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Application of artificial intelligence in agriculture and allied sectors

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Abstract
The integration of artificial intelligence (AI) in agriculture signifies a significant shift towards more efficient and sustainable farming practices. With a growing global population increasing food demand, AI technologies offer farmers the tools to optimize operations like crop management, soil health assessment, and resource allocation. These advancements enable precise monitoring of environmental conditions and crop health, empowering data-driven decisions that minimize waste and enhance yields. Beyond traditional farming practices, AI applications span supply chain management and livestock monitoring, providing a holistic approach to agricultural innovation. This summary explores the diverse applications of AI in agriculture, showcasing how these technologies are reshaping agricultural practices and addressing critical challenges faced by the sector in the modern era.

Keywords: Artificial intelligence, machine learning, agriculture

1. Introduction

The integration of artificial intelligence (AI) in agriculture and allied sectors represents a transformative shift in farming practices, promising enhanced efficiency and sustainability. As the global population continues to rise, the demand for food production intensifies, stressing existing agricultural systems. By harnessing AI technologies, farmers can optimize various processes, including crop management, soil health assessment, and resource allocation. These advancements enable precise monitoring of environmental factors and crop conditions, allowing for data-driven decisions that significantly reduce waste and increase yields. Moreover, AI applications extend beyond traditional farming; they encompass aspects such as supply chain management and livestock monitoring, creating a comprehensive framework for agricultural innovation. This essay will explore the multifaceted applications of AI in agriculture, examining how these technologies are not only reshaping farming landscapes but also addressing critical challenges faced by the agricultural sector in the 21st century.

2. Definition of Artificial Intelligence (AI)

As we delve into the role of artificial intelligence (AI) in agriculture and allied sectors, it is essential to establish a clear definition of AI itself. AI refers to the capability of a machine to imitate intelligent human behavior, utilizing algorithms and data to perform tasks that typically require human cognitive functions such as learning, reasoning, and problem-solving. The advancements in AI technologies have led to their application in various domains, including agriculture, where AI systems can optimize production processes and improve resource efficiency. For instance, effective AI implementation relies on continuous advancements in research and development, as highlighted by (Commission NS on Intelligence A (US) 2020) [20] which emphasizes the importance of increasing AI investments and promoting cooperation among allies. Moreover, (Commission NS on Intelligence A (US) 2021) [21] illustrates how these technologies must be ethically applied to ensure sustainability in agricultural practices, thus enhancing both productivity and environmental stewardship.

3.0 Importance of AI in modern agriculture

In the contemporary agricultural landscape, the integration of artificial intelligence (AI) has emerged as a transformative force, addressing pivotal challenges and enhancing productivity. AI technologies facilitate precision farming, allowing for the optimized use of resources through data-driven insights into crop health, soil conditions, and weather patterns. This capability not only increases yield but also promotes sustainability by minimizing waste and reducing the overuse of fertilizers and water. Furthermore, automated systems powered by AI enable timely interventions, improving operational efficiency and reducing labor costs. As evidenced by the recommendations from the National Security Commission for Artificial Intelligence, adapting AI strategies is crucial for maintaining competitive agricultural practices in a rapidly evolving technological era (Commission NS on Intelligence A (US) 2021) [21]. In a time when agriculture faces pressures from climate change and population growth, the importance of AI is increasingly underscored in its role to enhance agricultural resilience and food security (BIBI *et al.*, 2020) [10] (BIBI *et al.* 2020)[11], (Chamberlain *et al.*, 2023) [12].

4. Overview of the essay structure

In constructing an effective essay on the Application of Artificial Intelligence in Agriculture and Allied Sectors, a well-defined structure is imperative for clarity and coherence. This essay will begin with an introduction that outlines the significance of artificial intelligence in enhancing agricultural productivity and practices. Following this, the second section will delve into specific applications, such as machine learning in crop yield prediction and the utilization of IoT for monitoring agricultural conditions . The third part will analyze the impact of AI on sustainable farming practices and its role in addressing economic challenges within agriculture . Finally, the conclusion will synthesize these insights, reaffirming the transformative potential of AI in agriculture while highlighting areas for future research. This structured approach will ensure a comprehensive exploration of the topic, facilitating a clear understanding of AIs multifaceted role in modern agriculture.

