



Reimagining the Indian Sundarbans

BIOCHAR

REPORT – PILOT PHASE , April - October 2025

Project Goal(s)

- SDG 2: Zero Hunger.**
- SDG 3: Good Health & Well-being.**
- SDG 4: Quality Education.**
- SDG 5: Gender Equality.**
- SDG 6: Clean Water and Sanitation.**
- SDG 7: Clean Energy.**
- SDG 8 : Decent Work and Economic growth.**
- SDG 10: Reduced Inequalities.**
- SDG 13: Climate Action.**
- SDG 15: Life on Land.**



CSS

Center for
Sustainable Solutions

RE- ENGINEERING POVERTY

Introduction

This document is presented in the form of a report, highlighting how we started exploring “biochar” as a likely and viable solution for climate stressed and food insecure small and marginal farmers in the island of Mousuni in the Indian Sundarbans. This report puts together what we have done till date during the pilot phase which began in late April 2025, what we have learned during this time and how we wish to proceed to understand better and refine our solutions. We hope to build on this work and continue to share our experiences as we undertake this journey of co-creating community resilience.

At **CSS**, we empower **rural communities in Low Elevation Coastal Zones (LECZs)**, who are disproportionately vulnerable to climate change, to forge sustainable pathways for their development. We focus on enabling these frontline communities to adapt, build resilience, and achieve long-term well-being.

Our core work involves **partnering with communities and stakeholders** to collaboratively **identify, prioritize, and address their most pressing development challenges**. We actively contribute to the **localization of the Sustainable Development Goals (SDGs)**, translating global targets into tangible, context-specific actions that benefit local populations. A key outcome of our efforts is the **inclusion of these community-led solutions and localized SDG priorities directly within local government development plans**, ensuring lasting impact and integration into broader policy frameworks. Our approach recognizes the profound **interconnectedness of the SDGs**, understanding that holistic progress in one area influences all others.”

The CSS “**Reimagining the Indian Sundarbans**” Program is an articulation of our organization's model is built on deep collaboration, efficiency, and continuous learning. We operate in a distinctive action research mode, an iterative cycle of engaging, exploring, co-creating, and rigorously pilot testing solutions. This ensures our work is evidence-based, adaptive, and directly responsive to community needs.

