MONETIZING SOIL CARBON FOR CLIMATE ACTION IN BANGLADESH

M.M. Billah[1], M.A. Rahath[2], N. Islam[1], Z. Jany[1], M.M. Rahman[1]*

[1] *Department of Soil Science, Gazipur Agricultural University, Gazipur 1706, Bangladesh*

[2] *Envolead Ltd., Dhaka, Bangladesh*

Corresponding e-mail: mizan@gau.edu.bd

Abstract

Soils are central to sustaining food systems, regulating ecosystem services, and mitigating climate change. In Bangladesh, the capacity of soils to act as long-term carbon sinks represents both a scientific opportunity and a strategic development frontier. Soil-based carbon crediting, supported by international carbon markets and the Paris Agreement's Article 6 mechanisms, offers a viable pathway to incentivize regenerative agricultural practices, restore degraded landscapes, and mobilize climate finance at scale. Despite this promise, soil carbon finance remains underdeveloped, constrained by institutional gaps, limited measurement, reporting and verification (MRV) capacity, data scarcity, and restricted market access. This paper provides an integrated assessment of the scientific basis, methodological frameworks, economic potential, institutional enablers, and policy reforms required to operationalize soil carbon finance in Bangladesh. It draws on internationally recognized standards such as Verra, Gold Standard, Plan Vivo, and Puro.earth, while incorporating recent advances in MRV technologies. Together, these foundations inform a national roadmap that embeds soil carbon into climate policy, strengthens farmer aggregation mechanisms, and secures durable and predictable carbon revenues. The analysis concludes that targeted investments in soil data systems, institutional capacity building, and fiscal incentives, combined with strong governance aligned with NDC 3.0, are essential. With these measures, Bangladesh can position itself as a credible participant in soil carbon markets, delivering co-benefits for food security, climate resilience, and rural livelihoods.

Keywords: Carbon trading, Carbon market, Paris Agreement, Climate vulnerability

1. Introduction

Bangladesh's agricultural sector is the backbone of its economy, contributing nearly one-fifth of the national GDP and employing more than 45% of the labor force, and supports about 75% of the country's population (World Bank, 2023). However, this sector also accounts for roughly one-third of national greenhouse gas emissions, largely due to methane emissions from rice paddies and nitrous oxide emissions from nitrogen fertilizers. As climate change intensifies, driving salinity intrusion, erratic rainfall, soil erosion, and declining fertility the need for sustainable climate-smart solutions becomes paramount. A growing body of scientific research highlights soils as a powerful but undervalued carbon sink. With about 8.5

million hectares of cultivable land, Bangladesh holds significant potential to store atmospheric carbon through practical interventions such as biochar application, composting, alternate wetting and drying (AWD), integrated nutrient management, and agroforestry (Alam *et al.,* 2025). Globally, soils store more carbon than the atmosphere and vegetation combined. Enhancing soil organic carbon (SOC) has gained attention not only as a mitigation strategy but also as an adaptation solution that improves soil fertility, water retention, and crop resilience. However, despite its potential, Bangladesh's access to carbon finance remains minimal. Less than 15 percent of the 50+ million carbon credits issued in Bangladesh have been monetized (MoEFCC, 2021). Weak MRV systems, lack of standardized methodologies, limited technical capacity, and absence of a national registry remain core barriers for carbon trading in Bangladesh (Waste Concern, 2023).

This paper argues that soil carbon finance in Bangladesh presents a unique opportunity to enhance agricultural resilience, contribute to climate mitigation, and open avenues for international funding. International carbon markets now recognize SOC as a credible emission reduction pathway. Therefore, the study examines how Bangladesh can operationalize soil carbon finance at scale, integrate it into national climate planning, and unlock economic opportunities for farmers while contributing to global mitigation goals. To operationalize this opportunity, Bangladesh must align soil carbon projects with national climate pledges (NDC 3.0), strengthen institutional systems, and adopt rigorous monitoring standards. The following sections synthesize current scientific understanding, market mechanisms, sequestration practices, economic prospects, institutional requirements, and policy priorities for scaling soil carbon finance nationwide.

2. Soil Carbon as a Climate Solution

2.1 Soil health and ecosystem functions

Soils underpin critical ecosystem functions, including food production, water regulation, nutrient cycling, and biodiversity conservation. Approximately one-quarter of global biodiversity resides in soils, which also serve as a source of many pharmaceuticals and genetic resources (FAO, 2020). However, soil degradation is accelerating worldwide due to intensive cultivation, nutrient mining, salinization, erosion, and organic matter depletion. In Bangladesh, more than half of cultivated land is affected by nutrient deficiencies, salinity stress, or erosion, directly threatening productivity, farmer incomes, and national food security (Rahman *et.al,* 2023).

2.2 Dynamics of soil organic carbon

Soil organic carbon (SOC) accumulates when carbon inputs such as crop residues, root biomass, and microbial necromass exceed outputs like microbial respiration and erosion. SOC exists along a stability spectrum: particulate organic matter (POM), which is relatively labile, and mineral-associated organic matter (MAOM), which can persist for centuries (Lal, 2018).

