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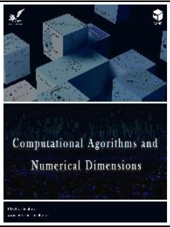

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Software Based Agricultural Monitoring with the Integration of Sensor Technology

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Abstract

This study investigates how the current academic literature discusses Wireless Sensor Network (WSN) applications in agriculture. The WSN is widely used to build decision support systems to overcome many problems in the real world. Using the basic principles of Internet and WSN technology, precision agriculture systems based on the Internet of Things (IoT) technology are explained in detail, especially on the hardware architecture, network architecture, and software process control of the precision agriculture system. The software monitors data from the wireless sensors, but implementing a WSN will optimize the usage of water fertilizers and maximize crop yield. Nowadays, the climatic conditions are not the same and predictable. There are many ways to cultivate healthy crops in a year. But it requires a lot of human resources, which is a burden nowadays. We are designing a WSN for smart agriculture to make it smart and straightforward and give correct input to the corp.

Keywords: WSNs, Precision agriculture, Internet of things, Agriculture.

1 | Introduction

The global population has grown considerably from 2.5 billion in 1950 to 7.8 billion today. It is estimated that the world population will reach 9.7 billion by 2050. As the most prominent food source, agriculture has played a significant role in human civilization [1]. However, the exponential increase in food demand due to population growth creates several pressing problems: water and air pollution, greenhouse gas emissions, and global warming [2]. These issues and resource scarcity accentuate the urgent need for novel and sustainable solutions [3]. Several researchers have incorporated cutting-edge technologies to address these problems, including WSNs, the Internet of Things (IoT), Artificial Intelligence (AI) techniques, spatial technologies, remote sensing, computing technologies, blockchain technology, big data, and Radio Frequency Identification (RFID) [4]. These technologies gave birth to smart and precision agriculture, estimated to reach $14.3 billion in worth by 2025.

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Microelectromechanical Systems (MEMS) Enhancements make these nodes smaller, less expensive, and more energy-efficient. These nodes are distributed across the field and collect data from the farm and environment [5]. These various data include soil moisture, temperature, humidity, and crop conditions, to name a few. Furthermore, minor processing is enabled by the microcontrollers built into these nodes [6]. Data and information are transmitted directly or indirectly to a base station or a hub, resulting in considerable improvements in the decision-making process [7]. The significant benefits and capabilities WSN offers (e.g., monitoring, automation, optimization, etc.) have prompted several scholars to investigate the potential of this technology for agriculture, highlighting the vital importance of WSN in precision agriculture [8], [9]. The authors discuss using different sensors in sensing other parameters and applying various communication technologies for data transmission [10]. Authors have investigated the extant literature and summarized the different WSN technologies for implementing precision agriculture [11]. The role of WSN in monitoring fields, optimizing irrigation, and measuring temperature and soil property is also illustrated [12].

Similarly, Refs explored agricultural challenges and WSN solutions, including resource optimization, decision-making support, land monitoring, and energy efficiency [13]. Authors have investigated the developments and applications of WSN and RFID in agriculture [14]. Aznoli and Navimipour explored the enabling strategies as one of the most challenging aspects of incorporating WSN in agriculture [15].

1.1 | Methodoloy

Among literature review methodologies, bibliometric analysis is a powerful quantitative tool using different measures to extract the behavior and dynamics of a knowledge domain [16]. We drew on best practices to investigate comprehensively and objectively the entire field of WSN in agriculture [17]. Scopus was selected to conduct this study because it is regarded as one of the most reliable and trustworthy databases with the largest abstract and citation database of peer-reviewed research utilized by many scholars [18]. *Fig. 1* illustrates the research process [19]. Keywords including WSN agriculture, farming, farmer*, and agricultural were searched in titles, abstracts, and keywords [20]. The keywords were connected with the logical connectors OR and AND. We carried out a truncated search for one keyword by including one asterisk (*). For instance, farmer* can represent "farmers." The timespan was set from 2002 to 2021. All types of documents were included in the analysis [21]. *Table 1* shows the primary information about the data. Moreover, the science mapping tool VOSviewer and the web-based data analysis framework Biblioshiny were adopted for the text mining and quantitative analysis of the findings [22].

Table 1. List of investigation.

S/N	Questions
1	What are the publication dynamics on the interplay between WSN and agriculture?
2	How is WSN being used in agriculture?
3	What are the main research gaps regarding WSN applications in agriculture?

1.1.1 | Wireless sensor network in precision agriculture

Precision agriculture is a crop management concept that allows farmers to manage spatial and temporal variability within the agricultural field, such as reduction of natural resources, irrigation management, production management, fertilizer management, intrusion attacks, and real-time data monitoring [23]. The aim behind the adoption of sensors in precision agriculture is to enhance the overall production of crops. Sensors can help measure various parameters of agricultural land, like humidity, soil moisture, climatic conditions, intrusion detection, and water level, which can lead to better production [22]. Further, sensors can collect information regarding various parameters and process the collected information for better farming. The significant role of sensors in the agricultural field is listed below, collecting information on weather conditions, soil, crops, etc. Surveying of the land for better cultivation.

Measuring the needs of resources for crops. Determine the time-to-time requirement for crops such as fertilizers, irrigation, pesticides, etc. Protect farming fields from intruder attacks [9].

