



Climate Smart Agriculture (CSA): A Key to Sustainability

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Abstract

An integrated strategy that tackles the relationships between agriculture, climate change and sustainable development is known as “climate-smart agriculture” (CSA). It places a strong emphasis on putting practices and technology into place that increase agricultural output, strengthen resilience to climate change and variability and reduce greenhouse gas emissions. Adoption of crop varieties resistant to climate change, effective water management strategies, agro-forestry systems and soil conservation measures are important elements of CSA. Through the integration of early warning systems and climate information, CSA empowers farmers to make well-informed decisions and modifies their methods in response to changing weather patterns. Aside from guaranteeing food security, CSA also encourages the sustainable expansion of agricultural production while protecting biodiversity and natural resources. By taking a comprehensive strategy, CSA helps to meet the global climate goals, rural development and poverty alleviation. Moreover, CSA is important for developing resilient and sustainable agricultural systems that can handle the demands of a changing climate and support millions of farmers worldwide.

Keywords: Agriculture, Climate, Climate Smart Agriculture, Sustainability

Introduction

The integrated management of landscapes, including fisheries, forests, livestock and crops, with a focus on climate change and food security, is known as climate-smart agriculture (CSA). Insecurity regarding food and nutrition and climate change represents two of the biggest development challenges. CSA is a creative strategy that tackles the problems of climate change and food security together. It's a comprehensive approach with the goal of achieving increased agricultural incomes and productivity in a sustainable manner; constructing resilience against climate change; and, lowering or eliminating greenhouse gas emissions. Since 9 billion people are expected to be fed by 2050, the globe will need to produce almost 70% more food. Climate change will make the environmental effects of meeting this rising need for food much worse (Azadi *et al.*, 2021).

The adoption of CSA practices is gaining momentum around the globe, driven by a growing recognition of the need for

sustainable agricultural solutions. In developing countries, smallholder farmers are particularly vulnerable to the impacts of climate change, making CSA essential for their livelihoods. One example of CSA in action is the promotion of agroecological farming techniques. By mimicking natural ecosystems and harnessing biodiversity, agroecology fosters resilient farming systems that are less reliant on external inputs like synthetic fertilizers and pesticides. This not only benefits the environment but also improves the long-term productivity and profitability of farms (Chandra *et al.*, 2018). Moreover, CSA extends beyond the farm gate, encompassing the entire agricultural value chain. From reducing food waste and promoting sustainable consumption to enhancing market access for smallholder farmers, CSA offers a comprehensive approach to building a more sustainable and equitable food system. In addition to its environmental and social benefits, CSA also presents economic opportunities for farmers. By adopting climate-smart practices, farmers can increase their yields, reduce production costs and

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access premium markets that value sustainably produced goods. This not only improves farmers' incomes but also strengthens rural economies and fosters inclusive growth (Anonymous, 2024).

However, realizing the full potential of CSA requires concerted efforts from governments, policymakers, researchers and stakeholders across sectors. Investments in research and development, extension services and infrastructure are needed to support the widespread adoption of climate-smart practices. Furthermore, policies and incentives must be put in place to incentivize sustainable agricultural practices and ensure that smallholder farmers have access to the resources they need to thrive. Climate Smart Agriculture offers a promising pathway towards a more sustainable and resilient food future. By embracing the principles of adaptation, mitigation and resilience, CSA holds the key to safeguarding our planet's resources while nourishing its people.

Climate Change and Its Characteristics

Farmers may sustain yields while adapting to the consequences of climate change by using climate-smart agriculture, or CSA. It's an integrated approach that tackles the issues of food security and climate change while managing landscapes such as farmland, forests, fisheries and livestock. Unlike traditional agricultural growth, climate change is systematically included in the planning and development of sustainable agricultural systems using CSA. CSA rests upon three key pillars: mitigating emissions, bolstering resilience and increasing productivity. These pillars are interconnected, yet oftentimes, decisions prioritize one over the others, missing opportunities for holistic optimization. CSA safeguards vital ecological services crucial for agriculture. Ecosystems provide invaluable resources like clean water, fertile soil and sunlight, all of which underpin agricultural sustainability. CSA endeavors to preserve and enhance these services, preventing their decline. Importantly, CSA isn't a rigid framework but rather a flexible concept adaptable to diverse contexts (Goswami et al., 2023).

Impact of Climate Change on Agriculture

Natural disaster-related economic losses are increasing on a global scale, with the agriculture sector being particularly susceptible to these events. The United Nations Office for Disaster Risk Reduction (UNISDR) (2018) reports that from 1998 to 2017, disaster-affected nations incurred direct economic losses totalling US\$ 2908 billion. 77% of the total losses were a result of calamities linked to climate change. The effects of climate change on the agriculture sector have increased recently. Between 2010 and 2039, India may experience a 9% reduction in key crop yields nationwide as a result of the consequences of climate change; the situation is expected to get worse over time. Depending on the region and predicted climate, the loss for rice, wheat, sorghum, barley and corn can reach 35%, 20%, 50% and 60%, respectively (Srinivasa Rao et al., 2019).

