Case Studies on Assessing Internet of Things' Influence and its Role in Agricultural Efficient Sourcing

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ABSTRACT

This study assesses the influence and role of the Internet of Things (IoT) in agricultural supply chain management, mainly efficient sourcing. The data was collected through published studies on the internet. Based on the findings, it highlights the applications, trends, processes of supply chain management, and challenges in the integration of IoT in the agriculture sector. Furthermore, the researcher acknowledges limitations in discussing the implementation of IoT in the agriculture sector in the Philippines.

Keywords: Internet of Things, Agriculture, Supply Chain Management, Efficient Sourcing, Smart Farming

INTRODUCTION

The term Internet of Things (IoT) was first used in 1999 when Radio Frequency Identification (RFID) was in the developmental phase but the practical application of this term has greatly advanced by the advancement of mobile devices, the incorporation of communication into devices, and availing of cloud and analytics. IoT is a further evolution of the business of computing where physical assets like smartphones, cars, and medical devices communicate and can exchange data in a certain format that can be used for data restructuring or timely updates (Talukdar & Dutta Baruah, 2024). Indeed, this connectivity has revolutionized several sectors such as the agricultural sector in terms of production and the healthcare sector in terms of delivery. IoT also plays an important role in the agricultural sector through monitoring IoT devices such as moisture, temperature, and humidity in the soil or weather information that will help farmers in producing crops, tend livestock, and use available resources (Harris and Fuller, 2014). It also underlines enhanced productivity in the food sector, sustainability, and food security on the ground. In the field of Supply chain management (SCM), IoT and artificial intelligence are employed in lifecycle tracking, data analytics, and ethical sourcing which help to optimize operational efficiency in addition to costs and improved customer satisfaction levels (Fernando, 2024).

The Internet of Things (IoT) is highly advantageous to multiple industries or sectors globally, these includes healthcare, power, production, supply chain and transportation, finance, accommodation, and agriculture (Thingsup, 2023). In these aspects, according to Crockett (2023), the trends that govern the future of IoT are a growing concern in the aspect of security threats, healthcare, the development of 5G networks, IoT data specialization and an increasing use of bundled IoT solutions for the enterprise. The IoT has benefited in enhancing health care services such as operations that are carried out at the patient's home or hospital, transporting patients and analyzing their information in the production of medication. The advantages of 5G are flexibility, reliability, performance, security hence can be adopted for use in manufacturing plants. The IoT environment implies a real-time data stream of unimaginable amounts; thus, metadata management remains critical. The IoT solutions are designed for organizations that require connectivity and analysis functionality, but do not have time or resources to go through a full development cycle. However, security risks are seen to arise, thus implying the need for integration, security evaluation, and proper security measures and steps. These trends will remain more relevant to the IoT environment, thus offering great chances for the effective advancement in more industries worldwide.

According to Kumar and Yadav (2023), supply chain management (SCM) in agriculture involves the coordination and streamlining of processes to ensure the efficient flow of products, data, and finances, which is essential for meeting customer demands, controlling costs, reducing waste, and enhancing productivity. The key components of SCM in agribusiness encompass the procurement of inputs like machinery and seeds, strategic production planning for demand forecasting and resource allocation, inventory management through just-in-time techniques, efficient transportation and logistics for timely delivery and cost reduction, effective distribution and customer service, and the use of SCM software and ERP systems for information management, along with strong collaboration with farmers, processors, distributors, and retailers. In line with this, agricultural current trends are in need of more efficiency, cost-effectiveness, and sustainability therefore, key trends were being established such as the adoption of digital technologies like IoT, blockchain, and AI according to the research conducted by Econ Market Research, and Precedence Research. It was also highlighted in the study of Syromyatnikov et al. (2020) that using blockchain technology as part of the digital supply chains is becoming popular because of the decentralization, security, transparency, and smart execution that results in the smooth process of monitoring with the collaboration of both logistics partner and manufacturers. On the other hand, blockchain as a part of digital technology provides an affordable option for supply chain management, cost reduction, and expanding the products and markets even though there are factors that need to be overcome such as the systemic, external challenges, intra- and inter-organizational barriers. Moreover, the cloud-based software is also popular in the supply chain management of the agricultural sector as stated by Dharmadhikari (2024) because it offers flexible, accessible, and cost-saving functions while modernizing processes without the need for large hardware, and investment in infrastructure which makes it available to both large and small enterprises of agriculture.

The application of IoT in the Philippines has several challenges most especially in the rural areas. Having poor connections was one of the challenges faced by farmers in rural areas and regions according to the study of Yasay (2021). This challenge causes delays in the transmission of data that one of the needs so that the IoT device works efficiently. It can be worse by cables of communication, plants, and canopies because it can cause interruptions to the signal paths. According to Hassan et al., (2017), The Internet of Things (IoT) faces several significant challenges as it evolves. One of the key issues is interoperability is critical due to the diverse nature of networks, hardware, and software involved. This diversity requires smooth communication and collaboration among all components. Openness is also essential, requiring systems to balance functionality, human interaction, and privacy. Furthermore, security and privacy concerns are heightened due to the large volume of data and reliance on wireless communications, necessitating robust protection across all layers, especially in sensitive applications like healthcare. Additionally, scalability is crucial with predictions of 20 billion connected devices in 2020, many with low power and unstable connections, requiring solutions for network and data scalability and energy consumption. Lastly, effective failure handling including self-configuration and self-repair, is necessary for building trust, though it complicates development by demanding a balance between application logic and error handling.

LITERATURE REVIEW

IoT: Features, Characteristics, and Application

The features of the Internet of Things nowadays are significant and affect the daily living of people considering Internet of Things (IoT) devices are equipped with microcontrollers to communicate through ZigBee, Wi-Fi, Bluetooth, and 3-5G thereby enabling global IP connectivity for smart devices. In this context, efficient machine-to-machine communication is ensured by Advanced Message Queuing Protocol (AMQP), Message Queuing Telemetry Transport (MQTT) and Simple Text Oriented Messaging Protocol (STOMP) protocols. The fact that IoT devices can be programmed makes it possible for them to process and store data hence allowing two-way communication as well as informed decision making based on analysis of the collected data. As a result, IoT changes from simply logging information into a system that enables informed decision-making to take place. Thus, by leveraging these insights IOT devices become capable of making informed decisions thus improving their applicability in areas such as smart cities and disaster management among others (Granell et al., 2016).

Identifying the characteristics of the Internet of Things is crucial for people to be able to be knowledgeable on

how the Internet of Things (IoT) devices can function effectively. Internet of Things (IoT) devices are characterized by their ability to communicate through the Internet and various wireless technologies such as Wi-Fi, Bluetooth, 3G/4G/5G, and ZigBee, facilitating quick and efficient data transfer and communication without human involvement. Their programmability makes them adaptable and allows them to take autonomous actions based on environmental cues with AI-improved systems usually developed for this purpose. Furthermore, IoT devices that have actuators added make it possible to monitor and control accurately so as to optimize processes independently in areas such as agriculture (Quan, 2021).

Application of the Internet of Things in smart agriculture deals with networking the communication that enables the real-time information sharing between the sensors and the devices hence allowing for the most appropriate decision-making. Such information is also sensitive real-time data about the conditions of the soil as well as the crops hence enabling farmers to come up with the right measures that would warrant the right practices between irrigation and pest control among others. Also, the fact that IoT systems are programmable further strengthens this characteristic, as actions and data exchange can be performed independently. Applying actuating capabilities in agriculture makes processes such as watering, use of fertilizers/pesticides among others to be auto-controlled. For example, IoT traps capture and analyze insects' data in real-time while agricultural robots using multispectral sensors help to manage pests effectively increasing yields, reducing cost, and minimizing harm to the environment (Dhanaraju et al., 2022).