4.1 Precision Agriculture

Precision agriculture stands as a pivotal implementation of artificial intelligence, significantly transforming farming practices through enhanced decision-making and resource management. By utilizing AI-driven technologies, such as machine learning and predictive analytics, farmers can optimize crop yields while minimizing waste and environmental impact. This paradigm shift not only increases efficiency but also fosters sustainable practices, aligning with Industry 5.0's goals, which emphasize agility and responsiveness in agricultural operations (Ali *et al.*, 2023) [6]. Moreover, initiatives like the Queensland AgTech Roadmap 2023–2028 indicate a commitment to advancing AgTech innovation, further solidifying the states status as a hub for cutting-edge agricultural developments . Challenges remain, such as technology adoption and ethical considerations; however, the benefits of AI in automating soil and disease management, as well as crop monitoring, illustrate its potential to alleviate historical difficulties in agriculture . Ultimately, precision agriculture underscores the promise of AI in driving the agricultural sector toward greater productivity and sustainability (Abu-Naser *et al.*, 2024) [1].

4.2 Use of AI in crop monitoring and management

The integration of artificial intelligence in crop monitoring and management has revolutionized agricultural practices, enhancing efficiency and productivity. AI enables precision agriculture through advanced techniques such as automated disease detection and forecast modeling, which significantly mitigate yield losses attributed to plant diseases, estimated at 10–16% annually. Utilizing image recognition, AI surpasses human capabilities with reported accuracies exceeding 95% in diagnosing crop health, thus facilitating timely interventions (Department of Agriculture and Fisheries *et al*., 2023) [16]. Furthermore, employing machine learning algorithms to sift through complex agricultural data allows for the identification of nuanced correlations, ultimately informing better management decisions (Md. Hossen I *et al.,* 2023) [19]. AI tools not only automate soil and disease management but also optimize resources, ensuring minimal manpower is required for agricultural tasks . Consequently, leveraging AI fosters sustainable practices and strengthens crop resilience, proving essential in addressing contemporary challenges within the agricultural sector (Department of Agriculture and Fisheries *et al.*, 2023) [16].

4.3 Implementation of AI-driven irrigation systems

The implementation of AI-driven irrigation systems represents a significant advancement in agricultural practices, optimizing water usage and enhancing crop yields. These systems utilize real-time data from various sources such as soil moisture sensors and weather forecasts to determine the precise irrigation needs of crops, thereby minimizing water waste and promoting sustainability. By employing machine learning algorithms, farmers can analyze historical data and predictive analytics to refine their irrigation schedules, as detailed in (Abu-Naser *et al.*, 2024) [1]. Additionally, the integration of IoT devices allows for continuous monitoring and immediate adjustments to irrigation practices, addressing potential threats to crop health, such as drought or pest infestation, as noted in . The efficiency gains from AI-driven systems not only reduce labor costs but also align agricultural practices with environmental conservation goals, ultimately demonstrating the transformative potential of artificial intelligence in the agricultural sector.

4.4 Benefits of AI in soil health assessment

The incorporation of artificial intelligence (AI) in soil health assessment has revolutionized agricultural practices, enabling farmers to optimize soil management and enhance crop productivity sustainably. By leveraging machine learning algorithms and remote sensing technologies, AI can analyze vast amounts of soil data, identifying variables such as nutrient levels, pH, and moisture content with remarkable precision. This analytical capability allows for tailored interventions that promote healthier soils and improved agricultural outcomes. For instance, AI-driven technologies facilitate the monitoring of soil conditions over time, aiding in the detection of degradation patterns and enabling timely remediation efforts, which is essential for achieving sustainable food systems as outlined in recent sustainability frameworks (Varzakas T *et al*,. 2024) [30]. Furthermore, as AI advances, it promotes integration across various agricultural sectors, fostering collaboration among stakeholders to address complex issues such as environmental impact and climate resilience (Yannis E Doukas *et al.*, 2023) [31]. The future of agriculture hinges on leveraging these intelligent systems for holistic soil management , ensuring food security while maintaining environmental integrity.