CSA is becoming more and more important as a result of the growing problems that climate change is causing.

Traditional farming methods are becoming less dependable due to changing weather patterns, a rise in the frequency of catastrophic weather events and rising temperatures. By supporting strategies that increase resilience to climate variability, such as enhanced water management practices, drought-resistant crop types and conservation agriculture approaches, CSA provides a means of adapting to these changes. Additionally, by supporting carbon-sequestering techniques like agro-forestry and better soil management, CSA seeks to reduce greenhouse gas emissions from agriculture. Farmers may more effectively endure the effects of climate change and contribute to international efforts to lower emissions and create a more sustainable food system by implementing climate-smart agriculture (Srinivasa Rao et al., 2019).

Climate Change in India Scenario

India ranks fourth on the list of countries most affected by climate change in 2015 (Anonymous, 2024). India emits about 3 gigatonnes (Gt) CO_{2eq}, or 2.5 tonnes CO_{2eq} per person yearly, less than the rest of the world (Srinivasa Rao et al., 2019). Even with 17% of the world's population, the country only makes up 7% of emissions worldwide (Goswami et al., 2023). Growing temperatures on the Tibetan Plateau are causing the Himalayan glaciers to recede, threatening the flow of important rivers like the Yamuna, Brahmaputra and Ganges. Based on an assessment conducted in 2007 by the World Wide Fund for Nature (WWF), the Indus River could dry up for the same reason (Chandra et al., 2018). India is seeing increasingly frequent and severe heat waves as a result of climate change. Severe landslides and floods are predicted to occur more often in places like Assam (Taylor, 2018). India ranks seventh in the world's climate change performance index out of 63 nations that would produce 92% of the world's greenhouse gas emissions in 2021 (Azadi et al., 2021).

Government Policies on CSA

Government policies on climate-smart agriculture (CSA) encompass a range of initiatives aimed at promoting sustainable agricultural practices in the face of climate change. These policies often involve investments in research and development of climate-resilient crop varieties, support for adoption of eco-friendly farming techniques and incentives for farmers to mitigate greenhouse gas emissions. Additionally, governments may implement programs to improve soil health, enhance water management and promote agro-forestry practices. Such policies are crucial for ensuring food security, conserving natural resources and building resilience in agricultural systems to the impacts of climate change (Srinivasa Rao et al., 2019).

National Innovation on Climate Resilient Agriculture (NICRA)

Established in February 2011 with an initial investment of 350 crore rupees by the Indian Council of Agricultural Research (ICAR), NICRA network is dedicated to strengthening Indian agriculture against the challenges posed by climatic fluctuations and climate change. Through the development and deployment of cutting-edge production and risk management technologies tailored for crops, livestock and

fisheries, NICRA strives to bolster the resilience of Indian agriculture.

National Mission on Sustainable Agriculture (NMSA)

Within the framework of the National Action Plan on Climate Change (NAPCC), NMSA stands out as a mission targeting specific sectors. NMSA consolidates diverse programmatic initiatives including the Soil Health Card, Rainfed Area Development, Mission Organic Value Chain Development for Northeastern Region, National Bamboo Mission and Sub-mission on Agro-Forestry. Through the adoption of energy-efficient machinery, eco-friendly technologies and the promotion of integrated farming, NMSA strives for sustainable agricultural development, emphasizing enhancements in agronomic practices such as soil health management and water consumption efficiency.

National Adaptation Fund for Climate Change (NAFCC)

Established during the fiscal year 2015-16, the NAFCC provides assistance to vulnerable states and union territories to adapt to the adverse impacts of climate change, especially within the agricultural sector. Through financing tangible adaptation projects, NAFCC endeavors to alleviate the negative repercussions of climate change across diverse industries, placing a notable emphasis on agriculture.

Climate-Smart Village (CSV)

CSV, as an institutional strategy, is designed to empower farmers in testing, implementing and advocating for CSA at the local level, thus aiding in adaptation to climate change. Through the execution of various activities tailored to address agricultural challenges arising from climate variability, CSVs serve as pivotal agents in promoting sustainable agricultural practices. The collaboration between national research bodies and CGIAR (Consultative Group on International Agricultural Research) institutions fosters the proliferation of CSVs throughout India, with notable successful implementations observed in states such as Haryana, Bihar, Punjab, Andhra Pradesh and Karnataka.