Industrial IOT Market Share at Present

The Internet of Things is a reality and has significant impacts on various industries and activities of life throughout the world; these include agriculture, energy, finance, healthcare, manufacturing, retail and hospitality, transportation and logistics, Things Up (2023). In an agricultural sector, smart farming as well as automated greenhouses are used to monitor and control wastes effectively while at the same time enhancing the process of production. As to energy, IoT assists with the climate, which results in the alteration of the processes that can raise efficiency and reduce costs. Thus, in terms of finance, IoT provides benefits to this industry in improving customer relations and operations through the automation of some systems. The Internet of Things in healthcare involves remote monitoring and personalized healthcare. Today's manufacturing industries use IoT for predicting and monitoring the maintenance of their equipment to improve the functional capacity for efficiency or production. Regarding businesses that utilize IoT, retail and hospitality businesses benefit from IoT due to the use of improved Inventory management systems resulting in a better experience for the customer. In the last, the transport and logistics industry stands to have benefitted from IoT through the application of tracking & monitoring systems that encourage timely delivery and also offer additional supply chain transparency.

The Global Internet of Things (IoT) Market Size, Share and Trend has estimated market value at USD 405.69 Billion in 2023 based on current analysis of Precedence Research (2024) and the market is forecasted to reach approximately USD 3,152.17 Billion by 2033. The Region of North America is expected to remain the market's apex due to their higher demand for smart devices rises, AI studies unfolds further, industrial IoT expands its application to manufacturing, and smart infrastructure and cities gain governmental support. Then it is also the high growth achieved in IoT applications for retail, healthcare, agriculture sectors and availability of key players in the region that permits the market growth. On the other hand, Asia Pacific region is expected to dominate the market with a Compound Annual Growth Rate (CAGR), due to a rise in investment, technological development, use of smart devices, and elaborated product and service providing from the markets and businesses in the region (Precedence Research, 2024).

The result of Markets and Markets (2023) research, the industrial IoT market is expected to grow from $194.4 billion in 2024 to $286.3 billion by 2029, at a CAGR of 8.1% during the forecast period. The current structure of the market shows that the segment with hardware occupies the largest share and during the forecast period this position remains dominant, because industrial automation and sensor technology exist to this day. The application segment that holds the largest market in the North American industrial IoT is the healthcare segment due to factors such as a growing population of elderly people and the need for monitoring patients remotely and use of telemedicine and connected healthcare devices. During the forecast period, Asia Pacific is expected to dominate the market of industrial IoT solutions because of the existing and potential orientations

on industrialization in countries like China, India, and Singapore.

The Internet of Things (IoT) has myriad advantages in different industries such as agriculture, energy, finance, healthcare, and transportation. These include the following, in agriculture IoT enhances the cultivation and management of crops of animals taken care of by use of real-time monitoring that is automated. In the energy sector where it optimizes energy processes, offers efficient grid balancing, and ensures great customer experiences. In relation to finance, IoT improves risk assessment through personalized services while automating business processes. Also worth mentioning about Healthcare is that IoT allows remote monitoring as well as improves patient treatment plus medical equipment maintenance will be improved greatly. It drives up client satisfaction with its cutting—edge features and tailored support. This technology assists firms to track their equipment and materials in real-time which results in increasing productivity in businesses. On top of this, it also ensures security for employees by tracking their whereabouts as well as activities. One can deploy IoT into many other sectors resulting in a variety of advantages like streamlined operations or even more efficient functioning that eventually increases revenue levels for any industry Zelinska J. (2023).

As stated by Lafitte, M. (2022) the Internet of Things (IoT) is causing change in various sectors. This has driven growth and innovation in different industries. The IoT has been widely adopted within the communications sector whereby 53% of companies have IoT incorporated into their processes or key business areas. In monitoring asset performance, improving customer service, and increasing efficiency. Energy companies are also using IoT. Financial services organizations are now using IoT to boost security and improve network connectivity. Healthcare and manufacturing sectors have seen significant impacts from IoT with some applications such as patient monitoring, medical devices, and predictive maintenance among others experiencing a remarkable increase. Moreover, retail enterprises apply the Internet of Things to comprehend clients' desires better thus providing unique experiences. The industrial division is also undergoing a huge move towards digitalization and interconnectivity with an IoT market valued at $2 trillion by 2020. Media & entertainment businesses are being transformed by IoT through customization of content and localized consumption patterns. Generally speaking, investment in IoT could range between $3.9 trillion to $11 trillion annually by the end of 2025 for economic growth forecasts considered accurate.

Strategic development plan using IoT in efficient sourcing in agricultural SCM

IoT-based supply chain management (SCM) integrates circular economy principles as one of the development plans for using IoT in efficient sourcing to create sustainable and eco-friendly products through effective resource management and reuse. This approach involves recycling returned goods and using IoT data to optimize inventory, automate replenishment, and enhance supply chain visibility. Moreover, enhancing the transparency and security throughout the product life cycle of the IoT, allows the monitoring or tracing of the raw materials to retail and identify counterfeit products. IoT sensors and smart tags such as NFC, RFID, and DL-Tags enhance warehouse management and shipment efficiency in supply chain management (Taj et al., 2023).

According to Khan et al. (2022), enhancing transportation efficiency involves closely monitoring vehicles, cargo, and driving practices to reduce costs and minimize losses. The company must do real-time tracking of vehicle locations, speed, fuel consumption, and tire pressure using GPS technology. Data analysis systems proposed to use Bluetooth technology to manage vehicle density and traffic congestion. Moreover, the integration of AI, IoT, and 5G technologies is further advancing the development of intelligent logistics systems. The automated systems help in managing cargo rerouting and condition monitoring without the involvement of humans, communication with each other, and a centralized hub. Furthermore, automating forklifts with RFID readers facilitates precise warehouse operations for efficient item distribution, while Internet-connected robots assist in handling tasks under operator supervision. Additionally, IoT-based systems optimize intelligent goods delivery, the use of unmanned aerial vehicles, autonomous vehicles, and smart containers is essential to ensure precise delivery timing and monitor goods' health. Smart containers are integrated with wireless sensory and communication networks so that it can provide information that is real-time on conditions of the environment, types of cargo, transportation costs, and status of order.

When implementing digital solutions having a proper infrastructure was one of the factors that needed to be

considered. Through proper infrastructure, management, and staff can recognize the value of digital solutions. Also, in order to use digital technologies in remote monitoring, manufacturing locations, and control centers, the digital requirements must be met. It also includes providing rural areas with 4G internet access and developing mobile applications that can be use for digital solutions (Kulikov et al., 2019).

