 biochar per year are required to measure the feedstock humidity with an appropriate device and record it in the production protocols. Here, the average humidity is recorded using five measurements with the handheld device per m3 of feedstock. 

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 labeling the biochar with the aim of becoming an C-sink 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 fulfills the analytical threshold values, so no damage is caused to the environment, emissions limits of the pyrolysis unit are adhered to, and storage procedures are environmentally sound.

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

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

Flame Curtain Pyrolysis (the Kon-Tiki method)

The principle of flame curtain pyrolysis consists of pyrolyzing biomass layer by layer in a conically-, polygonal-, rectangular-, or cylindrical-formed metal, concrete, or soil kiln.

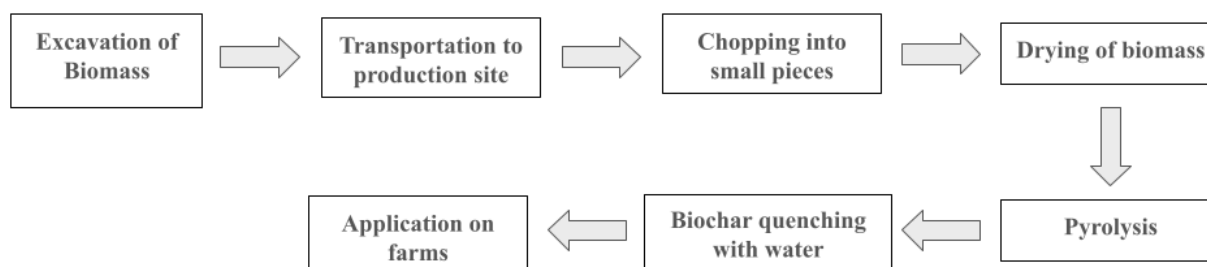
A fire is started in the kiln, and the embers spread to form a first layer on the bottom of the kiln. A thin layer of biomass is then added on top of the embers, heats quickly and starts outgassing. The rising pyrolysis gas is caught in the flame curtain and reacts with combustion air entering the kiln from the top. When ash appears on the outside of the carbonizing biomass, the next layer of biomass is homogenously spread on top. Convective and radiant energy from the flames above and from the hot pyrolyzing layers below heat up the fresh biomass layer, which starts to pyrolyze.

The biochar below the upper pyrolysis layer is shielded from oxygen access by the fire curtain itself. The combustion zone thus forms a flame curtain that protects the underlying biochar from oxidizing and cleanly burns all pyrolysis smoke and gases as they pass through this hot fire front. The manual layering of biomass is repeated until the metal kiln or soil pit is filled.

The pyrolysis process is then actively ended by quenching with water or a nutrient solution (e.g., diluted urine, dissolved fertilizer) which is fed into the kiln from below if possible or, where water is not easily available, by snuffing with a layer of soil.



3.3.1. Example of biochar production flowchart



3.4. Suitability of Artisan Biochar for Agriculture

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

3.5. Application and trade of biochar

The artisan producers take the initiative to enrich biochar by inoculating it with compost or manure. They then directly apply this enhanced biochar to the rehabilitated areas within the Banni grasslands, where invasive encroacher bushes have been eradicated. With removal of the invasive wood the grasslands rejuvenate and a significant biomass production starts happening in grasslands. These grasslands are then also storing carbon into soil more reliably.

The following applications are possible for this project:

- Geological C-sink (biochar applied to soil)

