Vol. 1, No. 2, 2026
https://dkujournals.edu.et
Ras Dejen Journal of Sciences

A structured Review on the Implementations of Autonomous Technologies in Agricultural Production and Post-Harvest Processing

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Article History:

Received:December 9, 2025

Revised: May 26, 2026

Published: July 24, 2026

Abstract

AI- based autonomous technology on agriculture starts on the beginning of Information Age in the 21st century by the introduction of agricultural robots, drones, and driverless tractors becoming commonplace on farms. Agricultural robots are important for crop production, and more specifically to ground robots participating in open field operations that range from plant breeding to crop establishment, cultivation and harvest. These robots and techniques are improving farming by solving big problems and helping farms run more smoothly, produce more, and harm the environment less. The integration of advanced robotics and AI in farming operations is poised to revolutionize agricultural practices, making it a critical area of research and development for the future of food security and environmental sustainability. They are different agricultural machines used in the production and processing process like drone, plantix and soil analyzer. Robotic field Preparation and monitoring, Spraying of Agrochemicals, seed sowing,yield assessments, Machine Vision Systems, Robotic ArmsandAutonomous Guided Vehicles are the major activities and materials used by autonomous agricultural technology during production and processing.While recognizing the advantages of AI for sustainable farming, implementing this technology does come with its fair share of significant obstacles that

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need to be addressed including: high cost, Lack of experience with emerging technologies and Climate and Geographic Constraints. In the future an autonomous AI-based technology promises as the technology continues to advance and revolutionize the industry.

Keywords: Autonomous technology, Robotics, Application of robot on agriculture, Limitation and precision agriculture

1.Introduction

Agricultural mechanization provides the power and equipment essential for preparing the soil and establishing, maintaining, storing, and processing agricultural crops in the field and on the farm. Over the years, it has evolved from basic hand tools and animal-powered implements to sophisticated engine-powered equipment (Clarke, 2000). Unfortunately, hand tools and animal power are still in common use in developing countries, hampering agricultural productivity and negatively affecting the livelihoods of small-scale farmers (FAO, 2008). Mechanization developments are therefore driven by the desire to reduce drudgery and eliminate hard work during labor peaks such as land preparation, weeding, harvesting, and transport.

Agricultural robots for crop production, and more specifically to ground robots participating in open field operations that range from plant breeding to crop establishment, cultivation and harvest. Post-harvest processing has been traditionally served by “hard automation” technologies, although mechatronics and robotics are increasingly becoming part of post-harvest and food manufacturing systems (Khan ZH et al. 2018).These robots and techniques are improving farming by solving big problems and helping farms run more smoothly, produce more, and harm the environment less. AI based autonomous farming have many different uses, all of which aim to make farming more efficient, productive, and eco-friendly (Rai AKMJ et al. 2023). Moreover, the integration of green nanotechnology into agriculture, utilizing biosensors and green-synthesized nanomaterials, further supports the eco-friendly aspect of robotic farming by reducing excessive pesticide use and enhancing crop productivity (Sundararajan N. et al 2023). The integration of robotics into agriculture is driven by the need to address various challenges such as labor shortages, the environmental impact of traditional farming methods, and increasing food demand (Rai AKMJ et al. 2023). A key use is for robots that work independently in the field. These robots have tools such as sensors, cameras, and GPS to move around, spot plants, and perform tasks such as seeding, getting rid of weeds, and spraying very accurately. They help reduce the need for people to work in the fields, lower the money spent on materials, and increase the amount of crops grown, while being better for the environment.

Moreover, the development of agricultural robots, or autonomous farming is not only a technological endeavor but also a socio-economic one, as it necessitates acceptance and accessibility within the farming community, particularly in agriculture-based societies like India (Charles OA et al, 2022). The role of robotics in agriculture is further complicated by the need for innovation in technology and adaptation of farming practices to meet the challenges of modern agriculture (Karthikeyan D et al, 2021). The role of robotics in agriculture is multifaceted, offering solutions to enhance productivity, sustainability, and profitability. The integration of advanced robotics and AI in farming operations is poised to revolutionize agricultural practices, making it a critical area of research and development for the future of food security and environmental stewardship (NSYRAG et al, 2024). Therefore, the Objectives of the review are how AI-based autonomous systems can improve harvesting efficiency and field monitoring in agriculture and Reviewing the historical background of autonomous agriculture and the impact of these technologies on productivity, labor costs, and sustainability.

