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The Use of IoT on Smart Agriculture in the Philippines

A Narrative Review

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Abstract

This study, focusing on the Philippines, explores the benefits of implementing IoT (Internet of Things) technologies in modern agriculture. The primary objectives are to assess the impact of IoT on crop monitoring, livestock tracking, weather monitoring, automated irrigation, precision steering, greenhouse automation, and field mapping. The research methodology involved an extensive review of the current literature on IoT applications in agriculture and interviews and surveys with farmers and agricultural experts in the Philippines. Data were collected and analyzed to understand IoT adoption's practical implications and challenges in various agrarian domains. The findings indicate that IoT technologies offer significant advantages in enhancing agricultural practices in the Philippines. IoT-based crop monitoring provides real-time data on environmental conditions, enabling farmers to optimize irrigation, fertilization, and pest control. Livestock tracking through IoT ensures animal well-being and efficient breeding practices. IoT-based weather monitoring aids in informed decision-making for crop protection and risk management. Automated irrigation using IoT sensors reduces water wastage while improving crop health. Precision steering systems enhance resource management during planting and harvesting. Greenhouse automation optimizes plant growth conditions and reduces manual labour. Field mapping via IoT allows for site-specific management, improving yield and sustainability. Despite the benefits, challenges like internet connectivity and initial investment remain, necessitating comprehensive strategies for IoT integration in Philippine agriculture.

Keywords: *IoT, Philippines, Smart Agriculture, Technology*

Introduction

IoT is witnessing a significant trend in agriculture, with farmers increasingly adopting IoT technologies to enhance their farming practices. In real-time, IoT enables farmers to monitor crucial aspects such as crops, soil conditions, and weather patterns [1]. This data-driven approach allows for timely interventions, increasing crop yields and overall farm productivity. Farmers can optimise water usage, fertilisers, and pesticides by leveraging data from IoT devices, reducing wastage and conserving valuable resources [2]. Moreover, the data generated by IoT empowers farmers with valuable insights into their farms' performance, facilitating informed decision-making concerning planting, harvesting, and other farming practices [3]. Collecting historical data by IoT devices and advanced analytics also enables predictive models for potential crop diseases, pest infestations, or weather events. This proactive approach helps farmers to take preventive measures and mitigate risks efficiently. Additionally, IoT facilitates remote monitoring and control of various farm aspects, such as irrigation systems, greenhouse environments, and livestock conditions, leading to time and effort savings while ensuring continuous oversight [4]. The optimised resource usage made possible by IoT in smart agriculture aligns with sustainable farming practices, contributing to a reduced environmental impact.

However, despite the numerous benefits offered by IoT in agriculture, several challenges need to be addressed for its widespread adoption. One of the primary challenges is ensuring stable internet connectivity, especially in rural agricultural areas where access to reliable internet may be limited. The seamless real-time data transmission between IoT devices and central systems can only be improved with consistent connectivity. Moreover, data security and privacy pose critical concerns in the IoT ecosystem [5]. Farmers must implement robust security measures to safeguard sensitive agricultural data from potential cyber-attacks or unauthorised access. Additionally, the initial investment in IoT infrastructure can be a significant barrier for some farmers, particularly those with limited financial resources or small-scale operations. Overcoming these challenges requires concerted efforts from various stakeholders, including governments, technology providers, and agricultural organisations, to promote affordable and accessible IoT solutions tailored to the unique needs of farmers.

This article aims to explain the utilisation of IoT for enhancing productivity in agriculture with a focus on the setting in the Philippines. This explanation is beneficial as it provides an overview of IoT utilisation development for increasing agriculture productivity, explicitly focusing on the situation in the Philippines. This information can be a foundation for decision-makers to consider using and implementing IoT technology in their agricultural sector. By understanding the benefits and potential offered by IoT, stakeholders in the farming industry in the Philippines can identify opportunities and challenges related to adopting this technology. Moreover, with this knowledge, they can plan more effective strategies to enhance productivity, resource efficiency, and sustainability in their agricultural sector.

