BioCarbonGrow:

Biochar as Soil Amendment in the Paraíba River Valley

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Introduction to BioCarbonGrow

Project Summary

BioCarbonGrow is pioneering a sustainable approach to carbon dioxide removal (CDR) in the heart of Brazil's Paraíba River Valley. By utilising sustainably sourced woody biomass from Eucalyptus plantations, BioCarbonGrow converts this biomass into biochar through pyrolysis at approximately 600°C. This innovative process not only sequesters carbon effectively but also recycles syngas emissions to create a virtuous cycle of heat production for the industrial process, further supported by backup renewable solar energy to ensure sustainable energy consumption.

The Paraíba River Valley, with high demand for fertiliser and significant agricultural output, provides an ideal setting for BioCarbonGrow's operations. The region's history of Eucalyptus plantation for cellulose and paper production, particularly following the migration of major cellulose processors further to the interior of Brazil where topographical conditions favour harvesting, presents a unique opportunity. BioCarbonGrow's intervention converts what would otherwise be biomass waste or material for low-value charcoal production into a valuable resource for carbon removal and soil revitalization.

Building Local Climate Resilience

BioCarbonGrow's mission extends beyond the removal of CO2 from the atmosphere. The project is committed to improving agricultural climate resilience within a hundred-kilometre radius of the production unit. By processing Eucalyptus woody biomass and integrating it into agricultural lands as biochar-based organic fertiliser, BioCarbonGrow not only sequesters carbon but also revitalises soil, reduces the need for chemical fertilisers, reduces water consumption and enhances agricultural productivity.

Collaborative Climate Action

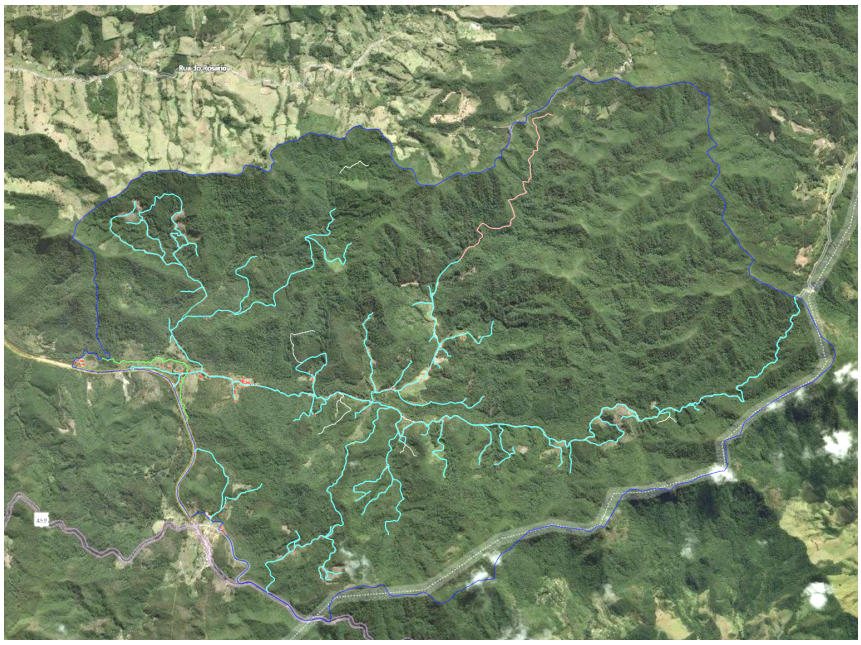
At the core of BioCarbonGrow's philosophy is deep collaboration with local communities, foresters, and farmers. The project is structured to provide extensive support to local Eucalyptus landowners, assisting them in transitioning to sustainable forest management practices and obtaining PEFC certification. This collaborative effort not only ensures the sustainability of the biomass sourcing strategy but also promotes local economic growth and environmental justice.

Project Implementation

Phase 1: Fazenda Corrego Alegre

Phase 1 of the BioCarbonGrow project lays the foundational operations for biochar production, focusing on establishing the necessary infrastructure and protocols on the 4000-hectare property of Fazenda Córrego Alegre, owned by Agropecuaria Sao Paulo Minas S/A. This phase is dedicated to transitioning traditional charcoal production methods to sustainable biochar production, leveraging long-standing expertise in forestry management.

Image 1: Vegetation and internal roads of the Fazenda Corrego Alegre.



Production:

1. **Biomass Sourcing:** Utilising the established expertise of Agropecuaria Sao Paulo Minas S/A in tree planting, harvesting, and processing, biomass is sustainably harvested from eucalyptus trees grown on-site. With over a million tonnes of eucalyptus woody biomass available, the process is designed to be sustainable with continuous replanting to ensure ongoing CO2 removal from the atmosphere.
2. **Biochar Production:** We expect 7889 tonnes of biochar to be produced in the first year of operation. At a 2.3 CO2e coefficient this would produce 18,145 CORCs.

3. **Soil Application:** Produced biochar is then applied to agricultural lands within a 100-kilometre radius of the production unit. This application aims to improve soil health and carbon sequestration, leveraging the natural properties of biochar to enhance soil fertility and reduce the dependency on chemical fertilisers.

   Image 2: Biochar production machinery as provided by the contracted manufacturer

Goals for Phase 1:

- Establish a fully operational biochar production facility on Fazenda Córrego Alegre, leveraging the existing infrastructure and forestry expertise of Agropecuaria Sao Paulo Minas S/A.
- Sustainably source and process 23,667 tonnes of eucalyptus biomass annually, with a continuous cycle of replanting to support long-term carbon dioxide removal.
- Enhance soil productivity and initiate carbon sequestration processes in surrounding agricultural lands, measuring the impact on crop yields and soil health.

This first phase is crucial for establishing the BioCarbonGrow project as an economically viable alternative for regional Eucalyptus foresters.

Phase 2: Expansion and Scale-Up

Phase 2 focuses on expanding the project's reach and scaling up production. This phase will see local Eucalyptus landowners and farmers participate in a revenue-sharing collective to extend biochar applications across the Paraíba River Valley.

Production Process:

1. **Biomass Sourcing:** Expanding the biomass sourcing to include additional local Eucalyptus landowners, helping them achieve PEFC certification and integrating their output into our supply chain .
2. **Biochar Production:** Production capacity is increased to accommodate the additional biomass sourced from new collective members. By growing the collective with neighbouring Eucalyptus foresters and the addition of a second pyrolysis site by the end of year 4 and then a new production site every year thereafter. This timeline allows for the self-funding of all subsequent sites. Please refer to our cashflow and production documentation.
3. **Soil Application:** Broadening the scope of biochar application to more farms and agricultural lands, which involves comprehensive monitoring and verification to ensure efficacy and benefits .

   Image 2: View of the Paraiba Valley as seen from the Fazenda Corrego Alegre.

Goals for Phase 2:

- Incorporate an expanded network of sustainably managed forests for biomass sourcing.
- Implement widespread soil application practices across the Paraíba River Valley, maximising agricultural productivity and carbon sequestration on a larger scale .
- Community Inclusion and Training: The collective framework aims to foster significant community involvement. BioCarbonGrow provides extensive support through training

programs, facilitating the adoption of sustainable practices and enhancing local capacities in biochar production and application .

- Economic and Environmental Benefits: By involving more local stakeholders and expanding the areas of biochar application, the project not only boosts local economies but also scales up its environmental impact. The collective helps ensure that the benefits of the project—such as increased soil fertility, higher crop yields, and carbon sequestration—are realised on a larger scale .
- Governance and Transparency: The governance structure of the collective is designed to ensure transparency and equitable participation. BioCarbonGrow supports the formalisation of the collective, which plays a crucial role in project oversight and decision-making, reflecting a shared leadership model that empowers local stakeholders .

This phase of the project solidifies BioCarbonGrow's commitment to both environmental sustainability and community prosperity, leveraging collective action to achieve greater impacts in carbon management and agricultural enhancement. Through strategic expansions and inclusive engagement, Phase 2 aims to set a precedent for community-integrated environmental projects.

Project Documentation

Designed in Alignment with High-Quality Carbon Removal Criteria

BioCarbonGrow, a pioneering biochar project designed and implemented through a partnership between Aetlas Labs and Agropecuaria Sao Paulo Minas S/A. This collaboration aims to harness biochar technology for carbon sequestration and soil enhancement in Brazil's Paraíba River Valley.