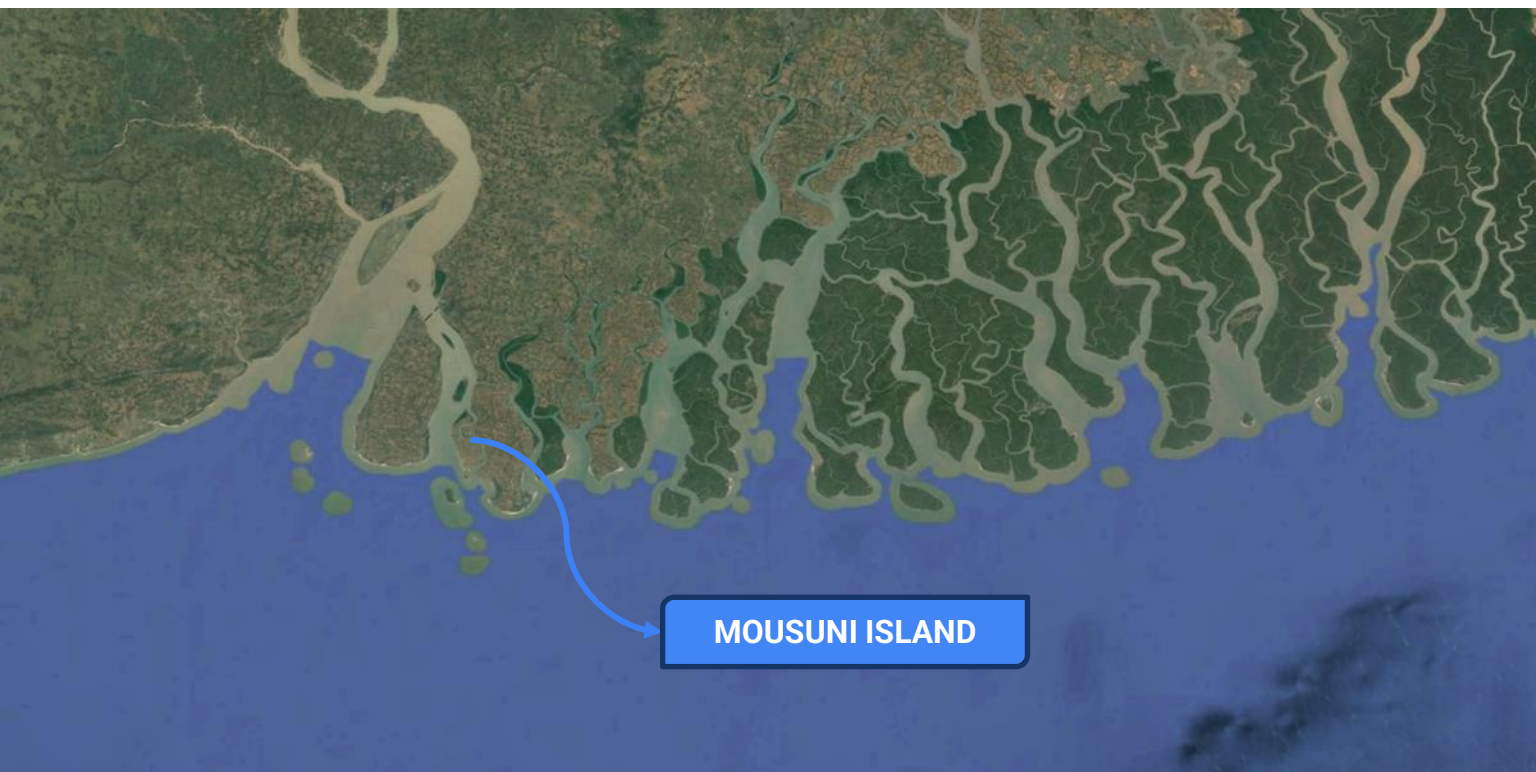
We champion **truly participatory approaches**, meaning we don't just 'do for' communities; we co-lead the process with them. We bring together **diverse domain experts** to collaborate on complex problems, ensuring comprehensive and effective solutions are developed *with* and *by* the communities themselves. Crucially, our process is designed to **strengthen the science-policy-society interface**, bridging the gap between local realities, scientific understanding, and policy formulation.



Location of the intervention*

The **Sundarbans**—the world’s largest contiguous mangrove forest—is internationally recognized for its unique biodiversity and ecological importance. The United Nations Educational, Scientific, and Cultural Organization (UNESCO) declared the Indian and Bangladesh portions of the Sundarbans World Heritage Sites in 1987 and 1997, respectively. The region is also internationally recognized under the Ramsar Convention. Despite this recognition, including conservation obligations under international conventions and treaties, the Sundarbans is under threat from climate change, along with a combination of natural factors and human actions. Over time, the eastward meandering of the Ganges River is affecting sedimentation and reducing freshwater inflows. In recent decades, human actions—construction of upstream dams, embankments to protect land from tides, overexploitation of mangrove timber, urban and industrial pollution, and mangrove clearing for agriculture and aquaculture—have affected the region’s water supplies., sedimentation, topography, and hydrology.

Beyond these concerns, climate-induced changes have significant implications for managing this critical ecosystem and the forest-dependent livelihoods of surrounding inhabitants, which include some of South Asia’s poorest and most vulnerable communities. Multifaceted, climate- related threats include sea-level rise, increased atmospheric carbon dioxide (CO₂), higher air and water temperatures, and greater frequency and intensity of precipitation and storms. Climate change has already affected the Sundarbans significantly in terms of sea-level rise and resulting salinization of water and soil. Currently, the Sundarbans is one of the highest impact zones for tropical cyclones in the Bay of Bengal. As a result, massive losses from recurrent cyclonic storms are one of the region’s primary development challenges. In a changing climate, a rising sea level and increased ocean-surface temperature is expected to further intensify storm surges. Planning for resilience is thus critical for the region’s sustainable development.



