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Feasibility Study (FS) for Biochar Carbon Projects

Version Number 1.00

Credynova Solutions

Presented To
Client

Presented by
Credynova

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Executive Summary

Overview of the Biochar Carbon Opportunity

Biochar—produced through the thermal decomposition of biomass under oxygen-limited conditions—is rapidly emerging as a scalable, science-backed solution for long-term carbon dioxide removal (CDR). With its ability to sequester carbon for centuries while enhancing soil health, conserving water, and supporting circular biomass utilization, biochar is recognized as a high-integrity pathway in the global portfolio of climate mitigation tools.

Recent methodological approvals such as Verra's VM0044, Puro.Earth's biochar CDR protocol, and Gold Standard's land-use frameworks have created clear, bankable routes for credit generation. Leading carbon credit buyers are increasingly seeking durable removals with co-benefits, positioning biochar as a climate-smart, nature-aligned, and market-viable technology.

Amid increasing pressure to decarbonize supply chains, regenerate degraded land, and build rural economies, biochar offers a rare triple win—climate, soil, and livelihoods. The opportunity lies not just in biochar production, but in building a robust ecosystem around its carbon science, market frameworks, and community integration.

Feasibility Scope, Approach, and Key Recommendations

This Feasibility Study (FS), developed by Credynova Climate Tech, assesses the viability of deploying a biochar carbon project that can scale across multiple geographies while remaining aligned with international climate finance protocols.

The study follows a multi-phase, evidence-based approach:

- **Context and Baseline Assessment:** Feedstock sustainability, technology pathways, land access, and community context.
- **Carbon Project Design:** Methodology alignment (Verra, Puro), carbon estimation, and MRV readiness.
- **Techno-Economic and Environmental Analysis:** Lifecycle emissions (LCA), financial viability (TEA), and biochar market linkages.
- **Risk, EIA, and Impact Evaluation:** Legal, social, and environmental safeguards; reversal and leakage analysis.
- **Strategic Roadmap:** Development, validation, registration, and long-term issuance pathway.

Key Findings and Recommendations:

- **Feedstock:** Abundant, underutilized agri-residues and forestry waste can be sustainably mobilized.
- **Carbon Credit Potential:** Estimated 1.5–2.8 tCO_2e per tonne of biochar produced and applied to soil (based on carbon stability indices).

- **Technology Readiness:** Modular pyrolysis units provide scalability and cost control.
- **Registry Readiness:** Eligible for Verra VM0044, Puro.Earth, and potential Article 6 pathways.
- **Impact Potential:** Strong alignment with multiple SDGs—climate action, soil restoration, rural jobs, and circular economy.

Strategic Positioning: Compliance-Ready, Impact-Oriented, Investor-Aligned

Credynova's proposal is strategically designed to meet the highest standards of integrity and transparency across the carbon credit lifecycle. The project is:

- **Compliance-Ready:** Built to align with Verra, Puro.Earth, and national climate mechanisms, including NDC-linked Article 6 programs.
- **Impact-Oriented:** Grounded in regenerative agriculture, gender and livelihood inclusion, and measurable environmental co-benefits.
- **Investor-Aligned:** Backed by robust LCA, MRV, and TEA modeling to ensure credibility, risk reduction, and returns visibility for carbon investors, buyers, and sustainability-linked funds.

In a landscape where high-durability removals are scarce and scrutiny is high, this biochar carbon project offers scalable, credible, and transparent carbon outcomes backed by science, field readiness, and climate market experience.

About Credynova

We are a mission-driven climate solutions provider

Credynova is an environmental credit and climate solutions startup that combines science, technology, and finance to address today's most urgent sustainability challenges. We empower project developers, governments, businesses, and communities to unlock carbon and nutrient credits, restore ecosystems, and access sustainable finance.

We are committed to building a future where climate action, pollution control, and circular economy solutions are not just possible—they are profitable and accessible.

Mission

Enabling verified carbon, water, plastic, and nutrient credit solutions by integrating science, technology, and finance for a sustainable planet.

Vision

To lead the global transition to a low-carbon, climate-resilient future through transparent, scalable, and science-based sustainability strategies.

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Our Team

Our team includes accomplished climate analysts, software engineers, ESG strategists, and policy advisors. Each member brings hands-on experience in LCA, carbon registry compliance, and stakeholder engagement across diverse geographies. Outside work, the team enjoys activities like cycling, volunteering, gaming, and sustainable gardening—fueling creativity and collaboration within a purpose-driven culture.

Teamwork Efficiency	Healthy Office Environment	Socialization Between Teams
92%	96%	91%

Organization and Management

Jani Chetankumar
CO-FOUNDER

Jayesh Thummar
CO-FOUNDER

Bhaveshkumar Thummar
CTO

Clovelle Lacson
CPO

Ankita T.
CSO

Haresh Somjiyani
CFO

Project Goals & Scope

This Feasibility Study is designed to evaluate the technical, environmental, carbon credit, and market viability of developing a biochar-based carbon removal project that complies with leading carbon standards and aligns with regenerative land-use and sustainable development goals.

The overarching goal is to determine whether the project site(s), biomass sources, pyrolysis technology, and application methods are suitable for generating high-durability, verifiable carbon credits—while also delivering measurable co-benefits such as soil health improvement, waste valorization, climate resilience, and rural economic development.

This feasibility study will provide the foundation for investment decision-making, registry engagement (e.g., Verra, Gold Standards, Puro.Earth and Many), and stakeholder alignment. It aims to establish a strong technical and market case for proceeding with full project development, credit registration, and long-term credit issuance.

Alignment with Carbon Methodologies

Verra VM0044

Focused on carbon sequestration via stable carbon pools, with explicit guidance on additionality, MRV protocols, biochar quality, and permanence.

Gold Standards

Focused on carbon sequestration via stable carbon pools, with explicit guidance on additionality, MRV protocols, biochar quality, and permanence.

Puro.Earth

Focused on carbon sequestration via stable carbon pools, with explicit guidance on additionality, MRV protocols, biochar quality, and permanence.

Scope of the Study

This study covers the entire value chain and decision-making architecture necessary for launching a high-integrity biochar carbon project. The scope is organized into six interlinked components:

Baseline Assessment

- Evaluation of biomass types (e.g., agricultural residues, forestry waste, organic municipal waste)
- Feedstock availability, sustainability filters, and seasonal variability
- Local land-use patterns and logistics mapping

MRV Readiness

- Monitoring protocols for biochar quantity, quality, stability, and field application
- Design of mass balance, sampling procedures, and digital data capture systems
- MRV compatibility with registry and investor expectations

Environmental and Social Impact

- High-level screening of EIA requirements (air, water, soil, biodiversity)
- Mapping of social benefits: jobs, income diversification, soil productivity, gender inclusion
- SDG alignment and co-crediting opportunities

Risk & Mitigation Analysis

- Identification of technical, legal, environmental, and supply chain risks
- Analysis of reversal potential, land tenure complexity, and community-level sensitivities
- Mitigation strategies aligned with registry requirements and local policy

Carbon Forecasting

- Estimation of CO_2e removals using IPCC guidelines and methodology-specific formulas
- Scenario modeling (conservative, realistic, optimistic) based on biochar yield and permanence
- Integration of co-benefit GHG impacts (e.g., methane avoidance, fertilizer offset)

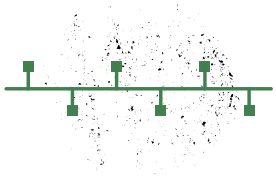
Project Roadmap and Recommendations

- Execution plan from feasibility to validation, registry registration, and credit issuance
- PDD development, field trials, stakeholder engagement, and permitting
- Timeline, budget estimate, and investment-readiness checklist

Deliverables

- A comprehensive technical and carbon viability report
- GIS maps, feedstock models, carbon yield projections, and risk registers
- A decision-support framework with go/no-go guidance for project development
- A registry-aligned development pathway for Verra, Puro.Earth, or Gold Standard

Proposed Timeline



Credynova follows a 7–10 day agile pre-feasibility study(Pre-FS) delivery model designed for rapid, high-quality decision support. This accelerated timeline balances technical depth with responsiveness—ideal for early-stage investors, project developers, or local partners needing quick go/no-go clarity while meeting international carbon registry expectations.

The process is modular and adaptable based on the availability of field data, stakeholder input, and biomass access conditions.