This document provides an in-depth analysis of the project's impact on local environments and communities, strategies for mitigating potential harms, and methods for promoting sustainable development. It also covers the project's operational phases, engagement with local communities, governance structures, and adherence to environmental justice principles.

This Table of Contents serves as a guide to navigate the extensive information on the project's goals, processes, and the measurable benefits it aims to achieve.

Table of Contents

1. Harms & Benefits

The BioCarbonGrow initiative, set in the rich landscape of the Paraíba River Valley, is rooted in a commitment to environmental sustainability and community welfare. In pursuing the transition of redundant eucalyptus biomass from charcoal production to biochar production, the project has assessed and mitigated potential harms while maximising its socio-economic and environmental benefits.

1.1. Potential Harms and Mitigation Strategies:

1.1.1. Soil Disruption:

Will the large-scale application of biochar could potentially disrupt soil microbiomes?

Mitigation: Before application, the biochar fertiliser is tailored to complement specific soil types based on extensive soil health analyses, ensuring that any disruption is minimised. Initial trials have demonstrated that appropriate application rates improve soil health without adverse effects.

1.1.2. Water Usage:

Will local water resources be strained by the transition to biochar production and biomass processing?

Mitigation: The pyrolysis process producing biochar generates multiple gases. One of the gases is water vapour. This vapour is captured and returned to its liquid state for any necessary use in the industrial process. In addition to this the project uses water recycling technologies and expects to be water consumption neutral or net-negative.

1.1.3. Economic Impact:

How will the shift to biochar production impact existing biomass markets both economically and environmentally?

Mitigation: We anticipate a welcomed adoption by regional Eucalyptus land owners who have suffered from the reduced demand for biomass due to the decline of region cellulose production. BioCarbonGrow will actively engage with combustion purchasers to mitigate both the potential economic impact

and increased emissions from fuel-change. The main mitigation strategy is to support the replacement of biomass furnaces with small-scale biochar production units for heat or electricity cogeneration.

1.2. Quantified Benefits:

1.2.1. Agricultural Productivity:

Studies have shown that fields treated with biochar see a yield increase of up to 20%, in the first year after application with a slowly tapering curve thereafter if no further applications are made, due to enhanced soil fertility and water retention. This translates to increased food security and income.

1.2.2. Incentivising Sustainable Forestry:

The project introduces a strong market incentive for the regional transition to sustainable forestry practices as the project introduces regional demand for sustainably sourced biomass. Additionally, the project plans to directly support new biomass suppliers with the PEFC sustainable certification with an initial target to sustainably manage 4000 hectares of local forest land.

1.2.3. Community-Led Reinvestment:

BioCarbonGrow is committed to allocating 10% of revenue into community development projects, including educational programs, direct and indirect job opportunities and micro-power infrastructure installations, aiming to uplift and empower local communities and industry. We envision the governance of these funds to be managed by our future collective, see 2.3 Community Engagement and Transparency for more information.

BioCarbonGrow's approach is not just about carbon removal but also about creating a harmonious balance between economic development, environmental sustainability, and community well-being. Through diligent planning, continuous monitoring, and adaptive management, the project is poised to serve as a model for sustainable carbon dioxide removal that truly benefits both people and the planet.

2. Environmental Justice

BioCarbonGrow is committed to advancing environmental justice, ensuring that its biochar project not only contributes to carbon dioxide removal but also delivers positive socio-economic impacts to the local and regional communities within the Paraíba River Valley region. Recognizing the importance of procedural equity and substantive benefits, the project adheres to the following strategies:

2.1. Promoting Sustainable Livelihoods

BioCarbonGrow is committed to catalysing significant economic empowerment in the Paraíba River Valley region, leveraging the biochar project to bring about sustainable economic development. A pivotal aspect of our mission is to address the economic void left by the bankruptcy of Nobrecel, historically a key player in purchasing Eucalyptus biomass from local farmers. Our project introduces an alternative, more sustainable avenue for these farmers to sell their abundant Eucalyptus biomass, thereby providing much-needed economic stability and fostering a transition towards more environmentally friendly agricultural practices.

2.1.1. Economic Empowerment through Biochar

Our economic empowerment goals are multifaceted, focusing on the wider impact of biochar within the regional economy:

Sustainable Agricultural Practices: Promoting biochar use among local farmers not only enhances soil health and crop yields but also opens up new markets and revenue streams for biomass producers.

Local Economic Revitalization: The introduction of biochar as an alternative buyer for Eucalyptus biomass provides a much-needed economic boost to the region, offering stability to farmers and landowners affected by Nobrecel's bankruptcy.

2.1.2. Support for Local Entrepreneurship and Businesses

BioCarbonGrow is dedicated to supporting local entrepreneurship and businesses through a series of initiatives designed to increase the adoption of biochar application among local farmers and educate Eucalyptus landowners on the alternative uses for their biomass.

Initiatives Include:

- **Support Sessions:** Organising hands-on sessions for farmers and foresters to demonstrate the benefits and applications of biochar, focusing on its role in enhancing soil fertility and supporting sustainable farming practices.
- **Online Local Biochar Forum:** Establishing an online platform where the community can access resources, share experiences, and discuss the benefits and challenges of biochar. This forum will serve as a hub for knowledge exchange and community engagement.
- **Educational Campaigns:** Launching targeted campaigns to raise awareness about the economic and environmental benefits of converting Eucalyptus biomass into biochar, highlighting success stories from the region and beyond.
- **Partnership Development:** Collaborating with agricultural cooperatives, research institutions, and local businesses to promote biochar adoption, ensuring that farmers and landowners have the support and knowledge they need to develop into more sustainable and productive practices smoothly.

2.1.3. Community Investment and Infrastructure Development

In a strategic move to further empower the local economy, BioCarbonGrow plans to expand the project through the establishment of new biochar production facilities. The biochar production facilities will be strategically located on land leased from Eucalyptus landowners, ensuring that the benefits of the project are widely distributed within the community. The farmers which join the collective will receive biochar free-of-charge and subsidised fertiliser in exchange for the right for on-going soil monitoring.

Development Strategy:

- **Fair Profit Share:** Landowners and farmers participating in the lease agreements and soil amendment agreements will benefit from a fair profit-sharing model, ensuring that they receive a proportional share of the profits generated from the biochar produced and applied on their land.

- **Infrastructure Investments:** The development of these new facilities will include investments in local infrastructure, enhancing accessibility and utility services, which, in turn, benefits the broader community.
- **Sustainable Development:** This expansion not only increases the project's capacity to produce biochar and sequester carbon but also contributes to sustainable economic development by creating new jobs and supporting local supply chains.

By focusing on these key areas, BioCarbonGrow aims to create a robust ecosystem of economic empowerment, sustainability, and community resilience, demonstrating a comprehensive approach to leveraging environmental projects for regional economic development.

2.2. Commitment to a Living Wage

All project workers are compensated at or above the living wage, with benefits including subsidised housing, electricity, and internet, ensuring dignified living conditions.

Definition of a Living Wage

A living wage in Southern and Southwestern Minas Gerais, Brazil, is defined as the minimum income necessary for a worker to maintain a basic but decent standard of living for themselves and their family. This includes expenses for housing, food, healthcare, education, transportation, utilities, and other essential needs, along with some discretionary income. As of June 2023, the living wage is calculated to be BRL 2621 (USD 540) per month, which accounts for mandatory deductions and taxes, ensuring workers can afford a dignified life amidst local economic conditions.

2.2.1. Regional Cost-of-Living Analysis

The cost of a decent standard of living for a family in the region, as updated for 2023, is estimated at BRL 3899 (USD 804) per month. This figure represents the total monthly expenses needed to cover a family's basic needs, confirming the importance of implementing a living wage that supports this standard of living amidst rising costs.

- **Housing:** Rent in Minas Gerais can vary significantly depending on the location and size of the property. For a family-sized home in the Southern and Southwestern regions, an average monthly rent could be estimated based on local real estate listings and housing market

reports. For example, a 3-bedroom home in a semi-urban area might average around BRL 1,200 to BRL 1,800 per month.

