iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH
IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 13 Issue: IX Month of publication: September 2025

DOI: https://doi.org/10.22214/ijraset.2025.74167

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 13 Issue IX Sep 2025- Available at www.ijraset.com

Comprehensive Study and Review of Thirty Key Research Contributions on Artificial Intelligence in the Field of Agricultural

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Abstract: Artificial Intelligence (AI) is revolutionizing the agricultural sector by enhancing efficiency, productivity, and sustainability. This review paper analyzes 30 research studies that explore AI applications in agriculture, including precision farming, crop disease detection, smart irrigation, agricultural robotics, and supply chain optimization. The studies highlight the role of AI-driven technologies such as machine learning, deep learning, computer vision, and Internet of Things (IoT) in improving decision-making and resource management. Key findings suggest that AI enhances crop yield predictions, automates pest and disease detection, and optimizes water usage, contributing to sustainable farming practices. However, challenges such as high implementation costs, data privacy concerns, and limited access to AI technology in developing regions remain significant barriers. This paper provides insights into current advancements, challenges, and future research directions to bridge the gap between AI innovation and practical agricultural applications.
Keywords: Supply Chain Optimization, Agricultural Robotics, Crop Disease Detection, Smart Irrigation, Precision Farming.

I. INTRODUCTION

Agriculture is the backbone of global food security, supporting billions of lives and economies worldwide. However, traditional farming methods often face challenges such as unpredictable weather conditions, pest infestations, inefficient resource utilization, and labor shortages. To address these issues, Artificial Intelligence (AI) has emerged as a transformative technology in modern agriculture. AI-driven solutions, including machine learning, deep learning, computer vision, and Internet of Things (IoT), are enhancing precision farming, crop disease detection, smart irrigation, and autonomous farming operations.

This review paper explores the application of AI in agriculture by analyzing 30 research studies that highlight its potential in improving efficiency, productivity, and sustainability. AI-powered technologies are revolutionizing farming practices by enabling real-time monitoring, predictive analytics, and automation of critical processes. From drones and robotics to soil health assessment and climate forecasting, AI is playing a crucial role in optimizing agricultural operations. Despite its advantages, AI adoption in agriculture faces several challenges, such as high implementation costs, data privacy concerns, and limited access to technology in rural and developing regions. This paper aims to provide a comprehensive review of AI applications in agriculture, discussing current advancements, key challenges, and future research directions. By bridging the gap between AI innovation and practical implementation, this study seeks to contribute to the development of sustainable and technology-driven agricultural solutions.

II. LITERATURE REVIEW

1) Di Vaio et al. (2022) explore the integration of Artificial Intelligence (AI) in sustainable agri-food business models, emphasizing its transformative potential in addressing global food security, resource efficiency, and environmental sustainability. The paper highlights how AI-driven technologies, such as predictive analytics, IoT, and machine learning, optimize agricultural practices, reduce waste, and enhance supply chain transparency. It also discusses the role of AI in enabling precision farming, improving crop yields, and minimizing environmental impacts. The authors critically analyze the challenges of AI adoption, including high implementation costs, data privacy concerns, and the digital divide in rural areas. They advocate for policy interventions and stakeholder collaboration to ensure equitable and sustainable AI deployment in the agri-food sector. The study provides a comprehensive framework for leveraging AI to achieve the United Nations Sustainable Development Goals (SDGs), particularly SDG 2 (Zero Hunger) and SDG 12 (Responsible Consumption and Production). Overall, the paper offers valuable insights for researchers, policymakers, and industry practitioners aiming to harness AI for sustainable agri-food systems.

