

# From Field to Credit: The Role of Farmers in the Indian Carbon Economy

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## ABSTRACT

As India faces dual challenges of climate risks and agricultural sustainability, Voluntary Carbon Markets (VCMs) become crucial for engaging farmers in climate solutions. However, the carbon economy raises serious concerns over equity, autonomy, and farmers' roles in this nascent market. This paper investigates their roles by analyzing current carbon farming projects in India.

The findings reveal the market's dichotomy, with small footprints alongside mega-projects with revolutionary targets. The research identified two farmer-led pathways: high-intensity land use transformation and low-intensity soil health management. The study concludes that agricultural carbon markets should be climate-resilient and equitable, with policy reframed to integrate carbon revenue with co-benefits, advancing rural empowerment.

**Keywords:** Carbon Economy, Carbon Farming, Climate-Smart Agriculture, Farmers, Voluntary Carbon Market

## INTRODUCTION

India's agricultural sector is crucial for its economy, with 56.4% of the workforce, incorporating 18.6% of Gross Value Added (GVA) (DAFW, 2024). According to Land Use Statistics (2022-23), over 58% (179982000 hectares) of India's area is used for agriculture (ESED & DAFW, 2024). India is the largest producer of milk and pulses and the second-largest of rice, wheat, etc. However, population growth, natural resource depletion, and decreasing farm income risk Indian agriculture with area reduction from 66.70% (1950-51) to 58.69% (2022-23) (ESED & DAFW, 2024; Gopinath et al., 2025). The IPCC's Sixth Assessment Report warns that global warming is expected to exceed 1.5-2°C if emissions are not reduced (Gopinath et al., 2025).

The agricultural sector both emits and sequesters carbon (Gopinath et al., 2025), contributes through CO<sub>2</sub>, methane (CH<sub>4</sub>), and nitrous oxide (N<sub>2</sub>O) (IPCC, 2001). The sector aims for sequestration by adopting eco-friendly practices, like agroforestry and crop diversification (Gopinath et al., 2025).

VCMs in India are expected to generate carbon credits worth USD 480 billion in 2030-70 (DAFW, 2024). VCMs in agriculture align with India's Paris Agreement commitment to sequester 2.5-3 billion tonnes CO<sub>2</sub>e through forest cover by 2030. Soil organic carbon (SOC) is vital for healthy soil, but is lower in rainfed soils (< 5g/kg) than the optimal (11g/kg). Therefore, VCMs can generate demand from SOC sequestration through incentives for climate-smart practices (Gopinath et al., 2025).

The Indian Government has encouraged sustainable agricultural practices, moving beyond "yield per hectare" to increase income while promoting social equity and environmental management through VCM and Green Credit Program (GCP). Sustainable agriculture supports Mission LiFE (Lifestyle for Environment), encouraging carbon markets for financial stability, farmer income, and agroecological benefits (DAFW, 2024).

This study investigates Indian farmers' roles in the emerging carbon market. While carbon trading policies have flourished, a gap remains in translating frameworks into incentives, barriers, and agency for farmers. This research employs secondary data analysis to evaluate farmers' contribution to sequestration and emissions reduction. It examines the socioeconomic obstacles to participation and fair benefit distribution, positing farmers as active, indispensable stakeholders in India's low-carbon transition.

## LITERATURE REVIEW

This thematic review synthesizes existing literature by identifying, organizing, and evaluating patterns (Synder, 2019). This approach is crucial to understand intersecting technical, economic, social, and policy elements and categorize themes, thus constructing patterns and research gaps.

### The Scientific Context: Agricultural Emissions and Mitigation Potential

The FAO notes that agriculture accounts for 18% of global emissions, while 14% in India, majorly from enteric fermentation (53%), rice cultivation (17.4%), and fertilizers (21%) (Gopinath et al., 2025). According to the MoEFCC (2024), approximately 92Mt of crop residue are burned annually in India. Sustainable agricultural practices aim to enhance rural livelihoods and generate carbon credits (TERI, 2023; Khurana et al., 2024).

India, the second-largest producer of rice, emits substantial CH<sub>4</sub> and N<sub>2</sub>O, as over 80% of paddy fields are flooded, releasing methane, leading to degradation (Sejian et al., 2011; DAFW, 2024). Rice production technologies, like direct-seeding, crop diversification, etc., intend to generate credits (Sejian et al., 2011; DAFW, 2024).

VCMs encourage practices (agroforestry, micro-irrigation, etc.), enhancing soil health while reducing emissions and generating income (TERI, 2023; Khurana et al., 2024). A NICRA study showed shifting to direct-seeded rice improved farmers' earnings by 15.36% (Gautam et al., 2019; DAFW, 2024).

Micro-irrigation minimizes climate effects on agriculture, as ICAR noted, from 13.78 million ha under micro-irrigation, 10.90 million tCO<sub>2e</sub> was reduced. Agroforestry and dryland horticulture comprise 50% of the country's cultivated land, promoting livelihood, ecological security, and emission reduction (DAFW, 2024).

Adopting sustainable practices also safeguards traditional farming, indigenous seeds, and develops socioenvironmental resilience. It encourages social equity, enhancing smallholder farmers' access to resources (Gupta et al., 2021).

### The Economic Structure: International and National Carbon Markets

Two types of carbon markets include the compliance market and VCMs. Most Indian VCM projects are registered in global registries like Verra and Gold Standard (DAFW, 2024). The Verra lists over 140 Indian agricultural projects generating 27 million carbon credits (estimated annual reduction 27Mt CO<sub>2e</sub>) valued at INR 2200 crores, with 60% assumed for farmers (Cariappa, 2023; Gopinath et al., 2025). Indian VCMs rose to USD 1 billion in 2021 and are projected at USD 50 billion by 2030. VCM credits are often costlier due to co-benefits like biodiversity from USD 5/tCO<sub>2e</sub> (agriculture) to USD 25/tCO<sub>2e</sub> (clean cooking), offering income for smallholder farmers (Singh, 2022; Khurana et al., 2024).

