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IoT Based Precision Farming and Agriculture - Aspects and Technologies

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Abstract

The emergence of Internet of Things (IoT) technologies has presented novel prospects for precision farming and agriculture. This paper presents a comprehensive analysis of recent research studies pertaining to Internet of Things (IoT) applications in the agricultural sector. The objective of this review is to furnish a thorough examination of the diverse facets and technologies linked with precision farming based on the Internet of Things (IoT).

The aforementioned review presents a comprehensive overview of the primary discoveries and perspectives derived from said investigations. This study investigates the utilisation of sensor networks and data collection methodologies to facilitate the contemporaneous monitoring of soil moisture, temperature, humidity, and crop health. The utilisation of remote sensing methods, such as the utilisation of satellite imagery and drones, was examined as a means of monitoring crops and estimating yield.

The study investigated the efficacy of resource optimisation and automation tactics, including intelligent irrigation systems, in the domains of resource conservation and productivity enhancement. The convergence of Internet of Things (IoT) technologies and Decision Support Systems (DSS) was a key area of focus, examining the creation of data-centric insights and suggestions for agricultural practitioners. The successful implementation of IoT-based agricultural systems was found to be influenced by critical factors such as connectivity and communication infrastructure, as well as security and privacy concerns.

The present review article offers significant perspectives on the progress and constraints of precision farming and agriculture based on the Internet of Things (IoT), underscoring the significance of additional research and development endeavours in this swiftly developing domain.

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I. **Introduction**

The incorporation of Internet of Things (IoT) technologies in the domains of precision farming and agriculture has garnered noteworthy interest in contemporary times. The implementation of Internet of Things (IoT) technology in the agricultural sector has the capacity to transform conventional farming methods by facilitating instantaneous monitoring, optimising resource allocation, and facilitating informed decision-making based on data analysis. The objective of this review article is to furnish a thorough examination of the diverse facets and technologies linked with precision farming based on the Internet of Things

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(IoT), offering a synopsis of the most recent research investigations carried out in this domain [2].