- **Food:** The cost of a basic but nutritious monthly food basket for a family would include staples such as rice, beans, meat, vegetables, and other essentials. Based on national statistics and adjustments for regional variations, this could be estimated at around BRL 600 to BRL 900 for a family of four.
- **Healthcare:** While Brazil offers universal healthcare through the SUS (Sistema Único de Saúde), many opt for private health insurance for more comprehensive coverage. The average cost for basic health insurance coverage for a family might range from BRL 300 to BRL 600 per month, depending on the plan's extent.
- **Education:** Public schooling in Brazil is free, but expenses such as uniforms, books, and supplies can incur costs. For families choosing private education, tuition fees can vary widely. An estimated cost for educational supplies and potential fees might range from BRL 200 to BRL 500 per child per month.
- **Transportation:** The average expenses for commuting to work or school, considering public transport, fuel for private vehicles, or other modes, could be estimated at BRL 150 to BRL 300 per adult per month, depending on distance and mode of transportation.
- **Utilities:** This includes electricity, water, gas, and internet services. An average monthly utility bill for a family-sized home might range from BRL 400 to BRL 700, reflecting variations in usage and local tariffs.

2.2.2. Calculation Methodology

Living Wage Calculation

The living wage calculation for individual workers in the BioCarbonGrow project adheres to the methodology outlined in the "Living Wage Update Report: Minas Gerais South/Southwestern Region, Brazil, 2023" by the Anker Research Institute. This methodology involves:

- **Basic Needs Assessment:** Identifying the cost of essential living components for an individual, incorporating regional data on housing, food, healthcare, education, transportation, and utilities expenses, as reported in the 2023 Anker report. The report highlights a

comprehensive approach to estimating these costs, ensuring they reflect a basic but decent standard of living.

- **Family Size Adjustment:** The living wage is calculated based on the needs of a typical family in the region, considering the average number of dependents an individual worker supports. The Anker report specifies a gross living wage of BRL 2621 (USD 540) per month for 2023, which accounts for an average family's needs after mandatory deductions.
- **Mandatory Deductions:** Including income taxes, social security contributions, and other payroll deductions as per the 2023 legal framework in Brazil, as detailed in the Anker report. This adjustment is critical to determining the gross living wage required to meet a worker's net living wage needs.

Decent Standard of Living for a Family Calculation

To determine the necessary income for a family to maintain a decent standard of living, the methodology updates the base year's family living expenses for inflation to reflect 2023 economic conditions:

- **Total Family Expenses:** Aggregating the updated costs for housing, food, healthcare, education, transportation, and utilities for a family. The 2023 Anker report updates these living expenses to BRL 3899 (USD 804) per month, providing a realistic benchmark for a family's decent standard of living in the region.
- **Inflation Adjustment:** Applying a total inflation rate of 53.9% from July 2015 to June 2023, as per the Anker report's methodology, ensures the living wage reflects the current purchasing power necessary for maintaining a decent standard of living.
- **Real-World Financial Conditions:** Factoring in current laws and mandatory deductions based on June 2023 conditions, including changes in social security tax rates and income tax provisions detailed in the Anker report. This ensures the calculated wage is compliant with Brazilian labour laws and taxation policies.

By adopting the methodology and findings from the "Living Wage Update Report: Minas Gerais South/Southwestern Region, Brazil, 2023," this revised section ensures that the living wage and family living expenses calculations for the BioCarbonGrow project are robust, accurate, and reflective of current

economic realities in Minas Gerais. This commitment to transparency and adherence to established research standards reinforces the project's dedication to fair labour practices and its positive impact on local communities.

2.2.3. Project Commitment to Compensation & Benefits

Our dedication to fostering a supportive and equitable work environment extends beyond our commitment to environmental sustainability. Recognizing the integral role our collaborators play in achieving our goals, we are committed to providing a compensation and benefits package that not only meets but exceeds the basic requirements set forth by law and ensures a dignified family life for all team members.

Committed to a Living Wage

Addressing the cost of living in the region, we provide a comprehensive benefits package alongside wages above the legal minimum. This includes free housing, which significantly reduces the living expenses for our workers by an estimated BRL 1,200 to BRL 1,800 monthly, considering the average rent for a family-sized home in the region. Additionally, we offer subsidies for essential utilities, effectively valuing BRL 300 monthly for electricity, water, and fibre-optic internet services. By integrating these substantial benefits with competitive wages, we ensure our workers can enjoy a dignified family life, fully embodying our commitment to fostering a supportive, equitable, and thriving work environment.

Comprehensive Benefits Package

Understanding that financial compensation is just one aspect of a holistic approach to employee well-being, BioCarbonGrow offers a robust benefits package designed to address the diverse needs of our workforce. This package includes:

- **Free Housing:** Recognizing the significant portion of income typically dedicated to housing, we provide free family-sized housing to our collaborators, directly enhancing their quality of life and financial stability.
- **Subsidised Utilities:** To further ease the financial burden on our employees, we offer substantial subsidies for electricity and fibre-optic

internet services, ensuring that our team members have access to essential utilities without undue financial stress.

- **Free Running Water:** Access to clean running water is a fundamental need. BioCarbonGrow ensures that all collaborators have free access to this vital resource, underscoring our commitment to their health and well-being.
- **Above Minimum Wage Compensation:** Coupled with our benefits, our policy of paying wages above the minimum legal wage ensures that our collaborators' compensation reflects the true cost of living and allows for a standard of living that goes beyond mere necessities.

Exceeding the Minimum Legal Wage

In 2024, the minimum legal wage in Brazil was established at 1,412 Brazilian Reals (BRL) per month. BioCarbonGrow proudly exceeds this baseline, offering wages that surpass the minimum legal requirement. By providing a salary above the minimum wage, we aim to ensure that our collaborators are not just surviving but thriving, enabling them to contribute more effectively to our collective mission while securing a comfortable standard of living for themselves and their families.

A Culture of Respect and Dignity

BioCarbonGrow's approach to compensation and benefits is rooted in a deep respect for our team and a commitment to fostering a work environment that promotes dignity, respect, and mutual growth. We understand that our success is intrinsically linked to the well-being of our team, and we are dedicated to ensuring that every member of our workforce feels valued, supported, and motivated.

2.2.4. Future Adjustments to Compensation and Benefits

To ensure that our commitment to a living wage remains effective and relevant amidst changing economic conditions, BioCarbonGrow will implement a dynamic adjustment mechanism. This mechanism will be guided by principles of procedural equity, ensuring that all employees have a voice in the process and that adjustments are fair and transparent.

Mechanism for Adjustment

- **Annual Review:** Conduct annual reviews of wages and benefits in relation to local economic conditions, including inflation rates, cost of living adjustments, and regional economic data.
- **Adjustment Formula:** Develop a clear formula for adjusting wages that inline with the Brazilian consumer price index (CPI), local wage trends, and company performance metrics.
- **Transparent Communication:** Communicate changes and the reasons behind them to all employees through internal bulletins and 1-to-1 meetings.

2.2.5. Documentation and Public Reporting

To maintain transparency and accountability, BioCarbonGrow will implement a bi-annual reporting system that details the status and changes to compensation and benefits, as well as compliance with the living wage commitment.

Reporting Structure

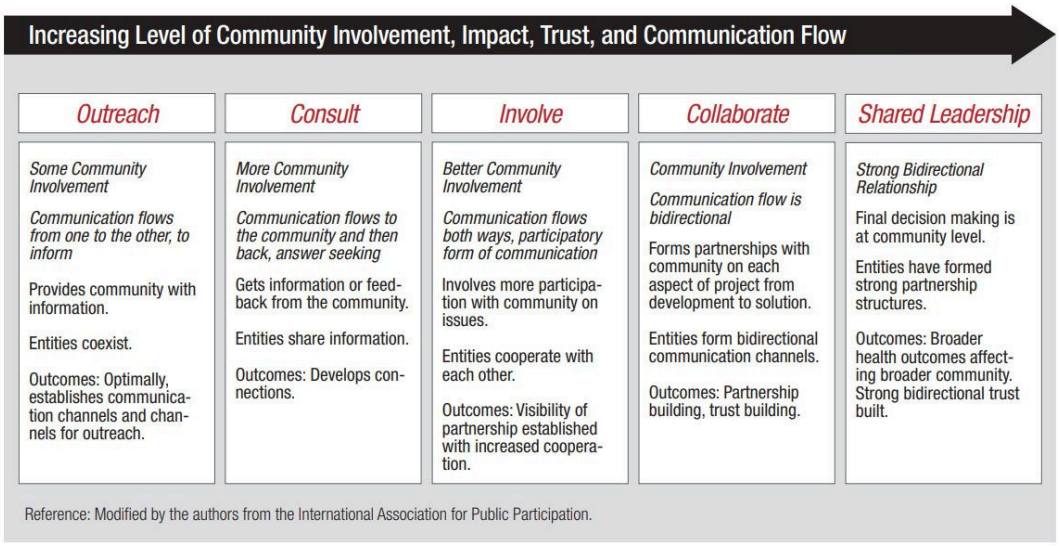
- **Content of Reports:** Each report will include detailed information on current wage levels, benefits provided, the outcome of adjustment reviews, and a summary of employee feedback and involvement.
- **Public Accessibility:** Make reports publicly accessible to all stakeholders, including employees, investors, and community members, through the company's website.
- **Feedback Mechanism:** Incorporate a feedback mechanism within the report, allowing stakeholders to provide input on the compensation system and suggest improvements.
- **Compliance and Impact Assessment:** Include an assessment of compliance with local laws and the impact of the compensation system on employee satisfaction and retention.