Carbon markets are required for net-zero targets, worth USD 30-50 billion by 2050 through agriculture and land restoration. For instance, smallholder farmers can earn USD 7-20 per year per acre from credits (Gopinath et al., 2025; Singh, 2022).

### The Indian Policy Framework

The ICAR launched NICRA in 2011 to encourage climate-adaptive technologies, introducing about 2900 plant varieties (PIB, 2025). The National Mission for Sustainable Agriculture (2014-15) under the National Action

Plan on Climate Change (NAPCC) encompasses sustainable agriculture schemes, including waste management, and climate-resilient crops (PIB, 2025; DAFW, 2024).

The Energy Conservation (Amendment) Act 2022 established the Indian Carbon Market (ICM) and Carbon Credit Trading Scheme (CCTS) (Malhotra & Aggarwal, 2022), which aims to transform VCMs into a compliance-based system by 2026 (BEE, 2024).

At COP28 (2023), India launched the Green Credit (GC) Rules under the LIFE, involving GCs as environmental rewards for positive actions such as tree plantation, sustainable agriculture, etc., which is distinct from the CCTS credits (Gopinath et al., 2025).

MoAF&W initiated several carbon-related projects, including a Verra-registered project in Beed (Gujarat), aimed at issuing 675,280 Certified Emission Reductions (CERs) through sequestration. The Ministry frames VCMs in agriculture, recognizing its potential (Sishodia et al., 2024).

### **Farmer-centric Perspectives: Motivations, Challenges, and Obstacles**

Rewarding carbon programs higher than implementation costs is crucial to attract farmers (Gopinath et al., 2025). Farmers' reluctance should be acknowledged, as sequestration focuses on soil carbon, neglecting co-benefits (Phelan et al., 2024; Amin et al., 2023).

Farmers adopt practices realizing that sequestration reverses soil degradation. It also provides co-benefits like improved food and biodiversity. Nevertheless, they are not motivated to adopt soil health practices (Phelan et al., 2023). In contrast, Dumbrell et al. (2016) reinforce that farmers are motivated by co-benefits over financial advantages. This emphasizes focusing on socio-economic and environmental integration to adopt practices.

Distinguishing between barriers to adopting practices and participating in carbon markets is important to understand farmers' disengagement (Phelan et al., 2023). Their engagement is undermined by complex methodologies and price uncertainty. Farmers are high-risk actors due to monitoring, reporting, and verification (MRV) challenges, requiring education and training (Gopinath et al., 2025; Phelan et al., 2023).

The URVARA Project by Boomitra, India's first soil carbon removal project, tackles degradation and climate risks through carbon finance. It involves 6,000 farmers across 25,000 acres, merging socioenvironmental co-benefits through reduced tillage and crop residue reincorporation. It incorporates satellite and AI-based MRV to reduce costs and enable even one-acre participation. The project generated 47,311 credits in its first issuance and expects 315,735 in over 20 years. As of 2025, farmers earn INR 10,218/month on average from credits (Boomitra, 2025).

Indian farmers have irregular access to carbon markets, as only 12% of projects incorporate smallholders due to tenure insecurity and improper aggregation mechanisms. VCMs provide direct income (INR 780-2,000/credit) with indirect benefits, but involvement remains limited to organized farmer groups. Low credit prices (USD 16-30/ha) in Punjab and Bihar undermine project permanence (Cariappa et al., 2024; Gopinath et al., 2025). Haryana and Madhya Pradesh surveys reveal that marginalized farmers account for only 5% of the land within carbon projects versus 17% among non-carbon farmers with larger landholdings (Sirur, 2024).

Engaging smallholder farmers (86% of India's agricultural workforce) is challenging due to high transaction costs, limited awareness, and inequitable resource access, making FPOs and NGOs pivotal in forming collective groups to decrease costs and encourage participation (Boomitra, 2025).

Upfront participation costs, price ambiguity, and non-payment risks pose risks for farmers, aggravated by fragmented land holdings. An individual farmer's transaction cost outweighs the potential advantages; thus, aggregation becomes essential to structure the farmer's autonomy within the market (Gopinath et al., 2025).

The carbon market's principles, including additionality and permanence, also hinder participation, penalizing

innovative farmers who historically manage farm sustainability and compelling them into long-term contracts that restrict their agility to accommodate climatic conditions (Gopinath et al., 2025).

## GAPS

Few studies focus on farmers' lived experiences and the process of incentivization to promote them and contribute to the carbon market (Amin et al., 2023).

The literature provides a foundation for understanding the agricultural carbon economy's perspective and challenges; several gaps exist that this study aims to address. Longitudinal socioeconomic impact studies are absent. The proponent models are recognized, but a critical comparison of their structures and benefit-sharing standards is missing. A divide prevails between the high-level policy and grassroots reality; thus, this research examines the integration of national agricultural schemes with VCM projects on the ground. This research aims to fill these gaps through a bottom-up analysis of existing projects, investigating their scale, carbon efficiency, and farmers' roles.

## RESEARCH METHODOLOGY

### Rationale

VCMs are a mitigation strategy for climate-smart agriculture, but top-down discourses often neglect farmers' realities. While literature entails potential, a gap remains in the empirical and comparative analysis of carbon farming initiatives. This research addresses this through evidence-based evaluation of such projects to critically evaluate how VCMs frame the farmers' role in the carbon economy.

### Research Questions

The study addresses one primary question and two subsequent questions:

1. How do diverse VCM projects in Indian agriculture shape the role of farmers?
  - 1.1. What are the key attributes of current carbon farming projects?
  - 1.2. How do different proponents engage farmers, and contribute to risks and rewards with climate-smart agricultural practices?

