

# **Role of Sustainable Development and Climate Smart Agricultural in West Bengal**

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## **Abstract :**

West Bengal, which is in the eastern region of India, is one of India's most important agricultural states. Agriculture in India, particularly in West Bengal, faces a series of critical challenges including decreasing farm sizes, lack of modern farming knowledge, migration from rural areas, and low farmer income despite high workforce participation. By integrating skill training, marketplace access, and architectural design principles, the project proposes a self-sustaining model to Agriculture is the backbone of the frugality and a source of livelihood for a large section of the pastoral population in West Bengal. This pivotal sector, still, is oppressively hovered by the rising prevalence of climate change, which is taking the form of irregular downfall, adding temperatures, recreating cataracts, and deteriorating soil quality. These challenges impel the perpetration of smart husbandry, a strategy where data- driven technology, sustainable agronomic practices, and climate- flexible exploration are combined in order to forestall pitfalls as well as achieve productivity enhancement. This exploration explores the situation at hand, strategic fabrics, and prospects for smart husbandry as a climate adaption and mitigation agent in West Bengal. In farmer income, promote environmental sustainability, and strengthen rural–urban linkages. s. These technologies promote better resource application, prompt responses to rainfall and pest pitfalls, and enhanced vulnerability of husbandry systems to climate query. The exploration also examines government programs, institutional arrangements, and public private institutions that have promoted or impeded the dispersion of smart technologies among growers. Major enterprises like the Bangla Krishi Sech Yojana, Krishi Vigyan Kendras, and climate-smart village models are examined to determine their influence on sustainability and agrarian invention. From a critical perspective, the exploration examines the donation of climate- flexible crop kinds, solar- powered irrigation, water operation systems, and low- carbon husbandry to lowering the environmental.

**Keywords:** Sustainability development, smart agriculture, climate change, AI in agriculture, Farmer Training

## **Introduction:**

Agriculture as their means of sustenance, the sector constitutes the base of the state's economy and food security system (Government of West Bengal, Agricultural Profile of West Bengal). The state's rich alluvial soil, long river networks and good climate have traditionally favoured a range of crops such as rice, jute, pulses, oilseeds, and vegetables. Even with these natural resources, West Bengal's agricultural sector is increasingly plagued by challenges induced by the deepening effects of climate change and the constraints of conventional farming systems. One of the biggest issues for West Bengal's agrarian economy is its

extreme susceptibility to climatic risks. The state has a wide variety of agro-climatic conditions ranging from the humid coastal plains in the south to the floodplains of the Ganges and the semi-arid western districts. This geographical variation exposes various regions of the state to a range of climate-related risks. Coastal areas, and especially the Sundarbans, are regularly prone to cyclones, intrusion of saline water, and flooding, whereas western plateau districts experience perennial droughts and depleting groundwater levels (CSE, Climate Smart Agriculture: Case Studies from India). Seasonal unpredictability, frequency of extreme events, and continuous temperature increase have all helped cause declining agricultural productivity, rising costs of inputs, and socio-economic pressure on farmers. Climate change mitigation methods in smart agriculture also include agro forestry-driven carbon sequestration, utilization of renewable power for irrigation, and reduced emission agricultural approaches. Utilization of solar pumps, biogas plants, and organic framings also enhances climate change reduction through minimized use of inputs along with increased farm profits. Besides that, promotion of digital infrastructure in financial services as well as in crop insurance helps further develop farming communities' socio-economic resilience. Noting the promise of smart agriculture, the Government of India and state-level organizations in West Bengal have launched a number of programs focused on encouraging climate-resilient agriculture. Krishi Vigyan Kendras in the state are the critical knowledge centers for demonstration and training of new-age farming methods. Bangla Krishi Sech Yojana encourages micro-irrigation and water management, whereas the Mati Tirtha program emphasizes enhancing soil health based on data-driven fertilizer application. Public-private partnerships (PPPs), including Aristech start-ups such as Agro Star and DeHaat, have also started contributing to the provision of tailor-made inputs, advisory services, and market linkages to marginal and small farmers Agriculture contributes to 20% of India's GDP while employing almost 60% of the workforce. However, smallholder farmers who produce 80% of food in the developing world often struggle with limited market access, outdated techniques, and declining profitability. In West Bengal, where 96% of farm families are small and marginal, these challenges are acute. The Urban Agricultural Skill Development Centre is proposed to address these issues through skill enhancement, market integration, and sustainable infrastructure. Under such circumstances, the term "smart agriculture" or "climate-smart agriculture" appears as an important framework to promote agricultural sustainability and resilience. Smart agriculture is the infusion of cutting-edge technologies like precision farming, Internet of Things, Geographic Information Systems, remote sensing, artificial intelligence (AI), and machine learning in agricultural systems for enhanced productivity, optimized resource allocation, and lowered environmental footprint. answering these queries, the study adds to existing literature on sustainable agriculture, technology adoption in farming, and climate adaptation policy in the Global South. It further lays the foundation for more discussions on harmonizing traditional knowledge systems with modern science, thus nurturing an inclusive perspective on agricultural growth in the light of a fast changing climate.