Delivery Model Pre-FS (7–10 Days)

Day 1

Feedstock & Site Baseline

Biomass type/quantity mapping, site suitability, land access, GIS overlays

Feedstock Map, Sustainability Check, Land Screening

Day 2

Technology & Biochar System Assessment

Pyrolysis system selection, biochar stability, yield estimation, process mass-energy balance

Tech Summary Sheet, Energy Flowchart, Biochar Quality Spec

Day 3

Carbon Methodology Alignment

Eligibility screening under Verra VM0044 / Puro.Earth, permanence, leakage, additionality analysis

Methodology Fit Report, Registry Readiness Matrix

Day 4

MRV & Monitoring Plan

Sampling protocols, application tracking, IoT/sensor integration, field/lab plan

Draft MRV Plan, Monitoring Tools Template

Day 5

Carbon Estimation & Modeling

CO_2e removal forecasting (tCO_2e/ton biochar), scenario modeling, sensitivity factors

Carbon Forecast Model, Assumptions Table

Day 6

Techno-Economic Analysis (TEA)

CAPEX/OPEX modeling, IRR, payback period, credit pricing scenarios

Financial Summary Sheet, TEA Dashboard

Day 7

Risk, Impact, and Strategic Roadmap

Risk matrix, mitigation plan, EIA screening, SDG alignment, development roadmap

Risk Register, SDG Map, Project Roadmap

Day 8-10

Stakeholder Engagement & Finalization

Validation of assumptions with local partners or field teams, review and iteration

Final Pre-FS Report, Presentation Deck, Supporting Files

Delivery Model Full Feasibility Study (30–45 Days)

Duration: Approx. 30–45 working days, depending on region, field data availability, and stakeholder coordination

Day 1-3

Feasibility Kickoff & Planning

- Stakeholder confirmation
- Field team mobilization
- Registry preference finalized

Kickoff meeting notes, TOR sign-off, registry pathway selected

Day 4-8

Biomass & Feedstock Mapping

- GIS biomass quantification
- Local survey validation
- Moisture & contamination screening

Feedstock supply map, baseline volumes, sustainability screening matrix

Day 9-12

Pyrolysis Tech Assessment

- Tech vendor comparison
- Mass/energy balance simulation
- Site fitment & capacity planning

Tech spec sheet, energy yield sheet, tech selection memo

Day 13-15

Carbon Methodology Alignment

- Verra VM0044/Puro.Earth fit analysis
- Registry forms initiation
- Buffer pool & permanence review

Methodology eligibility report, carbon accounting framework draft

Day 16-18

MRV System Design

- Field data flow mapping
- Lab testing protocols
- Sensor & mobile tool integration plan

Draft MRV plan, sample data collection templates

Day 19-22

Carbon Removal & Forecast Modeling

- Carbon content analysis
- Stability index calculation
- Scenario modeling (conservative to optimistic)

Carbon credit forecast (Excel), verification assumptions document

Days 23–25

Life Cycle Assessment (LCA)

- Boundary definition (cradle-to-credit)
- Emissions & offsets modeling
- Impact categories aligned to SDGs

LCA report (openLCA), emissions savings charts

Days 26–28

Techno-Economic Analysis (TEA)

- CAPEX/OPEX analysis
- IRR, NPV, Payback model
- Sensitivity test: credit price, feedstock, downtime

TEA model workbook, investor readiness dashboard

Days 29–31

Environmental & Social Impact (EIA/SIA)

- EIA screening
- FPIC documentation
- Grievance and safeguard matrix

Environmental screening memo, social impact narrative

Days 32–34

Risk Matrix & Legal Framework

- Land & carbon rights mapping
- Reversal mitigation plan
- Draft benefit-sharing agreements

Legal review brief, draft CBAs, risk mitigation table

Days 35–37

Project Governance & Capacity Model

- Cooperative model draft
- Training design
- MRV user flow confirmation

Governance charter, training plan outline

Days 38–40

Final Report Compilation

- Integration of all components
- Visual formatting
- Investor/registry review draft

Full Feasibility Report – Draft version

Days 41–45

Review, Validation & Final Submission

- Client and stakeholder feedback
- Executive summary finalization
- Submission to investor/registry

Finalized Full Feasibility Report (PDF + Annexes), editable Word/Excel deck

Phase I Context and Baseline Assessment

Project Geography & Justification

The selection of the project geography is a foundational step in establishing the technical, environmental, and financial viability of the biochar carbon initiative. It directly influences the sustainability of biomass supply, the efficiency of carbon credit generation, and the long-term success of project operations and verification cycles.

Credynova applies a multi-criteria framework to evaluate geography, integrating biophysical, socio-economic, and policy parameters.

Location Rationale: Biomass Density, Market Proximity, and Policy Incentives

High Biomass Availability

The area hosts substantial volumes of underutilized biomass such as agricultural residues (e.g., rice husk, sugarcane bagasse, cotton stalks), forestry waste (e.g., sawdust, pruned branches), or organic municipal solid waste (MSW). Biomass estimates are verified using local surveys, GIS modeling, and secondary data from FAO, national agricultural databases, and regional biomass atlases.

Market and Credit Buyer Access

- Agricultural demand centers for soil-amendment biochar
- Carbon credit aggregators, brokers, and buyers aligned with biochar-based CDR pathways
- Logistics corridors that reduce transport emissions and operational cost (roads, rail, decentralized processing potential)

Supportive Policy Environment

National and sub-national policies support bioeconomy development, waste-to-value incentives, carbon pricing mechanisms, or land restoration programs. The region aligns with climate finance objectives outlined in NDCs, SDG strategies, or state-level net-zero commitments.

Land Access, Infrastructure, and Environmental Setting

Land Tenure & Use Compatibility

The proposed project sites involve lands that are either under secure private/community ownership or long-term lease arrangements. There is no displacement of food crops or biodiversity-sensitive ecosystems. Due diligence is conducted to prevent conflicts, support Free Prior Informed Consent (FPIC), and respect Indigenous or customary land rights where applicable.

Logistics and Infrastructure

The area is logistically viable for deploying mobile or semi-mobile pyrolysis units or for setting up centralized production hubs. Proximity to utilities (electricity, water), skilled labor, and local governance structures supports both low setup costs and smooth regulatory processing.

Environmental Considerations

Climatic conditions are favorable for year-round or seasonally optimized biomass processing. Risk of floods, droughts, or fire is assessed as part of the project's environmental and risk mitigation strategy. The area does not intersect with protected zones or wetlands, reducing EIA compliance complexity.

Readiness for Article 6 or National Registry Alignment

Eligible for voluntary carbon market registration under globally recognized registries such as Verra (VM0044) and Puro.Earth, or Positioned within a jurisdiction actively participating in or preparing for Article 6.2/6.4 transactions under the Paris Agreement.

This enables the project to be potentially included in host-country NDC registries and ensures the option of future Corresponding Adjustment (CA) compliance, if necessary. The regional carbon governance framework is conducive to:

- Securing Letters of Approval (LoAs) from relevant authorities
- Aligning with national MRV and benefit-sharing systems
- Unlocking co-financing from climate funds or domestic carbon price mechanisms.

Phase I Context and Baseline Assessment

Biomass Feedstock Assessment

A comprehensive understanding of feedstock type, availability, quality, and sustainability is essential for the technical and carbon feasibility of a biochar carbon project. Biomass feedstock is not only the source material for biochar production but also a key determinant of the carbon removal potential, registry eligibility, and long-term viability of the project.

This assessment applies a multi-layered approach using satellite data, field surveys, supply chain analysis, and sustainability criteria to ensure both environmental and carbon integrity.

Biomass Types Considered

Agricultural Residues

- Rice husk, wheat straw, corn cobs, sugarcane bagasse, cotton stalks
- Often burned or left to decay, emitting CH_4 and N_2O under baseline conditions

Forestry By-products

- Sawdust, bark, pruned branches, woodchips, mill residues
- Sourced from sustainably managed forests or certified sawmills

Bamboo Waste

- Fast-growing, high-lignin biomass with strong carbon permanence characteristics
- Includes bamboo trimmings and industrial bamboo residue

Organic Municipal Solid Waste

- Separated organic fractions such as food waste, vegetable peels, market waste
- Pre-treated to remove contaminants, moisture optimized for pyrolysis

The project targets locally abundant, underutilized, and non-food biomass types that meet eligibility conditions under Verra VM0044, Puro.Earth, and other carbon standards. Each type is evaluated for compatibility with pyrolysis technology, biochar yield potential, carbon stability, and post-application safety.

Quantity Mapping: Satellite & Field-Based Approach

GIS-Based Biomass Mapping

Using Sentinel-2, Landsat 8, and MODIS data to estimate cropping intensity, harvest cycles, forest coverage, and agri-waste hotspots

Local Field Validation

Interviews with farmers, mill operators, and cooperatives; biomass-to-area ratios; harvest timing and residue recovery rates

Seasonality Consideration

Assessment of crop calendar and rainfall data to model biomass supply windows and ensure year-round or staggered feedstock availability

For each biomass stream, volumetric estimates are generated (in dry tonnes/year), along with logistics distance (km) and price range (USD/ton delivered). This supports cost-risk modeling and TEA inputs.

Sustainability & Quality Assurance

No Competing Food or Fodder Uses

Biomass must not displace food/feed markets or jeopardize local food security. Straw needed for animal bedding or mulch is excluded unless surplus is confirmed.

No Land Use Change

Only residues, by-products, or waste biomass are used. The project does not involve clearing natural vegetation, forests, or converting wetlands.

No Competing Food or Fodder Uses

Biomass sources are screened for industrial pollutants, agrochemical residues, or wastewater sludge. Biochar quality must meet IBI/EBC thresholds for: PAHs, Heavy Metals, pH and ash content within safe limits for soil application.

Moisture and Energy Suitability

Feedstock must fall within optimal moisture range (10–25%) to ensure pyrolysis efficiency. High-moisture biomass is either pre-dried or excluded.

Documentation and Traceability

Feedstock supply agreements or MoUs with local partners

Field photos, moisture readings, lab test reports

GIS coordinates and logistics route maps

Digital ledger records for registry traceability

Phase I Context and Baseline Assessment

Technology & Biochar Production System

The success of any biochar carbon project hinges on the selection and configuration of pyrolysis technology that maximizes carbon permanence, operational efficiency, and environmental safety. Credynova proposed the biochar production system, focusing on its technical design, performance characteristics, and alignment with leading carbon methodologies such as Verra VM0044, Puro.Earth, and IBI/EBC biochar quality standards.