1. Brief history of AI based autonomous technology on agriculture

A stroll through the pages of history reveals that the evolution of agriculture has been intricately woven with the threads of technological progress. Dating back thousands of years, the annual agriculture narrate a tale of innovation and adaptation. The Neolithic Revolution, a pivotal moment some 10,000 years ago, witnessed humanity's shift from nomadic hunter-gatherer societies to settled agricultural communities (Smith, 1998). By taming important plants and animals, farming took a big leap, making extra food and helping civilizations thrive (Diamond, 1997).

The winds of change blew even stronger during the Industrial Revolution, ushering in a new era of mechanized agriculture. The seed drill and steam-powered tractors transformed farming, leading to the rise of agricultural societies and colleges focused on improving farming methods.

As we stepped into the 20th century, synthetic fertilizers, pesticides, and mass-produced tractors marked significant milestones. The beginning of Information Age technologies in the 21st century introduced a new chapter like agricultural robots, drones, and driverless tractors becoming commonplace on farms.

The digital agriculture and precision agriculture movement leverages extensive data collection and computation to enhance farm efficiency, embracing precision beekeeping, livestock farming, and viticulture. From ancient civilizations to the digital age, the historical journey of farming technology is a testament to the resilience of agriculture, forever adapting to the rhythms of innovation.

AI-based autonomous agricultural production and harvesting gaining traction in the late 2010s. Key developments included advancements in robotics, machine learning, and computer vision, which enabled precision agriculture and automated harvesting systems (Liakos et al., 2018). Companies like Blue River Technology and others started to integrate AI in agricultural machinery, leading to more efficient farming practices (John Deere, 2020). By the early 2020s, these technologies had become more widely adopted in various agricultural sectors (Wolfert et al., 2017).

3.1 Types of autonomous machines on agricultural production and processing

Agricultural robots, pick apples, gather strawberries, harvest lettuce and strip away weeds. Drones gather aerial images that help farmers quickly assess crop health. And robotic greenhouses are sprouting up thousands of miles away from traditional farmland regions, growing vegetables in the backyards of high-consumption urban markets. So to performed the above agricultural tasks it can use different robotic machines.

Agricultural robot

An agricultural robot is a robot deployed for agricultural purposes. The main area of application of robots in agriculture today is at the harvesting stage. Emerging applications of robots or drones in agriculture include weed control cloud planting seeds, harvesting, environmental monitoring and soil analysis.

Precision Agriculture Systems:

These systems integrate various technologies, including drones, sensors, and AI, to optimize farming practices based on real-time weather and soil data. The foundation of precision farming lies in three core principles: “Right place, Right time, and Right products.” This cutting-edge agricultural approach aims to replace labor-intensive, repetitive tasks with highly precise and controlled technology. An example of this precision is the measurement of plant stress levels, which can be achieved using high-resolution photos and data from various plant sensors. Using the sensor data as its input, a machine-learning model is then used to recognize stress (Ampatzidis, 2018).

Automated Weather Observation Systems (AWOS)

These systems are used to collect weather data, which can be used for forecasting. These systems provide critical information for pilots and other aviation personnel, aiding in decision-making and ensuring safety. AWOS systems typically provide a computer-generated voice message broadcast via radio frequency, which is mandatory for AWOS. Key Features and Functions of the technology are Real-time weather data record, Voice reports, Data dissemination, Special observations, Customization and Backup systems.

On-the-Spot Soil Analyzers (OSA):

These devices can simultaneously measure soil properties at a specific depth, providing real-time data for farmers. A precision soil analysis bot can predict nutrient needs and recommend fertilizers. Additionally, information about soil conditions plays a crucial role in determining the suitable crop varieties and expected yields. Leveraging AI technology allows for swift and accurate assessment of soil texture, nutrient levels, organic matter content, and other relevant factors, thereby assisting in making informed decisions regarding crop selection and the necessary farming inputs (Sudarsan et al., 2016).