By facilitating transparent, real-time data transferring, enhancing inventory management, and strategic integration, the implementation of IoT in supply chain management improved its efficiency and resilience. Top management support or TMS is responsible for creating a flexible SC system that handles future risks in supply chain management once the hazards or disruptions are discovered, it is one of the key enablers of IoT-based coordination in agricultural supply chains. Other than that, it also provides different facilities such as IoT, efficient labor, finance, and raw supplies used in transferring data in supply chain management. The next key enabler is the IoT infrastructure which can support automated farming practices, make cloud-based networks available, smart irrigation system installation, supply technical staff, and other innovative functions. The third-party logistics provider or also known as the 3PL is part of the key enablers which serve as an external agency offering short-term distribution and storage services. When the agricultural supply chain is disrupted by the risks of operation such as changes in demand or natural disasters, 3PL offers services like logistics, infrastructure that is IoT-based, warehouse management, smart packaging of agricultural goods, and customer support that has product return facilities. Moreover, IS or also known as an information system is one of the key enablers. It manages data that is needed for inventories, orders of customers, and details of products. Organizations use technology-based traceability systems in agricultural supply chain management so that they can keep updated on the different trends in the market, purchasing, warehousing, and processing which helps in creating effective management and coordination to supply chain. Lastly, the Just-In-Time (JIT) processing is also part of the key enablers. Its purpose is to guarantee quick and efficient production shipment through reacting fast to innovative technologies and inter-enterprise interactions (Yadav et al., 2020).

Based on the study conducted by Lelechenko (2024), the use of IoT, predictive analytics, and other advanced technologies in improving supply chain management includes a number of steps such as the utilization of real-time IoT that is for predictive analytics so that it can plan efficient harvesting cycles and planting which is aligned to the market demands. It also includes the optimization in logistics and supply chain management by the timely optimization of the route and enhanced tracking of transport vehicles in speeding up the process of supply chain, reducing waste, and lowering costs. Other than that, to facilitate a seamless transition to IoT-based systems, training, and support are offered to the farmers and agribusiness. There are also steps such as evaluating how effective the IoT-based SCM system is continuously, collecting feedback from the stakeholders, and adapting adjustments that can help in maintaining relevance in the middle of changing market demands and weather conditions are all part of improving the supply chain management.

Factors to Consider in Implementing IoT-Based Agriculture Solution

The integration of Internet of Things (IoT) technologies expanded the concept of the old system to smart solutions to apply an innovative approach to increase efficiency, productivity, and sustainability. However, the implementation needs to have careful consideration to ensure effectiveness, flexibility and regulatory compliance. According to Srivastava (2023) every factor is important in agriculture. Data Management Strategy prioritizes scalability and adaptability to handle increasing data. To prevent cyber threats, data security and privacy is essential for safeguarding the sensitive agricultural data. This involved implementing access control to secure communication protocols, and encryption to prevent cyber risks. Interoperability is crucial to prevent compatibility issues and ensures effective communication between agricultural system components. It must be conducted regularly to be always upgraded and maintained. Regulatory Compliance ensures that the IoT solution conforms with applicable regulations to safeguard data integrity and user rights. Scalability ensures easy integration of more sensors and devices and periodically reviews and updates scalability plans to meet changing needs and growth.

According to Shalimov (2023), the use of IoT in the field of agriculture is endless and it is not easy. Here are the things that need to be considered before implementing an IoT-based solution. The first one is the sensor selection or the hardware, choosing a specific sensor tailored to agriculture is crucial. It impacts data accuracy and reliability, influencing the effectiveness of the solution. Data analytics or the brain, is essential for

extracting insights from collected data including predictive algorithms and machine learning to enable actionable decision-making based on data analysis. Another factor is maintenance, ensuring the hardware's durability is important to prevent any malfunction or any technical incidents. Field-based sensors are prone to damage, it requires robust maintenance to ensure consistent operation. Mobility, the owner of the farm should have been able to access the information on-site or via smartphone or any devices that have an internet connection and have a wireless range to communicate with other devices or send data to the server. The infrastructure is necessary to ensure that farming is performing efficiently and data handling. Moreover, connectivity, reliable connectivity is very important for transmitting data between agricultural facilities. It should be reliable to resist strong weather conditions. Standardized connection protocols and advancements in technologies like 5G are essential for overcoming connectivity challenges. Moreover, the data collection frequency and the frequency of optimizing the data collection are critical to decision making. Various data types need to be collected at different frequencies, and it is crucial to assess the frequencies to ensure compliance with the rules and the organisation. And lastly the topic which covers data security in the agriculture industry. It is important to safeguard agricultural data against threats from the cyber world. Encrypting data, monitoring the flow of data and employing artificial intelligence to create newer security tools strengthens data security and credibility.

IoT implementations are tough and expensive Burak (2022) stated. That is why when implementing the IoT into farming you better do it correctly and here is the list to think about before planning it. First, Specialization is one of the keys when it comes to agriculture solutions to monitor livestock and manage the entire garden or fields. There is an end-to-end farm management that provides farmers with a comprehensive strategy to completely control their farm, but they are expensive. It is crucial to address and prioritize the urgent matter of the farm before implementing IoT. The second one is connectivity. Connectivity is another important factor to consider. Choosing the right technology is crucial for stable and timely data transfer. Smaller farms might benefit from RFID (radio frequency identification) or NFC (near-field communication), while larger farms are suited for LPWAN (low-power wide-area network). All equipment needs power sources, and livestock wearable sensors need regular recharging and investing in solar panels or brancher-out power grid is necessary. Lastly, the frequency of data collection is also vital for achieving best results. Additionally, equipment monitoring requires real-time updates. To minimize the traffic usage expenses it is important to select the appropriate data processing mode (Burak 2022).

According to Kuprenko and Altynpara (2023), there are a lot of ways that IoT can help us but out-of-the-box solutions are not always the best solution to the needs of every farmer. And one of the solutions they see is the IoT solution for agriculture and here are several things to consider before implementing it. The first thing to consider is that you need to define your purpose. By clearly defining your goals and objectives you can manage to optimise your resources and expenses. Understanding what parameters you need will help and guide you in selecting appropriate IoT sensors. However, special consideration should be given when selecting the power sources for each of the sensors. Robust considerations here include whether the sensors require much power and the effect that transmitting data has on the battery. Another factor that functions to ascertain power consumption is the distance which data needs to travel. Another thing to consider is the frequency of collecting data and it depends on your needs to manage the farm. Additionally, the installation of sensors should be properly installed to gather all the benefits from them.

Research gap

The adoption of IoT in different industry sectors has numerous benefits and it has become one of the tools that helps enhance productivity and efficiency in such sectors. Despite the numerous benefits of IoT, several challenges hinder its effective implementation, especially in agriculture. These include the lack of standard discovery methods for IoT devices, the lack of studies that discuss issues in privacy concerns in IoT, insufficient connectivity solutions in rural areas, and the absence of a clear framework for efficient IoT sourcing. Tackling these challenges is important for enhancing efficiency and sustainability in agriculture.

These gaps emphasize the imperative to advance research and development in the following aspects: IoT devices standardization, all-inclusive IoT acquisition systems, IoT applications within agricultural supply chains, and specific connectivity methods appropriate for smart agriculture in rural settings. Addressing these

gaps will provide a more streamlined and efficient application of IoTs within agricultural supply chains and consequently, enhance better effectiveness and efficiency of agricultural activities sustaining and boosting the agricultural economy.

Aim of the Study

To emphasize the necessity to develop appropriate guidelines for the application of IoT in agriculture that promote interoperability and efficient sourcing. This also satisfies the need of increasing connectivity in remote locations, which is where a majority of agriculture is situated. The agricultural sector can, therefore, accelerate the adaptation of the technology through the guidance of risk frameworks for IoT device sourcing, negotiation, and inventory management. In addition to that, the rationale stresses the importance of assessment and management of risks imposed by IoT deployments. This is very important in safeguarding operational efficiency of agriculture and protecting sensitive information. Addressing challenges like these empowers the agricultural sector to tap into the IoT benefits in raising production levels, resilience on the system, food security, and agriculture sustainability in the end fostering a better food system.