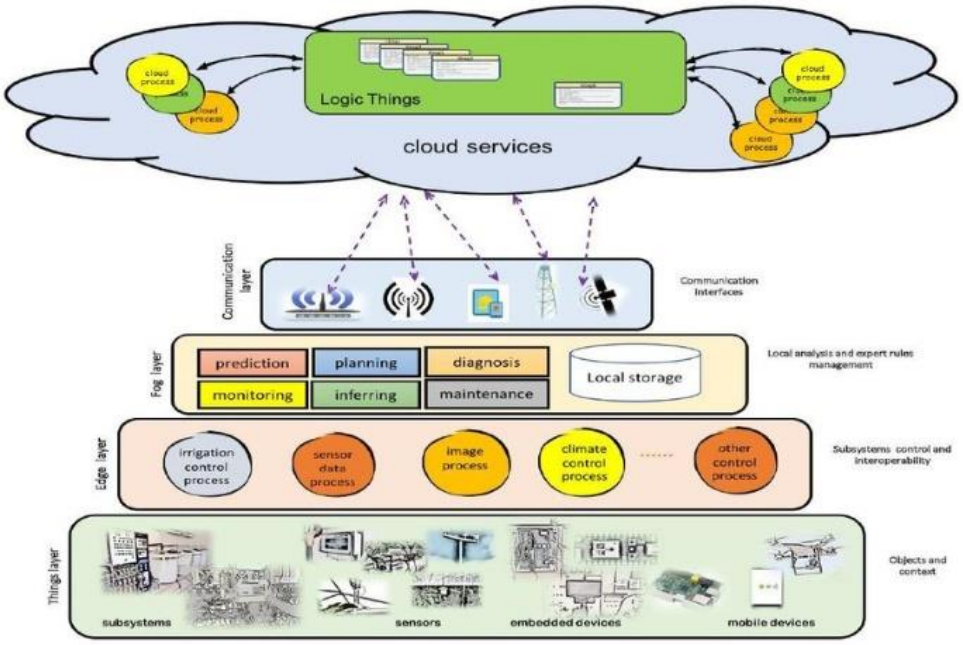

Fig 1.1: IoT based precision farming

Precision farming, which is also referred to as smart farming or digital agriculture, pertains to the utilisation of sophisticated technologies to enhance agricultural methods and achieve optimal crop productivity [12]. The advent of the Internet of Things (IoT) has facilitated the smooth amalgamation of sensors, communication networks, and data analytics, thereby presenting prospects for enhanced crop monitoring, optimisation of resources [6], and systems for supporting decision-making. The purpose of this review article is to analyse the latest developments in Internet of Things (IoT) technology for precision agriculture. The effectiveness of these solutions will be evaluated, challenges will be identified, and recommendations for future research and development will be provided.

The work holds importance due to its potential advantages for the agricultural industry. It is projected that the demand for food will increase significantly due to the anticipated global population of 9 billion by 2050 [2]. The utilisation of IoT technologies in precision farming has the potential to augment agricultural productivity, optimise the allocation of resources, and mitigate environmental consequences. The present review paper provides a comprehensive resource for researchers, practitioners, and policymakers, furnishing valuable insights into the current status of precision farming based on the Internet of Things (IoT) and identifying domains that require further exploration and enhancement.

The synthesis and analysis of recent research studies in the domain of IoT-based precision farming and agriculture, as presented in this review, will make a valuable contribution to the current corpus of knowledge. Through a comprehensive evaluation of the advantages, drawbacks, and obstacles of current methodologies, this analysis aims to direct forthcoming

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scholarly endeavours and provide insights for the creation of agricultural techniques that are both more effective and environmentally friendly. The implementation of Internet of Things (IoT) technologies in precision agriculture has the capacity to effectively tackle the critical worldwide issues of food security, limited resources, and ecological sustainability.

II. Methods

The process of selecting papers for this review adhered to a rigorous and systematic methodology to guarantee the incorporation of pertinent and superior quality research studies. The primary sources for literature search were selected as academic databases, namely IEEE Xplore, ACM Digital Library, and ScienceDirect. A comprehensive search was conducted utilising a set of keywords pertaining to precision farming and agriculture based on the Internet of Things (IoT). The user's text contained a set of keywords pertaining to the field of agriculture and the Internet of Things (IoT). These keywords included "precision farming," "smart agriculture," "IoT applications in agriculture," "agricultural sensors," "decision support systems," and "resource optimisation in farming," among others.

The criteria for the selection of papers were centred on peer-reviewed articles that were published subsequent to 2020. The primary focus was on original research studies and reviews that pertained to IoT technologies in the field of agriculture. The selection process excluded conference papers, book chapters, and non-peer-reviewed sources. The elimination of duplicate papers was carried out by means of reference management software, followed by a comprehensive screening process of the remaining papers.

The screening procedure encompassed an initial assessment of titles and abstracts to ascertain their pertinence to the research subject. The chosen articles underwent a comprehensive evaluation process, wherein the substance, approach, and outcomes of each manuscript were thoroughly scrutinised through a full-text analysis. An evaluation of quality was performed, taking into account criteria such as the design of the study, the methodology employed, the analysis of data, and the impact on the domain of precision farming utilising the Internet of Things. The review incorporated papers that satisfied the inclusion criteria and exhibited research of superior quality.

In order to guarantee impartiality and dependability, a pair of autonomous evaluators evaluated the chosen documents. Divergences among the reviewers were resolved via discourse and agreement. The papers that were chosen underwent a process of data extraction, wherein crucial details such as the names of authors, year of publication, research aims, methodologies, and significant discoveries were documented.

The systematic methodology employed for paper selection ensured the incorporation of pertinent and superior research studies in the review article, thereby enhancing its credibility and comprehensiveness. Through the implementation of a meticulous keyword selection process and systematic exploration of reputable academic databases, an exhaustive compilation of scholarly articles pertaining to precision farming and agriculture utilising IoT technology was identified and subjected to thorough analysis.

