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IOT IN AGRICULTURE: PRECISION FARMING, CROP MONITORING, AND ENVIRONMENTAL SUSTAINABILITY

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Abstract

Introduction: The main principle of this study is to discuss the importance of IoT in the agricultural field to maintain sustainability. IoT also plays an essential part in the crop monitoring process, therefore, with the aid of this technology crop health, and growth rates have to be monitored. Therefore, farmers are also capable of identifying the potential issue that has to be faced by this organization. **Literature Review:** Based on the research objectives, thematic analysis is highlighted in this section. This analysis helps to understand that, real-time data on various factors like moisture of the soil, humidity, temperature, as well as crop health, has to be collected with the aid of IoT sensors. Therefore, this information helps the farmers to make decisions about the farming process.

Methodology: In this study, researchers are capable of collecting data with the support of various online sources. Therefore, "theoretical analysis" helps to analyze collected data. Deep conceptual understanding is promoted by this theoretical analysis.
Findings: Valuable environmentally friendly data are collected by this IoT technology. Therefore, this information has a positive impact on the fertilization-related data. On the other hand, policy decisions like climate conditions, weather patterns, and pest infections help to maintain the sustainability of the agriculture field.
Discussion: Overall discussion about this selected topic is highlighted in this section. Therefore, this section helps to understand that, IoT technology helps to monitor the crop health, and growth rates. Therefore, farmers are also capable of identifying the potential issue that has to be faced by this organization. The weather station of IoT helps to provide real-time data which helps the farmers to identify the present condition of the weather.
Conclusion: The Impact of IoT in the agricultural field is discussed in this study. Therefore, with the aid of this study, it has to be noticed that, Implementing IoT technology in the agriculture field become expensive. Farmers in developing areas are unable to afford this technology. Therefore, it is noticed that cost is the main barrier to this advanced technology.

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Keywords: Agriculture, IoT, Precision farming, Sustainability, Climate change, Farming process, Crop monitoring

Introduction

The Internet of Things in agriculture helps to use connected sensors and devices to foster farming processes. IoT allows the farmers to look out and manage their farming process, moreover, livestock with precision has to be fostered with the aid of this advanced technology. After that, IoT helps to provide sensors which are capable of measuring the moisture of soil, and nutrient level (Phupattanasilp and Tong, 2019). Therefore, temperature is also measured with the aid of this advanced technology. With the aid of IoT technology, better management of the agriculture process has to be generated, therefore, it also helps to minimise irrigation (Raj *et al.* 2022). After that, this IoT technology also detects the animals' health condition and location, which helps foster a better management process.

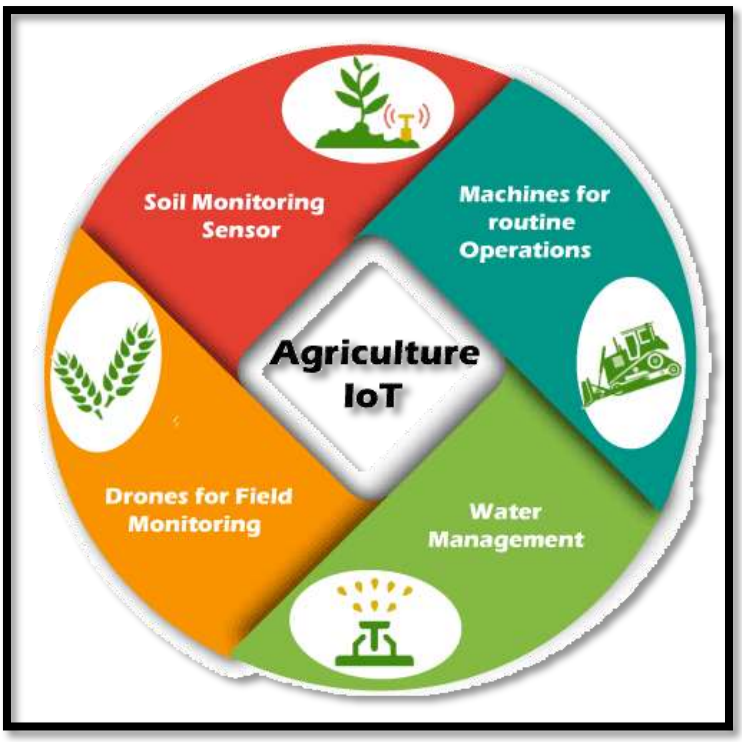

Figure 1: IoT in Agriculture

(Source: Pooja *et al.* 2019)