Reimagining the Indian Sundarbans (RTIS), is a programme that challenges the ennui of policy makers with regards to the climate vulnerable population of the Indian Sundarbans.

The **RTIS** programme set in the island Gram Panchayat of Mousini [21° 39' 46 " N to 21° 43' 30 " N and 88° 12' 5 " E to 88° 15' 00 " E] , overlooking the Bay of Bengal in West Bengal, is a long term, multisectoral programme to build resilience in the communities and specially empower women and children to create their sustainable development pathways.

Theory of Change Framework:

1. The Core Problem (The Starting Point).

The long-term viability and profitability of small and marginal agriculture on Mousuni Island is collapsing due to a vicious cycle of climate-induced salinity intrusion and increasing dependence on costly, unsustainable chemical inputs, resulting in diminishing yields, severe soil and water ecological degradation, and heightened livelihood vulnerability for primary caretakers, the local women farmers.

Key Elements of the Problem	How Biochar Intervenes
Vicious Cycle of High Input Costs: Increasing use of chemical inputs (fertilizers, pesticides) for diminishing returns, driving up poverty.	Inputs/Interventions: Test co-mixing urea with biochar to reduce chemical usage and costs.
Climate-Induced Salinity: Floods contaminate soil and freshwater ponds/Khal's, crippling rain-fed rice and winter vegetable (gourds/chilies) crops.	Outputs & Outcomes: Produce high-CEC biochar proven to immobilize salt and improve soil structure for water retention.
Ecological Collapse: Fields are "chemically loaded," resulting in loss of soil fauna (snails, frogs, snakes) and new issues like algal blooms.	Outputs & Outcomes: Create the material and knowledge base to shift to a sustainable model that restores soil biodiversity and mitigates algal blooms.
Gendered Vulnerability: Women farmers manage the high-risk system with inadequate adaptive knowledge and skills along with few alternative income opportunities.	Inputs/Interventions: Utilize the invasive Prosopis from stressed zones (embankments) for community-owned, artisanal production.



2. Pilot Inputs and Interventions (What We Did):

(April – September 2025)

These actions established the foundational technology, material, and testing pipeline, focusing on simple, artisanal solutions.

Low-Tech Pyrolysis System Fabrication: Fabricated and installed one artisanal pyrolysis drum (using a 200-liter oil drum) on the island, committing to a simple, low-cost, community-owned technology pathway.

Targeted Feedstock Procurement: Procured *Prosopis Juliflora* feedstock from stressed areas (eastern embankment/southern tip), directly linking material production to coastal stabilization needs.

Pilot Production and Commissioning: Commissioned and operated the artisanal kiln for initial production, allowing for key learning on small-scale pyrolysis operation before the monsoon season.

Scientific Partnership Establishment: Secured a technical partnership with the Department of Agricultural Engineering & Technology, School of Engineering & Technology, Nagaland University, India to guide the biochar testing process.

Initial Field Trials: Launched small-plot rice field trials (10 farmers, 15,000 sq ft total) across the island, applying a biochar and urea co-mix to directly test chemical reduction potential and yield improvement.



3. Pilot Outputs (Immediate Results)

These are the tangible, measurable deliverables that confirm the pilot's viability and provide the basis for future scaling.

Biochar Material Produced: 200 KG of artisanal *Prosopis Juliflora* biochar was successfully produced prior to monsoon-related shutdown.

Biochar Quality Verification: Completed and obtained preliminary results for **Proximate, Ultimate Elemental Composition, and FTIR tests**, confirming the biochar's high quality with a critical **carbon content of approximately 80%**.

Trial Plots Established: 10 farmer demonstration plots were established and commissioned for the current rice season, setting the stage for measurable results at harvest.

Technological Proof-of-Concept: Successfully validated the use of the low-tech, artisanal **pyrolysis drum** for local production, proving the model is feasible without expensive, centralized facilities.

