Chapter 11
AI-Based Soil Quality Monitoring and Improvement Techniques Predicting and Mitigating Soil Erosion and Degradation

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ABSTRACT

Soil health remains a cornerstone of sustainable agriculture and food production, yet it faces mounting challenges from nutrient depletion, erosion, and degradation, often driven by unsustainable farming practices, climate change, and over-reliance on chemical inputs. The emergence of artificial intelligence (AI) in agriculture has introduced a transformative solution to these issues by enabling highly accurate soil quality assessments and predictive capabilities that aid in the conservation

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and improvement of soil health. This chapter explores the application of AI-based techniques in soil monitoring and improvement, focusing on how they predict, detect, and mitigate soil erosion and degradation to ensure long-term soil fertility and agricultural productivity.

1. INTRODUCTION

Soil is the foundation of agricultural production, playing a central role in crop growth and food production. However, soil degradation, primarily caused by soil erosion, has become one of the most pressing challenges to global food security. The degradation of soil can be attributed to factors like deforestation, unsustainable agricultural practices, climate change, and overgrazing. This results in the loss of fertile soil, which in turn threatens the very basis of food production, jeopardizing global efforts to meet the increasing demand for food (Lal 242-255). Given the impact of soil degradation on food systems and the environment, finding innovative solutions to monitor, predict, and mitigate these challenges is of paramount importance.

In this context, artificial intelligence (AI) has emerged as a transformative tool in soil monitoring and management. AI-based systems leverage machine learning algorithms, real-time data collection from sensors, and satellite imagery to offer more precise, accurate, and timely insights into soil conditions (Chen et al. 102657). By applying AI to soil quality monitoring, we can enhance our understanding of soil health, improve soil conservation efforts, and predict the potential for soil erosion and degradation. This chapter explores the role of AI in soil monitoring, examining its significance, benefits, and potential to revolutionize agriculture by mitigating soil erosion and degradation.

1.1 The Impact of Soil Erosion and Degradation on Global Food Production

Soil erosion and degradation are significant threats to global agricultural productivity. These processes, driven by natural forces such as wind and water, as well as human activities like deforestation and overgrazing, lead to the loss of nutrient-rich topsoil that is crucial for plant growth. As soil erodes, it becomes less fertile, reducing the land's ability to support crops. Studies have shown that soil degradation affects approximately one-third of the world's arable land, leading to a marked decrease in agricultural yields (Borrelli et al. 273). This loss of productive soil not only decreases food production but also disrupts the global food supply chain.