Agro smart:

A precision soil analysis bot can predict nutrient needs and recommend fertilizers. Agro smart generates market intelligence and creates agronomic models based on seed genetics, soil type and microclimate. It combines ground truth data and best-in-class analytical capabilities to provide actionable insights for a more productive and sustainable agriculture. It monitors crops using sensors to collect ground truth data and satellite imaging to generate recommendations regarding irrigation, climate and diseases to help farmers make better decisions: increasing yield, saving water and energy to achieve sustainability and climate resilience. Agro smart brings transparency, sustainability and traceability to the food and beverage industries, making their value chain more transparent and climate resilient.

Plantix:A company uses AI to help farmers optimize irrigation based on weather forecasts and soil moisture levels.Progressive Environmental & Agricultural Technologies (PEAT) developed an application to identify soil deficiencies, plant diseases, and pests. This application offers farmers insights and recommendations on utilizing improved fertilizers to enhance the quality of their produce. Using AI's image recognition technology, farmers can capture plant images with the app and gain valuable insights into their quality (Krishna, 2020)

3.2. Autonomous technology on Agricultural Production systems

The latest strides in artificial intelligence and machine learning have prompted engineers to assess if there could be productive usage of the same in agriculture – and the results have been rewarding. Like in the case of all innovations, these technologies are taking baby steps in gaining customer confidence and investor interest whilst staying focused on financial sustainability.

Robotic field Preparation and monitoring

There are technologies that can correctly assess the field layout and guide a tractor (with or without a driver) to prepare the field for maximum production (Zhang et al., 2021; Wolfert et al., 2017). These technologies, including drones and IoT sensors, provide real-time monitoring and insights through AI-powered analysis (Liakos et al., 2018; FAO, 2022).Effective field monitoring is crucial for precision agriculture, as it enables farmers to collect real-time data on crop health, soil conditions, and environmental factors. Drones equipped with multispectral and thermal imaging cameras can capture highresolution images of fields, providing insights into plant health, moisture levels, and potential pest problems. Similarly, IoT sensors embedded in the soil can measure parameters like temperature, humidity, and nutrient levels, sending continuous data to cloud platforms for analysis(Liakos et al., 2018). These data are then processed using AI models to generate actionable insights that inform farmers' decisions about irrigation, fertilization, and pest control. The ability to monitor crops and field conditions in real-time allows for more precise management, reducing waste and optimizing resource usage.

Sowing of Seeds

Traditionally, sowing and planting tasks are performed by specialized planting equipment connected behind the tractor. However, tractors are characterized by being heavy machinery and, therefore, their constant locomotion throughout the farm intensifies soil compaction. But AI-based robotic applications of sowing and planting have now made it possible to sow seeds in a straight line with adequate space between them, replacing seed-drills and manual sowing.In 1996, Sakaue was already developing robotic systems to automate the sowing and planting process in Japan, (Sakaue,1996)with the elaboration of four variations of a wheeled robot. The Australian Center for Field Robotics (ACFR) at the University of Sydney also started in 2015, the development of the Digital Farmhand project of with a clear objective of developing a robotic sowing system by created the Di-Wheel robot.

Spraying of Agrochemicals

Pesticides, herbicides, and other agrochemicals are usually sprayed all over the plants and sometimes even randomly around un-affected areas. Current innovations in image-based analytics have made it possible for drone-based sprayers to target infected areas of the plant.AI-technology Spraying Systems Work on by Sensing and Detection through Cameras,thermal, and multispectral sensors are mounted on drones, tractors, or robots.These sensors detect weed species, crop stress, pests, or disease symptoms in real time Shamshiri, R. R., et al. (2018).Spray Application of agrochemicals also apply in Precision sprayers activate only over targeted areas.Some systems also use robotic arms, automated booms, or variable-rate nozzles. Drones use GPS-guided flight paths and variable-rate control to apply the exact amount needed.

