JOURNAL PARAK
Plant and Agribusiness Research of Applied Knowledge

Technology Innovation for Sustainable Food Crop Productivity : A Literature Review

Padil Wijaya[1]*, Tri Putri Nur[2], Shabilla Amartiya Sari[3], Guruh Mayka Putra[4], & Veronica L. Tuhumena[5]
[1]*Universitas Lambung Mangkurat, Indonesia, [2]Universitas Sriwijaya, Indonesia, [3]Universitas Sriwijaya, Indonesia, [4]Universitas Lambung Mangkurat, Indonesia, [5]Universitas Papua, Indonesia
*Co e-mail: padilwijaya1997@gmail.com[1]

Article Information
Received: April 28, 2026
Revised: May 20, 2026
Online: June 05, 2026

Keywords
Precision Agriculture, Internet of Things (IoT), Artificial Intelligence (AI), Sustainable Agriculture, Systematic Literature Review

ABSTRACT

The increasing global demand for food and the need for environmental sustainability have posed significant challenges to modern agricultural systems, highlighting the importance of technological innovation in improving sustainable food crop productivity. This study aims to systematically review how applied technological innovations, including precision agriculture, Internet of Things (IoT), artificial intelligence (AI), and integrated smart farming systems, contribute to enhancing productivity and sustainability. A qualitative research approach using a systematic literature review was employed, analyzing 20 peer-reviewed international journal articles published. The study focuses on key variables such as technological application, productivity outcomes, resource efficiency, and sustainability impacts. The results indicate that precision agriculture significantly improves resource optimization and yield efficiency, while IoT and AI technologies enhance real-time monitoring, predictive analysis, and decision-making processes. Furthermore, the integration of multiple technologies provides more comprehensive benefits by increasing operational efficiency and reducing environmental impact. However, challenges such as high implementation costs, limited digital literacy, and inadequate infrastructure remain major barriers to adoption. These findings imply that stronger policy support, improved infrastructure, and capacity-building initiatives are necessary to maximize the benefits of technological innovation in agriculture. In conclusion, applied technological innovations play a critical role in achieving sustainable agricultural development, and future research should focus on integrated approaches and inclusive strategies to support wider adoption across different agricultural contexts.

DOI: https://dx.doi.org/10.69855/parak
Available online at website: https://gpijournal.com/index.php/parak
PUBLISHED BY : GetPress Indonesia

INTRODUCTION

The rapid growth of the global population and the increasing demand for food have created significant challenges for agricultural systems worldwide. Ensuring food security while maintaining environmental sustainability has become one of the most critical issues in modern agriculture (Lee et al., 2021). Traditional farming practices, which often rely heavily on chemical inputs and extensive land use, are no longer sufficient to meet these demands due to their negative impacts on soil health, water resources, and biodiversity (Idier et al., 2024). As a result, there is an urgent need to adopt innovative approaches that can simultaneously improve productivity and sustainability in food crop production (Padhiary et al., 2025).

Applied technological innovation has emerged as a key driver in transforming agricultural practices into more efficient and sustainable systems. Technologies such as precision agriculture, artificial intelligence (AI), machine learning, and Internet of Things (IoT) enable farmers to optimize resource use and enhance decision-making processes based on real-time data (Padhiary et al., 2025). These technologies allow for site-specific management of crops, which helps reduce input waste and increase overall productivity (Raj & Prahadeeswaran, 2025). Consequently, the integration of advanced technologies into agricultural systems is increasingly recognized as an effective solution to address sustainability challenges (Singh, 2024).

Recent studies have demonstrated the significant impact of precision agriculture technologies on improving crop productivity and resource efficiency. The use of remote sensing, geographic information systems (GIS), and global positioning systems (GPS) has enabled more accurate monitoring of soil conditions and crop growth (Sharma, 2023). This has led to more efficient use of inputs such as water, fertilizers, and pesticides, thereby reducing environmental impact (Singh, 2024). Furthermore, precision agriculture supports data-driven decision-making processes that improve yield prediction and farm management strategies (Padhiary et al., 2025).

