International Journal of Social Impact
ISSN: 2455-670X
Volume 10, Issue 4, DIP: 18.02.S26/20251004
DOI: 10.25215/2455/1004S26
www.ijsi.in |October-December, 2025

Research Paper

Is India's Agriculture Climate Smart? An Evidence Based Study

Prof. (Dr.) Bikram Singh[1]*

ABSTRACT

According to World Bank (2024), the most important development challenges are climate change and food and nutrition insecurity. The challenge is two-fold. While global population is expected to reach 9.7 billion by 2050; the global food demand will also increase leading to more emissions. Thus, a vicious cycle of increased emissions and threat to sustainability needs to be addressed. Developing countries are the largest contributors towards emissions from agriculture and agriculture is the primary cause of deforestation. The World Bank has significantly scaled up its engagement and investment in climate-smart agriculture (CSA). India being a developing country and primarily an agrarian economy is characterized by smallholder driven farming and substantial rural livelihoods. It exhibits persistent structural fragility over 2015–2023. The share of agriculture in GDP is around 14%. The paper focuses on CSA with reference to India and highlights its adoption, implementation and challenges.

Keywords: *Climate Smart Agriculture, Climate Change, Climate Smart Village, Carbon Sequestration*

United Nations Sustainable Development Goal 2 strives to "End hunger, achieve food security and improved nutrition and promote sustainable agriculture." (https://sdgs.un.org/topics/food-security-and-nutrition-and-sustainable-agriculture).

According to World Bank (2024), the most important development challenges are climate change and food and nutrition insecurity. The challenge is two-fold. While global population is expected to reach 9.7 billion by 2050; the global food demand will also increase leading to more emissions. Thus, a vicious cycle of increased emissions and threat to sustainability needs to be addressed. The World Bank report clearly mentions that food systems which use around 70% of fresh water are the leading source of methane emissions and biodiversity loss. Developing countries are the largest contributors towards emissions from agriculture and agriculture is the primary cause of deforestation, threatening pristine ecosystems such as the Amazon and the Congo Basin. It is imperative that the Paris Agreement goals cannot be reached without significant climate mitigation action in the agri-food sector. The World Bank has significantly scaled up its engagement and investment in climate-smart agriculture (CSA). The World Bank has increased financing for CSA by eight times, to almost $3 billion annually (https://www.worldbank.org/en/topic/climate-smart-agriculture). India being a developing country and primarily an agrarian economy is characterized by smallholder driven farming and substantial rural livelihoods. It exhibits persistent structural

[1]Department of Commerce, University of Calcutta, Kolkata, India
*Corresponding Author

Received: November 17, 2025; Revision Received: November 22, 2025; Accepted: November 26, 2025

fragility over 2015–2023. The share of agriculture in GDP is around 14% despite rapid overall expansion, reflecting high dependence on weather and policy cycles (https:// agrinextcon.com/the-economic-impact-of-agriculture-on-indias-gdp/). The study focuses on India's readiness towards Climate Smart Agriculture (CSA) and its adoption implementation and challenges.

Climate Smart Agriculture- An Overview

Climate-Smart Agriculture (CSA) is a holistic framework to achieve three interlinked objectives namely, sustainably increase agricultural productivity and incomes, adapt and build resilience to climate change, and reduce or remove greenhouse gas emissions where possible. It emphasises on context-specific, farm-level decisions that balance productivity, adaptivity, and mitigation. The objectives of the three interlinked pillars namely productivity, adaptation and mitigation are tabled as under:

Productivity	**Adaptation**	**Mitigation**
• Using evidence based practices to improve farm yields and farm profitability. • Sustaining resilience to climate disruptions such as floods, droughts, etc. • Spreading of risk through diversification.	• Developing a climate-informed risk management such as seasonal forecasts, early warning systems, etc. • Improving Water security through efficient irrigation (drip, sprinkler), soil moisture management and rainwater harvesting. • Conserving Soil health through tillage, cover crops, organic matter addition to improve carbon sequestration and moisture retention. • Mainlining Biodiversity by introducing diverse cropping systems and integrated pest management to reduce vulnerability.	• Adopting practices that lower greenhouse gas fluxes such as enteric methane reductions in ruminants reduce fertilizer emissions, and soil carbon. • Improving energy efficiency and adopt renewable energy. • Enhancing the nutrient use efficiency through precision farming, soil testing, balanced fertilization. • Promoting agro forestry and sustainable land management to sequester carbon.