### Research Objectives

1. To delineate the current Indian carbon farming projects by scale and carbon intensity, and identify key patterns.
2. To compare different project models, evaluating their governance and significance for farmer participation.
3. To evaluate the key socioeconomic potentials, barriers, and risks associated with farmers' engagement.

### Research Design

The study employs secondary research to synthesize and evaluate the farmers' role in the Indian carbon economy, emphasizing participation and co-benefits. It employs a sequential explanatory mixed-methods design with initial quantitative analysis, followed by a qualitative phase to elaborate on the findings (Creswell & Plano, 2017).

### Data Collection

Purposive sampling was used to select a representative sample of literature and carbon farming projects, proponents, climate-smart, and registration statuses.

The dataset was compiled from authoritative sources from 2012-2025, sourced from:

1. **Government Reports:** “Framework for Voluntary Carbon Market in Indian Agriculture” (DAFW, 2024) and “Voluntary Carbon Market in Indian Agriculture: Status, Challenges and Way Forward” (Gopinath et al., 2025). Datasets were created for Practice-level (Table 1) and Project-level (Table 2).
2. **VCM Registries:** The Verra database for registration information.
3. **Peer-reviewed literature:** Academic articles to collect case study data.

### Limitations

The research includes a comprehensive secondary analysis of the farmers’ roles; its findings should be contemplated under several inherent limitations.

The study is based on publicly available secondary data; its viability depends on the original sources’ precision. Reporting bias cannot be eliminated. The dataset is representative but limited by insufficient data (unavailability of the CZAFI project area), preventing a comprehensive quantitative analysis. Similarly, the case studies were analyzed with incomplete farmers’ perspectives.

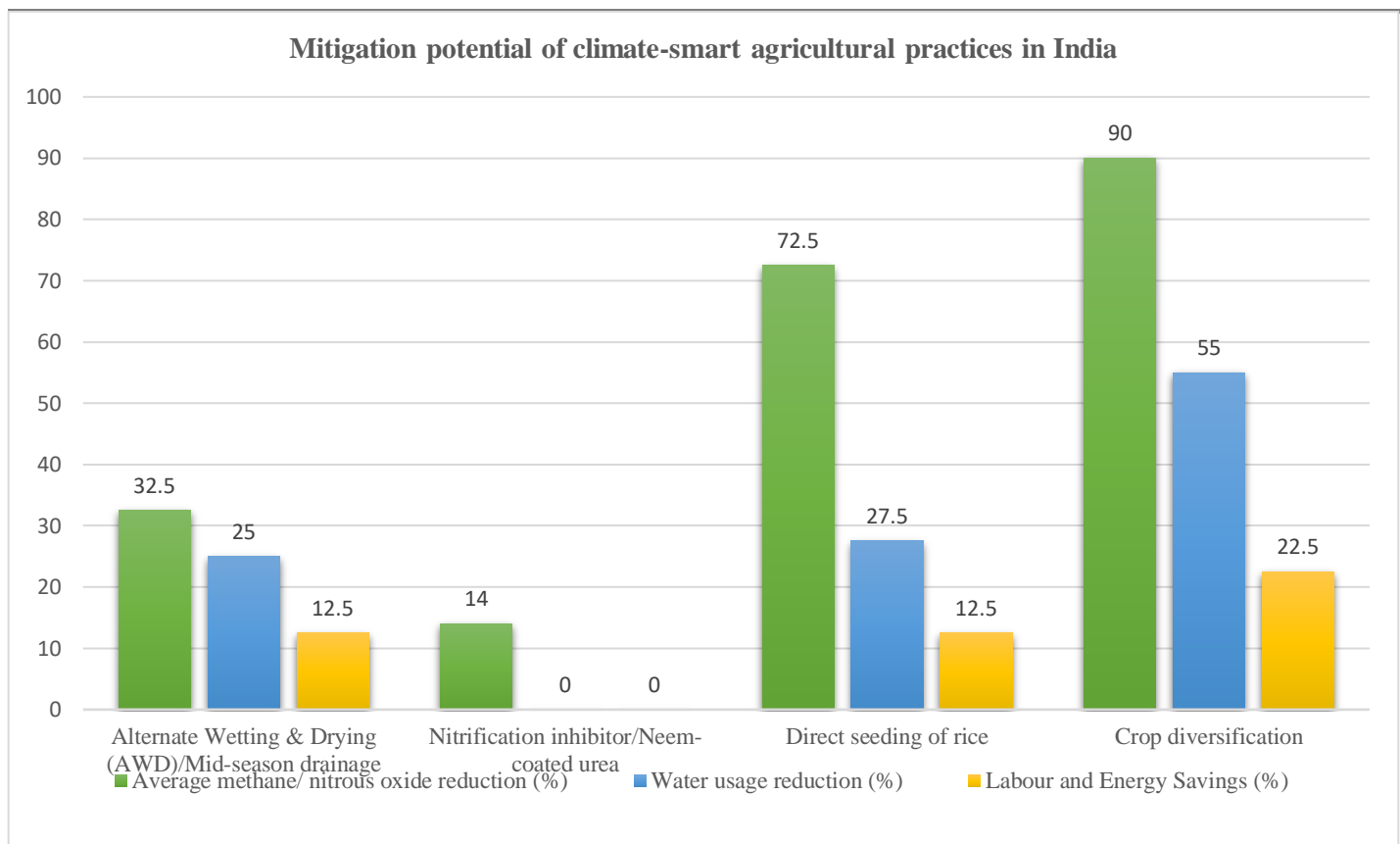
The cross-sectional analysis presents the carbon market at a specific moment but fails to reproduce longitudinal impacts, long-term socioeconomic effects, farmer disengagement rates, etc. This study evaluates farmers’ roles based on existing data, failing to incorporate their lived realities.

