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RADemics

AI in Climate Smart Agriculture for Risk Mitigation and Adaptation Strategies

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Abstract

Climate change poses a significant threat to global agriculture, requiring innovative solutions to enhance resilience and sustainability in farming systems. Artificial Intelligence (AI) has emerged as a transformative tool for addressing climate-related challenges, enabling precise risk mitigation and effective adaptation strategies. This chapter explores the integration of AI in climate-smart agriculture (CSA), focusing on its applications for risk assessment, crop management, and resource optimization. Key AI technologies, including machine learning, computer vision, and predictive analytics, are examined in the context of climate-smart practices, demonstrating their potential to optimize agricultural productivity while minimizing environmental impact. The chapter also addresses critical challenges related to data collection, quality, and accessibility, emphasizing the need for standardized frameworks and robust data infrastructures. Furthermore, ethical and legal considerations, including data privacy and security, are discussed in relation to AI implementation in agriculture. By highlighting the role of AI in improving climate resilience, this chapter provides a comprehensive overview of its potential to revolutionize agricultural practices in the face of changing environmental conditions. The findings underscore the importance of interdisciplinary collaboration in advancing AI-driven solutions for sustainable agriculture, ensuring food security, and mitigating the effects of climate change.

Keywords: Artificial Intelligence, Climate-Smart Agriculture, Risk Mitigation, Data Accessibility, Precision Agriculture, Sustainability

Introduction

The agricultural sector faces unprecedented challenges as climate change accelerates, causing unpredictable weather patterns, droughts, floods, and extreme temperature variations [1]. These climatic shifts significantly impact food security, crop yields, and the sustainability of farming practices. Traditional agricultural systems, heavily reliant on predictable climate conditions, struggle to adapt to such volatility, resulting in diminished productivity, inefficient resource use, and environmental degradation [2]. As the effects of climate change intensify, the need for innovative approaches to safeguard food production becomes more pressing [3]. One such

approach is climate-smart agriculture (CSA), a concept designed to integrate sustainable farming practices with adaptive strategies to mitigate climate-related risks [4]. CSA emphasizes improving productivity, enhancing resilience to climate variability, and reducing greenhouse gas emissions. The growing interest in AI technologies offers promising solutions to address these challenges, driving the transition toward more resilient, resource-efficient agricultural systems [5].

Artificial Intelligence (AI) has rapidly emerged as a transformative force in agriculture, enabling smarter, data-driven decision-making [6]. By processing vast amounts of data, AI can predict weather patterns, optimize irrigation schedules, detect pests, monitor soil health, and improve crop yields [7]. Machine learning, computer vision, and predictive analytics play a significant role in these applications, allowing farmers to make real-time, informed decisions [8]. These technologies provide farmers with tools to enhance productivity while minimizing resource wastage, ultimately supporting the sustainability of farming practices [9]. Through AI-powered systems, climate-smart agriculture becomes more efficient and adaptable, empowering farmers to respond proactively to shifting climatic conditions. As climate risks continue to grow, AI's potential to foster sustainable farming systems becomes increasingly apparent [10].

AI, several challenges remain in its integration into climate-smart agriculture. One of the most significant barriers is the accessibility, quality, and consistency of data [11]. AI systems rely heavily on accurate, real-time data to generate meaningful insights and predictions [12]. In many regions, particularly in developing countries, the availability of such data is limited, and the infrastructure to collect, process, and analyze it is often lacking [13]. For AI models to be effective, they require high-quality, standardized data that is consistent across various sources, such as remote sensing, weather forecasts, and ground-based sensors [14]. However, data collected in agricultural environments is often fragmented, incomplete, or subject to inconsistencies, which hinders AI's ability to produce reliable predictions and recommendations. Addressing these data challenges is essential for the widespread adoption of AI in climate-smart agriculture [15].