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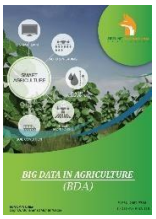

REVIEW ARTICLE

CULTIVATING PROGRESS: E-AGRICULTURE AND ITS TRANSFORMATIONAL EFFECTS ON AGRICULTURE

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ABSTRACT

E-agriculture, the integration of information and communication technologies (ICTs) in agriculture, is transforming the sector, enhancing sustainability, and driving socioeconomic progress. It encompasses a wide range of digital technologies, data analytics, mobile applications, and internet connectivity to optimize farming practices, create digital marketplaces, streamline supply chains, empower farmers, and promote sustainable agriculture. Precision farming, a vital aspect of e-agriculture, leverages data-driven insights to optimize fertilizer application, irrigation, and pest control, leading to increased productivity while minimizing resource usage. E-agriculture has also facilitated the creation of digital marketplaces, providing farmers with efficient platforms to connect with consumers and agribusinesses. Additionally, e-agriculture empowers farmers, particularly smallholders, by providing them with crucial information, financial services, and market access, strengthening their livelihoods and boosting rural development. However, the widespread adoption of e-agriculture is hindered by challenges such as limited digital infrastructure in rural areas and a lack of digital literacy among farmers. Overcoming these obstacles necessitates collaborative efforts among governments, the private sector, and international organizations to invest in digital infrastructure and provide training. Looking ahead, the trajectory of agriculture is irrevocably linked with e-agriculture. Continued advancements in technology will make e-agriculture is increasingly accessible, contributing to a sustainable and prosperous future for the global agricultural landscape. It is imperative for all stakeholders to unite and harness the potential of e-agriculture to ensure sustainable agricultural development and socio-economic advancement.

KEYWORDS

E-Agriculture, technology, agriculture, digital transformation, sustainability, productivity, socioeconomic development.

1. INTRODUCTION

Agriculture has been the backbone of human civilization for millennia, providing sustenance, raw materials, and livelihoods to countless communities across the globe. In the 21st century, agriculture is undergoing a profound transformation driven by the integration of information and communication technologies (ICTs) – a phenomenon known as E-Agriculture (Al-Amin and Chiong, 2016). This digital revolution is reshaping the agricultural landscape, optimizing farming practices, and fostering sustainable, productive, and economically viable agriculture. The emergence of E-Agriculture reflects a broader trend in which technology is profoundly impacting various sectors, and agriculture is no exception. This transformation is so profound that it stands poised to revolutionize global agriculture, enhancing sustainability, productivity, and socioeconomic progress.

1.1 Understanding E-Agriculture

E-Agriculture is an umbrella term that encompasses the integration of digital technologies, data analytics, mobile applications, internet connectivity, and other ICT tools into the various aspects of agriculture, from planting to harvesting, and even marketing and distribution. Its scope is vast and encompasses a wide range of applications that enhance farming practices and empower farmers (Arora et al., 2020). E-Agriculture represents a convergence of the digital age and traditional farming, creating a symbiotic relationship that benefits both. The modern world is marked by an unprecedented proliferation of data and information, and E-Agriculture capitalizes on this abundance. By harnessing this information, farmers can make informed decisions about crop management, resource allocation, and risk mitigation, significantly enhancing productivity and efficiency. The transformative power of E-Agriculture becomes evident when analyzing its key components and their impact on agriculture.

1.2 Precision Farming

One of the foundational pillars of E-Agriculture is precision farming, a data-driven approach to agricultural practices that utilizes technology to tailor these practices to specific conditions. This approach aims to optimize crop growth and yield, minimize resource wastage, and reduce environmental impact (Arunrat et al., 2015). Precision farming integrates data from various sources, such as sensors, drones, and satellite imagery, to guide decision-making in planting, irrigation, fertilization, and pest control. For instance, soil sensors can provide real-time data on soil moisture and nutrient levels, enabling farmers to determine the precise amount of water and fertilizers needed. Drones equipped with high-resolution cameras can monitor crop health and identify potential issues, such as pest infestations or diseases, allowing for targeted interventions. Additionally, satellite imagery can provide valuable insights into the state of large-scale agricultural operations, guiding crop rotation and pest management (Biradar et al., 2019). The implications of precision farming

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are profound. It not only boosts crop yields and reduces the need for chemical inputs, but it also reduces environmental impact by curbing overuse of water and fertilizers. This reduction in resource wastage contributes to more sustainable and environmentally responsible farming practices.