### Data Collection

**Table 1: Composite Score Analysis of Climate-smart Agricultural Practices in India (DAFW, 2024)**

Practices	Average methane/nitrous oxide reduction (%)	Water usage reduction (%)	Labour and Energy Savings (%)	Composite score	Rank
Crop diversification	90	55	22.5	0.558	1
Direct seeding of rice	72.5	27.5	12.5	0.375	2
AWD/Mid-season drainage	32.5	25	12.5	0.233	3
Nitrification inhibitor	≈11 (methane) and 17 (N <sub>2</sub> O), i.e., Avg 14	0.0*	0.0*	0.047	4

Note: Unavailable data = zero.



**Table 2: Project Area (%) & Carbon Intensity of Carbon Farming Projects in India (Gopinath et al., 2025; Verra, 2025; ESED & DAFW, 2024)**

Projects	Proponent(s)	Location	Registration status	Duration	Annual estimated emissions reduction (tCO <sub>2</sub> e)	State Sown Area (NSA) (ha, 2022-23)	Net Area (000 ha)	Total Project Area (ha)	Project Area %	Carbon Intensity (tCO <sub>2</sub> e/ha)	Rank (as per Carbon Intensity)
Horticulture plantation in Central India	AadharStambh Consultancy Services Pvt. Ltd.	Madhya Pradesh	Under validation	2021-2041	115000	15848	1000	0.00631	115	1	
Community-based reforestation	Indian Farm Forestry Cooperative Ltd.	Uttar Pradesh	Registered	2008-2038	5651	16121	189	0.00117	29.9	2	
Aaraku Valley livelihood project	Livelihoods Fund SICAV SIF France	Andhra Pradesh	Registered	2010-2030	80660	5725	6002	0.1048	13.44	3	
Agricultural land management	Godrej Properties Ltd.	Maharashtra	Registered	2017-2037	33764	16491	3275	0.01986	10.31	4	
GHG emission reduction through intermittent flooding in ricefields	Landmark Agri-Exports Private Limited	Madhya Pradesh	Under validation	2020-2027	58722	15848	8085	0.51	7.26	5	

Transformational Regenerative Integrated Biodiverse Agriculture for Livelihoods (TRIBAL)	Archipel India Foundation	Telangana	Under validation	2023-2043	219473	5897	33000	0.56	6.65	6
Improved agricultural practices for rice cultivation India	Kosher Climate India Pvt. Ltd.	Assam, West Bengal	Withdrawn	2023-2043	217728 expected (83599)	AS: 2744; WB: 5216	13169	0.165 -0.480*	-6.35	7
Incentivizing smallholder farmers to transition to low-emissions agriculture and agroforestry	Climeverse Private Limited	Central Plateau, Southern Plateau, East Coast Plains region of India	Underdevelopment	2022-2032	463650	AP: 5725; KA: 11161; MP: 15848; MH: 16491; OD: 4269; TN: 4838; TG: 5897	133603	0.21 -3.13*	-3.47	8
Enhancing livelihoods of farmers in Gujarat through agroforestry	Shri Hari BhujalVikash Mandal (SHBVM)	Gujarat	Under validation	2020-2050	6465	9748	1977	0.02028	3.27	9
Maharashtra and Gujarat initiative for regenerative agriculture and income creation	GrowIndigo Private Ltd	Maharashtra, Gujarat	Under development	2020-2040	4861245	MH: 16491; GJ: 9748	300000	11.433 -30.776*	-1.62	10
Promoting regenerative agriculture and growth through income generation	Grow Indigo Pvt. Ltd.	Andhra Pradesh, Chhattisgarh, Karnataka, Odisha, Telangana	Under development	2020-2040	5326066	AP: 5725; CG: 4592; KA: 11161; OD: 4269; TG: 5897	400000	12.6 -93.7*	-1.33	11
Mahogany Plantation in India	Mahogani Vishwa Agro Pvt Ltd.	Maharashtra, Madhya Pradesh, Karnataka, Gujarat, Telangana	Registered	2019-2049	8446	MH: 16491; MP: 15848; KA: 11161; GJ: 9748; TG: 5897	15000	0.025 -0.254*	-0.56	12
Afforestation, Reforestation, and Revegetation (ARR)	Crop Zone Agro Forestry Limited (CZAFL)	Andhra Pradesh, Telangana, Karnataka, Maharashtra	Registered	2017-2036	10673	AP: 5725; TG: 5897; KA: 11161; MH: 16491	NA	NA	NA	13

### Case Study 1: Bagepalli Afforestation Case Study

The Bagepalli CDM Reforestation Program (06/05/2013- 06/05/2023), a certified Gold Standard project, in Chikkaballapur, Karnataka, covers approximately 8,933 hectares across five taluks and focuses on profoundly degraded lands owned by marginalized “Coolie” farmers.

This project incorporates local fruit and fodder species plantations on barren lands to restore fertility, improve productivity, and sequester carbon through CERs. Over 91,092 CERs were issued, with approximately 96% of INR 6.18 crores (INR 5.93 crores) distributed to farmers in 2019 and INR 4.4 crores to 1,024 farmer families in 2021.

Through participatory approaches, it enables farmers to choose species appropriate for their areas and adopt climate-smart techniques, which increase saplings’ survival rates by approximately 40%. These responsive strategies, integrated with shared carbon revenue, substantially improved land use while promoting livelihood provisions for marginalized communities.

### Case Study 2: Nandurbar Socio-Agroforestry Case Study

The Nandurbar socio-agroforestry project in Maharashtra is an intervention in sustainable land management to improve climate conditions and community livelihoods. Nandurbar, a tribal-dominant and socio-economically marginalized area with severe weather conditions, incorporates land management under Verra with an estimated generation of 234,000 CERs over a two-decade crediting period. It includes tree plantation and cover crops across 90,000 hectares to mitigate irregular rainfall, soil degradation, and low yields, while accounting for SDGs 2, 12, 13, and 15.