Our commitment to exceeding legal requirements for wages and providing a comprehensive benefits package is more than just a policy—it is a reflection of our values and our vision for a world where environmental sustainability and social

responsibility go hand in hand. By investing in our stakeholder's well-being, we are building a foundation for sustainable growth, innovation, and collective achievement in our mission to combat climate change through high-quality carbon dioxide removal.

2.3. Community Engagement and Transparency

Following the ATSDR community engagement continuum, the project plans to develop an increasing level of community trust and engagement culminating in the formation of a regional collective to oversee project expansion. Outlined below is an overview of how the project plans to progress across the ATSDR community engagement continuum, more information on the engagement activities can be found further below.



Outreach: Inform local stakeholders (local Eucalyptus foresters, farmers and biomass purchasers) on the BioCarbonGrow biochar project and establish clear points of contact and escalation. Our initial Support Sessions will be to engage prospective members of the collective and introduce the benefits of PEFC certification, biochar application and production.

Consult: Obtain feedback from early support sessions on project impact and improve the value provided in future support sessions. For early participants, we aim to form our Community Advisory Panel.

Involve: Sponsor community-led support sessions. A continuation of the support provided to prospective collective members and stakeholders led by early members

of the Community Advisory Panel. We aim to foster the beginnings of a collaborative relationship between biomass suppliers and farmers.

Collaborate: The early formation of informal community-led groups centred around each activity, sustainable forestry, agricultural application of biochar and distributed biochar production. We aim to localise activity knowledge and foster community leadership to elevate both the reach and impact of the community-led workshops

Shared Leadership: With an established activity-based community leadership, we will support the formalisation of the BioCarbonGrow Collective. The collective will be deeply involved with the project expansion and governance of community allocated funding.

2.3.1. Engagement Goals and Metrics

Objectives:

- **Enhance Local Economic Opportunities:** Increase access to jobs and business opportunities related to biochar production and application.
- **Improve Agricultural Practices:** Promote the use of biochar to improve soil health, increase agricultural productivity, and support sustainable farming practices.
- **Foster Environmental Stewardship:** Provide direct support for local eucalyptus farmers to adopt PEFC or FSC certified forest management practices, as part of our biomass supplier expansion.
- **Build Local Capacity and Knowledge:** Develop local expertise in biochar production and application techniques, including training programs and knowledge-sharing sessions.

Key Performance Indicators (KPIs):

- **Number of Jobs Created:** Track the number of direct and indirect jobs generated by the project within the community.
- **Number of Participating Smallholder Farms:** Tracking the number of participating farms and reported improvements in crop yields or soil health where biochar has been applied.
- **Hectares of Newly Certified Sustainable Forests:** Tracking the number of community Eucalyptus landowners at each stage of their sustainable forestry certification journey and the total hectares of newly certified sustainable forests..

- **Number of Training Sessions Conducted and Participants:** Keep a record of the training sessions related to biochar production and application, and the number of community members who participated.

2.3.2. Engagement Actions and Timeline

Engagement Actions

- **Community Outreach: (For Involvement)** We will engage with local biomass producers, farmers and affected industries to foster strong and collaborative relationships that will promote a sustainable regional adoption of biochar production and application. We will ensure inclusivity by targeting underrepresented groups through specific outreach programs that address their unique needs and perspectives.
- **Collective Support Sessions: (For Adding Value)** Every 3 months we will hold educational and consultative support sessions informed by our community-led workshops. These support sessions will be for current and prospective collective members, including biomass producers, farmers, local industry and community leaders.
- **Community-led Workshops: (For Feedback)**Every 3 months we will hold community-led workshops for Eucalyptus foresters, farmers and affected industry to better understand how BioCarbonGrow can support their PEFC certification, adoption of biochar use and better mitigate the effects of changes to local biomass supply.

Engagement Timeline

- **Initial Community Outreach:** Within the first 3 months of project initiation.
- **Ongoing Community Outreach:** Every subsequent 6 months.
- **Community-led Workshops:** Every 3 months.
- **Collective Support Sessions:** Every 3 months.

2.3.3. Mechanisms for Feedback and Governance

Feedback Mechanisms:

- **Community Feedback Forum:** Establish an online forum where stakeholders can leave feedback, share insights and learnings.

- **Regular Community-Led Workshops:** In addition to participant support, our workshops are where local stakeholders actively shape project activities and outcomes, discuss new challenges, gather feedback on support offered, and adjust support sessions and project plans as needed.

Governance and Empowerment:

- **Feedback Review Sessions:** Hold internal quarterly sessions to review feedback and identify actionable items.
- **Community Advisory Panel:** Form a panel consisting of community members to advise on project adjustments based on feedback.
- **Community-led Collective:** Form a collective consisting of activity-based community-led groups, expanding the role of the Community Advisory Panel to advise on project expansion and govern the allocation of community development funds (10% of profits).

Feedback and Governance Timeline

- **Implementation of Community Suggestions:** Feedback incorporated within 3 months of suggestions being made. (Prior to the next support session)
- **Community Advisory Panel Formed:** Within the first 3 months of project initiation.
- **Community-led Collective Formed:** Within the first 12 months of project initiation.

2.3.4. Documentation and Public Reporting

To maintain transparency and accountability, BioCarbonGrow will implement a bi-annual reporting system that details community engagement, economic and environmental impact reports.

Documentation Strategy:

- **Engagement Activity Log:** Maintain a detailed log of all engagement activities, participant lists, and feedback received.
- **Economic Impact Assessment Reports:** Document the direct and indirect jobs and business opportunities created by biochar production and application in the Paraiba river valley.

- **Environmental Impact Assessment Reports:** Document the outcomes of biochar application on soil and crop productivity in participating farms.

Public Reporting Plans:

- **Public Repository:** Publish engagement summaries and outcome reports on the publicly available repository.
- **Bi-Annual Community Meetings:** Present annual reports on project progress and outcomes during meetings open to all stakeholders, ensuring transparency and accountability.

2.4. Indigenous Groups and Stakeholders

BioCarbonGrow is dedicated to conducting operations responsibly and ethically, ensuring that all activities respect local communities and the environment. This section explains our methodologies for confirming the absence of indigenous territories in the initial project area and outlines our ongoing commitment to vigilance and evaluation as the project scales.

Phase 1: Verification of Indigenous Territory Absence

BioCarbonGrow has confirmed that there are no recognized indigenous territories within the 4000-hectare project site in the Paraíba River Valley. This determination was made through a thorough investigation to ensure that our project aligns with national and international guidelines on indigenous rights.

Confirmation Process

- **Consultation with ISA's Database:** Using the Socio-Environmental Institute (ISA) database, a comprehensive and respected source that maps legally recognized indigenous territories in Brazil. The database confirmed the absence of indigenous lands in the project area.
- **Engagement with FUNAI:** Consulting with the National Indian Foundation (FUNAI), which is responsible for protecting indigenous rights in Brazil, to verify the absence of unrecognised indigenous claims.
- **Public Records and Historical Research:** Conducted a review of public records and historical research to cross-verify the absence of both current and historical indigenous territories.

Documentation and Transparency

- **Public Reporting:** All findings and documentation from the verification process are available upon request. These findings will be made publicly available on the BioCarbonGrow website to maintain transparency after the project launches.
- **Ongoing Monitoring:** Established a process for ongoing monitoring to ensure that no new indigenous claims arise within the project area.

