ARTIFICIAL INTELLIGENCE AND INTERNET OF THINGS FOR SUSTAINABLE FARMING AND SMART AGRICULTURE

A SEMINAR REPORT

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CERTIFICATE

*This is to certify that the seminar report entitled " **Artificial Intelligence and Internet of Things for Sustainable Farming and Smart Agriculture"** submitted by **EVANA ANN BENNY (AJC21CS070)** to the APJ Abdul Kalam Technological University in partial fulfillment of the requirements for the award of the Degree of Bachelor of Technology in Computer Science and Engineering during the year 2024-2025, is a bonafide work carried out by him/her under my guidance and supervision.*

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ABSTRACT

The study titled “Artificial Intelligence and Internet of Things for Sustainable Farming and Smart Agriculture” explores the integration of advanced technologies in agriculture to enhance productivity and sustainability. It highlights the critical role of Artificial Intelligence (AI) and the Internet of Things (IoT) in transforming traditional farming practices. By leveraging these technologies, farmers can obtain real-time data on various agricultural parameters, enabling them to make informed decisions. The study emphasizes the importance of adopting modern technological solutions to address the challenges posed by population growth and environmental changes, ultimately aiming to improve food security and resource management.

The research methodology involved a comprehensive literature review, analyzing various scholarly articles and conference proceedings related to smart farming and technology implementation in agriculture. The authors utilized prominent academic databases such as Scopus, IEEE, and Science Direct to gather relevant information. The study focused on key terms like “smart farming”,“AI and IoT in farming,” and irrigation facilities.” This systematic approach ensured that the findings were grounded in credible research, providing a solid foundation for the conclusions drawn regarding the benefits of AI and IoT in sustainable agriculture.

The findings of the study reveal that the integration of AI and IoT technologies can significantly enhance agricultural efficiency, quality, and yield. The authors categorize the essential aspects of intelligent and sustainable agriculture, including crop management, soil health, weather monitoring, and pest control. By implementing these technologies, farm-

ers can optimize resource usage, reduce waste, and improve overall productivity. The paper also discusses the potential of AI and IoT to facilitate better decision-making processes, ultimately leading to more sustainable farming practices that can adapt to changing environmental conditions.

The authors advocate for the development of an integrated AI and IoT platform tailored for smart and sustainable agriculture (SSA). This framework aims to address the fragmented nature of agricultural production and enhance collaboration among stakeholders. By embracing these modern technologies, the agricultural sector can not only improve its efficiency but also contribute to global efforts in achieving food security and environmental sustainability.

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ABBREVIATIONS

- AI - Artificial Intelligence
- IoT - Internet of Things
- SSA - Smart Sustainable Agriculture
- cGAN - Conditional Generative Adversarial Network
- DA-GAN - Dual-Agent Generative Adversarial Network
- RSP - Researchers Supporting Project

CHAPTER 1

INTRODUCTION

Agriculture has been a cornerstone of human civilization, providing sustenance and economic stability for thousands of years. In recent times, the integration of advanced technologies such as Artificial Intelligence (AI) and the Internet of Things (IoT) has revolutionized traditional farming practices, paving the way for Smart Sustainable Agriculture (SSA). This study explores the transformative potential of AI and IoT in enhancing agricultural productivity, sustainability, and efficiency.

1.1 Overview

The convergence of AI and IoT technologies in agriculture enables real-time monitoring and management of farming operations. These technologies facilitate data-driven decision-making, optimize resource utilization, and improve crop yields. By leveraging AI algorithms and IoT devices, farmers can gain insights into soil health, weather patterns, pest management, and irrigation needs, ultimately leading to more sustainable farming practices.

1.2 Motivation and Objectives

The motivation behind this study stems from the pressing need to address the challenges faced by the agricultural sector, including climate change, resource scarcity, and the growing global population [1]. The objectives of this work are to:

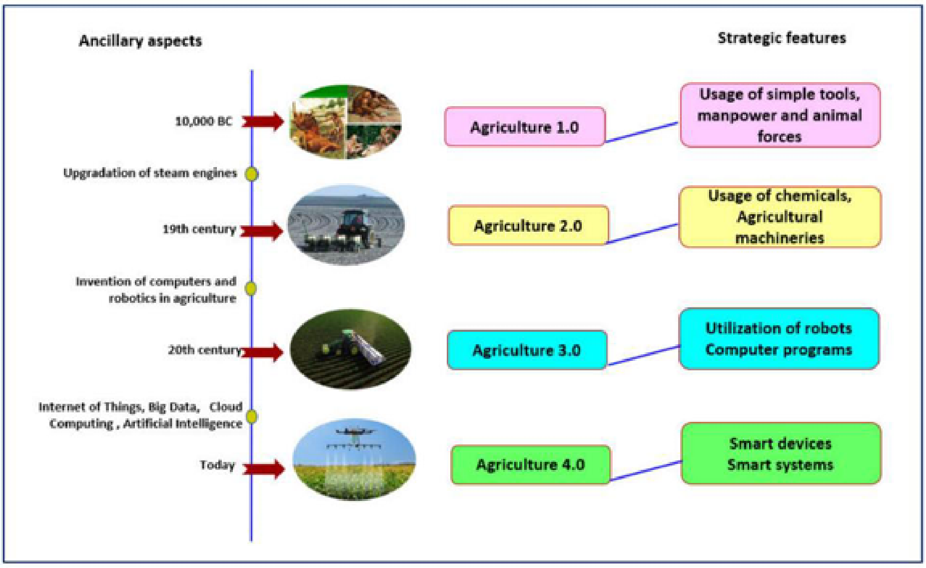

Figure 1.1: Upgradation of agriculture [1].

Analyze the current state of AI and IoT technologies in agriculture. The agricultural sector has evolved into different phases as shown in fig 1.1. Identify the key categories and tools used in the implementation of these technologies [2]. Propose a framework for integrating AI and IoT in sustainable farming practices to enhance productivity and sustainability.

1.3 Report Organization

This report is organized as follows: Section 2 provides a literature review on the application of AI and IoT in agriculture, highlighting various categories and tools. Section 3 outlines the research methodology employed in this study, including data sources and analysis techniques. Section 4 presents the results and discussion, focusing on the impact of AI and IoT on farming efficiency and the challenges faced in their implementation. Finally, Section 5 concludes the study and suggests future directions for research in this field.

CHAPTER 2

LITERATURE SURVEY

The integration of Artificial Intelligence (AI) and the Internet of Things (IoT) in agriculture has emerged as a transformative force, enabling farmers to enhance productivity, sustainability, and efficiency. This literature survey examines various technologies employed in smart farming, their applications, benefits, and the challenges faced in their implementation.

2.1 Artificial Intelligence in Agriculture

AI technologies are transforming modern agriculture by enabling data-driven decision-making and automating processes. They facilitate precision farming, optimizing planting, irrigation, and fertilization for increased yields. AI also aids in pest and disease management through predictive analytics, allowing timely interventions. Additionally, AI enhances supply chain management by analyzing market trends, helping farmers align production with demand. Robotics and automation reduce labor costs and address labor shortages by handling tasks like planting and harvesting. Overall, AI improves efficiency, sustainability, and profitability in agriculture, paving the way for smarter farming systems.

2.2 Machine Learning in Agriculture

Machine learning (ML), a subset of artificial intelligence (AI), develops algorithms that learn from data to make predictions. In agriculture, ML is notably used for yield prediction, analyzing historical data and environmental factors like temperature and rainfall to forecast future yields. Techniques such as regression analysis and Random Forest have improved forecast accuracy [3]. Additionally, ML algorithms classify crop images to detect pests and diseases, with convolutional neural networks (CNNs) effectively identifying issues in crops like tomatoes and potatoes, allowing for timely interventions and reduced pesticide use.

2.3 Deep Learning

Deep learning, an advanced form of machine learning, uses multi-layered neural networks to analyze complex data patterns. In agriculture, it is applied in image analysis, where models process images from drones or smartphones to assess crop health by evaluating leaf color and texture, enabling the detection of nutrient deficiencies and diseases. Additionally, deep learning enhances predictive analytics by analyzing large datasets from sources like weather forecasts and soil conditions, providing insights into optimal planting times and resource allocation, thus helping farmers make informed decisions to improve crop yields.

2.4 Natural Language Processing (NLP)

Natural Language Processing (NLP) technologies facilitate the analysis of textual data, offering significant benefits for farmers. For market analysis, NLP can evaluate social media and news articles to identify market trends and consumer preferences, aiding farmers in crop selection and marketing strategies. Additionally, NLP can process agricultural research papers and reports to extract relevant insights, helping farmers stay updated on the latest practices and innovations in agriculture [4].