Pyrolysis Technology Options

Biochar is produced through thermochemical conversion of biomass in an oxygen-limited environment. The project considers three core categories of pyrolysis systems, depending on scale, feedstock type, and operational context:

Batch Pyrolysis Units

- Low-cost and suitable for decentralized or pilot-scale operations
- Manual loading and cooling cycles limit throughput but offer flexibility
- Ideal for seasonal agri-residue processing in rural contexts

Continuous Pyrolysis Reactors

- Automated feed-in and biochar discharge
- Higher throughput, thermal efficiency, and control over residence time
- Suitable for centralized processing of forestry waste or municipal biomass

Gasification-Based Systems (with Biochar Recovery)

- Partial combustion used to generate syngas and residual char
- Lower biochar yield but integrated energy co-generation
- Requires advanced emissions controls and feedstock uniformity

Modular and Mobile Units

- Containerized systems with <500 kg/hr capacity
- Transportable to biomass hotspots, reducing hauling emissions
- Easily scalable and ideal for multi-site distributed projects

Each system will be evaluated using a mass-energy balance approach, including inputs (kg of dry biomass), outputs (kg biochar, MJ of energy), emissions profile, and O&M requirements.

Biochar Quality Parameters

To qualify for durable carbon removal credits and ensure safe soil application, the produced biochar must meet specific physical and chemical quality thresholds. These include:

Parameter	Target Specification	Compliance Framework
H/Corg ratio	< 0.7 (indicates high carbon stability)	Verra VM0044, EBC, IBI
Stability Index	> 80% stable C content (measured via lab protocols)	Biochar permanence estimation
Ash Content	< 50% (preferably <30% for agronomic use)	IBI / EBC
pH	6.0 – 10.0 (depending on biomass type)	Soil compatibility
PAHs (Toxicity)	Within EBC limits (<12 mg/kg for HMW-PAHs)	Safety for land application
Moisture Content	< 15% (for storage and application)	Field handling and durability

Laboratory analysis will be conducted in ISO/IBI-accredited labs and repeated per batch or per month to ensure consistency.

Energy Balance, Yield, and Heat Recovery

The pyrolysis process offers an opportunity for energy recovery through combustion of syngas and heat reuse, contributing to project sustainability and operational cost savings.

Energy and Mass Balance Snapshot (Typical Values)

- Input: 1,000 kg of dry biomass
- Output: ~250–350 kg of biochar (yield: 25–35%)
- Energy Recovered: 1.5 – 4.0 MJ/kg (depending on system efficiency)
- Emission Output: Controlled via flue gas treatment and condensation systems

Recovered heat can be used for:

- Pre-drying high-moisture feedstock
- Generating hot air or steam for nearby agri-processing
- Supplying energy to auxiliary operations (e.g., sanitation-linked drying)

The carbon intensity and efficiency of the production system are central to the project's LCA and TEA. Thermal integration and emissions control will be validated to meet registry-approved emissions thresholds and local air quality norms.

Phase I Context and Baseline Assessment

Baseline Emissions & Counterfactual Scenario

Establishing a scientifically credible and conservative baseline emissions scenario is a critical component of carbon project validation. It defines the "business-as-usual" (BAU) fate of the biomass in the absence of the biochar project and serves as the reference against which actual emission reductions or carbon removals are measured.

Credynova outlines the expected baseline behavior of biomass, associated GHG pathways, and the approach used to estimate emissions using IPCC Tier 1/2 emission factors and region-specific activity data.

Business-as-Usual Fate of Biomass

In most regions targeted by this project, agricultural and forestry residues, as well as organic municipal waste, are typically managed through one or more of the following conventional disposal practices:

Open Burning

- Common for crop residues (e.g., rice straw, wheat stubble, sugarcane trash)
- Releases large amounts of CO_2, CH_4, CO, N_2O, black carbon
- Short-term air pollution and long-term climate impact

Composting or Mulching (Partial)

- Less frequently practiced and often unmanaged
- May still emit N_2O and CH_4 under low-oxygen conditions

Uncontrolled Decomposition / Decay

- Biomass is left in fields, ditches, or forest edges to rot
- Anaerobic conditions promote methane (CH_4) formation
- Wet biomass (e.g., food or vegetable waste) further enhances CH_4 generation

Landfilling (for MSW)

- Leads to significant methane emissions due to anaerobic degradation
- Often poorly managed or non-engineered, lacking methane capture systems

These practices create short-lived climate pollutants (SLCPs) and contribute heavily to regional GHG inventories, yet often remain unaccounted for in mitigation planning.

GHG Estimation: IPCC Tier 1/2 Approach

The project's baseline GHG estimation applies IPCC default (Tier 1) and locally refined (Tier 2) emission factors, consistent with Verra VM0044, Puro.Earth standards, and UNFCCC guidance.

Disposal Pathway	Primary GHGs	IPCC Emission Factors (Example)	Notes
Open Burning	CO_2, CH_4, N_2O	2.7 g CH_4/kg DM, 0.07 g N_2O/kg DM (crop residues, IPCC)	Burning efficiency and completeness factored in
Anaerobic Decay	CH_4	4–30 g CH_4/kg DM (depending on wetness and oxygen)	Site-specific adjustments for moisture and temp.
Composting (Unmanaged	CH_4, N_2O	0.3–1.0% of N to N_2O, 0.3–0.6 g CH_4/kg DM	Based on nitrogen content of residue
Landfilling (MSW)	CH_4	0.06–0.21 t CH_4/t DM (varies by region and landfill type)	Assumes no gas capture unless shown otherwise

GHG Estimation: IPCC Tier 1/2 Approach

To ensure conservative yet credible estimates, the baseline scenario is customized for the region using:

- Climate Zone Adjustments: Warmer, wetter climates accelerate anaerobic decay and methane formation
- Residue Type Factors: High-lignin materials decay slower but may still burn; soft, moist residues decay rapidly
- Practice Prevalence Surveys: Field data on dominant residue management practices (burning vs. dumping vs. composting)
- Historical Activity Data: Use of remote sensing (e.g., VIIRS fire maps), household surveys, and satellite biomass burn proxies

Scenario modeling includes three emissions pathway

- Conservative (Low CH_4 and N_2O) – Optimistic BAU behavior (e.g., partial composting)
- Realistic (Field-Verified) – Weighted mix based on actual disposal patterns
- Worst-Case (High Emission) – Full-scale open burning and anaerobic decay assumptions

Phase II Carbon Project Design

Methodology & Carbon Credit Alignment

Establishing alignment with internationally recognized carbon credit methodologies is essential to ensure the biochar project's eligibility for registration, verification, issuance, and market acceptance. Credynova outlines the applicable methodologies, evaluates key integrity principles—additionality, leakage, and permanence—and provides a comparative overview of registry-specific features, including costs and co-benefit stacking opportunities.

Applicable Methodologies

Credynova's biochar project design is compatible with the following leading carbon standards and methodologies:

Verra VM0044: Methodology for Biochar Utilization in Soil and Non-Soil Applications

- Focuses on quantifying net GHG removals from the production and use of biochar
- Incorporates lifecycle emissions, biochar stability (via H/Corg ratio or lab tests), and application verification
- Addresses additionality, leakage, and permanence in alignment with VCS program requirements
- Suitable for soil application, construction use, and animal feed (where scientifically justified)

Puro.Earth Biochar Protocol

- Tailored specifically for carbon removal buyers (CORCs – CO_2 Removal Certificates)
- Emphasizes durable carbon storage (>100 years) and third-party certification
- Streamlined project onboarding and shorter issuance cycles
- Focused on tech-enabled MRV, suitable for modular pyrolysis and batch delivery models

Gold Standard for the Global Goals (GS4GG)

- Offers potential for co-benefit crediting alongside carbon (e.g., soil productivity, livelihood enhancement)
- May be used in combination with other land-use methodologies for agroforestry-linked biochar
- Useful for funders seeking SDG-verified outcomes

Each registry has slightly different scopes, procedures, and credit buyer audiences. Credynova will select the most appropriate registry based on project size, buyer demand, co-benefits, and timing.

Integrity Principles: Additionality, Leakage, and Permanence

Additionality

- The project passes the financial additionality test: without revenue from carbon credits, the pyrolysis infrastructure, monitoring, and biochar logistics would not be economically viable.
- It also meets the regulatory additionality test: there are no local mandates requiring biochar production, soil carbon sequestration, or thermal biomass processing.
- Common practice benchmarks (e.g., % of local farmers using biochar) fall far below thresholds set by Verra and Puro.Earth, confirming the activity is not widespread or business-as-usual.

Leakage

- Minimal risk of activity-shifting leakage, as biomass sources are agricultural/forestry residues or organic waste with no competing productive use.
- Transport emissions and energy inputs are accounted for in LCA and net carbon removal calculations.
- Project boundaries and biomass sourcing will be defined clearly in contracts, and biomass baselines validated during verification.

Permanence

- The carbon sequestered in biochar is highly stable (recalcitrant carbon), with scientific consensus indicating 100–1,000 year lifetimes in soil or construction matrices.
- The H/Corg ratio of <0.7 and biochar stability indices are used to conservatively estimate the permanent fraction of carbon stored.
- Non-permanence buffer reserves (typically 5–10%) will be maintained per registry rules to address reversal risk from fire, erosion, or misapplication.