Scientific Viability Confirmed: Encouraging preliminary lab reports established the high carbon content and physical properties of the biochar, validating its potential for both soil and water applications.

4. Outcomes (Anticipated Change)

ToC Component	Anticipated Change within 1-5 Years
Short-Term Outcomes (0-1 yr)	Verifiable success of urea/biochar co-mix trials (increased yield and/or reduced input cost); Initial data on biochar efficacy for soil/water remediation; Established technical partnership for testing.
Medium-Term Outcomes (1-3 yrs)	Significant and sustained reduction in chemical input purchases; Increased profitability and confidence in farming; Established local, artisanal biochar market; Restoration of non-saline irrigation access.
Long-Term Outcomes (3-5 yrs)	Widespread community adoption of the biochar-organic model; Reversal of the trend of chemical dependency; Regeneration of local soil biodiversity; A financially stable, diversified agriculture sector sustaining livelihoods and food security of small and marginal farmers.

4. Proposed Next Steps and Immediate Action Plan (Phase 2: Scaling and Validation)

The success of the initial pilot—specifically the confirmation of the biochar's high quality ($\geq 80\%$ carbon content)—validates the core technology and material. Phase 2 focuses on scaling production to meet demand, diversifying its application, and securing the necessary funding and partnerships.

4.1 Immediate Focus: Data Collection and Validation.

The immediate priority remains the scientifically rigorous analysis of the pilot plots to validate the environmental and economic model.

Action Item	Rationale
Harvest Data Collection & Economic Analysis	Record the final crop yield and quantify / qualify the benefits for the biochar-amended plots versus control plots, proving the financial return on reduced chemical inputs.
Soil Analysis (Post-Harvest)	Re-sample and analyze soil for changes in SOC, EC (salinity), and pH to scientifically confirm the regenerative impact and salt mitigation potential. Assess microbial activity in treated and untreated soils.
Establishing biochar properties in line with the International Biochar Standards and the Indian National Standards.	Further laboratory tests including contaminants, physical and chemical properties of the feedstock, emission from burning the feedstock.. Explore partnerships and collaborations with domain experts. / institutions.



4.2 Scaling Production and Technology.

To reach the goal of producing a few metric tonnes of biochar and reaching more farmers, the production strategy will be decentralized and integrated in the Food – Water – Energy System.

Production Technology Upgrade: Upgrade the artisanal pyrolysis drums to ensure **slow pyrolysis** conditions, optimizing the biochar properties (high fixed carbon, increased surface area) for long-term soil amendment and contaminant adsorption.

Introducing Improved Cookstoves (ICS): Integrate production with traditional livelihoods by introducing **biochar-producing improved cookstoves**. This leverages the community's existing use of *Prosopis* branches and twigs for cooking fuel, generating biochar as a valuable co-product and expanding overall volume.

Sustainable Feedstock Management: Formalize the feedstock strategy around **managing *Prosopis* growth (not uprooting)**. This ensures a sustainable supply chain that respects traditional fuel use, provides ongoing clearing of stressed areas (embankments/southern tip), and avoids environmental conflicts related to plant eradication.

Waste Stream Integration: Finalize the assessment of agricultural and other local waste streams to secure diversified feedstock, minimizing dependence on *Prosopis* and expanding production capacity.

4.3 Advanced Testing and Application Diversification.

The project will expand its application research based on the confirmed quality of the biochar. **Advanced Biochar Characterization:** Conduct further in-depth tests, including assessing the presence of **Polycyclic Aromatic Hydrocarbons (PAHs)** to ensure the safety and regulatory compliance of the biochar for use in food production and water systems.

Water Remediation Trials: Launch dedicated trials to explore the biochar's full potential for water treatment, focusing specifically on **reducing salinity and other key pollutants** found in local water sources.

Rice-Fish Integrated Farming: Initiate trials integrating biochar application with **rice cultivation alongside fish**, assessing its impact on aquatic health, fish productivity, and potential for mitigating **algal bloom** conditions in the paddy environment [2026]



4.4 Financing, Carbon Strategy, and Partnerships.

Securing the financial resources and strategic backing is paramount for scaling to a metric-tonne production level.