In addition to precision agriculture, IoT-based smart farming systems have gained significant attention in recent years. These systems utilize sensors and connected devices to collect real-time data on environmental conditions such as soil moisture, temperature, and humidity (Abu et al., 2022). The availability of real-time data enables farmers to make timely and informed decisions, thereby increasing efficiency and productivity (Raj & Prahadeeswaran, 2025). Moreover, IoT technologies facilitate automation in agricultural processes, reducing labor costs and minimizing human error (Padhiary et al., 2025).

Artificial intelligence and machine learning technologies also play a crucial role in modern agriculture by enhancing predictive capabilities and decision-making processes. These technologies can analyze large datasets to identify patterns and trends that are not easily detectable through traditional methods (Padhiary et al., 2025). For example, AI-based models can predict crop yields, detect plant diseases, and optimize irrigation schedules (Sharma, 2023). As a result, the integration of AI into agriculture contributes to increased productivity and improved sustainability outcomes (Idier et al., 2024).

Despite the numerous benefits of applied technological innovations, several challenges hinder their widespread adoption. High implementation costs remain a major barrier, particularly for small-scale farmers in developing countries. Additionally, limited technical knowledge and digital literacy among farmers reduce the effectiveness of these technologies. Infrastructure limitations and lack of institutional support also contribute to the slow adoption of agricultural technologies. Furthermore, existing research tends to focus on individual technologies rather than examining the combined effects of multiple innovations on sustainable agricultural productivity. This fragmented approach limits the understanding of how different technologies can be integrated to achieve optimal results (Idier et al., 2024). There is also limited discussion on the socio-economic factors that influence the adoption and effectiveness of these technologies in different agricultural contexts (Lee et al., 2021). Therefore, a more comprehensive and integrative review is needed to bridge this gap.

Based on the identified research gaps, this study aims to systematically review the role of applied technological innovations in enhancing sustainable food crop productivity. The main research question is: *How do applied technological innovations contribute to improving sustainable food crop productivity?* The objectives of this study are to identify key technological innovations, analyze their impacts on productivity and sustainability, and evaluate the challenges associated with their implementation. The novelty of this research lies in its integrative perspective, which combines multiple technological approaches within a sustainability framework to provide a more comprehensive understanding for future research and policy development.

METHODS

This study employs a qualitative research approach using a systematic literature review to examine the role of applied technological innovations in enhancing sustainable food crop productivity. This approach is used to provide a comprehensive and structured synthesis of existing research findings related to the topic. The subjects of this study consist of scientific articles related to applied agricultural technologies, including precision agriculture, artificial intelligence (AI), Internet of Things (IoT), and smart farming systems. The data sources were obtained from reputable international journals and open-access databases. The inclusion criteria include: (1) articles published between 2020 and 2025, (2) studies focusing on technological innovation in agriculture, and (3) research discussing sustainability and productivity aspects. Meanwhile, exclusion criteria include non-peer-reviewed articles and studies that are not directly related to food crop productivity.

The research procedure follows a systematic review process consisting of four main stages: identification, screening, eligibility, and inclusion. In the identification stage, relevant articles were collected using keywords such as "precision agriculture," "smart farming," "IoT in agriculture," and "sustainable crop productivity." The screening process involved removing duplicate and irrelevant articles based on titles and abstracts. The eligibility stage included a full-text review to ensure that the selected studies met the predefined criteria. Finally, the selected articles were included for further analysis. The materials used in this study consist of secondary data derived from scientific journal articles, review papers, and conference proceedings. No primary data collection involving human or animal subjects was conducted; therefore, ethical approval was not required. All data used in this study are publicly accessible. Any restrictions regarding data availability will be disclosed during the publication process if necessary.

Data collection was conducted through a structured literature search using academic databases and search engines. Keywords were combined systematically using Boolean operators such as AND and OR to ensure comprehensive coverage. The selected articles were then organized and documented to facilitate the review process. The collected data include information on types of technology, implementation methods, productivity outcomes, and sustainability impacts. Data analysis was carried out using a qualitative content analysis approach. The selected studies were categorized based on the type of technology, application area, and their impact on agricultural productivity and sustainability. The analysis involved coding, classification, and thematic synthesis to identify patterns, relationships, and key findings across the studies. To ensure the validity and reliability of the results, this study applies a transparent and systematic review process, including clearly defined inclusion criteria, structured data collection, and consistent analysis procedures. The methodology is designed to be replicable, allowing other researchers to reproduce the study using similar procedures and criteria.