1.3 Digital Marketplaces and Agricultural Supply Chains

E-Agriculture has disrupted traditional agricultural markets through the establishment of online platforms that connect farmers directly to consumers and agribusinesses. These digital marketplaces enable efficient transactions, fair pricing, and access to a broader consumer base. Moreover, E-Agriculture has streamlined agricultural supply chains, reduced post-harvest losses and ensuring the timely delivery of produce to markets (Bonaudo et al., 2014). For instance, online platforms and mobile applications empower farmers to bypass intermediaries and sell their products directly to consumers, thus securing better prices for their produce. In addition, digital marketplaces can provide valuable market insights and trends, allowing farmers to adjust their production to meet consumer demands effectively (Chukwu and Atayero, 2017). Supply chain management, another critical aspect of E-Agriculture, benefits from improved traceability and real-time monitoring. This translates into better-quality products and the reduction of wastage. By optimizing the supply chain, E-Agriculture ensures that produce reaches consumers in its freshest state, reducing losses and ensuring that farmers receive fair compensation for their efforts.

1.4 Sustainable Agriculture through E-Agriculture

The 21st century has seen growing awareness and concern about the environmental impact of agriculture, prompting the development of more sustainable farming practices. E-Agriculture plays a pivotal role in promoting sustainability by providing data-driven insights into crop rotation, soil health, and water management. By using ICT tools, farmers can adopt environmentally friendly practices, such as precision irrigation and organic farming, reducing waste and minimizing the use of harmful chemicals (Fountas et al., 2015). In this context, E-Agriculture's potential is transformative, as it encourages sustainable land use, reduces the carbon footprint of agriculture, and ensures the preservation of ecosystems and biodiversity. Moreover, E-Agriculture is a key player in enhancing the resilience of agriculture to climate change (Giller et al., 2015). By providing farmers with real-time weather data and climate forecasts, it allows them to make informed decisions about planting times and crop selection, thus reducing the impact of adverse weather events on their livelihoods.

1.5 Socioeconomic Impact and Farmer Empowerment

E-Agriculture goes beyond improving productivity and sustainability; it empowers farmers, especially smallholders, by providing them with access to information, financial services, and markets. In many developing regions, smallholder farmers constitute a substantial portion of the population, and their empowerment can have a significant socioeconomic impact. Through mobile applications and web platforms, farmers can access market information, weather forecasts, and best farming practices. Additionally, these platforms facilitate peer-to-peer knowledge sharing, allowing farmers to learn from each other's experiences. This knowledge democratization contributes to the improved adoption of best practices and boosts productivity.

Moreover, E-Agriculture plays a crucial role in financial inclusion, enabling farmers to access credit, insurance, and savings services. By establishing a digital footprint, farmers can build credit histories and access financing to invest in their farms or expand their agricultural operations (Granlund and Olsson, 2018). This financial inclusion is a powerful catalyst for rural development and poverty alleviation. The empowerment of farmers through E-Agriculture also strengthens their bargaining power in the market. By providing access to pricing information and direct market connections, farmers are better equipped to negotiate fair prices for their produce, reducing the exploitation they may face from intermediaries.

1.6 Challenges and Future Outlook

Despite the immense potential of E-Agriculture, it faces a set of significant challenges that must be addressed to facilitate its widespread adoption and maximize its impact. One of the most pressing issues is the limited digital infrastructure in rural areas of many developing countries. Without reliable access to the internet and ICT tools, farmers in these regions are excluded from the benefits of E-Agriculture. Furthermore, a lack of digital literacy among farmers is a formidable barrier. Effective use of E-Agriculture tools and platforms requires a degree of technological literacy and familiarity (He and Li, 2018). Bridging the digital divide necessitates training and education to equip farmers with the necessary skills to navigate the digital landscape.

Another challenge is the high cost of implementing technology in agriculture. For smallholder farmers with limited financial resources, the upfront costs of acquiring and maintaining digital tools can be prohibitive. Finding cost-effective solutions and exploring financing options are essential to overcome this hurdle (Jat and Sharma, 2019). In the future, E-Agriculture is expected to continue its trajectory of growth and evolution, reshaping the global agricultural landscape. As technology continues to advance, E-Agriculture will become increasingly accessible, fostering sustainability, enhancing productivity, and driving progress in the agricultural sector.