4.5 Pest and Disease Management

The introduction of artificial intelligence (AI) into pest and disease management is transforming agricultural practices, offering innovative solutions to longstanding challenges. AI technologies facilitate early detection and monitoring of crop diseases, which is critical in mitigating losses and ensuring sustainable agricultural productivity. For instance, deep learning algorithms are now utilized to analyze visual data of crops, enabling precise identification of disease symptoms and potential pests, thus optimizing intervention strategies . Moreover, as global demands for food increase against the backdrop of climate change, the integration of AI can streamline resource use and improve overall farming efficiency (Pokhariyal S *et al.*, 2023) [29]. By automating pest detection and management, AI not only reduces the reliance on chemical treatments but also enhances crop resilience (Hassebo A *et al.*, 2023) [2]. These advancements illustrate the pivotal role of AI in promoting sustainable agricultural practices and highlight a promising direction for future research and implementation.

4.6 AI applications in pest detection and identification

The integration of artificial intelligence (AI) in pest detection and identification marks a significant advancement in agricultural practices, enhancing productivity and sustainability. Sophisticated machine learning algorithms facilitate the analysis of vast amounts of data from various sources, enabling farmers to identify pest infestations early and accurately. For instance, convolutional neural networks (CNNs) have been instrumental in processing images for pest recognition, minimizing yield losses through timely interventions (Prof. Prof KAH. Prof PRS. Asha P Prof S. Sharayu A Prof L. Prof YTH. Lonare M 2023) [25]. Additionally, AI-driven solutions harness drone technology, where UAVs equipped with advanced imaging sensors monitor crop health and detect pests over extensive areas. Furthermore, the AI applications extend to thermal imaging techniques, efficiently diagnosing the presence of pests and diseases during the post-harvest stage. Such innovations not only streamline pest management processes but also contribute to informed decision-making, ultimately fostering a more resilient agricultural sector (Reiger *et al.*, 2022) [26].

4.7 Predictive analytics for disease outbreaks

The integration of predictive analytics through artificial intelligence (AI) has proven essential in managing disease outbreaks, which directly impacts agricultural productivity and sustainability. By utilizing large datasets, AI models can anticipate disease spread among crops, enabling farmers to implement timely interventions that mitigate yield loss. For instance, predictive analytics allows for the identification of potential disease hotspots, which is crucial in preventing outbreaks that can devastate entire harvests. Technologies such as machine learning algorithms analyze historical data, climate variables, and other relevant parameters to yield accurate predictions, thereby enhancing decision-making in crop management. Moreover, this proactive approach supports resource allocation by directing attention and materials to areas at highest risk, promoting both efficiency and resilience in agricultural practices. Such advancements underscore the transformative role of AI in not only improving agricultural outputs but also safeguarding food security in the face of evolving ecological challenges (P Pathmanaban *et al.*, 2023) [24], (Ali ZA *et al.*, 2023) [32].

4.8 Integration of AI with biocontrol methods

The integration of artificial intelligence (AI) with biocontrol methods represents a transformative approach within agricultural practices, enhancing pest management and promoting sustainable ecosystems. AI technologies, such as machine learning algorithms, can analyze extensive datasets on pest populations and environmental factors, allowing farmers to implement targeted biocontrol strategies more effectively. For instance, digital yellow water traps equipped with AI have been utilized for continuous monitoring of pests, enabling real-time data collection and informed decision-making regarding insecticide applications, thereby minimizing chemical usage and supporting the European Farm to Fork strategy to reduce pesticide dependence . Additionally, bacteriophages are being explored as alternative antimicrobials in agricultural contexts, indicating the promise of combining AI insights with biological control agents to enhance crop health while addressing consumer demands for reduced chemical inputs (Anany *et al.*, 2023) [7]. This synergy highlights a significant step toward precision agriculture, fostering both productivity and environmental stewardship (Akan *et al.*, 2024) [4].