Carbon Credit Strategy: Develop a strategy to pursue **carbon credits** under frameworks that recognize **low-scale, artisanal biochar production and soil sequestration**. This leverages the project's high fixed carbon content and aligns with global climate goals.

Targeted Funding Outreach: Actively seek **grants and other investments** by packaging the validated pilot results and the scalable Phase 2 plan into compelling proposals.

Strategic Partnerships: Initiate outreach to key stakeholders for collaborations:

Academia: Expand technical collaboration for advanced testing and developing the **algal bloom solution**.

Domain Experts: Expand technical collaboration with experts in agriculture, soil, water, energy, health for co-creating adaptation and mitigation strategies.

Corporate: Seek financing, expertise in supply chain management, or technical support for **improved cookstove** adoption and biochar application.

Financiers: Engage impact investors and grant organizations interested in climate change adaptation, women's livelihoods, and sustainable agriculture in vulnerable coastal regions.



Biochar at Mousuni*

Call to Action: Join Us to Co-Create Scalable, Low-Cost Solutions for Coastal Resilience.

The catastrophic combination of climate change, salinity intrusion, and chemical dependency is rapidly collapsing smallholder agriculture in low-elevation coastal zones (LECZs). Our pilot project on **Mousuni Island** in the Indian Sundarbans has moved beyond proof-of-concept, establishing a viable, artisanal model for generating high-quality **biochar from the invasive *Prosopis Juliflora*** feedstock.

Now, with our production scaled up and critical harvest data imminent, we are seeking collaborative partners to accelerate the transition from local pilot to regional model.

The Challenge and the Opportunity.

Our findings reveal problems common to LECZs worldwide, where an estimated **700 million people will reside by 2050**: diminishing crop yields, unsustainable input costs for marginalized farmers (especially women), and contaminated water sources.

We need to move fast. With $\geq 80\%$ carbon biochar confirmed, we have the material solution. We now seek expertise to fully unlock its potential:

We Are Actively Seeking Partners for Co-Learning and Co-Creation:

Partner Type	Expertise We Need	How We Can Collaborate
Academia & Research Institutions	Advanced analysis (PAHs, heavy metals), algal bloom ecology, integrated rice-fish farming, and long-term soil health studies.	Co-design advanced field trials, publish joint findings, and develop best practices for biochar application in saline environments.
Financers & Impact Investors	Access to grants, equity, and innovative investment mechanisms to scale production, finance the introduction of biochar-producing cookstoves, and expand FFS training.	Fund Phase 2 scaling to metric-tonne production and support the development of our low-scale carbon credit strategy.
Corporate & Technical Partners	Expertise in supply chain efficiency, advanced slow-pyrolysis technology upgrading, sustainable ICS distribution, and developing new markets for biochar products.	Provide in-kind support, technical mentorship, and explore off-take agreements for biochar products or credits.