Baseline assessments incorporated drone technology for detailed mapping and monitoring, as 2,000 hectares were evaluated to develop a benchmark for future comparison. Further, IoT-enabled flow meters monitored water utilization and contributed to robust evaluation in a region with water scarcity and unpredictable supply.

### Data Analysis

#### The Quantitative Analysis of the Indian Agricultural Voluntary Carbon Market

This section demonstrates key quantitative findings from the data analysis:

#### Analysis of Mitigation Potential of Agricultural Practices in India (TABLE 1)

A composite scoring (CS) methodology for Table 1 integrates three performance dimensions: GHG emission reduction (%), water usage reduction (%), and labour and energy savings (%), into single value for holistic evaluation.

$$CS_i = \sum_{j=1}^3 w_j \times \frac{M_{ij}}{100}$$

This analysis demonstrates notable variations across these climate-smart agricultural practices, with composite scores ranging from 0.047 to 0.558.

**High-Impact (>0.35):** Crop diversification (0.558) and direct seeding (0.375), the highest-performing interventions with remarkable benefits across all three dimensions.

**Moderate-Impact (0.15-0.35):** AWD (0.233), moderate with major impact in GHG emission reduction.

**Specialized (<0.15):** Nitrification inhibitors (0.047), focused emission benefits but restricted resource efficiency incentives.

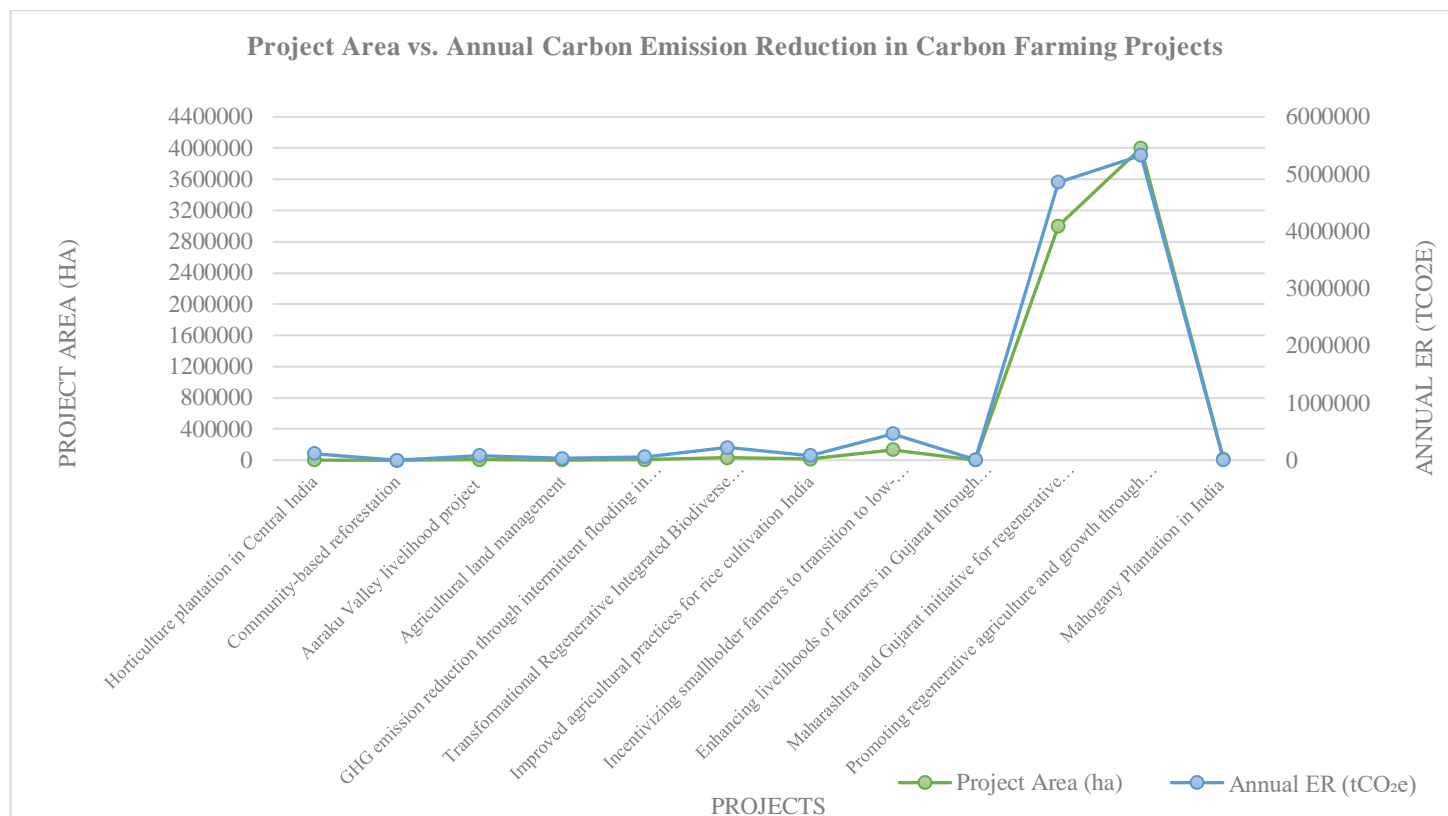
**Analysis of Carbon Farming Projects in India (Table 2)**

For Table 2, two metrics were assessed: Project Area as a percentage of NSA to estimate the penetration scale, and Carbon Intensity to quantify the potency of the project’s emission reduction per hectare.

$$\text{Project Area \% NAS} = \left( \frac{\text{Total Project Area (ha)}}{\text{State Net Area Sown (ha)}} \right) \times 100$$

For multi-state projects, the researcher calculated a range of minimal potential impact (widest distribution) relative to the total NSA of all states, and the maximum potential impact (highest concentration) relative to the smallest state’s NSA.

$$\text{Carbon Intensity} = \frac{\text{Annual Estimated Emissions Reduction (tCO}_2\text{e)}}{\text{Total Project Area (ha)}}$$



The data reveal a nascent carbon farming market with most projects covering less than one percent of a state’s NSA, but corporate-led initiatives (like Grow Indigo with 7 million ha) intend to transform the market into a dominant practice, transitioning the farmers’ role from gatekeeper to scale, as the market’s growth banks on their collective contribution.

