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Editorial: Technologies to assess soil quality towards sustaining food security

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Editorial on the Research Topic

Technologies to assess soil quality towards sustaining food security

Soil quality is the ability of a soil to support human health and habitation, maintain or improve water and air quality, and sustain plant and animal productivity within the bounds of a natural or managed ecosystem (Karien et al., 1997). Globally, one of the most important resources that can help bridge the gap between food supply and demand is well-assessed and managed soil to achieve food security (Yousif et al., 2025). By employing new technologies such as machine learning and deep learning methods for soil quality prediction, regional governments and decision-makers can identify the most effective strategies for enhancing soil quality, implement efficient soil management practices, and tackle food security challenges (El Behairy et al., 2024a,b). This challenge is enumerated among the 2030 Agenda for Sustainable Development's most critical issues (Weiland et al., 2021).

The aim of this Research Topic is to examine the impact of technological advancements on soil quality and crop yield, as well as food security, utilizing high-resolution remote sensing images, geographic information systems (GIS), artificial intelligence (AI), and big data analysis within cloud computing environments. This Research Topic encompasses the current research findings of various global academicians.

The articles accepted under this Research Topic have primarily highlighted five categories. Impact of rotation technique on soil fertility, effect of nano fertilizers on crop performance in arid regions, how the integrated farming system (IFS) affects soil physical properties, organic farming and the role of precision farming and machine learning of crop yield. According to Rau et al., over the past 10 years, there has been a decline in yields and crop profitability on agricultural lands within the Kyzylkum irrigation massif in southern Kazakhstan, as well as a decrease in soil fertility. The effectiveness of the alfalfa-cotton rotation method in enhancing soil fertility, productivity, water productivity, and gray soil productivity in Kyzylkum irrigated fields was demonstrated (Rau et al.). As, the six-pole rotation of alfalfa and cotton showed notable gains in soil fertility (30–40%), cotton output

(18–23%), alfalfa yield (20–28%), and water consumption (5–6%) when compared to the seven and nine-pole rotations (Rau et al.).

Due to the recent discovery of silicon (Si) effectiveness in crop production, further information about its properties is necessary, particularly regarding its role as a nano fertilizer for crop performance (Khaitov et al.). The results indicate that the nano Si product used can be broadly applied to enhance crop productivity, particularly on degraded land in arid environments (Khaitov et al.). The integrated farming system (IFS) seeks to diversify agricultural landscapes by integrating various components to address the diverse needs of a growing population (Rao et al.). According to the study, the fodder-based production system exhibited superior performance regarding soil physical health, specifically in enhancing aggregate stability and soil carbon content (Rao et al.). This indicates the benefits of a perennial-based system compared to seasonal or annual cropping systems for soil sustainability in the Eastern Indo-Gangetic Plains (Rao et al.). Overreliance on fertilizers, chemicals, and irrigation damages soil fertility, resulting in lower yields and degradation (Sharma et al.). Thus Organic farming presents a promising solution (Sharma et al.). The choice of land configurations and nutrient management method has been shown via careful testing and analysis to play a crucial influence in determining the soil health parameters and organic wheat production. The furrow irrigated raised bed sowing (FIRB) land arrangement produced ~7 and 11% more dry matter in wheat, respectively, than the flat sowing and zero-tillage approaches. Furthermore, compared to flat sowing and zero-tillage, this technique produced grain yields that were around 6 and 12% higher, respectively (Sharma et al.).

Soybean yield is influenced by soil, terrain, biology, and various other factors. However, there have been limited studies examining the primary and secondary factors affecting soybean yield and the interactions among these factors within a catchment area in the black soil region (Tan and Wang). The findings indicate that the physical properties of soil are crucial to soybean yield. Therefore, enhancing soil quality in small catchments—by reducing bulk density, increasing porosity, and improving soil water retention capacity—is essential for boosting soybean yield (Tan and Wang). Precision farming is a method of agricultural management that can tackle various challenges by monitoring and quantifying the variability of field crops, utilizing precise and prompt data regarding agricultural resources. The modeling process was successful in categorizing the study area (newly reclaimed area in Ismailia, Egypt) into three management zones for soil treatments and three additional management zones for plant treatments (Ali et al.). Utilizing such a method will reduce the expenses associated with soil analysis and food security, thereby enhancing overall agricultural income (Ali et al.).

The Folorunso et al. study introduces GeaGrow, a cutting-edge mobile application that uses artificial neural networks (ANN) to predict soil characteristics and offer customized fertilizer recommendations for yam, maize, cassava, upland

rice, and lowland rice in southwest Nigeria. The study shows how machine learning (ML) can revolutionize soil nutrient management and boost crop yields, aiding sustainable farming in Nigeria (Folorunso et al.). As a major development in agriculture technology, the GeaGrow app offers farmers location-based, easily accessible soil information and customized crop recommendations. Additionally, the GeaGrow app offers smallholder farmers scalable, user-friendly mobile application development (Folorunso et al.).

The quality of food and its quantity are both directly linked to the quality of the soil. The soil has been exhausted by high-intensity farming in numerous countries, jeopardizing its capacity to yield sufficient food for both present and future generations. This Research Topic certainly shed light on some promising research themes and confirmed that food quality and quantity are directly linked to soil quality. The soil has been exhausted by high-intensity farming in numerous countries, jeopardizing its capacity to yield sufficient food for both present and future generations.

Author contributions

MS: Conceptualization, Investigation, Methodology, Project administration, Resources, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. EM: Writing – original draft. AG: Writing – original draft, Writing – review & editing.

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Conflict of interest

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