Source: https://www.drishtiias.com/daily-updates/daily-news-editorials/navigating-climate-change-through-climate-smart-agriculture

BRIEF REVIEW OF LITERATURE

The Food and Agriculture Organization (FAO) (2010) of the United Nations characterizes Climate-Smart Agriculture (CSA) as an approach to farming that bolsters resilience, boosts productivity, reduces greenhouse gas emissions, and actively works toward achieving national objectives of food security and sustainable development. Climate information is important for agricultural decision-makings. Intensity of use of climate information increased adoption of CSA practices (Hagos, et.al. 2025). Sun. et.al (2023) studied the effect of supply chain management methods on business success. Findings from this study support the notion that agri-food supply chains benefit from increased emphasis on traceability,

transparency, information sharing, and a culture of risk management. Ameli et al. (2021) studied how modelled decarbonisation pathways for developing economies are disproportionately impacted by different weighted average cost of capital (WACC). A climate investment trap arises for developing economies when climate-related investments remain chronically insufficient. Given that the increase of published papers in the agricultural field applying Data Envelopment Analysis (DEA), Kyrgiakos, et al. (2023) sought to classify papers under sustainability aspects such as economic, environmental and social. Ehsan et al. (2022) suggested that farmers should be trained and institutional services in the form of consultancy. The focus should be on climate-centric farming resulting in climate-smart agricultural practices for better food security. All the studies highlight the importance of CSA.

CSA: Importance in Indian agriculture

According to the Agriculture Census (2019) based on 2015-2016 data, most landholdings are small and marginal, with over 86% of holdings being less than two hectares in size. The average size of holdings has also consistently decreased over the years from 2.28 hectares in 1970-71 to 1.08 hectares in 2015-16. Female participation in agriculture now constitutes a higher percentage of total holders and operated area. Although irrigation coverage has improved but with high reliance on monsoons and ground water depletion in several districts the situation is far from satisfactory. Input efficiency and drought resilience still remains a problem. According to the National Statistical Office (NSO) survey report (2019), Situation Assessment Survey (SAS) of Agricultural Households, as part of the All India Debt and Investment Survey (AIDIS), reported that almost 51% of agricultural households were indebted. Inspite of the slight drop in the percentage of indebted households, the average outstanding loan has increased from ₹47,000 in 2012-13.to ₹74,121 in 2018-19. Almost 50% of the debt was due to capital or current expenditure in farm business and meeting up consumption needs like ceremonies and marriages.

CSA – Adoption in India

The National Mission for Sustainable Agriculture (NMSA) under the Department of Agriculture and Farmers Welfare, Government of India derives its mandate from Sustainable Agriculture Mission which is one of the eight Missions outlined under National Action Plan on Climate Change (NAPCC). The aim is to promote sustainable agriculture through a series of adaptation measures focusing on ten key dimensions encompassing Indian agriculture namely; 'Improved crop seeds, livestock and fish cultures', 'Water Use Efficiency', 'Pest Management', 'Improved Farm Practices', 'Nutrient Management', 'Agricultural insurance', 'Credit support', 'Markets', 'Access to Information' and 'Livelihood diversification'. (https://nmsa.dac.gov.in/).