The projects are ranked by carbon intensity to create a hierarchy of intervention models and define the farmers’ roles, exposing substantial variation from 115-0.56 tCO<sub>2</sub>e/ha.

The top-tier projects, with the highest intensity, are horticulture (115 tCO<sub>2</sub>e/ha), community-based reforestation (29.9 tCO<sub>2</sub>e/ha), and the Aaraku Valley project (13.4 tCO<sub>2</sub>e/ha). The mid-tier projects, intermittent flooding (7.26 tCO<sub>2</sub>e/ha), necessitate technical specialization. The foundation-tier projects, with the lowest intensity, are

regenerative agricultural practices (1.33-1.62 tCO<sub>2e</sub>/ha) and mahogany plantation (0.56 tCO<sub>2e</sub>/ha), revealing a complex paradox with the highest estimated annual emissions reduction.

### **Analysis of Project Proponents: Defining the Role of Farmers**

The data manifests the farmers' role in the carbon economy as determined by the proponent's models:

#### **Producers in Corporate Value Chains**

Corporate-led initiatives (Grow Indigo and Mahogany Agro) employ contractual agreements and technology-driven MRV systems, placing farmers as producers who integrate best practices and acquire compensation through verified CERs, while restricting their autonomy in engineered value chains.

#### **Stewards in Livelihood Models**

Livelihood projects (Araku Valley, TRIBAL, Climeverse, etc.) depict the carbon revenue accumulation with improved socio-economic welfare, fostering agroforestry products in premium markets by pooling smallholder farmers' lands. Although individual contribution is modest, collective efforts result in significant emissions reductions, reconciling decentralization with incremental benefits.

The composite score analysis (Table 1) is essential to understanding farmers' roles shaped by climate-smart practices within the carbon economy, and adopting high-composite-score methods for sustainability and co-benefits. Crop diversification has the most potential for farmers, resulting in a 90% emissions reduction. Direct rice seeding enables earning CERs, but technological barriers remain to weed management. AWD, crucial for paddy farmers, even being moderate, can reach a carbon market threshold through outreach services and training programs. Nitrification inhibitors, the lowest impact, demonstrate policy-driven interventions, like the neem-coated urea in 2015, enabling millions of farmers' participation in nitrogen management practices.

For Table 2, the farmers' roles for the highest-ranked initiatives are land-use transformation and long-term stewardship, for mid-tier projects, technical specialists in methane reduction, and for the lowest-ranked initiatives, soil health managers, as climate mitigation is not achieved through intensity but through adopting sustainable practices.

#### **Member-Owners in Cooperative Models**

Community-led initiatives (Indian Farm Forestry and Shri Hari Mandal) incorporate collective governance, social equity, and co-benefits, thus empowering farmers as owners with decision-making and economic advantages.

However, farmers have restricted engagement due to expensive MRV carbon tracking, such as with AWD in rice, thereby hampering projects like the withdrawal of Kosher Climate. CERs' compensation often delays practices' endorsement by years due to fluctuating market prices and restricts farmers' engagement, further backed by the unavailability of the VCM regulatory framework in Indian agriculture.

### **Analysis of Case Studies: The Role of MRV Technologies and Promoting Climate Justice**

#### **Case Study Analysis 1: Bagepalli Afforestation Project**

The analysis demonstrates a strategic intent of holistic, tangible advantages beyond sequestration. The selection of fruit and fodder plantations places farmers as carbon managers and stewards of productive initiative, reinforcing that successful carbon projects should integrate climate resilience with a system aimed at improving local livelihood and food security.

The project's economic analysis provides transparent profits, as INR 10.33 crore was distributed, i.e., substantial revenue to the engaged farmers. The 2021 distribution of INR 4.4 crore among 1024 families (average of INR 42,968/family) strengthens the farmers' roles as direct financial beneficiaries with a

transparent benefit-sharing strategy, and also as active and adaptive agents, as they switched to climate-resilient techniques to improve the low sapling survival rate by 40%. This intervention places farmers as knowledgeable innovators and problem solvers, validating their on-the-ground expertise for long-term project success.

## Case Study Analysis 2: Socio-Agroforestry Project in Maharashtra

The analysis demonstrates two emerging facets of the Indian carbon economy: strategic intervention in climate-vulnerable areas and the role of technology in conquering structural barriers. The project area of 90,000 hectares represents 0.55% of Maharashtra's NSA, with a relatively low carbon intensity of 2.6 tCO<sub>2</sub>e/ha, positioning it in the "low intensity, broad acre" classification, which demonstrates that positive transformation over a large landscape is more desirable than maximizing carbon sequestration in a small area.

The project focuses on Nandurbar, a predominantly tribal area, which proves that carbon finance is a crucial instrument for climate justice and adaptation. The interventions of tree plantation and cover crops deal with drought and irregular rainfall, promote soil health, and provide financial incentives to the community. Thus, the farmers' role is carbon producers and agents of climate adaptation, while the project finances the mechanisms required to develop resilience.

This project also employs cutting-edge technologies to tackle MRV challenges. The drones' utilization for baseline assessment and IoT-enabled flow meters for water management reshapes the farmers' roles by lessening their data provision burden, initiating remote monitoring, and facilitating their integration into a tech-enabled framework to evaluate practices more efficiently. Thus, enabling large-scale projects to be economically viable for smallholder-inclusive carbon initiatives.