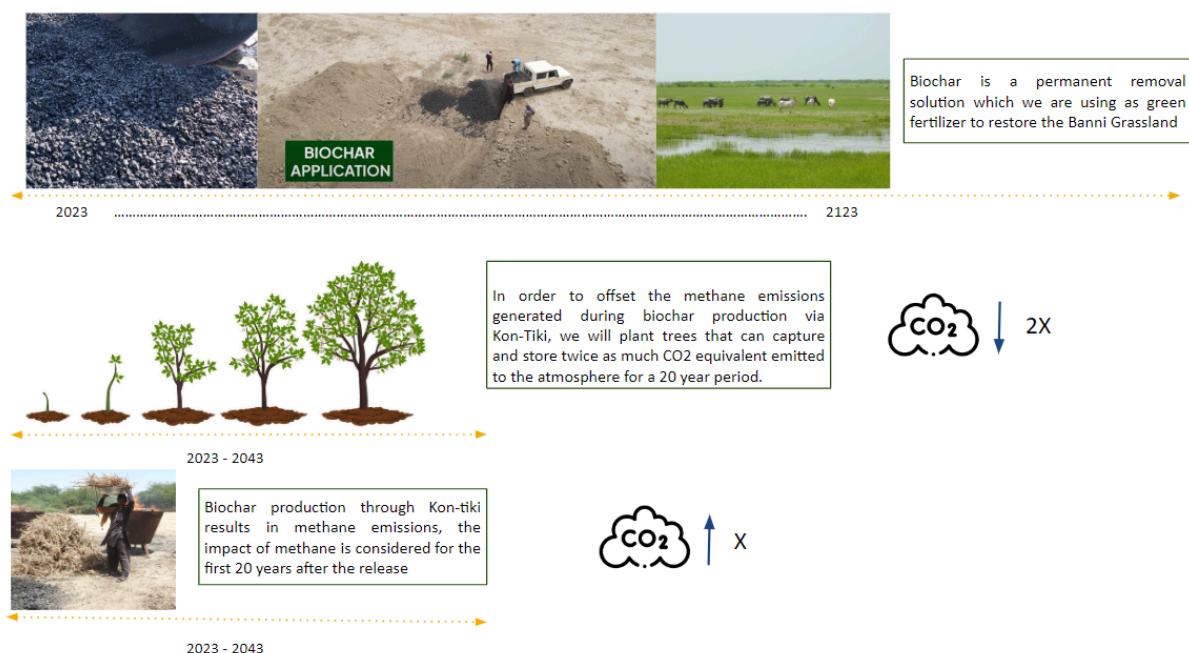
3.6. Methane emissions compensation

Compensation of methane emissions by growing additional biomass

The methane emissions could be effectively offset by doing additional plantations. The average CO₂ sequestration potential of a particular tree species could be calculated for 20 years. The factor of 30 KgCH₄/tonne of Biochar produced has been utilized in the compensation matrix which is double the amount of the upper limit of emissions in our case. The local tree species are evaluated for their cooling potential and a comprehensive plantation plan is devised with the local NGO partners and implemented parallel to the production Activity. The plantations are done in community-protected areas where there is strong oversight from the government authorities against deforestation. We will also be monitoring the plantations using Varaha's remote sensing models that have been developed for the ARR projects. Also, the areas from where the *Prosopis Juliflora* is removed shows recovery of good biomass generation in the form of grasses as the grasses now get the opportunity to grow well in absence of the invasive wood.

Below are the details and background of the plantations done for the pilot project.

Species	Avg 20 years (tCO ₂)	CH ₄ /t of biochar (Kg)	CH ₄ (GWP20) IPCC 6	t CO ₂ eq	trees required /t of biochar	%age	No of tree (individual)	No of trees (Group of sps)	TCO ₂ eq
<i>Prosopis cineraria</i>	0.51	30	80.8	2.42	5	40	3500	1400	280
<i>Acacia nilotica</i>	0.41	30	80.8	2.42	6	10	4200	420	70
<i>Ziziphus sp.</i>	0.04	30	80.8	2.42	54	10	37800	3780	70
<i>Pithecellobium</i>	0.22	30	80.8	2.42	11	10	7700	770	70
<i>Salvadora sp.</i>	0.33	30	80.8	2.42	7	5	4900	245	35
<i>Avicennia sp.</i>	0.3	30	80.8	2.42	8	5	5600	280	35
<i>Azadirachta sp.</i>	0.6	30	80.8	2.42	4	15	2800	420	105
<i>Rhizophora sp.</i>	0.22	30	80.8	2.42	11	5	7700	385	35
	2.63					100	74200	7700	700



Stepwise Calculation of CO₂ Sequestration and Methane Compensation in Biochar Production

This document outlines the calculation for carbon sequestration and methane compensation associated with biochar production using the Kon-Tiki technology in a tropical environment with sufficient precipitation and average soil quality.

Step 1: Tree-Based CO₂ Sequestration

1.1. Annual CO₂ Removal Capacity: Consider a fast-growing tree species like Acacia Nilotica. After reaching maturity (20 years), this tree can potentially remove 1.553 tonnes (t) of CO₂ from the atmosphere annually.

1.2. Average CO₂ Removal Over 20 Years: However, young trees have a lower CO₂ removal capacity. To account for this, we calculate the average CO₂ removal over the entire 20-year period. While the exact calculation may vary depending on the specific growth model used, here we assume a simplified approach. We consider the average CO₂ removal to be half the mature tree's capacity, resulting in an average annual removal of 0.48 t CO₂ per tree.