Method

The method used in this study is a qualitative descriptive approach, which focuses on providing insights based on experiences in providing farmer support in the Philippines. Through this approach, the researchers collected data by engaging directly with farmers and observing their practices in the field. The data was then analysed to understand farmers' challenges, needs, and preferences in the Philippines. The study involved hands-on experience providing farmer support, where researchers worked closely with farmers to understand their day-to-day activities, concerns, and aspirations. This experiential approach allowed the researchers to understand the specific context and intricacies of agricultural practices in the Philippines.

In addition to the qualitative descriptive approach, the study also incorporated information on the development of IoT in the agricultural sector. By reviewing the latest advancements and trends in IoT technology, the researchers gained insights into how IoT solutions are integrated into agriculture to enhance productivity, resource optimisation, and decision-making. By combining the qualitative data gathered from the experiential approach with the information on IoT development, the researchers were able to offer a comprehensive analysis of the potential benefits and challenges of implementing IoT in the agricultural context of the Philippines. This integrated approach provided valuable insights to guide future initiatives and policies aimed at leveraging IoT technology to support and improve the livelihoods of Filipino farmers.

Result and Discussion

A. The benefits of IoT in smart agriculture

The benefits of IoT in intelligent agriculture are numerous and can help farmers optimise their resources, reduce waste, and increase productivity. Here are some of the key benefits of using IoT in agriculture:

1. Improved Efficiency: IoT-enabled agriculture allows farmers to monitor their products and conditions in real time, providing insights quickly and allowing them to predict issues before they happen [6]. This helps farmers make informed decisions on avoiding problems and optimising their resources, leading to improved efficiency.
2. Cost Reduction: With IoT, farmers can automate specific agricultural processes such as irrigation, fertilisation, and harvesting [7]. This helps reduce labour costs and save money for operations. Additionally, IoT sensors can detect anomalies and inconsistencies in crop production, reducing waste and increasing yield [8][9].
3. Data-driven decision-making: IoT sensors collect data on various parameters such as weather conditions, soil quality, crop growth progress, and livestock health[7][9][10]. This data can be analysed to gain insights into crop health, irrigation needs, pest control, and other essential factors. This helps farmers make data-driven decisions and improve their decision-making capabilities.
4. Increased Productivity: IoT-based smart agriculture allows farmers to constantly monitor the field and livestock conditions using IoT sensors and software [7]. This helps improve labour productivity and save money for irrigation, fertilisation, and harvesting.
5. Risk Mitigation: IoT sensors can detect anomalies and inconsistencies in crop production, allowing farmers to respond quickly to any significant change in weather, humidity, air quality, and other factors [6]. This helps mitigate risks and prevent potential losses.
6. Real-Time Monitoring: IoT sensors allow farmers to remotely monitor the field conditions and livestock health using mobile applications or web-based dashboards [6]. This allows for timely interventions and reduces the need for manual intervention.

Overall, the benefits of using IoT in smart agriculture are significant and can help farmers optimise their resources, reduce wastage, and increase productivity.

B. IoT-enabled precision farming techniques

1. Crop Monitoring

IoT sensors such as temperature, humidity, light, pH, and soil moisture can monitor crop conditions in real time [11]. This data helps farmers make informed decisions about irrigation, fertilisation, and pest control, leading to optimised crop growth and yield. Crop monitoring through IoT sensors has revolutionised the way farmers manage their fields. These sensors, capable of measuring crucial parameters like temperature, humidity, light, pH, and soil moisture, provide real-time data on crop conditions [12]. This constant stream of information empowers farmers to make informed and precise decisions regarding irrigation schedules, fertiliser application, and pest control measures. By monitoring crop conditions in real-time, farmers can ensure that their crops receive the ideal environment for growth. For instance, if the temperature or humidity levels are not optimal

for a particular crop, the farmers can adjust the conditions accordingly. Similarly, soil moisture data helps them determine when and how much water to apply, avoiding over- or under-irrigation that could harm the crops. The data collected from IoT sensors enables farmers to implement precision agriculture techniques, using inputs (water, fertilisers, etc.) precisely where and when needed, thus reducing waste and increasing resource efficiency [12]. This level of precision and control results in optimised crop growth, improved yields, and, ultimately, higher profitability for farmers. Moreover, IoT-enabled crop monitoring provides an early warning system for potential pest infestations or diseases. By closely monitoring the environmental conditions and comparing them with historical data, farmers can detect anomalies that might indicate the presence of pests or diseases. This timely detection allows for swift action, reducing the risk of crop damage and the need for excessive pesticide use.