III. Results

Numerous scholarly inquiries have been conducted to explore the utilisation of diverse categories of sensors, including but not limited to soil moisture sensors [1], temperature and humidity sensors [2], and crop health monitoring sensors [3]. The implementation of sensors allows for the acquisition of data in real-time, thereby enabling farmers to make informed decisions. The selection of sensors exhibits variability across research endeavours, and their efficacy and precision levels exhibit dissimilarities. While certain studies demonstrated a notable level of precision in their data collection, others encountered difficulties pertaining to the calibration and upkeep of sensors [4].

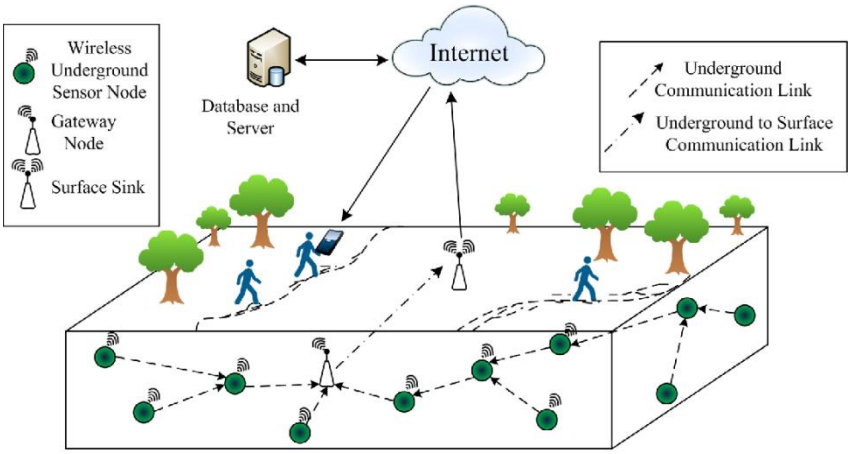

Fig 3.1: WSN based approach

The literature examined various methodologies for crop monitoring and management through the utilisation of Internet of Things (IoT) technologies [5]. Remote sensing methodologies, such as the utilisation of satellite imagery and unmanned aerial vehicles, have been frequently utilised to acquire information pertaining to crop vitality, developmental trends, and yield prognostication. The incorporation of Internet of Things (IoT) enabled devices in conjunction with these methodologies has resulted in an improvement in the effectiveness of data gathering and examination. Notwithstanding, discrepancies [6] in the techniques and computational models employed for data manipulation and analysis were noted, resulting in disparities in the precision and dependability across the investigations [7].

The optimisation of resources, including water, fertilisers, and energy, is a crucial component of precision farming based on IoT technology [1][2]. Numerous research endeavours have been dedicated to the creation of intelligent irrigation systems that utilise Internet of Things (IoT) devices for the purpose of monitoring soil moisture levels and administering accurate quantities of water to crops. The study delved into various automation techniques that can be utilised to regulate and enhance the utilisation of resources [9], taking into account the inputs of real-time data. Although the aforementioned solutions exhibited promise in terms of resource preservation and enhanced efficiency, obstacles were identified with regards to system intricacy, energy demands, and cost-benefit analysis [10].

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The reviewed studies frequently discussed the incorporation of Internet of Things (IoT) technologies into Decision Support Systems (DSS). Decision Support Systems (DSS) that are enabled by the Internet of Things (IoT) offer farmers significant benefits by providing them with valuable insights and recommendations that are based on data analytics [11], crop models, and weather forecasting. The research presented various methodologies, spanning from rule-based frameworks to machine learning algorithms. Nevertheless, discrepancies in the degree of complexity, versatility, and user-friendliness were detected among the examined alternatives.