Phase II Carbon Project Design

Registry-Specific Costs and Co-Benefit Stacking

Registry	Registration & Verification Costs	Co-Benefit Options	Best Fit For
Verra	Moderate	SDG tagging, CCB optional	Projects with large-scale soil application
Puro.Earth	Lower onboarding cost, per-ton fee model	No co-benefit credits but high removal trust	Tech-focused buyers, fast issuance
Gold Standard	Moderate, plus additional verification for co-benefits	Multiple SDG outcomes and community impact	Donor-funded or socially-focused credit buyers

Credynova also explores co-financing and credit layering models where:

- Carbon credits fund infrastructure and MRV
- Soil productivity data supports SDG-linked investment (e.g., soil organic carbon programs)
- Buyers receive story-based carbon credits enhanced by digital dashboards and verified impact metrics

Phase II Carbon Project Design

Carbon Removal Estimation & Forecast

Quantifying the net carbon removal potential of a biochar project is central to its value proposition in climate markets. Credynova provides an estimate of carbon dioxide equivalent (tCO_2e) sequestered per tonne of biochar produced and applied, along with modeling of co-benefits and multi-scenario forecasting based on methodological and field data.

The carbon removal estimate is stability-weighted, factoring in the permanence of carbon stored in biochar over time. It also includes secondary mitigation benefits such as methane (CH_4) avoidance, synthetic fertilizer offset, and reduced pressure on forests.

Primary Carbon Removal: tCO_2e per Ton of Biochar

Based on peer-reviewed literature, project-specific biochar lab testing, and Verra VM0044 guidance, the carbon sequestered per dry tonne of biochar is calculated as:

$$tCO_2e_{sequestered} = (\text{Carbon content} * \text{Stability factor}) * (44/12)$$

Where:

- Carbon content: % of total mass, typically 60–80% for quality biochar
- Stability factor: Long-term stable fraction, based on H/Corg ratio or lab oxidation tests
- 44/12: Molecular conversion from C to CO_2

Typical Project Ranges (based on expected feedstock and pyrolysis conditions):

- Carbon content: 65–75%
- Stability fraction: 70–90% (aligned with Verra/Puro protocols)
- tCO_2e/ton biochar: 1.5 to 2.8 tCO_2e, depending on stability and co-benefits

The conservative value of 1.5 tCO_2e is used for baseline credit projections; higher values may be validated during field trials and verification.

Additional Carbon Co-Benefits

Methane (CH_4) Avoidance

- Avoided anaerobic decomposition of high-moisture biomass (e.g., food/agro waste)
- Typical CH_4 avoidance potential: 0.2 – 0.8 tCO_2e per ton biomass, depending on the counterfactual scenario (IPCC Tier 1/2)

Fertilizer Offset and Nitrous Oxide Reduction

- Biochar improves nutrient retention, enabling reduction in N fertilizer use by up to 15–30%
- Avoided N_2O emissions from reduced fertilizer input: 0.1 – 0.3 tCO_2e/ha/year depending on soil type and crop

Avoided Deforestation and Fuelwood Demand

- In cases where biochar is produced from forestry residue, it reduces pressure on forest biomass used for low-efficiency fuel
- Reduces CO_2 emissions from charcoal production or forest degradation

These co-benefits are registry-eligible in Verra's additional modules, and strengthen the impact case in both voluntary and compliance-linked markets.

Scenario Modeling: Conservative, Realistic, Optimistic

To ensure project robustness and planning under uncertainty, three forecast scenarios are modeled:

Scenario	tCO_2e / Ton Biochar	Co-Benefit Options
Conservative	1.5 tCO_2e	Min. 65% carbon, 70% permanence, no co-benefits included
Realistic	2.1 tCO_2e	Avg. 70% carbon, 80% permanence, includes methane avoidance and minor fertilizer offset
Optimistic	2.8 tCO_2e	High-grade biochar (75% C), 90% permanence, methane + fertilizer + forest offset

Each forecast includes sensitivity to:

- Moisture content and feedstock variability
- Pyrolysis efficiency and operational control
- Biochar application method and verification traceability

Carbon yield projections are modeled using Excel tools and OpenLCA, with embedded mass balance calculations, registry buffer pool deductions (e.g., 5–10%), and per-batch crediting forecasts.

Phase II Carbon Project Design

Monitoring, Reporting & Verification (MRV)

Effective Monitoring, Reporting & Verification (MRV) is essential for ensuring the credibility, transparency, and traceability of carbon credits issued through biochar projects. A robust MRV system supports regulatory compliance, enhances investor and buyer trust, and enables high-quality issuance under standards such as Verra VM0044, Puro.Earth, and emerging Article 6 mechanisms.

Credynova adopts a hybrid MRV approach, integrating field protocols, digital tools, and lab-certified data streams into a unified, scalable platform that is registry-ready and audit-friendly.

Laboratory Sampling & Quality Verification

To meet carbon registry requirements for carbon permanence, toxicity, and application safety, biochar produced will undergo regular third-party laboratory analysis, including:

H/Corg Ratio (target < 0.7)
For permanence and carbon stability validation

Carbon Content (% dry weight)
For tCO_2e calculation

pH and Ash Content
For agronomic compatibility

PAH & Heavy Metals Screening
To meet IBI/EBC and Verra safety thresholds

Sampling Frequency

Per batch (for small-scale/mobile units)

Monthly composite sampling (for continuous operations)

Per application zone (for soil- or construction-use traceability)

Lab results will be archived, digitally tagged, and linked to biochar production lots via QR codes or blockchain ledger IDs, ensuring verifiability during audits and issuance.

Biochar Production, Delivery & Application Tracking

Credynova deploys logistics-integrated MRV tracking to ensure that each tonne of biochar is traceable from production to final application. This includes:

Batch Production Logs
Time, feedstock type, energy use, and reactor ID

Weighbridge Receipts & Load Data
Verified tonnage at origin and destination

Transport Tracking
GPS-enabled vehicle logging (mobile/IoT integration)

Application Receipts
Proof-of-use documents signed by end users (farmers, cooperatives, contractors)

For soil-applied biochar, GPS-tagged field coordinates and application photos will be collected through a mobile app and verified against delivery records. For biochar used in construction or composites, batch matching and product specifications will be documented.

Digital MRV Platform

For soil-applied biochar, GPS-tagged field coordinates and application photos will be collected through a mobile app and verified against delivery records. For biochar used in construction or composites, batch matching and product specifications will be documented.

Mobile MRV App (Field-Level)

- User-friendly interface for farmer/co-op input
- Offline data sync with cloud when connectivity is restored
- Geo-tagged images, signatures, application timestamps

MRV Dashboard (Analyst & Admin View)

- Live overview of production, delivery, and application data
- Carbon credit projections based on verified biochar parameters
- Registry documentation prep (PDFs, data exports, audit bundles)

Phase II Carbon Project Design

Blockchain-Ready Traceability

- Immutable ledger for each credit batch: feedstock ID → batch ID → application ID
- QR or RFID tagging for tamper-proof verification
- Integration with emerging decentralized carbon marketplaces (e.g., Toucan, Carbonmark, CIX)

Registry Compliance & Third-Party Verification

- All data captured through the MRV system is aligned with the specific evidence requirements of Verra, Puro.Earth, and Gold Standard, including audit trails for permanence, leakage, and co-benefits.
- Verification will be conducted by accredited third-party auditors, with support from digital evidence repositories maintained by Credynova.
- MRV records will be made read-only accessible to buyers or investors as part of transparency and risk assurance.

Phase III Economic & Environmental Viability

Life Cycle Assessment (LCA)

A Life Cycle Assessment (LCA) provides a comprehensive evaluation of the net environmental benefit of the biochar carbon project by accounting for all emissions and energy inputs throughout the project life cycle. It is essential for establishing net carbon removals, informing project design, and meeting compliance requirements under Verra VM0044, Puro.Earth, and ISO 14040/14044 standards.

Credynova outlines the LCA scope, system boundaries, methodologies, and expected emission reductions and co-benefits.

System Boundary Definition

The LCA follows a modular approach, considering two nested system boundaries depending on project and registry requirements:

Cradle-to-Farm (or Soil) Boundary

- Includes biomass harvesting or collection
- Transportation to pyrolysis site
- Pyrolysis process emissions (e.g., fuel, electricity, flue gas)
- Biochar transport and field application
- Excludes downstream carbon use or long-term decomposition
- LCA to assess soil-applied biochar projects aligned with agricultural benefits and Verra VM0044.

Cradle-to-Credit (Cradle-to-Gate with MRV)

- Lab testing of biochar
- MRV infrastructure and energy use
- Credit issuance processing (registry admin, digital systems)
- LCA for full project emissions calculation for carbon registries, buyer disclosures, and TEA modeling.

Emission Inputs and Savings Considered

The LCA quantifies both GHG emissions generated and GHG emissions avoided or removed.