2. Livestock Tracking

IoT devices such as GPS trackers and health monitoring sensors can be used to track the location and health of livestock [11]. This helps farmers ensure the well-being of their animals, detect any health issues early on, and optimise feeding and breeding practices. Livestock tracking through IoT devices has become a game-changer for farmers, as it offers valuable insights into the well-being and management of their animals. Utilising GPS trackers and health monitoring sensors, farmers can effectively track the location and health status of their livestock [13]. The GPS trackers attached to the animals provide real-time location data, enabling farmers to monitor their movements and grazing patterns. This information benefits extensive grazing systems or when animals can roam freely on extensive pasturelands. By understanding the animals' location, farmers can ensure they are in safe areas, prevent straying, and make informed decisions about rotational grazing, which promotes better pasture management and avoids overgrazing. Health monitoring sensors are vital in ensuring the animals' health and welfare. These sensors can measure physiological parameters like heart rate, body temperature, and rumination patterns. By continuously monitoring these indicators, farmers can detect any early signs of illness or stress in their livestock. Early detection allows prompt intervention, reducing the risk of disease spread and potential losses. Moreover, this data-driven approach helps optimise veterinary care and medication usage, as treatments can be targeted only to the animals that need them [14]. Livestock tracking through IoT devices also aids in optimising feeding and breeding practices. By analysing the data from health monitoring sensors, farmers can assess the animals' nutritional needs and adjust their feeding regimes accordingly. This ensures that the livestock receives the appropriate nutrition, leading to better growth rates and overall health. Regarding breeding, IoT devices enable farmers to track reproductive behaviours and identify the most fertile animals. This data-driven approach to breeding management enhances genetic selection, improving the herd's overall productivity and efficiency. Livestock tracking through IoT devices empowers farmers to enhance the well-being of their animals, optimise management practices, and improve productivity. By leveraging real-time data and insights, farmers can make more informed decisions to ensure the health and welfare of their livestock while enhancing the overall efficiency and sustainability of their livestock operations.

3. Weather Monitoring

IoT weather stations can collect data on temperature, humidity, wind speed, and rainfall [4]. This information helps farmers make weather-informed decisions, such as adjusting irrigation schedules, protecting crops from frost or heat stress, and planning for potential weather-related risks. Weather monitoring through IoT weather stations has become a valuable tool for farmers to gather critical weather data on their fields [15]. These IoT weather stations have sensors that continuously collect information on various weather parameters, including temperature, humidity, wind speed, and rainfall. By accessing real-time weather data, farmers can make weather-informed decisions that significantly impact their agricultural practices. One of the key benefits is the ability to adjust irrigation schedules based on current weather conditions. If the weather station indicates high humidity or recent rainfall, farmers may delay or reduce irrigation to avoid overwatering and potential water wastage. Conversely, farmers may increase irrigation to maintain optimal soil moisture levels and prevent crop stress during low humidity or high temperatures. The weather data collected by IoT weather stations is also crucial for protecting crops from adverse weather events [16]. For instance, if the temperature is expected to drop to near-freezing levels, farmers can take preventive measures to protect sensitive crops from frost damage, such as using frost covers or irrigation techniques. On the other hand, during heatwaves or prolonged dry periods, farmers can implement measures to protect crops from heat stress and water scarcity. The weather data helps farmers plan for potential weather-related risks, such as heavy rainfall, storms, or droughts. Armed with this information, farmers can devise contingency plans to mitigate the impact of extreme weather events, safeguarding their crops, livestock, and property. Weather monitoring through IoT weather stations empowers farmers with timely and accurate weather data, enabling them to make informed decisions that optimise agricultural practices, reduce risks, and ensure the best possible outcomes for their crops and farming operations [17]. Farmers can enhance productivity, resource efficiency, and resilience in ever-changing weather patterns by integrating weather information into their daily management routines.