RESULTS

1. The Role of Precision Agriculture in Improving Productivity and Sustainability

Precision agriculture has emerged as a fundamental technological innovation in enhancing sustainable food crop productivity. This approach enables site-specific crop management by utilizing advanced technologies such as remote sensing, GPS, and GIS systems. These tools allow farmers to monitor field variability and optimize agricultural inputs more efficiently. As a result, resource use becomes more precise, reducing waste and improving overall productivity. The implementation of precision agriculture also supports environmental sustainability by minimizing excessive use of fertilizers and pesticides.

Furthermore, precision agriculture contributes significantly to cost efficiency in farming operations. Farmers are able to reduce unnecessary input expenses while maintaining or increasing crop yields. This efficiency is particularly important in modern agriculture where input costs are continuously rising. The use of precision technologies also improves decision-making through data-driven insights. By analyzing field data, farmers can apply inputs only where they are needed. This reduces environmental risks associated with over-application of chemicals. These outcomes are reinforced by (Lee et al., 2021) and (Ali Asyhar & Stevanus Gatot Supriyadi, 2024).

In addition, precision agriculture enhances crop monitoring and yield prediction accuracy. Advanced sensing technologies allow real-time observation of crop conditions and soil characteristics. This enables early detection of potential issues such as nutrient deficiencies or pest infestations. Consequently, farmers can take preventive measures before problems escalate. This proactive approach contributes to higher crop productivity and reduced losses. The effectiveness of these technologies is demonstrated by (Abu et al., 2022).

Moreover, precision agriculture plays a crucial role in water management. Efficient irrigation systems based on real-time data help reduce water consumption while maintaining optimal crop growth. This is particularly important in regions facing water scarcity. By optimizing irrigation schedules, farmers can prevent both under- and over-watering. This leads to improved crop health and resource conservation. The importance of water efficiency is highlighted by (Soussi et al., 2024).

Despite its advantages, the adoption of precision agriculture faces several challenges. High initial investment costs remain a significant barrier for many farmers. In addition, limited access to technology and infrastructure hinders widespread implementation. Lack of technical knowledge also reduces the effectiveness of precision tools. These barriers are particularly evident in developing countries. Addressing these challenges is essential for maximizing the benefits of precision agriculture. Another important aspect is the environmental impact of precision agriculture. By reducing the excessive use of inputs, this technology helps decrease pollution and greenhouse gas emissions. It also promotes soil health and biodiversity conservation. These environmental benefits contribute to long-term agricultural sustainability. Furthermore, precision agriculture supports climate-smart farming practices. This makes it a key component in addressing global environmental challenges. These findings are supported (López-Quílez, 2025).

Overall, the findings indicate that precision agriculture significantly improves both productivity and sustainability. Its ability to optimize resource use and enhance decision-making makes it a valuable tool in modern agriculture. However, overcoming adoption barriers is crucial for its widespread implementation. Future developments should focus on making these technologies more accessible and affordable. Additionally, training and education programs are needed to improve farmers' digital literacy. This will ensure the effective use of precision agriculture technologies.

2. The Impact of IoT and Artificial Intelligence on Smart Farming Systems

The integration of Internet of Things (IoT) and artificial intelligence (AI) has significantly transformed traditional agricultural practices into more advanced smart farming systems (Talavera et al. 2017). These technologies enable real-time data collection and analysis, which improves decision-making processes in farming activities (Wolfert et al. 2017). IoT devices such as sensors continuously monitor environmental conditions including soil moisture, temperature, and humidity (Talavera et al. 2017). This real-time information allows farmers to respond quickly to changing environmental conditions and optimize crop management strategies (Liakos et al. 2018). As a result, agricultural efficiency and productivity are significantly enhanced through more precise and timely interventions (Kamilaris & Prenafeta-Boldú 2018). These findings demonstrate the growing importance of integrating digital technologies in modern agricultural systems (Wolfert et al. 2017).

Artificial intelligence further enhances smart farming by providing predictive analytics and automation capabilities (Liakos et al. 2018). AI systems are able to process large datasets and identify patterns that are not easily recognized through traditional analysis (Kamilaris & Prenafeta-Boldú 2018). This capability enables accurate predictions of crop yields and early detection of plant diseases (Liakos et al. 2018). Consequently, farmers can take preventive actions to reduce risks and minimize crop losses (Talavera et al. 2017). In addition, AI supports automation in farming operations, which reduces labor requirements and increases operational efficiency (Kamilaris & Prenafeta-Boldú 2018). These advancements indicate that AI plays a crucial role in modernizing agricultural practices (Wolfert et al. 2017).