Application of Fertilizers

Artificial Intelligence (AI) is increasingly used in precision agriculture to enhance fertilizer application by making it more efficient, site-specific, and environmentally sustainable. AI-based systems analyze soil, crop, weather, and historical yield data to determine the optimal type, amount, timing, and method of fertilizer application Misra, N. N.et al. (2020). Now it is possible for users to map the lay of the land basis the existing soil nutrients. This is very useful for the application of Urea, DAP, MOP, SSP, and separate doses of N, P & K which can be appropriately applied on the ground without compromising soil health by using machinery or drones.AI systems gather data from Soil sensors (for NPK levels, moisture, pH), Remote sensing (drones or satellites), Farm machinery and Weather stations. It also analysis data by Machine learning models to predict nutrient deficienciesRecommend site-specific fertilizer doses and optimize timing of application World Bank (2021).

Harvesting and Assessing Yield of Crops

Machines can now harvest crops more precisely and cleanly, thanks to AI and robotic systems that assess ripeness and harvest without damaging crops (Bac et al., 2014; Shamshiri et al., 2018; FAO, 2022). These smart systems reduce reliance on manual labor and improve yield by operating continuously, even in challenging conditions. Ituses a combination of AI, robotics, and sensor technologies to detect the ripeness of crops and harvest them without damaging the plants. One key advantage of autonomous harvesting is that it reduces the reliance on manual labor, which is increasingly difficult to secure, especially for seasonal tasks. Robotic harvesters can work around the clock, picking crops at the optimal time to ensure maximum yield and quality. Additionally, the ability to harvest at night or during inclement weather can further optimize harvest efficiency. However, there are challenges in ensuring that these systems are capable of handling different types of crops, varying field conditions, and the unpredictable nature of agricultural environments. Ongoing research focuses on improving the flexibility and adaptability of harvesting robots to make them more versatile and suitable for a wide range of crops.

3.3. Autonomous technology on Agricultural post- harvest processing System

Post-harvest processing means handling, storing, and processing of crops after harvest to maintain quality and reduce losses. With the advancement of autonomous technologies, many post-harvest activities such as sorting, grading, packaging, transporting, and storing have been automated to improve efficiency, reduce human labor, and increase product quality. Example of Autonomous Technologies Used for post- harvest processing System are:

Machine Vision Systems: it is used for Grading and Sorting based on color, size, shape, or defects using cameras and sensors.Quality Detection detecting mold, bruises, or other imperfections.Apple sorting machines using hyperspectral imaging is an example to identify and remove defective fruits autonomously (Tripicchio et al., 2015).

Robotic Arms: Used for handling delicate crops like fruits without damage and it can perform repetitive tasks like placing produce into packaging or onto conveyor belts (Kumar, A., & Ghosh, R. K. 2020). Example of these Autonomous robotic arms is packing strawberries and tomatoes with in packaging machine.

Internet of Things (IoT) Sensors: Monitor temperature, humidity, and gas concentration in storage to prevent spoilage.Data collected is used by AI systems to autonomously adjust storage conditions(Yamamoto, K *et al*.2018).

Artificial Intelligence (AI) and Machine Learning (ML): AI algorithms predict spoilage and optimize storage conditions.ML models analyze past data to improve packaging and shipping strategies(Kumar, A., & Ghosh, R. K. 2020).

Autonomous Guided Vehicles (AGVs) and Drones: AGVs transport products within warehouses and storage areas.Drones can monitor large warehouses or facilities for security and process monitoring(Yamamoto, K et al.2018).

2. Challenges on the application ofautonomous machines

While recognizing the advantages of AI for sustainable farming, implementing this technology does come with its fair share of significant obstacles that need to be addressed including:

Lack of familiarity with AI machines

Utilizing AI in agriculture are large portion of the global population remains unaware of its applications in farming solutions and machinery (Pal, 2020). AI firms should provide farmers with the basic instruments they need to handle the problems, and then when they have become used to them, give them more advanced ones.