2.5 Internet of Things in Agriculture

IoT technologies facilitate the collection, transmission, and analysis of data from various sensors deployed in agricultural fields, enabling real-time monitoring and management.

2.5.1 Sensor Technologies

IoT sensors play a vital role in agriculture by collecting data on various environmental parameters. Soil sensors measure moisture, temperature, and nutrient levels, providing real-time information that helps optimize irrigation and fertilization practices; for instance, soil moisture sensors can trigger irrigation systems only when necessary, conserving water resources. IoT-enabled weather stations gather data on local conditions such as temperature, humidity, and wind speed, assisting farmers in making informed decisions regarding planting, harvesting, and pest management. Additionally, advanced crop health sensors, including multispectral and hyperspectral cameras, assess plant health by capturing data across different wavelengths, enabling early detection of diseases and nutrient deficiencies for targeted interventions.

2.6 Drones and UAVs

Unmanned Aerial Vehicles (UAVs), or drones, have become essential tools in precision agriculture. They are equipped with high-resolution cameras that capture detailed images of fields, enabling farmers to monitor crop health, assess growth patterns, and identify areas requiring attention. Additionally, drones facilitate variable rate application, allowing for the precision application of fertilizers and pesticides, ensuring that inputs are applied only where needed. This targeted approach not only reduces waste but also minimizes environmental impact.

2.7 Smart Irrigation Systems

IoT-enabled irrigation systems optimize water usage through automation, significantly enhancing agricultural efficiency. Smart irrigation systems utilize data from soil moisture sensors and weather forecasts to automate watering schedules, ensuring that crops receive the right amount of water at the right time, which improves water efficiency and crop health. Additionally, IoT technology can enhance traditional drip irrigation systems by continuously monitoring soil moisture levels and adjusting water delivery accordingly. This method not only reduces water consumption but also promotes sustainable farming practices.

2.8 Integration of AI and IoT Technologies

The combination of AI and IoT technologies creates a powerful ecosystem for smart agriculture:

2.8.1 Data Analytics

AI algorithms analyze data collected from IoT devices to provide actionable insights that enhance agricultural practices. Through predictive analytics, AI integrates data from various sources to forecast future agricultural trends, such as pest outbreaks or yield fluctuations, enabling farmers to take proactive measures. Furthermore, AI-driven decision support systems assist farmers in making informed choices regarding crop management, resource allocation, and risk mitigation, ultimately leading to more efficient and sustainable farming practices.

2.8.2 Automation

The integration of AI and IoT enables the automation of various agricultural processes, significantly enhancing operational efficiency. AI-powered machinery can perform tasks such as planting, harvesting, and weeding with minimal human intervention, which increases efficiency and reduces labor costs. Additionally, farmers can remotely monitor and control agricultural operations through mobile applications, allowing for real-time adjustments based on data insights, further optimizing productivity and resource management.

2.9 Challenges and Future Directions

Despite the promising advancements in AI and IoT technologies, several challenges remain:

2.9.1 Data Management

The vast amount of data generated by IoT devices requires effective storage, processing, and analysis solutions. Developing robust data management systems that can handle large datasets while ensuring data security and privacy is crucial.

2.9.2 Interoperability

Different IoT devices and platforms often lack compatibility, hindering seamless integration. Establishing standardized protocols and frameworks for data exchange among various devices is essential for maximizing the benefits of smart agriculture.

2.9.3 Adoption Barriers

Smallholder farmers may face challenges in adopting these technologies due to costs, lack of technical knowledge, and limited access to resources. Future research should focus on developing user-friendly interfaces, enhancing data interoperability, and creating cost-effective solutions for small-scale farmers to ensure widespread adoption of AI and IoT in agriculture.

2.9.4 Sustainability Considerations

As agriculture increasingly relies on technology, it is essential to consider the environmental impact of these innovations. Research should explore sustainable practices that minimize resource consumption and reduce the carbon footprint of agricultural operations.

Category	Tool/Company	Description
Greenhouse automation	Far mapp	It is quicker and more effective to monitor pests and illnesses while also producing information for mobile applications. The synced data from the server and the data that was previously saved enables real-time viewing of metrics like a satellite map, sanitary status, comparison heatmaps, and graphs and reports on pests and illnesses.
	Grow link	a system that combines hardware and software to provide wireless automation, data collecting, optimization, and monitoring, among other smarter working features.
	Green IQ	a solution that connects IoT devices to automation platforms and allows users to control irrigation and lighting from any place.
Climate conditions Monitoring	allMETEO	a gateway for managing Internet of Things (IoT) micro weather sensors, gathering data in real-time, making a weather map, and offering an API for simple data transmission.
	Smart Elements	a group of technologies that increase productivity by employing sensors to provide reports to an internet dashboard, enabling quick choices based on current circumstances.
Agriculture machines /drones	Sky Squirrel	a drone system intended to increase crop productivity and lower expenses. A drone's path is preprogrammed by users, and computer vision is used to capture photographs. Users may download the data from the drone when its trip is complete and upload it to a cloud drive. The collected data and photographs are then combined and analyzed by algorithms to produce a comprehensive report on the health and condition of crops.
	See & Spray	a machine built to manage forests and safeguard crops. To monitor and accurately spray weeds and diseased plants, it makes use of computer vision.
	CROO	a machine that helps in crop picking and packing. According to the manufacturer, this robot can complete the task of thirty human employees and harvest eight acres in a single day.
Crop management	Arable	a gadget that combines measurements of the weather and plants and sends the information to the cloud for immediate retrieval from any place. It provides constant signs of illness, pests, and stress.
	Semios	a system that enables farmers to use real-time data to monitor and react to pests, diseases, and crops, forming on-the-ground sensing, big data, and predictive analytics solutions for long-term agricultural goods.
Crop and Soil Health Monitoring	Plantix	a technology based on machine learning for managing and controlling the farming process, preventing illness, and growing superior crops
	Trace Genomics	By analysing a soil sample's DNA and comparing it to a sizable soil DNA database, a soil monitoring system employs a machine learning technique to create a health report for the sample.
Predictive Analytics	Farm shots	a system that maps possible disease, pest, and malnutrition indications in agriculture fields using satellite and drone imagery. To create prescriptions, generated data may be sent to agricultural software.
Livestock monitoring and management	Cowlar	a smart neck collar for tracking the temperature, activity, and other behavioural traits of dairy cows. It employs a solar-powered base unit and a minimally intrusive, waterproof monitoring device that are both comfortable for the animal. To accurately diagnose oestrus, it may track body movement patterns and gait.
End-to- end farm Management systems	Farm Logs	This technology keeps track of field conditions, making it easier to plan and control crop output. Additionally, it sells agricultural goods.
	Cropio	a tool for making decisions that integrates meteorological data with satellite data to track crops and make field forecasts while optimising fertilisation and watering.

Figure 2.1: Describes different categories in which AI is used in the field of agriculture, what tools are used and how it is being implemented in farming [1].

CHAPTER 3

METHODOLOGY

3.1 Methodology

This section outlines the methodology employed in this study to analyze the integration of Artificial Intelligence (AI) and the Internet of Things (IoT) in agriculture. The methodology encompasses the research design, data sources, search and screening process, and analytical techniques.

3.2 Research Design

The research adopts a systematic literature review approach to gather, evaluate, and synthesize existing studies on AI and IoT technologies in agriculture. This approach allows for a comprehensive understanding of the current state of research, identifies gaps in the literature, and provides insights into future directions for the integration of these technologies in smart agriculture. Fig 3.1 shows the implication of IoT into Smart Agriculture.

3.3 Data Sources

The data for this study was collected from reputable academic databases and journals that focus on agricultural technology, computer science, and environmental science. The primary data sources include: [5]

- Scopus: A multidisciplinary database that provides access to peer-reviewed literature across various fields, including agriculture and technology.
- IEEE Xplore: A digital library for research in engineering and technology, offering access to journals, conference proceedings, and standards related to IoT and AI applications.
- ScienceDirect: A leading full-text scientific database offering articles from a wide range of disciplines, including agricultural sciences and technology.
- Google Scholar: A freely accessible web search engine that indexes scholarly articles across various disciplines, providing a broader search scope.

