

CARBON CREDIT BASED MANGROVE AFFORESTATION IN THE SUNDARBANS

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1. Overview

This report presents a potential sustainable solution to the environmental and socio-economic challenges faced by the Sundarbans communities through carbon credit-based mangrove afforestation. It outlines a model where mangrove restoration efforts are aligned with carbon credit generation, providing a continuous funding source to support local communities and improve climate resilience.

The report details the current challenges threatening the Sundarbans region, including mangrove forest loss, poverty, and severe cyclones. Current efforts to tackle these issues through mangrove afforestation are discussed, and their limitations are highlighted. Then, the use of carbon credits as a sustainable source of funding for mangrove afforestation is proposed. The report additionally highlights the current status of this initiative and outlines a roadmap, including developing a standard operating procedure for the planting of mangroves in alignment with accreditation protocols, collaborating with accreditation bodies, and engaging local NGOs.

2. Introduction to Sundarbans



The Sundarbans, the largest mangrove forest in the world, is known for its rich biodiversity and unique ecosystem. Spanning 10,000 square kilometers across India and Bangladesh, it's located in the delta region of the Ganges, Brahmaputra, and Meghna rivers (Islam, 2019). The Sundarbans includes both closed and open mangrove forests, agricultural land, mudflats, and barren areas and is intersected by several tidal streams and channels. In the Indian Sundarbans ecoregion, there are 100 deltaic islands, of which 54 are variably inhabited, totaling about 4.5 million in population (Sen & Ghorai).

3. Challenges faced by Sundarbans

3.1 Environmental Challenges

The Sundarbans currently face a host of environmental and socio-economic challenges. In the past three decades, across India and Bangladesh, the Sundarbans has lost 24.55 percent of mangroves due to sea level rise, erosion, and deforestation, which poses a severe and immediate threat to residents (Islam, 2019). Furthermore, the Sundarbans is one of the most disaster-prone regions in the world. Over just the past five years, the Sundarbans have faced four tropical cyclones — Fani (May 2019), Bulbul (November 2019), Amphan (May 2020), and Yaas (May 2021). More than 80 percent of the global fatalities associated with tropical cyclones occur in the Bay of Bengal (BoB) region, although only 5 percent of such storms occur in this area (Danda). These severe cyclones have caused death, homelessness, and the destruction of agricultural land due to saltwater intrusion. The loss of mangroves, which act as a coastal barrier, has worsened the impact of severe storms.



3.2 Socio-economic Challenges

The Sundarbans region is amongst the poorest places on Earth with about 44% of individuals below the poverty line (BPL), numerous households without access to drinking water, and half the population without any land holding. Additionally, the population is forest-dependent with 28% of the population being completely reliant on the forests for their livelihood (Cernea). This dependence on the forest has led to numerous cases of human- wildlife conflict. From 1985 to 2008, tiger attacks led to 664 deaths and 126 injuries. Over 70% of the victims were either fishermen or crab collectors by profession. A similar trend of casualties has continued since (Danda).

3.3 How Are Challenges Being Dealt With

The primary societal response to cyclone-induced loss of livelihoods has been relocation. Families severely impacted by cyclones often move to the city in search of job opportunities (Hajra et al.). Many migrants end up in informal settlements with poor living conditions. Without access to stable employment, they are frequently exploited as cheap labor in industries like construction or domestic work.

With regards to the human- wildlife conflict, when there is a death resulting from wildlife conflict, the government gives a fixed payment to the family of the victim. However, since tiger-caused deaths are often a result of illegal fishing or crab collection within the forest, human- wildlife conflict cases often go unreported though this may now change due to a recent Calcutta High Court ruling in 2024.



One way the environmental challenges in the Sundarbans are being addressed is through mangrove afforestation. Both government and private efforts have been made to plant mangroves in previously degraded areas.

Local government efforts, however, are believed to be insufficient due to slow rate of implementation and poor utilization of funds. Several local NGOs have adopted this cause by planting mangroves and hiring Sundarbans residents to serve as their labor force. These NGOs include The Nature Environment and Wildlife Society (NEWS), Friendship, and Mangrove Action Project (MAP), which have collectively planted millions of mangroves, restoring thousands of hectares of land. For example, NEWS has planted over 16 million mangroves across 5,011 hectares, while Friendship has afforested 140 hectares with 300,000 trees (Sharmeen).

4. Benefits of Mangroves

Before discussing the mangrove plantation efforts further, it is important to understand the benefits provided by mangroves.