Project Emissions (Gross Inputs)

- Fuel use during biomass collection and transport
- Electricity and fuel consumption during pyrolysis
- Emissions from syngas flare or gasifier exhaust
- Emissions from transport of biochar to application sites

Emission Savings / Avoided Emissions

- Avoided CH_4 and N_2O from decomposition or open burning of biomass
- Avoided emissions from synthetic fertilizer production and use (if biochar reduces N demand)
- Avoided emissions from forest degradation (where fuelwood use is displaced)
- Long-term carbon sequestration in biochar (stability-weighted, aligned with IPCC/Verra)

Co-Benefits Captured in LCA (Qualitative & Quantitative)

While not all co-benefits are monetized in carbon accounting, Credynova's LCA also tracks:

Soil organic carbon (SOC) increase over time

Improved crop yields and water retention (indirect GHG relevance through input savings)

Reduced air pollution from eliminating open burning

Waste diversion from landfills and dumping sites

Phase III Economic & Environmental Viability

LCA Tools and Modeling Platforms

Credynova uses internationally recognized software to ensure transparency, replicability, and compliance:

openLCA

Open-source LCA platform with Ecoinvent, AGRIBALYSE, and custom databases

SimaPro

Commercial tool used for industry-standard carbon modeling and policy reporting

IPCC Tools

Tier 1/2 EF databases and carbon sequestration calculators

Custom Excel Models

For mass-energy balance, emission factor mapping, buffer pool adjustments

Phase III Economic & Environmental Viability

Techno-Economic Assessment (TEA)

The Techno-Economic Assessment (TEA) provides a financial evaluation of the biochar carbon project's viability by analyzing capital and operational expenditures, carbon credit revenues, and financial return metrics such as Net Present Value (NPV), Internal Rate of Return (IRR), and Payback Period. It also models sensitivity to core variables including biomass cost, carbon credit price, and plant downtime.

The TEA builds upon real-world cost benchmarks, registry fee structures, and operational data from similar biochar deployments globally, and is calibrated for local feedstock pricing, energy use, and MRV requirements.

CAPEX and OPEX Modeling

Capital Expenditures (CAPEX)

CAPEX is modeled based on the size and configuration of the pyrolysis system (batch, continuous, modular), site infrastructure, and digital MRV systems.

Component	Estimated Cost (USD)
Pyrolysis unit (5–10 t/day)	$80,000 – $150,000
Feedstock handling and storage systems	$10,000 – $25,000
MRV hardware (sensors, load cells, GPS)	$5,000 – $10,000
Site preparation and utilities	$10,000 – $20,000
Lab setup or third-party testing	$2,500 – $5,000/year
Total CAPEX Estimate	$105,000 – $210,000

Operational Expenditures (OPEX)

OPEX includes labor, fuel/electricity, transport, maintenance, feedstock procurement (if paid), verification, and registry fees.

Component	Estimated Cost (USD)
Labor and management	$12,000 – $20,000
Biomass collection and transport	$8 – $20/ton (location-dependent)
Electricity/fuel consumption	$0.05 – $0.12/kg biochar
Biochar logistics and spreading	$3 – $10/ton biochar
Verification and registry fees	$10,000 – $25,000/year
Maintenance and downtime buffer	$5,000 – $10,000

OPEX is adjusted based on scale, automation, feedstock access model (owned vs purchased), and verification cycle frequency.

Phase III Economic & Environmental Viability

Financial Viability Metrics

Credynova uses DCF (Discounted Cash Flow) modeling to calculate:

NPV (Net Present Value)

Based on 10-year cash flows at 8–12% discount rate

IRR (Internal Rate of Return)

Target IRR ≥ 15–18% for climate impact investors

Payback Period

Estimated between 2.5 to 4.5 years, depending on credit prices and crediting rate

Assumptions Used in Base Model

Biochar yield

25–35% (dry weight basis)

Carbon credit price

$60–$120/tCO_2e (spot + forward blend)

Carbon removal

1.8–2.2 tCO_2e per ton of biochar (conservative scenario)

Annual production

800–1,500 tons biochar/year

Registry deduction (buffer, fees)

10–15%

Revenue Range

Carbon credit income

$100,000 – $250,000/year

Biochar sales (optional)

$15,000 – $50,000/year

Sensitivity Analysis

A multi-variable sensitivity analysis is performed to evaluate financial resilience across key project drivers:

Parameter	Impact
Biomass Cost	High sensitivity — >$20/ton reduces IRR unless offset by high credit prices
Carbon Credit Price	Strong positive correlation — IRR rises sharply above $75/$tCO_2e$
Plant Downtime	10–15% downtime reduces credit generation significantly — redundancy and scheduled maintenance critical
Registry Delays	Affects cash flow timing, especially in early years — mitigated through forward agreements

Dynamic models also simulate three financial scenarios (conservative, baseline, optimistic) based on credit issuance timing, verification cost variability, and operational scale-up potential.

Phase III Economic & Environmental Viability

Market and Credit Buyer Landscape

The success of a biochar carbon project depends not only on credit integrity but also on understanding the market demand for biochar products and identifying reliable carbon credit buyers. Credynova outlines the dual market opportunities for the project—biochar product sales and carbon removal credit monetization—and explores the growing interest in insetting mechanisms within corporate ESG strategies.

Biochar Product Demand Landscape

Biochar is gaining traction across multiple use cases, offering strong co-benefit alignment with agriculture, environmental remediation, and sustainable infrastructure. Key markets include:

Agricultural Soil Amendment

- Enhances soil fertility, water retention, and microbial activity
- Reduces fertilizer loss and increases crop yields (5–30% in field trials)
- Popular in both smallholder systems (India, Kenya) and commercial farms (Brazil, USA)
- Growing interest in blending biochar with compost, manure, or organic fertilizer

Green Building Materials

- Used in cement, bricks, and plaster as a lightweight, insulating, and carbon-negative filler
- Applications in Europe, Japan, and North America are expanding under green construction mandates (e.g., LEED, BREEAM)
- Biochar-based concrete can achieve carbon-negative footprints when offsetting production emissions

Composites & Filtration

- Biochar as a sustainable additive in polymers, packaging, and water filtration media
- Emerging applications in activated carbon replacement and odor control
- Potential niche markets for specialty-grade biochar with high surface area and adsorptive properties

Credynova's project will map regional offtake channels (e.g., agri-cooperatives, construction firms, municipal buyers) and explore co-branding with sustainable input distributors.

Carbon Dioxide Removal (CDR) Credit Buyers

High-quality, durable carbon removal credits from biochar projects are in increasing demand as companies seek science-based net-zero targets and remove emissions beyond avoidance. The following buyer segments are especially relevant:

Tech Sector & Digital Marketplaces

- Patch, CarbonFuture, CIX (Climate Impact X), Klimate.co and others act as carbon credit procurement platforms for durable CDRs
- These platforms favor projects with digital MRV, traceability, and third-party validation
- Puro.Earth CORCs have been bought by Microsoft, Shopify, Zurich Insurance, and others

Industrial & Consumer Goods Companies

- Multinational corporations (Unilever, Nestlé, PepsiCo, IKEA) seek removal-based credits to meet Scope 3 emission targets
- Willing to pay premium prices ($40–$300/tCO_2e) for traceable, long-lived removals like biochar
- Require co-benefits such as rural livelihood support, waste reduction, or soil regeneration

Institutional Buyers & Blended Finance

- Family offices, sovereign ESG funds, and climate-focused VCs are entering carbon markets to secure future removal supply
- Some offer forward purchase agreements or project development loans in return for credit delivery guarantees

Credynova will position the project for both spot and forward markets, while building registry-compliant documentation for Verra, Puro.Earth, and Article 6.2 transactions.

Phase III Economic & Environmental Viability

Insetting Use Cases and ESG Integration

Insetting refers to companies offsetting their own supply chain emissions by funding carbon reduction/removal within their sourcing regions—often generating both emissions impact and brand equity.

Example Insetting Use Cases:

- A tea or cotton exporter funds biochar production near grower networks, improving soil while offsetting their freight or processing emissions
- A food processor offsets its Scope 1 emissions by purchasing credits from Credynova's nearby biochar deployment
- Retailers support verified local climate projects in line with their sustainability-linked financing (SLF) commitments

Insetting buyers often prefer:

Geographic alignment (credits from their sourcing regions)

Co-benefit narratives (e.g., water security, female employment, soil health)

Measurable, digitally reported outcomes (enabled via Credynova's MRV tools)

Phase IV Social, Environmental & Regulatory

Social & Economic Impact Assessment

Biochar carbon projects have the potential to create transformative socio-economic impacts when designed with an inclusive, locally grounded, and co-benefit-oriented approach. Credynova will ensure that the project not only delivers high-integrity carbon credits but also contributes meaningfully to livelihood enhancement, social equity, and rural climate resilience.

Stakeholder Mapping: Smallholders, Youth, and Women

The project is designed to prioritize engagement and benefit-sharing with the following key stakeholders:

Smallholder Farmers

- As primary feedstock providers (agri-residues) and biochar users (soil amendment), smallholders are central to the project's carbon and agronomic outcomes.
- Biochar application can reduce fertilizer costs, improve drought resilience, and boost yields by 10–30%—directly improving farm income and food security.

Rural Youth and Labor Force

- The project creates job opportunities in feedstock aggregation, pyrolysis unit operation, quality testing, field application, and monitoring.
- Youth can be trained as biochar field technicians, MRV operators, or cooperative mobilizers, building local climate entrepreneurship.

Women and Women's Groups

- Women's involvement in agriculture, biomass collection, and composting makes them vital agents in biochar integration.
- The project encourages gender-equitable labor distribution, leadership roles in biochar cooperatives, and access to training and benefit-sharing mechanisms.

FPIC Process and Social Safeguards

Credynova is committed to upholding the principles of Free, Prior, and Informed Consent (FPIC) in every geography where projects are developed. This includes:

Free
Participation is voluntary, without coercion or economic pressure.