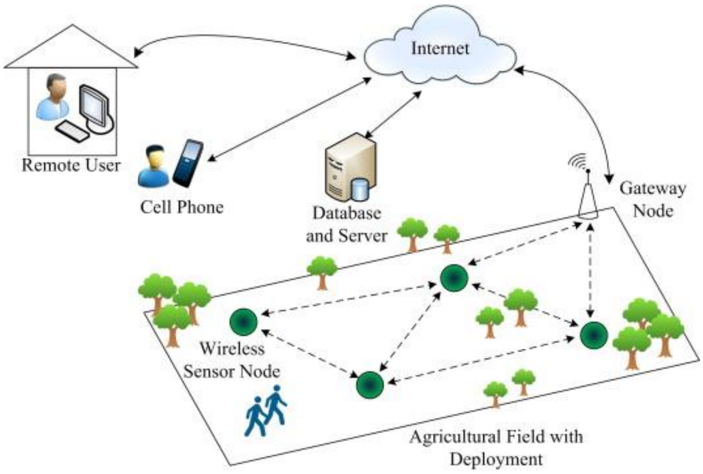

Fig. 1. WSN in agriculture.

2 | Literature Survey

This section describes the literature survey of various research articles on precision agriculture using WSNs. This section includes various techniques, sensors, algorithms, and sensor motes for collecting information from agricultural fields [8]. The literature survey on the usability of sensor nodes in PA is divided into three categories. These categories are:

I. Monitoring of crops.
II. Irrigation management of crops.

3 | Monitoring

This subsection describes the works reported on monitoring of the crops. Sanchez et al. [24] proposed an integrated WSN as a solution for precision agriculture. This model can help to assimilate crop data acquisition, transmission of data from the end user, and video-supervision tasks [7]. This model aims to secure the crops from intruders and identify them in the agricultural field. The detection and identification of intruders are done with the help of video surveillance. High energy consumption and end-to-end delay problems remain unsolved [11]. If unusual behavior of a plant is identified during monitoring, a warning message is sent to end users. With the help of wireless sensor nodes deployed in the field, the wastage of resources needed for plant cultivation is minimized. The proposed method based on data fusion of fuzzy comprehensive evaluation helps provide a well-organized way to monitor plant strength in many phases of agriculture. Zouetal proposed an OASNDFA algorithm for achieving intelligent agricultural monitoring with minimum sensor nodes deployed in the field. This algorithm helps find the suitable location of nodes. This algorithm works in three phases. The first phase considers the different relevant factors. In the second phase, a mathematical model is designed with the help of relevant factors. The third phase consists of critical points with maximum features. This subsection presents the literature on irrigation management for crops. The proposed irrigation system comprises a distributed wireless soil moisture and temperature sensor network.

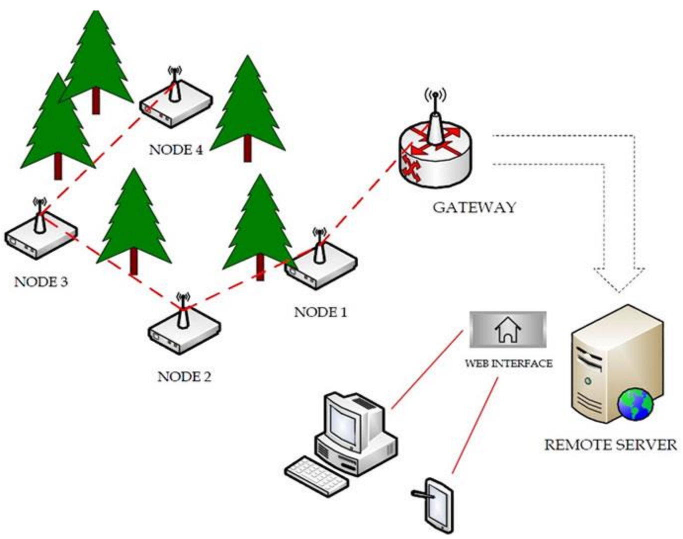

Fig. 2. Monitoring through WSN.

4 | Conclusion

In this study, the adaptability of WSNs in precision agriculture is explored, highlighting the observed incremental growth in their adoption and their wide applicability range. WSNs have become a valuable tool in monitoring agricultural fields, optimizing crop irrigation, and measuring temperature and soil properties. Additionally, they have proven to be highly efficient in monitoring various environmental parameters such as humidity, light intensity, pH levels, and nutrient concentrations in the soil. This wealth of real-time data empowers farmers to make informed decisions and implement precise interventions, ultimately leading to enhanced crop yields and optimized resource utilization.

One of the key advantages of WSNs in precision agriculture is their ability to provide continuous monitoring over large agricultural areas. Traditional manual monitoring methods are time-consuming and labor-intensive, often resulting in delayed detection of critical conditions or anomalies. With WSNs, farmers can remotely monitor multiple aspects of their fields simultaneously, allowing for timely responses to changing environmental factors such as water stress, pest infestations, or disease outbreaks. This real-time monitoring capability enables proactive management practices, ensuring that farmers can take immediate action to mitigate risks and optimize crop health. Moreover, the adaptability of WSNs extends beyond crop monitoring in precision agriculture. These networks can be integrated with automated irrigation systems, enabling precise and targeted water delivery based on real-time soil moisture data. By optimizing irrigation practices, farmers can significantly reduce water wastage, conserve scarce water resources, and promote sustainable farming practices. This not only leads to more efficient water usage but also contributes to cost savings and environmental conservation.

In summary, the adaptability of WSNs in precision agriculture offers numerous benefits to farmers. From real-time monitoring of environmental parameters to optimizing irrigation practices and resource management, WSNs empower farmers with valuable data-driven insights. By leveraging this technology, farmers can make informed decisions, improve crop yields, conserve resources, and promote sustainable farming practices. The integration of WSNs in precision agriculture is transforming the way farming is practiced, ensuring a more efficient and environmentally conscious approach to food production.

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