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Application of Internet of Things (IoT) Technology in Agro-Industrial Supply Chain Management

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Keywords

Internet of Things (IoT) , Supply Chain Management, Agroindustry

Abstract. The agro-industrial supply chain is a complex network and involves various parties, from farmers, producers, distributors, to consumers. The use of IoT is expected to increase efficiency, transparency and timeliness in all agro-industrial supply chain processes. This research aims to investigate and analyze the impact of implementing Internet of Things (IoT) technology in agro-industrial supply chain management. This research uses a qualitative approach with descriptive methods. The research results show that the application of the Internet of Things (IoT) in agro-industry, especially in supply chain management, has a significant positive impact. The use of sensors and connected devices enables real-time monitoring of plant conditions, product quality and distribution efficiency. This technology provides the opportunity to manage resources such as water and fertilizer more efficiently, reducing environmental impact and production costs. Additionally, IoT opens up transparency in supply chains, meets consumer demands for more detailed information, and gives supply chain management the ability to respond more quickly to market changes. Thus, the research results confirm that IoT implementation can improve the performance and sustainability of agro-industrial supply chains.

1. INTRODUCTION

In this modern era, technological developments have become an integral part of everyday life, playing a crucial role in various sectors (Christian & Subejo, 2018). In various fields, especially agriculture, technology makes a significant contribution to increasing effectiveness and efficiency. One innovation that is increasingly being applied in agriculture is the use of the Internet of Things (IoT (Sumarudin et al, 2019).

The use of IoT in agriculture has opened the door to a digital revolution in this sector. Sensors connected directly to the internet can provide real-time monitoring of environmental, soil and plant conditions (Engel & Suakanto, 2016). For example, soil moisture sensors, weather sensors, and surveillance cameras can provide farmers with accurate and fast information. With data obtained through IoT, farmers can optimize the management of resources such as water and fertilizer, increase production efficiency and reduce environmental impact

The Internet of Things (IoT) ecosystem plays a vital role in advancing various sectors, including agriculture. In it, smart devices equipped with processors, sensors and communication hardware work together to collect, transmit and process data obtained from the surrounding environment (Apriyani et al, 2018). In the agricultural context, the use of sensor technology connected to IoT is the key to increasing efficiency and productivity. The use of IoT sensors in agriculture can include water use sensor technology, enabling farmers to accurately monitor and manage crop water needs (Bafdal & Ardiansah, 2020).

In addition, pest attack detection sensors can provide early warning to farmers, enabling them to take preventive action in a timely manner (Hidayat, 2017). Meanwhile, sensors to measure environmental emissions can help monitor the impact of agriculture on the surrounding ecosystem (Amalia et al, 2022). By adopting IoT-based sensor technology, farmers can optimize resources, increase the quality and quantity of agricultural products, and reduce environmental impacts effectively. This innovation not only helps improve food security, but also contributes to the establishment of a more sustainable and technologically intelligent agriculture (Husdi & Lasena, 2020).

Agro-industry refers to a form of integration between agricultural activities and industrial activities to increase the added value of agricultural products (Pratiwi et al, 2017). This involves processing agricultural raw materials into finished products through industrial processes involving

technology, equipment, and labor (Syafruddin & Darwis, 2021). Agro-industry includes sectors such as food processing, textiles, chemicals and bioenergy which utilize agricultural products as the main material for their production (Septrianes & Raharja, 2020).

Agro-industry has an important role in economic development and increasing a country's food security. By integrating agricultural and industrial processes, agro-industry not only increases the added value of agricultural products, but also creates new jobs, reduces waste of raw materials, and increases the efficiency of the agricultural system as a whole (Udayana, 2011). Thus, agro-industry is not only a driver of economic growth, but also plays a strategic role in achieving sustainability and economic diversification at the global level (Arianti & Waluyati, 2019).

The importance of supply chain management in agro-industry is enormous because it forms the basis for optimizing production, increasing efficiency, and ensuring the smooth distribution of agricultural products (Melly et al, 2019). Supply chain management in agro-industry involves coordination and integration of all processes from upstream to downstream, from procurement of agricultural raw materials to distribution of finished products to final consumers (Putri et al, 2020).

In agro-industry, supply chain management helps minimize risk and waste through careful monitoring of each production stage (Yusriana et al, 2023). The use of technology such as tracking systems and IoT sensors helps optimize raw material supplies, ensure product quality sustainability, and increase the efficiency of production processes (Risqiyah & Santoso, 2017). Additionally, effective supply chain management enables the adoption of sustainable practices, such as more efficient energy use, waste management and reduced carbon footprint.