Mangroves provide several services which are crucial to the livelihoods of individuals living in the Sundarbans. 28% of the population is dependent on selling goods extracted from the forest (Cernea). These goods include honey, fish, and crabs which serve as vital resources for sustaining local economies and providing food security. Moreover, mangroves support fisheries by acting as nurseries for a variety of commercially valuable fish and crustaceans, directly contributing to the livelihoods of coastal communities.

Secondly, mangroves act as a natural coastal barrier, protecting against recurring cyclones and storm surges. Their dense root systems stabilize shorelines by reducing soil erosion, while their above-ground biomass dissipates the energy of waves and storm surges, thereby reducing the impact of extreme weather events on human settlements and agricultural lands (Blankespoor).

In addition, mangroves serve as efficient blue carbon solutions and have been proven to sequester four times the amount of carbon sequestered by terrestrial forests (Islam). They store carbon both above and below ground, with their root systems trapping organic material that remains buried for centuries. Furthermore, mangroves contribute to global biodiversity, serving as habitats for numerous species of flora and fauna, some of which are endangered.

Beyond their environmental benefits, mangroves also provide socio-economic advantages, including opportunities for ecotourism, which can generate alternative income streams for residents.

Furthermore, mangrove plantation activities themselves benefit local communities by creating employment. For instance, the plantation efforts by the NGO Friendship have benefited nearly 14,000 residents (Sharmeen).

5. Problems with Current Mangrove Plantation Efforts

Local NGOs are engaged in efforts to plant mangroves in previously degraded areas. Based on our conversations with them, we conclude that they are able to source mangrove saplings or grow them in nurseries, transport them effectively, and employ local labor to plant and maintain them.

However, their efforts are currently suffering from two major limitations. Firstly, their funding is sporadic with no reliable sources, resulting in inconsistent and unsustainable mangrove plantations. Secondly, they are unaware of and, therefore, do not follow plantation protocols that would make them eligible for carbon credit certification and monetization.

6. Solution in the Form of Carbon Credit-Based Financing

6.1 Carbon Credit Markets

Carbon credits are a vital and untapped resource. The Paris Agreement, a legally binding international treaty on climate change adopted by 196 Parties, aims to limit global warming to below 2 degrees Celsius (UNFCCC). As of June 2024, 107 countries, responsible for approximately 82% of global greenhouse gas emissions, have adopted net-zero pledges (United Nations). Additionally, numerous companies have committed to carbon neutrality, with 294 reaching the highest standard of corporate climate ambition as part of the Business Ambition for 1.5°C campaign (UNFCCC). Carbon credits play a central role in these commitments, enabling entities to offset emissions by investing in environmental projects. In 2023, global carbon pricing revenues reached a record \$104 billion, reflecting the growing importance of carbon markets in achieving climate goals (World Bank).

Carbon credit markets operate as mechanisms for pricing carbon emissions, incentivizing reductions, and funding sustainability initiatives. Traditional carbon markets function through cap-and-trade systems or carbon taxes, where entities purchase credits to offset their emissions.

6.2 Indian Carbon Credit Market

India's carbon market, shaped by the Energy Conservation (Amendment) Act of 2022, introduces both compliance and voluntary markets to align with national climate goals. Additionally, India's Green Credit Programme (GCP), launched in 2023, extends beyond carbon offsets by rewarding environmentally beneficial activities such as afforestation, water conservation, and biodiversity protection. The Bureau of Energy Efficiency in India is expected to release detailed regulations for the voluntary carbon offset mechanism soon, with Carbon Credit trading of voluntary offsets beginning in 2025 itself. Once Indian carbon markets become fully functional, it would offer a very convenient avenue for trading carbon credits.

6.3 Solution Overview and Feasibility

We propose to enable mangrove afforestation projects to generate and sell carbon credits as a sustainable source of funding. This economic model has 3 main steps. First, mangroves are restored through afforestation following carbon credit accreditation protocols. Second, carbon credits are generated through such mangroves and monetized on carbon markets. Third, the income generated is used to compensate the participants and drive further mangrove planting. This model has the potential to be self-sustaining.

Based on the CO₂ sequestration capacity of mangroves, the market price of carbon credits, and the period for which credits can be sold, a 25-hectare plot can generate 462,420 USD in revenue. The total cost of afforesting a 25-hectare plot and getting it certified is estimated to be 383,000 USD. This plot can sustain 75 labourers for a year at \$71 per month, which would more than double their current income. This does not include the employment that is created through the production and transportation of saplings. This model is scalable, and as larger tracts of land are afforested, more employment and impact can be generated.