5. Supply Chain Optimization

In the context of agricultural practices, the optimization of supply chains has become increasingly vital, particularly as the global population rises and food production demands intensify. Integration of Artificial Intelligence (AI) technologies is pivotal in enhancing this optimization by facilitating advanced analytics and predictive modeling. AI applications are transforming traditional supply chains, allowing for precision in forecasting and resource allocation, which are crucial in mitigating the impact of climate variability and market fluctuations (Saha S *et al.*, 2024) [28]. Studies reveal that through machine learning and big data analytics, significant improvements have been achieved in demand forecasting, resulting in more efficient inventory management and logistics operations (Elufioye OA *et al.*, 2024) [22]. Furthermore, AIs role extends to identifying inefficiencies and enhancing transparency within the supply chain, fostering collaboration among stakeholders. As these innovations continue to evolve, they promise to address pressing challenges while maximizing productivity and sustainability in the agricultural sector.

5.1 Role of AI in demand forecasting and inventory management

The integration of artificial intelligence (AI) into demand forecasting and inventory management within agricultural sectors represents a transformative step towards enhancing operational efficiencies and reducing wastage. AI systems leverage vast amounts of data, including historical sales, climate conditions, and market trends, enabling producers and suppliers to predict consumer demand with remarkable accuracy. This capability not only optimizes inventory levels but also minimizes the risks associated with overproduction and spoilage, particularly important for perishable goods. For instance, the strategic adoption of AI technologies can enhance logistics management and enable real-time decision-making, fostering greater collaboration among supply chain stakeholders and bolstering product traceability and visibility. Additionally, as explored in various studies, the role of AI in mitigating supply chain vulnerabilities is increasingly recognized, underscoring its potential to improve food security and operational resilience in both developed and developing regions (Oriekhoe OI *et al*,. 2024) [23]. Ultimately, the successful deployment of AI necessitates a thorough understanding of its implications on the entire supply chain, driving innovation and sustainability (Atadoga A *et al.*, 2024) [5], (Dang *et al.*, 2024) [13].

5.2 Enhancing logistics and transportation through AI

The integration of artificial intelligence (AI) into logistics and transportation systems within the agricultural sector plays a critical role in enhancing efficiency and sustainability. As supply chains grow more complex due to increasing global demands, AI-driven solutions offer significant improvements in operations, such as optimizing routing and scheduling. For instance, applications of AI can streamline transportation by predicting demand and adjusting logistics accordingly, thereby minimizing waste and lowering costs (Ault *et al.,* 2021) [8]. Furthermore, advancements in automated systems not only increase output but also contribute to reducing the environmental impact of agricultural practices, aligning with efforts to combat climate change. The importance of policy interventions to support these technological integrations cannot be overstated, as they facilitate increased collaboration between stakeholders and guide the ethical deployment of AI in the industry . Thus, leveraging AI in logistics and transportation emerges as a vital strategy for building more resilient agricultural supply chains.

5.3 Impact of AI on reducing food waste

The integration of artificial intelligence (AI) in agriculture significantly mitigates food waste, demonstrating its potential for transforming sustainable practices. Advanced AI algorithms enable more accurate demand forecasting, as evidenced by research that applied machine learning to predict consumer demand at grocery stores, resulting in optimized production planning and a substantial decrease in food waste (Commission NS on Intelligence A (US) 2020) [20]. Furthermore, AI technologies enhance agricultural efficiency through precision agriculture and crop monitoring, thus ensuring food supply meets the growing global demand (Bajwa *et al.*, 2020) [9]. This optimization not only reduces excess production but also improves overall supply chain management, highlighting AIs role in food processing and quality control (Gao *et al.*, 2023) [17]. Additionally, the adaptability of AI solutions to the unique challenges faced by African agriculture illustrates the technologys broad applicability and potential to address food insecurity while minimizing waste. Collectively, these advancements underscore AIs critical impact on promoting sustainability within agricultural systems.