The Zero Based Natural farming (ZBNF) promotes the use of natural farming techniques in which farming is done without the use of chemicals and use of credit or spending any money for purchase of inputs. It has been renamed as Bhartiya Prakritik Krishi Padhati (BPKP) as a sub-scheme under Paramparagat Krishi Vikas Yojana (PKVY), which aims at promoting organic farming and soil health. BPKP is a centrally sponsored scheme, initiated for a period of six years (2019-25). Currently eleven states namely, Andhra Pradesh, Chhattisgarh, Kerala, Gujarat Himachal Pradesh, Jharkhand, Odisha, Madhya Pradesh, Rajasthan, Uttar Pradesh, and Tamil Nadu practice ZBNF in over 6.5 Lakh hectares. States like Andhra Pradesh (AP) has adopted ZBNF over 1 lakh hectares of land and aims to convert its entire agriculture land pool (80 lakh hectares) under ZBNF by 2027 (https://visionias.in/current-affairs/monthly-magazine/2024-04-15/environment/zero-budget-natural-farming).

In the private sector ITC is collaborating with Climate Change, Agriculture and Food Security (CCAFS) to help agriculture-dependent communities to implement and scale-up the Climate-Smart Village (CSV) approach in its outreach areas. In the first phase (2016-2019) the project implementation started in three states namely, Madhya Pradesh, Maharashtra and Rajasthan and aims to cover about 2000 villages in 6 states of India. In the second phase Bihar, Uttar Pradesh and Punjab will be covered (https://ccafs.cgiar.org/news/private-sector-involvement-building-climate-change-resilient-agriculture-production-system-india).

PepsiCo has introduced collaborative farming of process-grade potatoes in India that includes assured buy-back of produce at pre-agreed price. This insulates farmers from open market price fluctuations. In collaboration with DuPont, Bayer and BASF it supplies high quality planting material, proprietary advanced seed varieties along with advanced plant protection programme and technical knowhow. Soft loans are provided through a national level tie-up with State Bank of India. Moreover, in order to protect farm incomes PepsiCo facilitates crop/weather risk insurance in partnership with leading insurance companies. (https://ioraecological.com/wp-content/uploads/2022/09/Private-Sector-Approaches-for-Climate-Change-Adaptation.pdf)

Jain Irrigation Systems Ltd. (JISL) is the third largest processor of dehydrated onions in the world and is an integrated agribusiness. JISL has more than 70 extension associates who reside the villages and provide farmers with high quality seeds, access to Micro-Irrigation System (MIS), saplings, fertilizers and other inputs. Training is imparted in all aspects of farm functions. (https://ioraecological.com/wp-content/uploads/2022/09/Private-Sector-Approaches-for-Climate-Change-Adaptation.pdf).

Dabur has joined hands with 150 marginal farmers in Bundelkhand region. These farmers grow Bhumyamlaki, a key Dabur ingredient in Chyawanprash, which is then bought back by the company (https://ioraecological.com/wp-content/uploads/2022/09/Private-Sector-Approaches-for-Climate-Change-Adaptation.pdf).

Mahindra supplies farmers with high quality mini-tubers which are produced at their facility in Palampur (HP). The seeds are bought back from the farmers at a minimum guaranteed price and are further distributed through a well spread out network to potato growers in Uttar Pradesh, Mahindra and Madhya Pradesh, Gujarat, Maharashtra and West Bengal (https://ioraecological.com/wp-content/uploads/2022/09/Private-Sector-Approaches-for-Climate-Change-Adaptation.pdf).