IoT also plays an essential part in the crop monitoring process, therefore, with the aid of this technology crop health, and growth rates have to be monitored (Pooja *et al.* 2019). Therefore, farmers are also capable of identifying the potential issue that has to be faced by this organization. The weather station of IoT helps to provide real-time data which helps the farmers to identify the present condition of the weather. Therefore, this weather forecasting helps the farmers to make the right decision for farming. After that, with the aid of this smart technology, energy consumption in the agriculture field becomes reduced. Moreover, this process also helps to foster sustainability practices. On the other hand, with the aid of this IoT technology productivity has to be increased (Njoroge *et al.* 2019). IoT has a potential impact on tracking agriculture products to deliver from farm to market, which helps to foster efficiency. Moreover, IOT has a positive impact on reducing wastage and helps to maintain environmental sustainability.

Aim

The main principle of this study is to discuss the importance of IoT in the agricultural field to maintain sustainability.

Research Objectives

RO 1: To analyze the importance of IoT in the precision farming process

RO 2: To discuss the role of IoT in the crop monitoring process

RO 3: To highlight the impact of IoT on maintaining sustainability in the agricultural field

RO 4: To find out the negative impact of the use of IoT in the agricultural field

Research Questions

RQ 1: What is the importance of IoT in the precision farming process?

RQ 2: How to discuss the role of IoT in the crop monitoring process?

RQ 3: What is the impact of IoT on maintaining sustainability in the agricultural field?

RQ 4: What is the negative impact of the use of IoT in the agricultural field?

Literature Review

Critically analyze the importance of IoT in the precision farming process

Real-time data on various factors like moisture of the soil, humidity, temperature, as well as crop health, has to be collected with the aid of IoT sensors. Therefore, as commented by Sreekantha and Kavya, (2019), this information helps the farmers to make decisions about the farming process. Moreover, farmers are capable of identifying the right decision of fertilization, and pest control. On the other hand, as stated by Ali *et al.* (2020), resource utilization is also reduced with the aid of this advanced technology. Moreover, this technology helps to foster efficiency, which has a positive impact on the production process. Automated machinery helps to reduce the time and a huge amount of production in a short time has to be facilitated by this process.

Figure 2: Impact of IoT in agriculture

(Source: Saleh *et al.* 2022)

This process also helps to reduce the wastages and helps to significantly enhance the efficiency. As stated by Saleh *et al.* (2022), the efficiency of the farming process has to be facilitated with the aid of this advanced technology. Moreover, this process also has a potential impact on the environment. After that, with the aid of this process production costs have to be reduced and farmers can easily identify the global challenges.

Discuss the impact of IoT on maintaining sustainability in the agricultural field

IoT has a significant role in maintaining sustainability in the agricultural field. Therefore, IoT has a positive impact on maintaining biodiversity which helps to assist in protecting and monitoring natural ecosystems. After that, as highlighted by Fresco and Ferrari, (2019), overall environmental sustainability has to be maintained by this process. Pest infection is identified quickly by this IoT process; therefore, this process is more environmentally friendly by using chemicals to detect pests. On the other hand, as commented by Tong and Phupattanasilp, (2021), renewable energy sources are used in agriculture felid by this advanced technology.

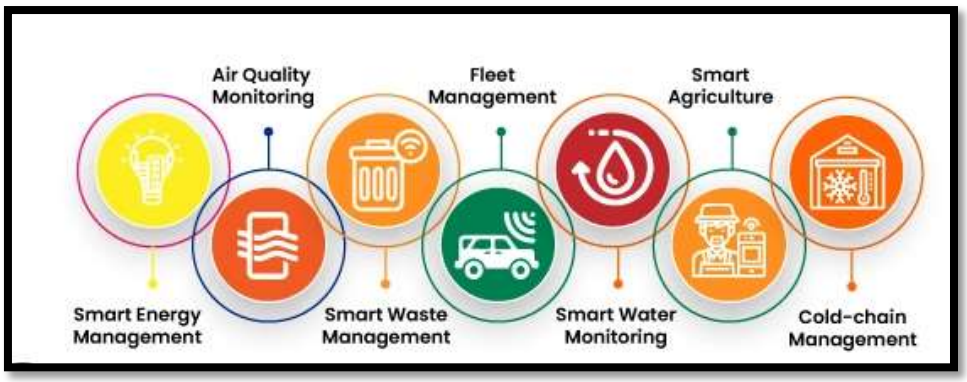

Figure 3: Impact of IoT to maintain sustainability

(Source: Mishra, 2021)

