Volume 3, Issue 7
July I 2025
Agri Roots
e- Magazine
www.agrirootsmagazine.in
ISSN: 2583-9071

Carbon Farming: A Sustainable Strategy for Climate Resilience

ARTICLE ID: 0221

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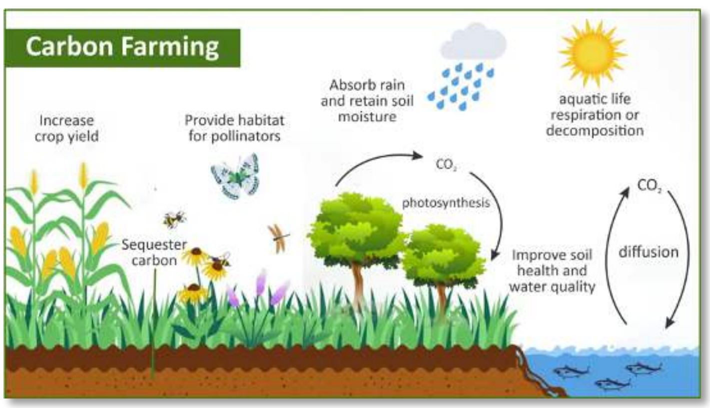
As climate change accelerates, agriculture is both a contributor to greenhouse gas (GHG) emissions and a potential solution. "Carbon farming" is emerging as a promising practice that incentivizes farmers to adopt land management strategies aimed at sequestering atmospheric carbon in soil and vegetation. This article explores the concept, techniques, policy implications, and socio-economic challenges of carbon farming, with a specific lens on India's agricultural landscape. Drawing from global literature and national case studies, it evaluates the feasibility and limitations of transforming farmers into frontline climate warriors through climate-smart practices that also generate income from carbon credits. The article emphasizes the need for robust policy support, capacity building, and digital monitoring tools to make carbon farming scalable, measurable, and equitable.



1. Introduction

The relationship between agriculture and climate change is deeply intertwined and multi-dimensional. On one hand, agriculture is a major contributor to greenhouse gas (GHG) emissions through methane released by livestock and flooded rice paddies, and nitrous oxide emissions resulting from synthetic fertilizers. These emissions make up a significant portion of India's and the world's carbon footprint. On the other hand, farming also presents a unique opportunity often overlooked to combat climate change by turning soils and plants into carbon sinks. This ability to draw carbon dioxide (CO_2) out of the atmosphere and store it in soils and biomass is known as carbon sequestration, a process central to the emerging practice of carbon farming. Carbon farming is increasingly recognized as a nature-based solution that offers dual benefits: it helps mitigate climate change while also enhancing soil fertility, water retention, and long-term agricultural sustainability. Lal (2020) emphasizes that improving soil organic carbon through sustainable land practices could offset a significant share of global emissions. By adopting practices such as cover cropping, agroforestry, reduced tillage, and organic amendments, farmers can improve soil health while locking away atmospheric carbon. Paustian *et al.* (2016) argue that with proper support, agricultural soils could serve as an effective, low-cost strategy for carbon removal.

2. What is Carbon Farming?

Carbon farming refers to a suite of agricultural techniques that increase the storage of carbon in soil organic matter and biomass (trees, crops, roots). The primary goal is to turn farmland into a carbon sink instead of a carbon source. Key Practices in Carbon Farming includes:

- Agroforestry: Integrating trees and shrubs into croplands or pastures.
- Cover cropping and crop rotation: Enhancing soil carbon by keeping land covered year-round.
- Reduced or no-till farming: Minimizing soil disturbance to protect organic carbon.
- Biochar application: Adding charcoal-like material to soil to stabilize carbon.
- Organic composting and residue retention: Recycling organic waste to boost soil carbon.
- Improved livestock grazing management: Controlling grazing to improve pasture health.

These practices are not only beneficial for the environment but also improve soil fertility, water retention, and crop yields making them economically attractive in the long run.

3. Scientific Basis and Carbon Sequestration Potential

According to Lal (2004), soil can sequester up to 0.4–1.2 giga-tonnes of carbon annually if sustainable land practices are adopted worldwide. The IPCC's 2019 Special Report on Climate Change and Land also identified soil carbon sequestration as a highly cost-effective mitigation measure. India has around 157 million hectares of arable land and immense potential for restoring degraded soils. A study by Venkatesh *et al.* (2018) found that practices like residue retention and organic inputs could raise soil organic carbon (SOC) stocks by 0.1–0.3 Mg/ha/year. Even a small increase in SOC across India's farmland could lock away millions of tonnes of CO_2 annually. However, measuring carbon sequestration accurately remains a challenge, especially for smallholder farms with diverse cropping patterns.

4. Carbon Credits and the Economics of Carbon Farming

4.1 What are Carbon Credits?

A carbon credit represents 1 tonne of CO_2-equivalent that has been removed from the atmosphere or not emitted. Farmers who implement verified carbon farming practices can earn these credits and sell them on carbon markets.

4.2 Voluntary Carbon Markets (VCMs)

Unlike regulated markets (like the EU Emissions Trading System), VCMs allow private buyers to offset their emissions by purchasing credits from projects such as afforestation, soil management, or renewable energy. Prices vary widely from \$5 to \$50 per tonne depending on the methodology and co-benefits.