Prior
Communities are informed before any decisions or activities are undertaken.

Informed
Information is shared transparently in local languages, with full disclosure of benefits, risks, and rights.

Consent
Engagement processes culminate in recorded and verifiable agreement from local stakeholders.

Safeguard Mechanisms:

- Community meetings and feedback sessions before project launch
- Inclusion of local governance structures and traditional authorities
- Grievance redressal mechanisms accessible via phone, local contact, or platform
- Safeguard screening aligned with Verra CCB Standards and Gold Standard Safeguarding Principles

Phase IV Social, Environmental & Regulatory

Cooperative Models and Shared Benefit Frameworks

Credynova actively promotes cooperative and community enterprise models to ensure long-term equity and project sustainability:

Feedstock Cooperatives

- Farmer groups or village committees coordinate biomass collection and negotiate pricing or incentive structures.
- Co-ops may receive carbon revenue shares based on volume or supply reliability.

Biochar User Networks

- Farmers using biochar receive agronomic training, soil testing support, and preferential access to quality input blends (e.g., biochar + compost).
- Demonstration plots and participatory trials build user confidence and replicate success.

Shared Revenue and Upskilling

- A pre-defined percentage of carbon credit revenue is allocated for: Training programs, Co-op equipment upgrades, Community infrastructure (e.g., water filters, solar drying, etc.)
- Transparent accounting and community monitoring tools ensure accountability

Credynova may also pilot community carbon credit wallets or mobile-based dashboards where smallholders can track their contribution to climate action and share in the project's financial benefits.

Phase IV Social, Environmental & Regulatory

Environmental Impact & EIA Screening

A biochar carbon project must deliver not only climate benefits but also demonstrably low environmental risk and high co-benefit potential. Credynova provides a preliminary Environmental Impact Assessment (EIA) screening, focusing on key environmental parameters associated with biochar production, transport, application, and post-use behavior. The assessment follows guidance from national EIA regulations, Verra CCB standards, and Voluntary Carbon Market (VCM) due diligence frameworks.

Air Emissions, Water Usage, Heavy Metals, and Dust Risk

Air Emissions

Pyrolysis Process

If uncontrolled, pyrolysis may emit particulates, CO, VOCs, or dioxins. Credynova's selected technology includes:

- Secondary combustion chambers (afterburners)
- Flue gas filters (cyclones or scrubbers)
- Emissions monitoring sensors (as part of MRV)

Baseline Comparison

The project eliminates open burning, drastically reducing $PM_{2.5}$, black carbon, and SLCPs (short-lived climate pollutants).

Water Use

Biochar production is a low water intensity process. Water is used primarily for:

- Cooling biochar to prevent combustion
- Dust suppression during storage or transport
- Closed-loop cooling and rainwater harvesting are considered for sustainability.

Heavy Metals and Dust Management

Feedstock Screening

Only clean, non-contaminated biomass is used—no treated wood, sludge, or industrial waste

Lab Analysis

Biochar is regularly tested for:

- Heavy metals (e.g., Cd, Pb, Hg, As)
- Polycyclic Aromatic Hydrocarbons (PAHs)
- pH, electrical conductivity (EC)

Dust Risk

Dry, fine biochar can become airborne during handling.

- Risk mitigated by wetting, granulation, or pelletization
- Workers provided with PPE (e.g., masks, gloves) and training

Phase IV Social, Environmental & Regulatory

Soil Health, Leachability, and Biodiversity Impact

Soil Health Enhancement

Biochar improves:

- Soil structure and porosity
- Water-holding capacity (15–25%)
- Nutrient retention (especially N, P, K)
- Microbial diversity

Field trials will monitor yield impact and soil organic carbon (SOC) over time

Leachability and Residual Impact

- Biochar is tested under leaching protocols (e.g., EN 12457, TCLP) to ensure no harmful runoff
- Biochar with high ash or high pH is only applied at prescribed dilution rates
- Buffer zones maintained to protect water bodies and wetlands

Biodiversity Considerations

- No forest clearing or habitat alteration is involved
- Biochar use may reduce pressure on natural forests (e.g., by replacing charcoal or reducing fertilizer runoff)
- Pollinator-friendly buffer zones or agroforestry practices can be incorporated as co-benefits

Licensing and Compliance Filters

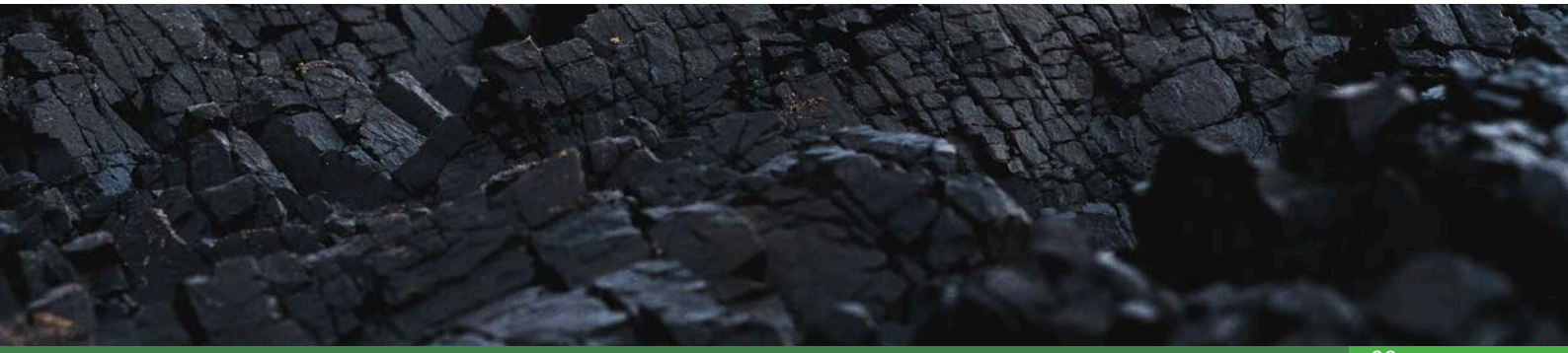
Credynova will conduct a formal EIA screening to determine:

- Whether the project qualifies for an EIA exemption, or Requires a Rapid or Full EIA, based on:
- Pyrolysis plant size (typically <10 TPD qualifies for simplified review)
- Proximity to sensitive ecosystems (wetlands, protected forests, human settlements)
- National/state pollution control norms (e.g., air, water, noise)

Required Clearances

- Environmental clearance from the State Pollution Control Board or equivalent authority
- Land use certificate and No Objection Certificate (NOC) from local administration
- Waste handling and transport permits, if feedstock includes MSW organics
- Water and air consent to operate (CTO) from local regulatory boards

Credynova will ensure all documentation is prepared in line with host country regulations and, where applicable, Verra's Climate, Community & Biodiversity (CCB) standards or Gold Standard safeguarding principles.



Phase IV Social, Environmental & Regulatory

Legal, Land, and Credit Ownership Review

Establishing clear legal frameworks for biomass access, land and carbon ownership, and permanence liability is critical to ensuring the credibility, enforceability, and long-term durability of carbon credits generated from a biochar project. Credynova outlines the legal and institutional arrangements that will govern resource access, credit issuance rights, and post-issuance obligations in line with registry and investor expectations.

Biomass Access Rights

The project will source biomass from agricultural, forestry, and municipal streams. To ensure transparency and avoid disputes, Credynova will secure formal biomass procurement agreements with:

Farmer cooperatives and individual landowners (for crop residues)

Sawmills or timber processors (for forestry waste)

Municipal waste departments or market authorities (for sorted organics/MSW)

Each biomass source will be documented with:

Letters of Intent (LOIs) or Memorandums of Understanding (MoUs) stating

- Type, quantity, and seasonality of biomass
- Rights to process biomass into biochar
- Price (if applicable) or mutual benefit terms
- Chain-of-custody records to verify that the biomass meets sustainability criteria (non-food, non-contaminated, surplus)

These contracts are necessary for verifying feedstock additionality and for tracking the origin of the carbon sequestered in the biochar product.

Land and Carbon Ownership

Credynova ensures full transparency and legality in defining who owns:

- The land where biochar is produced
- The land where biochar is applied
- The resulting carbon credits issued under a recognized registry

Land Ownership and Use Agreements

- Project sites (production units) will either be company-owned, leased, or hosted under shared-use models with cooperatives or municipalities.
- For soil-applied biochar, landowners must consent to use their land for crediting purposes, often via: FPIC forms, Application agreements, and Monitoring access agreements

Carbon Credit Ownership and Assignment

- Carbon credit rights will be defined through Carbon Benefit Agreements (CBAs) or Emission Reduction Purchase Agreements (ERPAs) stating: Who retains title to the credits, Who has the right to sell, retire, or transfer credits, and How benefits are shared with local stakeholders (especially for co-developed projects).

Registry rules (e.g., Verra and Puro.Earth) require documented evidence of undisputed ownership of carbon claims throughout the value chain. This is also essential to prevent double-counting or non-authorized transfers, especially under Article 6.

Phase IV Social, Environmental & Regulatory

Permanence Contracts, Liability, and Buffer Pool Contributions

Permanence in biochar projects refers to the long-term stability of carbon stored in soils or construction materials. To ensure permanence and assign liability:

Permanence and Reversal Contracts

All biochar applications will be covered by:

- End-use agreements defining responsible parties
- Monitoring clauses allowing for spot checks
- Reversal protocols in the event of loss (e.g., fire, erosion, excavation)

These clauses will clarify which entity assumes legal liability if the sequestered carbon is lost before the registry's defined permanence period (typically ≥100 years).

