Chapter 17

# Smart Sensors and IoT Devices for Precision Agriculture

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**Abstract**

Agriculture, which is essential to the world economy and human life, has developed from conventional practices to more innovative methods like precision farming as a result of population growth and resource scarcity, which have led to increased production and utilization of resources.The objective of the study is to optimize crop yields by creating an autonomous agricultural robot that employs an Internet of Things (IoT) module to perform responsibilities like irrigating, seeding, and ploughing. IoT allows for almost real-time data collection from large networks, connecting wireless sensor networks (WSNs) and sensing a variety of information. This is particularly beneficial for row crop systems, which collect data from numerous sources. By integrating machine learning and artificial intelligence, precision agriculture (PA) employs technology to boost crop yield and solve issues including soil degradation, climate change, and growing expenditures. In addition to emphasizing its role in minimizing crop output gaps, food waste, and resource inefficiencies, this paper highlights the advantages of integrating ICT into precision agriculture for sustainable growth. By incorporating digital systems with machinery, Industry 4.0 is revolutionizing farming, particularly precision agriculture. This article includes a general overview of these systems and addresses how the changing environment of digital agriculture influences equipment design approaches. UAVs and sensors are employed in precision agriculture for detecting sickness, however their accuracy is limited. Classification and identification activities are performed by image processing software and machine learning models. However, successful application of these tools depends on the training and verification of databases. This article explores innovations in precision agriculture, especially technological breakthroughs like machine learning and drones. It also considers issues with data management, adoption of novel innovations, and cost-effectiveness. The growing demand for cloud computing can be attributed to advancements in processing and management. IoT and AI are promising productivity boosters. IoT data is readily available for research, revolutionizing

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conventional methods of cultivation and anticipating crop yield. Humanity may undergo profound transformation as a consequence of this.

**Keywords**

Autonomous Agricultural Robot, Crop Moisture Levels, Fossil Fuels, Precision Agriculture

## 1. Introduction

Agricultural productivity and quality are being enhanced through the application of ICT technology, including information and autonomous management. This entails creating technological solutions to maximize crop growth while sustaining quality [1]. Through the adoption of cutting-edge technologies, precision agriculture promises to meet the requirements of the world's expanding population while reducing waste and increasing agricultural productivity thus having a minimal adverse effect on the ecosystem [2]. With Industry 4.0 systems, digital systems, IoT, and autonomous tools revolutionizing equipment design, the world's expanding population demands higher productivity, efficiency, and sustainability in agriculture [3]. Smart agriculture incorporates wireless technology, such as IoT and Wireless Sensor Networks, for facilitating remote operations. However, it confronts several obstacles, including inadequate infrastructure, inappropriate data warehouse architecture, an absence of experienced staffing, and data integration challenges [4]. Utilizing precise amounts of inputs for higher crop production and economic viability, precision farming—a technology-enabled approach to agriculture—has transformed the field and surpassed traditional techniques in modern agriculture [5]. By leveraging information technology for enhanced productivity and lower energy inputs, digital agriculture is transforming agricultural practices. Minimizing the amount of fossil fuels used, addressing concerns about climate change and production cost, is being accomplished through the adoption of advanced agricultural technology, robots, and communication networks [6]. Incorporating sensors to identify pests, regulate crop moisture levels, and minimize labor costs, smart irrigation systems maximize agricultural productivity and crop welfare [7]. With the assistance of AI, ML, SDN, and WSNs, precision agriculture can improve agricultural yield while strengthening farm management and addressing issues like soil deterioration, environmental degradation, and expenditure [8]. IoT-based digital agriculture promotes productivity, decision-making, and data processing in connected farms, allowing for more accurate application of soil nutrients while minimizing negative ecological impact [9]. Researchers are exploring innovations in software that utilize rovers for efficient utilization of resources and minimize labor-intensive tasks, integrating robotics and conventional farming techniques [10]. By employing robotics in agricultural operations, challenges and expenditures can be minimized while promising farmers the ability to use their capital and restricting the impact on the environment while optimizing production [11].

