Chapter 9
Precision Agriculture Meets Sustainable Chemistry:
Innovations for Eco-Friendly Farming

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ABSTRACT

Precision agriculture with the emergence of sustainable chemistry has modernized farming by enhancing efficiency, minimizing environmental impacts, and encouraging the conservation of resources. It makes use of more advanced techniques, such as drones, remote sensing, the Internet of things, and artificial intelligence. Sustainable chemistry focuses on biodegradable inputs, bio-based fertilizers, and globally inert insecticides. This chapter examines the entities between precision agriculture and supply chain, including AI-driven decision support systems, blockchain for traceability, and biopesticides for pest control. It also analyzes leading frameworks, financial incentives, and the development of digital networks. Future

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research needs to concentrate on AI-driven precision agriculture, uses of nanotechnology, and climate-resilient agricultural approaches. Connecting precision agriculture with sustainable agriculture enhances the sustainability, productivity, and sustainability of farming systems, securing long-term food security and lowering agriculture's ecological footprint.

1. INTRODUCTION

1.1 Overview

Precision agriculture (PA) and sustainable chemistry are two fundamental concepts designed to enhance production and reduce environmental effects in agriculture. PA uses sophisticated technologies, such as artificial Intelligence (AI), internet of things (IoT), drones, and GIS, to meticulously monitor and manage agricultural processes, allowing farmers to enhance resource efficiency, increase crop yields, and minimize waste. The global PA market has shown substantial expansion, valued at $9.3 billion in 2024 and anticipated to attain $21.5 billion by 2033 (Bade and Tomomewo, 2024). IoT devices furnish real-time data regarding soil conditions, crop health, and meteorological patterns, allowing educated decision-making. In 2024, North America dominates PA adoption, capturing more than 51.2% of the market share (Foong et al., 2024). Sustainable chemistry (SC) in agriculture involves the development of products and processes that minimize the use and production of harmful substances, hence enhancing environmental health and resource efficiency. Green agrochemicals, including bio-based fertilizers and pesticides, aim to diminish the environmental impacts of agricultural practices (Dhuldhaj et al., 2023). Global governments are enacting laws to promote sustainable chemicals in agriculture, providing incentives for activities that match environmental conservation objectives.

1.2 Importance of Eco-Friendly Farming Practices

Ecologically sustainable farming practices are essential for sustaining food production, environmental preservation, and long-term agricultural sustainability (Padhiary & Kumar, 2024a). Traditional agricultural practices frequently result in soil erosion, low fertility, and desertification, which can be alleviated by sustainable techniques such as crop rotation, organic fertilizers, and conservation tillage (Diop et al., 2022). These techniques also reduce water contamination by promoting biofertilizers and integrated pest management (IPM). They also help reduce greenhouse gas (GHG) emissions, as agriculture accounts for 17–20% of global GHG emissions (Chataut et al., 2023). Eco-friendly agriculture increases food security and health by reducing