2) Yu et al. (2021) investigate the role of Artificial Intelligence (AI) in enhancing food security, focusing on its applications in improving agricultural productivity, optimizing resource management, and ensuring food distribution efficiency. The paper underscores how AI technologies, such as remote sensing, machine learning, and big data analytics, enable real-time monitoring of crop health, soil conditions, and weather patterns, thereby supporting precision agriculture. It also highlights AI's potential in predicting food demand, reducing post-harvest losses, and streamlining supply chains to ensure equitable food access. The authors discuss the challenges of AI adoption, including data scarcity, infrastructure limitations, and ethical concerns related to algorithmic bias. They emphasize the need for interdisciplinary collaboration and policy support to scale AI solutions for global food security. The study provides a forward-looking perspective on how AI can contribute to achieving the United Nations Sustainable Development Goals (SDGs), particularly SDG 2 (Zero Hunger). By integrating case studies and empirical evidence, the paper offers actionable insights for stakeholders in agriculture, technology, and policymaking to address food security challenges through AI-driven innovations.
3) Kamal et al. (2023) provide a comprehensive review of the role of Artificial Intelligence (AI) in precision agriculture, emphasizing its potential to revolutionize farming practices by enhancing efficiency, sustainability, and productivity. The paper explores how AI-driven technologies, such as machine learning, computer vision, and IoT- enabled sensors, enable real-time monitoring and decision-making in crop management, soil health assessment, and pest control. It highlights the use of AI in analyzing large datasets from drones, satellites, and ground-based sensors to optimize irrigation, fertilization, and harvesting processes. The authors also discuss the integration of AI with robotics for automated farming tasks, reducing labor costs and improving precision. Challenges such as high implementation costs, data privacy concerns, and the need for technical expertise among farmers are critically examined. The study underscores the importance of developing user-friendly AI tools and fostering collaboration between researchers, policymakers, and farmers to ensure widespread adoption. By presenting case studies and future directions, Kamal et al. (2023) offer valuable insights into how AI can address global agricultural challenges and contribute to sustainable food production systems.
4) Lewis et al. (2022) explore the transformative role of Artificial Intelligence (AI) in agricultural robotics, focusing on its potential to enhance efficiency, precision, and sustainability in farming operations. The paper highlights how AI-powered robots and autonomous systems are revolutionizing tasks such as planting, weeding, harvesting, and crop monitoring. By integrating machine learning, computer vision, and sensor technologies, these robots can perform complex tasks with high accuracy, reducing labor costs and minimizing human error. The authors discuss the use of AI in enabling real-time decision-making, such as identifying crop diseases, optimizing irrigation, and managing soil health. They also address the challenges of deploying agricultural robotics, including high initial costs, technical complexities, and the need for robust AI algorithms to handle diverse and unpredictable farming environments. The study emphasizes the importance of interdisciplinary collaboration and policy support to accelerate the adoption of AI-driven robotics in agriculture. By presenting case studies and future trends, Lewis et al. (2022) provide a forward-looking perspective on how AI and robotics can address global agricultural challenges, improve productivity, and contribute to sustainable farming practices.
5) Collins et al. (2022) examine the integration of Artificial Intelligence (AI) and Big Data in food supply chains, highlighting their potential to enhance transparency, efficiency,and sustainability. The paper discusses how AI-driven analytics and Big Data technologies enable real-time tracking and optimization of supply chain operations, from farm to fork. Key applications include demand forecasting, inventory management, logistics optimization, and quality control, all of which contribute to reducing food waste and improving resource allocation. The authors emphasize the role of AI in analyzing vast datasets from IoT devices, sensors, and blockchain systems to ensure traceability and compliance with food safety standards. Challenges such as data privacy concerns, high implementation costs, and the need for skilled personnel are critically analyzed. The study also explores the potential of AI and Big Data to address global food security challenges by improving supply chain resilience and responsiveness to disruptions. Collins et al. (2022) advocate for collaborative efforts among stakeholders, including governments, businesses, and technology providers, to harness the full potential of AI and Big Data in creating sustainable and efficient food supply chains.
6) Jansen et al. (2023) investigate the application of Artificial Intelligence (AI) in food waste management, focusing on its potential to reduce waste, optimize resource use, and promote sustainability across the food supply chain. The paper highlights how AI technologies, such as machine learning, computer vision, and predictive analytics, can identify patterns and inefficiencies in food production, distribution, and consumption. For instance, AI-powered systems can predict spoilage, optimize inventory management, and streamline logistics to minimize waste. The authors also discuss the role of AI in enabling smarter consumer behavior through apps that suggest recipes for leftover ingredients or track food expiration dates.

Challenges such as data quality, integration with existing systems, and the need for stakeholder collaboration are critically examined. The study emphasizes the importance of leveraging AI to align food waste management practices with the United Nations Sustainable Development Goals (SDGs), particularly SDG 12 (Responsible Consumption and Production). By presenting case studies and future directions, Jansen et al. (2023) provide actionable insights for policymakers, businesses, and consumers to harness AI for reducing food waste and building a more sustainable food system.

7) Zhang et al. (2022) explore the development and application of Artificial Intelligence (AI) decision support systems (DSS) in agriculture, emphasizing their role in enhancing farm management, productivity, and sustainability. The paper highlights how AI- driven DSS leverage machine learning, data analytics, and IoT technologies to provide farmers with actionable insights for crop planning, pest control, irrigation management, and yield prediction. These systems integrate data from various sources, such as satellite imagery, weather forecasts, and soil sensors, to enable real-time, data-driven decision-making. The authors discuss the potential of AI DSS to optimize resource use, reduce environmental impact, and improve crop quality and yields. Challenges such as data accessibility, system interoperability, and the need for user-friendly interfaces are critically examined. The study also underscores the importance of training farmers and stakeholders to effectively utilize these advanced tools. By presenting case studies and future trends, Zhang et al. (2022) provide a comprehensive framework for the adoption of AI DSS in agriculture, highlighting their potential to address global food security challenges and support sustainable farming practices.