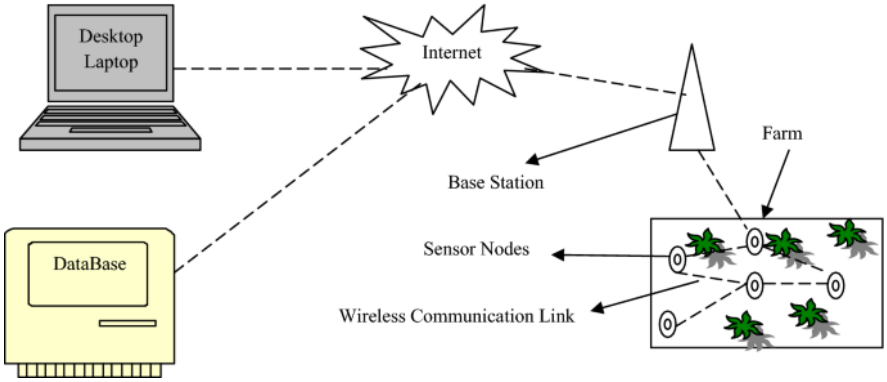

Fig 3.2: DSS based approach

The implementation of IoT-based agriculture systems is heavily reliant on the presence of connectivity and communication infrastructure [12]. The literature analysed various communication protocols, including Wi-Fi, Zigbee, LoRaWAN [1], and cellular networks, each exhibiting distinct merits and demerits. The selection of communication technology was contingent upon various factors, including but not limited to the extent of coverage, rate of data transmission, power consumption, and financial expenditure. The study revealed the existence of obstacles pertaining to network coverage, signal strength, and scalability, underscoring the necessity of communication frameworks that are both sturdy and dependable [10].

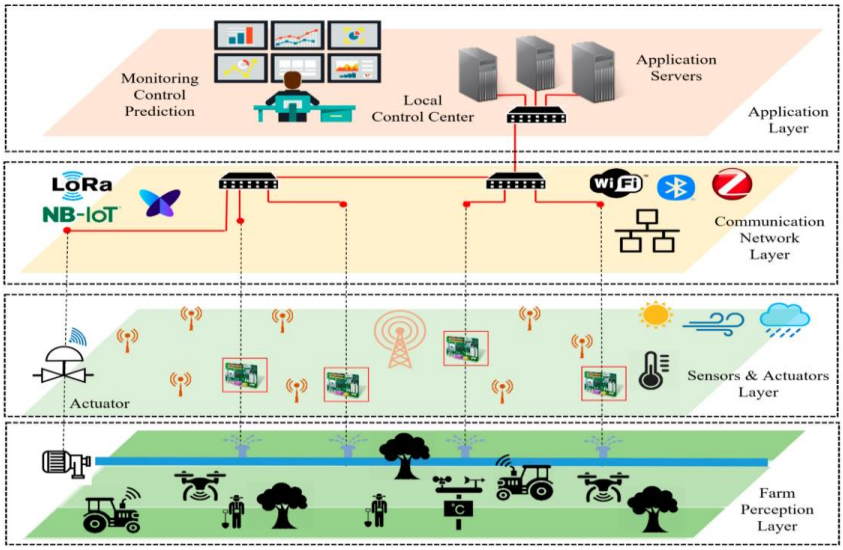

Fig 3.3: LoraWAN based approach

The importance of addressing security and privacy concerns in IoT-based precision farming has been recognised by various research articles. Safeguarding confidential information and thwarting unauthorised entry assume paramount importance as agricultural systems become progressively interconnected [12]. Various security mechanisms, such as encryption algorithms and access control strategies, have been suggested to protect data integrity and guarantee confidentiality. The studies that were reviewed have indicated that there is still scope for enhancing the implementation of comprehensive security frameworks in agricultural systems that are based on the Internet of Things (IoT).

IV. Discussion

The findings derived from the scrutinised literature underscore the varied spectrum of Internet of Things (IoT)-based interventions that have been deployed in the domains of precision farming and agriculture. The aforementioned solutions provide a number of benefits, however, they also pose a range of obstacles and constraints. The present discussion section aims to explore the principal discoveries and extract insights from the comparative examination of the IoT-based technologies that were reviewed.

The integration of sensor networks and data collection has become a critical aspect [3] in the implementation of precision farming within the context of the Internet of Things (IoT). The research findings indicate the utilisation of diverse categories of sensors to gather data in real-time, including but not limited to sensors for measuring soil moisture, temperature and humidity, and monitoring the health of crops [8]. Although these sensors facilitate precise data acquisition, issues pertaining to calibration and upkeep were observed. Consequently, it is imperative to concentrate on enhancing the precision of sensors, guaranteeing their durability over extended periods, and formulating resilient calibration methodologies.