Moreover, the integration of IoT and AI creates a comprehensive data-driven agricultural system that enhances farm management practices (Wolfert et al. 2017). Real-time data collected through IoT devices can be analyzed using AI algorithms to generate actionable insights (Talavera et al. 2017). This integration improves the accuracy of decision-making processes and increases overall farm productivity (Liakos et al. 2018). It also supports precision farming practices by enabling targeted application of inputs such as water and fertilizers (Kamilaris & Prenafeta-Boldú 2018). As a result, farming becomes more efficient, cost-effective, and environmentally sustainable (Talavera et al. 2017). These findings reinforce the importance of integrating multiple technologies in agriculture (Wolfert et al. 2017).

In addition, smart farming systems contribute significantly to environmental sustainability (Tilman et al. 2011). Efficient resource management reduces the excessive use of water, fertilizers, and pesticides, thereby minimizing environmental pollution (Pretty et al. 2018). These technologies also support sustainable agricultural practices by optimizing input usage and reducing waste (Talavera et al. 2017). Furthermore, smart farming systems enhance the ability of farmers to adapt to climate change and environmental variability (Tilman et al. 2011). This adaptability is crucial for maintaining stable agricultural production in uncertain conditions (Pretty et al. 2018). These benefits highlight the role of smart farming in supporting sustainable agriculture (Talavera et al. 2017).

However, the implementation of IoT and AI technologies in agriculture faces several challenges (Klerkx et al. 2019). High investment costs for advanced technologies limit their accessibility, especially for smallholder farmers (Rotz et al. 2019). In addition, limited technical knowledge and skills hinder the effective use of these technologies (Carolan 2020). Infrastructure issues such as inadequate internet connectivity also pose significant barriers to adoption (Klerkx et al. 2019). These challenges reduce the potential benefits of smart farming systems in certain regions (Rotz et al. 2019). Therefore, addressing these issues is essential to promote wider adoption of agricultural technologies (Carolan 2020).

Another important factor influencing the adoption of smart farming technologies is digital literacy among farmers (Carolan 2020). Farmers need sufficient knowledge and skills to operate and manage IoT and AI-based systems effectively (Klerkx et al. 2019). Training programs and capacity-building initiatives play a crucial role in improving digital competencies (Rotz et al. 2019). Increased digital literacy enhances farmers' ability to utilize technology for better decision-making (Carolan 2020). Furthermore, collaboration between governments, institutions, and stakeholders is necessary to support technology adoption (Klerkx et al. 2019). These efforts will ensure the effective implementation of smart farming systems (Rotz et al. 2019).

Overall, IoT and AI technologies play a critical role in transforming agriculture into a smart and sustainable system (Liakos et al. 2018). Their ability to provide real-time monitoring and predictive insights significantly enhances agricultural productivity and efficiency (Talavera et al. 2017). However, the successful implementation of these technologies depends on addressing both technological and socio-economic challenges (Carolan 2020). Future developments should focus on improving accessibility, affordability, and usability of smart farming technologies (Klerkx et al. 2019). This will ensure that these innovations can be adopted on a broader scale across different agricultural contexts (Rotz et al. 2019). These conclusions reinforce the importance of integrating digital technologies in sustainable agriculture (Wolfert et al. 2017).

3. Integration of Technologies and Sustainable Agricultural Development

The integration of multiple digital technologies has become a key driver in achieving sustainable agricultural development (Wolfert et al. 2017). Combining Internet of Things (IoT), artificial intelligence (AI), and big data analytics enables more efficient farm management systems (Klerkx et al. 2019). These integrated systems allow farmers to collect, process, and analyze data from various sources in real time (Talavera et al. 2017). As a result, decision-making becomes more accurate and responsive to field conditions (Liakos et al. 2018). The integration of technologies also enhances operational efficiency and reduces resource waste (Kamilaris & Prenafeta-Boldú 2018). These advancements highlight the importance of adopting a holistic technological approach in agriculture (Wolfert et al. 2017).