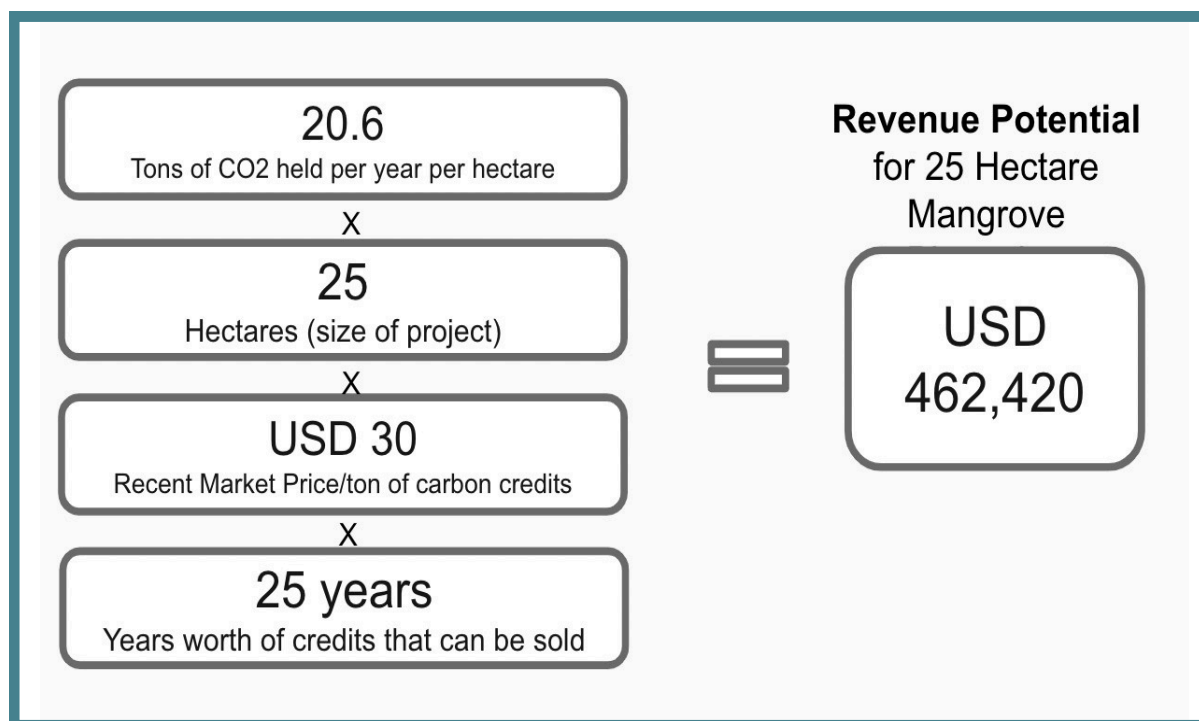


Fig: Revenue Potential of a 25 Hectare Mangrove Plantation in Sundarbans

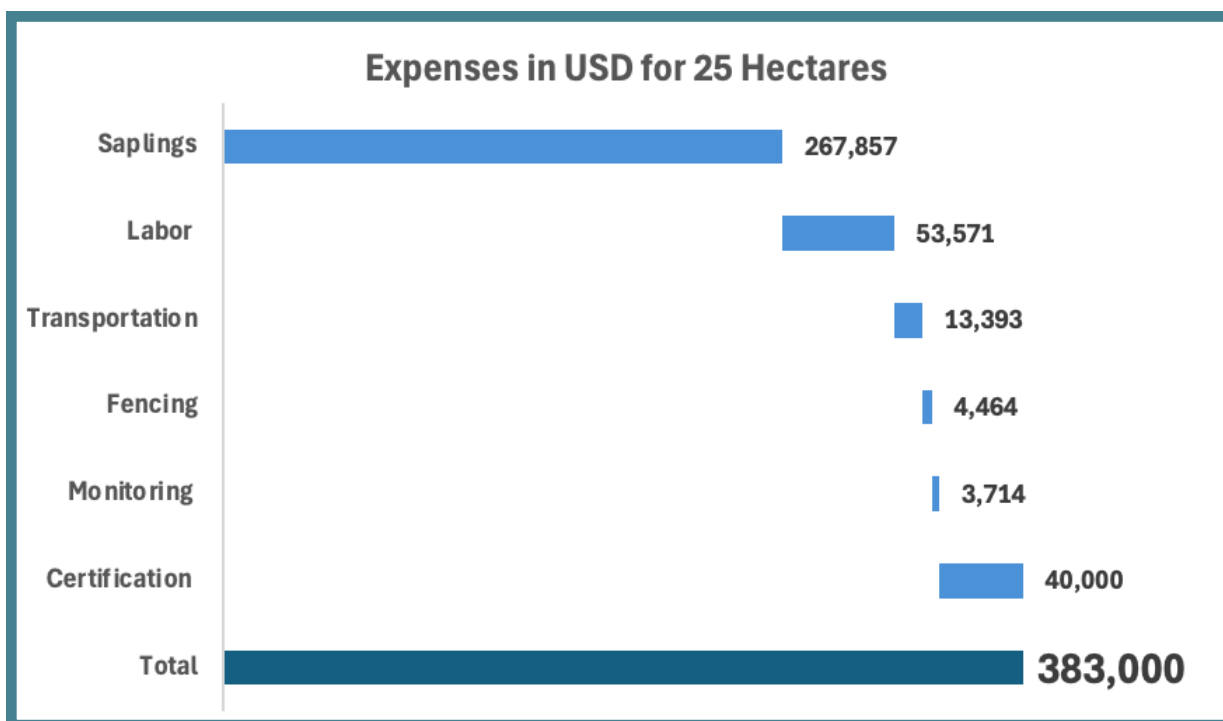


Fig: Expenses incurred in development of a 25 Hectare Mangrove Plantation in Sundarbans

The implementation of this model will directly address three Sustainable Development Goals.

1. First, this initiative helps work towards **poverty alleviation** in the Sundarbans by providing a sustainable source of income to vulnerable communities.
2. Second, improving mangrove afforestation efforts increases the storm resilience of **communities** in the Sundarbans, making them more **sustainable**.
3. Finally, by increasing the mangrove cover in the Sundarbans, **climate change** is better **combated** due to the greater carbon sequestration capacity of the forests.

7. Recommended Way Forward

Based on established and approved mangrove plantation protocols and carbon credit accreditation programs, we have curated and documented a Standard Operating Procedure (SOP), in simple, easy-to-understand steps for the planting and monitoring of afforestation projects to enable such projects to receive carbon credit accreditation. This document is intended to be distributed to local NGOs in the Sundarbans with the intent to encourage them

to seek accreditation. Along with this, we intend to conduct workshops to help the NGOs understand the opportunity to generate carbon credits and how to follow the SOP. We hope that through these initiatives, the local communities in Sundarbans will be able to create a sustainable source of financing for their afforestation efforts and realize the full benefits offered by mangroves.

8. Standard Operating Procedure for developing a Mangrove Project for Carbon Markets

We found the standards, protocols, and documentation involved in the development and accreditation of Mangrove projects to generate carbon credits to be quite complex and confusing. We felt that these would be quite challenging and inaccessible for the local communities and local NGOs in Sundarbans to comprehend and follow, given their complexity.

After researching the various GHG (Greenhouse Gas) crediting programs and methodologies, we found that a program called Plan Vivo might be the best suited for the present scenario due its better fit with small-scale and community-driven projects. The relevant methodology that is recommended in this document is Plan Vivo's Coastal Blue Carbon Methodology.

We have then attempted to present the steps required to be followed in simple language, retaining only those aspects relevant to mangroves (the protocols are generally designed to work for any carbon reduction projects). Even with that, we believe that the local NGOs would need to work with expert consulting agencies to meet the requirements. We have researched and recommended a couple of such agencies that are known to work on smaller-scale projects.

With this context, the following are the major steps that need to be undertaken to successfully implement a mangrove afforestation project and get it certified to generate and sell carbon credits.

