Chapter 13
Revolutionizing Agricultural Sustainability and Food Security and Management to Achieve SDGs Goals via Nanotechnology

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ABSTRACT

Modern farming has evolved by adopting technological development such as machines for tillage and harvesting, controlled irrigation, fertilizers, pesticides, crop breeding, genetics research, and biotechnological tools for trait improvement. These innovations helped farmers to produce a large quantity of quality crop yield. However, achieving the best possible yield from various types of soil is still in prog-

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ress, and there are major losses related to food wastage - especially during and post-harvest - where the production is not monitored and handled well. The industry needs a smart and accurate solution that is possible through new technologies. Various tools and technology in agriculture can help in smart farming such as GIS remote sensing, nanotechnology, and genome editing tools including molecular biological techniques. Smart farming aims to use modern technological tools to improve crop yield and product quality.

1. INTRODUCTION

Traditionally, agriculture has served as a repository of intergenerational knowledge transfer. However, contemporary challenges like climate change as well as dwindling viability of farming pose significant hurdles (Singh et al., 2022; Singh, Rajput, Sharma, et al., 2023; Singh, Rajput, Varshney, et al., 2023). The United Nations showed that the global population will surge to 9.8 billion by 2050, a leap of 2.2 billion from current levels. To accommodate this burgeoning population, crop production needs to escalate (Rajput et al., 2021; Singh, Rajput, et al., 2024). The urbanization and climate shifts have adversely affected agricultal sector. At United States, urbanization as well as climate change has caused decrease in the total average from about 913 million acres from the year 2014 to 899 million acres in year 2018.

In this technology-driven era, innovative concepts have emerged, including GIS remote sensing, artificial intelligence (A.I), big data analysis, nanotechnology, transformative technology, genome editing, and pond soil culture technology (Singh, Rajput, et al., 2024; Singh, Sengar, et al., 2024; Vardumyan et al., 2024). These advancements aid in analyzing soil architecture, weather forecasting, recommending fertilizers, managing diseases, addressing climate change, mapping crops, and enhancing crop quality, among other applications.

GIS remote sensing functions in agricultural field like to capture the information layer, including crop quanity, soil survey maps, remotely sensed data, scouting reports along with the nutrient distribution levels (Barrett, et al., 2014). Artificial intelligence helps in minute monitoring the crop health, growth rate, and production rate. Nanotechnology, transformation technology, genome editing technologies help in growing the crops and produced grain with macronutrients, micronutrients, virus and insect resistance, resistance to bacterial and fungal diseases, herbicide resistance, etc (Singh et al., 2021).

2. MORDEN TECHNOLGIES FOR SUSTINABLE AGRICULTURE AND FOOD SECURTIY

2.1 GIS Remote Sensing

Geographic Information Systems (GIS) encompass computer software as well as hardware which utilize both feature attributes and location in order to generate maps (Lucas & Chhajed, 2004). Within agriculture, GIS serves crucial functions, including the storage of various layers of information such as yield data, soil survey maps, remotely sensed information, crop scouting reports, and soil nutrient levels (Barrett et al., 2014). When combined with big data sources obtained from earth observation satellites, UAVs, and ground sensors such as temperature and moisture sensors, GIS tools collect vast amounts of data, which are then analyzed in different forms such as visual images, audio, and video for weather fore-