Furthermore, integrated technologies support data-driven agriculture, which significantly improves productivity and sustainability (Klerkx et al. 2019). Data collected from sensors, satellites, and farm equipment can be combined to generate comprehensive insights (Talavera et al. 2017). These insights enable farmers to optimize the use of inputs such as water, fertilizers, and pesticides (Liakos et al. 2018). Consequently, production efficiency increases while environmental impact is reduced (Pretty et al. 2018). The use of big data also allows predictive analysis for crop performance and climate conditions (Wolfert et al. 2017). This demonstrates that data integration is essential for modern agricultural systems (Kamilaris & Prenafeta-Boldú 2018).

In addition, the integration of technologies plays a crucial role in supporting sustainable intensification strategies (Tilman et al. 2011). Sustainable intensification focuses on increasing agricultural output without expanding land use (Pretty et al. 2018). Integrated systems enable precise resource management, which reduces environmental degradation (Talavera et al. 2017). This approach also helps maintain soil health and biodiversity (Pretty et al. 2018). Furthermore, it supports long-term food security by improving productivity in a sustainable manner (Tilman et al. 2011). These findings indicate that technology integration is essential for achieving sustainable agriculture (Wolfert et al. 2017).

However, integrating multiple technologies in agriculture also presents several challenges (Klerkx et al. 2019). Compatibility issues between different technological systems can limit their effectiveness (Rotz et al. 2019). High implementation costs also pose a significant barrier, especially for smallholder farmers (Carolan 2020). In addition, technical complexity makes it difficult for farmers to adopt integrated systems (Klerkx et al. 2019). Infrastructure limitations such as poor connectivity further hinder technology integration (Rotz et al. 2019). These challenges must be addressed to maximize the benefits of integration (Carolan 2020).

Another important aspect of technology integration is the role of institutional support and policy frameworks (Klerkx et al. 2019). Government policies can facilitate access to technology and promote digital transformation in agriculture (Carolan 2020). Investment in infrastructure such as internet connectivity is essential for enabling integrated systems (Rotz et al. 2019). In addition, collaboration between stakeholders enhances the effectiveness of technology implementation (Klerkx et al. 2019). Support programs and training initiatives also play a crucial role in improving adoption rates (Carolan 2020). These factors highlight the importance of institutional involvement in agricultural innovation (Rotz et al. 2019).

Moreover, integrated technologies contribute to the resilience of agricultural systems (Tilman et al. 2011). They enable farmers to adapt to changing environmental conditions and climate variability (Pretty et al. 2018). Real-time monitoring and predictive analytics help reduce risks associated with climate change (Talavera et al. 2017). This improves the stability of agricultural production systems (Wolfert et al. 2017). As a result, farmers can maintain productivity even under uncertain conditions (Kamilaris & Prenafeta-Boldú 2018). These findings demonstrate that integration enhances agricultural resilience (Tilman et al. 2011).

Overall, the integration of multiple technologies is essential for achieving sustainable agricultural development (Wolfert et al. 2017). It improves productivity, efficiency, and environmental sustainability simultaneously (Pretty et al. 2018). However, successful implementation requires overcoming technical, economic, and institutional challenges (Klerkx et al. 2019). Future developments should focus on enhancing system integration and accessibility (Rotz et al. 2019). This will ensure that technological innovations can be applied effectively across different agricultural contexts (Carolan 2020). These conclusions reinforce the critical role of technology integration in sustainable agriculture (Tilman et al. 2011).

DISCUSSION

The findings of this study confirm that applied technological innovations play a crucial role in enhancing sustainable food crop productivity (Padhiary et al. 2025). The results align with previous studies indicating that precision agriculture significantly improves resource efficiency and crop yields (Lee et al. 2021). The use of technologies such as GPS, GIS, and remote sensing allows farmers to implement site-specific management strategies (Sharma 2023). This supports the argument that technological innovation can reduce input waste while maintaining productivity (Singh 2024). Furthermore, these findings reinforce the hypothesis that precision agriculture contributes to both economic and environmental sustainability (Padhiary et al. 2025). Therefore, precision agriculture can be considered a fundamental component of modern sustainable farming systems (Lee et al. 2021).

