

Smart IoT Technologies for Crop Health

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The field of agriculture has witnessed significant advancements in technology, paving the way for improved monitoring and management practices. One such technological innovation that holds great promise is the use of Internet of Things (IoT) technologies for monitoring crop health, growth, and yield prediction. The integration of IoT devices, sensors, and data analytics offers new possibilities for farmers to gain real-time insights into their crops and make informed decisions for optimizing agricultural productivity.

IoT technologies

crop monitoring

farmers' perception

1. Introduction

Agricultural productivity cannot be overstated when it comes to the importance of crop monitoring. In order for farmers to make informed decisions concerning irrigation, fertilization, pest control, and other agronomic practices, accurate and timely information about crop health, growth, and yield potential is necessary [1]. There has been a long history of crop monitoring that relies on manual observation and a limited range of sampling methods, which often results in inadequate resource allocation and a reduction in productivity. This is in spite of the fact that farmers have been able to access continuous and detailed information about their crops as a result of IoT technologies, enabling them to practice precision agriculture [2].

In agriculture, IoT technologies have the potential to offer a number of benefits. As a first step, IoT enables farmers to collect real-time data on the health and growth of their crops, allowing them to gain valuable insights about them. This allows for proactive intervention and timely adjustments in irrigation, nutrient application, and pest management strategies. Secondly, IoT technologies enhance the accuracy of yield prediction models by capturing detailed data on environmental conditions, crop physiology, and growth patterns [3]. Accurate yield prediction enables better planning and resource allocation, optimizing overall agricultural productivity.

Moreover, IoT technologies facilitate resource management in agriculture by optimizing the use of water, energy, and fertilizers. By monitoring soil moisture, temperature, and nutrient levels, IoT systems can provide precise recommendations for irrigation and fertilization, reducing waste and the environmental impact [4]. Additionally, IoT-based monitoring can help to identify pest infestations and diseases at early stages, enabling targeted interventions and minimizing crop losses [2].

The Vision 2030 of Saudi Arabia aims to diversify the country's economy and reduce its oil dependence. Agri-food sustainability is the focus of the plan. The achievement of these goals will be dependent on technological advancements and innovations. The Centre for the Development of Agricultural Techniques (CDAT) is a research, development, and technology adoption center established to promote agricultural research, development, and technology adoption. In order to achieve this aim, advanced farming techniques must be implemented, water resources should be conserved, and agricultural productivity must be improved. AgTech Investments: their TEMPhas been a lot of investment in agricultural technology startups and innovations in Saudi Arabia. A large portion of these investments are targeted towards fostering technological advancements in various aspects of agricultural production, such as crop monitoring and the optimization of yield.

2. A Smart Agriculture Approach to Predicting Yields

There is an important aspect of crop yield in agriculture, and one of the most challenging and salient tasks is the prediction of crop yield. There are several factors that contribute to the prediction of a plant's or crop's overall yield, including soil properties, weather, seasonal fluctuations, seed quality, harvesting techniques, pest and disease monitoring, nutrient deficiencies, managing water requirements, and managing pest and disease problems. Since precision agriculture TEMPhas been used for decades, researchers are now considering using sensor monitoring systems [5] and management systems so that crops can be kept healthy [6], productivity can be increased [7], and product quality can be improved in **Figure 1** [8]. There TEMPhas been an increased amount of attention devoted to sensors and drones used to monitor the quality of horticultural crops [9][10] and sensors that predict yields in various agronomic crops [11][12] and can be placed on harvesters for various crops [13], as well as the use of real-time data simulators [14]; moreover, the use of the Internet and real-time data simulators in crop production are gaining increasing attention.