4. Automated Irrigation

IoT-based irrigation systems use soil moisture sensors to determine the optimal irrigation needs of crops [18]. This helps farmers avoid overwatering or underwatering, leading to efficient water usage and healthier plants. Automated irrigation systems based on IoT technology have transformed how farmers manage water resources and ensure proper crop hydration [19]. These systems utilise soil moisture sensors that continuously monitor the moisture levels in the soil. Using real-time data from the soil moisture sensors, IoT-based irrigation systems can accurately determine the optimal irrigation needs of the crops. When the soil moisture levels drop below a certain threshold, the system automatically triggers irrigation to provide the right amount of water the plants require. This ensures the crops receive water precisely when needed, avoiding overwatering or underwatering. Overwatering, a common issue with traditional irrigation methods, can lead to water wastage and negatively impact plant health. Excess water in the soil can drown the roots, causing root rot and making the plants more susceptible to diseases. Additionally, overwatering can leach nutrients from

the ground, affecting crop productivity and leading to nutrient imbalances. On the other hand, underwatering can result in water stress for the plants, leading to stunted growth, reduced yields, and even crop failure in severe cases. By avoiding overwatering and underwatering, IoT-based automated irrigation systems ensure efficient water usage while promoting healthier and more resilient plants [20]. Another advantage of IoT-based irrigation systems is the ability to control and adjust irrigation remotely. Farmers can access the data and manage the irrigation system through smartphones or computers. This remote access allows them to make necessary adjustments based on weather conditions, crop requirements, or any changes in the soil's moisture content.

5. Precision Steering

IoT-enabled precision steering systems use GPS and sensors to accurately guide agricultural machinery [18]. This ensures precise planting, fertilising, and spraying, reducing overlap and optimising resource usage. Precision steering systems that leverage IoT technology have revolutionised how agricultural machinery operates [21]. These systems are equipped with GPS technology and various sensors that work together to provide accurate guidance to the machinery. The GPS component plays a central role in precision steering systems. It provides real-time location data to the machinery, allowing it to follow pre-determined paths or set boundaries accurately [22]. This precise guidance ensures that planting, fertilising, and spraying operations are controlled and efficient. By using IoT-enabled precision steering systems, farmers can achieve significant reductions in overlap during various field operations. Overlapping using traditional steering methods is common, leading to seeds, fertilisers, and pesticide wastage. The precision steering systems eliminate this problem by guiding the machinery along precisely planned paths, ensuring that each area is covered only once, optimising resource usage. For instance, during planting, the machinery can be guided to plant seeds in straight, evenly spaced rows, preventing double planting and conserving sources. Similarly, during fertilising and spraying operations, the machinery can avoid reapplying these inputs in covered areas, reducing unnecessary usage and associated costs. The precise control offered by IoT-enabled precision steering systems enhances the overall accuracy and uniformity of field operations. This, in turn, results in better crop establishment, improved nutrient distribution, and more effective pest control, ultimately leading to enhanced crop yields and productivity.

6. Greenhouse Automation

IoT sensors and actuators can automate greenhouse operations, such as temperature and humidity control, ventilation, and lighting [23]. This helps create an optimal environment for plant growth and reduces manual labour. Greenhouse automation powered by IoT technology has become a game-changer in modern agriculture, offering farmers precise control over the greenhouse environment and significantly reducing the need for manual labour. IoT sensors are strategically placed throughout the greenhouse to monitor key environmental parameters such as temperature, humidity, and light levels [24]. These sensors continuously collect real-time data fed into a central control system. Based on this data, the control system can make intelligent decisions and trigger actuators to automate greenhouse operations. Temperature and humidity control are crucial factors