CSA: Government initiatives

The Government of India implements various measures for climate-smart practices primarily through National Action Plan on Climate Change (NAPCC) and other targeted missions. These initiatives focus on adaptation and mitigation across key sectors like energy, agriculture, water, and urban development. India has updated its Nationally Determined Contributions (NDC) under the Paris Agreement, targeting a 45% reduction in the emission intensity of its GDP by 2030 and aiming for net-zero emissions by 2070. Mission LIFE (Lifestyle for Environment) an India-led global mass movement was introduced at COP26, held in Glasgow 2021, to nudge individual and community action towards environmentally conscious practices and mindful consumption. National Adaptation Fund for Climate Change (NAFCC) was established in 2015 to support concrete adaptation measures in states and Union Territories most vulnerable to the impacts of climate change with NABARD as the national implementing entity. National Mission for Sustainable Agriculture (NMSA)

promotes climate-resilient agriculture through National Innovations in Climate Resilient Agriculture (NICRA), Soil Health Card Scheme, Pradhan Mantri Krishi Sinchayee Yojana (PMKSY) and Pradhan Mantri Fasal Bima Yojana (PMFBY) (https://nmsa.dac.gov.in/). Apart from the direct initiatives taken by the Government, research institutions backed by government such as Divecha Centre for Climate Change (DCCC) of Indian Institute of Science (IISc), Bangalore, National Institute of Urban Affairs (NIUA), Climate Centre for Cities (C-Cube), The Energy and Resources Institute (TERI), Indian Council of Agricultural Research (ICAR), Mahatma Gandhi Institute for Combating Climate Change (MGICCC), Institute for Climate Change Studies (ICCS), Kerala and The Climate Institute of Ahmedabad University participate in national programs focus on research, capacity building and policy formulation. Non-governmental organisations such as Council on Energy, Environment and Water (CEEW), Watershed Organisation Trust (WOTR), Borlaug Institute for South Asia (BISA), Climate Policy Initiative (CPI) India and Environmental Defence Fund (EDF) India play a crucial role in community engagement, policy advocacy and implementation of field projects.

CSA - Challenges in Implementing

Although the need for CSA has been well received and identified, yet it is far from satisfactory. The main challenges that are hindering its progress are limited access for small and marginal farmers to reliable climate forecasts, advisory services and misalignment of local farming practises, languages and CSA. Most of the small holders cannot afford climate risk insurance. This is further aggravated by long payback periods of CSA, high interest rates and collateral requirements. There exists a knowledge gap among farmers with respect to maintaining and operating new technologies. The small holding size adversely affects the economies of scale making output costly. There is a lack of training in accordance to context specific CSA packages that fit local soils, water availability, and cropping calendars. Most of the small and marginal farmers do not have land rights that are detrimental to the long-term soil health investments. As returns become uncertain due to market access and price volatility, farmers are unwilling to invest in CSA. Lack of coordination between different organisations at the ministerial level is a major challenge to CSA. Gender disparity is prevalent in the agricultural sector. Women farmers have less access to resources, credit, and extension services that constrain CSA adoption. With rise in global warming the extreme events such as floods, droughts, heat waves, etc. have increased disrupting CSA implementation and learning cycles. The tracking of long term benefits like emission reductions, carbon sequestration and soil health are extremely difficult (https://www.drishtiias.com/daily-updates/daily-news-editorials/navigating-climate-change-through-climate-smart-agriculture).

CONCLUSION

India is taking rapid strides in CSA. However, the need is towards integrating climate smart targets into all the sectors with clear targets. Organisations both public and private should take initiatives to train farmers with latest technologies and promote climate resilient agriculture. Financial institutions should expand credit access to small and marginal farmers adopting CSA. The need is towards fostering public – private partnerships and community led adaptation projects. The energy sector can work towards renewable energy projects while expanding grid resilience. In order to mitigate risk, crop insurance and enhancing climate finance through innovative instruments can be deployed. The decision makers need to understand that the key to India's growth and development stands on the strong foundation of being Atmanirbhar and agriculture plays a key role. Adopting CSA can bolster India's development landscape.