Phase 2: Continued Evaluation and Monitoring

As BioCarbonGrow plans to expand operations with new collective members by sourcing woody biomass from eucalyptus landowners and applying biochar in soil in farms across the wider Paraíba River Valley, stringent evaluation and documentation practices will be implemented.

Evaluation Strategy

- **Regular Review of ISA and FUNAI Updates:** Regularly review updates from ISA and FUNAI regarding any changes in the mapping of indigenous territories or new claims that might arise in the broader region.
- **Engagement with Local Stakeholders:** Maintain open lines of communication with local communities and stakeholders to gather any new information regarding indigenous claims or concerns that may not yet be legally recognized.
- **Environmental and Social Impact Assessments:** Conduct comprehensive environmental and social impact assessments (ESIAs) for new areas under consideration for expansion, ensuring these assessments include a specific focus on potential indigenous claims.

Documentation and Transparency

- **Public Reporting:** All findings and documentation from the verification process will be available upon request. These findings will be made publicly available on the BioCarbonGrow website to maintain transparency after the project launches.
- **Ongoing Monitoring:** Established a process for ongoing monitoring to ensure that no new indigenous claims arise within the project area.

3. Additionality

The BioCarbonGrow project is 100% additional as its carbon removal would not have occurred without dedicated carbon finance. This project is designed to transform unused eucalyptus biomass, previously allocated to low-value charcoal production, into biochar, providing both durable carbon storage and soil fertility improvements. Several critical elements establish BioCarbonGrow's additionality:

3.1. Dependency on Carbon Finance:

The BioCarbonGrow initiative relies entirely on revenue from carbon credits to fund operational costs associated with biochar production, secure CapEx funding and make repayments on the capital-intensive pyrolysis machinery. Without this carbon finance, the project would not have been economically feasible given the absence of local incentives or requirements for biochar production, confirming that revenue from carbon credits is essential to project execution.

3.2. No Legal or Regulatory Requirements

The production of biochar and its application as a soil amendment are voluntary practices in the region, with no existing legal mandates or local government programs driving this transformation. The project is thus neither required by law nor incentivized through regional regulations, further establishing that its activities are additional.

3.3. Counterfactual Scenario (Baseline)

The baseline scenario assumes the continued low-value use of eucalyptus biomass for charcoal production, which has minimal carbon storage potential. Without the BioCarbonGrow project, this biomass would release carbon dioxide through combustion, with no substantial carbon sequestration benefits. Therefore, the project's activities yield a significant increase in net carbon removals, compared to the baseline of emissions from conventional charcoal production.

Through these aspects, BioCarbonGrow demonstrates its adherence to additionality principles, ensuring that its carbon removal activities are genuine and uniquely driven by the support of carbon finance.

4. Carbon Accounting & MRV

The project's carbon accounting framework is rooted in detailed elemental analysis of the biochar (focusing on carbon, hydrogen, oxygen composition) to substantiate its storage durability and account for biochar's recalcitrance and potential carbon loss over a 1000-year timeframe. Through comprehensive life cycle analysis (LCA), the project evaluates the entire spectrum of the biochar's life cycle, from its production to its final application as a soil amendment. This thorough assessment guarantees that each phase of the process yields a net-negative carbon impact, affirming our dedication to sustainable environmental practices.

- **Life Cycle Analysis (LCA):** The project conducts a comprehensive LCA that covers a broader scope of the biochar's journey, from cradle-to-grave. This includes the emissions from producing and supplying the biomass, converting it into biochar, and the distribution and utilisation of biochar as a soil amendment. Such comprehensive accounting ensures that every aspect of the process contributes to a net-negative carbon impact, reinforcing our commitment to a sustainable environmental footprint.

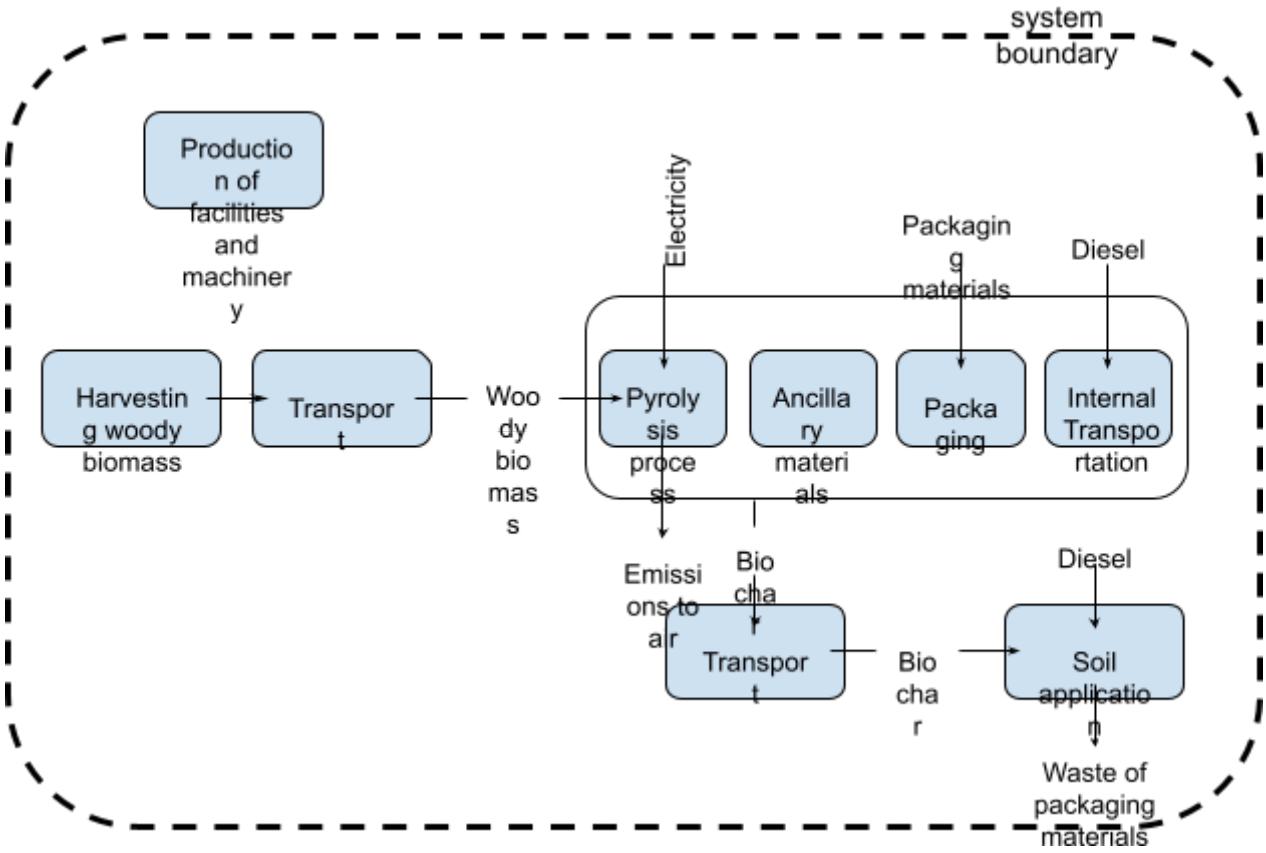
Monitoring, Reporting, and Verification (MRV) processes are meticulously designed to ensure the ongoing integrity and transparency of the BioCarbonGrow project's carbon removal efforts, in alignment with Puro.earth’s biochar methodology.

- **Monitoring:** BioCarbonGrow implements a robust monitoring system, including periodic soil measurements to assess the biochar's stability and effectiveness in enhancing carbon sequestration in agricultural lands. These measurements are complemented by regular audits of biochar production volumes and application rates.
- **Reporting:** Comprehensive reports are generated annually, detailing the project's carbon sequestration performance, any observed reversals, and the effectiveness of mitigation measures. These reports are made publicly available to ensure transparency and foster trust among stakeholders.
- **Verification:** Independent third-party verification is conducted to assess the accuracy of the project's carbon accounting and the reliability of its MRV practices. This verification follows the standards set by Puro.earth and other relevant bodies, providing an added layer of credibility to the project's carbon removal claims.