8.1 For New Projects:

Step 1: Pre-Feasibility

Timeline: 0 – 6 months

The pre-feasibility stage is essential to determine whether there is potential for a blue carbon project at the proposed site. This involves:

- 1) Investigating the site's suitability, ensuring it has historically supported mangroves and that natural tidal systems are unobstructed by dams or embankments.
- 2) Rights to the land and carbon must be confirmed through discussions with the local government.
- 3) Additionally, stakeholders who are relevant to or will be affected by the project should be identified. These stakeholders typically include local communities, government agencies, and potential investors.
- 4) The project area must be clearly defined and mapped
- 5) The project team needs access to tools and expertise for collecting and analyzing greenhouse gas (GHG) data. If the technical capacity of the project team is lacking, GHG auditing organizations can provide the necessary support to calculate expected emissions reductions. Example organizations include:
 - a) Carbon Check - <https://www.carboncheck.co.in/>
 - b) EPIC Sustainability - <https://www.epicsustainability.com/>
- 6) Next, a suitable GHG crediting program and methodology must be selected. Options include the Gold Standard, Verified Carbon Standard, or Plan Vivo. Plan Vivo is recommended due to its experience working with small-scale and community-led projects. The relevant methodology that will guide the project is Plan Vivo's Coastal Blue Carbon Methodology. In the rest of the document, we will refer to this as the 'Selected Methodology'.

Step 2: Feasibility Report

Timeline: 0 – 6 months

Once the site is deemed suitable, a feasibility report is created to secure support and funding. This report should include:

1. The goals and objectives of the project

2. Details of the site's ecology and restoration plans
3. Descriptions of interactions with the community and stakeholders
4. Supporting data, such as an estimation of the carbon sequestration capacity of the project
5. Costs of planting and monitoring. While these estimations can be based on local averages, the report should align with the information required by the Selected Methodology.

For Sundarbans, here are estimates of expenses associated with 1 hectare of mangrove plantation. Table based on values from Chowdhury et al.. and interviews with local NGOs

Expense	Cost in INR
Cost of Saplings	900000
Transportation cost	45000
Labor cost for planting 1 hectare	150000
Labor supervision and welfare cost	30000
Fencing cost for 1-hectare	15000
Monitoring cost for 5 years	1140000

Step 3: Project Idea Note (PIN)

Timeline: 6 – 12 months

The next step involves drafting a Project Idea Note (PIN) to engage with the GHG crediting program and obtain initial approval. The PIN should include basic project details, such as location, area, and start date, along with the selected methodology. Preliminary carbon benefits must be outlined, such as estimated annual carbon sequestration and total expected carbon sequestration over the project duration. Additionally, the PIN should highlight additional benefits provided by the project, such as improved water quality, storm protection, job creation, improved livelihoods, and increased climate resilience. This document is submitted to the GHG crediting program for review. See Appendix A for the PIN template.

Step 4: Project Design Document (PDD)

Timeline: 6 – 12 months

Once the PIN is accepted by the GHG crediting program, the project team may move on to creating the Project Design Document (PDD). The PDD serves as a formal application to the GHG crediting program. It should provide detailed project information, including location, area, start date, and application of the selected methodology. The PDD must include estimates of the carbon reductions or removals (ERRs) the project will achieve, focusing on aboveground woody biomass, belowground biomass, and soil organic carbon as per the Selected Methodology. Details of stakeholder engagement and environmental safeguards must also be provided, including documentation of initial meetings with local communities and authorities, evidence of how stakeholder input shaped the project, and measures to protect biodiversity. Examples include species selection guidelines for mangrove planting and monitoring measures to mitigate adverse impacts. Once complete, the PDD is submitted to the carbon crediting program for review. See Appendix B for the PDD template.

Step 5: Validation Audit

Timeline: 6 – 12 months

A validation audit ensures that the project complies with the GHG crediting program's standards and is ready for implementation. Conducted by an independent third-party auditor, such as Carbon Check or EPIC Sustainability, the audit involves a review of the PDD and may include a site visit to verify that the information provided in the PDD is valid. The auditor may issue findings requiring clarification, corrective actions, or forward actions, which must be addressed before the project can proceed.

Step 6: Project Registration

Timeline: 6 – 12 months

Following a successful validation audit, the project is officially registered under the GHG crediting program. During this process, the audit results and the PDD are reviewed once more. Note that registration incurs fees, which must be accounted for in the project budget.

Step 7: Activity Implementation and Monitoring

Timeline: Year 1 – Year 6

With registration complete, the project moves to the implementation phase, where restoration activities are carried out according to the project plan. Monitoring begins simultaneously, tracking progress and documenting the project's carbon, environmental, and social benefits. Monitoring reports must adhere to the methodologies specified in the selected program and are typically submitted annually throughout the project's lifespan. A recommended document template for the monitoring report is available in the Appendix of this document.