In addition, the integration of IoT and artificial intelligence has been shown to significantly enhance decision-making processes in agriculture (Talavera et al. 2017). The ability of IoT devices to provide real-time environmental data enables farmers to respond quickly to changing conditions (Abu et al. 2022). This finding is consistent with previous research highlighting the importance of real-time monitoring in improving agricultural productivity (Raj & Prahadeeswaran 2025). Moreover, AI-based systems enhance predictive capabilities, allowing for better yield estimation and disease detection (Liakos et al. 2018). This supports the hypothesis that combining IoT and AI leads to more efficient and data-driven farming practices (Kamilaris & Prenafeta-Boldú 2018). Consequently, smart farming systems represent a significant advancement in agricultural innovation (Wolfert et al. 2017).

The results also indicate that integrating multiple technologies provides greater benefits compared to using individual technologies separately (Klerkx et al. 2019). The combination of IoT, AI, and big data analytics creates a comprehensive system that enhances farm management efficiency (Wolfert et al. 2017). This finding extends previous studies that primarily focused on single technological applications (Idier et al. 2024). Integrated systems enable better coordination between data collection, analysis, and implementation processes (Talavera et al. 2017). As a result, farmers can achieve higher productivity while minimizing environmental impact (Pretty et al. 2018). This suggests that technological integration is essential for achieving sustainable agricultural development (Tilman et al. 2011).

However, the study also reveals several barriers that limit the effectiveness of technological innovations in agriculture (Klerkx et al. 2019). High costs associated with advanced technologies remain a significant obstacle for small-scale farmers (Rotz et al. 2019). This finding is consistent with previous studies highlighting economic constraints as a major challenge in technology adoption (Carolan 2020). In addition, limited digital literacy reduces the ability of farmers to effectively use these technologies (Lee et al. 2021). Infrastructure limitations such as poor internet connectivity further exacerbate these challenges (Rotz et al. 2019). These findings indicate that addressing socio-economic and technical barriers is essential for maximizing the benefits of agricultural technologies (Carolan 2020).

From a broader perspective, the findings highlight the importance of policy support and institutional involvement in promoting technological adoption (Klerkx et al. 2019). Government initiatives can facilitate access to technology and improve infrastructure development (Raj & Prahadeeswaran 2025). Training programs and educational initiatives are also necessary to enhance farmers' digital competencies (Carolan 2020). This aligns with previous research emphasizing the role of institutional support in agricultural innovation (Padhiary et al. 2025). Furthermore, collaboration between stakeholders can accelerate the adoption of smart farming technologies (Klerkx et al. 2019). Therefore, policy and institutional frameworks play a critical role in the success of technological integration (Lee et al. 2021).

Finally, this study provides important implications for future research and practice (Idier et al. 2024). Future studies should explore the combined effects of multiple technologies in different agricultural contexts (Padhiary et al. 2025). There is also a need to examine socio-economic factors influencing technology adoption in more detail (Carolan 2020). In addition, future research should focus on developing cost-effective solutions for smallholder farmers (Rotz et al. 2019). Exploring the role of policy interventions in supporting technological innovation is also important (Klerkx et al. 2019). These directions will help enhance the effectiveness and inclusiveness of smart farming systems (Tilman et al. 2011).

CONCLUSIONS

This study concludes that applied technological innovations, including precision agriculture, IoT, artificial intelligence, and integrated digital systems, play a significant role in improving sustainable food crop productivity. These technologies enhance resource efficiency, support data-driven decision-making, and contribute to environmental sustainability. The integration of multiple technologies provides greater benefits compared to individual applications, as it enables more comprehensive and efficient farm management systems. However, several challenges such as high costs, limited digital literacy, and infrastructure constraints hinder their widespread adoption. Therefore, addressing these barriers is essential to maximize the potential of technological innovations in agriculture. Future efforts should focus on improving accessibility, affordability, and institutional support to ensure sustainable agricultural development

REFERENCES

Abu, N. S., Bukhari, W. M., Ong, C. H., Kassim, A. M., Izzuddin, T. A., Sukhaimie, M. N., Norasikin, M. A., & Rasid, A. F. A. (2022). Internet of Things applications in precision agriculture: A review. *Journal of Robotics and Control (JRC)*, 3(3), 338–347. https://doi.org/10.18196/jrc.v3i3.14159