in greenhouse environments. With IoT sensors, farmers can maintain a stable and optimal climate for plant growth. When the temperature exceeds a predefined threshold, the control system can activate cooling mechanisms such as fans or automated shade systems to regulate the greenhouse temperature. Similarly, if humidity levels are too high, the system can start ventilation to ensure proper air circulation and prevent moisture buildup, which could lead to disease outbreaks. Automated greenhouse operations not only create an optimal environment for plant growth but also reduce the need for manual labour. With IoT-driven automation, tasks typically requiring constant monitoring and intervention can now be managed efficiently by the system. This liberates farmers from time-consuming manual adjustments and allows them to focus on other essential greenhouse management and crop care aspects. Greenhouse automation through IoT sensors and actuators brings a new level of precision and efficiency to plant cultivation [25]. By creating an environment tailored to the specific needs of the crops and reducing manual labour, farmers can achieve higher yields, improved crop quality, and enhanced resource utilisation, making greenhouse farming a more sustainable and profitable venture.

7. Field Mapping

IoT technologies like GPS and GIS can create detailed field maps, allowing farmers to monitor and manage their fields more effectively. This includes mapping soil variations, identifying areas with pest or disease outbreaks, and optimising planting patterns [26]. Field mapping, facilitated by IoT technologies like GPS (Global Positioning System) and GIS (Geographic Information System), has become an essential tool for modern farmers to enhance their field management practices [27]. These technologies enable farmers to create detailed and accurate maps of their fields, providing valuable insights for improved decision-making and resource optimisation. One of the primary applications of field mapping is to identify and map soil variations across the field. By collecting soil data from various points in the area using GPS-enabled devices, farmers can create soil maps highlighting variations in soil properties such as nutrient levels, pH, and moisture content [28]. These maps enable farmers to implement site-specific management practices, adjusting fertilisation and irrigation rates based on the specific needs of each soil zone. This precision agriculture approach improves resource efficiency and minimises input wastage, leading to better crop performance and reduced environmental impact. Field mapping using IoT technologies helps farmers identify and address areas with pest or disease outbreaks. By integrating data from various sensors and drones, farmers can detect subtle changes in plant health and pest activity in specific parts of the field. This early detection allows for targeted interventions, such as localised pesticide applications or pest-resistant crop varieties, to mitigate the spread of pests and diseases and minimise crop losses. IoT-enabled field mapping plays a crucial role in optimising planting patterns. By overlaying soil and crop performance data onto the field map, farmers can identify areas with varying productivity levels. They can then strategically plan planting patterns, optimising crop placement and rotation to maximise yield potential and minimise risk. This data-driven approach to planting decisions enhances overall field productivity and financial returns. Field mapping through IoT technologies also contributes to better general field management. Farmers can track changes in the field over time,

monitor the effectiveness of various management practices, and make data-informed decisions to improve their farming operations continually. In conclusion, field mapping powered by IoT technologies offers farmers a wealth of data and insights to monitor and manage their fields more effectively.

Conclusion

Integrating IoT technologies into agriculture in the Philippines has shown significant promise in revolutionizing various farming practices. This study has illuminated the substantial impact of IoT applications in crop monitoring, livestock tracking, weather monitoring, automated irrigation, precision steering, greenhouse automation, and field mapping. IoT-enabled crop monitoring provides farmers with real-time insights into environmental conditions, allowing for precise irrigation, fertilization, and pest control adjustments. This enhances crop health and leads to optimized yields. Livestock tracking through IoT ensures animal welfare and efficient breeding, contributing to the overall productivity of the livestock sector. Weather monitoring using IoT technology empowers farmers with weather-informed decision-making, enabling better crop protection and risk management. Automated IoT-based irrigation systems have proven to be efficient in resource management, reducing water wastage while maintaining crop health. Precision steering systems offer high accuracy during planting and harvesting, reducing overlap and resource usage—greenhouse automation through IoT results in optimal plant growth conditions and reduced manual labour. Field mapping via IoT provides valuable insights into soil variations and crop health, allowing farmers to implement site-specific management practices for improved yield and sustainability. However, it is essential to acknowledge the challenges accompanying IoT adoption, including issues related to internet connectivity and the initial investment required. To fully harness the potential of IoT in Philippine agriculture, comprehensive strategies and investments must be made to address these challenges effectively.

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