Moreover, with the aid of this process, the environmentally friendly agricultural business has to be facilitated. Environmental-friendly farm equipment is also used in the field of this technology (Mishra, 2021). Moreover, it helps to decrease carbon emissions, advanced technology also helps to reduce the unnecessary use of tractor fuel consumption, therefore, it helps to maintain sustainability within the workplace.

Theoretical framework

Von Thunen's Location Theory

This theory helps the farmers to collect more money from their fields. Therefore, adopting this theory within the agriculture field helps the farmers to understand the current situation of the field (Obaideen *et al.* 2022). Moreover, with the aid of this theory, the use of IoT technology within the agricultural field has to be facilitated. This theory helps to propose agricultural activities into the concentric rings. Therefore, with the aid of this ring growth of the agricultural field has to be facilitated. High-value crops are produced by the farmers with the aid of advanced technology (Abdalla and El-Ramady, 2022). After that, this technology helps to foster efficiency and reduce the production cost.

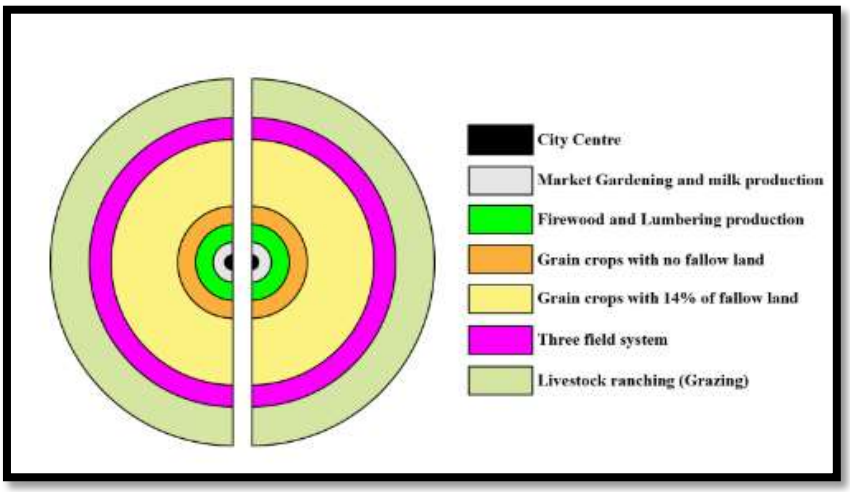

Figure 4: Von Thunen's Location Theory

(Source: Karunathilake *et al.* 2023)

On the other hand, with the aid of this theory, sustainability within the agricultural field has to be fostered and it helps to enhance the growth of the business. Additionally, with the aid of this theory, crop monitoring processes are facilitated and it helps to bring innovation to the

agricultural process (Karunathilake *et al.* 2023). Moreover, the economic growth of the organization is facilitated by this process which helps to enhance the modern agriculture process.

Literature gap

The lack of research about this advanced technology has a negative socio-economic impact on the agriculture field. Therefore, it has a diverse effect on the livelihoods of farmers. On the other hand, rural development becomes reduced, and it has a negative impact on income distributions (Anand *et al.* 2021). After that, lack of research also brings trouble for the environment as a sustainability aspect. Therefore, soil health, ecological balance, and water conservation become imbalanced. Cyber security is another issue that has to be facilitated by this process; moreover, the IoT-based agriculture process faces difficulties due to a lack of research.

Methodology

In this study, researchers are capable of collecting data with the support of various online sources. Therefore, "theoretical analysis" helps to analyze collected data. Deep conceptual understanding is promoted by this theoretical analysis. Moreover, this analysis process helps to predict the possible outcomes of the research (Monteiro *et al.* 2021). Therefore, with the aid of this data collection process, researchers are capable of collecting a vast amount of data which helps to gather pieces of information about this research topic. Moreover, with the aid of this theoretical analysis, researchers are capable of identifying the importance of IoT in the agriculture field. A wide range of scenarios has to be collected with the aid of this theoretical analysis (Roychowdhury, 2023). After that, generalizable information is gathered with the aid of this data collection method. This data collection process is also cost-effective; therefore, researchers are capable of conducting experiments which help to enhance their problem-solving capabilities (Srivastava and Prakash, 2023). Additionally, researchers are capable of analyzing the collected data with the aid of the "thematic analysis". Moreover, this theoretical analysis refers to a valuable tool which helps to gain advanced knowledge and develop the vast field of study.