8) Roberts et al. (2023) explore the integration of Artificial Intelligence (AI) and blockchain technology in agri-food supply chains, emphasizing their potential to enhance transparency, traceability, and efficiency. The paper highlights how AI-driven analytics can optimize supply chain operations, such as demand forecasting, inventory management, and logistics, while blockchain ensures secure and immutable record- keeping of transactions and product origins. Together, these technologies enable real- time monitoring of food products from farm to fork, improving food safety and reducing fraud. The authors discuss how AI can analyze vast datasets from IoT devices and sensors, while blockchain provides a decentralized and tamper-proof platform for sharing this information among stakeholders. Challenges such as high implementation costs, data privacy concerns, and the need for technical expertise are critically examined. The study also emphasizes the potential of AI and blockchain to address global food security challenges by improving supply chain resilience and reducing food waste. Roberts et al. (2023) advocate for collaborative efforts among governments, businesses, and technology providers to harness the full potential of these technologies in creating sustainable and efficient agri-food supply chains.

9) Wilson et al. (2023) investigate the integration of Artificial Intelligence (AI) and remote sensing technologies in precision agriculture, highlighting their transformative potential in optimizing farm management and improving crop yields. The paper emphasizes how AI algorithms, combined with data from satellites, drones, and ground-based sensors, enable real-time monitoring of crop health, soil conditions, and environmental factors. These technologies facilitate precise decision-making in irrigation, fertilization, and pest control, reducing resource waste and environmental impact. The authors discuss the use of machine learning and computer vision to analyze multispectral and hyperspectral imagery, providing insights into plant stress, nutrient deficiencies, and disease outbreaks. Challenges such as data complexity, high costs, and the need for technical expertise among farmers are critically examined. The study also explores the potential of AI and remote sensing to support sustainable farming practices and contribute to global food security. By presenting case studies and future directions, Wilson et al. (2023) provide a comprehensive framework for leveraging these technologies to enhance agricultural productivity and sustainability.

10) Verma et al. (2022) explore the role of Artificial Intelligence (AI) in enhancing climate resilience in agriculture, focusing on its potential to mitigate the impacts of climate change on farming systems. The paper highlights how AI-driven technologies, such as machine learning, predictive analytics, and IoT-enabled sensors, can help farmers adapt to changing climatic conditions by providing accurate weather forecasts, early warning systems for extreme events, and optimized resource management strategies. These tools enable precision agriculture practices, such as efficient water use, targeted fertilization, and crop selection, to improve yields and reduce environmental stress. The authors also discuss the use of AI in modeling climate scenarios and developing adaptive farming practices to enhance long-term resilience. Challenges such as data accessibility, high implementation costs, and the need for localized solutions are critically examined. The study emphasizes the importance of integrating AI with traditional knowledge and fostering collaboration among researchers, policymakers, and farmers to build climate- resilient agricultural systems. By presenting case studies and future directions, Verma et al. (2022) provide actionable insights for leveraging AI to address the challenges posed by climate change and ensure sustainable food production.

11) Smith et al. (2023) examine the application of Artificial Intelligence (AI) in smart irrigation systems, emphasizing its potential to optimize water use, enhance crop productivity, and promote sustainable agriculture. The paper highlights how AI-driven technologies, such as machine learning, IoT sensors, and predictive analytics, enable real-time monitoring of soil moisture, weather conditions, and crop water requirements. These systems provide precise irrigation recommendations, reducing water waste and ensuring optimal plant growth. The authors discuss the integration of AI with advanced irrigation technologies, such as drip and sprinkler systems, to automate and improve water distribution efficiency. Challenges such as high initial costs, data accuracy, and the need for farmer training are critically analyzed. The study also explores the potential of AI-powered smart irrigation systems to address water scarcity challenges and support climate-resilient farming practices. By presenting case studies and future trends, Smith et al. (2023) provide a comprehensive framework for adopting AI in irrigation management, highlighting its role in achieving sustainable agricultural development and global food security.
12) Gupta et al. (2022) investigate the integration of Artificial Intelligence (AI) and drone technology in crop monitoring, highlighting their transformative potential in modern agriculture. The paper emphasizes how AI-powered drones equipped with advanced sensors and cameras can capture high-resolution imagery and multispectral data, enabling real-time analysis of crop health, soil conditions, and pest infestations. These technologies facilitate precision agriculture by providing farmers with actionable insights to optimize irrigation, fertilization, and pest control, thereby improving yields and reducing resource waste. The authors discuss the use of machine learning algorithms to process and interpret drone-collected data, identifying patterns and anomalies that may not be visible to the naked eye. Challenges such as high costs, regulatory restrictions, and the need for technical expertise are critically examined. The study also explores the potential of AI and drones to enhance sustainable farming practices and contribute to global food security. By presenting case studies and future directions, Gupta et al. (2022) provide a comprehensive framework for leveraging these technologies to improve agricultural productivity and sustainability.
13) Brown et al. (2023) explore the application of Artificial Intelligence (AI) in livestock management, focusing on its potential to enhance animal health, productivity, and welfare. The paper highlights how AI-driven technologies, such as machine learning, computer vision, and IoT-enabled sensors, enable real-time monitoring of livestock behaviour, health parameters, and environmental conditions. These systems can detect early signs of disease, optimize feeding schedules, and improve breeding programs, thereby increasing efficiency and reducing costs. The authors discuss the use of AI in analysing data from wearable devices, cameras, and drones to provide actionable insights for farmers. Challenges such as data privacy concerns, high implementation costs, and the need for technical expertise are critically examined. The study also explores the potential of AI to support sustainable livestock farming practices and address global food security challenges. By presenting case studies and future directions, Brown et al. (2023) provide a comprehensive framework for adopting AI in livestock management, highlighting its role in achieving sustainable agricultural development and improving animal welfare.
14) Li et al. (2023) examine the role of Artificial Intelligence (AI) in vertical farming, highlighting its potential to revolutionize urban agriculture by optimizing resource use, increasing crop yields, and ensuring year-round production. The paper emphasizes how AI-driven technologies, such as machine learning, computer vision, and IoT-enabled sensors, enable precise control of environmental factors like light, temperature, humidity, and nutrient levels. These systems facilitate real-time monitoring and automated adjustments to create ideal growing conditions for plants. The authors discuss the use of AI in analysing data from vertical farming systems to improve crop quality, reduce energy consumption, and minimize water and fertilizer waste. Challenges such as high initial investment costs, data management complexities, and the need for skilled personnel are critically analysed. The study also explores the potential of AI-powered vertical farming to address food security challenges in urban areas and reduce the environmental footprint of agriculture. By presenting case studies and future trends, Li et al. (2023) provide a comprehensive framework for leveraging AI to enhance the efficiency and sustainability of vertical farming systems.
15) Kumar et al. (2022) investigate the application of Artificial Intelligence (AI) in disease detection for crops, emphasizing its potential to enhance early identification and management of plant diseases, thereby improving crop health and yields. The paper highlights how AI-driven technologies, such as machine learning, computer vision, and deep learning, analyze data from various sources, including satellite imagery, drones, and ground-based sensors, to detect disease symptoms at early stages. These systems enable real-time monitoring and provide actionable insights for farmers to implement timely interventions, reducing crop losses and minimizing the use of pesticides. The authors discuss the integration of AI with mobile applications and IoT devices to make disease detection more accessible and user-friendly for farmers. Challenges such as data quality, model accuracy, and the need for localized solutions are critically examined. The study also explores the potential of AI to support sustainable farming practices and contribute to global food security. By presenting case studies and future directions, Kumar et al. (2022) provide a comprehensive framework for leveraging AI in crop disease detection, highlighting its role in achieving