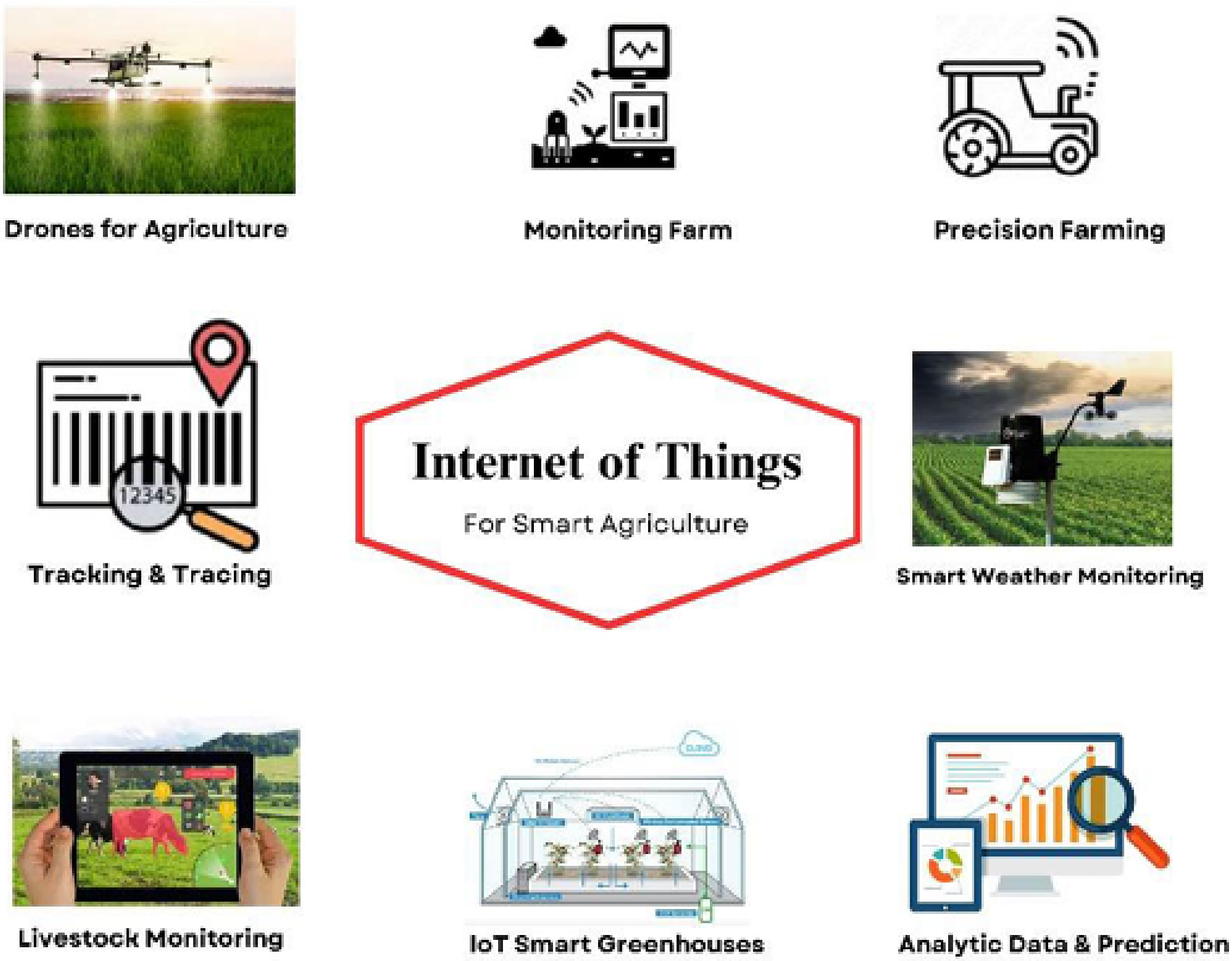

Figure 3.1: IoT for Smart agriculture [1].

3.4 Search Process

The search process involved the following steps:

3.4.1 Keyword Identification

A set of relevant keywords and phrases was identified to guide the search. These keywords included:

- "Artificial Intelligence in agriculture"
- "Internet of Things in agriculture"
- "Smart farming technologies"
- "Precision agriculture"
- "AI and IoT applications in farming"
- "Sustainable agriculture technologies"
- "Data analytics in agriculture"

3.4.2 Search Queries

Using the identified keywords, search queries were formulated for each database. Boolean operators (AND, OR, NOT) were employed to refine the search results. For example, a search query in Scopus might look like:

3.5 Screening Process

The screening process involved several stages to ensure the relevance and quality of the selected studies:

3.5.1 Inclusion Criteria

The following inclusion criteria were established to select relevant articles:

- Articles published in peer-reviewed journals or conference proceedings.
- Studies focusing on the application of AI and IoT in agriculture.
- Research published within the last ten years (2013-2023) to ensure the inclusion of recent advancements.
- Articles available in English.

3.5.2 Exclusion Criteria

The following exclusion criteria were applied to filter out irrelevant studies:

- Articles not focused on agriculture or related technologies.
- Studies that do not provide empirical data or case studies.
- Duplicate articles or those with insufficient information.

3.6 Initial Screening

The initial screening involved reviewing the titles and abstracts of the articles retrieved from the databases. Articles that met the inclusion criteria were selected for further evaluation.

3.7 Full-Text Review

The full texts of the selected articles were reviewed to assess their relevance and quality. A detailed evaluation was conducted based on the following aspects:

- Research objectives and questions.
- Methodological rigor and data collection techniques.
- Findings and contributions to the field of AI and IoT in agriculture.

3.8 Final Selection

A final selection of articles was made based on the full-text review. A total of 50 articles were included in the literature review, providing a comprehensive overview of the current state of research on AI and IoT applications in agriculture.

3.9 Data Extraction and Analysis

Data extraction involved summarizing key information from the selected articles, including:

- Authors and publication year.
- Research objectives and methodologies.
- Key findings and contributions.
- Technologies and applications discussed.

The extracted data was organized into a structured format, allowing for thematic analysis. Thematic analysis was employed to identify common themes, trends, and gaps in the literature. This analysis facilitated the synthesis of findings and the development of insights regarding the integration of AI and IoT in agriculture.

3.10 Limitations

While this methodology provides a comprehensive overview of the literature, certain limitations should be acknowledged:

- The focus on English-language articles may exclude relevant studies published in other languages.
- The selection of articles was limited to specific databases, which may not encompass all relevant research in the field.

- The rapidly evolving nature of technology means that new studies may emerge after the completion of this review.

CHAPTER 4

FINDINGS AND ANALYSIS

This section presents the key findings from the literature review on the integration of Artificial Intelligence (AI) and the Internet of Things (IoT) in agriculture. The analysis focuses on the applications, benefits, challenges, and future directions of these technologies in promoting sustainable agriculture.

4.1 Applications of AI and IoT in Agriculture

The integration of AI and IoT technologies in agriculture has led to the development of various applications aimed at enhancing productivity, efficiency, and sustainability. Key applications identified in the literature include:

- Precision Agriculture: AI and IoT technologies enable farmers to monitor crop health, soil conditions, and weather patterns in real time. Sensors collect data on moisture levels, temperature, and nutrient content, which AI algorithms analyze to provide actionable insights for optimizing irrigation, fertilization, and pest control.
- Smart Irrigation Systems: IoT devices facilitate the development of smart irrigation systems that adjust water usage based on real-time data. These systems help conserve water and reduce costs while ensuring optimal crop growth.
- Crop Monitoring and Disease Detection: AI-powered image recognition tools analyze images captured by drones or cameras to detect diseases and pests early. This proac-

tive approach allows for timely interventions, reducing crop losses and minimizing pesticide use.

- Yield Prediction and Analytics: Machine learning algorithms analyze historical data and current conditions to predict crop yields accurately. This information aids farmers in making informed decisions regarding planting and resource allocation.
- Supply Chain Optimization: IoT technologies enhance supply chain management by providing real-time tracking of agricultural products from farm to market. This transparency helps reduce waste and improve efficiency in distribution.

4.2 Benefits of AI and IoT in Agriculture

The integration of AI and IoT technologies in agriculture offers several significant benefits:

- Increased Productivity: The use of precision agriculture techniques has been shown to increase crop yields by optimizing resource use and minimizing waste. Studies indicate that farms utilizing AI and IoT technologies can achieve yield increases of up to 20
- Resource Efficiency: Smart irrigation and precision farming practices lead to more efficient use of water, fertilizers, and pesticides. This not only reduces costs for farmers but also minimizes the environmental impact of agricultural practices.
- Enhanced Decision-Making: The data-driven insights provided by AI and IoT technologies empower farmers to make informed decisions. This leads to better management of agricultural practices and improved overall farm performance.
- Sustainability: The adoption of smart farming practices contributes to sustainable agriculture by reducing resource consumption and environmental degradation. IoT-enabled monitoring systems help ensure compliance with sustainability standards and regulations.