Buffer Pool Contributions

As per Verra and Puro.Earth protocols, the project will contribute a percentage of issued credits (5–10%) to a shared buffer pool as insurance against non-permanence.

The contribution rate is determined by:

- Feedstock stability
- Biochar carbon content and H/Corg ratio
- End-use type (e.g., soil vs construction)
- Risk of environmental loss

Credynova will model buffer requirements using registry-provided calculators and retain reserves to cover unexpected reversals.

Phase V Rollout Strategy & Risk Management

Project Execution Roadmap

Launching and scaling a successful biochar carbon project requires a stepwise, registry-compliant, and stakeholder-inclusive roadmap. Credynova presents a clear timeline from feasibility to credit issuance, including registry engagement milestones, capacity-building, and long-term governance mechanisms.

Credynova's execution model is designed to ensure speed, integrity, and adaptability—from local piloting to national or multi-regional scaling.

From Feasibility to Credit Issuance

Stage	Scope of Work	Estimated Timeline
Feasibility Study	Baseline mapping, biomass analysis, MRV design, risk assessment	Weeks 1-6
Project Design Document (PDD)	Development of full carbon project documentation, including baseline scenario, MRV plan, LCA, TEA	Weeks 40-48
Validation	Third-party auditor (VVB) reviews the PDD and verifies conformity with methodology	Weeks 4-8
Registration	Submission and acceptance into Verra, Puro.Earth, or another selected registry	Weeks 4-8
Monitoring & Verification (M&V)	First crediting period begins. Data logged and submitted for verification at regular intervals	Quarterly or Annually
Credit Issuance & Sale	Verified emission reductions (tCO_2e) issued and made available to buyers	Post Verification

Note: Forward credit agreements or pre-purchase arrangements may be secured prior to issuance to de-risk revenue streams.

Stakeholder Timeline

Phase	Stakeholder Involvement
Pre-FS	Farmer surveys, local government briefings, FPIC consultations
PDD Development	Co-op input on biomass volumes, application areas, biochar co-benefits
Validation	Site visits with auditor, farmer field engagement
Monitoring	Farmer or field staff data entry via mobile MRV tools
Revenue Sharing	Co-op-level meetings for credit benefit disclosure and co-investment decisions

Stakeholders will be engaged through quarterly review meetings, capacity-building sessions, and grievance redressal mechanisms managed at the village or cooperative level.

Phase V Rollout Strategy & Risk Management

Registry Stages

Verra (VM0044)
Project ID → PDD → Validation → Registration → Monitoring → Verification → Issuance

Puro.Earth
Pre-registration review → LCA and documentation → Verification → CORC issuance

Gold Standard (optional co-benefit)
Activity Design Document (ADD) → Stakeholder inputs → Validation → SDG verification

Credynova maintains a registry-specific checklist to track compliance and submission deadlines for each process stage.

Capacity-Building and Governance Support

Credynova embeds long-term sustainability by establishing local governance models and training programs tailored to the project context.

Capacity-Building Components

- Farmer training modules on biomass supply, biochar application, and soil management
- Youth technical certification for pyrolysis unit operation, MRV, and sample collection
- Women's groups engagement in logistics, cooperative leadership, and value-added use of biochar

Governance Structures

- Village Biochar Committees (VBCs) to oversee day-to-day implementation, grievance redress, and transparency
- Community Benefit-Sharing Agreements tied to verified credits and revenue inflow
- Optional project steering committee including government, registry advisor, and local cooperative representatives

These structures are designed to ensure long-term trust, data quality, and resilience—especially important for a project expected to deliver credits for 10–30 years.

Phase V Rollout Strategy & Risk Management

Risk Matrix & Mitigation Strategy

Carbon removal projects like biochar must manage a range of technical, financial, policy, and environmental risks to ensure the credibility and durability of issued credits. Credynova outlines the key risks, corresponding mitigation strategies, and adaptive planning mechanisms Credynova will deploy across the project lifecycle.

The strategy reflects best practices from the Verra VM0044 risk assessment framework, Puro.Earth requirements, and lessons learned from over a decade of biochar and carbon market implementations globally.

Key Risk Categories and Mitigation Measures

Risk Category	Risk Details	Mitigation Strategy
Feedstock Supply Risk	Seasonal scarcity, competition from other industries (e.g., livestock, biomass fuel)	Diversified feedstock portfolio, forward supply agreements, GIS-based biomass tracking
Feedstock Price Volatility	Unexpected price increase due to labor, transport, or competing demand	Buffer inventory, local sourcing radius optimization, cooperative pricing arrangements
Operational Downtime	Equipment failure, poor maintenance, power interruptions	Preventive maintenance, modular backups, training of operators, solar/biogas redundancy
Reversal Risk (Carbon Loss)	Biochar loss due to fire, erosion, misapplication, or unauthorized excavation	End-use contracts, application verification, field bunding, insurance or buffer pool contributions
Policy & Regulatory Risk	Changing biomass regulations, registry rules, or national climate strategy	Legal advisory watch, adaptive project documentation, dual-registry alignment
MRV or Data Loss Risk	Incomplete field data, mobile app failure, inconsistent lab results	Cloud-based MRV backups, third-party lab rotation, blockchain ledger (optional)
Carbon Credit Price Volatility	Market downturn or oversupply leading to low credit prices	Pre-sale contracts, credit hedging mechanisms, diversified revenue from biochar product sales

Redundancy, Traceability & Technical Safeguards

The strategy reflects best practices from the Verra VM0044 risk assessment framework, Puro.Earth requirements, and lessons learned from over a decade of biochar and carbon market implementations globally.

Redundancy Measures

- Modular pyrolysis units can be operated independently if one fails
- Dual fuel configurations (biomass and syngas or biogas) to avoid downtime
- Secondary application zones secured in case of access delays or weather disruption

Digital Traceability Tools

- Unique digital IDs for each biochar batch (linked to lab data, GPS-tagged application)
- Mobile MRV apps with offline capability and auto-sync to secure cloud storage
- Optional blockchain ledger to create an immutable trail from feedstock to credit issuance

Phase V Rollout Strategy & Risk Management

Insurance and Buffer Pool Strategies

To address non-permanence and post-issuance liability, the project includes:

- Buffer pool contributions as required by Verra and Puro.Earth (5–10% of credits)
- Local monitoring teams to conduct post-application inspections and fire/hazard tracking
- Optional third-party insurance (e.g., permanence insurance or performance guarantees) for buyers/investors seeking additional risk protection

These measures are particularly important for large-volume or long-duration credit purchases (10+ years) by corporate ESG buyers.

Carbon Credit Price Hedging

Carbon markets remain volatile, with voluntary credit prices ranging from \$40–\$250/tCO_2e depending on quality, removal durability, and co-benefits. To ensure revenue stability:

- Forward Sale Agreements (FSAs): Pre-agreed minimum pricing with buyers (e.g., \$60–90/tCO_2e)
- Blended Pricing Models: Spot + forward contracts to manage liquidity
- Portfolio Diversification: Selling into multiple buyer platforms (e.g., Patch, CarbonFuture, CIX) and jurisdictions (including Article 6.2 buyers)
- Revenue Buffering: Allocation of credit revenue to contingency reserves for feedstock, equipment, or MRV-related emergencies

Credynova's finance team also tracks policy-linked pricing mechanisms, such as carbon tax floors, removal auctions, and insetting premiums, to capture upside where possible.

Phase V Rollout Strategy & Risk Management

Partnerships & Climate Finance Channels

Unlocking the full potential of biochar carbon projects requires not only strong technical execution but also strategic partnerships and diverse financing mechanisms. Credynova is engaging to deliver high-quality carbon removal, and the channels through which climate finance—both public and private—can be accessed to scale implementation.

Technical Partners, Platforms, and MRV Tool Providers

Credynova actively collaborates with a network of technology innovators, digital MRV providers, and verification platforms to ensure projects are scientifically robust, field-ready, and registry-compliant.

Key Partner Types:

Pyrolysis Technology Providers

Modular, mobile, and continuous pyrolysis system manufacturers with proven performance in developing country contexts (e.g., India, Africa, Southeast Asia)

Sensor and MRV Tool Providers

- GPS-based mobile monitoring apps
- IoT sensors for temperature, gas flow, and feedstock tracking
- Load cells, RFID/QR-based tagging systems for traceability
- Blockchain-based ledgers for batch verification (e.g., Carbonfuture, Toucan)

Carbon Platforms & Credit Registries

- Verra, Puro.Earth, Gold Standard for credit issuance
- Patch, CIX, Carbonfuture for market access and buyer matching
- Integration-ready APIs to automate reporting, issuance, and retirement workflows

Carbon Finance Sources

Credynova works across a spectrum of climate finance channels to de-risk development and expand access to upfront capital and long-term revenue:

CSR & ESG-Aligned Capital

- Corporate CSR departments seeking domestic climate action projects
- SDG-linked carbon removal investments with community co-benefits (e.g., agri, water, gender)
- Can fund infrastructure, farmer training, or co-op capacity-building

Venture Capital (VC) and Climate Tech Investors

- Early-stage carbon removal funds and impact VCs focused on high-integrity CDR (e.g., Lowercarbon Capital, Breakthrough Energy Ventures)
- Blended equity–credit models or milestone-based disbursements
- Potential to support hardware scaling, MRV platform deployment, and working capital

Donor and Development Funding

- Multilateral funds (e.g., GCF, Adaptation Fund, GEF) for land restoration and climate-smart agriculture
- Bilateral aid (e.g., GIZ, USAID, DFID) supporting sustainable biomass, circular economy, and SDG-linked impact
- Foundation grants for piloting biochar projects with inclusive governance (e.g., IKEA Foundation, Good Energies)

Article 6-Aligned Transactions

- Country-to-country carbon transfers (ITMOs) under Paris Agreement Article 6.2
- Voluntary cooperation frameworks with host country approval and corresponding adjustments
- Potential for sovereign buyers (e.g., Switzerland, Singapore) to support high-durability removals like biochar

Phase V Rollout Strategy & Risk Management

Forward Credit Contracts and Guarantee-Backed Pre-Sales

Given the long lead time in carbon project cash flows, Credynova is structuring forward sale agreements and guarantee-backed pre-purchase contracts to secure predictable revenue and finance upfront capital costs.