Step 8: Verification Audit

Timeline: Year 6 – Year 7

Typically occurring 5 years after activity implementation, verification audits are conducted by an independent third-party auditor to confirm that the project has achieved the carbon reductions or removals stated in its monitoring reports. This involves a desk review of all monitoring reports and supporting data, as well as a site visit to verify activities, measurements, and stakeholder involvement. Findings from the audit must be addressed before final approval.

Step 9: Carbon Credit Issuance

Timeline: Year 6 – Year 7

After passing the verification audit, the project undergoes a final review by the carbon crediting program. Verified carbon reductions are then converted into carbon credits. A portion of these credits is withheld in a buffer pool to account for risks such as natural disasters. The remaining credits are available for purchase, providing a source of funding for the project.

Step 10: Periodic Verification and Credit Issuance

Timeline: Every 5 years

Throughout the project's lifespan, periodic verification audits are conducted every five years to ensure ongoing compliance and results. Credits may be adjusted based on updated data or

project performance, and any non-compliance with program standards could result in suspension or revocation of credits. Monitoring and annual reporting must continue to document the project's impacts and maintain accreditation. See Appendix C for the annual report template.

8.2 For Existing Projects (where planting has already started):

Step 1: Preliminary Assessment

Timeline: 0 – 6 months

The preliminary assessment stage is essential to determine whether the existing project has the potential to be accredited. This involves the following steps:

- 1) Document the plantation's history, including the date of establishment, species planted, and maintenance records.
- 2) Confirm rights to land and carbon
- 3) Clearly define and map project area
- 4) Ensure that the carbon sequestration achieved by the plantation would not have happened at the same scale or rate without the incentive of carbon credits. This demonstrates that the project is "additional" and not just a continuation of the natural course of mangrove growth. This includes:
 - a. Evaluating financial need (e.g., does the project require funding from carbon credits for further planting and maintenance).
 - b. Confirming that the plantation was not mandated by government regulation.
 - c. Comparing the current plot to similar but degraded reference plots to establish that the carbon sequestration is above and beyond what would have happened naturally if plantation was not done.
- 5) Next, a suitable GHG crediting program and methodology must be selected. Options include the Gold Standard, Verified Carbon Standard, or Plan Vivo. Plan Vivo is recommended due to its experience working with small-scale and community-led projects. The relevant methodology that will guide the project is Plan Vivo's Coastal Blue Carbon Methodology. In the rest of the document, we will refer to this as the 'Selected Methodology'.

Step 2: Baseline Carbon Stock Assessment

Timeline: 0 – 6 months

The purpose of this is to establish the pre-existing carbon stock level in the plantation and determine eligibility for crediting past sequestration.

Determining current carbon levels for future comparison:

Conduct field measurements using standard carbon sequestration assessment techniques. The project team needs access to tools and expertise for collecting and analyzing greenhouse gas (GHG) data. If the technical capacity of the project team is lacking, GHG auditing organizations can provide the necessary support to calculate expected emissions reductions. Example organizations include Carbon Check and EPIC Sustainability.

Determining Past Sequestration for Retroactive Crediting:

If field measurements were not conducted in the past, there is no way to determine the exact amount of carbon sequestered by the plantation. However, there are a few methods that can be used to estimate this value.

- 1) Use historical satellite images to track vegetation growth over time
- 2) Use published biomass accumulation and carbon sequestration rates for the specific mangrove species to estimate past sequestration.
- 3) Use any available records on planting density, tree mortality rates, and management practices to infer past sequestration.

Step 3: Project Idea Note (PIN)

Timeline: 6 – 12 months

The next step involves drafting a Project Idea Note (PIN) to engage with the GHG crediting program and obtain initial approval. The PIN should include basic project details, such as location, area, and start date, along with the selected methodology. Preliminary carbon benefits must be outlined, such as estimated annual carbon sequestration and total expected carbon sequestration over the project duration. Additionally, the PIN should highlight additional benefits provided by the project, such as improved water quality, storm protection, job creation, improved livelihoods, and increased climate resilience. This document is submitted to the GHG crediting program for review. See Appendix A for the PIN template.