4.3 Revenue Potential for Farmers

Projects in countries like Kenya and Australia have demonstrated successful models like Australia's Emissions Reduction Fund (ERF) provides payments for carbon farming activities. In Kenya, smallholder farmers under the "Soil Carbon Project" earned \$27/ha over 5 years from carbon credits (FAO, 2020). For India, if scaled and verified properly, carbon farming could offer additional income streams, especially for marginal farmers in rain-fed or degraded zones.

5. Indian Initiatives and Case Studies

5.1 National Mission for Sustainable Agriculture (NMSA)

Launched as part of India's broader climate strategy under the National Action Plan on Climate Change (NAPCC), the National Mission for Sustainable Agriculture (NMSA) has been instrumental in encouraging climate-resilient farming. It emphasizes practices like agroforestry, rainwater harvesting, integrated nutrient management, and the distribution of soil health cards to help farmers better understand and improve their soil fertility. These efforts not only promote productivity but also align closely with carbon farming principles by improving soil carbon storage and reducing emissions. In essence, NMSA serves as a government-backed platform that subtly embeds carbon sequestration into everyday agricultural practices.

5.2 Indian Institute of Soil Science (IISS), Bhopal

The Indian Institute of Soil Science (IISS), based in Bhopal, plays a crucial role in making carbon farming scientifically viable in India. It has created standardized protocols for measuring carbon stocks across different agro-ecological zones in the country. These protocols provide reliable methods for assessing how much carbon is stored in soils under different crops and management systems—an essential step for enabling farmers to earn verified carbon credits. By anchoring scientific research in real-world farm conditions, IISS bridges the gap between agricultural sustainability and climate finance.

5.3 DeHaat and E-Carbon Platforms

Startups like DeHaat and tech platforms like E-Carbon are bringing innovation and digital solutions to the frontlines of Indian agriculture. DeHaat, a fast-growing agri-tech company, is piloting ways to link smallholder farmers with carbon markets through mobile-based services, advisory tools, and input delivery systems. Similarly, E-Carbon is leveraging blockchain technology to ensure transparency and traceability in carbon credit generation. These platforms simplify the process of farmer registration, monitor climate-smart practices through remote sensing, and aim to help farmers—especially smallholders—earn income from carbon sequestration activities without being bogged down by complex paperwork or bureaucracy.

5.4 Organic Farming Model, Sikkim

Sikkim's journey to becoming India's first 100% organic state is a powerful example of how eco-friendly policies can transform agriculture and contribute to climate goals. By eliminating synthetic inputs and encouraging composting, crop rotation, and biodiversity, Sikkim has significantly improved its soil health and boosted soil organic carbon levels. The state's farming model proves that organic agriculture is not just about health and food quality—it can also be a major contributor to carbon sequestration and emission reduction. Sikkim's success offers both a practical and inspirational blueprint for other states considering climate-smart farming transitions.

6. Challenges in Implementing Carbon Farming in India

Despite its potential, carbon farming in India faces several critical challenges. Measurement, Reporting, and Verification (MRV) of carbon sequestration require scientific tools, satellite data, or soil sampling methods that are often too costly and complex for smallholder farmers. Additionally, the country's highly fragmented landholdings and unclear land tenure systems hinder the implementation of uniform carbon farming practices and aggregation of carbon credits. A major barrier is the widespread lack of awareness and technical knowledge among farmers, highlighting the urgent need to strengthen agricultural extension systems. Equity concerns also arise, as without inclusive policies, only large or well-connected farmers may benefit from carbon markets, leaving smallholders behind. Furthermore, voluntary carbon markets are prone to volatility and credibility issues, with growing worries about corporate greenwashing and the lack of transparency in some crediting mechanisms.

7. Policy Support and Future Directions

To make carbon farming viable in India, a multi-pronged approach is essential. First, providing targeted incentives and subsidies such as through existing schemes like PM-KUSUM and Rashtriya Krishi Vikas Yojana (RKVY) or a dedicated carbon credit initiative can encourage adoption of low-emission agricultural practices. Second, deploying digital MRV (Measurement, Reporting, and Verification) systems using mobile apps and satellite-based tools will help reduce the cost and complexity of tracking carbon sequestration. Third, promoting farmer aggregation models through Farmer Producer Organizations (FPOs) and cooperatives can enable smallholders to pool resources and carbon credits, lowering transaction costs and enhancing market access. Fourth, fostering public-private partnerships (PPPs) with agri-tech companies and NGOs will be key for scaling up capacity building and developing robust carbon trading platforms. Lastly, implementing carbon literacy programs to educate farmers and extension workers on climate-smart practices, carbon markets, and sustainable land management is critical to ensure inclusive and long-term participation in carbon farming.

8. Conclusion

Carbon farming presents a rare convergence of environmental necessity and economic opportunity. By transforming farms into carbon sinks, we can address climate change while improving livelihoods especially in rural India. However, this transition needs robust institutional frameworks, digital infrastructure, and inclusive financial models. The road ahead requires scientific rigor, social equity, and political will. If done right, farmers could indeed become the frontline climate warriors rewarded not just for what they grow, but for the carbon they store beneath their feet.

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