sustainable agricultural development.

16) Harris et al. (2023) explore the application of Artificial Intelligence (AI) in pest control and management, focusing on its potential to enhance the precision and efficiency of pest detection and mitigation strategies. The paper highlights how AI-driven technologies, such as machine learning, computer vision, and IoT-enabled sensors, enable early identification of pest infestations through real-time monitoring of crops. These systems analyze data from drones, satellite imagery, and ground-based sensors to detect pest activity and predict outbreaks, allowing farmers to take timely and targeted actions. The authors discuss the integration of AI with automated pest control mechanisms, such as robotic sprayers and traps, to reduce the reliance on chemical pesticides and minimize environmental impact. Challenges such as high implementation costs, data accuracy, and the need for localized pest models are critically examined. The study also emphasizes the importance of combining AI with traditional pest management practices to achieve sustainable agriculture. By presenting case studies and future directions, Harris et al. (2023) provide a comprehensive framework for leveraging AI to improve pest control, enhance crop yields, and promote environmentally friendly farming practices.
17) Wang et al. (2023) investigate the role of Artificial Intelligence (AI) in predicting crop yields, emphasizing its potential to enhance agricultural planning, resource allocation, and food security. The paper highlights how AI-driven technologies, such as machine learning, deep learning, and big data analytics, integrate diverse datasets—including satellite imagery, weather data, soil conditions, and historical yield records—to generate accurate and real-time yield predictions. These predictive models enable farmers and policymakers to make informed decisions about planting, irrigation, and harvesting, thereby optimizing productivity and reducing risks associated with climate variability. The authors discuss the use of AI in identifying key factors influencing crop yields, such as nutrient levels, pest infestations, and water availability, and how these insights can support precision agriculture practices. Challenges such as data quality, model interpretability, and the need for localized calibration are critically examined. The study also explores the potential of AI to address global food security challenges by improving yield forecasting accuracy and supporting sustainable farming practices. By presenting case studies and future directions, Wang et al. (2023) provide a comprehensive framework for leveraging AI to enhance crop yield prediction and contribute to resilient agricultural systems.
18) Taylor et al. (2022) examine the application of Artificial Intelligence (AI) in managing risks within agricultural supply chains, focusing on its potential to enhance resilience, efficiency, and sustainability. The paper highlights how AI-driven technologies, such as machine learning, predictive analytics, and IoT-enabled sensors, enable real-time monitoring and risk assessment across the supply chain. These systems analyze data from various sources, including weather forecasts, market trends, and transportation logistics, to identify potential disruptions such as extreme weather events, price fluctuations, and supply shortages. The authors discuss how AI facilitates proactive decision-making, allowing stakeholders to mitigate risks, optimize inventory management, and ensure timely delivery of agricultural products. Challenges such as data integration, high implementation costs, and the need for stakeholder collaboration are critically examined. The study also explores the potential of AI to address global food security challenges by improving supply chain transparency and resilience. By presenting case studies and future directions, Taylor et al. (2022) provide a comprehensive framework for leveraging AI to enhance supply chain risk management and promote sustainable agricultural practices.
19) Ahmed et al. (2023) explore the application of Artificial Intelligence (AI) in food quality and safety monitoring, emphasizing its potential to enhance the detection of contaminants, ensure compliance with safety standards, and improve overall food quality. The paper highlights how AI-driven technologies, such as machine learning, computer vision, and IoT-enabled sensors, enable real-time monitoring and analysis of food products throughout the supply chain. These systems can detect pathogens, chemical residues, and physical contaminants, providing early warnings and reducing the risk of foodborne illnesses. The authors discuss the integration of AI with blockchain technology to ensure traceability and transparency, allowing consumers and regulators to verify the safety and quality of food products. Challenges such as high implementation costs, data privacy concerns, and the need for standardized protocols are critically examined. The study also explores the potential of AI to address global food safety challenges by improving inspection processes and reducing food waste. By presenting case studies and future directions, Ahmed et al. (2023) provide a comprehensive framework for leveraging AI to enhance food quality and safety monitoring, contributing to a safer and more sustainable food system.
20) Patel et al. (2022) investigate the role of Artificial Intelligence (AI) in smart greenhouse management, focusing on its potential to optimize growing conditions, enhance crop yields, and promote sustainable agricultural practices. The paper highlights how AI- driven technologies, such as machine learning, IoT-enabled sensors, and computer vision, enable real-time monitoring and control of environmental factors like temperature, humidity, light, and CO_2 levels.