## Background:

Agriculture in India is facing multiple interlinked challenges. Farm sizes have been steadily shrinking, declining from 2 hectares in 1976–77 to just 1.08 hectares in 2015–16. Every day, nearly 180,000 people migrate from rural communities to urban areas, further reducing the agricultural workforce. Despite engaging about 60% of the country's workforce, agriculture contributes only 20% to the national GDP,

reflecting a significant economic imbalance. Between 1995 and 2019, over 296,000 farmers have taken their own lives, highlighting the depth of farmer distress. A major contributing factor is the lack of exposure to modern farming techniques and effective marketing strategies, which results in low yields and poor market returns. In response, the Urban Agricultural Skill Development Centre (UASDC) is envisioned as both a training hub and a marketplace, empowering farmers to sell directly to urban consumers while enhancing both the quality and quantity of their produce.

## Methodology:

This is an analytical study based on literature survey. Secondary data like research articles, journals, magazines and different database from websites are considered in this study. Content analysis of the literature which extracts the outcomes of the present study with thematic analysis and corroboration of the data.

## Climate Agricultural Issues in West Bengal:

**Agro-Climatic Profile:** West Bengal state has a varied and rich agro-climatic profile, which is instrumental in determining its agricultural output and cropping stages. Geographically, the state has a number of well-differentiated ecological zones: Himalayan foothills in the north, the alluvial plains of the Ganges basin in central and southern regions, coastal belts in the southeast, and lateritic uplands in the west. This biodiversity allows a diverse range of cropping patterns from rice-potwa and rice-potato in the productive Gangetic plains to tea plantations and horticulture in the hilly tracts of Darjeeling and Kalimpong (Department of Agriculture, Government of West Bengal). The Lower Gangetic Plains, the most fertile agricultural regions, are particularly prone to seasonal floods because they are near the Ganges and its tributaries. Western districts such as Purulia, Bankura, and Birbhum experience water shortages and drought-like situations, particularly during Rabi season, owing to undulating landscapes and unpredictable monsoon patterns. The Sundarbans deltaic area, which is already faced with saline water intrusion and increasing sea levels, is frequently affected by cyclones 2020 and 2021, which cause havoc in standing crops and infrastructure.

**Climate Change Impacts on Agriculture:** Climate change impacts on agriculture in West Bengal are growing and present long-term threats to food security and rural livelihoods. Climatic models predict a 6–10% reduction in rice and wheat productivity by 2050, if greenhouse gas emission pathways continue as at present (ICAR, Impact of Climate Change on Indian Agriculture, 2022). These downturns are concerning for a country where rice alone commands almost 50% of gross cropped area. Observations by the India Meteorological Department indicate that the monsoon season is currently characterized by brief but intense episodes of rainfall, leading to both flash floods and dry spells in the same crop cycle. Another upcoming issue is soil degradation caused by extensive chemical use, flooding, and over-farming. Climate-related salinity intrusion in coastal regions has made vast areas of agricultural land non-cultivable, especially in the Sundarbans. Soil organic matter and micro-nutrient depletion also hinder long-term productivity and require restorative farming.

**Concept of Smart Agriculture:** Smart agriculture—often referred to as Climate-Smart Agriculture—is a paradigmatic shift from conventional farming to technology-based, data-intensive, and environmentally friendly practices. Described by the Food and Agriculture Organization as a system that is designed to increase productivity in a sustainable way, improve resilience, lower greenhouse gases, and secure food, smart agriculture has a range of tools, methodologies, and innovations, Climate-Smart Agriculture Sourcebook, 2017). Smart agriculture is not a uniform approach but a system consisting of multiple interdependent elements that can be tailored to suit regional and crop-specific needs.

## ICT Applications:

Application of Information and Communication Technology (ICT) in agriculture is growing very fast, particularly with greater mobile phone penetration in rural regions. ICT platforms offer real-time weather forecasts, pest warnings, market prices, and agronomic recommendations to farmers via mobile applications, SMS services, and call centres. Government-subsidized services such as M-Krishi in West Bengal and private enterprises such as Agro Star provide location-based advisories in local languages. These services enable farmers to take timely and well-informed decisions that reduce losses and increase profitability. ICT also enables digital extension services, where physical field visits are substituted by virtual consultations, thus enhancing outreach.