Overall, good supply chain management in agro-industry can generate significant economic benefits, increase competitiveness, and support sustainable development (Pamungkassari, 2018). By optimizing work flow, reducing waste, and ensuring product quality, supply chain management becomes the main pillar in responding to increasingly complex global market demands in the agro-industrial industry (Tutuhatunewa, 2018).

This research aims to investigate and analyze the impact of implementing Internet of Things (IoT) technology in agro-industrial supply chain management. The main objective is to understand how IoT implementation can improve efficiency, traceability and sustainability in the entire agro-industrial supply chain process, from procurement of agricultural raw materials to distribution of finished products. The benefits of this research include providing in-depth insight to relevant industry players regarding the potential for increasing productivity, reducing waste, and increasing competitiveness through the use of IoT technology in managing agro-industrial supply chains effectively. This research is expected to make a positive contribution to the development of more adaptive and sustainable supply chain management strategies in the agro-industry context Form

2. METHOD

In the framework of this research, the researcher decided to adopt a qualitative descriptive approach as a method to describe, analyze and understand the phenomenon being investigated. The choice of qualitative methods was guided by the research objectives, which focused on in-depth exploration of real-life contexts. The aim of this research is to produce a systematic, factual and accurate description of the characteristics and relationships of the phenomena that are the focus of the research (Moleong, 2014). This approach involves the use of data collection techniques through literature studies, by referring to various literary sources such as books, magazines, journals and previous research reports. This selection of literature aims to present information that is relevant to research, while avoiding duplication of results. In accordance with Moleong's (2014) view, library research is considered to provide benefits for researchers in utilizing all information and thoughts that are relevant to the research they are conducting.

3. RESULTS AND DISCUSSION

In the midst of advances in the digital era, the role of technology is becoming increasingly crucial in changing business operational paradigms. One of the most dynamic technological

developments is the Internet of Things (IoT). The broad concept of connections introduced by IoT enables interaction and exchange of data between various objects and devices. When applied in the context of supply chains or agro-industrial supplies, IoT brings great potential to increase responsiveness and transparency in operational management. The application of IoT in the agro-industrial supply chain opens up opportunities to monitor and optimize various aspects of the production and distribution process. Connected sensors can provide real-time data on environmental conditions, storage temperatures, inventory status, and even the logistics footprint of agricultural products. In this way, stakeholders in the supply chain can make faster and more precise decisions based on accurate information.

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The transparency obtained through IoT also gives customers confidence regarding the origin and quality of agro-industrial products. With a clear digital footprint, consumers can trace the history of a product from the farm to their dinner table. In this case, the adoption of IoT technology in agro-industry not only increases operational efficiency, but also forms the foundation for a more reliable and sustainable supply chain. By continuing to integrate IoT in the agro-industry, we can face future challenges more adaptively and ensure the continuity of this industry in the ever-growing digital era.

Following are some of the benefits of the Internet of Things (IoT) in Agro-industrial Supply Chain Management.

Production Process Optimization

The application of the Internet of Things (IoT) in agriculture brings a significant revolution by utilizing sensors to monitor and optimize various production parameters. For example, temperature sensors can provide real-time information about environmental conditions around plants, allowing farmers to take necessary actions to keep plants growing in optimal conditions. The use of soil moisture sensors enables accurate monitoring of soil moisture levels, which is crucial for efficient irrigation management. This allows farmers to provide water according to crop needs, reducing water waste and increasing resource use efficiency.

Additionally, water availability sensors can provide invaluable information about water adequacy for plants. This allows farmers to adjust their irrigation practices according to actual conditions, optimizing crop growth and avoiding excess or lack of water that can affect crop yields. By integrating information obtained from these sensors, farmers can make more timely and accurate decisions, resulting in increased productivity and overall quality of agricultural produce. Thus, IoT not only provides advanced monitoring tools, but also opens up new opportunities for farmers to manage their farms more efficiently and sustainably.

Efficiency in Distribution and Logistics

In the context of the supply chain, the Internet of Things (IoT) is bringing fundamental changes by leveraging sensors and connected devices for real-time monitoring of transport vehicles and inventory status across distribution channels. Sensors installed on logistics vehicles can provide direct information regarding the location, condition and performance of the vehicle. This allows supply chain management to accurately monitor product journeys, identify the quickest routes, and respond to changes in situations that may occur during transit.

Additionally, real-time monitoring of inventory status at every point in the supply chain provides better visibility into product availability. With accurate information, companies can manage inventory more effectively, avoid excess or shortage of stock, and optimize product distribution. The ability to detect potential risks of product damage early, such as undesirable temperature changes or excessive vibration during transportation, allows preventative action to be taken to ensure product quality is maintained.