Practices that increase biomass, reduce disturbance, and improve soil structure promote long-term SOC storage. For carbon crediting, SOC must be real and measurable, requiring standardized protocols for sampling, laboratory analysis, and model calibration (Smith *et al.,* 2020). Ensuring measurability is critical to market integrity because credits must represent verifiable and quantifiable reductions in greenhouse gas emissions.

2.3 Global mitigation potential and the "4 per 1000" initiative

The global land sector, including agriculture, forestry, and wetlands, offers an annual mitigation potential of 8 to 14 Gt CO_2-equivalent. Soil carbon alone could contribute up to 6 Gt CO_2-equivalent, making it indispensable in reaching net-zero pathways. The "4 per 1000" Initiative posits that increasing global SOC stocks by just 0.4 percent annually could offset anthropogenic CO_2 emissions (FAO, 2020). However, for soil carbon credits to be recognized, projects must demonstrate additionality, meaning sequestration beyond business-as-usual, permanence to ensure long-term storage without reversal, and safeguards against leakage to prevent displacement of emissions to other areas (Gold Standard, 2021). These principles, along with measurability, verification, and no double counting, ensure that soil carbon projects deliver genuine climate benefits and maintain credibility in both voluntary and compliance markets.

2.4 Relevance of soil carbon in Bangladesh

For Bangladesh, soil carbon is not only a mitigation tool but also an adaptation strategy. SOC-rich soils retain water, buffer crops against drought, and strengthen resilience against climate shocks (Rahman et al., 2023). Enhancing soil carbon therefore delivers dual benefits: improved productivity and reduced emissions. However, realizing this potential requires robust measurement, permanence safeguards, and additionality verification. Moreover, verification and no double counting are critical to ensure environmental integrity and market confidence. This means soil carbon credits must be transparently registered in national and international registries, aligned with Article 6 of the Paris Agreement, and independently verified by accredited third parties (Verra, 2023). By adhering to these integrity principles, Bangladesh can position itself as a credible participant in global carbon markets while simultaneously advancing food security and climate resilience.

3. Soil Carbon Finance and Carbon Markets

3.1 Evolution of soil carbon in carbon markets

Carbon markets first emerged under the Kyoto Protocol and expanded significantly with the Paris Agreement. Early credits focused on industrial and forestry sectors, but advances in soil science and nature-based solutions (NBS) have elevated soil carbon within both voluntary and compliance markets. Several international platforms now include methodologies for agricultural soil carbon projects. These include Verra's Verified Carbon Standard (VCS), the Gold Standard (GS), the American Carbon Registry (ACR), the Climate Action Reserve (CAR),

and the Plan Vivo Foundation (PV), which specializes in smallholder and community-based projects. In addition, Puro.earth has developed methodologies for durable carbon removals such as biochar, while the Sustainable Agriculture Network (SAN) and the Soil Carbon Initiative (SCI) are emerging frameworks that emphasize regenerative agriculture. Importantly, the International Organization for Standardization (ISO) has established the ISO 14064 series, which provides globally recognized standards for greenhouse gas accounting, verification, and project methodologies, including soil carbon projects. These ISO standards are increasingly referenced to ensure consistency, transparency, and credibility in soil carbon accounting.

The current dynamics of the soil carbon market are characterized by significant variability and several structural challenges. MRV accuracy differs widely across protocols, with assessments often requiring high costs, labor-intensive procedures, and complex scientific expertise, which can affect the credibility of reported carbon reductions (Sustainability Directory, 2025). Market liquidity remains limited, with most transactions occurring over-the-counter (OTC), leading to low transparency, inconsistent pricing, and cautious investor participation. Farmer engagement is generally moderate to low, as project participation entails navigating complex management requirements, incurring upfront costs, and assuming perceived financial and operational risks. Finally, policy support is fragmented and region-specific, with inconsistent incentives and regulatory ambiguity that may hinder market development and investment. Together, these factors underscore the need for standardized methodologies, robust verification mechanisms, targeted farmer support, and coherent policy frameworks to scale soil carbon initiatives effectively (Table 1).

Table 1. Current soil carbon market (Global) dynamics

Aspect	Current State	Challenges
MRV Accuracy	Highly variable depending on the methodological protocol	High costs, labor-intensive procedures, and scientific uncertainty
Market Liquidity	Limited, predominantly over-the-counter transactions	Lack of standardization, low transparency, and buyer caution
Farmer Participation	Moderate to low levels of engagement	Complexity of implementation, significant upfront costs, and perceived risk
Policy Support	Fragmented and region-specific	Inconsistent incentives and regulatory ambiguity

Under Article 6.4 of the Paris agreement, soil carbon is expected to gain prominence through jurisdictional programs, enabling countries like Bangladesh to integrate soil carbon into national climate pledges. Key integrity principles are central to this evolution. Permanence requires that soil organic carbon remain stored for decades or centuries.

Additionality ensures that credits represent sequestration beyond business-as-usual practices. Leakage safeguards prevent emissions from being displaced to other areas. Measurability and verification demand that soil carbon changes be scientifically quantified and independently validated. Finally, no double counting requires that credits be transparently registered to avoid duplication across markets. Together, these principles ensure that soil carbon projects deliver genuine climate benefits and maintain credibility in both voluntary and compliance markets (Gold Standard, 2021; Verra, 2023). Mechanisms of compliance and voluntary carbon markets is provided in the Fig. 1.