## Artificial intelligence in Agricultural:

Artificial intelligence (AI) presents an opportunity to offer innovative solutions to long-standing challenges in agriculture. This review study provides an overview of AI applications in agriculture, focusing on its applications to predict and monitor crop growth rate and yield, climate change and weather patterns, pests and diseases management, weed management, animal production, agricultural machinery, crop irrigation, and soil management, and crop fertilization. AI technologies, including machine learning, computer vision, and precision agriculture, are explored. This review highlights the significant potential of AI to improve agricultural productivity, efficiency, and sustainability. Furthermore, the challenges and limitations of AI adoption in agriculture, including data quality and availability, infrastructure requirements, and ethical considerations, are also discussed. Overall, this study demonstrates the transformative power of AI in agriculture and highlights the need for continued research and investment in this critical field to build more resilient and sustainable agricultural production systems.

## Farming:

Farming employs Global Positioning Systems (GPS), geo-tagged sensors, and variable rate technologies to monitor and control agricultural inputs with high spatial precision. Precision farming allows farmers to deliver fertilizers, pesticides, and water exactly where and when needed, minimizing input costs and environmental degradation. In West Bengal, where fragmented and small landholdings are prevalent, precision farming technologies like soil moisture sensors, automated drip irrigation systems, and mobile mapping devices can make a big difference.

## **Water Management:**

Water management is of utmost importance in a state with agriculture that is largely rain-fed and characterized by spatial-temporal variability in the availability of water. Smart agriculture encourages technologies that enhance water-use efficiency through controlled irrigation and resource planning. Drip irrigation and sprinklers, while historically applied in horticulture, are being implemented for row crops and vegetables. These systems enable accurate water application at the root zone, which greatly minimizes evaporation losses and maximizes crop yield per unit of water.

## **Digital Learning:**

Smart farming relies intensely on digital infrastructure, such as mobile connectivity, internet access, and data-centric tools. But there is still a wide digital divide in rural West Bengal, where network coverage and internet speed are below par. Therefore, such platforms as mKisan, eNAM, and Agri Stack, aimed at enabling real-time advisories and market reach, are still not being exploited in these areas. In addition, gendered digital exclusion creates a new level of complexity. Women farmers tend to have lower access to mobile phones and digital literacy initiatives, which restrict their engagement with smart farming schemes. This emphasizes the necessity of gender-sensitive policy and outreach-oriented interventions to achieve inclusive technology uptake.

## **Awareness and Training:**

Effective implementation of smart farming technologies depends not just on access but also on the knowledge and ability of farmers to effectively use these technologies. For many farmers, however, these technologies in the form of Geographic Information Systems (GIS), soil health cards, or AI-powered pest management systems do not even exist or are unknown to them. There is a general impression that smart farming is only for large-scale or commercial farming ventures, thus deterring smallholders. Training programs are often sporadic, inadequately funded and not specific to the local context. Delivery of extension services through KVKs and ATMA is patchy and manpower shortages are frequent. In addition, the language in which training modules are replete makes many farmers lose interest in training due to the shame of illiteracy.

## **Conclusion:**

Smart agriculture is a paradigm shift in the way agriculture is thought about, practiced, and maintained in the context of climate change. In the context of West Bengal, where agriculture remains both a livelihood and a cultural cornerstone, the integration of digital technologies, ecological principles, and community-driven approaches holds immense promise. The successful implementation of precision agriculture in Hooghly, Burdwan and the climate-smart village model in the Sundarban serve as powerful illustrations of how targeted, context-specific interventions can significantly enhance productivity, resilience, and environmental sustainability. But the massive deployment of smart agriculture cannot take place in silos. There has to be a systemic shift backed by sound institutional arrangements, financial inclusion, infrastructure and participatory policies. There is a need to bridge the difference between technological

invention and community based adoption, which can be attained only through continuing investments in training, education, and awareness generation. Additionally, inclusive policies aiming at addressing geographic disparities, gender inequalities, and digital exclusion need to be the pillars of the change. West Bengal, blessed with rich agro-ecological zones and robust institutions, is best suited to lead the smart agriculture revolution in India. Based on the success of pilot projects, resolution of implementation hindrances, and the cultivation of an innovative, collaborative spirit, the state can forge a future course. Smart agriculture is not just a set of high-tech tools; it is a dream of inclusive, resilient, and adaptive farming that respects tradition and welcomes change.

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