Lack of experience with emerging technologies

Indeed, the adoption of AI and emerging technologies in agriculture can pose significant challenges for developing countries. Selling and introducing such technologies in regions where there is little to no existingagricultural technology can be a daunting task. In such areas, farmers may require external assistance to understand, implement, and make effective use of these advanced technologies. The lack of familiarity and expertise can act as barriers, and support from knowledgeable individuals or organizations may be necessary to facilitate successful integration (Lenniy, 2023).

Privacy and security issues

The absence of well-defined regulations and policies governing AI usage may give rise to several legal concerns. Additionally, the incorporation of software and internet-based solutions may lead to privacy and security issues, such as cyberattacks and data breaches. Moreover, there is a possibility of malicious individuals exploiting AI to monitor farmers' activities. These combined issues can pose significant challenges for farm owners and other farmers (Dara et al., 2022).

Higher cost

The fixed cost for the procurement and settlement of these AI based techniques is high and needs expert's involvement. This can pose as one of the main challenges with these technologies, which can be prohibitive for small farmers.The cost of an advanced fruit-sorting robot can exceed $100,000 (Tripicchio et al., 2015).

Shortfall of input data

For proper results of some particular activities like soil monitoring we need region specific data to feed in the system. In certain areas, the absence of data on crop growth and weather conditions can hinder the efficiency and effectiveness of AI-based solutions (Singh, 2023).

Climate and Geographic Constraints

In flood-prone, mountainous, or arid areas, autonomous ground machines may not operate reliably.Dust and temperature extremes can degrade sensors and electronic components.Sensors may give faulty readings due to condensation or poor calibration in humid environments.

3. possible future directions of autonomous technology on agriculture

In the future an autonomous AI-based technology promises as the technology continues to advance and revolutionize the industry. Here are some key areas where AI is expected to have a significant impact:

Enhanced Automation*:* AI-powered robots and autonomous machinery will become more prevalent in agriculture, performing a wide range of tasks such as planting, harvesting, weeding, and spraying. These robots will be equipped with advanced sensors, computer vision, and machine learning algorithms to navigate fields, identify crops, and make intelligent decisions in real-time.

Advanced Crop Monitoring:AI will play a vital role in improving crop monitoring techniques. Drones and satellites equipped with high- resolution imaging sensors will provide real-time data on crop health, growth rates, and yield predictions. Machine learning algorithms will analyze this data to detect diseases, nutrient deficiencies, and pest infestations with greater accuracy and speed.

Smart Irrigation and Water Management:AI algorithms will optimize irrigation schedules by considering various factors like weather conditions, soil moisture levels, and crop requirements. Smart irrigation systems will use sensor data and AI analytics to deliver the right amount of water to crops, minimizing water wastage and maximizing efficiency.

Predictive Analytics and Decision Support*:* AI will continue to advance in predictive analytics, enabling farmers to make data-driven decisions. Through the analysis of historical data, weather patterns, market trends, and other pertinent variables, AI algorithms will offer valuable insights for crop planning, yield predictions, risk assessments, and efficient resource allocation.

Genetic Improvement and Crop Breeding*:* AI can accelerate genetic improvement in crops by analyzing large-scale genomic data. Machine learning algorithms can identify genetic markers associated with desirable traits and assist in targeted breeding programs. This will help develop crops that are more resilient to climate change, pests, and diseases, ultimately enhancing crop productivity and quality.

Digital Farming Platforms*:* Digital farming platforms empowered by AI will seamlessly integrate data from diverse sources, including farm machinery, sensors, and weather stations. These platforms will offer farmers comprehensive insights and personalized recommendations to enhance their sustainable farming practices. These platforms will facilitate real-time monitoring, data sharing, and collaboration among farmers and experts. As AI technologies continue to advance and become more accessible, the future of AI in agriculture holds immense potential for increased productivity, sustainability, and resilience in the face of global food challenges. However, it is crucial to address concerns such as data privacy, ethical considerations, and equitable access to technology to ensure that the benefits of AI in agriculture are shared widely.