3.2 Voluntary carbon markets

- **Nature:** Optional and self-regulated, though often overseen by third-party standards.
- **Purpose:** For companies, governments, or individuals to voluntarily offset their carbon footprint to meet sustainability goals.
- **How they work:** Companies buy carbon credits from projects that reduce or remove greenhouse gases, such as reforestation or renewable energy projects.
- **Participants:** A broader range of businesses, organizations, and individuals.
- **Regulation:** Less direct government regulation; credits are verified by third-party standards like Verra or Gold Standard.
- **Examples:** Projects that generate credits for sale in the open market, which can be used to achieve carbon neutrality goals.

3.3 Compliance market

- **Nature:** Mandatory and regulated by governments.
- **Purpose:** To ensure regulated entities meet legally binding emission reduction obligations.
- **How they work:** Typically operate as cap-and-trade systems, where a total limit is set on emissions, and permits (or allowances) can be traded between regulated companies.
- **Participants:** Primarily energy-intensive industries like power generators, airlines, and heavy manufacturing.
- **Regulation:** Strict, with penalties for non-compliance. Verification is enforced by regulatory authorities.
- **Examples:** European Union Emissions Trading System (EU ETS) and California's cap-and-trade program.

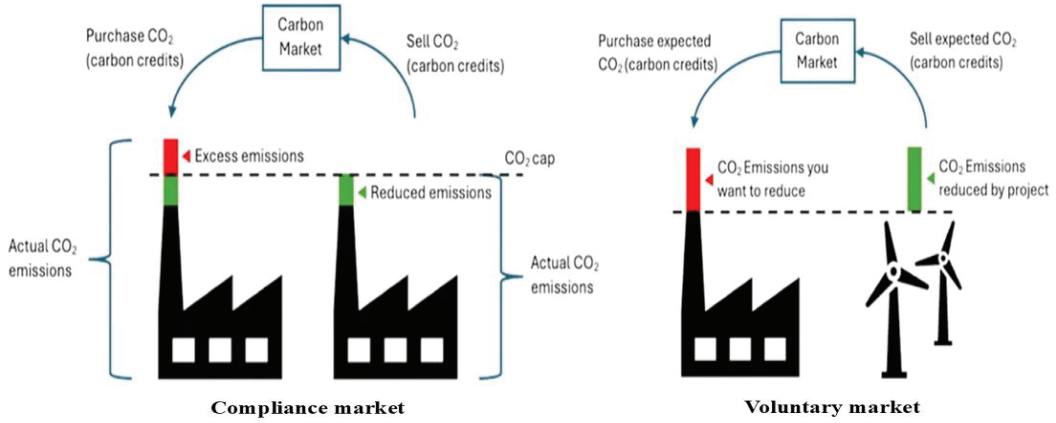

Fig. 1 Mechanisms of compliance and voluntary carbon markets

4. Practices and Technologies for Soil Carbon Sequestration

Around the world, diverse technologies are being deployed to increase SOC or reduce methane and nitrous oxide emissions. For Bangladesh, priority practices include:

- **Alternate Wetting and Drying (AWD):** Reduces methane emissions by up to 47% and increases water productivity by 32% over the continuous flood irrigation (Hossain and Islam, 2022).
- **Biochar:** Provides long-term carbon stability and improves soil fertility in saline or degraded soils (Haque *et al.,* 2019; Hasnat *et al.,* 2022).
- **Composting and Organic Amendments:** Boost SOC and microbial activity (Anik *et al.,* 2017).
- **Agroforestry and Silvopasture:** Integrate trees with crops and livestock, increasing biomass (Rahman *et al.,* 2023).
- **Reduced Tillage and Cover Cropping:** Reduce soil disturbance and erosion, reduce greenhouse gas emission, improve soil structure and carbon sequestration, and increase water holding capacity of soil (Rahman *et al.,* 2020).
- **Legume Integration:** Enhances nitrogen fixation and reduces fertilizer demand (Alam *et al.,* 2023).

4.1 Methodologies for soil carbon projects

Relevant methodologies include Verra's VM0017, VM0021, and VM0032; Gold Standard's regenerative agriculture frameworks; Plan Vivo's smallholder aggregation models; and Puro.earth's biochar-focused protocols. Bangladesh could adapt these methodologies while developing nationally tailored AWD and rice-based protocols. Bangladesh can adopt these methodologies while developing its own AWD protocol tailored to rice ecosystems. Fig. 2 and 3 depicted the life cycle and core principles of a carbon project, respectively.