Findings and Analysis

Theme 1: IoT has a positive impact on agriculture to enhance productivity

Various devices and sensors are capable of noticing the conditions of soil. Therefore, IoT sensors also help to monitor the temperature, condition of weather, as well as crop health. With the aid of these real-time data helps to make clear decisions about the fertilization process (Liang and Shah, 2023). On the other hand, the pest control process is also facilitated by these IoT sensors, therefore, the productivity of the organization becomes facilitated and it helps to foster the growth of the country. The economic structure of the country becomes enhanced, and it helps to eliminate the use of resource wastages. Moreover, implementing this advanced technology helps to enhance crop yield (Tomar and Kaur, 2021). Monitoring the location and the condition of the livestock process becomes easier with the help of this technology, after that, GSB tracking and wearable sensors help to collect the live pieces of information about the livestock. Better animal care is also facilitated, which helps to foster productivity. On the other hand, as mentioned by Symeonaki *et al.* (2020), with the help of IoT technologies, farmers are capable of identifying the required types of equipment for their

fields to enhance productivity. Therefore, these types of equipment help to save time and produce more crops which help to bring the development of the agriculture field.

Theme 2: IoT helps to maintain environmental sustainability aspects of the agriculture field

Valuable environmentally friendly data are collected by this IoT technology. Therefore, this information has a positive impact on the fertilization-related data. On the other hand, policy decisions like climate conditions, weather patterns, and pest infections help to maintain the sustainability of the agriculture field (Tong and Phupattanasilp, 2021). Therefore, positive environmental impact has to be facilitated by this IoT technology. IoT device also helps to identify the condition of soil moisture. Therefore, these data help to reduce the use of the resources. Valuable environmental-related data are collected by these IoT devices, moreover, policy decisions become environmentally friendly, and it helps to make decisions according to the climate pattern (Fresco and Ferrari, 2019). Supply chain optimization is another important factor that is facilitated with the aid of these IoT devices; moreover, food wastage is eliminated by tracking the exact location of the delivery of the products. After that, agricultural products become free for a long period with the aid of this IoT sensor. Moreover, proper delivery, and storage processes are done timely manner with the aid of this advanced technology (Saleh *et al.* 2022). Energy consumption is another important factor that has to be generated properly with the aid of these IoT devices. Farmers are capable of monitoring and controlling excessive energy consumption and try to provide sustainable energy usage.

Theme 3: Discuss the negative impact of IoT in the agricultural field

Implementing IoT technology in the agriculture field become expensive. Farmers in developing areas are unable to afford this technology. Therefore, it is noticed that cost is the main barrier to this advanced technology. The vast amount of data and sensitive pieces of information are collected by IoT, therefore, lack of security brings trouble for the farmers (Ali *et al.* 2020). Important pieces of information about the crop, fertilization process, and farming practices are disclosed. After that, proper privacy and security is the main challenge that is faced by implementing the innovative farming process. Implementing IoT is a complex process; therefore, farmers are unable to use this technology in their workplace (Sreekantha and Kavya, 2019). Moreover, technical experts are required which has a negative impact on the economic system. Lack of technological knowledge faces various difficulties; therefore, rural areas become unaware of this technology. Additionally, this technology has a negative impact on the environment (Njoroge *et al.* 2019). Energy consumption from implementing these devices has contributed to carbon emissions. On the other hand, the required manual power is eliminated by technological uses. Therefore, it has a negative impact on the job security of the farmers. The lack of technological infrastructure in the rural areas brings various troubles for the farmers; moreover, it is highly required to maintain sustainability in the agricultural field (Pooja *et al.* 2019). After that, various innovative ideas help to reduce the agricultural problem and foster productivity.