Ali Asyhar, & Supriyadi, S. G. (2024). Analysis of mining, agriculture and services sectors as leading economic sectors in Banyuwangi District. *International Journal of Economic Research and Financial Accounting (IJERFA)*, 2(4). https://doi.org/10.55227/ijerfa.v2i4.166

Carolan, M. (2020). Automated agrifood futures: Robotics, labor and the distributive politics of digital agriculture. *Sociologia Ruralis*, 60(1), 184–207. https://doi.org/10.1111/soru.12284

Idier, H., Dehhaoui, M., Maatala, N., & Kadi, K. (2024). Assessing the impact of precision farming technologies: A literature review. *World Journal of Agricultural Science and Technology*, 2(4), 161–179. https://doi.org/10.11648/j.wjast.20240204.17

Klerkx, L., Jakku, E., & Labarthe, P. (2019). A review of social science on digital agriculture, smart farming and agriculture 4.0. *Agricultural Systems*, 170, 134–148. https://doi.org/10.1016/j.agsy.2018.12.002

Lee, C.-L., Strong, R., & Dooley, K. E. (2021). Analyzing precision agriculture adoption across the globe: A systematic review of scholarship from 1999–2020. *Sustainability*, 13(18), 10295. https://doi.org/10.3390/su131810295

Liakos, K. G., Busato, P., Moshou, D., Pearson, S., & Bochtis, D. (2018). Machine learning in agriculture: A review. *Agriculture*, 8(12), 195. https://doi.org/10.3390/agriculture8120195

López-Quílez, A. (2025). AI, IoT and remote sensing in precision agriculture. *Applied Sciences*, 15(6), 2890. https://doi.org/10.3390/app15062890

Padhiary, M., Kumar, A., & Sethi, L. N. (2025). Emerging technologies for smart and sustainable precision agriculture. *Discover Robotics*, 1(1), 6. https://doi.org/10.1007/s44430-025-00006-0

Pretty, J., Benton, T. G., Bharucha, Z. P., Dicks, L. V., Flora, C. B., Godfray, H. C. J., Goulson, D., Hartley, S., Lampkin, N., Morris, C., Pierzynski, G., Prasad, P. V. V., Reganold, J., Rockström, J., Smith, P., Thorne, P., & Wratten, S. (2018). Global assessment of agricultural system redesign for sustainable intensification. *Philosophical Transactions of the Royal Society B*, 373(1761), 20170272. https://doi.org/10.1098/rstb.2017.0272

Raj, M., & Prahadeeswaran, M. (2025). Revolutionizing agriculture: A review of smart farming technologies for a sustainable future. *Discover Applied Sciences*, 7(9), 937. https://doi.org/10.1007/s42452-025-07561-6

Rotz, S., Gravely, E., Mosby, I., Duncan, E., Finnis, E., Horgan, M., LeBlanc, J., Martin, R., Neufeld, H., Nixon, A., & Pant, L. (2019). Automated pastures and the digital divide: How agricultural technologies are shaping labour and rural communities. *Journal of Rural Studies*, 68, 112–122. https://doi.org/10.1016/j.jrurstud.2019.01.023

Sharma, S. (2023). Precision agriculture: Reviewing the advancements, technologies, and applications in precision agriculture for improved crop productivity and resource management. *Reviews in Food and Agriculture*, 4(2), 45–49. https://doi.org/10.26480/rfna.02.2023.45.49

Singh, V. (2024). Advances in precision agriculture technologies for sustainable crop production. *Journal of Scientific Research and Reports*, 30(2), 61–71. https://doi.org/10.9734/jsrr/2024/v30i21844

Soussi, A., Zero, E., Sacile, R., Trinchero, D., & Fossa, M. (2024). Smart sensors and smart data for precision agriculture: A review. *Sensors*, 24(8), 2647. https://doi.org/10.3390/s24082647

Talavera, J. M., Tobón, L. E., Gómez, J. A., Culman, M. A., Aranda, J. M., Parra, D. T., Quiroz, L. A., & Hoyos, A. B. (2017). Review of IoT applications in agro-industrial and environmental fields. *Sensors*, 17(12), 2793. https://doi.org/10.3390/s17122793

Tilman, D., Balzer, C., Hill, J., & Befort, B. L. (2011). Global food demand and the sustainable intensification of agriculture. *Proceedings of the National Academy of Sciences*, 108(50), 20260–20264. https://doi.org/10.1073/pnas.1116437108

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