4. Summery and Conclusion

Throughout human history, farming has consistently incorporated technology to increase efficiency and minimize the reliance on intensive human labor. Innovations such as enhanced ploughs, advanced irrigation methods, tractors, and contemporary AI have transformed the agricultural landscape since agriculture began. AI has the capability to significantly influence the future of agriculture, but effective utilization necessitates assistance to enable farmers to adopt it successfully. The majority of challenges are present solely in the adaptation phase, hence educating farmers on managing AI-powered IoTs should be our main objective, enabling them to fully utilize AI's advantages. They may also acquire these technologies through small groups or local associations to obtain the devices. It is essential to communicate to farmers the concrete advantages of AI in tackling genuine issues, especially in minimizing manual work. By recognizing how AI can ease their challenges and enhance productivity, farmers can fully harness its potential. The future of AI in agriculture is highly encouraging, presenting beneficial results that can transform farming practices in better way.

5. Reference

Ampatzidis, Y. (2018). Applications of Artificial Intelligence for Precision Agriculture. *EDIS, 2018*(6). https://doi.org/10.32473/EDIS-AE529-2018.

Bac, C. W., van Henten, E. J., Hemming, J., &Edan, Y. (2014). Harvesting robots for high-value crops: State-of-the-art review and challenges ahead. *Journal of Field Robotics*, 31(6), 888–911. https://doi.org/10.1002/rob.21525.

Charles OluwaseunAdetunji, Daniel Ingo Hefft, Olaniyan T. Olugbemi, Chapter 17 - Agribots: A gateway to the next revolution in agriculture,Editor(s): Ajith Abraham, Sujata Dash, Joel JPC. Rodrigues, BiswaranjanAcharya, Subhendu Kumar Pani, In Intelligent Data-Centric Systems,AI, Edge and IoT-based Smart Agriculture, Academic Press. 2022;301- 311. ISBN 9780128236949.https://doi.org/10.1016/B978-0- 12-823694-9.00007-4.

Clarke, L. J. (2000). *Strategies for the development of agricultural mechanization in sub-Saharan Africa*. FAO Agricultural Services Bulletin No. 143. Food and Agriculture Organization of the United Nations.

Dara, R., Fard, S. M. H., & Kaur, J. (2022). Recommendations for ethical and responsible use of artificial intelligence in digital agriculture. *Frontiers in Artificial Intelligence*, *5*. https://doi.org/10.3389/FRAI.2022.884192.

Diamond, J. (1997). *Guns, germs, and steel: The fates of human societies*. W. W. Norton & Company.

FAO. (2022). *The state of food and agriculture 2022: Leveraging automation in agriculture for transforming agrifood systems*. Food and Agriculture Organization of the United Nations. https://www.fao.org/documents/card/en/c/cc2219en

Food and Agriculture Organization (FAO). (2008). *Agricultural mechanization in sub-Saharan Africa: Time for a new look*. FAO and United Nations Industrial Development Organization (UNIDO). Retrieved from https://www.fao.org/3/i0219e/i0219e00.htm

John Deere. (2020). *See & Spray technology by Blue River Technology*. Retrieved from https://www.deere.com/en/technology-products/see-and-spray/

Karthikeyan D, Pandian DS. Science and technology in the modern agricultural sector: An overview. International Journal of Advanced Research in Science, Communication and Technology (IJARSCT). 2021;7(2). doi:10.48175/IJARSCT-179

Khan ZH, Khalid A, Iqbal J. 2018. Towards realizing robotic potential in future intelligent food manufacturing systems. *Innovative Food Science & Emerging Technologies*. 48:11-24.