4.3 Challenges in Implementing AI and IoT in Agriculture

Despite the numerous benefits, the integration of AI and IoT in agriculture faces several challenges:

- Data Management and Interoperability: The fragmentation of agricultural processes and the variety of data sources create challenges in data sharing and management. Ensuring interoperability between different IoT devices and platforms is crucial for effective implementation.
- High Initial Costs: The adoption of AI and IoT technologies often requires significant upfront investment in hardware, software, and training. This can be a barrier for smallholder farmers who may lack the financial resources to implement these technologies.
- Technical Expertise: The successful implementation of AI and IoT solutions requires a certain level of technical expertise. Many farmers may not have the necessary skills to operate and maintain these technologies, necessitating training and support.
- Data Privacy and Security: The collection and storage of large amounts of data raise concerns about data privacy and security. Farmers must be assured that their data is protected and used responsibly.

4.4 Future Directions

The findings from the literature suggest several future directions for research and development in the field of AI and IoT in agriculture:

- Integration of Advanced Technologies: Future research should explore the integration of AI and IoT with other emerging technologies, such as blockchain and big data analytics, to enhance transparency and efficiency in agricultural supply chains.
- Focus on Smallholder Farmers: Developing affordable and accessible AI and IoT solutions tailored for smallholder farmers can help bridge the technology gap and promote inclusive agricultural practices.

- Policy and Regulatory Frameworks: Establishing supportive policies and regulatory frameworks is essential to facilitate the adoption of AI and IoT technologies in agriculture. This includes addressing data privacy, security, and interoperability issues.
- Sustainability Metrics: Future research should focus on developing metrics to assess the sustainability impacts of AI and IoT technologies in agriculture. This will help stakeholders evaluate the effectiveness of these technologies in promoting sustainable farming practices.

CHAPTER 5

CONCLUSION AND FUTURE WORK

The integration of Artificial Intelligence (AI) and the Internet of Things (IoT) in agriculture represents a transformative shift towards more efficient, productive, and sustainable farming practices. Fig 5.1 shows the evolution of AI in agriculture over the years .This study has highlighted the critical role that these technologies play in addressing the challenges faced by the agricultural sector, including resource scarcity, climate change, and the need for increased food production to meet the demands of a growing global population.

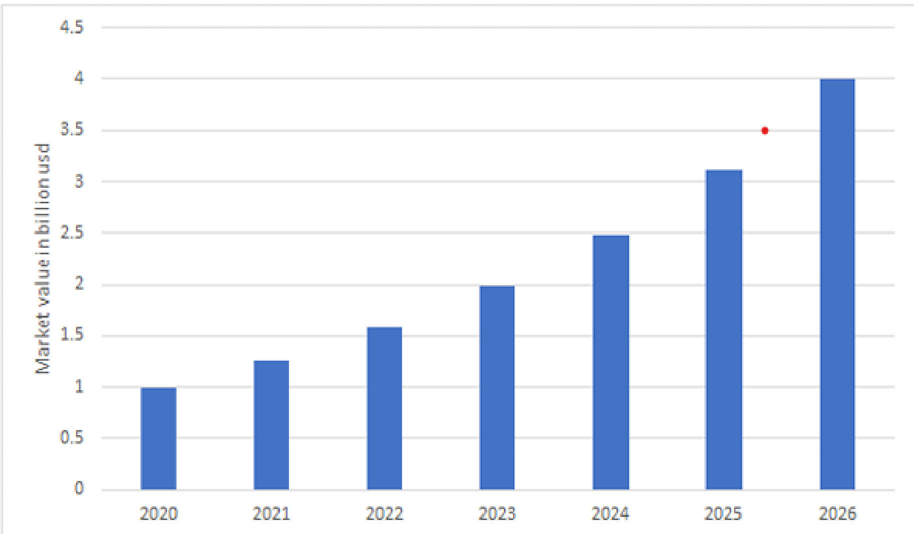

Figure 5.1: Projected artificial intelligence in agriculture market from 2020 to 2026 [1].

The findings indicate that AI and IoT applications, such as precision agriculture, smart irrigation systems, and crop monitoring, significantly enhance productivity and resource efficiency. By leveraging real-time data and advanced analytics, farmers can make informed decisions that optimize their operations, reduce waste, and improve crop yields. Moreover, the adoption of these technologies contributes to sustainable agricultural practices by minimizing environmental impacts and promoting responsible resource management [5].

However, the journey towards widespread adoption of AI and IoT in agriculture is not without its challenges. Issues such as data management, interoperability, high initial costs, and the need for technical expertise pose significant barriers, particularly for smallholder farmers. Addressing these challenges is crucial for ensuring that the benefits of these technologies are accessible to all segments of the agricultural community [6].

In conclusion, integrating AI and IoT in agriculture is not merely a technological advancement; it is a necessary evolution that aligns with sustainable development goals. As the agricultural sector continues to embrace these innovations, it is imperative to foster collaboration among stakeholders, including farmers, technology providers, policymakers, and researchers, to create an ecosystem that supports the effective implementation of AI and IoT solutions [2].

5.1 Future Work

Looking ahead, several avenues for future research and development can further enhance the impact of AI and IoT in agriculture:

5.1.1 Development of Cost-Effective Solutions

Future work should focus on creating affordable and scalable AI and IoT solutions tailored for smallholder farmers. This includes developing low-cost sensors, user-friendly software interfaces, and accessible training programs that empower farmers to adopt these technologies without significant financial burden.

5.1.2 Enhancing Data Interoperability

Research should prioritize the development of standards and protocols that facilitate data interoperability among various IoT devices and platforms. This will enable seamless data sharing and integration, allowing farmers to leverage a comprehensive view of their agricultural operations and make more informed decisions.

5.1.3 Exploration of Advanced Technologies

The integration of AI and IoT with other emerging technologies, such as blockchain, machine learning, and big data analytics, presents an exciting opportunity for innovation in agriculture. Future studies should explore how these technologies can work together to enhance transparency, traceability, and efficiency in agricultural supply chains.

5.1.4 Focus on Sustainability Metrics

Future research should aim to establish metrics and frameworks for assessing the sustainability impacts of AI and IoT technologies in agriculture. This will help stakeholders evaluate the effectiveness of these technologies in promoting sustainable practices and guide future investments in agricultural innovation.

5.1.5 Policy Development and Advocacy

There is a need for research that informs policy development and advocacy efforts aimed at creating a supportive regulatory environment for the adoption of AI and IoT in agriculture. This includes addressing issues related to data privacy, security, and the ethical use of technology in farming practices.

5.1.6 Longitudinal Studies on Impact Assessment

Conducting longitudinal studies to assess the long-term impacts of AI and IoT adoption on agricultural productivity, sustainability, and farmer livelihoods will provide valuable insights.

These studies can help identify best practices and inform future technology development and implementation strategies.

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APPENDIX A

PRESENTATION SLIDES

ABSTRACT

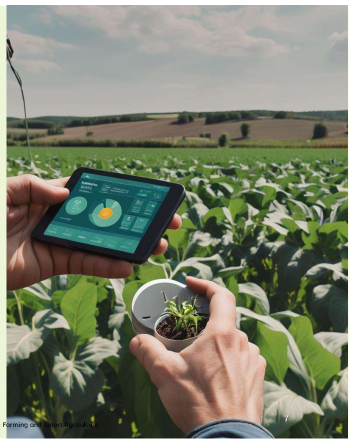
The integration of Artificial Intelligence (AI) and the Internet of Things (IoT) in agriculture has evolved over the years, with a clear trend towards adopting advanced farming tools. Agriculture, essential for human sustenance, benefits from ongoing technological advancements aimed at optimizing crop production and management. Recent IoT innovations enable unprecedented monitoring of agricultural ecosystems, facilitating Smart Sustainable Agriculture (SSA). However, SSA faces challenges such as the deployment and management of IoT and AI devices, data sharing, interoperability issues, and big data analysis. The paper reviews existing IoT technologies in SSA, identifies potential architectural elements for improved platforms, and emphasizes the need for coherent frameworks to address integration complexities. It aims to provide guidance for advancing SSA by proposing a framework that tackles device and data management challenges, enhances interoperability, and supports big data analysis, ultimately contributing to more sustainable and efficient agricultural practices.