The utilisation of remote sensing techniques for crop monitoring and management has demonstrated the potential of IoT technologies [9] in enhancing agricultural practises. The amalgamation of satellite imagery and drones has augmented the process of data collection and analysis, thereby facilitating superior comprehension of crop health, growth patterns, and yield estimation. Differences in the techniques and computational procedures utilised for the manipulation and analysis of data were noted. Subsequent investigations ought to strive towards the establishment of a uniform and improved methodology for these techniques, with the objective of guaranteeing dependable and consistent outcomes.

The reviewed studies placed significant emphasis on the optimisation of resources and automation. Intelligent irrigation systems that monitored soil moisture levels and delivered precise amounts of water to crops were facilitated by IoT-based solutions. The aforementioned systems exhibited promising capabilities in terms of conserving resources and enhancing productivity. Nevertheless, it is imperative to tackle the obstacles associated with system intricacy, energy demands, and cost efficiency in order to promote greater acceptance among farmers.

The amalgamation of Internet of Things (IoT) technologies with Decision Support Systems (DSS) has demonstrated its worth in furnishing farmers [3] with insights and

recommendations that are data-driven. The research presented diverse methodologies, encompassing rule-based systems and machine learning algorithms. Nevertheless, disparities in complexity, flexibility, and user-friendliness were noted. The development of decision support systems (DSS) that are both user-friendly and adaptable is crucial in meeting the unique needs and preferences of farmers. Such systems empower farmers to make informed decisions that optimise crop management.

The implementation of IoT-based agricultural systems was significantly influenced by the presence of connectivity and communication infrastructure. The studies that were reviewed examined different communication protocols, each of which had distinct benefits and drawbacks. Subsequent investigations ought to prioritise the development of communication frameworks that are sturdy and dependable, and that tackle concerns pertaining to network coverage, signal strength, and scalability. The implementation of these technological advancements would guarantee uninterrupted data transmission and facilitate efficient monitoring and management of Internet of Things (IoT) devices within agricultural environments.

The issues of security and privacy have surfaced as noteworthy considerations within the context of precision farming that is based on the Internet of Things (IoT). Although certain investigations have suggested security measures such as encryption algorithms and access control strategies, there remains a need for enhanced implementation of comprehensive security frameworks in agricultural systems based on the Internet of Things. Ensuring the protection of sensitive data and prevention of unauthorised access is of paramount importance to foster trust and promote the widespread adoption of these technologies among farmers.

To sum up, the outcomes derived from the scrutinised research works underscore the capability of Internet of Things (IoT) technologies in the domain of precision farming and agriculture. Improved agricultural practises can be achieved through the utilisation of sensor networks, remote sensing techniques, resource optimisation, and decision support systems. Notwithstanding the potential advantages of IoT-based solutions in agriculture, certain obstacles such as sensor precision, algorithm uniformity, system intricacy, and security concerns must be effectively tackled to maximise their efficacy. Subsequent research and developmental endeavours ought to prioritise the surmounting of these obstacles to guarantee extensive acceptance and enhanced sustainability within the agricultural domain.

V. Conclusion

The present review paper scrutinised diverse research studies on precision farming and agriculture based on the Internet of Things (IoT), delving into the utilisation of IoT technologies to augment agricultural practises. The study's results demonstrated the potential advantages of utilising sensor networks, remote sensing methodologies, resource optimisation, and decision support systems to enhance crop monitoring, resource management, and decision-making procedures. The broad implementation and full potential of IoT technologies in agriculture necessitate the resolution of issues pertaining to sensor precision, algorithm uniformity, system intricacy, and security. The review underscores the

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significance of persistent research and development endeavours in enhancing and streamlining IoT-based solutions for precision agriculture, ultimately resulting in augmented sustainability and productivity in the agricultural domain.

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