## FINDINGS

The researcher yielded these core findings by analyzing the data:

- 1. The carbon market is shaped by the dichotomy of range:** The Indian agricultural carbon market has minimal impact (less than one percent of state NSA), yet is also designated by mega-projects with targets (like Grow Indigo). This dualism places farmers as both "pioneers" in niche markets and as the "moderators" of globe-spanning scale.
- 2. The farmers' roles are determined by two distinctive mitigation routes:** The carbon intensity ranking offers two fundamental models for farmer participation. The high-intensity projects of agroforestry and horticulture place them in "land-use transformation and long-term stewardship", whereas the low-intensity projects of regenerative agriculture, as "soil health managers", where climate benefits are achieved through a wide variety of subtle practice adjustments.
- 3. Project proponent structures shape the farmer agency:** Project models determine the farmer autonomy, such as in corporate-based strategies, they are "producers or contractors", while in cooperative-based models, "member-owners, direct beneficiaries, and adaptive managers", as farmers have greater autonomy and focus on livelihood advantages over absolute carbon revenue.
- 4. The additional incentives and farmer-led innovation are key determinants:** The Bagepalli and Nandurbar case studies (**from south and west India to analyze diverse contexts**) emphasize that projects consolidating carbon finance with livelihood co-benefits, economic incentives, and climate adaptation are most promising. The Bagepalli case reinstates that farmer-led transformation is crucial for tackling grassroots challenges and ensuring success.

## CONCLUSION

This research concludes that the farmers' role in the emerging Indian carbon economy is multifaceted and nascent, primarily shaped by project proponents. The sequential explanatory design demonstrates that while

sustainable agricultural practices provide substantial GHG emission reduction, their adoption and consolidation in the carbon market primarily depend on socio-economic and policy factors.

The study highlights that smallholder farmers face hurdles due to fragmented lands, high costs, CERs price uncertainty, and complex MRV methodologies, thereby limiting their involvement in VCMs. Institutional assistance, policy structure, and capacity-building are crucial for aid farmers' participation, not as passive recipients of carbon incentives but as active participants with indigenous knowledge and innovative strategies needed for carbon sequestration efforts while advancing livelihood co-benefits.

While the research delivers a critical in-depth analysis of current projects, its conclusion sets the stage for subsequent primary and field-based research, as longitudinal studies and direct qualitative involvement with farmers are further steps to build upon the findings presented.

## RECOMMENDATIONS

The following recommendations are proposed, based on the findings:

1. **The smallholder farmers' integration into the carbon market:** Organizations, FPOs, and NGOs should integrate fragmented landholdings into large landscapes. They should aim at decreasing transaction costs and facilitating collective agreements to improve farmers' participation, autonomy, and bargaining powers.
2. **The participatory MRV methodologies should be institutionalized:** Government and corporate projects should promote participatory MRV tools and capacity-building methods for farmers, enabling them to democratize project evaluation and ensure transparency and reliability in carbon revenue production and financial incentives.
3. **The carbon revenue should be linked with co-benefits:** Policies should be reframed to integrate carbon revenue with added benefits to foster **farmers'** active participation, like punctual payment, improved productivity, and social co-benefits.
4. **The longitudinal studies should be encouraged:** Future research should investigate the farmers' first-hand experiences, outcomes, and innovative strategies over multiple crediting cycles to deeply evaluate both socio-economic benefits and climate mitigation.

## REFERENCES

1. Amin, M.N., Lobry de Bruyn, L., Hossain, M.S., Lawson, A., & Wilson, B. (2023). The Social-Ecological System of Farmers' Current Soil Carbon Management in Australian Grazing Lands. *Environmental Management*, 72, 294–308. <https://doi.org/10.1007/s00267-023-01801-4>
2. Boomitra. (2025, April 25). India: Boomitra and Social Carbon Announce Landmark Soil Carbon Credit Issuance from Smallholders Farmers in India. Global AGTech Initiative. <https://www.globalagtechinitiative.com/digital-farming/india-boomitra-and-social-carbon-announce-landmark-soil-carbon-credit-issuance-from-smallholder-farmers-in-india/>
3. Bureau of Energy Efficiency. (n.d.). National Carbon Market. Ministry of Power, Government of India. <https://beeindia.gov.in/sites/default/files/publications/files/NCM%20Final.pdf>
4. Cariappa, A.A.G., & Krishna, V.V. (2024). Carbon farming in India: are the existing projects inclusive, additional, and permanent? *Climate Policy*, 25(5), 756-771. <https://doi.org/10.1080/14693062.2024.2416497>
5. Cariappa, A.G. (2023). Understanding Carbon Credits from Agriculture. [Blog Post]. AESA Network. [https://www.researchgate.net/publication/374470331\\_Understanding\\_Carbon\\_Credits\\_from\\_Agriculture/citations](https://www.researchgate.net/publication/374470331_Understanding_Carbon_Credits_from_Agriculture/citations)
6. Creswell, J.W., & Plano Clark, V.L. (2017). *Designing and Conducting Mixed Methods Research*. (3<sup>rd</sup> ed.). SAGE Publications
7. Department of Agriculture & Farmers Welfare. (2024, February 1). Framework for Voluntary Carbon Market In Agriculture Sector. Ministry of Agriculture & Farmers Welfare, Government of India.