6. Conclusion

In conclusion, the application of artificial intelligence in agriculture and allied sectors represents a transformative shift towards more sustainable and efficient farming practices. The integration of AI technologies not only addresses immediate challenges such as crop yield optimization and resource management but also plays a crucial role in mitigating the long-term impacts of climate change on agriculture. Innovative techniques like gene-based crop modeling, aided by AI, allow for enhanced breeding methodologies that promise increased resilience and adaptability of crops ((SIAD S 2023) [27]. Furthermore, as climate-induced risks become more pronounced, AI systems can be pivotal in developing risk management strategies that lower insurance costs for farmers while fostering a more stable agricultural economy. Collectively, these advancements underscore the urgent need for continued research and development in this field, which should strive to fill existing gaps and to harness AIs full potential in promoting global food security and sustainable agriculture practices.

6.1 Summary of AI applications in agriculture

The integration of artificial intelligence (AI) in agriculture presents transformative opportunities for enhancing productivity and sustainability within the sector. AI applications, such as precision agriculture, utilize data-driven insights to optimize resource allocation, leading to improved crop yields and reduced waste. By employing techniques such as machine learning and IoT, farmers can effectively monitor soil health, predict weather patterns, and manage pest control, which are critical factors in increasing agricultural efficiency . Furthermore, mobile applications and digital platforms empower farmers, particularly in rural regions, by providing access to vital information and market trends, thus supporting better decision-making processes (Gupta *et al.*, 2021) [18]. The potential for AI to streamline operations and ensure sustainable practices positions it as a crucial tool in addressing the challenges faced by the agricultural sector, such as climate change and resource management (David-Olawade *et al.*, 2024) [14]. As research progresses, the collaborative applications of AI in agriculture will undoubtedly pave the way for a resilient agricultural future.

6.2 Future prospects of AI in the agricultural sector

The future prospects of artificial intelligence (AI) in the agricultural sector are both promising and multifaceted, reflecting the urgent need for sustainable practices amid evolving environmental challenges. AI technologies are anticipated to enhance crop yield through precision agriculture, enabling tailored irrigation and nutrient management solutions that increase efficiency and reduce waste. Additionally, AI can play a vital role in climate adaptation by optimizing resource use and predicting adverse weather impacts, which is crucial for maintaining food security in a changing climate. Recent findings highlight the integral role of AI in achieving net-zero emissions and promoting sustainable development in agriculture (David-Olawade *et al.*, 2024) [15]. Furthermore, collaboration across sectors will be paramount in addressing ethical challenges and ensuring equitable access to AI solutions (Commission NS on Intelligence A (US) 2020) [20]. As AI continues to evolve, its applications in pest management and resource optimization will solidify its importance in modern agricultural practices, ultimately fostering resilience and sustainability in this essential sector (David-Olawade *et al.*, 2024) [15], (Ahmed *et al.*, 2024) [3].

6.3 Final thoughts on the importance of embracing AI technology

In conclusion, embracing artificial intelligence technology represents a pivotal opportunity for the agriculture and allied sectors to enhance productivity and sustainability. As farmers increasingly confront challenges such as climate change, resource scarcity, and fluctuating market demands, AI provides innovative solutions that facilitate data-driven decision-making and optimize resource allocation. The integration of AI tools, such as precision agriculture and predictive analytics, not only increases crop yields but also encourages environmentally sustainable practices. Furthermore, the adoption of AI has the potential to revolutionize food supply chains, ensuring that high-quality produce reaches consumers efficiently. By prioritizing the incorporation of AI technologies, stakeholders within these sectors can harness their transformative capabilities, foster resilience against future uncertainties, and contribute to a more sustainable agricultural system. Thus, the significance of AI in shaping the future of agriculture cannot be overstated, as it embodies the pathway toward enhanced efficiency and security in food production.