Theme 4: Impact of precision farming in the agricultural field

Crop yield has been increased with the aid of this farming process. Therefore, a GPS-guided, data analytics process becomes fostered with the aid of this farming process. Moreover, input costs become reduced with the aid of this type of farming process in agriculture (Raj *et al.*

2022). Moreover, various resource costs like fertilizers, raw materials supply, and use of pesticides become reduced and it helps to foster the productivity of the organization. On the other hand, profitability becomes increased with the support of this farming process, after that, overuse of the chemicals as well as water becomes reduced, and it helps to mountain sustainability (Phupattanasilp and Tong, 2019). Environmental pollution has to be reduced by implementing this farming process, and it helps to reduce the use of carbon footprint in the agricultural field. Sustainability agriculture is promoted by this process, after that, the precision farming process helps to promote biodiversity (Abu *et al.* 2022). Informed decisions are promoted by the farmers adopting this process. Therefore, crop performance becomes manageable and it helps to bring efficiency to the agricultural field. Quality of the products becomes fostered and it helps to capable of meeting market demand (Zhou *et al.* 2022). After that, economic growth has to be fostered, and better risk management capabilities of the farmers have to be facilitated.

Discussion

The overall discussion of the research study is highlighted in this section. In the introduction section, basic information about the impact of IoT in the agricultural field is highlighted. With the aid of this study, it has to be noticed that, "IoT allows the farmers to look out and manage their farming process; moreover, livestock with precision has to be fostered with the aid of this advanced technology (Qureshi *et al.* 2022). After that, IoT helps to provide sensors which are capable of measuring the moisture of soil, and nutrient level". Therefore, the aim of the research study is discussed all over the study. After that, research objectives, and research questions play a significant role within this study. Based on the research objectives, thematic analysis is highlighted in the literature review section (Dhanaraju *et al.* 2022). Therefore, this section helps to understand that, "IoT has a significant role in maintaining sustainability in the agricultural field. Therefore, IoT has a positive impact on maintaining biodiversity which helps to assist in protecting and monitoring natural ecosystems". In this study, theoretical analysis is highlighted. After that, based on the collected keywords themes are created that help to understand the details information about this selected topic (Abraham *et al.* 2021). Additionally, this study helps to understand that, "Various devices and sensors are capable of noticing the conditions of soil. Therefore, IoT sensors also help to monitor the temperature, condition of weather, as well as crop health (Symeonaki *et al.* 2021). With the aid of these real-time data helps to make clear decisions about the fertilization process".

Conclusion

The Impact of IoT in the agricultural field is discussed in this study. Therefore, with the aid of this study, it has to be noticed that, Implementing IoT technology in the agriculture field become expensive. Farmers in developing areas are unable to afford this technology. Therefore, it is noticed that cost is the main barrier to this advanced technology.

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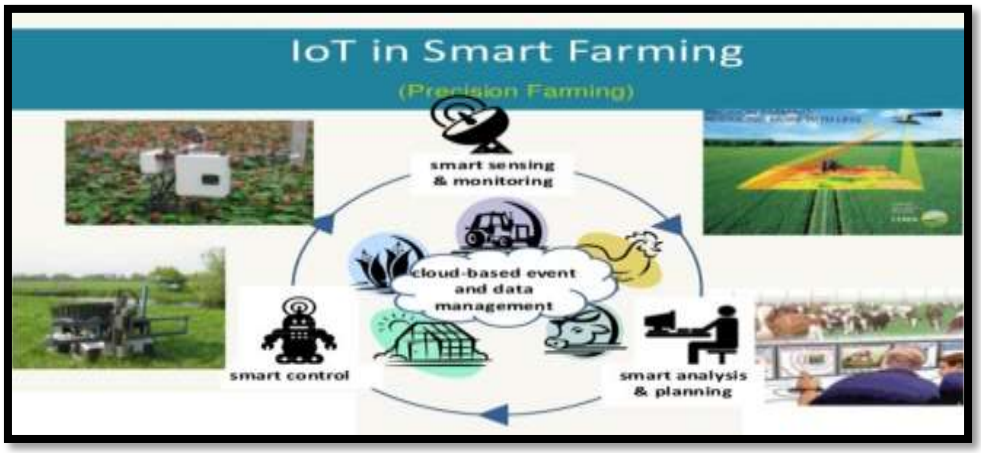
Appendix 1: Role of IoT in smart farming process



(Source: https://www.arcweb.com/blog/iot-steps-smart-farming-precision-agriculture)