INTRODUCTION

INTRODUCTION

The paper "Artificial Intelligence and Internet of Things for Sustainable Farming and Smart Agriculture" explores the significant role of AI and IoT in transforming agriculture. It highlights how these technologies can enhance productivity, efficiency, and sustainability by enabling real-time monitoring, data-driven decision-making, and improved resource management. The study reviews existing applications and tools in smart agriculture while addressing challenges such as data management, interoperability, and investment costs. To facilitate the adoption of these technologies, the authors propose a comprehensive framework for Smart Sustainable Agriculture (SSA), aiming to overcome barriers and promote innovative solutions that contribute to food security and environmental sustainability.

EXISTING WORKS/ LITERATURE SURVEY

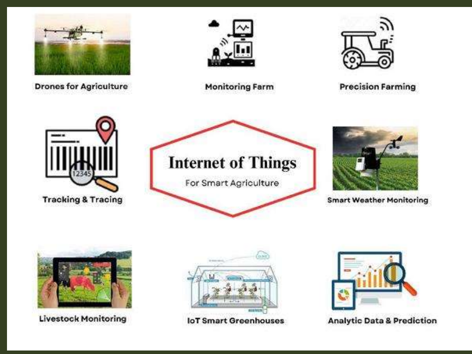


SUMMARY OF FINDINGS

- **Punjabi et al.**: Developed a temperature sensing application using GSM and Arduino for real-time data collection in agricultural settings.
- **Uddin et al.**: Utilized Unmanned Aerial Vehicles (UAVs) for data collection in specific areas, aiding in crop health monitoring and timely detection of issues such as nutrient deficiencies and pest infestations.
- **Farooq et al.**: Presented a comprehensive list of various IoT devices and their underlying network architecture, highlighting security concerns and applications for different stages of farming.
- **Jagadale**: Discussed the transformative impact of IoT and AI technologies in agriculture, including the use of drones for forecasting meteorological conditions and optimizing resource use.
- **Alam and Khan**: Addressed the challenges of feeding the growing global population and emphasized the role of AI and IoT in enhancing agricultural productivity and sustainability

KEY FINDINGS

- The integration of **AI and IoT technologies** significantly improves crop management practices and optimizes resource utilization in agriculture.
- **Smart farming** using IoT and AI can transform traditional farming methods, leading to increased productivity and reduced waste.
- Despite the benefits, **security concerns** and **economic challenges** hinder widespread adoption, especially among small farmers, who may struggle with the capital investment and maintenance costs associated with these technologies.



OBJECTIVES

OBJECTIVES

1. To analyze the current state of IoT and AI in agriculture
2. To propose a framework for Smart Sustainable Agriculture (SSA)
3. To identify challenges and opportunities in implementing these technologies

METHODOLOGY

1. **Data collection**: Gathered data from prominent academic databases such as Scopus, IEEE, and Science Direct using keywords like "smart farming," "AI and IoT in agriculture," and "sustainable agriculture practices."
2. **Filtering criteria**: applied strict filtering criteria based on the quality of journals and the publication year to ensure the relevance and credibility of the selected studies.
3. **Analysis of technologies**: analyzed various IoT and ai technologies currently implemented in agriculture, categorizing them based on their applications (e.g., Crop monitoring, soil management, pest control).
4. **Framework development**: proposed a framework for integrating IoT and AI technologies in smart sustainable agriculture (SSA) to address existing challenges and enhance operational efficiency.

Category	Tool/Company	Description
Greenhouse automation	Far mapp	It is quicker and more effective to monitor pests and illnesses while also producing information for mobile applications. The synced data from the server and the data that was previously saved enables real-time viewing of metrics like a satellite map, sanitary status, comparison heatmaps, and graphs and reports on pests and illnesses.
	Grow link	a system that combines hardware and software to provide wireless automation, data collecting, optimization, and monitoring, among other smarter working features.
	Green IQ	a solution that connects IoT devices to automation platforms and allows users to control irrigation and lighting from any place.
Climate conditions Monitoring	allMETEO	a gateway for managing Internet of Things (IoT) micro weather sensors, gathering data in real-time, making a weather map, and offering an API for simple data transmission.
	Smart Elements	a group of technologies that increase productivity by employing sensors to provide reports to an internet dashboard, enabling quick choices based on current circumstances.
Agriculture machines /drones	Sky Squirrel	a drone system intended to increase crop productivity and lower expenses. A drone's path is preprogrammed by users, and computer vision is used to capture photographs. Users may download the data from the drone when its trip is complete and upload it to a cloud drive. The collected data and photographs are then combined and analyzed by algorithms to produce a comprehensive report on the health and condition of crops.
	See & Spray	a machine built to manage forests and safeguard crops. To monitor and accurately spray weeds and diseased plants, it makes use of computer vision.
	CROO	a machine that helps in crop picking and packing. According to the manufacturer, this robot can complete the task of thirty human employees and harvest eight acres in a single day.

Crop management	Arable	a gadget that combines measurements of the weather and plants and sends the information to the cloud for immediate retrieval from any place. It provides constant signs of illness, pests, and stress.
	Semios	a system that enables farmers to use real-time data to monitor and react to pests, diseases, and crops, forming on-the-ground sensing, big data, and predictive analytics solutions for long-term agricultural goods.
Crop and Soil Health Monitoring	Plantix	a technology based on machine learning for managing and controlling the farming process, preventing illness, and growing superior crops
	Trace Genomics	By analysing a soil sample's DNA and comparing it to a sizable soil DNA database, a soil monitoring system employs a machine learning technique to create a health report for the sample.
Predictive Analytics	Farm shots	a system that maps possible disease, pest, and malnutrition indications in agriculture fields using satellite and drone imagery. To create prescriptions, generated data may be sent to agricultural software.
Livestock monitoring and management	Cowlar	a smart neck collar for tracking the temperature, activity, and other behavioural traits of dairy cows. It employs a solar-powered base unit and a minimally intrusive, waterproof monitoring device that are both comfortable for the animal. To accurately diagnose oestrus, it may track body movement patterns and gait.
End-to- end farm Management systems	Farm Logs	This technology keeps track of field conditions, making it easier to plan and control crop output. Additionally, it sells agricultural goods.
	Cropio	a tool for making decisions that integrates meteorological data with satellite data to track crops and make field forecasts while optimising fertilisation and watering.

TECHNIQUES

1. **Qualitative analysis**: evaluated AI and IoT impacts through case studies.
2. **Quantitative analysis**: analyzing data to measure technology effectiveness on crop yield.
3. **Comparative analysis**: compared IoT devices and AI algorithms for agricultural challenges.
4. **Predictive analytics**: forecasted outcomes using historical and real-time IoT data.
5. **Machine learning**: employed regression, decision trees, and neural networks for crop management.
6. **Remote sensing**: used satellite imagery and drones for crop health monitoring.
7. **Wireless sensor networks**: collected real-time soil moisture and climate data.
8. **Big data analytics**: processed large datasets to identify agricultural trends.
9. **Blockchain technology**: enhanced supply chain traceability and food safety.
10. **Cloud computing**: facilitated data storage and collaborative decision-making.

RESULTS AND DISCUSSIONS

- **Key Results Obtained**:
  - AI has reduced agricultural emissions by 20%.
  - IoT devices help monitor critical parameters such as soil conditions and pest infestations.
- **Interpretation and Discussion**:
  - Enhanced data collection leads to timely interventions in crop management.
  - Economic barriers remain a significant challenge for small-scale farmers.

CONCLUSION AND FUTURE WORK

•**Summary of Findings**:
- AI and IoT are crucial for modernizing agriculture and improving sustainability.
- There is a need for cooperative models to support small farmers in adopting these technologies.

•**Implications**:
- Improved food security and resource management.

•**Future Work**:
- Further research on cost-effective IoT solutions for small farmers.
- Development of integrated AI and IoT platforms for comprehensive agricultural management.

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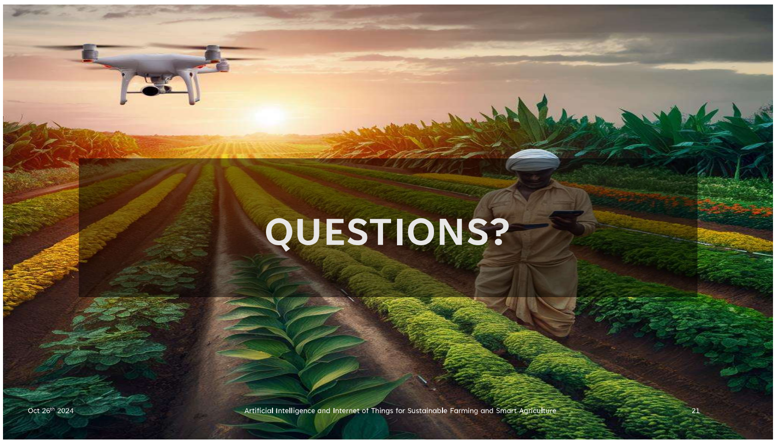
I would also like to extend a special thanks to my fellow students. Your role as a thoughtful and engaged audience has been invaluable.