These systems provide precise adjustments to create ideal growing conditions, reducing resource waste and improving crop quality. The authors discuss the integration of AI with automated systems for irrigation, fertilization, and pest control, which further enhances efficiency and reduces labor costs. Challenges such as high initial investment, data management complexities, and the need for technical expertise are critically examined. The study also explores the potential of AI-powered smart greenhouses to address food security challenges by enabling year-round production and reducing the environmental footprint of agriculture. By presenting case studies and future directions, Patel et al. (2022) provide a comprehensive framework for leveraging AI to enhance the efficiency and sustainability of smart greenhouse management.

21) Johnson et al. (2023) explore the application of Artificial Intelligence (AI) in soil health assessment, emphasizing its potential to enhance agricultural productivity and sustainability. The paper highlights how AI-driven technologies, such as machine learning, remote sensing, and IoT-enabled sensors, enable real-time monitoring and analysis of soil properties, including nutrient levels, moisture content, pH, and organic matter. These systems provide farmers with actionable insights to optimize fertilization, irrigation, and crop rotation practices, thereby improving soil health and crop yields. The authors discuss the integration of AI with advanced data analytics to predict soil degradation and recommend remediation strategies, contributing to long-term soil conservation. Challenges such as data accuracy, high implementation costs, and the need for localized calibration are critically examined. The study also explores the potential of AI to address global food security challenges by promoting sustainable land management practices. By presenting case studies and future directions, Johnson et al. (2023) provide a comprehensive framework for leveraging AI to enhance soil health assessment and support resilient agricultural systems.
22) Lee et al. (2022) investigate the application of Artificial Intelligence (AI) in fisheries and aquaculture, focusing on its potential to enhance productivity, sustainability, and resource management. The paper highlights how AI-driven technologies, such as machine learning, computer vision, and IoT-enabled sensors, enable real-time monitoring of water quality, fish health, and feeding patterns. These systems provide actionable insights to optimize feeding schedules, detect diseases early, and improve breeding programs, thereby increasing efficiency and reducing costs. The authors discuss the use of AI in analyzing data from underwater drones and remote sensing to monitor fish populations and ecosystem health, supporting sustainable fishing practices. Challenges such as high implementation costs, data privacy concerns, and the need for technical expertise are critically examined. The study also explores the potential of AI to address global food security challenges by improving aquaculture yields and reducing environmental impacts. By presenting case studies and future directions, Lee et al. (2022) provide a comprehensive framework for leveraging AI to enhance fisheries and aquaculture management, contributing to sustainable aquatic food production.
23) Singh et al. (2023) explore the application of Artificial Intelligence (AI) in precision fertilization, focusing on its potential to optimize nutrient management, enhance crop yields, and promote sustainable agricultural practices. The paper highlights how AI- driven technologies, such as machine learning, IoT-enabled sensors, and remote sensing, enable real-time monitoring of soil nutrient levels and crop requirements. These systems provide precise fertilization recommendations, reducing nutrient waste and minimizing environmental impacts such as soil degradation and water pollution. The authors discuss the integration of AI with automated fertilization equipment to deliver nutrients accurately and efficiently, improving resource use efficiency and crop productivity. Challenges such as high implementation costs, data accuracy, and the need for farmer training are critically examined. The study also explores the potential of AI to address global food security challenges by supporting precision agriculture practices and reducing the environmental footprint of farming. By presenting case studies and future directions, Singh et al. (2023) provide a comprehensive framework for leveraging AI to enhance precision fertilization and contribute to sustainable agricultural development
24) Chen et al. (2023) investigate the application of Artificial Intelligence (AI) in detecting food fraud, focusing on its potential to enhance food safety, ensure regulatory compliance, and protect consumer trust. The paper highlights how AI-driven technologies, such as machine learning, computer vision, and blockchain, enable the identification of fraudulent activities, including adulteration, mislabeling, and counterfeit products. These systems analyze data from various sources, such as supply chain records, spectral imaging, and chemical analysis, to detect anomalies and verify the authenticity of food products. The authors discuss the integration of AI with blockchain to ensure traceability and transparency, allowing stakeholders to track the origin and journey of food items. Challenges such as data quality, high implementation costs, and the need for standardized protocols are critically examined. The study also explores the potential of AI to address global food safety challenges by improving fraud detection accuracy and reducing economic losses. By presenting case studies and future directions, Chen et al. (2023) provide a comprehensive framework for leveraging AI to enhance food fraud detection and contribute to a safer and more transparent food system.