Step 4: Project Design Document (PDD)

Timeline: 6 – 12 months

Once the PIN is accepted by the GHG crediting program, the project team may move on to creating the Project Design Document (PDD). The PDD serves as a formal application to the GHG crediting program. It should provide detailed project information, including location, area, start date, and application of the selected methodology. The PDD must include estimates of the carbon reductions or removals (ERRs) the project will achieve and has achieved, focusing on aboveground woody biomass, belowground biomass, and soil organic carbon as per the Selected Methodology. Details of stakeholder engagement and environmental safeguards must also be provided, including documentation of initial meetings with local communities and authorities, evidence of how stakeholder input shaped the project, and measures to protect biodiversity. Examples include species selection guidelines for mangrove planting and monitoring measures to mitigate adverse impacts. Once complete, the PDD is submitted to the carbon crediting program for review. See Appendix B for the PDD template.

Step 5: Validation Audit

Timeline: 6 – 12 months

A validation audit ensures that the project complies with the GHG crediting program's standards and is ready for implementation. Conducted by an independent third-party auditor, such as Carbon Check or EPIC Sustainability, the audit involves a review of the PDD and may include a site visit to verify that the information provided in the PDD is valid. The auditor may issue findings requiring clarification, corrective actions, or forward actions, which must be addressed before the project can proceed.

Step 6: Project Registration

Timeline: 6 – 12 months

Following a successful validation audit, the project is officially registered under the GHG crediting program. During this process, the audit results and the PDD are reviewed once more. Note that registration incurs fees, which must be accounted for in the project budget.

Step 7: Activity Implementation and Monitoring

Timeline: Year 1 – Year 2

With registration complete, the project moves to the implementation phase. Since the plantation exists, implementation focuses on refining planting and management practices in accordance with the results of the PDD review and validation audit. Monitoring begins simultaneously, tracking progress and documenting the project's carbon, environmental, and social benefits. Monitoring reports must adhere to the methodologies specified in the selected program and are typically submitted annually throughout the project's lifespan. A recommended document template for the monitoring report is available in the Appendix of this document.

Step 8: Verification Audit

Timeline: Year 2 – Year 3

After 1 year of activity implementation and monitoring, verification audits are conducted by an independent third-party auditor to confirm that the project has achieved the carbon reductions or removals stated in its monitoring reports. This involves a desk review of all monitoring reports and supporting data, as well as a site visit to verify activities, measurements, and stakeholder involvement. Findings from the audit must be addressed before final approval.

Step 9: Carbon Credit Issuance

Timeline: Year 2 – Year 3

After passing the verification audit, the project undergoes a final review by the carbon crediting program. Verified carbon reductions are then converted into carbon credits. A portion of these credits is withheld in a buffer pool to account for risks such as natural disasters. The remaining credits are available for purchase, providing a source of funding for the project.

Step 10: Periodic Verification and Credit Issuance

Timeline: Every 5 years

Throughout the project's lifespan, periodic verification audits are conducted every five years to ensure ongoing compliance and results. Credits may be adjusted based on updated data or project performance, and any non-compliance with program standards could result in suspension or revocation of credits. Monitoring and annual reporting must continue to document the project's impacts and maintain accreditation. See Appendix C for the annual report template.

9. Conclusion

This report presents an overview of the current environmental challenges facing the Sundarbans Mangrove Forests and its communities. Specifically, it looks at the mangrove reforestation efforts being undertaken by the local communities and the issues they are facing in funding their efforts. Their primary source of funding currently is through donations and corporate CSR funds, both of which are intermittent and unpredictable, leading to uncertainties for the reforestation efforts.

The report introduces carbon credits as a funding mechanism that could provide a reliable source of financing for the Sundarbans mangrove reforestation projects. By considering the various costs involved in reforestation and the market price of carbon credits, we demonstrate its feasibility as a financing option.

Noting that carbon credit accreditation protocols are quite complicated and technical, we recommend a specific protocol called Plan Vivo, which is better suited to small-scale, community-driven projects and is relatively simpler compared to other protocols.

We then present a Standard Operating Procedure that lists out in simple language the various steps that need to be followed to successfully organize a mangrove planting project and get it accredited to generate carbon credits that can be sold. The steps are presented both for new projects as well as projects where the plantation efforts have already started.

10. Acknowledgement

I would like to thank Dr. Bappaditya Mukhopadhyay for introducing me to the Sundarbans Mangrove Forest and the local communities there. His passion for this beautiful place is inspiring. I am also grateful for his guidance throughout this work. Lastly, I also thank him for acting as a translator to help me communicate with the Sundarbans residents. I also thank Mr. Umashankar and Mr. Anurag, both residents of Sundarbans, for providing me data on the costs they are incurring in their mangrove plantation efforts and also supporting me on my numerous trips to the Sundarbans.