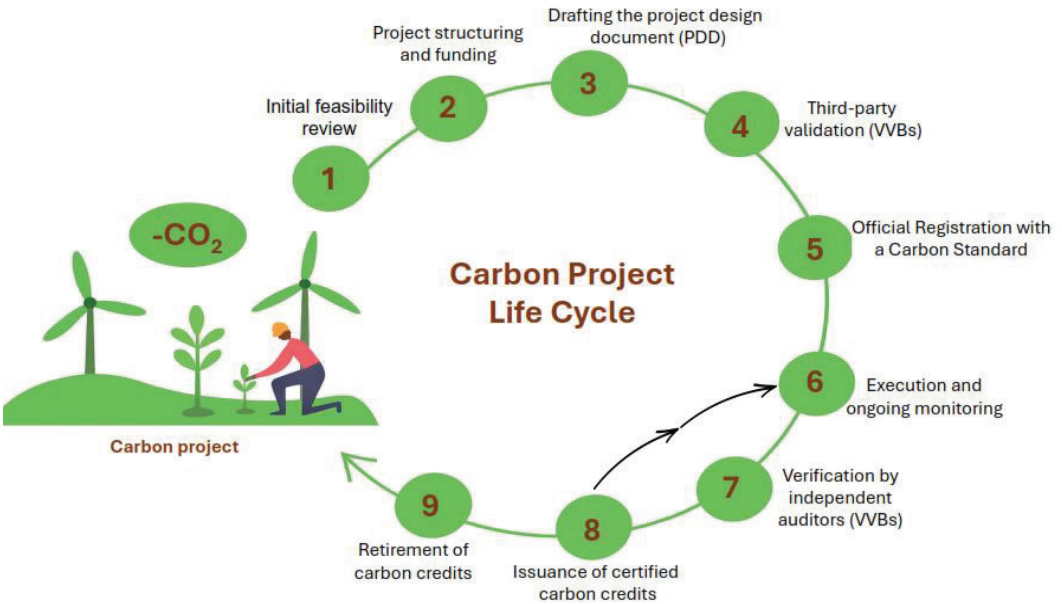

Fig. 2 Hypothetical life cycle of a carbon project

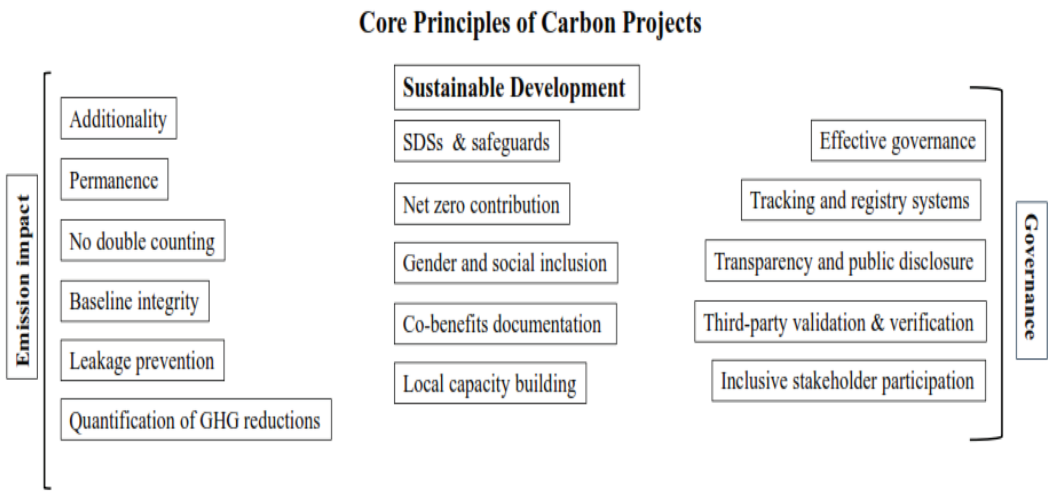

Fig. 3 Core principles of a carbon project

5. Bangladesh's Soil Carbon Frontier

5.1 Agricultural potential and revenue forecasts

Agriculture in Bangladesh is not only a victim of climate change; it can also be a solution. Regenerative agriculture offers a pathway to resilience by restoring soil health, increasing organic matter, rotating crops, and reducing chemical dependency. Crop diversification and improved soil management strengthen resilience while enabling carbon sequestration. The promise of carbon credit mechanisms adds another dimension, particularly within the AFOLU sector highlighted in Bangladesh's NDC 3.0, which emphasizes climatesmart agriculture, biochar, AWD, and agroforestry as priority measures (Government of Bangladesh, 2024). Bangladesh produces approximately 45–50 million tons of rice straw annually (Islam et al., 2020), much of which is traditionally burned or left unused. Similarly, jute stick production exceeds 2.5 million tons per year (Rahman & Hossain, 2019). These residues represent a significant feedstock for biochar production, which can sequester carbon for centuries while improving soil fertility. If even 20 percent of rice straw and jute sticks were converted into biochar, Bangladesh could generate millions of tons of durable carbon credits, valued at premium prices in voluntary markets.