REFERENCES

Agriculture Census (2019), Agriculture Census 2015-2016, All India Report on Number and Area of Operational Holdings, Agriculture Census Division Department of Agriculture, Co-Operation & Farmers Welfare Ministry of Agriculture & Farmers Welfare Government of India

Ameli, N., Dessens, O., Winning, M. Cronin, J., Chenet, H., Drummond, P., Calzadilla, A., Anandarajah, G. and Grubb, M. (2021), Higher cost of finance exacerbates a climate investment trap in developing economies, *Nature Communications*, 12(1), https://www.nature.com/articles/s41467-021-24305-3.pdf

Ehsan, N., Hoogenboom, G., Qamar, M.K., Wilkerson, C.J., Wajid, S.A. and Aziz, F.(2022), Climate change risk perception and adaptation to climate smart agriculture are required to increase wheat production for food security. Italian Journal of Agronomy. 17.4. https://doi.org/10.4081/ija.2022.2129

FAO, F. (2010), Climate smart agriculture: policies, practices and financing for food security, adaptation and mitigation. Food and Agriculture Organization, Rome

Hagos, T.,Tadesse, T., Berhe, and M., Kassa,B. (2025), Access to and Level of Climate Information Use: Implications for Adoption of Adaptation and CSA Practices, *Environmental Management*, 75(5), 1267-1280

Kyrgiakos, L. S., Kleftodimos, G., Vlontzos, G. and Pardalos, P.M. (2023), A systematic literature review of data envelopment analysis implementation in agriculture under the prism of sustainability, *Operational Research*, 23(1), 7

National Statistical Office (NSO) survey report (2019), NSS Report No. 587: Situation Assessment of Agricultural Households and Land and Livestock Holdings of Households in Rural India, 2019 (January – December 2019), https://www.pib.gov.in/Pressreleaseshare.aspx?PRID=1753856&reg=3&lang=2#:~:text=1.1%20National%20Statistical%20Office%20(NSO,in%20separate%20sets%20of%20households.&text=2.1%20The%20integrated%20survey%20on,members%20of%20the%20agricultural%20households

Navigating Climate Change Through Climate-Smart Agriculture. (2024). Drishti IAS. https://www.drishtiias.com/daily-updates/daily-news-editorials/navigating-climate-change-through-climate-smart-agriculture

Private Sector Approaches for Climate Change Adaptation Private Sector Approaches for Climate Change Adaptation 3. (2017). https://ioraecological.com/wp-content/uploads/2022/09/Private-Sector-Approaches-for-Climate-Change-Adaptation.pdf

Private sector involvement in building climate change resilient agriculture production system in India. (2017, August 3). CCAFS: CGIAR Research Program on Climate Change, Agriculture and Food Security. https://ccafs.cgiar.org/news/private-sector-involvement-building-climate-change-resilient-agriculture-production-system-india

Sun, D., Qi, P.P., Zhong, C. M. and Xu, C. (2023), Achieving resilience through knowledge management practices and risk management culture in agri-food supply chains, *Environmental Science and Pollution Research*, 30(56), https://app.dimensions.ai/details/publication/pub.1165509065

The World Bank. (2024, February 26). *Climate-Smart Agriculture*. World Bank. https://www.worldbank.org/en/topic/climate-smart-agriculture

United Nations. (2015). *Food security and nutrition and sustainable agriculture | Department of Economic and Social Affairs*. Sdgs.un.org; United Nations. https://sdgs.un.org/topics/food-security-and-nutrition-and-sustainable-agriculture

VisionIAS. (2024, April 14). *Zero Budget Natural Farming | Current Affairs | Vision IAS*. Current Affairs | Vision IAS. https://visionias.in/current-affairs/monthly-magazine/2024-04-15/environment/zero-budget-natural-farming

Acknowledgment
The author(s) appreciates all those who participated in the study and helped to facilitate the research process.

Conflict of Interest
The author(s) declared no conflict of interest.

How to cite this article: Singh, B. (2025). Is India's Agriculture Climate Smart? An Evidence Based Study. *International Journal of Social Impact*, *10*(4), 269-275. DIP: 18.02.S26/ 20251004, DOI: 10.25215/2455/1004S26