Appendices

Appendix A

Link to the PIN (Project Idea Note) template for Project Vivo:

https://drive.google.com/file/d/179RYvShfkJp1R4jo8CLUd07paO8Ta_I/view?usp=sharing

Appendix B

Link to the PDD (Project Description Document) template for Project Vivo:

<https://drive.google.com/file/d/1mSu-k86SZUL1MfFGuHh0XxAnBnWYOr9K/view?usp=sharing>

Appendix C

Link to the Annual Report template for Project Vivo:

<https://drive.google.com/file/d/1TEGiez7BVLb9NhSzp0IoY2XzRYuT2MDR/view?usp=sharing>

References

- Blankespoor, Brian, et al. "Mangroves as a Protection from Storm Surges in a Changing Climate." *Ambio*, U.S. National Library of Medicine, pmc.ncbi.nlm.nih.gov/articles/PMC5385662/.
- Cernea, Michael M. (2004) "Impoverishment Risks, Risk Management, and Reconstruction: A Model of Population Displacement and Resettlement". Keynote address at the UN Symposium on Hydropower and Sustainable Development.
- Chowdhury, A., Naz, A., Bhattacharyya, S., & Sanyal, P. (2018). "Cost-benefit analysis of 'Blue Carbon' sequestration by plantation of few key mangrove species at Sundarban Biosphere Reserve," *India. Carbon Management*, 9(6), 575–586.
<https://doi.org/10.1080/17583004.2018.1518105>
- Danda, A. A; N Ghosh; J Bandyopadhyay & S. Hazra (2019): "Managed retreat: adaptation to climate change in the Sundarbans ecoregion in the Bengal Delta", *Journal of the Indian Ocean Region*, DOI: 10.1080/19480881.2019.1652974
- Hajra, R., Szabo, S., Tessler, Z. et al. Unraveling the association between the impact of natural hazards and household poverty: evidence from the Indian Sundarban delta. *Sustain Sci* 12, 453–464 (2017). <https://doi.org/10.1007/s11625-016-0420-2>
- Islam, S.N. (2019). Sundarbans a Dynamic Ecosystem: An Overview of Opportunities, Threats and Tasks. In: Sen, H. (eds) *The Sundarbans: A Disaster-Prone Eco-Region*. Coastal Research Library, vol 30. Springer, Cham. https://doi.org/10.1007/978-3-030-00680-8_2
- Islam, S.M.DU., Bhuiyan, M.A.H. Sundarbans mangrove forest of Bangladesh: causes of degradation and sustainable management options. *Environmental Sustainability* 1, 113–131 (2018). <https://doi.org/10.1007/s42398-018-0018-y>
- Sen, H.S., Ghorai, D. (2019). The Sundarbans: A Flight into the Wilderness. In: Sen, H. (eds) *The Sundarbans: A Disaster-Prone Eco-Region*. Coastal Research Library, vol 30. Springer, Cham. https://doi.org/10.1007/978-3-030-00680-8_1

Sharmeen. "The Plight of the Mighty Mangroves in the Sundarbans." Friendship NGO, 30 July 2024, <https://friendship.ngo/conservation-of-mangrove/#:~:text=The%20accelerated%20declared%20in%20the,rate%20compared%20to%20other%20forests>.

UNFCCC. "Commitments to Net Zero Double in Less Than a Year." United Nations Climate Change, 21 September 2020, unfccc.int/news/commitments-to-net-zero-double-in-less-than-a-year#:~:text=Net%20Zero%20C

United Nations. "Net Zero Coalition." United Nations Climate Action, www.un.org/en/climatechange/net-zero-coalition.

World Bank Group. "State and Trends of Carbon Pricing 2024." World Bank, World Bank Group, 21 May 2024, www.worldbank.org/en/news/press-release/2024/05/21/global-carbon-pricing-revenues-top-a-record-100-billion.

Roots for Change

Roots for Change is a not-for-profit initiative by Raina Lakhamraju focused on supporting sustainable mangrove restoration/afforestation as well as improving livelihoods of vulnerable communities. Through research-driven experimentation, fund-raising, information and knowledge dissemination, awareness generation and other efforts, Roots for Change aspires to enable self-sustaining, long-term economic solutions. In the Sundarbans, Roots for Change is developing and supporting the implementation of sustainable carbon credit based financing solutions for mangrove restoration.