Problem Statement

Agricultural sector is a direct contributor to food security and growth of the economy around the world however, it is now facing challenges in efficiency, productivity and sustainability. The Internet of Things (IoT) Technologies give opportunities to address the challenges or conflicts arising in agricultural operations. Integration and utilization of IoT can provide ways to solve existing problems by real-time monitoring, automation processing, and effective decisions based on actual and efficient data. Ultimately IoT enhances the transportation of goods and reduces waste throughout the agricultural supply chain management.

This research aims to assess the following:

1. How does the IoT technology affect the production and distribution of agricultural products especially in terms of real-time monitoring, automation of processes and ways to improve product delivery and waste reduction on the supply chain?

2. What are the privacy concerns and data security issues associated with the use of IoT technology in agriculture across different regions of the world, and how have these concerns been addressed in the existing literature?

3. What specific challenges related to data interoperability, technology adoption barriers, cost implications, and the effects of IoT integration on supply chain logistics, sustainability practices, and overall agricultural productivity have been identified in the literature?

4. What challenges hinder the widespread adoption of IoT solutions in smart agriculture, and what effective strategies have been proposed in the literature to ensure efficiency, productivity, and sustainability while addressing these key factors?

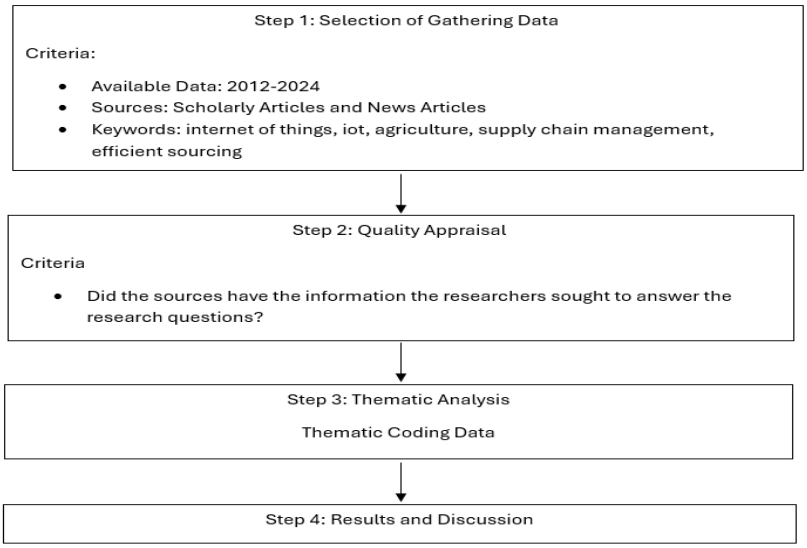
The findings of this research will enhance a better understanding of how IoT possesses the potential to transform the agricultural sector. By examining the impact of the IoT on manufacturing and distribution processes, and addressing the challenges associated with IoT adoption, this study will contribute to the development of more efficient, productive, and sustainable agricultural operations. The insights that will be collected from this research will help farmers, industry stakeholders, and technology providers in designing and implementing effective IoT-based solutions that address the pressing needs of the agricultural sector, ultimately enhancing efficient sourcing and promoting sustainable development.

METHODS

This study examines and shows relevant answers to the statement of the problem. The researcher used Thematic analysis with a semantic approach to extract the data from different published studies such as scholarly articles and new articles. Thematic analysis is a systematic approach used to identify, organize, and

interpret patterns of meaning (themes) within qualitative data. It focuses on shared meanings and experiences across a dataset rather than individual or unique interpretations. By examining common themes, the researchers can understand how a topic is discussed or represented, facilitating insights into collective experiences Braun et al., (2012). The researcher also used comparative analysis to analyze and determine clear options and narrow down the information to formulate an idea and possible process or strategies that can help the researcher research questions. Comparative analysis involves a side-by-side comparison that highlights both commonalities and distinctions among the subjects being examined. It can apply to data sets, products, processes, or strategies (Dovetail Editorial Team, 2023). Keywords such as "internet of things," "iot," "agriculture," "supply chain management", and " efficient sourcing." were used to identify and extract the data that aligns with our questions. The objective is to enhance the effectiveness of IoT in agriculture by developing standardized reference methods that promote interoperability and efficient sourcing, improving connectivity solutions in rural areas, and establishing clear frameworks for IoT device sourcing, negotiation, and inventory management. Additionally, it aims to evaluate IoT systems to reduce security risks, ultimately enabling the agricultural sector to fully leverage IoT technologies to increase productivity, sustainability, and food security. With this method, the researcher will be able to further understand the influence of the Internet of Things on the agriculture sector in efficient sourcing through the interpretation of data that can help to provide valuable information to create standardized reference methods for the supply chain management.

Figure1. Data Gathering and Preparation



Source: (Delmo et al., 2023)

RESULTS

The smart irrigation systems in Vietnam based on the case study of Thi (2024) discussed the use of Internet of Things (IoT) Technologies in improving the agricultural operations, producing healthy crops and increasing yields of the farmers. Soil moisture sensors are used by farmers to measure the levels of moisture in the soil, for them to know when to irrigate because sensors provide real-time data. Vietnamese farmers use IoT technologies to monitor environmental conditions which are the temperatures and humidity to assess further when is the best time to irrigate the soil. The automated irrigation controllers can regulate the amount of water that is delivered to the soils depending the decision on the real-time monitoring of sensors if the crops need more water or less. In addition, for agricultural purposes, drones are used to identify zones on the surface of the soil for farming that require irrigation through aerial views. Importantly, technologies related to the Internet of Things (IoT) contribute to enhancing food security in Vietnam and increasing the sustainable agricultural practices.

The case study of Meechoovet (2022) focuses on implementation of Smart Agriculture in Ayutthaya Province in Thailand. The study shows some of the major problems the agricultural sector in this country is facing

including low level of irrigation management, increased production costs, and a drop in the prices of commodities. Some of the participants' interviews showed that smart agriculture is cost-effective as it minimizes production costs and maximizes productivity, however, some farmers especially the elderly refuse to use these Internet of Things (IoT) technologies because they are expensive and their technical skills and knowledge is limited. The recommendations include empowering the farmers to practice Smart Agriculture efficiently. The implications of the findings focus on the importance of a consolidated strategy in which infusion of technology takes into account the farmers' terrain and their socio-economic marginalization. Overall, the research suggests that the success of opting for smart agriculture goes beyond acquisition of advanced technology but includes putting up structures that support farmers.

The Precision Agriculture for Rice Production in the Philippines highlights the important role in the more advanced rice farming methods. IoT devices that can be utilized in agriculture may include aerial systems like drones used to measure critical variables such as soil moisture, temperature, and climate conditions at any given time. This information results in control over irrigation and application of fertilizers that minimizes the losses and increases the volume of the harvest. For instance, the system of automatic field management ensures that the optimal amount of water is always utilized during irrigation by assessing the situation at the field. Furthermore, IoT technology aids in the risks' management by helping in prevention of threats like pests and weather extremes through the help of timely warning systems. Such technologies are especially important when it comes to the control of resources to combat the effects of climate change. The adoption of IoT enables the farmers in the Philippines to be able to practice environmentally sustainable methods, increase output, and profits. This case also indicates the wide range of applications that the IoT has on farming which is revolutionizing how farming is done to being more efficient, adaptivity, and environmentally friendly (Tallada, 2020).

