

Chapter 1

Computational Intelligent Systems for Crop and Soil Monitoring Through Digital Imaging: A Survey

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ABSTRACT

The world's population is predicted to grow by nearly 10 billion in the year 2050, which increases the food and agricultural demands. Hence, farmers worldwide are under continuous pressure to increase crop yield to satisfy the increasing food demand. To support the farmers in food production, crop monitoring and soil management are essential tasks. The traditional human observation-based crop and soil monitoring require more time and manpower. Hence, there is a need for smart crop and soil monitoring systems. This chapter is focused on different digital imaging-based Artificial Intelligence (AI) approaches such as machine learning, and deep learning that are used for smart crop and soil monitoring. There has been limited research work on the usage of smart intelligent techniques in crop and soil monitoring. This chapter attempts to identify the research gap in smart crops and soil monitoring. Future research trends would focus on integrating hybrid AI and reinforcement learning techniques for agricultural monitoring and management.

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INTRODUCTION

Agriculture is a practice of farming, which includes cultivating the soil, crops, and domesticating animals. The commonly used traditional agricultural practices are agroforestry, crop rotation, intercropping, cover crops, organic composting, shifting cultivation, and integrated farming. These conventional farming practices are preferred still today because they were developed based on indigenous knowledge and vast experience accumulated over many years. Even though there are many advantages due to these conventional farming practices, such as enhanced soil fertility, resource usage, carbon sequestration, biodiversity preservation, sustainability and environmental protection, a few agricultural practices, like shifting agriculture have drawbacks (Hamadani *et al.*, 2021).

Crop production is an important agricultural practice followed by farmers all over the world, aimed at growing and producing crops for domestic and commercial purposes. In terms of crop production, India ranks among the top three countries in the world. Wheat and rice are the major two crops farmed in India's traditional seasonal agriculture. Nowadays, High-Yielding Variety (HYV) seeds were also sowed with the help of increased usage of fertilisers, insecticides, and pesticides to attain better crop productivity. However, farmers still struggle to choose the most profitable crop for their land due to the wide variety of soil types found worldwide and the limited technical facilities available for crop selection. Hence, the agricultural industry is transitioning from conventional to contemporary practices (Nisha and Megala, 2015).

Soil testing and monitoring are vital requirements for crop production. Generally, the soil comprises primary nutrients such as nitrogen, phosphorous, and potassium (commonly known as NPK), which are essential for plant growth. Hence, the testing of soil is a very essential procedure for farmers. To test the soil, the farmers must take the soil samples to any testing laboratory. The conventional soil testing process is time-consuming and the cost of soil testing is also high. Hence, many farmers avoid the soil testing process. To reduce the complexities in existing soil testing and classification, a few cost-effective theoretical frameworks were developed. These soil classification frameworks were guided by empirical data and practical circumstances. Moreover, these soil classification frameworks establish a connection between soil samples and different types of natural entities on the land surfaces (Eswaran H, Ahrens R, Rice T. J., 2002).

Issues in Traditional Crop and Soil Monitoring

The traditional crop and soil monitoring methods have few limitations related to the increasing food demand. According to a study conducted by Van Dijk *et al.* (2021), the demand for food is increasing due to the increase in the global population. Hence, there is a vital need to improve crop production also. A productive soil with the proper nutrients, such as nitrogen, phosphorus, and potassium, is essential for improved crop production. Poor quality crops may result if such nutrients are not adequately presented in the soil. Soil quality identification is a challenging task in traditional soil monitoring. Moreover, climatic factors such as temperature, rainfall, and humidity also play a vital role in traditional cropping. Due to these climatic factors, farmers are struggling to prepare their soil and select the proper plant seeds. Hence, traditional crop and soil monitoring heavily depend on expert's opinion and labour-intensive procedures. Due to this limitation, the traditional crop and soil monitoring methods are inadequate to meet the increasing food demand.

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