- [https://agriwelfare.gov.in/Documents/HomeWhatsNew/Framework\\_for\\_Voluntary\\_Carbon\\_Market\\_1\\_Feb\\_2024\\_Revised\\_compressed\\_1.pdf](https://agriwelfare.gov.in/Documents/HomeWhatsNew/Framework_for_Voluntary_Carbon_Market_1_Feb_2024_Revised_compressed_1.pdf)
8. Dumbrell, N.P., Kragt, M.E., & Gibson, F.L. (2016). What carbon farming activities are farmers likely to adopt? A best-worst scaling survey. *Land Use Policy*, 54, 29-37.  
<https://doi.org/10.1016/j.landusepol.2016.02.002>
  9. Economics, Statistics and Evaluation Division, Department of Agriculture & Farmers Welfare. (2024, September). Land Use Statistics At A Glance: 2022-23. Ministry of Agriculture & Farmers Welfare, Government of India. <https://desagri.gov.in/wp-content/uploads/2024/09/Final-file-of-LUS-2022-23-for-uploading.pdf>
  10. Gautam, U.S., Singh, A., Dubey, S.K., Pandey, S., Singh, R., & Yemul, S.N. (2019). Impact of NICRA Activities during 2015-16 to 2017-18. *National Innovations on Climate Resilient Agriculture*. [https://www.researchgate.net/profile/Shantanu-Dubey-5/publication/332751826\\_Impact\\_of\\_NICRA\\_project\\_in\\_UP/links/5cc7d821a6fdcc1d49b998bd/Impact-of-NICRA-project-in-UP.pdf](https://www.researchgate.net/profile/Shantanu-Dubey-5/publication/332751826_Impact_of_NICRA_project_in_UP/links/5cc7d821a6fdcc1d49b998bd/Impact-of-NICRA-project-in-UP.pdf)
  11. Gopinath, K.A., Singh, V.K., & Prabhakar, M. (2025). Voluntary Carbon Market in Indian Agriculture: Status, Challenges and Way Forward (Policy Paper No. 01/2025). ICAR-Central Research Institute for Dryland Agriculture. [https://www.icar-crida.res.in/assets\\_c/img/Polycypapers/VCM-Policy\\_paper-2025.pdf](https://www.icar-crida.res.in/assets_c/img/Polycypapers/VCM-Policy_paper-2025.pdf)
  12. Gupta, N., Pradhan, S., Jain, A., & Patel, N. (2021). Sustainable Agriculture in India 2021: What We Know and How to Scale Up. Council on Energy, Environment and Water. <https://www.ceew.in/publications/sustainable-agriculture-india>
  13. Intergovernmental Panel on Climate Change. (2001). *Climate Change 2001: The Scientific Basis. Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change* (J.T. Houghton, Y. Ding, D.J. Griggs, M. Noguer, P.J. van der Linden, X. Dai, K. Maskell, & C.A. Johnson, Eds.). Cambridge University Press. [https://www.ipcc.ch/site/assets/uploads/2018/03/WGI\\_TAR\\_full\\_report.pdf](https://www.ipcc.ch/site/assets/uploads/2018/03/WGI_TAR_full_report.pdf)
  14. Khurana, A., Kajale, D., Cariappa, A. A., & Krishna, V. V. (2024). Shaping India's climate future: A perspective on harnessing carbon credits from agriculture. *Outlook on Agriculture*, 53(2), 113-130. <https://doi.org/10.1177/00307270241240778>
  15. Ministry of Environment, Forest and Climate Change (MoEFCC). (2024). India: Fourth Biennial Update Report to the United Nations Framework Convention on Climate Change. Government of India. <https://unfccc.int/sites/default/files/resource/India%20BUR-4.pdf>
  16. Phelan, L., Chapman, P.J., & Ziv, G. (2024). The emerging global agricultural soil carbon market: the case for reconciling farmers' expectations with the demands of the market. *Environmental Development*, 49. <https://doi.org/10.1016/j.envdev.2023.100941>
  17. Press Information Bureau, Government of India. (2025, August 01). Promotion of Climate-Resilient and Sustainable Farming Practices. Ministry of Agriculture & Farmers Welfare. <https://www.pib.gov.in/PressReleaseDetail.aspx?PRID=2151359>
  18. Sejian, V., Lal, R., Lakritz, J., & Ezeji, T. (2011). Measurement and prediction of enteric methane emission. *International Journal of Biometeorology*, 55, 1-16. <https://doi.org/10.1007/s00484-010-0356-7>
  19. Singh, S. (2022, Jun 08). How India can benefit from voluntary carbon markets. *The Economic Times*, [https://economictimes.indiatimes.com/small-biz/sme-sector/how-india-canbenefit-from-voluntary-carbon-markets/articleshow/92077194.cms?utm\\_](https://economictimes.indiatimes.com/small-biz/sme-sector/how-india-canbenefit-from-voluntary-carbon-markets/articleshow/92077194.cms?utm_)
  20. Sirur, S. (2025, January 23). Carbon farming projects not always inclusive and equitable, says new study. *Mongabay India*. <https://india.mongabay.com/2025/01/carbon-farming-projects-not-always-inclusive-and-equitable-says-new-study/>
  21. Sishodia, G., Philip, D. K., Daga, K., Vikas, N., Hari, S., Tandon, S., Bansal, A., Kumar, R., & Goel, S. (2024). Carbon markets as a tool for climate financing: The India story. *auctusESG, Carbon Markets Association of India, Invest India, & National Institute of Public Finance and Policy*. [https://static.investindia.gov.in/s3fs-public/2024-09/carbon\\_markets\\_as\\_a\\_tool\\_for\\_climate\\_financing\\_the\\_india\\_story\\_0.pdf](https://static.investindia.gov.in/s3fs-public/2024-09/carbon_markets_as_a_tool_for_climate_financing_the_india_story_0.pdf)
  22. Synder, H. (2019). Literature review as a research methodology: An overview and guidelines. *Journal of Business Research*, 104, 333-339. <https://doi.org/10.1016/j.jbusres.2019.07.039>

23. The Energy and Resource Institute. (2023, August 14). Obtaining Carbon finance through mangrove ecosystem. <https://www.teriin.org/project/obtaining-carbon-finance-through-mangrove-ecosystem>