Structure & Benefits:

- Advance Purchase Agreements (APAs) with climate-conscious corporates (e.g., Microsoft, Shopify)
- Guaranteed Minimum Pricing (e.g., $60–100/$tCO_2e$) to hedge price volatility
- Performance-Based Milestones: Funds released upon verification or field deployment
- Blended Returns: Some buyers offer co-funding for MRV upgrades or farmer incentives as part of the deal

Phase V Rollout Strategy & Risk Management

SDG Alignment & Project Impact Metrics

Biochar carbon projects present a rare opportunity to simultaneously advance climate mitigation, regenerative agriculture, circular economy, and inclusive development. Credynova project aligns with key UN Sustainable Development Goals (SDGs) and the impact metrics we will use to quantify, track, and report co-benefits alongside carbon removal.

Our monitoring approach combines field data, digital MRV tools, and community feedback to build a transparent and verifiable impact ecosystem.

SDG Alignment

2 ZERO HUNGER	Increases crop yields through improved soil fertility and water retention
7 AFFORDABLE AND CLEAN ENERGY	Enables thermal energy recovery and reduces reliance on firewood/charcoal
8 DECENT WORK AND ECONOMIC GROWTH	Creates jobs in biomass aggregation, pyrolysis operation, MRV, and field application
12 RESPONSIBLE CONSUMPTION AND PRODUCTION	Transforms agricultural and forestry waste into valuable, carbon-negative products
13 CLIMATE ACTION	Removes and stores CO_2 in long-term stable form (biochar), verified through global registries
15 LIFE ON LAND	Restores degraded soils, improves biodiversity in soil ecosystems, and reduces chemical runoff

Phase V Rollout Strategy & Risk Management

Impact Indicators

Credynova will track and report the following quantitative indicators as part of its co-benefit and climate impact disclosure:

Impact Area	Metric	Target Range (Year 1–5)
Climate Mitigation	Verified CO_2e removed and stored	5,000 – 25,000 tCO_2e
Farmer Engagement	Farmers trained and applying biochar	500 – 2,500
Land Restoration	Hectares of land treated with biochar	300 – 1,000 ha
Soil Productivity	% yield increase (avg across plots)	10% – 30%
Job Creation	Local jobs generated (direct & indirect)	40 – 100 FTEs equivalent
Waste Utilization	Tons of biomass diverted from open burning	8,000 – 40,000 tons
Gender Inclusion	% of women in field and governance roles	>35%

These indicators will be updated annually and shared with stakeholders through an open-access impact dashboard.

Impact Dashboard and Audit Trail

Credynova is developing a digital impact dashboard for real-time tracking and reporting. Features include:

- Carbon Metrics: Verified credits issued, tCO_2e removed, buffer contributions
- Socioeconomic Metrics: Farmer participation, gender breakdown, training records
- Environmental Indicators: Soil organic carbon levels, water retention, avoided deforestation
- Spatial Tracking: Geo-tagged maps of application sites, feedstock zones, and training clusters
- Audit Trail: All field activities, documents, and verifications timestamped and digitally archived for registry and investor due diligence

The dashboard will also support registry reporting, CSR disclosure, and climate impact storytelling to buyers and funders, increasing project transparency and replicability.

Biochar Carbon Development Process

From Pre-FS to Carbon Credit Issuance

7 Days
Desktop Pre-FS

2-3 Months
Field Feasibility Study

Project Design Document (PDD) Document

10-12 Months

3-5 Months
Validation

1-2 Months
Hosting/Listing

1-2 Months
PDD Review as per Selected Standards

1-2 Months
Project Registration

12-60 Months
Monitoring, Reporting and Verification (MRV)

3-5 Months
MRV Report Review by Selected Standards

1-2 Months
Credits Issuance

1-2 Months
Sales of Credits

Annexures

The following annexures are attached to provide supporting evidence, tools, and documentation referenced throughout the feasibility study and project proposal. These materials ensure traceability, transparency, and audit readiness for registry registration, financing, and implementation.

Annex 1: Biomass Maps and Feedstock Data

- GIS-based biomass density maps (Sentinel-2/Landsat overlays)
- Crop calendar alignment and harvest seasonality
- Feedstock volume estimates (dry tonnes/year by biomass type)
- Feedstock sustainability screening checklist

Annex 2: Biochar Laboratory Results

- Sample certificates from accredited labs (carbon %, H/Corg, pH, ash, PAH)
- Stability index calculation template
- EBC/IBI compliance summary
- Leachability and heavy metal test results (TCLP, EN 12457)

Annex 3: Carbon Removal Estimation Models

- Excel-based carbon credit forecast calculator (with variable input scenarios)
- Carbon permanence modeling: conservative, realistic, optimistic
- Emission factor references (IPCC Tier 1/2)
- Biochar co-benefit GHG estimation: CH_4 avoidance, N_2O offset

Annex 4: Life Cycle Assessment (LCA) and Techno-Economic Assessment (TEA) Files

- openLCA model setup (.zol file or screenshot summary)
- TEA model with IRR, NPV, payback simulation sheets
- Energy and mass balance diagrams for pyrolysis unit
- LCA system boundary visuals (cradle-to-farm and cradle-to-credit)

Annex 5: Monitoring, Reporting & Verification (MRV) Templates

- MRV flowchart (field → digital → registry)
- Sample data entry forms (mobile app screenshots)
- Sampling frequency and lab log templates
- Carbon credit issuance documentation checklist

Annex 6: Legal & Ownership Documents

- Draft biomass supply MoUs and access agreements
- Carbon Benefit Sharing Agreement (CBSA) sample
- Application site access forms and FPIC templates
- Buffer pool contribution calculation sheet

Annex 7: Stakeholder Engagement Records

- FPIC summary logs (signatures/photos)
- Training attendance sheets (farmers, operators)
- Community meeting minutes
- Grievance redressal framework and contact directory

Annex 8: Environmental & Regulatory Compliance Documents

- EIA screening checklist
- Licensing tracker (CTE, CTO, land NOCs)
- Emissions control and mitigation plan
- Waste management plan for ash, fines, and by-products

Annex 9: Registry Readiness Matrix

- Verra VM0044 alignment table
- Puro.Earth CORC eligibility checklist
- Gold Standard safeguard alignment
- Article 6/NDC interoperability checklist (if applicable)

Annex 10: Visual Portfolio

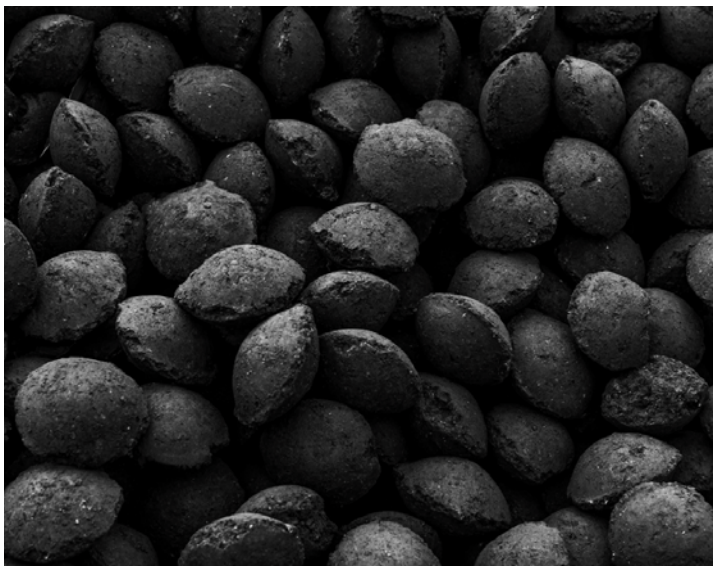
- Photographs of pyrolysis units, feedstock, field plots
- Drone imagery of biomass zones and soil restoration areas
- Dashboards and sample MRV visualizations
- Infographics on co-benefits, SDG impact, project flow

Why Credynova?

As a purpose-built startup, Credynova brings a bold, focused, and agile mindset to carbon project screening—qualities large firms often lack. Our strength lies not in legacy, but in our ability to disrupt traditional consulting through precision, innovation, and local-global alignment.

What sets us apart:

- Partnership Mentality, Not Vendor Mindset
- Financially Viable and Investor Aligned Result
- Startup Agility, Zero Bureaucracy
- Ground-Up Innovation
- Science Based Impact Driven Climate Projects



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