7. References

1. Abu-Naser SS, Abunasser BS, Al-Hanjor MM, El-Habib. Artificial Intelligence in Agriculture: Enhancing Productivity and Sustainability. 2024. Available from: https://core.ac.uk/download/619510753.pdf
2. Hassebo A, Tealab M. Global Models of Smart Cities and Potential IoT Applications: A Review. IoT. 2023;4:366-411. Available from: https://doi.org/10.3390/iot4030017
3. Ahmed ZO, Al Marjani MF, Mohammed RK, Mohialden. Artificial Intelligence and the Silent Pandemic of Antimicrobial Resistance: A Comprehensive Exploration. Newinera Publisher. 2024. Available from: https://core.ac.uk/download/599582073.pdf
4. Akan OB, Babar AZ. Sustainable and Precision Agriculture with the Internet of Everything (IoE). 2024. Available from: http://arxiv.org/abs/2404.06341
5. Atadoga OA, Osasona F, Onwusinkwue S, Daraojimba AI, Dawodu SO. AI in Supply Chain Optimization: A Comparative Review of USA and African Trends. Int J Sci Res Arch. 2024;11:896-903. Available from: https://doi.org/10.30574/ijsra.2024.11.1.0156
6. Ali A, Ali A, Dadwal S, Dadwal. Investigating the Factors, Challenges, and Role of Stakeholders in Implementing Industry 5.0 and Its Impact on Supply Chain Operations: A Study of the Global Agri-Food Supply Chain. IGI Global. 2023. Available from: https://core.ac.uk/download/568109606.pdf
7. Anany H, Bastias R, Biosca EG, Brøndsted. ECOPHAGE: Combating Antimicrobial Resistance Using Bacteriophages for Eco-Sustainable Agriculture and Food Systems. Multidiscip Dig Publ Inst. 2023. Available from: https://core.ac.uk/download/598016455.pdf
8. Ault SJ. Analysis into Artificial Intelligence and Its Developing Dynamic and Relationship in Agricultural Supply Chains. DigitalCommons@CalPoly. 2021. Available from: https://core.ac.uk/download/533929552.pdf
9. Bajwa S, Bhusal S, Brown-Brandl TM, Brumm. Ground and Aerial Robots for Agricultural Production: Opportunities and Challenges. DigitalCommons@University of Nebraska - Lincoln. 2020. Available from: https://core.ac.uk/download/345183691.pdf
10. Bibi M. Training and Adaptive Performance of Healthcare Professionals in the Era of Digitization in Pakistan. Sarhad University of Science and Information Technology. 2020. Available from: https://core.ac.uk/download/327161512.pdf
11. Bibi M. Training and Adaptive Performance of Healthcare Professionals in the Era of Digitization in Pakistan. Sarhad University of Science and Information Technology. 2020. Available from: https://core.ac.uk/download/553168855.pdf
12. Chamberlain B, Fernberg P. Artificial Intelligence in Landscape Architecture: A Literature Review. Hosted by Utah State University Libraries. 2023. Available from: https://core.ac.uk/download/573446146.pdf
13. Dang QH, Nguyen CTU, Nguyen HP, Pham. Artificial Intelligence and Machine Learning for Green Shipping: Navigating towards Sustainable Maritime Practices. Soc Vis Inform. 2024. Available from: https://core.ac.uk/download/604579079.pdf
14. David-Olawade AC, Fapohunda O, Ige AO, Ling. Artificial Intelligence Potential for Net Zero Sustainability: Current Evidence and Prospects. Elsevier. 2024. Available from: https://core.ac.uk/download/603653349.pdf
15. David-Olawade AC, Fapohunda O, Ige AO, Ling. Artificial Intelligence Potential for Net Zero Sustainability: Current Evidence and Prospects. Elsevier. 2024. Available from: https://core.ac.uk/download/604346574.pdf
16. Department of Agriculture and Fisheries, Queensland. Queensland AgTech Roadmap 2023–2028. State of Queensland. 2023. Available from: https://core.ac.uk/download/591829886.pdf
17. Gao K, Witte J, Zöll A. Artificial Intelligence: The Future of Sustainable Agriculture? A Research Agenda. 2023. Available from: https://core.ac.uk/download/552657796.pdf
18. Gupta C, Gupta M, Joshi P, Kumar. Information and Communication Technology in Agribusiness: A Study of Mobile Applications in Perspective of India. ANSF Publications. 2021. Available from: https://core.ac.uk/download/477997020.pdf
19. Hossen MI, Fahad N, Sarkar MR, Rabbi MR. Artificial Intelligence in Agriculture: A Systematic Literature Review. Ninety Nine Publ. 2023. Available from: https://core.ac.uk/download/621417380.pdf
20. National Security Commission on Artificial Intelligence (U.S.). Interim Report and Third Quarter Recommendations, October 2020. National Security Commission on Artificial Intelligence (U.S.). 2020. Available from: https://core.ac.uk/download/482295821.pdf
21. National Security Commission on Artificial Intelligence (U.S.). Final Report: National Security Commission on Artificial Intelligence. National Security Commission on Artificial Intelligence (U.S.). 2021. Available from: https://core.ac.uk/download/482295827.pdf