In addition, Alternate Wetting and Drying (AWD) in rice cultivation has been shown to reduce methane emissions by 30–70 percent compared to continuous flooding (IRRI, 2019). With over 11 million hectares of rice cultivation, scaling AWD to just 20 percent of this area could reduce emissions by 8–10 million tons of CO_2e annually, creating a substantial pool of soillinked carbon credits. Globally, the voluntary agriculture carbon credit market is projected to grow from USD 53.8 million in 2025 to USD 648.3 million by 2034, at a CAGR of 31.9 percent (Market Analysis Report, 2025). Agriculturebased credits are currently valued between USD 10–20 per ton of CO_2e, but biochar and enhanced weathering credits can fetch much higher prices, often exceeding USD 100 per ton (Puro.earth, 2023). With 8.5 million hectares of cultivable land, even 20 percent adoption of soil carbon practices could generate 15–20 million tons of CO_2e annually, equating to USD 150–400 million in annual revenue at current market prices.

Barriers remain, including limited farmer awareness, underdeveloped verification systems, and weak institutional frameworks. Crop insurance penetration is below 5 percent nationwide, leaving farmers vulnerable to climate shocks (World Bank, 2022). Addressing these gaps through MRV systems, farmer aggregation, and integration with Bangladesh's planned National Carbon Registry will be critical to unlock soil carbon finance.

5.2 Regional Benchmarking

Regional benchmarking of carbon trading in South Asia reveals a complex, evolving landscape shaped by diverse economic structures, energy profiles, and institutional capacities. India provides a strong regional model, having generated 17 percent of global

carbon credits between 2010–2021 (ICVCM, 2023). Bangladesh can replicate this success by leveraging rice straw, jute residues, and coastal agroforestry systems. AWD, biochar, and agroforestry are particularly relevant technologies for scaling soil carbon credits. Smaller economies such as Nepal and Bhutan contribute minimally to regional emissions but have high sequestration potential through forest cover and REDD+ participation. Sri Lanka and the Maldives are exploring blue carbon credits tied to mangroves and seagrasses. Bangladesh and Pakistan, both highly vulnerable to climate change, are increasingly embedding carbon finance mechanisms within their NDCs. Aligning voluntary schemes with internationally recognized standards such as Verra, Gold Standard, Plan Vivo, and ISO 14064, as well as Article 6 mechanisms, will enhance credibility and attract investment. Ultimately, benchmarking underscores that while a onesizefitsall carbon market is unlikely in South Asia, targeted cooperation, capacity building, and adaptive policy design can create a synergistic regional framework. For Bangladesh, soil carbon credits represent a frontier opportunity to mobilize climate finance, strengthen resilience, and contribute to NDC 3.0 targets.

5.3 Future outlook by 2030

Carbon finance in Bangladesh's agricultural sector is entering a phase of accelerated growth, with soil carbon credits expected to play a transformative role in achieving NDC 3.0 targets. By 2030, Bangladesh could generate more than 100 million soillinked carbon credits, positioning itself as a regional leader in agricultural carbon finance. Large opportunities lie in the utilization of crop residues. Bangladesh produces 45–50 million tons of rice straw annually (Islam et al., 2020) and over 2.5 million tons of jute sticks (Rahman & Hossain, 2019). Much of this biomass is currently burned or discarded, but conversion into biochar could sequester 10–15 million tons of CO_2e per year, creating durable credits valued at premium prices in voluntary markets (Puro.earth, 2023). Methane reduction through Alternate Wetting and Drying (AWD) in rice cultivation offers another major pathway. With 11 million hectares of rice fields, adoption of AWD on 20 percent of this land could reduce emissions by 8–10 million tons of CO_2e annually (IRRI, 2019). These reductions align directly with Bangladesh's NDC 3.0 AFOLU priorities, which emphasize AWD, biochar, and agroforestry as scalable mitigation practices (Government of Bangladesh, 2024). By 2030, soil carbon credits could represent a USD 500 million–1 billion annual market for Bangladesh, depending on adoption rates and carbon prices. Integration into the National Carbon Registry and alignment with Article 6 mechanisms will be essential to ensure transparency, avoid double counting, and enable international trading.

6. Current Carbon Credit Landscape in Bangladesh

Bangladesh is emerging as a promising, yet underdeveloped, participant in the global carbon credit market, having generated millions of credits from initiatives such as solar home systems and improved cookstoves. With the support of the World Bank, including a 2.4 billion Tk investment for establishing a National Carbon Registry, the country aims to formalize its carbon trading framework and capture substantial revenue from international markets.

6.1 Current projects

Bangladesh has begun experimenting with soil and agriculturebased carbon initiatives that align closely with its Nationally Determined Contribution (NDC) 3.0 priorities. Early efforts span both farmlevel practices and institutional engagement. For example, Planboo's partnership with Better Cotton is piloting soil carbon monitoring in regenerative cotton systems, while Varaha's agroforestry projects integrate fruit trees into croplands to enhance soil organic carbon. Several Programmes of Activities (PoAs) are promoting AWD in rice fields to reduce methane emissions and improve soil water management. At the same time, Gold Standard (GS) initiatives are supporting regenerative agriculture and sustainable rice practices, and youth engagement programs such as Bangladesh's first Carbon Fest are raising awareness of soil carbon credits among farmers and students. Beyond grassroots efforts, policy dialogues led by the Economic Relations Division (ERD) are shaping pathways for integrating soil carbon into national trading frameworks. More targeted projects are also underway. The AWD Voluntary Project Activity (VPA) in Tangail encourages ecofriendly rice farming methods that reduce methane emissions and strengthen soil resilience. The Sustainable Agriculture PoA promotes crop residue management, crop rotation, and reduced tillage to increase soil organic carbon, while the Improved Agriculture Practices VPA advances minimum soil disturbance, natural farming, and biostimulant use to enhance soil carbon sequestration. Taken together, these initiatives demonstrate a growing ecosystem of soilfocused carbon projects that combine climate mitigation with resilience and farmer livelihood benefits. Figure 4 illustrates the ecosystem of Soil Carbon Credit Markets in Bangladesh, highlighting the interconnected roles of auditors, standards, exchanges, buyers, investors, and project developers that collectively enable soilbased carbon credit generation and trading.