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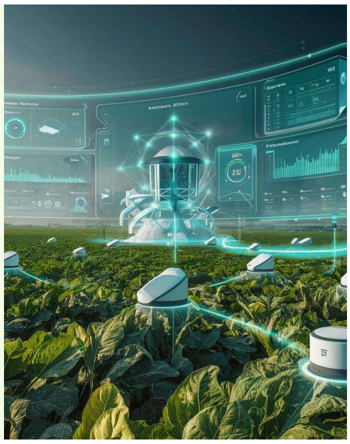

APPENDIX B

BASE PAPER

IEEE Access
Multidisciplinary ⋮ Rapid Review ⋮ Open Access Journal

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APPLIED RESEARCH

Artificial Intelligence and Internet of Things for Sustainable Farming and Smart Agriculture

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ABSTRACT Technologies like AI and IoT have been employed in farming for some time now, along with other forms of cutting-edge computer science. There has been a shift in recent years toward thinking about how to put this new technology to use. Agriculture has provided a large portion of humanity's sustenance for thousands of years, with its most notable contribution being the widespread use of effective agricultural practices for several crop types. The advent of cutting-edge IoT know-how with the ability to monitor agricultural ecosystems and guarantee high-quality production is underway. Smart Sustainable Agriculture continues to face formidable hurdles due to the widespread dispersion of agricultural procedures, such as the deployment and administration of IoT and AI devices, the sharing of data and administration, interoperability, and the analysis and storage of enormous data quantities. This work initially analyses existing Internet-of-Things technologies used in Smart Sustainable Agriculture (SSA) to discover architectural components that might facilitate the development of SSA platforms. This paper examines the state of research and development in SSA, pays attention to the current form of information, and proposes an Internet of Things (IoT) and artificial intelligence (AI) framework as a starting point for SSA.

INDEX TERMS Smart agriculture, Internet of Things (IoT), artificial intelligence (AI), smart sustainable agriculture (SSA), smart farming.

I. INTRODUCTION

Agriculture that is considered sustainable is characterized by long-term viability and ecological compatibility in its grain production practice. Sustainable agriculture serves to support techniques and methods that are beneficial to the long-term survival of humans and natural resources. It is practical from a financial standpoint, and it protects the quality of the soil, slows down the rate at which the soil degrades, conserves water resources, increases the biodiversity of the land, and guarantees a healthy and natural atmosphere. The practice of sustainable farming plays a vital role in the protection of natural resources, the slowing of the loss of biodiversity, and the reduction of greenhouse gas emissions.

"Sustainable agriculture" is a technique for maintaining nature without sacrificing the ability of future generations to meet their fundamental requirements. In addition, it is a technique for making farming more efficient. Sustainable agriculture is largely attributable to the central successes of intelligent farming, which include "harvest alternation, the management of nutrient deficits in crops, the control of pests and diseases, recycling, and water harvesting". These accomplishments lead to an overall safer world.

However, an ever-expanding worldwide population with increased hunger, rapidly changing climate conditions, overuse of resources, and wastage of food and water are obscuring the effect of sustainable agriculture. The need of time is to develop technologies and infrastructure capable of meeting the demands of the present as well as the future. Technological innovations have always been the fundamental means for the development of agriculture, from the pre-historic era to today, as illustrated in Figure 1. Breakthroughs like the development of simple tools and the utilization of animals; the use of fertilizers, pesticides, and small machinery; and the application of robots helped agriculture evolve to its present

The associate editor coordinating the review of this manuscript and approving it for publication was Yanli Xu.

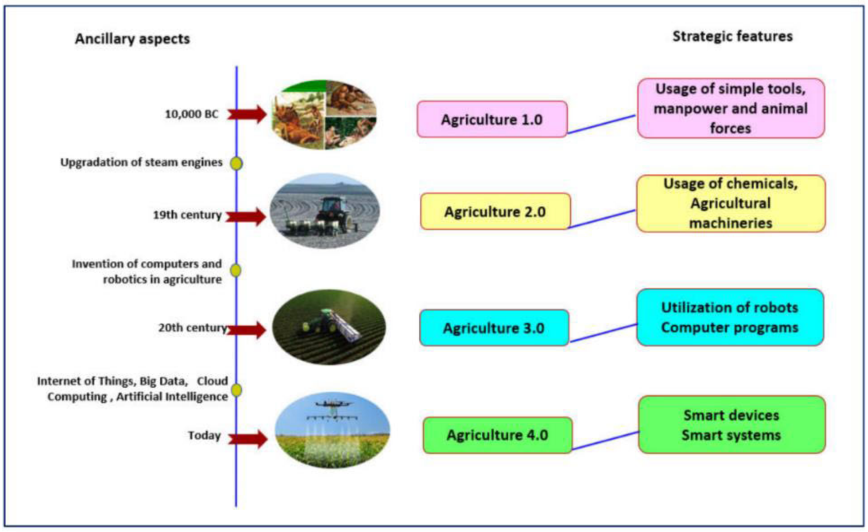

FIGURE 1. Upgradation of agriculture.

status, and now, with the use of smart technology, agriculture is impending to become smart.

Smart farming has become an important component of sustainable agriculture [1]. Traditionally, a huge amount of time, money, and effort is invested in growing any crop. It is worth mentioning the time and effort required in the processing, transportation, and marketing of harvested crops and all other logistics associated with them. Technologies of smart farming present a way to deal with and alleviate these problems, offering an improved way of doing agro-businesses.

In addition, farming is vulnerable to pesticides, poor environmental conditions, and the deteriorating quality of soil, air, and water due to pollution. The nature of biodiversity is essential to the survival of living species, and these organisms are vulnerable to contamination by waste emissions, the application of fertilisers and pesticides, decomposed dead plants, and other factors. Because the release of greenhouse gases has an effect on all living things, including plants, animals, and people, as well as the environment, it is necessary to create a more favourable atmosphere for living things.

Agriculture is the sector that contributes the most to India's GDP, accounting for 18% of the country's total and employing around 57% of the population in rural regions. Although India's overall agronomic production has grown over the years, the number of growers has decreased from 71.9% in 1951 to 45.1% in 2011. This decline occurred during the course of the country's history. The Economic Survey for 2018 found that the percentage of the entire employment that is comprised of agricultural employees would fall to 25.7% in the year 2050. In rural places, agricultural families progressively lose the next generation of farmers as they are overwhelmed by the increased expenses of agriculture, poor per capita production, insufficient soil upkeep, and migrations to occupations that are either non-farming or better paying than farming [2]. The globe is on the edge of a technological age; therefore, now is the time to connect the agricultural landscape with wireless technology to facilitate digital interaction among farmers. Agricultural landforms are characterised by large areas of open space.

Unfortunately, not all of the land on the surface of the earth can be farmed owing to a variety of factors, including the quality of the soil, the terrain, the temperature, and the climate; in addition, the majority of the regions that are appropriate for farming are not all the same. In addition, existing agricultural land is fragmented due to political and budgetary factors as well as rising urbanisation, all of which contribute to a persistent rise in the amount of pressure placed on the availability of arable land. In recent years, a smaller percentage of overall agricultural land has been put into use for food production [3]. In addition, the quality and quantity of each crop field's soil, the presence of nutrients, the flow of irrigation, and resistance to pests are all measured separately. These critical characteristics include the type of soil, the flow of irrigation, the presence of nutrients, and the resistance of the crop to pests. Differences in space and time are required for maximising crop production in the same field via crop rotation and a yearly crop growth development process. These differences are important for optimising crop output.

IoT and AI will assist companies in becoming more productive, reducing the amount of waste they create, and satisfying the need for food that customers have. Based on the findings of a number of studies, it has been determined that AI and IoT have a wide range of potential applications within the agricultural sector, as illustrated in figure 2.