Pradhan Mantri Krishi Sinchayee Yojna (PMSKY)

Initiated with the aim of increasing irrigated land and enhancing agricultural water management and conservation, the “HarKhetKoPaani” program under PMSKY endeavors to boost water efficiency in agriculture. Through the provision of holistic water solutions and the promotion of effective water utilization, PMSKY is dedicated to realizing the vision of “More Crop Per Drop.”

Pradhan Mantri Fasal Bima Yojna (PMFBY)

Introduced nationwide as a voluntary initiative during the *Kharif* 2016 season, PMFBY aims to extend insurance coverage to farmers, states and union territories, thereby mitigating agricultural risks. With over 2.9 crore farmer applications registered since its inception, PMFBY plays a vital role in safeguarding farmers’ livelihoods.

Soil Health Card Scheme

Launched in February 2015, the Soil Health Card Scheme furnishes farmers with comprehensive details regarding soil nutrient status and recommended fertilization doses, aiming

to boost productivity by optimizing input utilization. With a goal of distributing more than 10.48 crore Soil Health Cards, the scheme advocates for sustainable soil management practices.

National Water Mission (NWM)

NWM strives to achieve Integrated Water Resource Management (IWRM) to preserve water resources and enhance water use efficiency, particularly in agriculture. Programs such as the Paramparagat Krishi Vikas Yojna (PKVY) advocate for organic farming and soil health management, thereby aiding in water conservation endeavors.

Biotech-KISAN

Initiated in 2017, Biotech-KISAN facilitates partnerships between farmers and research laboratories to drive agricultural innovation. With the establishment of 146 Biotech-KISAN Hubs nationwide, the initiative has positively impacted over two lakh farmers and catalyzed the development of rural enterprises.

Sub-mission on Agroforestry

Commenced in the fiscal year 2016-17, this campaign seeks to plant trees on agricultural bunds, thereby enhancing agricultural yields, mitigating the impacts of climate change and advocating for sustainability.

National Livestock Mission

Launched by the Ministry of Agriculture and Farmers’ Welfare, this mission prioritizes sustainable growth in livestock to safeguard the environment, ensure biosecurity, preserve animal biodiversity and sustain farmers’ livelihoods.

Impact of National Programmes and Policies

National programs such as NICRA and NMSA have spearheaded the development of climate-resilient technologies and contingency plans, extending their benefits to agriculture across 572 rural districts. Initiatives like “More Crop per Drop” and the utilization of neem-coated urea have notably bolstered water use efficiency while curbing greenhouse gas emissions. Practices like Zero Budget Natural Farming (ZBNF) and agroforestry advocate for environmentally sustainable and economically viable agricultural methods. Furthermore, regulations and initiatives pertaining to livestock have contributed to record milk outputs and the nurturing of vibrant agripreneurship ecosystems.

Enhanced Resilience: Initiatives such as NICRA and NMSA focus on developing and disseminating climate-resilient technologies and practices. These efforts help farmers adapt to changing climate conditions, thereby enhancing the resilience of agriculture.

Improved Water Management: Programs like the PMKSY and the NWM promote efficient water management practices in agriculture. By encouraging the adoption of techniques such as drip irrigation and rainwater harvesting, these initiatives contribute to water conservation and enhance water use efficiency, crucial aspects of CSA.

Promotion of Sustainable Practices: Schemes like the Soil Health Card Scheme and the Paramparagat Krishi

Vikas Yojana (PKVY) advocate for sustainable agricultural practices. By providing farmers with information on soil health and promoting organic farming, these programs contribute to soil conservation, biodiversity preservation and reduced greenhouse gas emissions, key components of CSA.

Capacity Building and Knowledge Sharing: Initiatives such as Biotech-KISAN and CSVs program focus on capacity building and knowledge sharing among farmers. By providing training, resources and facilitating collaboration between farmers and research institutions, these programs empower farmers to adopt CSA practices effectively.

Insurance and Risk Mitigation: The PMFBY aims to mitigate the risks faced by farmers due to climate variability and extreme weather events. By providing insurance coverage against crop losses, PMFBY helps farmers recover from weather-related disasters and encourages them to adopt risk-reducing CSA practices.

Conclusion

Sustainable development faces increasing threats from climate change, which could severely impact global food production and exacerbate issues of hunger, malnourishment and poverty. To mitigate these risks, urgent action is needed to prepare agricultural sectors for potential environmental disruptions. Despite challenges posed by population growth and rising affluence, efforts to enhance agricultural output and alleviate poverty must be intensified to ensure food security, particularly in low-income nations of sub-Saharan Africa and South Asia. Integrating climate-smart agriculture goals into comprehensive policy frameworks can enhance the effectiveness of agricultural support programs in addressing these complex challenges.

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