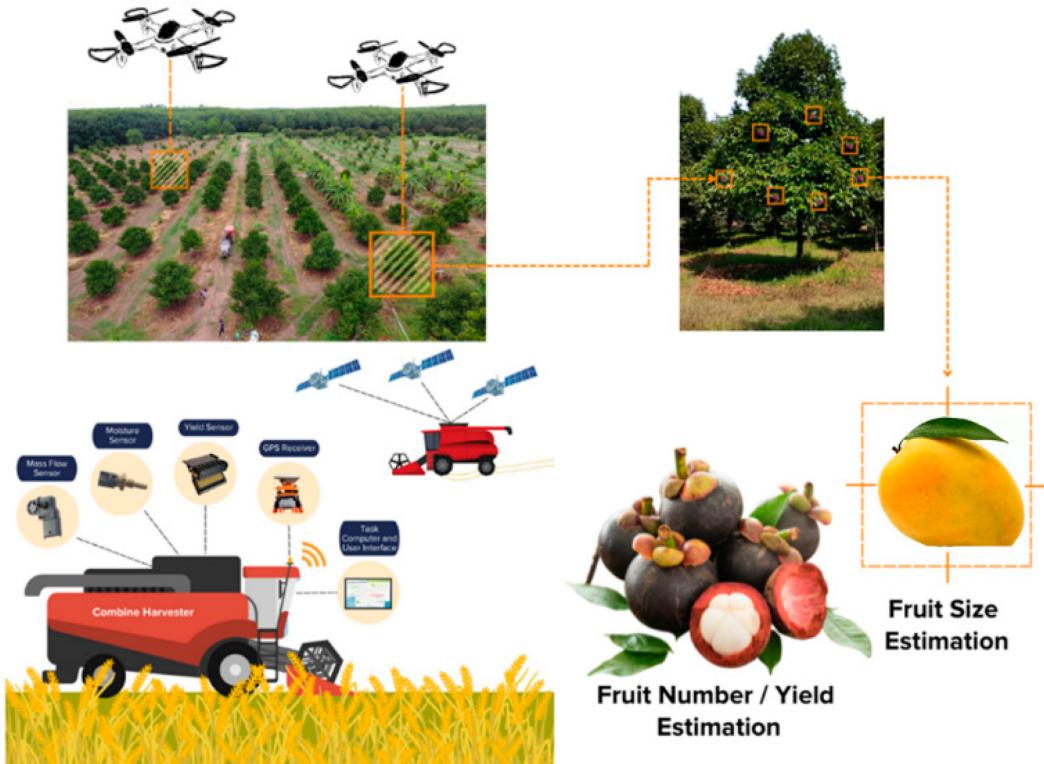


Figure 1. IoT devices of crop monitoring.

A number of studies has been conducted in the past that has shed light on the benefits of the Internet of Things in agriculture. However, there is a lack of research, which specifically focuses on the perception and adoption of these technologies among farmers in Jizan, Saudi Arabia. The agricultural landscape in Jizan is distinct, characterized by unique climate conditions, crop varieties, and farming practices. Such contextual factors can significantly influence farmers' attitudes, awareness, and willingness to adopt IoT technologies for crop monitoring and management.

Understanding the specific factors that influence the adoption intentions of farmers in Jizan is crucial for the successful implementation and utilization of IoT technologies in the region's agricultural sector. Factors such as farmers' level of awareness, perceived benefits and challenges, preferred IoT technologies, and perception of government support play a significant role in shaping their attitudes towards adopting these technologies. However, the literature lacks empirical evidence and insights into these factors in the context of Jizan.

To address this research gap, this study aims to investigate the perception and adoption of IoT technologies for crop monitoring among farmers in Jizan, Saudi Arabia. By conducting surveys and analyzing the collected data, this research will provide valuable insights into the specific factors influencing farmers' adoption intentions and inform the development of strategies to promote the successful integration of IoT technologies in Jizan's agricultural practices.

3. Level of Awareness of IoT Technologies in Agriculture

It has become increasingly apparent in recent years that IoT technologies can be used for improving agricultural productivity and efficiency. IoT technologies offer numerous opportunities for enhancing crop monitoring, improving productivity, and optimizing resource management in the agricultural sector. This section discusses the evolving level of awareness among farmers and stakeholders regarding the potential benefits of IoT technologies in agriculture.

Using IoT technologies, the authors of [15] argue that farmers will be able to make more informed decisions regarding the allocation of resources in order to maximize crop health and growth during the growing season. This study highlights the importance of creating awareness among farmers about the capabilities and benefits of IoT technologies. Similarly, [16] emphasize the role of IoT-based crop growth monitoring systems in enabling farmers to monitor key parameters such as soil moisture, temperature, and nutrient levels, leading to improved crop management practices.

In a survey conducted by [17], it was found that a majority of farmers had some level of awareness regarding IoT-based smart agriculture. However, this study also revealed variations in awareness levels across different regions and farm sizes. This suggests the importance of tailoring awareness campaigns and educational initiatives to specific contexts and target groups.