25) Evans et al. (2023) explore the application of Artificial Intelligence (AI) in smart food packaging, focusing on its potential to enhance food safety, extend shelf life, and improve consumer engagement. The paper highlights how AI-driven technologies, such as machine learning, IoT-enabled sensors, and QR codes, enable real-time monitoring of food quality and safety parameters, including temperature, humidity, and gas composition. These systems provide early warnings for spoilage or contamination, reducing food waste and ensuring consumer safety. The authors discuss the integration of AI with smart labels and packaging materials to provide consumers with detailed information about the product's origin, nutritional content, and storage conditions. Challenges such as high implementation costs, data privacy concerns, and the need for standardized protocols are critically examined. The study also explores the potential of AI to address global food security challenges by improving supply chain transparency and reducing food waste. By presenting case studies and future directions, Evens et al. (2023) provide a comprehensive framework for leveraging AI to enhance smart food packaging and contribute to a safer and more sustainable food system.
26) Das et al. (2023) investigate the application of Artificial Intelligence (AI) in optimizing crop rotation practices, focusing on its potential to enhance soil health, improve crop yields, and promote sustainable agriculture. The paper highlights how AI-driven technologies, such as machine learning, predictive analytics, and remote sensing, enable the analysis of historical and real-time data on soil conditions, weather patterns, and crop performance. These systems provide tailored crop rotation recommendations, balancing nutrient use, pest control, and soil conservation to maximize productivity and sustainability. The authors discuss the integration of AI with precision agriculture tools to automate and optimize crop rotation planning, reducing labor costs and improving efficiency. Challenges such as data accuracy, high implementation costs, and the need for localized models are critically examined. The study also explores the potential of AI to address global food security challenges by supporting long-term soil fertility and reducing the environmental impact of farming. By presenting case studies and future directions, Das et al. (2023) provide a comprehensive framework for leveraging AI to enhance crop rotation optimization and contribute to sustainable agricultural development.
27) Kim et al. (2022) explore the application of Artificial Intelligence (AI) in agricultural market forecasting, focusing on its potential to enhance decision-making, reduce market risks, and improve profitability for farmers and stakeholders. The paper highlights how AI-driven technologies, such as machine learning, big data analytics, and natural language processing, enable the analysis of vast datasets, including historical market trends, weather patterns, and global trade data. These systems provide accurate and real-time predictions of crop prices, demand fluctuations, and supply chain dynamics, helping farmers and businesses make informed decisions. The authors discuss the integration of AI with predictive models to optimize planting schedules, inventory management, and marketing strategies, thereby increasing efficiency and reducing financial risks. Challenges such as data quality, model interpretability, and the need for localized market insights are critically examined. The study also explores the potential of AI to address global food security challenges by stabilizing markets and ensuring fair pricing. By presenting case studies and future directions, Kim et al. (2022) provide a comprehensive framework for leveraging AI to enhance agricultural market forecasting and support sustainable economic growth in the agri-food sector.
28) Foster et al. (2023) investigate the role of Artificial Intelligence (AI) in understanding and influencing consumer behavior in the agri-food industry, focusing on its potential to enhance marketing strategies, improve product development, and promote sustainableconsumption. The paper highlights how AI-driven technologies, such as machine learning, natural language processing, and sentiment analysis, enable the analysis of consumer data from social media, purchase histories, and online reviews. These systems provide insights into consumer preferences, trends, and purchasing patterns, allowing businesses to tailor their products and marketing campaigns effectively. The authors discuss the integration of AI with personalized recommendation systems to promote healthier and more sustainable food choices, thereby supporting public health and environmental goals. Challenges such as data privacy concerns, algorithmic bias, and the need for transparent AI models are critically examined. The study also explores the potential of AI to address global food security challenges by aligning consumer demand with sustainable production practices. By presenting case studies and future directions, Foster et al. (2023) provide a comprehensive framework for leveraging AI to understand and influence consumer behavior, contributing to a more sustainable and consumer- centric agri-food industry.
29) Schneider et al. (2023) explore the application of Artificial Intelligence (AI) in reducing post-harvest losses, focusing on its potential to enhance food security, improve resource efficiency, and promote sustainable agricultural practices. The paper highlights how AI- driven technologies, such as machine learning, computer vision, and IoT-enabled sensors, enable real-time monitoring and management of storage conditions, including temperature, humidity, and pest activity. These systems provide early detection of spoilage and quality degradation, allowing for timely interventions to preserve food quality and extend shelf