A. SMART GREENHOUSES IN AGRICULTURE

The Internet of Things may help enhance yield in smart greenhouses by allowing for the development of proportional control systems. They employ sensors to give a regulated environment for the crops that they grow. The system is

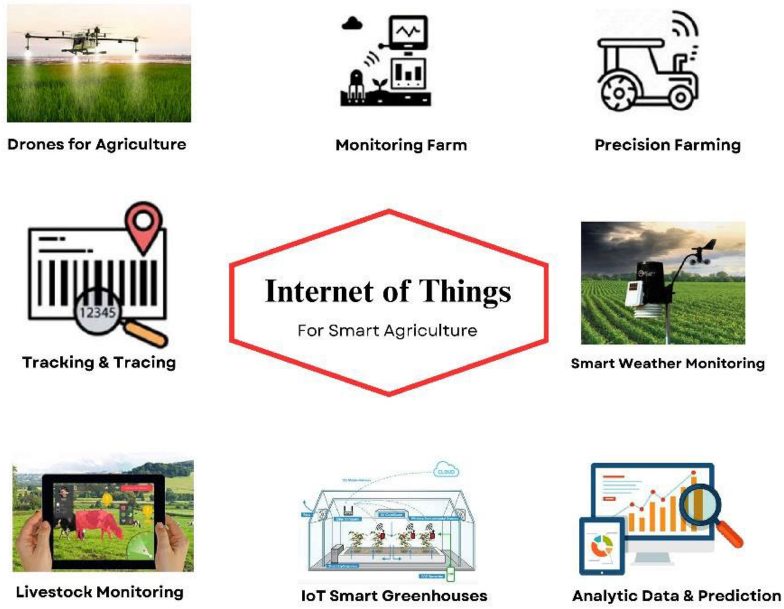

FIGURE 2. IoT for Smart agriculture.

monitored remotely, and the data processing is done via the use of cloud servers [4]. While reducing the need for human interaction, the smart greenhouse keeps track of the quantity of temperature, light, and humidity in the environment.

B. DRONES FOR AGRICULTURE

The drones that can operate both on the ground and in the air can help in the evaluation of crop health, the monitoring of infestations, and the examination of soil more efficiently. In addition, they may be used for the collection of real-time field data, the sowing of seeds, the management of irrigation systems, and the spraying of crops [5]. The information that was acquired may be used to make production forecasts, evaluate nutrient levels, and map external impacts.

C. SYSTEMS FOR PRECISION FARMING

One of the most common applications of agricultural technology is precision farming. It provides services such as variable rate irrigation (VRI) optimization, soil moisture testing, and cloud-based centralized water management. Through the use of sensors, autonomous equipment, and an internet connection, the system makes efficient use of the resource water.

D. SOLUTIONS FOR TRACKING AND MONITORING LIVESTOCK

Wireless Internet of Things networks and linked devices may reduce the amount of labour required at the ranch by keeping an eye on the cattle. Internet of Things devices are able to determine the location of an animal and even monitor its overall health [6]. On big farms, the farmers are able to quickly detect the animal and even halt the spread of illness by unscrambling sick animals from the rest of the herd. This helps safeguard the product and keeps the cost of cattle down.

E. SENSORS FOR CROP AND SOIL MONITORING

Robots and unmanned aerial vehicles armed with thermal or multispectral sensors are used to conduct continuous assessments of the state of crops and soil. This makes the application of fertilizer spray and controlled watering easier. The sensors analyze the levels of the various biomes in the soil in order to ensure that the crops have a high nutritional value. Additionally, in order to select the most profitable crops, AI analyses the features of the soil.

F. CURRENT WEATHER MONITORS

Smart sensors connected to the Internet of Things can assist gather real-time weather and climate data. Farmers are able to better analyze their crop requirements with the help of a thorough projection [7]. Farmers may also get alerts from some systems, allowing them to safeguard their crops in the event that severe weather strikes.

G. ROBOTS FOR AGRICULTURE

Agricultural robots lessen the need for manual work and save time by performing a number of tasks simultaneously on farms. They assist in agricultural monitoring and harvesting in a way that is more effective than using humans. They have received instruction in AI in order to maintain the crop's quality while also preventing the spread of weeds. These devices are able to sift the produce according to quality and pack it in a far more expedient manner than traditional procedures [8]. The use of AI in agriculture provides assistance to farmers with the goals of enhancing their output and minimising negative impacts on the environment.

H. DEVICES FOR ESTIMATING FUTURE HARVESTS AND PRICES

When estimating the yield of their crops, farmers are using a variety of new technologies, including AI, ML, and big data. When harvest time comes around, it is important to make price predictions by looking at historical data to analyze price fluctuations. Farm mapping makes it feasible to calculate yields per hectare with a high degree of accuracy. Farmers take into account a wide range of criteria in order to arrive at a conclusion [9], such as the amount of precipitation, the kind and number of pesticides used, the temperature, and other meteorological conditions.

II. REVIEW OF LITERATURE

Wolfert [10] explained in his study that agri-food systems face sustainability issues. Digital technologies like IoT may help achieve economic, environmental, and social sustainability objectives. However, it is difficult to assess how much such technologies contribute to sustainable development casting doubt on their influence. This study presents a stepwise method for assessing and monitoring IoT sustainability in real life. The approach's typology and presentation of sustainability as a business opportunity are based on the UN SDGs. The EU-funded IoF2020 project created and tested 33 use cases. The study shows how the measuring and monitoring tool is used in five agricultural subsectors to verify the strategy. The findings show that IoT improves sustainability, but they are also influenced by external variables that are hard to see. This method provides tools for practitioners to assess the sustainability effects of fast-changing technology like IoT in real life. Other stakeholders in major IoT initiatives that meet strategic sustainability goals may use these tools. The stepwise strategy helps farmers, policymakers, and investors make decisions.

In this study, Eissa [11] says that IoT, AI, and other sophisticated computer technologies have long been used in agriculture. Smart technologies are getting more attention. Agriculture has fed humans for thousands of years, including the creation of crop-specific agricultural practices. New IoT technology can monitor agricultural environments to assure high-quality goods. However, Smart Sustainable Agriculture (SSA) research and development is lacking, and the fragmentation of agricultural processes creates complex obstacles, such as data sharing and management, "the control and operation of IoT and AI machines, interoperability, and large amounts of data storage and analysis". This research first examines SSA IoT and AI technologies and then finds a technological architecture that can support SSA platform development. "This study examines SSA research and development and proposes an IoT/AI architecture for a Smart, Sustainable Agriculture platform". It also provides an exhaustive review of existing work in the field, highlighting various tools that are being implemented for the development of smart agriculture, such as Farmapp (to monitor pests and illnesses), Growlink (providing wireless automation, data collection, optimisation, and monitoring), GreenIQ (connects to home automation systems, controls irrigation, saves water), Farm Logs, Cropio, etc. (Table 1).

In his study report, Jagadale [12] states that IoT and AI are among the most preferred digital transformation technologies. Sensors gather ambient data, and AI algorithms analyze it to make gadgets act intelligently. This article discusses how IoT and AI have changed agriculture. It explores the agricultural revolution caused by AI and IoT technologies like drones and UAVs. Such technology simplifies forecasting meteorological conditions, including precipitation, temperature, humidity, fertilizer needs, water consumption, etc. IoT and AI technology boost agricultural productivity and reduce waste in agriculture. Smart farming using IoT and AI might transform traditional farming.

Punjabi et al. came up with a simple temperature sensing application with the goal of obtaining on-field information, which could be acquired by just sending a pre-programmed format of message to an already installed GSM+ARDUINO system that transmits the field data on the mobile phone [13].

Uddin et al., in order to overcome the difficulties in acquiring information from Wireless Sensor Networks (WSNs), developed a method of collecting data from specific areas through selected nodes by using Unmanned Aerial Vehicles (UAVs). Through simulation and proof-of-concept devices, they were able to show that this system succeeded in collecting real-time field data, helping in the detection of any nourishment deficiency, insect infestations, or diseases well in time, allowing timely remedies to save crops [14].

In the research of Alam and Khan [15], they argued that feeding the world's population growth is the biggest challenge. Food shortages have several causes, and agricultural advances are needed to solve them. ICT and other cutting-edge technology will accelerate the Sustainable Development Goals (SDGs). Mobile-broadband access devices, IoT, specialized drones, robots, big data analytics, and AI have given farmers tools to boost productivity and marketing. Smart Agriculture is transforming agriculture in Budaun, a tiny Uttar Pradesh city. Smart agriculture and blockchain technologies are helping agriculture develop sustainably. New technology has raised production/yield by 20% and earnings by 30%.

Dhanaraju et al. [16] write that smart farming emphasizes "ICT in machinery, equipment, and sensors in network-based high-tech farm monitoring cycles". Advanced know-how, the Internet of Things, and cloud computing are expected to spur expansion and introduce agricultural robots and AI. Groundbreaking agricultural practices are disturbing and challenging. This study examined the methods and equipment utilised in wireless sensor applications in IoT agriculture and the predicted problems of integrating technology with traditional farming. This technological information helps producers from planting to harvest and is researched for packaging and shipping.