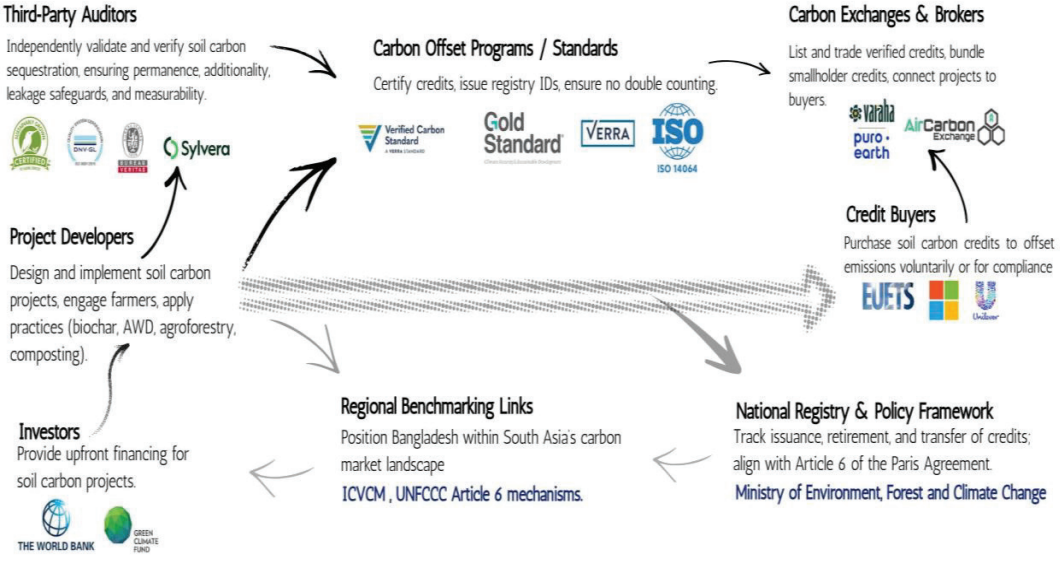

Fig. 4 Ecosystem of soil carbon credit markets in Bangladesh

6.2 Prospects

The prospects for soil carbon credits in Bangladesh are significant. With annual production of 45–50 million tons of rice straw and over 2.5 million tons of jute sticks, the country has vast feedstock for biochar, a durable carbon removal technology that can generate premium credits. Scaling AWD across rice systems could reduce 8–10 million tons of CO_2e annually, while agroforestry and regenerative practices offer additional sequestration potential. Together, these pathways could generate over 100 million soillinked carbon credits by 2030, translating into USD 500 million–1 billion in annual revenue depending on adoption rates and market prices. Integration into the planned National Carbon Registry and alignment with Article 6 mechanisms of the Paris agreement will ensure transparency, credibility, and access to international markets, positioning Bangladesh as a regional leader in agricultural carbon finance.

6.3 Challenges and way forward

Despite strong potential, several challenges remain. Farmer awareness of carbon markets is limited, institutional capacity for monitoring and verification is weak, and fragmented land holdings make aggregation difficult. Financial institutions also lack the technical expertise to appraise carbonbased investments, while MRV systems remain costly and underdeveloped. Moving forward, Bangladesh must strengthen MRV infrastructure with digital tools, promote farmer aggregation through cooperatives, and fasttrack the operationalization of its National Carbon Registry. Policy support, capacity building, and international partnerships with standards such as Verra, Gold Standard, and Plan Vivo will be essential. By leveraging agricultural residues for biochar, scaling AWD, and embedding soil carbon practices into NDC implementation, Bangladesh can transition from pilot projects to a structured, marketoriented soil carbon system that delivers climate mitigation, enhances food security, and improves rural livelihoods.