4.1. Carbon Accounting

4.1.1. Cradle-to-Grave System Boundary

The scope of the life cycle assessment extends from cradle-to-grave, specifically examining the entire process from the sourcing of raw materials to the application of biochar as a soil amendment. This assessment encompasses all life cycle stages, including the emissions from producing and supplying the biomass, converting the biomass into biochar, and the distribution and utilisation of biochar.



4.1.2. Inventory Analysis

4.1.2.1. Biomass Harvesting

- **Machinery:** Standard harvesting machinery with diesel consumption estimated based on industry standards.

- **Emissions:** Emissions from biomass harvesting are estimated based on industry norms for similar operations, considering the type and efficiency of machinery used.

Input/Output	Quantity	Units	Source/Methodology
Diesel Fuel	0.5	L/tonne of biomass	Estimated based on industry standards for harvesting machinery
CO2 Emissions from Diesel	2.68	kg CO2/L of diesel	Estimated using a standard emission factor for diesel

Note: Emissions are calculated using the emission factor for the combustion of diesel fuel.

4.1.2.2. Transportation

- **Fuel Consumption:** Diesel lorries' fuel consumption is estimated based on LCA databases, reflecting the average efficiency for the vehicle type and transport distance.
- **Transport Data:** N/A for input materials for pyrolysis as biomass is the primary input.

Input/Output	Quantity	Units	Source/Methodology
Diesel Fuel	0.33	L/km	Estimated based on average fuel consumption for heavy-duty lorries
CO2 Emissions	2.68	kg CO2/L of diesel	Estimated using a standard emission factor for diesel
Distance	200	km/round trip	Provided by BioCarbonGrow
Total Trips (Annual)	433	trips/year	Calculated from annual biomass transported and lorry capacity

Note: CO2 emissions are estimated based on the emission factor for the combustion of diesel fuel.

4.1.2.3. Pyrolysis Process

Energy Consumption:

- Crusher: 55 kW
- Spiral Conveyors: Various capacities, totaling 12 kW
- Rotary Dryer: 11 kW
- Diesel Burner: 1.5 kW
- Biochar Furnace: 4 kW
- Draft Fan and Water Pump: 3.75 kW

The total electrical energy demand will be calculated based on the operational hours and capacities provided, assuming a continuous production cycle.

- Emissions: Estimations of emissions from the pyrolysis process will consider syngas capture for heating with residual emissions calculated based on efficiency and combustion characteristics.

Machinery	Power Rating (kW)	Operational Time (hrs/tonne of biochar)	Electricity Consumption (kWh/tonne of biochar)
Crusher	55	0.33	18.15
Spiral Conveyors	12	0.33	3.96
Rotary Dryer	11	0.33	3.63
Diesel Burner	1.5	0.33	0.495
Biochar Furnace	4	0.33	1.32
Draft Fan and Water Pump	3.75	0.33	1.2375

Total Energy Consumption per Tonne of Biochar: 28.7925 kWh

Electricity Grid Emissions Factor: 0.3785488812 tCO2/MWh - Applied to the total electricity consumed.

4.1.2.4. Packaging and Storage

- Packaging Materials: Estimations for the types and weights of materials used for biochar packaging will be based on standard practices within the industry.
- Weight Ratio: The ratio of packaging material to biochar is estimated based on comparable products and practices.
- End-of-Life: Packaging material end-of-life scenarios are assumed based on standard recycling, reuse, or disposal processes within the industry.

Input/Output	Quantity	Units	Source/Methodology
Packaging Material	10	kg/tonne of biochar	Estimated based on industry standard for bulk biochar packaging
CO2 Emissions from Packaging Production	6	kg CO2/kg of packaging material	Estimated using a standard emission factor for plastic production

Note: The emissions from packaging production are estimated using standard plastic production emissions factors.

4.1.2.5. Soil Application

- Application Rate: 10-20 tonnes per hectare.
- Incorporation Method: The biochar is assumed to be incorporated via standard tillage practices at a depth consistent with agricultural best practices to ensure optimal carbon sequestration and soil health benefits.
- Emissions: Emissions associated with the application process are estimated based on similar agricultural practices.

Input/Output	Quantity	Units	Source/Methodology
Biochar Applied	15	tonnes/hectare	Average of provided application rates

Diesel for Application	5	L/hectare	Estimated based on typical diesel consumption for agricultural machinery
CO2 Emissions	2.68	kg CO2/L of diesel	Estimated using a standard emission factor for diesel

Note: CO2 emissions are estimated based on standard emission factors for the combustion of diesel fuel.

4.1.2.6. Energy Sources

- Electricity: The grid emissions factor provided by IGES at 0.3785488812 tCO2/MWh will be used to calculate the impact of electricity use.
- Diesel: Diesel consumption for facility operations, including machinery and the application process, is estimated using comparable project data.

4.1.2.7. End-of-Life

- Scenarios: Biochar is assumed to remain in the soil indefinitely, contributing to long-term carbon sequestration.
- Stability and Degradation: Biochar's stability in the soil is considered to be high with negligible degradation over the 1000-year timeframe, consistent with the stability criteria from Puro.earth's methodology.

4.1.3. Estimates, Assumptions & Sources

These tables contain estimated values for the LCA inventory analysis, assuming continuous operation and typical usage patterns. The energy consumption figures for the pyrolysis process are based on the power ratings of the equipment and an operational time per tonne of biochar produced, assuming 24-hour continuous operation.

Emission factors for CO2 from diesel and electricity are taken from established LCA databases and emissions reporting protocols.

Packaging material weight is estimated based on industry standards for bulk biochar handling, with CO2 emissions from the production of packaging materials estimated using standard emission factors for plastic production.

Soil application estimates are based on average application rates and standard agricultural practices for incorporating amendments into the soil.

Below is a table summarising the estimates used in the Inventory Analysis, showing the working and citing the sources for the data:

Stage	Detail	Calculation / Estimate	Data Source / Justification	Citation
Biomass Harvesting	Diesel Consumption	0.5 L/tonne	Industry standard for harvesting machinery	Ecoinvent Database
	CO2 Emissions	2.68 kg CO2/L diesel	Emission factor for diesel combustion	IPCC Guidelines for National Greenhouse Gas Inventories
Transportation	Fuel Consumption	0.33 L/km	Average for heavy-duty lorries	Ecoinvent Database
	CO2 Emissions	2.68 kg CO2/L diesel	Emission factor for diesel combustion	IPCC Guidelines for National Greenhouse Gas Inventories
Pyrolysis Process	Energy Consumption	equipment power ratings * operational time	Based on equipment specifications and continuous operation assumption	Manufacturer's data
	Electricity Emissions	0.3785488812 tCO2/MWh	Grid emissions factor	IGES Emission Factors Database
Packaging	Material Weight	10 kg/tonne of biochar	Estimated from industry standard	-
	CO2 Emissions	6 kg CO2/kg material	Emission factor for plastic production	PlasticsEurope Eco-Profiles

Soil Application	Diesel Consumption	5 L/hectare	Estimated from agricultural machinery standards	Ecoinvent Database
	CO2 Emissions	2.68 kg CO2/L diesel	Emission factor for diesel combustion	IPCC Guidelines for National Greenhouse Gas Inventories

Note: The calculations assume continuous operation and average values where specific data is not provided. These should be seen as preliminary estimates and will be refined with more detailed LCA

4.1.4. Life cycle impact assessment (LCIA)

4.1.4.1. Methodology for LCIA Calculation

Total CO2 Equivalent Emissions:

- Sum of all greenhouse gases converted to CO2 equivalents using their respective Global Warming Potential (GWP) factors.

4.1.4.2. Calculation Assumptions

- GWP Factors: CO2 = 1, CH4 = 28, N2O = 265 (from IPCC)
- Emissions from diesel are calculated based on fossil carbon.
- Grid electricity is considered to have emissions from a mix of sources; specifics depend on regional factors, which have been taken into account with the emissions factor provided.
- Direct emissions from the pyrolysis process are considered as part of biogenic emissions if they originate from the biomass.