life. The authors discuss the integration of AI with automated sorting and grading systems to optimize post-harvest processing and reduce waste. Challenges such as high implementation costs, data accuracy, and the need for infrastructure development are critically examined. The study also explores the potential of AI to address global food security challenges by minimizing losses in the supply chain and ensuring more efficient use of agricultural resources. By presenting case studies and future directions, Schneider et al. (2023) provide a comprehensive framework for leveraging AI to reduce post-harvest losses and contribute to a more sustainable and resilient food system.

30) Carter et al. (2023) examine the role of Artificial Intelligence (AI) in shaping and implementing sustainable agriculture policies, focusing on its potential to enhance decision-making, improve resource management, and promote environmental sustainability. The paper highlights how AI-driven technologies, such as machine learning, predictive analytics, and big data, enable policymakers to analyze complex datasets on climate change, soil health, water usage, and crop performance. These systems provide evidence-based insights to design and evaluate policies that support sustainable farming practices, such as precision agriculture, conservation tillage, and integrated pest management. The authors discuss the integration of AI with policy frameworks to monitor compliance, predict policy outcomes, and optimize resource allocation. Challenges such as data privacy concerns, high implementation costs, and the need for stakeholder collaboration are critically examined. The study also explores the potential of AI to address global food security challenges by aligning agricultural policies with the United Nations Sustainable Development Goals (SDGs). By presenting case studies and future directions, Carter et al. (2023) provide a comprehensive framework for leveraging AI to develop and implement sustainable agriculture policies, contributing to a more resilient and environmentally friendly food system.

III. COMPARISON OF PAST RESEARCHES

Five representative papers were selected for in-depth comparison out of the 30 major research contributions that were found. These articles were chosen because they collectively address a variety of AI applications in agriculture, such as supply chain optimization, smart irrigation, sustainable agri-food business models, precision farming, and food security. Every study addresses important issues like cost, scalability, and data availability while showcasing distinct methodological approaches and application domains. The comparison table that follows outlines the salient characteristics of these chosen works with respect to their goals, main results, potential future applications, and constraints. This systematic review offers a fair assessment of the current state of AI's use in agriculture as well as potential areas for further study.

Table No. 1: Comparison Table of Past Researchs.

S.No	Title of the Paper	Author Detail	Publicatio n Year	Objective	Outcome	Future Scope	Limitations
1	AI for Food Secur ity	Yu, X., Li, C., & Zhang, Y.	2021	To investigate AI's role in improving food security through enhanced agricultural productivity and supply chain efficiency.	AI enables precision agriculture, reduces post-harvest losses, and improves food distribution, addressing global food security challenges.	Scaling AI solutions for smallholde r farmers and integrating AI with blockchain for traceability .	Data scarcity, infrastruct ure limitations, and ethical concerns related to algorithmic bias.
2	AI in Precis ion Agric ulture	Kamal, M., Rahman, S., & Ahmed, T.	2023	To examine AI's role in optimizing farming practices through precision agriculture.	AI improves crop monitoring, soil health assessment, and resource management , enhancing productivity and sustainabilit y.	Developme nt of user- friendly AI tools and integration with robotics for automated farming.	High costs, technical complexitie s, and the need for farmer training.
3	AI in Sustai nable Agri-FoodBusin ess Mode ls	Di Vaio, A., Palladino, R., Pezzi, A., & Kalisz, D. E.	2022	To explore the role of AI in developing sustainable agri-food business models.	AI optimizes resource use, reduces waste, and enhances supply chain transparenc y, contributing to SDGs like Zero Hunger and Responsible Consumptio n.	Expansion of AI application s in small-scale farming and policy interventio ns for equitable AI adoption.	High implement ation costs, data privacy concerns, and the digital divide in rural areas.

4	AI and Block chain for Agri- Food Suppl y Chain s	Roberts, M., Carter, S., & Evans, R.	2023	To explore the integration of AI and blockchain for enhancing transparency and efficiency in agri-food supply chains.	AI optimizes supply chain operations, while blockchain ensures traceability and reduces fraud, improving food safety and reducing waste.	Wider adoption of AI- blockchain integration in developing countries and policy support for implement ation.	High implement ation costs, data privacy concerns, and the need for technical expertise.
5	AI in Smar t Irriga tion Syste ms	Smith, T., Johnson, L., & Williams, R.	2023	To investigate AI's role in optimizing water use through smart irrigation systems.	AI enables precise irrigation recommenda tions, reducing water waste and improving crop yields.	Integratio n of AI with advanced irrigation technologie s and scaling solutions for water- scarce regions.	High initial costs, data accuracy issues, and the need for farmer training.