Krishna, V. (2020, April 14).*Here's how this agritech startup is using AI to help farmers improve crop yield***.** Your Story. https://yourstory.com/2020/04/startup-plantixfarmers-retail-inputs-crop-health

Kumar, A., & Ghosh, R. K. (2020). *IoT-based post-harvest management system for small farmers in India*. International Journal of Agriculture and Environmental Information Systems, 11(3), 1-15. https://doi.org/10.4018/IJAEIS.2020070101

Lenniy, D. (2023, March 7**).** *Artificial Intelligence in Agriculture: Rooting Out the Seed of Doubt*. Intellias. https://intellias.com/artificial-intelligence-in-agriculture/

Liakos, K. G., Busato, P., Moshou, D., Pearson, S., &Bochtis, D. (2018). Machine learning in agriculture: A review. *Sensors*, 18(8), 2674. https://doi.org/10.3390/s18082674

Misra, N. N., Dixit, Y., Al-Mallahi, A. et al. (2020). *IoT, big data and artificial intelligence in agriculture and food industry*. IEEE Internet of Things Journal, 8(6), 4370-4393. https://doi.org/10.1109/JIOT.2020.3008259

NSYRAG, Saba U, Muskan A, Bhattacharjee G. The Impact of Machine Learning in Agriculture: Revolutionizing Farming Practices. Journal of Big Data Analytics and Business Intelligence. 2024;1(1). Available:https://doi.org/10.46610/JoBDABI.2024.v01i01.003

Pal, C. (2020). *Artificial Intelligence in Agriculture*. LatentView Analytics. https://www.latentview.com/blog/artificial-intelligence-in-agriculture/

Rai AKMJ, Kumar N, Katiyar D, Singh O, Bhojendra, Sreekumar G, Verma P. Unlocking productivity potential: The promising role of agricultural robots in enhancing farming efficiency. International Journal of Plant and Soil Science.2023;35(18):624–633. Available:https://doi.org/10.9734/ijpss/2023 /v35i183327

Sakaue, O. Development of seeding production robot and automated transplanter system. ***Jpn. Agric. Res. Q.*** 1996, ***30***, 221–226.

Shamshiri, R. R., Kalantari, F., Ting, K. C., Thorp, K. R., Hameed, I. A., Weltzien, C., ... &Ehsani, R. (2018). Advances in greenhouse automation and controlled environment agriculture: A transition to plant factories and urban agriculture. *International Journal of Agricultural and Biological Engineering*, 11(1), 1–22. https://doi.org/10.25165/j.ijabe.20181101.3210.

Singh, S. (2023, January 16). *AI In Agriculture: Using Computer Vision To Improve Crop Yields*. AnalyticsVidhya. https://www.analyticsvidhya.com/blog/2023/01/ai-inagriculture-using computer-vision-to-improve-crop-yields/

Smith, B. D. (1998). *The emergence of agriculture*. Scientific American Library.

Sudarsan, B., Ji, W., Biswas, A., &Adamchuk, V. (2016). Microscope-based computer vision to characterize soil texture and soil organic matter. Bios-ystems Engineering, ***152***, 41–50. https://doi.org/10.1016/j.biosystemseng.2016.06.006.

Sundararajan N, Habeebsheriff HS, Dhanabalan K, Cong VH, Wong LS, Rajamani R, Dhar BK. Mitigating global challenges: Harnessing green synthesize anomaterials for sustainable crop production systems. Global Challenges (Hoboken, NJ). 2023;8(1):2300187. Available:https://doi.org/10.1002/gch2.202 300187.

Tripicchio, P., Satler, M., Dabisias, G., Ruffaldi, E., &Avizzano, C. A. (2015). *Towards smart farming and sustainable agriculture with drones*. IEEE International Conference on Intelligent Environments. https://doi.org/10.1109/IE.2015.29.

Wolfert, S., Ge, L., Verdouw, C., &Bogaardt, M. J. (2017). Big Data in Smart Farming – A review. *Agricultural Systems*, 153, 69–80. https://doi.org/10.1016/j.agsy.2017.01.023.

World Bank (2021). *Harnessing AI to increase productivity and sustainability in African agriculture*.

Yamamoto, K., Yamaguchi, Y., & Kunii, Y. (2018). *Robotic Technologies for Automating Postharvest Operations in Rice Farming*. Journal of the Robotics Society of Japan, 36(3), 181–184.

Zhang, Q., Wang, J., & Han, Y. (2021). Development of intelligent agricultural machinery and its key technologies. *Journal of Agricultural Science and Technology*, 23(4), 1–10.