TABLE 1. Describes different categories in which AI is used in the field of agriculture, what tools are used and how it is being implemented in farming.

Category	Tool/Company	Description
Greenhouse automation	Far mapp	It is quicker and more effective to monitor pests and illnesses while also producing information for mobile applications. The synced data from the server and the data that was previously saved enables real-time viewing of metrics like a satellite map, sanitary status, comparison heatmaps, and graphs and reports on pests and illnesses.
	Grow link	a system that combines hardware and software to provide wireless automation, data collecting, optimization, and monitoring, among other smarter working features.
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	See & Spray	a machine built to manage forests and safeguard crops. To monitor and accurately spray weeds and diseased plants, it makes use of computer vision.
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Crop and Soil Health Monitoring	Plantix	a technology based on machine learning for managing and controlling the farming process, preventing illness, and growing superior crops
	Trace Genomics	By analysing a soil sample's DNA and comparing it to a sizable soil DNA database, a soil monitoring system employs a machine learning technique to create a health report for the sample.
Predictive Analytics	Farm shots	a system that maps possible disease, pest, and malnutrition indications in agriculture fields using satellite and drone imagery. To create prescriptions, generated data may be sent to agricultural software.
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End-to- end farm Management systems	Farm Logs	This technology keeps track of field conditions, making it easier to plan and control crop output. Additionally, it sells agricultural goods.
	Cropio	a tool for making decisions that integrates meteorological data with satellite data to track crops and make field forecasts while optimising fertilisation and watering.

Farooq et al. presented a comprehensive list of various components of IoT devices, along with the underlying network architecture and protocols, highlighting security concerns. In addition, applications for smartphones and sensors meant for various stages of farming were presented, such as the 3D Crop Sensor Array with PAR Addon to regulate the temperature, humidity, and carbon dioxide; Arable Mark, which connects the global weather data with the field observations, and Bluetooth-based Grofit, which stores data for 30 days and provides information about air humidity, temperature and radiation [17].

There are many other benefits that smart farming offers resulting in increased productivity by investing less labour and allowing better time management. All the data collected through various IoT devices are employed to gain knowledge regarding significant parameters such as soil conditions, water requirements, infestations, plant diseases, herbicidal growth, etc. Though these devices are now being employed by farmers, they are burdened by the increase in capital investment and maintenance costs especially the small farmers [18]. Hence, providing these facilities to farmers through cooperative organizations may be a more economical alternative.

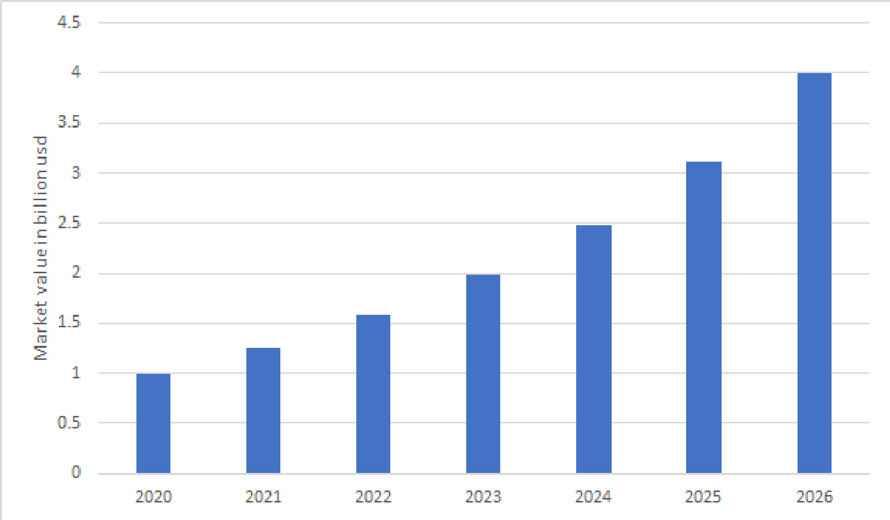

FIGURE 3. Projected artificial intelligence in agriculture market from 2020 to 2026.

Chukkapali et al. proposed a smart farming cooperative ecosystem connecting IoT devices on a community level with continuous incorporation of computational and physical components. This newly developed ecosystem adds small farmers to complicity with regulations and policies. They then discussed the benefits of the system classifying it into four broad categories of marketing and distribution, resources and equipment, labor, and service and supply. This system can prove beneficial in drawing small farmers towards the implementation of IoT for better crop production [18].

III. RESEARCH METHODOLOGY

This study analyzed papers from various periodicals and conference proceedings from respected scholarly sources. Most of the discoveries and methods have been used to build predictive analytics.

The research project consisted of a literature evaluation that began with a search for information on agriculture and practices related to it, and was performed using the three most prominent academic databases: Scopus, IEEE, and Science Direct. Some of the terms and phrases that were discussed were "smart farming," "irrigation facilities," "AI and IoT in farming," "Implementation of technology in agriculture," and "the situation of farming in India." The first round of filtering was performed based on two primary criteria: the quality of the journal and the year the article was published. The titles and abstracts of the studies were then modified to reflect the changes. In order to get perspective, a minimum of 20 articles were documented. The titles of ten different papers each made up one of the criteria used to remove those ten papers. In conclusion, a summary of ten different research articles has been created based on the recent advances that have been made in the field of technological agricultural operations. The operation of a certain implementation approach was the most important aspect that needed to be emphasized. Following an in-depth analysis of all of the papers, each of the proposed strategies that were found in the selected ones was taken into consideration and worked on.

IV. RESULTS AND DISCUSSION

In an attempt to affect a different outcome, the agriculture industry embraced AI with great fervor. As a by-product of advancements in artificial intelligence, the methods by which our food is produced are undergoing transformation, and as a consequence, the emissions produced by the agricultural sector have decreased by 20%. AI lends a hand in the management and regulation of any unanticipated natural situations. The majority of new businesses entering the agricultural sector have chosen to implement an AI-enabled approach in order to boost the efficiency of agricultural output. AI provides assistance to the agricultural industry in the processing of data in order to minimise the occurrence of undesirable results.

Recent studies have uncovered a number of efforts aimed at fostering smart farming techniques, such as the digitalization of farm cooperatives as agricultural producers, the nascent development of a start-up ecology, and "government-led digital farming projects". Other actions include the modernization of farm collectives as farmer-producer organisations. Unmanned aerial vehicles, often known as UAVs, find the greatest amount of use in the field of agriculture. According to the research findings, as the country's agricultural sector continues to develop, more businesses are anticipated to invest in reasonably priced drones. These drones may provide assistance to farmers and help them enhance their information, while also creating employment opportunities for young individuals living in rural areas. It is clear that the administration is helping to foster an environment that is conducive to the growth of farm technology businesses by funding and operating incubators. Under the banner of "AI for all," the government of India has developed comprehensive rules to be followed in order to cultivate India's AI ecosystem via the NITI Aayog. The good news is that it is projected that agriculture will have a substantially better structure in the not-too-distant future than it has right now.

Figure 3 states the data on projected AI in the agriculture market from 2020 to 2026, which was 1 billion USD in 2020 and is projected to be 4 billion USD by the year 2026 [19].

V. CONCLUSION

This study has shown that the use of contemporary and modern computer technologies, notably AI and IoT, is crucial to the success of the agricultural industry. Agriculture is often regarded as an essential component to the sustained existence of humans. Improving the efficiency, quality, and quantity of produce in conventional farming by incorporating more contemporary IoT and AI technology into existing farming processes is possible. In this study, an analysis of the current IoT and AI technologies was carried out using primary research journals in the field of agriculture. In addition to this, it provided a categorization of the most important aspects of intelligent and sustainable agriculture. These aspects include crops, human resources, soil, weather, fertilizer, agricultural products, pests, irrigation/water, animals, machinery, and fields. The AI or IoT technology framework for SSA is the key contribution that this paper brings to the table. As a direct result of this, there has been an increased emphasis placed on the investigation and advancement of an integrated AI and "IoT platform for SSA". This is being done with the intention of successfully fixing problems that have surfaced as a direct result of the fragmentary nature of farming production.

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CONFLICT OF INTEREST

There is no conflict of interests.

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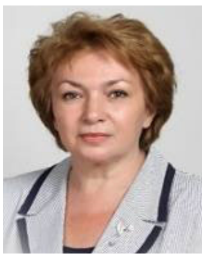

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