4.1.4.3. LCIA Results for 1 Tonne of Biochar (kg CO2-eq)

Impact Category	Description	Amount	Detailed Calculation
Climate Change – Total (GWP-total)	Total global warming potential from all sources.	107.972 kg	Sum of all subcategories

Subcategories:			
Biomass Harvesting	Emissions from diesel combustion.	6.7 kg	0.5 L/tonne ÷ 0.2 Biomass/Biochar × 2.68 kg CO2/L
Transportation	Emissions from diesel combustion in transport.	29.48 kg	200 km × 0.33 L/km ÷ 30 tonnes ÷ 0.2 Biomass/Biochar × 2.68 kg CO2/L
Pyrolysis	Emissions from electricity use.	10.899 kg	28.7925 kWh/tonne × 0.3785488812 tCO2/MWh
Packaging	Emissions from production of packaging materials.	60 kg	10 kg/tonne × 6 kg CO2/kg
Soil Application	Emissions from diesel used in soil application.	0.893 kg	5 L/hectare ÷ 15 tonnes/hectare × 2.68 kg CO2/L

Sources:

This analysis synthesises information from publicly available LCA databases (such as Ecoinvent) and specific studies on biochar's environmental impacts, including "Biochar and its effects on the environment" by Woolf et al. (2010) and "Life Cycle Assessment of Biochar Systems" by Lehmann et al. (2011). It's tailored to the BioCarbonGrow project using assumptions about operational efficiencies, regional soil conditions, and the regional Minas Gerais Brazilian electricity mix.

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4.2. MRV

BioCarbonGrow's approach to Monitoring, Reporting, and Verification (MRV) aligns with Puro.earth's methodology, ensuring high integrity and transparency in carbon credit issuance. We will implement a robust MRV system aligned with leading

practices for distributed biochar projects. This system is structured to ensure the highest integrity of data collection, reporting, and verification, enhancing the project's transparency and accountability.

4.8.1 Monitoring

Objective: Implement a comprehensive and precise monitoring system to ensure the production process, biomass sourcing, and biochar quality adhere to Puro's biochar methodology and general rules.

1. Sensor Integration and Automation

- **Description:** High-precision sensors will monitor key parameters like temperature, pressure, and output levels in pyrolysis reactors to manage biochar quality and process stability.
- **Methodology:** Sensors will be calibrated to detect deviations and ensure continuous data recording, supporting real-time adjustments to maintain process specifications.
- **Technology Utilised:** Advanced sensor technology will be integrated with automated systems for real-time data capture and alert generation in case of deviations from predefined norms.

2. Biomass Sourcing and Handling

- **Description:** Monitoring of biomass sourcing to ensure it is sustainably sourced or classified as waste biomass as per Puro standards, including the verification of the H/C_org ratio.
- **Methodology:** Implement checks to verify sustainable sourcing credentials and biomass quality before acceptance. Regular audits and documentation will support compliance.
- **Technology Utilised:** Use of digital tracking and database systems for traceability of biomass sources, documenting the chain of custody and sustainability certifications.

3. Biochar Quality Assurance

- **Description:** Continuous quality control of biochar to ensure it meets the stability criteria with an H/C_org ratio lower than 0.7, making it resistant to degradation.
- **Methodology:** Routine sampling and laboratory testing of biochar batches to measure the hydrogen to organic carbon ratio and other critical quality parameters.
- **Technology Utilised:** Laboratory information management systems (LIMS) to manage sample data, test results, and quality control reports efficiently.

4. Data Integrity and Security

- **Description:** Secure management of all data collected through monitoring activities, ensuring integrity and compliance with data protection regulations.
- **Methodology:** Data encryption, secure data storage, and controlled access will safeguard information. Regular data audits will ensure accuracy and reliability of the monitoring data.
- **Technology Utilised:** State-of-the-art cybersecurity solutions will be deployed to protect data transmissions and storage, with regular updates to security protocols.

5. Compliance Auditing

- **Description:** Regular internal and third-party audits to ensure the biochar production process adheres to all regulatory and Puro's standards.
- **Methodology:** Scheduled audits will review operational compliance, biochar quality, and safety measures. Auditors will also verify that the biochar's end use preserves its carbon storage properties.
- **Technology Utilised:** Audit management software to plan, execute, and document all audit activities. This software will facilitate real-time reporting and immediate corrective actions.

4.8.2 Reporting

Objective: Ensure detailed, accurate, and transparent reporting of all data related to the biochar production process, aligning with the guidelines of the Digital MRV system and Puro's standards.

1. Production and Quality Data Reporting

- **Description:** Comprehensive reports on biochar production volumes, operational parameters, and quality metrics, including the H/C_org ratio of the biochar, which confirms its stability and long-term carbon sequestration capacity.
- **Methodology:** Data collected from sensors and monitoring systems will be compiled into periodic reports. These reports will detail production efficiency, process stability, and deviations, if any, with a focus on ensuring the biochar produced meets the quality requirements of Puro's biochar methodology.
- **Technology Utilised:** Using advanced data aggregation and reporting software that can handle complex data sets and generate detailed reports automatically, reducing human error and increasing reporting efficiency.

2. Sustainability and Compliance Reporting

- **Description:** Annually publish a sustainability report that includes information on biomass sourcing, emissions controls, energy use, and compliance with environmental standards.
- **Methodology:** This report will collate information from various stages of the biochar production process, including biomass sourcing verification, emission measurements, energy consumption data, and compliance with sustainable practices as per Puro's criteria.
- **Technology Utilised:** Reporting tools integrated with environmental management systems to ensure that all sustainability metrics are accurately captured and reported. These tools will also enable the generation of customizable reports for different stakeholder needs.

3. Reporting Dashboard

- **Description:** Maintain a reporting dashboard accessible by stakeholders to foster transparency updated quarterly for regular insight into the production process.
- **Methodology:** The dashboard will provide stakeholders with quarterly data, including production rates, emission levels, and energy usage. It will also feature alerts and notifications for any significant changes or deviations from standard operating procedures.
- **Technology Utilised:** Dashboard software capable of reporting data streams from multiple sources including some live sources, providing a comprehensive overview of operations to stakeholders, including regulatory bodies and certification agencies.

4. Audit and Third-Party Verification Support

- **Description:** Facilitate the audit process by providing detailed and organised documentation that supports third-party verification.
- **Methodology:** Prepare and maintain all necessary documentation required for audits, including detailed records of biomass sourcing, production data, emission controls, and quality checks. This preparation will help streamline the third-party verification process and ensure compliance with Puro's biochar methodology.
- **Technology Utilised:** Document management systems that ensure secure storage, easy retrieval, and proper organisation of documents needed for third-party audits and verifications.

5. Environmental Impact and Community Feedback

- **Description:** Report on the environmental impacts and community engagement activities to highlight the project's broader contributions and areas for improvement.
- **Methodology:** Annual environmental impact reports will summarise the findings from environmental assessments, community feedback mechanisms, and impact mitigation strategies. These reports will also cover any social responsibilities initiatives undertaken by the project.

- **Technology Utilised:** Use of environmental impact assessment tools and community engagement platforms to collect and analyse data on the project's environmental and social impact, ensuring comprehensive and factual reporting.

5. Durability

The BioCarbonGrow project prioritises the longevity and stability of biochar in soil to ensure its role in long-term carbon sequestration, a critical component in combating climate change. This focus on durability is supported by rigorous standards and methodologies that highlight biochar's potential to contribute effectively to soil carbon storage over extended periods.

5.1. Biochar's Longevity and Stability in Soil

Research highlighted in the International Biochar Initiative's "Biochar Carbon Stability Test Method" document underpins our understanding of biochar's durability. Biochar exhibits remarkable stability in soil, with its carbon structure resistant to microbial degradation, ensuring that it remains in soil for thousands of years. This stability is pivotal for the BioCarbonGrow project, as it guarantees that the carbon sequestered through our biochar application provides a long-lasting contribution to climate change mitigation efforts.

Durability: Leveraging the International Biochar Initiative's guidelines, our baseline for biochar durability in soil is conservatively set at over 100 years, with scientific literature suggesting potential for 1,000 to 10,000 years, depending on factors like soil temperature and biochar production conditions.

Microbial Resistance and Chemical Stability: Biochar's resistance to microbial degradation is attributed to its pyrolyzed carbon structure, which is less accessible to soil microbes compared to other organic matter. Studies by Singh et al. (2012) have demonstrated that the physical and chemical properties of biochar, such as its high surface area and aromatic carbon content, play crucial roles in its stability.

Impact of Environmental Conditions: The durability of biochar in soil can be influenced by various environmental factors, including soil pH, temperature, and moisture levels. Research by Spokas (2010) indicates that while biochar generally shows remarkable stability, specific environmental conditions can affect its

degradation rate. BioCarbonGrow considers these factors in the selection of application sites to optimise biochar's longevity.