Increasing application of IoT and blockchain technology was utilized by the Indonesian farmers. It improves the traceability system of the agriculture because it allows tracking of products coming from farm to the consumer by the stakeholders which ensures that the transaction made within the sector is being recorded and secure. Other than that, with the help of blockchain technology, the farmers can ensure that the process within the production is safe and verify the product's legitimacy. The case study illustrates the applications of blockchain technology and IOT through using sensors in quality monitoring of the mangoes during the transportation which makes it easier for the stakeholders to access real-time information about the condition of the product. It was also mentioned in the case study the utilization of the both applications through the managing of logistics of melon that enhances the traceability starting from the production to the market (Arkeman et al., 2022).

Malaysia has an IoT based livestock monitoring system to improved efficiency and sustainable ruminant production sector, which embrace beef and dairy cattle, buffaloes, sheep and goats. The system employs Radio Frequency Identification Technology (RFID) whereby animals are implanted with chips to enable to monitor the breeding, diseases control and the inventory through the National Ruminant Database. This digital system can also allow fast data stock retrieval, safe individual animal identification, as well as permanent disease branding for legal action. It is developed using environmentally friendly material and its key functions include supporting precision farming by enabling farmers to remotely monitor and control the performance of the livestock. Although in its infancy, this Internet of things (IoT) approach is a start to transform the Malaysia's livestock industry into a more modern one and minimize the country's reliance on imported meat.

The researchers developed the tables below after the data was collected to illustrate the codes from the data and categorize them into themes. This process allows researchers to effectively interpret each table and meet their research objectives.

Table 1. Impact of IoT technology on the manufacturing and distribution of agricultural products.

Real-time monitoring	**Process automation**	**Efficiency improvements**	**Themes and Description**
IoT devices monitor soil moisture,	Automated irrigation systems adjust water	IoT enhances supply chain transparency, improving	*Smart Agriculture:* Based on data, IoT

temperature, and humidity, providing farmers with real-time data for crop management (Talukdar & Dutta Baruah, 2024)	supply based on sensor data, optimizing resource use (Dhanaraju et al., 2022)	inventory management and reducing waste (Kumar and Yadav, 2023)	technologies facilitate data-driven decision-making in agriculture, enhancing productivity and sustainability.
Sensors track environmental conditions, enabling timely interventions to enhance crop yield (Dhanaraju et al., 2022)	Smart farming technologies automate tasks such as pest control and fertilization based on real-time data analysis (Kumar and Yadav, 2023)	Integration of AI with IoT leads to predictive analytics, optimizing planting and harvesting cycles (Lelechenko, 2024)	*Automation in Farming*: Automation through IoT reduces labor costs and increases operational efficiency by streamlining farming processes.
Real-time data sharing between devices allows for immediate decision-making (Talukdar & Dutta Baruah, 2024)	IoT-enabled logistics optimize transportation routes and schedules, reducing delivery times and costs (Taj et al., 2023)	Enhanced visibility throughout the supply chain contributes to better resource allocation and reduced operational costs (Syromyatnikov et al., 2020)	*Supply Chain Optimization:* IoT improves logistics and supply chain management by providing real-time insights that enhance efficiency and reduce waste.

Source: Processed by authors

The table summarizes the primary and the most notable features of the loT technologies that influence agricultural manufacturing and production of goods known as Smart Agriculture. In terms of real-time monitoring, loT devices are being used by the farmers to assess the condition of the soil, the status of crops and any other environmental factors associated with farming that results in efficient real time management practices (Talukdar, 2024). The Internet of Things also helped agricultural activities such as irrigation, planting, pest control and harvesting by automation processes through sensors (Dhanaraju et al., 2022; Kumar and Yadav, 2023). The advantages of loT include increased product visibility, improved management of supply chain processes and the use of demand forecasts to match the production schedule to customers needs or supply chain optimization (Syromyatnikov et al., 2020; Taj et al., 2023). Overall, the Internet of Things integrates into agriculture in a disruptive manner, enhancing productivity, security of resources, and food.

Table 2. Issues associated with the use of IoT technology in agriculture across different regions of the world and how it has been addressed to new literature.

Privacy Concerns	**Data Security**	**Themes and Description**
Increased risk of data breaches in agriculture (Hassan et al., 2017)	Vulnerability to cyber-attacks on IoT devices (Kumar & Yadav, 2023)	*Vulnerability:* The state of being exposed to the possibility of being attacked or harmed, either physically or emotionally.
Lack of clear regulations around data usage and sharing (Yadav et al.,	Inadequate encryption methods for sensitive data (Burak, 2022)	*Insecurity:* The lack of safety or protection against potential threats.
Concerns over unauthorized access to	Weak authentication processes for IoT systems	*Exposure:*

personal information (Dharmadhikari, 2024)	(Kuprenko and Altynpara, 2023)	The state of being exposed to danger or harm, particularly in the context of data privacy.
Limited awareness among farmers about privacy rights (Yadav et al., 2020)	Insufficient data management strategies leading to breaches (Lelechenko, 2024)	*Negligence:* The failure to take proper care in doing something, which can lead to vulnerabilities.

Source: Processed by authors

The application of IoT in agriculture is faced with the following issues regarding privacy as well as data protection. Based on the table the privacy issues arise when there is unauthorized access to confidential data (Dharmadhikari, 2024). The cyber threats that may put at risk the farmers information and operational data (Hassan et al., 2017) and the lack of regulations on data usage and sharing can further increase these issues (Yadav et al., 2020). It also highlights that IoT devices used in agriculture are becoming the center of cyber threats because of the lack of security features (Kumar and Yadav, 2023). This vulnerability is caused by lack in the authentication processes, and the insufficient number of encryption techniques applied (Burak, 2022; Kuprenko and Altynpara, 2023). Addressing these challenges can help to increase trust and improve the effective implementation of IoT solutions in agriculture.

Table 3.1 Challenges on SCM logistics, sustainability practices, and agricultural productivity.

Data Interoperability	**Scalability**	**Cost implication**	**Themes and Description**
The need for seamless communication among diverse networks, hardware, and software to ensure effective data exchange and collaboration. (Hassan et al., 2017)	Scalability in IoT systems are crucial because they must accommodate a large number of devices and streams of data without degrading the performance and reliability most especially it was indicated that there are billions of connected devices. (Hassan et al., 2017)	The implementation of IoT solutions can be cost-prohibitive due to initial investments in technology and infrastructure, though it may lead to long-term savings. (Dharmadhikari, 2024)	*Security:* The protection of sensitive data from unauthorized access and breaches, which is critical given the reliance on interconnected systems for agricultural productivity.

Source: Processed by authors

The table highlights that the effective adoption of IoT technologies, especially in areas like agriculture, depends on addressing several critical challenges. Interoperability of data is still a significant issue; communication between different systems, networks, and devices is the key to successful data sharing and collaboration (Hassan et al., 2017). Other than that, the scalability in terms of IoT systems are crucial because they will need to accommodate a large number of devices without lowering the reliability of the applications (Hassan et al., 2017). Additionally, the financial aspect of IoT solutions is also an issue, as the initial capital investments are high due to the setting up of the necessary infrastructure and technology, although in the long run, there would be savings and increased efficiency (Dharmadhikari, 2024). Security issues concerning the confidentiality of data are crucial in interconnected environments mainly due to the vulnerability of the systems and the possibility of intrusion in such environments. Addressing these challenges through strategic investments and innovations will be key to unlocking the full potential of IoT technology in improving productivity and operational efficiency across various sectors.