Step 2: Methane Emissions from Biochar Production

2.1. Methane Emission Factor: The Kon-Tiki technology has a reported methane emission factor of 30 kg CH₄ per tonne (t) of biochar produced.

Step 3: Converting Methane Emissions to CO₂ Equivalent

3.1. Global Warming Potential (GWP20): To compare the climate warming effects of methane (CH₄) and carbon dioxide (CO₂), we utilize the GWP20 factor. GWP20 represents the relative warming potential of a gas compared to CO₂ over a 20-year timeframe. In this case, the GWP20 for CH₄ is 86 times that of CO₂.

3.2. CO₂ Equivalent Calculation: Multiply the methane emission factor (30 kg CH₄/t biochar) by the GWP20 factor (86 t CO₂/t CH₄) to obtain the CO₂ equivalent emissions from biochar production: (30 kg CH₄/t biochar) * (86 t CO₂/t CH₄) = 2.58 t CO₂/t biochar.

Step 4: Number of Trees Required for Methane Compensation

4.1. Compensation Ratio: Divide the CO₂ equivalent emissions per tonne of biochar (2.58 t CO₂/t biochar) by the average annual CO₂ sequestration of a single tree (0.48 t CO₂/year) to determine the number of trees needed to compensate for the methane emissions from producing one tonne of biochar: (2.58 t CO₂/t biochar) / (0.48 t CO₂/year) = 5.42 trees/t biochar.

Step 5: Accounting for Uncertainty and Project Efficiency

5.1. Buffer for Uncertainty: To account for potential variations in tree growth and CO₂ sequestration rates, we consider planting 30% more trees than the calculated minimum requirement. This buffer ensures sufficient compensation for methane emissions.

Example: Compensation for 1000 Tonnes of Biochar

Based on the calculations above, to compensate for the methane emissions associated with producing 1000 tonnes of biochar, we would need to plant:

Minimum Required Trees: 5.42 trees/t biochar * 1000 t biochar = 5422 trees

Accounting for Uncertainty: 5422 trees * 1.3 (30% buffer) = 7048.6 trees (rounded to 7049 trees for planting purposes)

Therefore, for the production of 1000 tonnes of biochar, planting and maintaining 7049 Acacia Nilotica trees for 20 years effectively compensates for the methane emissions generated during biochar production. This approach ensures the project achieves a net positive impact on climate change mitigation.

Detailed Biomass Calculation Sheet for Acacia Nilotica (Annex 7.3)

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

In many tropical countries, crop residues are burnt directly in the fields. While it has some positive effects on farming (ash fertilization, some pyrogenic carbon, elimination of pests), emissions of such practices are massive. Besides significant emissions of particulate matter that cause smog (the main reason for air pollution, e.g., in Delhi, methane and carbon monoxide emissions are very high due to the uncontrolled combustion of mostly wet or 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.

Feedstock like cotton stalk, rice and maize residue come under this option

3.7. digital Monitoring, Reporting and Verification (dMRV)

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

In this project, our dMRV system is endorsed by Carbon Standards will be used to fulfil the requirements of the Global Artisan C-Sink Standard. Our detailed D-MRV documentation can be accessed using this document (Annex 7.4)

3.8. Planned business development

You can access our business development and scale-up plan document through the following document (Annex 7.5)

3.9. Internal Control System

The internal Control System documentation can be accessed using this document (Annex 7.6)

4. Determination of C-sink

4.1. Monitoring

All data that is required to calculate the C-sink is entered into our dMRV System named KALKI which was developed by Varaha Climate Ag Pvt Ltd. Our dRMV is endorsed by CSI, refer certificate (Annex 7.7)

The data will be monitored as mentioned below.

4.1.1. General data

The following general data will be monitored:

Parameter	Monitoring frequency	Source of data
Artisan Biochar Producer Registration	per year	Annex 7.1
Proof of successful participation in an artisan biochar workshop	per year	Annex 7.8
Producers list	per year	Annex 7.1
H/Corg ratio	per feedstock type	Laboratory report (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	Annex 7.9 (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	Annex 7.4
Feedstock preparation	per feedstock type	Annex 7.4
Documentation of technology used	per Artisan Biochar Producer	Annex 7.4
Volume measuring device	per Artisan Biochar Producer	Annex 7.4

Definition of a production load	per production unit type	Annex 7.4
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The following general conversion rates are fixed ex-ante:

Parameter	Ex-ante definition; value	Source of data
CO ₂ emissions from diesel	2.7 kg CO ₂ eq / l diesel	Methodology, Juhrich, 2016
CO ₂ emissions from heavy fuel	65 t CO ₂ eq / TJ	Methodology, Juhrich, 2016

4.1.2. Artisan Biochar Production

Artisan Pro

For each Artisan Pro the following parameters will be monitored:

Parameter	Monitoring frequency	Source of data
Annual on-site inspection	per year	Annex 7.4
Feedstock type	per load	Annex 7.4
Moisture content of feedstock	per load	Annex 7.4
Total amount of feedstock (dry matter) used for the load	per load	Annex 7.4
Average feedstock size	per load	Annex 7.4
Location of production unit	per load	Annex 7.4
Registration of each biochar production load	per load	Annex 7.4
Amount of biochar produced	per load	Annex 7.4
Proof of retention sample	per load	Annex 7.4
Documentation of biochar mixing to matrix	per load	Annex 7.4
Amount of volume applied to each matrix	per load	Annex 7.4
Receiver address/location when biochar (mix) is sold	per trade	Annex 7.4

4.1.3. Compensation of Fossil Emissions

All fossil CO₂ emissions are offset by long-term carbon sinks before the registration of a biochar C-sink is validated in the Global C-Sink Registry.

CO₂ is only 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 are realized with the registered permanent biochar C-sink whose production had caused the emission.

Parameter	Monitoring frequency	Source of data
Proof of compensation	annually	

4.1.4. Production unit

☐	The production unit used in the project has a system certification, see system endorsement.
	Pyrolysis system Kontiki/Soil pit is accredited by Carbon Standards. The mean methane emission for Kontiki/Soil pit is known to be 30 kg CH ₄ /t DM biochar produced.

Accordingly, ex-ante definition of the following parameter:

Parameter	Ex-ante definition; value	Source of data
[CH ₄ _emissions_pyrolysis]	30 kg CH ₄ /t DM biochar	Global Artisan C-Sink Standard V 2.1

4.1.5. Compensation of methane 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 is compensated within 20 years after the initial emission.

Parameter	Monitoring frequency	Source of data
Proof of compensation	per C-Sink Unit	Annex 7.10

4.1.6. Margin of Security

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

This includes, for example, the emissions caused by:

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

$[Margin\ of\ Security] = [produced\ biochar\ (t)] * 0.02\ (t\ CO_2e\ per\ ton\ of\ biochar)$

4.1.7. Methane emissions

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

$$[Total\ methane\ emissions] = [Feedstock\ storage\ emissions\ per\ batch] + [CH_4\ emissions\ from\ pyrolysis\ of\ entire\ batch]$$

4.1.7.1. Methane emissions from the storage of biomass

If methane emissions are negligible according to Section 3.2.3 : 0 tCH₄

4.1.7.2. Methane emissions from production unit

Emissions are calculated in **kg CH₄**.

$$[CH_4\ emissions\ from\ production\ unit\ per\ load] = [CH_4\ emissions_{pyrolysis}] * [amount\ of\ biochar\ dry\ matter]$$

4.1.7.3. Compensation of the methane emissions

The AGWP_CH4(100) must then be compensated by a same-sized absolute global cooling potential (AGCP) over a maximum of 20 years. The compensating global cooling starts in the same year as the CH₄ emission occurred, provide annual global cooling in every following year, and finalize the compensation latest 20 years after the methane emission.

In order to claim that methane emissions where compensated it must be proven that

$$[AGCP(20)] \geq [AGWP_CH_4(100)].$$

4.1.7.4. Absolut Global Warming Potential of methane emissions

The Absolute Global Warming Potential of the methane emissions are calculated based on:

$$AGWP_CH_4(100) = \sum_{y=0}^{100} (IRF(CO_2, a(y)) * [CO_2\ e\ of\ CH_4\ emissions\ per\ load])$$

To calculate the *Absolute Global Warming Potential (AGWP)* over 100 years we are using Jeltsch-Thömmes & Joos (2019)⁴ to calculate the decay of the CO₂. Greenhouse gases decay in the atmosphere. The quantities of CO₂ 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.

The decay is described by the equation:

$$[IRF(CO_{2,a}(t))] = a_0 + \sum_{i=1}^5 a_i * \exp \exp \left(\frac{-t}{\tau_i} \right) \text{ for } t \geq 0$$

With the values

i	ai	ti
0	0.008	

⁴ Jeltsch-Thömmes, A., Joos, F., 2019. The response to pulse-like perturbations in atmospheric carbon and carbon isotopes 1–36.