Translocation and Sequestration: Studies indicate that while biochar may move within soil layers (translocation), it remains sequestered, contributing to carbon storage in both topsoil and subsoil. This movement does not detract from its overall stability or sequestration potential, with biochar eventually becoming a part of the soil matrix or potentially deposited in marine sediments, where it continues to act as a long-term carbon sink .

5.2. Mitigating & Addressing Reversals

BioCarbonGrow employs a comprehensive approach to monitoring the stored carbon and reliably detecting any potential reversal events. This approach includes:

Risk Analysis and Mitigation: An ongoing risk analysis, coupled with a robust mitigation strategy, ensures that any potential reversals are promptly addressed. This includes a buffer pool strategy to manage and mitigate risks, ensuring the reliability of our carbon sequestration efforts.

Adaptive Management: BioCarbonGrow's strategy involves site selection in low-risk areas and the implementation of risk mitigation measures. This approach, informed by ongoing monitoring and scientific research, enables the adaptation of our practices to ensure maximum durability of biochar and effectiveness in carbon sequestration.

5.2.1. Reversal Risk Mitigation

Risk Identification: We continuously assess potential sources of carbon reversal, including biochar degradation, land-use changes, and environmental factors such as wildfires or flooding, which could compromise the stability of sequestered carbon.

Preventive Measures: Our project employs several preventive measures to minimise the risk of reversals:

Biochar Stability Enhancement: By optimising the pyrolysis process, we ensure the production of highly stable biochar that resists degradation, further solidifying its longevity in soil.

Land Management Practices: Implementing sustainable land management and biochar application practices minimises the risk of biochar displacement or degradation due to environmental events.

Fire Risk Management: In fire-prone areas, we adopt fire management strategies, including creating firebreaks and promoting fire-resistant vegetation, to protect biochar-treated lands.

5.2.2. Buffer Pool Strategy

Buffer Pool Creation: To further secure against unforeseen reversals, BioCarbonGrow establishes a buffer pool—a reserve of carbon credits set aside to compensate for any potential loss of sequestered carbon. This pool represents a percentage of the project's total CORCs.

Size Determination: The size of the buffer pool is dynamically adjusted based on ongoing risk evaluations, taking into account the latest scientific research on biochar stability, regional environmental risk factors, and the project's historical performance.

Utilisation: In the event of a carbon reversal, credits from the buffer pool are retired to compensate for the lost sequestration, thereby maintaining the integrity of the carbon credits issued by the project.

Transparency and Reporting: BioCarbonGrow is committed to transparency in the management of the buffer pool. Regular reports detail the size of the buffer pool, contributions made, and any instances where the pool has been utilised to offset reversals, ensuring stakeholders are fully informed of the project’s risk management practices.

6. Leakage

Leakage refers to the unintended release of carbon dioxide or the displacement of emissions outside the project's boundaries, which can negate the benefits of carbon sequestration efforts. In the case of BioCarbonGrow, potential leakage could arise from the displacement of agricultural activities, changes in land use, or increased demand for biomass leading to unsustainable extraction practices elsewhere. Recognizing these risks, BioCarbonGrow has implemented comprehensive strategies to address and mitigate potential leakage.

6.1. Potential Sources of Leakage

Given BioCarbonGrow's sustainable approach to biomass sourcing and land use, potential leakage sources are less about direct land-use change and more about indirect impacts that might arise from project activities. Key areas of focus include:

Energy Consumption or Displacement: The project uses minimal electricity as both gases and bio-oil are combusted during the pyrolysis process to maintain heat. With that being said, there is an abundant and growing supply of electricity in the region with the state of Minas Gerais representing a significant contributor to Brazil's electricity generation. In 2022, the state of Minas Gerais produced 56,913.79 gigawatt-hours (GWh) of electricity. The minimal use of electricity and regional abundance of electricity leads us to believe there is limited consumption or displacement associated leakage risk during the initial phase or as the project scales.

Market Dynamics: The shift in market demand for redundant eucalyptus biomass from charcoal to biochar could potentially affect local industry energy consumption, which currently uses wood chips and woody biomass to generate heat and steam.

6.2. Mitigation Strategies

Given the potential leakage risks with shifts in market demand for biomass, BioCarbonGrow plans to adopt the following mitigation strategies:

Community-Based Resource Planning: Collaborating with local communities and stakeholders during our community-led workshops in resource planning to ensure that any increased demand for Eucalyptus biomass does not lead to unsustainable extraction practices or negatively impact local ecosystems.

Subsidised Heat Generation: As the project scales, we will collaborate with local industry potentially affected by any increased heat generation costs to replace woody biomass furnaces with onsite biochar pyrolysis machines for either electricity or heat generation. Thus subsidising heat generation with biochar sales via a joint venture with BioCarbonGrow. We have identified and engaged with suppliers of smaller scale cogeneration biochar production units that would meet the requirements.

Adaptive Management Practices: Continuously monitoring the project's impact on local market dynamics and resource competition, ready to adapt strategies in response to emerging challenges to minimise potential leakage.

6.3. Leakage Monitoring & Reporting

To accurately measure and address potential leakage, BioCarbonGrow will conduct:

Comprehensive Impact Assessments: Conducting bi-annual assessments to monitor the project's impact on local industries and ecosystems, ensuring early identification of potential leakage sources.

Transparent Reporting: Providing bi-annual reports on leakage assessments, including any identified risks and the effectiveness of mitigation measures, fostering transparency and accountability.

By focusing on these revised sources of potential leakage and implementing targeted mitigation strategies, BioCarbonGrow aims to ensure that its carbon sequestration efforts are sustainable, socially responsible, and contribute positively to the local economy and environment. This comprehensive approach underscores the project's dedication to minimising unintended impacts and maximising the benefits of biochar application for carbon dioxide removal.

7. Biomass Sourcing

BioCarbonGrow is dedicated to the sustainable sourcing of woody biomass, a critical input for our biochar production process. Understanding the importance of maintaining ecological balance and promoting social well-being, we exclusively source woody biomass from sustainably certified forests under the Programme for the Endorsement of Forest Certification (PEFC) or similar. This certification ensures that our biomass sourcing practices meet the highest global standards for environmental, social, and ethical responsibility.

7.1. Initial Phase: On-site Sustainable Forest Management

At the outset of the BioCarbonGrow project, all biomass required for biochar production will be sourced directly from our own 4,000 hectares of sustainably managed forest.

PEFC Certification: Our on-site forest management practices will undergo PEFC-certification, as part of our commitment to responsible forest management that conserves biodiversity, supports water quality, and enhances social outcomes for workers and local communities.

Sustainable Harvesting: The initial phase prioritises a sustainable harvesting approach that maintains the ecological balance of the forest, ensuring that biomass extraction does not exceed the forest's natural regenerative capacity.

7.2. Expansion Phase: Collaboration with Local Eucalyptus Landowners

As BioCarbonGrow scales its operations across the wider Paraíba River Valley, we recognize the importance of including local Eucalyptus landowners in our sustainable biomass sourcing strategy. This phase will focus on supporting the adoption of PEFC or FSC certified sustainable forest management by local landowners, with BioCarbonGrow providing necessary consultation and guidance to achieve these objectives.

Engagement and Support: We will actively engage with local Eucalyptus landowners, offering support and resources to transition their practices toward sustainable forest management. This includes assistance in understanding and achieving PEFC certification, which aligns their operations with recognized global standards.

Technical Assistance and Certification Guidance: BioCarbonGrow will provide technical assistance, educational workshops, and detailed guidance on sustainable forest management practices. Our team will assist landowners through the certification process, ensuring their biomass can be sustainably sourced for our biochar production.

7.3. Commitment to Sustainability and Community Development

This dual-phase biomass sourcing strategy underscores BioCarbonGrow's deep commitment to sustainability, community engagement, and responsible resource management. By starting with our own PEFC-certified forests and gradually incorporating local landowners into our sustainable biomass sourcing framework, we ensure that our biochar production not only contributes to carbon sequestration but also supports the ecological integrity and economic prosperity of the Paraíba River Valley.

Through these efforts, BioCarbonGrow sets a precedent for sustainable biomass sourcing in carbon removal projects, demonstrating how environmental stewardship and community collaboration can drive positive change in the fight against climate change.

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