Table 3.2 Effects of IoT Integration

Supply chain logistics	**Sustainability practices**	**Agricultural productivity**	**Themes and Description**
IoT-enabled logistics optimize transportation routes and schedules, reducing delivery times and costs (Taj et al., 2023)	Integration of AI with IoT leads to predictive analytics, optimizing planting and harvesting cycles (Lelechenko, 2024)	Smart farming technologies automate tasks such as pest control and fertilization based on real-time data analysis (Kumar and Yadav, 2023)	*Automation:* The use of IoT to streamline and optimize agricultural processes, reducing manual intervention and enhancing efficiency.
Enhanced visibility throughout the supply chain contributes to better resource allocation and reduced operational costs (Syromyatnikov et al., 2020)	IoT enhances supply chain transparency, improving inventory management and reducing waste (Kumar and Yadav, 2023)	IoT devices monitor soil moisture, temperature, and humidity, providing farmers with real-time data for crop management (Talukdar, 2024)	*Transparency:* The ability of IoT to provide real-time data and insights across the agricultural supply chain, enabling better decision-making and resource allocation.

Source: Processed by authors

The table reveals the significant effects of the integration of the IoT into supply chain logistics, sustainability practices, and agricultural productivity in the field of agriculture. By optimizing transportation routes and schedules, IoT-enabled logistics reduce delivery times and costs (Taj et al., 2023), while also enhancing transparency throughout the supply chain (Kumar and Yadav, 2023). Integrating AI-based IoTs over farming activities also enhances the prediction analysis of planting and harvesting cycles (Lelechenko, 2024). Furthermore, the environment monitoring technology, which regulates weather conditions with optimized farming, does automated tasks such as pest control and fertilizer more efficiently and sustainably (Kumar and Yadav, 2023; Talukdar, 2024). These innovations improve performance and environmental management in supply chain and farming (Syromyatnikov et al., 2020).

Table 4. Challenges in the adoption of IoT and strategies that have been proposed to literature to ensure efficiency, productivity, and sustainability. (Challenges in adaptation of IoT)

Challenges	**Themes and Description**	**Strategies**	**Philippines Setting**
Poor internet connectivity in rural areas limits real-time data transmission (Yasay, 2021)	*Connectivity:* The quality of network connections that enable seamless communication and data exchange.	Implementing reliable connectivity solutions, such as 5G and LPWAN, to enhance data transfer (Burak, 2022)	The Philippines remained ranked 6 in the speed of internet among the other countries in ASEAN (Quismorio, 2024). There are also only 15% Filipinos who have access to the internet (Araneta et al., 2022).
Interoperability issues among diverse networks and devices hinder integration (Hassan et al., 2017)	*Standardization:* The process of establishing common guidelines to ensure compatibility and interoperability among systems.	Developing standardized protocols to ensure compatibility between different IoT devices (Kuprenko and Altynpara, 2023)	There's a lack of standardized protocols in the adoption of IoT in the Philippines (Nathan Associates Inc., 2022).

Security and privacy concerns due to large volumes of data (Hassan et al., 2017)	*Security:* The measures taken to protect data from unauthorized access and breaches.	Implementing robust security measures including encryption and access control to protect data (Srivastava, 2023)	Filipino farmers hesitant in terms of adopting IoT in agricultural practices because there are breaches of data and privacy violations (Nathan Associates Inc., 2022).
High costs associated with IoT implementation in agriculture (Burak, 2022)	*Cost-Effectiveness:* The efficiency of a strategy in terms of its cost relative to the benefits it provides.	Utilizing cloud-based solutions for cost-effective scalability and flexibility in operations (Dharmadhikari, 2024)	The internet services are highly costly given that the internet services ranges around $22.24 per month that hindrance the adoption of IoT in the Philippines (Bondoc et al., 2022).

Source: Processed by authors

This table shows the challenges and strategies in adaptation of IoT in agriculture in the Philippines. The four major challenges are poor internet in rural areas, which will prevent data transmission in real-time; interoperability issues because of differences in various networks and devices (Yasay, 2021); interoperability ((Hassan et al., 2017) issues that lack standardization; security and privacy issues pertaining to large volumes of data (Hassan et al., 2017) and expensive implementation in order to encourage an integration (Burak, 2022). The table also shows four different strategies including 5G and LPWAN as reliable connectivity solutions (Burak, 2022); standardization protocols for a smooth compatibility of IoT-enabled devices (Kuprenko and Altynpara, 2023); secure mechanisms in the form of encryption and access control for robust security solutions (Srivastava, 2023); and cost-effective cloud-based solutions about scalability and flexibility are provided by (Dharmadhikari, 2024). It also show the percentage of internet connectivity of the Philippines where only 15% of Filipinos have reliable internet (Araneta et al., 2022). Despite of being in the 6th rank in ASEAN countries, there is lack of robust infrastructure and high cost which around $22.24 per month (Bondoc et al., 2022). There is a concerns of farmers about the security privacy (Nathan Associates Inc., 2022). Furthermore, communication between devices that form the Internet of Things is a problem as Kuprenko and Altynpara (2023) and Nathan Associates Inc. (2022) point out that the lack of well-defined protocols hampers IoT implementation.

DISCUSSION

IoT technologies significantly influence the process of producing and distributing agricultural goods especially in areas such as monitoring, determining efficiency, and automation of processes. With the use of IoT devices, farmers are able to observe soil and weather conditions as well as crop status. It provides them with the ability to make real-time decisions based on informed data. Then the information or data will significantly enhance productivity in agricultural practices. IoT also automates most farming processes - from irrigation to pest control - by analyzing data obtained from sensors. Such innovations ensure cost labor efficiency and improved operational efficiency since many farm processes are simplified. Furthermore, IoT brings about improvements in logistics and supply chain management through real-time information that improves efficiency and minimizes losses. IoT increases transparency and optimizes movement routes and schedules while using predictive analytics to adapt production based on market demand. The integration of IoT in the agricultural supply chain will bring improvements in inventory management, decrease delivery time and costs, and the best resource utilization for adding overall better product delivery with minimal wastage.

The use of IoT technology in agriculture raises global concerns about privacy and data security due to the large amounts of sensitive information collected. Major risks are unauthorized access, data breaches and misuse of information, particularly in countries with less strict data protection regulations. A vulnerability refers to weaknesses in IoT systems, due to weak security, which can be used by cyber hackers. Moreover, there is a growing threat of data loss and breaches on access control issues which can be reduced or totally eliminated by use of encryption and access restrictions. The risk of exposure of sensitive data from the extensive data sharing

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in IoT making it easier for unauthorized parties to gain access, the paper suggests that it is necessary to have transparent data management practices. Lastly, the concept of negligence highlights the duty of care towards organizations, and the necessity of security policies to mitigate both legal and reputational risks. These issues clearly underline the importance of security limitations in agricultural IoT. Effective measures such as putting up encryption, secure data transfer systems, and developing specific policies for agriculture can help to protect the information and the people from their own internet threats. And also by educating stakeholders on data security and enforcing regulatory frameworks aligned with international standards are also crucial.