6.4 Institutional and regulatory landscape for soil carbon projects in Bangladesh

Carbon projects must follow the laws and rules of the country where they are carried out. This includes getting approval from national or local authorities, especially for land use, and following any existing government guidelines. Many countries are now creating new rules for voluntary carbon markets (VCM) based on Article 6.4 of the Paris Agreement. Bangladesh has begun building the legal and institutional groundwork for participating in international carbon markets. In November 2025, Bangladesh signed a Host Country Agreement with the World Bank's Carbon Initiative for Development (Ci-Dev), establishing a formal framework for nationally authorized carbon crediting and engagement with market mechanisms aligned with the Paris Agreement. This includes development of a Standardized Crediting Framework (SCF) to support emission reduction activities and enhance access to market payments (Carbon Initiative for Development, 2025). National laws may decide who owns carbon rights. Some countries treat carbon stored in forests or soil as a state-owned natural resource. In such cases, developers must obtain government licenses to run projects. In other countries, rules

vary by sector. For example, in Madagascar the government controls forest carbon credits, while carbon from other land uses usually belongs to landowners, meaning legal agreements with farmers or landholders are required (GIZ, 2023). Bangladesh does not yet have a specific law defining carbon ownership. In practice, carbon rights are governed by existing land and forest laws. Carbon in state-owned forest lands is treated as a government-controlled resource, requiring official approval to implement projects (Rahman, 2022). Carbon benefits from private or community land are generally linked to land ownership or use rights, but still require government clearance. Overall, all carbon projects in Bangladesh must obtain authorization from relevant authorities, and forthcoming Article 6–related policies are expected to provide clearer rules on ownership and benefit sharing. Host countries may charge project approval fees and/or apply taxes on issued carbon credits. Tax rates can vary by sector or project type, for example, community-led projects may receive lower tax rates than private projects. National laws may also require a fixed share of carbon revenues to be distributed to local communities where projects are implemented. Project developers must account for these fees, taxes, and revenue-sharing obligations, as they can significantly affect the project's financial viability (GIZ, 2023). In Bangladesh, there is currently no dedicated carbon tax or fixed revenue-sharing law specifically for voluntary carbon market projects. However, project developers may be required to pay government approval fees, environmental clearance fees, and applicable corporate or income taxes under existing national tax laws. Developers should verify with the Department of Environment whether any fees apply to the issuance or transfer of carbon credits, especially in pilot or market-linked projects. Given the typical 20–30-year lifespan of carbon projects, developers in Bangladesh must secure clear and long-term land ownership or land-use rights in accordance with national land laws to ensure project permanence. In parallel, broader government policies, such as foreign investment regulations, climate-finance disclosure requirements, taxation, and foreign-exchange controls, can affect project financing and investor confidence and should be carefully assessed during project planning (GIZ, 2023). Incorporating these elements, Bangladesh may begin drafting a Carbon Credits (Carbon Farming Initiative) Act to formalize requirements, guidelines, and operational details for the country's carbon credit sector.

9. Conclusions

Soil carbon finance offers a compelling and integrated pathway for Bangladesh to address climate change while strengthening soil health, agricultural productivity, and rural livelihoods. By enhancing soil organic carbon through scientifically validated management practices, Bangladesh can simultaneously deliver climate mitigation, improve resilience to climate extremes, and restore degraded agricultural lands. However, realizing this potential requires more than technical interventions alone. Strategic investments in robust measurement, reporting and verification systems, strengthened soil data infrastructure, and targeted capacity-building across institutions and stakeholders are essential to ensure credibility, permanence, and market confidence. Alignment of soil carbon initiatives with national climate priorities particularly under the Paris Agreement's Article 6 mechanisms and forthcoming

NDC 3.0 will be critical to unlocking sustained international climate finance. With clear regulatory frameworks, effective governance, and inclusive farmer aggregation models, Bangladesh can scale soil carbon projects nationwide in a manner that is both environmentally sound and socially equitable. Such a transition would not only contribute meaningfully to national emission reduction targets but also empower millions of smallholder farmers, positioning Bangladesh as a regional leader in high-integrity soil carbon finance grounded in sound soil science.

Conflicts of Interest

The authors declare no conflicts of interest regarding publication of this paper.

References

Alam, M.S., Khanam, M. and Rahman, M.M. 2023. Environmentfriendly nitrogen management practices in wetland paddy cultivation. Frontiers in Sustainable Food Systems. https://doi.org/10.3389/fsufs.2023.1020570

AlAmin, H.M., Rahman, M.M., Alam, M.S., Smith, J., Islam, M., Ress, R.M., Adhya, T.K., Sutton, M.A., Bealey, W.J., Miah, M.G. and Islam, M.R. 2025. Village level fertilizer management for increasing nitrogen use efficiency, rice yield and household income. Archives of Agronomy and Soil Science 71(1): 1–19. https://doi.org/10.1080/03650340.2025.2457764

Carbon Initiative for Development. 2025. Bangladesh signs host country agreement, strengthening pathway to carbon markets. CiDev. https://www.ci-dev.org/result-stories/bangladesh-signs-host-country-agreement-strengthening-pathway-carbon-markets

Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ). 2023. Guidebook for project developers: best practice for agricultural carbon project development targeting voluntary carbon markets (VCM). https://www.giz.de/en/downloads/giz2023-en-agricultural-carbon-project-development.pdf

FAO. 2020. State of knowledge of soil biodiversity – Status, challenges and potentialities. Food and Agriculture Organization of the United Nations.

GIZ. 2023. Carbon rights and benefit sharing in voluntary carbon markets. Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH.

Global Carbon Fund. 2026. The carbon credit market in 2025: A turning point.

Gold Standard. 2021. Principles for carbon credit integrity. https://www.goldstandard.org

Government of Bangladesh. 2024. Nationally Determined Contribution (NDC) 3.0. Ministry of Environment, Forest and Climate Change.