22. Elufioye OA, Ike CU, Odeyemi O, Usman FO, Mhlongo NZ. AI-Driven Predictive Analytics in Agricultural Supply Chains: A Review: Assessing the Benefits and Challenges of AI in Forecasting Demand and Optimizing Supply in Agriculture. Comput Sci IT Res J. 2024;5:473-497. Available from: https://doi.org/10.51594/csitrj.v5i2.817
23. Oriekhoe OI, Ashiwaju BI, Ihemereze KC, Ikwue U, Udeh CA. Blockchain Technology in Supply Chain Management: A Comprehensive Review. Int J Manag Entrep Res. 2024;6:150-166. Available from: https://doi.org/10.51594/ijmer.v6i1.714
24. Pathmanaban P, Gnanavel BK, Anandan SS, Sathiyamurthy S. Advancing Post-Harvest Fruit Handling Through AI-Based Thermal Imaging: Applications, Challenges, and Future Trends. Discover Food. 2023;3. Available from: https://doi.org/10.1007/s44187-023-00068-2
25. Hule KA, Sonawane PR, Sathe AP, Lokhande SA, Hambir YT, Lonare M. Crop Diseases Identification Using Deep Learning in Application. Assoc Adv Zool. 2023. Available from: https://core.ac.uk/download/591404368.pdf
26. Reiger B. Adoption of Artificial Intelligence Based Technologies in Sub-Saharan African Agriculture. 2022. Available from: https://core.ac.uk/download/543997304.pdf
27. SIAD SM. AI-Powered Gene-Based Crop Modelling: Advancements and Future Directions. Modern Lang Assoc. 2023. Available from: https://core.ac.uk/download/561059107.pdf
28. Saha S, Ghimire A, Manik MM, Tiwari A, Imran MA. Exploring Benefits, Overcoming Challenges, and Shaping Future Trends of Artificial Intelligence Application in Agricultural Industry. Am J Agric Biomed Eng. 2024;6:11-27. Available from: https://doi.org/10.37547/tajabe/volume06issue07-03
29. Pokhariyal S, Patel NR, Govind A. Machine Learning-Driven Remote Sensing Applications for Agriculture in India—A Systematic Review. Agronomy. 2023;13:2302. Available from: https://doi.org/10.3390/agronomy13092302
30. Varzakas T, Smaoui S. Global Food Security and Sustainability Issues: The Road to 2030 from Nutrition and Sustainable Healthy Diets to Food Systems Change. Foods. 2024;13:306. Available from: https://doi.org/10.3390/foods13020306
31. Doukas YE, Salvati L, Vardopoulos I. Unraveling the European Agricultural Policy Sustainable Development Trajectory. Land. 2023;12:1749. Available from: https://doi.org/10.3390/land12091749
32. Ali ZA, Deng D, Shaikh MK, Hasan R, Khan MA. AI-Based UAV Swarms for Monitoring and Disease Identification of Brassica Plants Using Machine Learning: A Review. Comput Syst Sci Eng. 2023;48:1-34. Available from: https://doi.org/10.32604/csse.2023.041866