1	0.044	68521
2	0.112	5312
3	0.224	362
4	0.31	47
5	0.297	6

The resulting methane emissions of the produced biochar are calculated as below, with the GWP100 (CH₄) value of 25 CO₂e.

$$[CO_2e \text{ of } CH_4 \text{ emissions per load}] = [Total \text{ methane emissions}] * [GWP100_{CH_4}]$$

4.1.7.5. Absolut Global Cooling Potential of SPC fraction

The Absolut Global Cooling Potential (AGCP) of the SPC for the first 20 years is calculated as follow:

$$[AGCP(20)] = \sum_{t=0}^{20} (C_{remain}(t, SPC) * IRF(CO_{2,a}(t) * M_{biochar} * C_{content}))$$

With:

C_{remain} (t, SPC) as the adjusted equation 2 of Global Artisan C-Sink Standard for the SPC fraction of the biochar (25%)

$$[C_{remain}(t, SPC)] = \frac{M_{BC} * C_{Content}}{1000} * (750 + 45 * e^{-0.5232*t} + 205 * e^{-0.009966*t}) - 0.75$$

5. Registration of C-sink

Biochar carbon sinks is registered with the geo-localized area where the biochar or its derived products have been applied. This encompasses scenarios where biochar serves as a soil amendment or finds application in various contexts, such as construction for residential, infrastructural, or road-related purposes.

In certain specific instances where marginal quantities of biochar are applied or utilized in products, the registration of so-called diffuse carbon sinks (i.e., non-geo-localized) is permitted.

The following information are registered for biochar carbon sink:

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

5.1. Calculation of C -sink

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

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

$$[Carbon\ for\ C - sink\ (kg\ C)] = [dry\ mass\ of\ biochar\ applied\ (kg)] * [Carbon\ content\ (\%)]$$

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

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

5.1.1. Geological C-sink

According to the Global Artisan C-Sink standard, Biochar made in a Kon-Tiki reach highest treatment temperatures above 650°C and present an H/Corg ratio well below 0.4, indicating a PAC fraction of at least 75% when applied to soil. Certified artisan biochar is, therefore, registered with a PAC-fraction of 75% and SPC fraction of 25% in the Global C-Sink Registry.

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

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

For the compensation of the GHG emissions within the system boundaries, only the PAC fraction is used. The SPC-fraction of biochar can be used for methane emission offsets.

6. Public consultation

During public consultation the following comments were raised:

Comment	Was comment taken into account (Yes/ No)?	Explanation/ justification (Why? How?)
How biochar production from Prosopis species will benefit the community.	yes	Enhancing Biodiversity and Livelihoods: Grassland Restoration: The project addresses the ecological challenge of invasive Prosopis Juliflora by facilitating its removal. This targeted approach allows for the restoration of the natural Banni grassland ecosystem, promoting biodiversity and fostering a healthier environment. Regenerative Biochar Application: The biochar produced from the removed Prosopis is then strategically applied to the restored land. This application acts as a soil amendment, enhancing soil fertility and promoting the regeneration of native grasses. This enriches the ecosystem and creates a more sustainable foundation for the grassland. Community Empowerment: The entire process, from Prosopis removal to biochar production and application, actively engages local communities. This creates employment opportunities, empowers local residents, and fosters a sense of ownership in the project's success.
How biochar is different from the coal they are producing conventionally	yes	Sustainable Carbon Sequestration: Biochar production utilizes the pyrolysis method within kilns. This process minimizes emissions compared to traditional burning methods. The resulting biochar acts as a stable form of carbon that is then incorporated back into the soil. This approach effectively sequesters carbon in a long-term and beneficial way, promoting a more sustainable carbon cycle.

We have conducted public consultations and training at all the Artisan Pro locations pictures and videos of these trainings can be found in this document (Annex 7.11)

7. Annexes

Please submit the annexes on a separate document.

- 7.1 Approved Artisan Pros List
- 7.2 Artisan Biochar Producer Training
- 7.3 Methane emissions compensation by plantation
- 7.4 Varaha_dMRV_C-Sink
- 7.5 Biochar _ Scale-up Plan
- 7.6 Internal Control System
- 7.7 Varaha dMRV endorsement cert_CSI
- 7.8 Training Video Vaghura
- 7.9 Biochar lab report
- 7.10 Methane Emission Compensation Plan
- 7.11 Public Consultations & Trainings : [Link](#)