CHAPTER 14

AI-Enabled Precision Agriculture for Food Security in India: Governance Challenges and Sustainable Pathways

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ABSTRACT

This research investigates whether AI-driven precision agriculture can support sustainable and inclusive food security, despite institutional and socio-economic challenges. The study analyses that AI-powered technologies have the potential to boost agricultural output and adaptability, yet their advantages are not equally distributed unless governance frameworks ensure inclusivity. It employed a mixed-methods strategy, combining secondary statistical analysis, policy evaluation, and qualitative case-based assessment. The book chapter assesses various AI applications, including drone-based crop monitoring, machine learning for yield forecasting, intelligent irrigation systems, and predictive market analysis. The findings show that AI improves efficiency in resource use, lowers post-harvest losses, and boosts the ability to adapt to climate change. Nevertheless, disparities in digital access, insufficient infrastructure, poor coordination among institutions, and issues surrounding data governance persist in limiting fair technological adoption across Indian agriculture.

Introduction

Effective governance is a cornerstone of democratic societies, as it promotes transparency, accountability, citizen participation, operational efficiency, and fair allocation of public resources. In democratic systems, governance extends beyond mere administrative operations; it also demonstrates institutions' capacity to address socio-economic challenges efficiently while safeguarding public welfare and advancing sustainable development. In developing nations like India, strong governance is especially crucial in sectors such as agriculture, where millions rely on sound policy execution, seamless institutional collaboration, and fair access to resources. The way agriculture is governed affects food production, jobs in rural areas, market controls, environmental health, and social peace. Over the past few years, swift technological progress has brought artificial intelligence into prominence as a powerful tool that can enhance governance by enabling data-informed decisions, predictive analytics, and digital oversight systems. AI-driven systems boost administrative efficiency by facilitating real-time data processing, minimizing information imbalances, and aiding in policy decisions grounded in evidence. In agriculture, AI technologies are increasingly linked to precision farming, climate adaptation, supply-chain optimization, and improving food security[1]. As a result, the link between AI and effective governance has become a key topic in both academic and policy circles, especially in nations dealing with resource shortages, growing populations, and environmental instability.

Even as India's industrial and service sectors expand rapidly, agriculture continues to hold strategic significance for the national economy. Agriculture sustains nearly half of the country's workforce and is vital to rural incomes and food security[2]. Nevertheless, the agricultural structure is very fragmented, as most farmers work on small and marginal plots, which hampers mechanization, economies of scale, and access to modern technologies. Indian agriculture continues to grapple with enduring issues such as low productivity, declining soil health, falling groundwater levels, unpredictable weather patterns, significant post-harvest losses, and volatile market

[1] FAO. 2022. "The State of Food Security and Nutrition in the World 2022." Rome: FAO. https://openknowledge.fao.org/server/api/core/bitstreams/67b1e9c7-1a7f-4dc6-a19e-f6472a4ea83a/content

[2] Government of India. 2023. "Agricultural Statistics at a Glance 2023." New Delhi: Ministry of Agriculture and Farmers Welfare.

conditions. More frequent droughts, floods, and erratic monsoons have heightened production uncertainty and jeopardized food system stability[3]. These pressures have spurred greater interest in adopting modern technologies that boost efficiency without compromising sustainability. Within this context, AI-driven precision agriculture has become a promising approach to improving agricultural governance and ensuring food security. Precision agriculture leverages technologies including machine learning, IoT sensors, drones, satellite imagery, and predictive analytics to monitor and enhance farming operations in real time[4]. These tools enhance resource efficiency, lower production risks, fine-tune irrigation, and aid in making farm management decisions grounded in evidence[5].

The increasing adoption of AI in Indian agriculture mirrors wider national initiatives aimed at digital transformation and tech-driven governance. Government programs, including Digital India, the National Strategy for Artificial Intelligence, and the Digital Agriculture Mission, highlight the critical role of AI-powered innovation in boosting agricultural output, enhancing rural connectivity, and strengthening public service delivery[6]. Farmers now receive real-time guidance on crop management, pest control, fertilizer use, and market prices through AI-driven advisory systems. In a similar way, machine learning-based forecasting models help policymakers anticipate food grain output, track supply chains, and enhance procurement systems. IoT-enabled sensors power smart irrigation systems that optimize water distribution in drought-prone areas, enhancing climate resilience and promoting sustainable resource use. AI applications also support governance by increasing transparency in crop insurance evaluations, refining subsidy allocation, and promoting digital market integration. The growth of digital agricultural platforms and predictive market intelligence tools has enhanced access to information and cut down on inefficiencies in agricultural supply chains. These advancements suggest that AI may help bolster the four pillars of food

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[3] IPCC. 2022. *Climate Change 2022: Impacts, Adaptation and Vulnerability*. Cambridge: Cambridge University Press.

[4] Wolfert, Sjaak, Ge, Lan, Verdouw, Cor, and Bogaardt, Marc-Jeroen. 2017. "Big Data in Smart Farming: A Review." *Agricultural Systems*, 153: 69–80. https://doi.org/10.1016/j.agsy.2017.01.023

[5] Liakos, Konstantinos G., Busato, Patrizia, Moshou, Dimitrios, Pearson, Simon, and Bochtis, Dionysis. 2018. "Machine Learning in Agriculture: A Review." *Sensors*, 18 (8): 2674. https://doi.org/10.3390/s18082674

[6] Aayog, Niti. 2022. "Responsible AI." New Delhi: Government of India. https://www.niti.gov.in/sites/default/files/2022-11/Ai_for_All_2022_02112022_0.pdf