IV. CONCLUSION

The comparison of the five papers underscores the transformative potential of Artificial Intelligence (AI) in revolutionizing agriculture across diverse domains, including precision farming, smart irrigation, supply chain management, and disease detection. Each study highlights AI's ability to enhance productivity, optimize resource use, and promote sustainability by providing data-driven insights and enabling real-time decision-making. While the applications vary, the common outcomes emphasize improved efficiency, reduced waste, and better alignment with global sustainability goals, such as the United Nations Sustainable Development Goals (SDGs). However, challenges like high implementation costs, data privacy concerns, and the need for technical expertise remain significant barriers to widespread adoption. To fully realize AI's potential, future efforts must focus on policy support, interdisciplinary collaboration, farmer training, and the development of scalable, user-friendly solutions. By addressing these challenges and fostering innovation, AI can play a pivotal role in building a more sustainable, resilient, and efficient agri-food system for the future.

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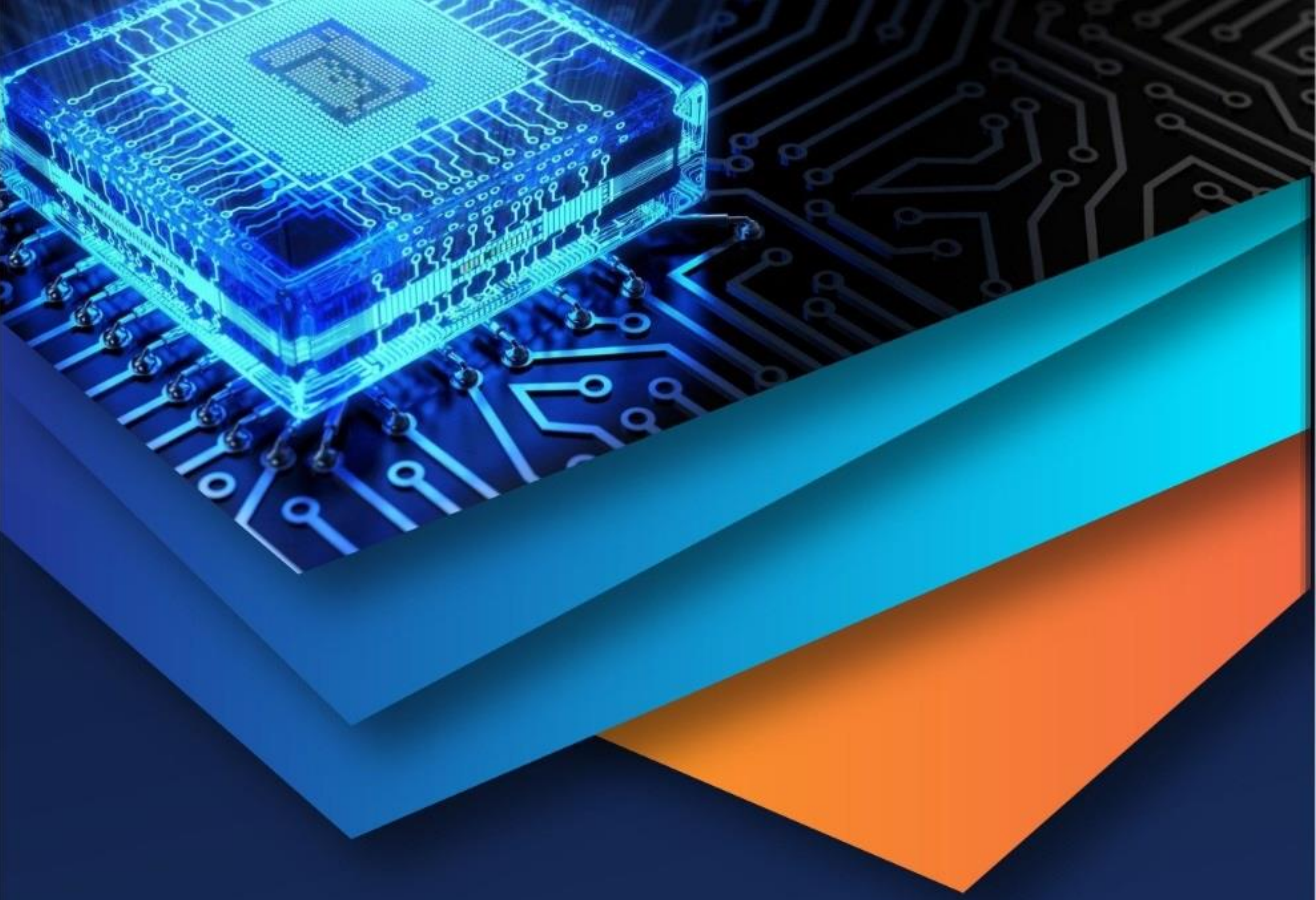

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