## 2. Precision Farming and IoT Integration

Considering limitations like interoperability, communication, and connectivity, the global population is expanding, and resources are becoming limited. As a result, precision farming and information technologies have become essential for superior crop management [12]. The establishment of smart agriculture is undergoing a revolution prompted by its transition to digital capabilities that utilize Internet of Things (IoT), Cloud Computing, Big Data technologies. This makes stakeholder collaboration and strategic planning imperative [13]. With the aim to establish smart farms, capture data from numerous sources, and provide real-time connectivity in processes such as soil specimens, applying nutrients, planting, scouting, sprinkling and harvesting—IoT devices and WSN strengthen digital agriculture systems [14]. Crop estimation, nutrient assessment, and operational decision-making are all being boosted by Artificial Intelligence (AI), and IoT technologies, which is revolutionizing agriculture. Adoption of cloud computing minimizes waste and elevates efficiency, facilitating these advancements [15]. Temperature, irrigation, pesticide use, and soil moisture are all regulated by IoT in agriculture. Connecting greenhouses minimizes planting expenses, and animal monitoring is improved. With respect to technological limitations, it has difficulties with hiring migrant users and maintaining quality control [16]. Crop yields and variety have increased as a result for farming technological breakthroughs including AI, robots, and the IoT. However, social issues and climate change provide new difficulties that will have an impact on agriculture's future as well as climatological and societal consequences [17]. By integrating machines, sensors, communications, clouds, and the internet, green IoT promises to preserve resources, minimize carbon footprints, and maximize energy efficiency [18]. IoT facilitates big data analytics and better devices by improving global connectivity. Green IoT utilizes versatility and energy-efficient technology to mitigate environmental issues [19]. Sustainable development could address concerns like rising populations and shortages of food with the aid of AI, IoT, and mobile internet. Intelligent agriculture with AI capabilities employs logic-based approaches to identify and control pests [20]. Although there are limitations, precision agriculture makes use of UAVs and sensors to diagnose pests. Plant diseases are categorized and identified employing machine learning models and image processing tools. Training and establishing datasets is a part of data analysis [21]. The processing and hosting capabilities of cloud computing is replacing conventional methods and revolutionizing society. AI and IoT are being used for forecasting, blockchain-based shipping facilitates appropriate distribution, and agricultural output is being boosted [22]. Leveraging automation, precision technology, and real-time monitoring, the Automatic Seed Sowing System is an innovative system that optimizes agricultural output and encourages sustainable practices [23]. An AVR At mega microcontroller and IoT data have been employed by researchers to develop an Agricultural Robot that can automatically seed and plough fields, saving labor and increasing crop yield [24]. Nanotechnology optimizes food safety and quality, minimizes the necessity for fertilizer and pesticides, enhances plant growth, production, and nutritional value, and regulates seed metabolism to strengthen agriculture's long-term sustainability [25]. By minimizing food waste and resource inefficiencies and promoting forecasting and proactive decision-making through sensor data processing, IoT and AI technologies are vital for long-term productivity in farming and global nutritional stability [26].

## 3. Recommendations

On the basis of literature review of the past studies conducted on farming techniques, we propose following recommendations.

- With the objective of tracking physiological markers in crops and livestock, precision agriculture demands an establishment of high-quality, sustainable, high-resolution agricultural sensors coupled with IoT.
- For dependable results, researchers have to carefully organize their data acquiring strategy, taking into account their objectives and maintaining a balance between quantity and quality.
- Yields are boosted, wastage is reduced, and resources are utilized more effectively when planting efficiency, sowing depth, homogenous separation, and exact seed placement will be strengthened.
- Innovative technologies such as blockchain, IoT, Big Data, AI, autonomous vehicles, yield forecasting, and image processing could be the subject of future agricultural research.

- The application of IoT in agriculture has the potential to establish higher technical standards and significantly boost the efficacy and efficiency of conventional approaches.
- To ensure the accomplishment of organizational goals, future research should take into account variables, system dynamics, objectives, impact assessment, simulation execution, and experimental capability analysis.
- It is recommended that future research investigate novel farming options, community supported agriculture (CSA), and sustainable farming practices in order to boost agricultural sustainability and explore production routes.
- In order improve work completion and educate inexperienced farmers by offering an abundance of training data, "Agriculture 6.0" plans to incorporate robotics and AI into agriculture.
- While Unmanned Aerial Vehicles (UAVs) offer precise data on crop status, their capability to identify crop diseases is still limited, necessitating collaboration and advancements in machine learning techniques.
- Although the use of big data technologies in agriculture is still uncertain, it promotes productivity and helps meet the global food necessities.

## Conclusion

The future smart farming revolution or precision agriculture will use advanced data acquisition technologies combined with network-communication technologies. Leveraging digitalization and Industry 4.0 technological advances like drones, IoT, and AI, precision agriculture is a crucial component of Agriculture 4.0 and enhances farmland management. But before a system is completely integrated, additional research is needed. Utilizing IoT sensors, precision agriculture captures data, evaluates it with big data, artificial intelligence, and machine learning, and integrates the findings to applications like disease forecast alarm systems to satisfy the world's food demands.

The review explores at how digital technologies impact design, scale economy, design factors, collaborative cooperation, decision-making, and R&D partnerships in agricultural machinery, including harvesters, tractor planters, sprayers, and mechanical weeders. Growth in the population and changes in the climate exacerbate food insecurity. The development of Unmanned Aerial Vehicles (UAVs) has helped farmers identify pests, illnesses, and crop stress, increasing yield and minimizing expenditures.

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