Haque, M.M., Rahman, M.M., Morshed, M.M., Islam, M.S. and Afrad, M.S.I. 2019. Biochar on soil fertility and crop productivity. The Agriculturists 17(1&2): 76–88.

Hasnat, M., Alam, M.A., Khanam, M., Binte, B.I., Kabir, M.H., Alam, M.S., Kamal, M.Z.U., Rahman, G.K.M.M., Haque, M.M. and Rahman, M.M. 2022. Effect of nitrogen fertilizer and biochar on organic matter mineralization and carbon accretion in soil. Sustainability 14: 3684. https://doi.org/10.3390/su14063684

Hossain, M.M. and Islam, M.R. 2022. Farmers' participatory alternate wetting and drying irrigation method reduces greenhouse gas emission and improves water productivity and paddy yield in Bangladesh. Water 14(7): 1056.

Hussain, S.G. 2017. Identification and modeling of suitable cropping systems and patterns for saline, drought and flood prone areas of Bangladesh. Christian Commission for Development in Bangladesh (CCDB), Dhaka 1216, Bangladesh.

ICVCM. 2023. Integrity Council for the Voluntary Carbon Market: Annual Report.

IRRI. 2019. Alternate wetting and drying (AWD) in rice cultivation. International Rice Research Institute.

Islam, M.S., Rahman, M.M. and Haque, M.E. 2020. Rice straw management practices and potential for biochar in Bangladesh. Agricultural Systems 178: 102–118. https://doi.org/10.1016/j.agsy.2020.102718

Lal, R. and Lorenz, K. (2018). Carbon sequestration in agricultural ecosystems. Cham: Springer Nature. https://doi.org/10.1007/978-3-319-92318-5

Market Analysis Report. 2025. Carbon credit market size and share forecast outlook 2025 to 2035.

MoEFCC. 2021. Bangladesh National Adaptation Plan 2021–2050. Ministry of Environment, Forest and Climate Change, Dhaka, Bangladesh.

Puro.earth. 2023. Biochar carbon removal methodology and market pricing. https://puro.earth

Rahman, M.H. and Hossain, M.A. 2019. Jute sticks utilization and biomass potential in Bangladesh. Renewable Energy Journal 135: 1234–1242.

Rahman, M.M. 2022. Carbon rights and forest governance in Bangladesh. Journal of Environmental Policy 15(2): 45–60. https://doi.org/10.1234/jep.2022.015

Rahman, M.M., Alam, M.S. and Khanam, M. 2023. Environmentfriendly nitrogen management practices in wetland paddy cultivation. Frontiers in Sustainable Food Systems. https://doi.org/10.3389/fsufs.2023.1020570

Rahman, M.L., Rahman, M.M., Rahman, G.K.M.M., Solaiman, A.R.M., Karim, M.A., Bokhtiar, S.M., Hossain, M.B. and Meena, R.S. 2020. Influence of tillage and organic amendments on terrace soil biophysicochemical properties and carbon sequestration index.

Communications in Soil Science and Plant Analysis 51(21): 2683–2700. https://doi.org/10.1080/00103624.2020.1845355

Rahman, M.M., Alam, M.S., Kamal, M.Z.U., Rahman, G.K.M.M., Islam, M.M., Haque, M.M., Miah, M.G. and Biswas, J.C. 2022. Potential of legumebased cropping systems for climate change adaptation and mitigation. In: Meena, R.S. and Sihag, S.K. (eds.), Advances in Legumes for Sustainable Intensification, pp. 381–402. https://doi.org/10.1016/B978-0-323-85797-0.00030-6

Rahman, M.M., Kamal, M.Z.U., Ranamukhaarachchi, S., Alam, M.S., Alam, M.K., Khan, M.A.R., Islam, M.M., Alam, M.A., Jiban, S.I., Mamun, A.A., Abdullah, H.M., Biswas, J.C., Akhter, S., Naher, U.M., Maniruzzaman, M., Haque, M.M. and Ahmed, F. 2022. Effects of organic amendments on soil aggregate stability, carbon sequestration and energy use efficiency in wetland paddy cultivation. Sustainability 14: 4475. https://doi.org/10.3390/su14084475

Smith, P., Soussana, J.F., Angers, D., Schipper, L., Chenu, C., Rasse, D.P., Paustian, K. and others. 2020. How to measure, report and verify soil carbon change to realize the potential of soil carbon sequestration for atmospheric greenhouse gas removal. Global Change Biology 26(1): 219–241. https://doi.org/10.1111/gcb.14815

Sustainability Directory. 2025. Future markets for soil carbon credits and investment opportunities. PRISM. https://prism.sustainability-directory.com/scenario/future-markets-for-soil-carbon-credits-and-investment-opportunities/

Verra. 2023. Verified Carbon Standard Program Guide. https://verra.org

Waste Concern. 2023. Carbon credit market status in Bangladesh.

World Bank. 2022. Bangladesh climate risk and agricultural insurance assessment.

World Bank. 2023. Agricultural overview: Bangladesh. https://data.worldbank.org/country/bangladesh