Product Quality Monitoring

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Loss Prediction and Prevention

The application of the Internet of Things (IoT) in agriculture opens up great opportunities to carry out data analysis that can provide deep insight into the condition of crops and agricultural products. IoT sensors connected to plants can collect data on environmental conditions, soil moisture levels and nutrient levels. By analyzing this data, farmers can gain a better understanding of crop health and production potential. For example, changes in data patterns can be early indicators of possible disease or nutrient deficiencies, allowing farmers to take preventative or corrective action before such problems develop.

In addition, in the agro-industrial supply chain, data analysis from IoT sensors can also be used to predict potential loss or damage to products during storage or transportation. Sensors that monitor temperature, humidity, or vibration can provide early clues to the risk of undesirable conditions. By leveraging data analysis technology, supply chain management can identify patterns or anomalies that may be causing losses, allowing them to take more proactive and efficient preventative action. With this prediction, the risk of loss can be minimized, productivity can be increased, and the sustainability of the agro-industrial supply chain can be maintained. Thus, IoT and data analytics provide powerful tools to improve risk management and overall performance in the world of agriculture and agricultural product supply chains.

Transparency and Product Footprint

The Internet of Things (IoT) has created an unprecedented layer of transparency in agro-industrial supply chains. Through sensors connected at every point in the chain, from farm to consumer, information can be monitored in real-time. Stakeholders, including manufacturers, distributors, and even consumers, can access real-time data about product location, condition, and status. For example, consumers can trace the origins and journey of an agricultural product, understand how and where it was produced, and ensure that it meets desired sustainability standards.

Additionally, the transparency afforded by IoT creates a detailed, digitally verified product footprint. Every stage in production and distribution can be monitored and verified, forming a complete footprint and accessible to all interested parties. This information is not just a regulatory requirement, but also meets consumer expectations for transparency and sustainability. As a result, consumer confidence can be increased, as they have full visibility into how agricultural products are produced, processed and distributed.

Efficient Resource Management

The use of the Internet of Things (IoT) in the agro-industrial sector opens the door to more efficient resource management. IoT sensors integrated into agricultural equipment can provide in-depth understanding of crop water needs and soil conditions. With real-time data on soil moisture, farmers can plan more timely and efficient irrigation, avoid wasting water, and support optimal plant growth. The use of sensors also allows for more accurate monitoring of environmental conditions, helping to determine the amount of fertilizer needed and when to apply it.

Additionally, information obtained from IoT sensors can be used to design sustainable resource management strategies. Detailed monitoring of water and fertilizer consumption can help farmers identify more efficient practices, reduce waste, and adjust resource inputs to actual crop needs. Smarter resource management not only reduces production costs, but also reduces the environmental impact caused by overusing resources . Thus, IoT provides a powerful tool to support sustainable agricultural practices, ensuring that precious natural resources are utilized wisely without harming the surrounding environment.

Quick Response to Change

The Internet of Things (IoT) has become key in strengthening the responsiveness of supply chain management in agro-industry. Through sensors and connected devices distributed throughout the supply chain, industry players can gain better visibility into changes in market conditions, weather or other circumstances. For example, weather sensors can provide real-time information about changing atmospheric conditions and weather forecasts that may affect crop production. With a better understanding of these factors, supply chain management can respond quickly, taking proactive measures such as earlier harvest scheduling or additional preparation for severe weather risks.

In addition, with data analysis from IoT sensors, supply chain management can predict and adapt to changes in market demand. Sensors connected to products can provide information about sales at a more detailed level, allowing industry players to manage inventory more efficiently. With real-time monitoring, adjustments can be made dynamically in response to fluctuations in demand or changes in market trends. The ability to respond quickly to these changes not only reduces the risk of inventory imbalances, but also opens up opportunities to maximize profits by taking advantage of emerging markets or favorable situations.

4. CONCLUSION

By integrating the Internet of Things (IoT) in agro-industry and supply chain management, it can be seen that this technology has a significant positive impact. The application of sensors and connected devices at various stages of production, distribution and consumption of agricultural products has opened up opportunities to increase operational efficiency, optimize resource use and reduce environmental impact. Through real-time monitoring, stakeholders, including farmers, producers, distributors and consumers, gain greater visibility into the entire supply chain. IoT helps farmers manage crops more efficiently, ensure optimal conditions for growth, and respond quickly to environmental changes. At the distribution level, the use of sensors helps ensure product quality is maintained during transit, reducing the risk of loss and increasing consumer satisfaction. In addition, data collected by IoT also supports supply chain management to predict and respond to market changes more adaptively. The entire IoT ecosystem in the agro-industry creates the necessary transparency, meeting consumer demands for more detailed information about the origin and quality of products. Additionally, this technology enables supply chain management to respond to challenges and opportunities more effectively, minimizing risks and maximizing profit potential.

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