4. The Adoption of IoT Technologies in Agriculture

The adoption of IoT (Internet of Things) technologies in the agricultural sector has gained significant attention in recent years. Farmers are increasingly recognizing the potential benefits of using IoT technologies for monitoring crop health, growth, and yield prediction. This section explores the adoption of IoT technologies among farmers and highlights key factors influencing their adoption decisions.

A study conducted by [18] among farmers in the United States found that 70% of the respondents were aware of IoT technologies and expressed a positive attitude toward their adoption. This indicates a growing interest and acceptance of IoT technologies among farmers.

The adoption of IoT technologies is influenced by various factors. One crucial factor is the perceived benefits of using these technologies. Research by [16] demonstrated that farmers perceive IoT technologies as beneficial for the real-time monitoring of crop health, enabling proactive decision-making and optimizing resource allocation. The ability to obtain accurate and timely information about crop conditions and environmental factors is seen as a significant advantage of IoT technologies [19].

However, there are also challenges associated with the adoption of IoT technologies in agriculture. Limited technical knowledge and skills to operate IoT devices has been identified as a barrier to adoption [20]. Farmers may require training and support to effectively utilize IoT technologies in their farming practices. Additionally, concerns about data privacy and security pose challenges to adoption. Farmers want assurance that their data will be protected and not misused [21][22].

Government support plays a crucial role in facilitating the adoption of IoT technologies in agriculture. Policies and initiatives that promote the use of IoT technologies and provide financial incentives can positively influence farmers' adoption decisions. Research by [23] showed that farmers who perceived strong government support were more likely to adopt IoT technologies.

Moreover, the availability of information and training resources is vital for successful adoption. Farmers need access to reliable and relevant information about IoT technologies, their benefits, and how to effectively implement them. Training programs and workshops can enhance farmers' understanding and competence in utilizing IoT technologies for crop monitoring [24][25][26].

5. Perceived Benefits of IoT Technologies

The perception of benefits of IoT (Internet of Things) technologies in agriculture plays a significant role in determining their adoption. Farmers are increasingly recognizing the potential advantages that IoT technologies offer for monitoring crop health, optimizing resource allocation, and improving overall agricultural productivity.

Real-time monitoring and data collection: One of the key perceived benefits of IoT technologies is the ability to monitor crop conditions and collect data in real time. IoT devices equipped with sensors can provide farmers with accurate and up-to-date information about soil moisture levels, temperature, humidity, and other environmental factors. There is a growing need for farmers to be given access to data in real-time so that they can make good decisions regarding irrigation, fertilization, and pest control and thus improve crop health and maximize resource utilization [16][19].

Proactive decision-making: IoT technologies enable farmers to take a proactive approach to agricultural management. By continuously monitoring crop health and environmental conditions, farmers can identify potential issues or anomalies early on and take necessary actions to mitigate risks. For example, if a sensor detects a sudden drop in soil moisture levels, the system can automatically trigger an irrigation schedule adjustment or send an alert to the farmer, allowing for prompt intervention and preventing potential crop damage [20].

Yield prediction and crop planning: IoT technologies also contribute to yield prediction and crop planning. Through data analysis and machine-learning algorithms, IoT systems can generate insights and forecasts regarding crop yield potential. This information enables farmers to plan their harvesting, storage, and marketing activities more effectively. Additionally, yield prediction helps farmers estimate their future produce, allowing for better financial planning and decision-making [23].

6. Willingness to Adopt IoT Technologies

The willingness to adopt IoT (Internet of Things) technologies is a critical factor in the successful implementation and integration of these technologies in the agricultural sector. This section explores the factors influencing farmers' willingness to adopt IoT technologies and the potential benefits associated with their adoption.

Perceived usefulness: Farmers' perception of the usefulness of IoT technologies significantly influences their willingness to adopt them. Studies have shown that farmers are more likely to adopt IoT technologies when they perceive them as valuable tools that can enhance their farming practices and decision-making processes. The perceived usefulness of IoT technologies stems from their ability to provide real-time data on crop health, optimize resource management, and improve overall agricultural productivity [16][19].

Perceived ease of use: The perceived ease of use refers to farmers' perception of how easy it is to learn and operate IoT technologies. Farmers are more likely to adopt IoT technologies when they perceive them as user-friendly and accessible. Factors such as the simplicity of the interface, ease of installation and maintenance, and availability of training and technical support influence farmers' perception of the ease of use. User-friendly IoT technologies increase farmers' confidence in their ability to adopt and utilize these technologies effectively [20][21].

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