There are different challenges related to data interoperability, technology adoption barriers, and cost implications that have been found from the data such as in data interoperability, As Hassan et al. (2017) highlight, there's a lack of seamless communication among networks, hardware, and software that hinges the ability of the devices and platforms to exchange data. Oher than that, the scalability that refers to the ability of IoT systems to accommodate large number of devices is one of the challenges (Hassan et al., 2017). Lastly, in terms of cost implications, the implementation of IoT was hampered by cost prohibition because of the initial investments needed for IoT solutions (Dharmadhikari, 2024). In line with this, security is one of the main concerns in implementing IoT in agriculture as part of efficient sourcing because in exchanging data, there are many security threats such as unauthorized access and breaches. Furthermore, other than challenges in data interoperability, technology adoption barriers, and cost implications there are also findings on the effects of integrating IoT in agriculture specifically in supply chain logistics, sustainability practices, and boosting productivity. IoT allows managers to optimize transportation routes and schedules that reduce delivery times as stated by Taj et al., (2023). Beyond transportation, IoT also enhances visibility across the entire supply chain. Enhanced visibility, as noted by Syromyatnikov et al. (2020), allows companies to allocate resources more effectively and reduce operational costs by minimizing waste and delays. These factors effectively enhance the supply chain logistics not just in terms of transportation but also in reducing operational costs. Moreover, the integration of IoT also enhances the sustainability practices in agricultural SCM. According to Lelechenko (2024), integration of AI and IoT enables predictive analytics which allows farmers to optimize planting, watering, and harvesting cycles. Other than that, according to Kumar and Yadav (2023, transparency and improving inventory management were also enhanced. In terms of agricultural productivity, the integration of IoT enhances it through real-time automated pest controls and fertilization (Kumar and Yadav, 2023) and boosts crop management because IoT devices can be able to monitor soil moisture, temperature, and humidity. With these data, the findings reveal that the integration of IoT resulted in automation that optimizes agricultural processes and enhances efficiency. The findings also revealed that transparency was one of the effects of IoT integration which is the ability of IoT to provide real-time data that can enable better decision making.

The implementation of IoT across several domains including agriculture encounters many obstacles which prevent a full realization of IoT and its capabilities. That includes challenges in the Philippine setting such as there are only 15% Filipinos who have access to the internet, lack of standardization, privacy concerns, and high cost in utilizing internet services. Connectivity, particularly in non-urban areas where reliable internet presence is scarce, is arguably one of the largest issues. This lack of reliable internet presence inhibits transmission and communication of the data in real time. Interoperability, or the fact that different devices may not be compatible with different networks is another challenge or obstacle as devices may create fragmented systems, and the data will not flow efficiently from one system to another. Security and privacy is an additional issue due to the amount of data IoT devices create. Organizations need to develop security to protect private data. Last, the transition of cost for implementing IoT solutions and regular maintenance can also be a significant barrier to growth for many organizations, especially for firms in constrained sectors represented in agriculture. The barriers can be addressed using various strategies. For instance, using solutions like 5G and LPWAN to provide a reliable source of connectivity, while developing standardization protocols to develop common standards or solutions to increase or ensure compatibility among devices. Organizations can secure the mechanism of the IoT devices with encryption and access control solutions to protect data or information sent through the devices. Lastly, organizations can focus or search for low-cost cloud-based solutions to aid with IoT accessibility. Each of these pathways or alternatives when implemented will assist in addressing the barriers and will develop a pathway in IoT to support efficiency, productivity, and sustainability.

CONCLUSIONS

The paper explores how IoT technologies are transforming agricultural practices by enhancing efficiency, sustainability, and productivity. Based on research, IoT technologies enhance the monitoring and automation of the agricultural processes and increase efficiency of resource usage throughout the supply chain. One of the main advantages of the IoT technology is the real-time data collection from several IoT devices, which can be used to improve irrigation, pest control, crop management and increase the rate of harvests and food security. Nevertheless, IoT in agriculture has its issues. One of the issues is not having proper equipment for the utilization of IoT in agriculture. But the IoT still has a huge impact on today's agricultural methods such as minimizing waste, reducing costs and enhancing overall productivity.

RECOMMENDATION

Based on the findings, the Internet of things has a huge impact in agriculture in terms of creating large amounts of data that emphasizes security and privacy concerns. The recommendation to address this concern based on the research study is by implementing security communication guidelines and standard protocols that will enhance the smooth sharing of data in the field of agriculture using IoT that will prevent further challenges such as vulnerability, insecurity, and negligence. In addition to that, there should be a collaboration between the government, agricultural stakeholders and technology providers to build infrastructure or facilities that will be used for enhancing the IoT adoption in agriculture for enhancing connectivity and compatibility. Lastly, considering the cost implications is a must wherein utilization of cloud-based solutions for more cost-effective operations. By applying these recommendations to the agriculture sector, the capability of widening the Iot implementation will lead to more sustainable and efficient sourcing in agriculture.

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REFERENCES

1. Araneta, A., Carrasco, B., Rahemtulla, H., Balgos, S., & Sy, S. (2021, February 22). Mapping Digital Poverty in ph. INQUIRER.net. https://business.inquirer.net/318223/mapping-digital-poverty-in-ph
2. Arkeman, Y., Fatullah, R., Saefurahman, G., & Kailaku, S. I. (2022). Applications of the internet of things (IOT) and blockchain for agriculture in Indonesia. FFTC Journal of Agricultural Policy. https://doi.org/10.56669/ueix9487
3. Bondoc, J. E., Magpoc, A. K., Cruz, C. J., Gonzales, J., Mansilongan, M. C., & Caragay, S. (2022). Technology as an Educational Dilemma: Disparities in Access to Quality Internet Connectivity and Their Implications on Students' Academic Performance , 4(1).
4. Burak, A., & Burak, A. (2022, September 1). Farming Done Right: Top 5 applications of IoT in agriculture. Relevant Software. https://relevant.software/blog/top-applications-of-iot-in-agriculture/
5. Braun, V., & Clarke, V. (2012). Thematic analysis. In H. Cooper, P. M. Camic, D. L. Long, A. T. Panter, D. Rindskopf, & K. J. Sher (Eds.), APA handbook of research methods in psychology, Vol. 2. Research designs: Quantitative, qualitative, neuropsychological, and biological (pp. 57–71). American Psychological Association. https://doi.org/10.1037/13620-004