Biochar and the SDGs*

SDG	Goal Title	Relevant Target	How Artisanal <i>Prosopis juliflora</i> Biochar Contributes
 1 NO POVERTY	No Poverty	Target 1.1: By 2030, eradicate extreme poverty for all people everywhere.	Creates new green jobs and income streams for local communities involved in harvesting the invasive biomass and biochar production/application, providing a sustainable livelihood source.
 2 ZERO HUNGER	Zero Hunger	Target 2.4: By 2030, ensure sustainable food production systems...	Biochar improves soil fertility, water retention, and nutrient use efficiency in degraded and saline soils, leading to increased and more resilient crop yields, which enhances food security and farmer income.
 3 GOOD HEALTH AND WELL-BEING	Good Health and Well-being	Target 3.9: By 2030, substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination.	1. Improved Nutrition: Increased crop yields from biochar application lead to better food supply and nutrition. 2. Clean Air: The promotion of biochar-producing cookstoves significantly reduces Household Air Pollution (HAP) by lowering emissions of harmful particulates (PM2.5) and Carbon Monoxide, reducing respiratory illnesses, particularly for women and children.
 4 QUALITY EDUCATION	Quality Education	Target 4.4: Substantially increase the number of youth and adults who have relevant skills... for employment, decent jobs and entrepreneurship.	Provides practical, technical skills training in sustainable resource management, biomass harvesting, pyrolysis technology operation, and biochar application techniques, enhancing vocational skills for decent jobs.
 5 GENDER EQUALITY	Gender Equality	Target 5.4: Recognize and value unpaid care and domestic work...	1. Reduces Unpaid Work Burden: Biochar-producing cookstoves are more efficient, requiring less fuel, which reduces the time women spend collecting fuelwood. 2. Economic Empowerment: Women are often engaged in the cookstove operation, biochar production, and application, providing them with direct income and ownership over new economic resources (Target 5.a).
 6 CLEAN WATER AND SANITATION	Clean Water and Sanitation	Target 6.3: By 2030, improve water quality by reducing pollution, eliminating dumping...	Biochar is an effective adsorbent used in filtration systems to remove contaminants like salinity, heavy metals, and other pollutants from water. Its ability to retain nutrients in soil helps reduce harmful nutrient runoff into coastal waters. Biochar can be used as a cost-effective, decentralized adsorbent for water/wastewater treatment, and the pyrolysis of faecal sludge produces a hygienic, nutrient-rich biochar end-product, facilitating the safe recycling and reuse of sanitation waste (nutrient and resource recovery).
 7 AFFORDABLE AND CLEAN ENERGY	Affordable and Clean Energy	Target 7.1: By 2030, ensure universal access to affordable, reliable and modern energy services.	1. Clean Cooking Fuel: Biochar-producing cookstoves convert waste biomass into efficient, smokeless cooking fuel (syngas/heat), providing affordable, modern energy access in rural areas. 2. Renewable Energy: Industrial pyrolysis produces bio-oil and syngas as by-products, which can be used to generate heat or electricity, reducing reliance on fossil fuels.
 8 DECENT WORK AND ECONOMIC GROWTH	Decent Work and Economic Growth	Target 8.5: By 2030, achieve full and productive employment and decent work for all men and women...	Provides decent work and an additional source of income for harvesting, pyrolysis, and distribution of biochar, creating productive and decent employment opportunities, particularly in rural coastal areas.
 10 REDUCED INEQUALITIES	Reduced Inequalities	Target 10.3: Ensure equal opportunity and reduce inequalities of outcome...	By targeting marginalized and vulnerable communities (e.g., smallholder farmers and rural populations) with a low-cost, high-impact soil amendment, it reduces the productivity gap (economic inequality) between larger commercial farms and small local producers, increasing resilience to climate change shocks.
 12 RESPONSIBLE CONSUMPTION AND PRODUCTION	Responsible Consumption and Production	Target 12.5: By 2030, substantially reduce waste generation through prevention, reduction, recycling and reuse.	Utilizes an invasive, unwanted biomass (<i>Prosopis juliflora</i>) and transforms it into a valuable, long-lasting product, contributing to waste upcycling and circular economy principles.
 13 CLIMATE ACTION	Climate Action	Target 13.2: Integrate climate change measures into national policies...	1. Carbon Sequestration: Biochar is a recognized Carbon Dioxide Removal (CDR) technology. By converting biomass into stable carbon, and applying it to soil, carbon is sequestered for centuries. 2. Climate Mitigation: Biochar cookstoves reduce emissions of non-CO ₂ greenhouse gases.
 15 LIFE ON LAND	Life on Land	Target 15.8: By 2020, introduce measures to prevent the introduction and significantly reduce the impact of invasive alien species	The project involves the controlled harvesting of the highly invasive <i>Prosopis juliflora</i> , which allows for ecosystem restoration, water table recovery, and a reduction in biodiversity loss.

Biochar at Mousuni*



We are ready to learn, share, and co-create sustainable futures for coastal communities. Will you join us?

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