6. Crockett, E. (2023, May 9). Top internet of things (IOT) trends: The future of IOT. Datamation. https://www.datamation.com/trends/internet-of-things-trends/
7. Delmo, E. S., Ulep, R. F. A., Urrutia, J. D., Morales, S. R., Gepila, E. S., Sagun, R. D., Mingo, F. L. T., Fernandez, A. A., Costales, J. A., Mas, M. B., & Morada, J. C. (2023). Smoking Playing as a Risk Factor to other Diseases: A Meta-Analysis. PNR Journal. https://doi.org/10.47750/pnr.2023.14.02.388
8. Dhanaraju, M., Chenniappan, P., Ramalingam, K., Pazhanivelan, S., & Kaliaperumal, R. (2022). Smart Farming: Internet of Things (IoT)-Based Sustainable agriculture. Agriculture, 12(10), 1745. https://doi.org/10.3390/agriculture12101745
9. Dharmadhikari, S. (2024, May 16). Agricultural Supply Chain Service market was estimated at USD 1.01 billion in 2024. Cognitive Market Research. https://www.cognitivemarketresearch.com/agricultural-supply-chain-service-market-report
10. Dovetail Editorial Team. (2023, April 18). What is Comparative Analysis? Guide with Examples. https://dovetail.com/research/comparative-analysis/?utm_source=perplexity
11. EconMarketResearch, https://www. econmarketresearch. com/. (2022, March). Agriculture Supply Chain Management Market Size, share: 2032. Econ Market Research. https://www.econmarketresearch.com/industry-report/agriculture-supply-chain-management-market/
12. Fernando, J. (2024, June 27). Supply Chain Management (SCM): How It Works & Why It's Important. Investopedia. https://www.investopedia.com/terms/s/scm.asp
13. Granell, C., Kamilaris, A., Kotsev, A., Ostermann, F.O., Trilles, S. (2020). Internet of Things. In: Guo, H., Goodchild, M.F., Annoni, A. (eds) Manual of Digital Earth. Springer, Singapore. https://doi.org/10.1007/978-981-32-9915-3_11
14. Hassan, Q. F., Khan, A. U. R., & Madani, S. A. (2017). Internet of things: Challenges, Advances, and Applications. CRC Press.
15. Harris, D.R., Fuller, D.Q. (2014). Agriculture: Definition and Overview. In: Smith, C. (eds) Encyclopedia of Global Archaeology. Springer, New York, NY. https://doi.org/10.1007/978-1-4419-0465-2_64
16. Industrial IOT market size, share, industry report, Revenue Trends and Growth Drivers. Marketsand Markets. (2024). https://www.marketsandmarkets.com/Market-Reports/industrial-internet-of-things-market-129733727.html
17. Khan, Y., Su'ud, M. B. M., Alam, M. M., Ahmad, S. F., Ahmad, A. Y. a. B., & Khan, N. (2022). Application of Internet of Things (IoT) in sustainable supply chain management. Sustainability, 15(1), 694. https://doi.org/10.3390/su15010694
18. Kulikov, I. M., Semin, A. N., Kislitskiy, M. M., & Strelka, E. A. (2019). Digital solutions of management issues and strategic planning for the development of agriculture and rural areas. International transaction journal of engineering management & Applied sciences & Technologies, 10.
19. Kumar, M., & Yadav, E. (2023). Agribusiness and Supply Chain Management. In Modern Approaches in Agricultural Economics (pp. 182–184). essay, Elite Publishing House
20. Kuprenko, V., & Altynpara, E. (2023c, June 6). A deep dive into IoT for agriculture industry. Cleveroad Inc. - Web and App development company. https://www.cleveroad.com/blog/iot-and-agriculture-what-options-are-there-and-how-to-develop-your-own-smart-farming-solution/
21. Lafitte, M. (2022, October 10). The rise and Rise Oof IOT - impact on different industries. The Rise and Rise oof IoT - Impact on different industries. https://www.cloudi-fi.com/blog/the-rise-and-rise-of-internet-of-things-impact-on-different-sectors-and-industries
22. Lelechenko, L. (2024, May 29). Enhancing Agricultural Supply Chain Resilience with IOT and Satellite Data. SupplyChainBrain RSS. https://www.supplychainbrain.com/blogs/1-think-tank/post/39646-enhancing-agricultural-supply-chain-resilience-with-iot-and-satellite-data
23. Meechoovet, Y. (2022, April). Thailand's Smart Agriculture and its Impacts on Thai Farmers: A Case Study of Smart Agriculture in Ayutthaya Province. Rangsit University Intellectual Repository. https://rsuir-library.rsu.ac.th/handle/123456789/2065
24. Nathan Associates Inc. (2024, September 13). 10 things cities and Local Government Units (lgus) can do to improve internet connectivity. Cadmus.https://cadmusgroup.com/articles/10-things-cities-and-local-government-units-lgus-can-do-to-improve-internet-connectivity/
25. Quan, D. M., & Van, T. T. H. (2022). Potential and trends of IoT application in agriculture in Vietnam. Open Journal of Social Sciences, 10(01), 170–182. https://doi.org/10.4236/jss.2022.101015

26. Quismorio, E. (2024, June 22). “Napakabagal”: Campos Rues Philippines’ drop in Global Mobile Internet Speed rankings . Manila Bulletin. https://mb.com.ph/2024/6/23/napakabagal-campos-rues-philippines-drop-in-global-mobile-internet-speed-rankings?fbclid=IwY2xjawGsNXRleHRuA2FlbQIxMAABHRiNXU6LG10ba8LUTXii3b_aXcgM_JUSlw0KklyWjuyB-6p8-ltLsll96g_aem_AqNgiPKjwSEz7vjm2MLI6Q
27. Rahman, M. S. A. (2020, July 16). IOT applications for ruminant profiling and disease monitoring. FFTC Agricultural Policy Platform (FFTC-AP). https://ap.fftc.org.tw/article/1627
28. Research, P. (2022, November 29). Agriculture Supply Chain Management Market Size, Report 2032. https://www.precedenceresearch.com/agriculture-supply-chain-management-market
29. Shalimov, A. (2023, March 1). IoT in agriculture: 9 technology use cases for smart farming (and challenges to consider). Eastern Peak - Technology Consulting & Development Company. https://easternpeak.com/blog/iot-in-agriculture-technology-use-cases-for-smart-farming-and-challenges-to-consider/
30. Srivastava, S. (2023c, November 21). Impact of IoT in the agriculture industry: Everything you need to know. Appinventiv. https://appinventiv.com/blog/iot-in-agriculture-industry/
31. Syromyatnikov, D., Geiko, A., Kuashbay, S., & Sadikbekova, A. (2020). Agile supply chain management in agricultural business. International Journal of Supply Chain Management, 9(3), 377-383.
32. Taj, S., Imran, A. S., Kastrati, Z., Daudpota, S. M., Memon, R. A., & Ahmed, J. (2023). IoT-based supply chain management: A systematic literature review. Internet of Things, 24, 100982. https://doi.org/10.1016/j.iot.2023.100982
33. Tallada, J. G. (2020, July 16). Precision agriculture for rice production in the Philippines. FFTC Agricultural Policy Platform (FFTC-AP). https://ap.fftc.org.tw/article/1416
34. Talukdar, N., & Dutta Baruah, C. (2024). Seeding Success: Harnessing IoT for Modern Farming . International Research Journal of Engineering and Technology (IRJET), 11(1), 49–55. chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.irjet.net/archives/V11/i1/IRJET-V11I109.pdf
35. Thi, P. (2024). IoT Applications in Agriculture: Enhancing Crop Yield in Vietnam. Asian Journal of Computing and Engineering Technology, 5(1), 35–36. https://doi.org/https:// doi.org/10.47604/ ajcet.2809
36. Thingsup. (2023, October 13). 8 Sectors That Can Benefit the Most from IoT Development. Thingsup. https://thingsup.io/8-sectors-that-can-benefit-the-most-from-iot-development/
37. Yadav, S., Luthra, S., & Garg, D. (2020). Internet of things (IOT) based coordination system in Agri-Food Supply Chain: Development of an efficient framework using DEMATEL-ism. Operations Management Research, 15(1–2), 1–27. https://doi.org/10.1007/s12063-020-00164-x
38. Yasay, J. J. R. (2021). Internet of things in the Philippine agribusiness. International Journal of Advanced Research in Science Communication and Technology, 518–525. https://doi.org/10.48175/ijarsct-1409
39. Zelinska, J. (2023, June 16). IOT across multiple industries: Benefits and future trends – Nix United. NIX United – Custom Software Development Company in US. https://nix-united.com/blog/crucial-trends-and-vital-benefits-of-iot-across-various-sectors/