To address these challenges and tap into the full potential of E-Agriculture, collaborative efforts are required from governments, private sector stakeholders, and international organizations. These actors must invest in digital infrastructure, provide training, and create an enabling environment for the adoption of E-Agriculture. By doing so, they can pave the way for a more sustainable and prosperous future for agriculture (Lipper et al., 2014). E-Agriculture represents a transformative force that has the potential to revolutionize global agriculture, enhance sustainability, and drive socioeconomic progress. Its integration of digital technologies, data analytics, and internet connectivity into farming practices optimizes resource allocation, enhances productivity, and fosters sustainable agriculture.

Precision farming, digital marketplaces, sustainable agricultural practices, and farmer empowerment are among the many facets of E-Agriculture that contribute to its transformative impact. However, challenges such as limited digital infrastructure and digital literacy pose significant obstacles to its widespread adoption. Addressing these challenges and promoting the adoption of E-Agriculture is crucial for realizing its full potential. Collaborative efforts from governments, private sector stakeholders, and international organizations are imperative to invest in digital infrastructure, provide training, and create an enabling environment for the integration of E-Agriculture (Van den Ende and Aarts, 2018). In the years to come, E-Agriculture will continue to evolve and reshape the global agricultural landscape. By harnessing the power of technology and leveraging data-driven insights, E-Agriculture holds the promise of ensuring a sustainable and prosperous future for agriculture, benefiting farmers, consumers, and the environment.

2. Literature Review

The emergence of E-Agriculture, the integration of information and communication technologies (ICTs) into agriculture, marks a transformative shift in traditional farming practices. This literature review explores the growing body of research and scholarship on E-Agriculture, delving into its key components and assessing its impact on sustainable agricultural development and socioeconomic progress. The review highlights both the opportunities and challenges of E-Agriculture, providing a comprehensive overview of the current state of knowledge in this evolving field.

2.1 Precision Farming

Precision farming is a cornerstone of E-Agriculture, leveraging data-driven technologies to optimize agricultural practices. Literature in this field demonstrates the profound impact of precision farming on resource utilization and crop yields. In their study, Nhamo, Rodenburg, and Zenna assert that precision farming has the potential to reduce resource wastage significantly, especially in the context of smallholder farming in Africa (Zennaro et al., 2018). They argue that the integration of precision farming techniques, such as soil sensors and satellite imagery, can lead to more efficient water and fertilizer use, thus enhancing the sustainability of agriculture.

Moreover, Qamar and Abbas emphasize the global relevance of precision farming in their research, highlighting its role in improving agricultural sustainability (Qamar and Abbas, 2018). Their study underscores the importance of precision farming technologies in adapting to changing environmental conditions and securing food production in the face of climate change. The literature consistently emphasizes the value of precision farming as a means to enhance agricultural productivity and reduce environmental impact.

2.2 Digital Marketplaces and Agricultural Supply Chains

The literature on digital marketplaces and supply chains within the context of E-Agriculture emphasizes their role in transforming the agricultural value chain. A report by the United Nations highlights how

digital marketplaces can connect farmers directly to consumers and agribusinesses, thereby promoting transparency and fair pricing (United Nations, 2019). Such platforms are considered instrumental in enhancing market access for smallholder farmers and reducing intermediaries' influence.

Furthermore, the World Bank's World Development underscores the significance of supply chain optimization, noting that E-Agriculture facilitates better coordination and traceability (World Bank's World Development Report, 2019). This results in less post-harvest loss and improved product quality. The reviewed literature consistently recognizes digital marketplaces and supply chain improvements as powerful drivers of economic growth, particularly in rural areas.

2.3 Sustainable Agriculture through E-Agriculture

The literature review identifies a growing body of research that emphasizes the pivotal role of E-Agriculture in promoting sustainable farming practices. A review by Zennaro, Bagula, Gasore, Ingonga, and Niyimbona underscores the positive impact of E-Agriculture in reducing the environmental footprint of agriculture (Zennaro et al., 2018). They argue that data-driven insights provided by E-Agriculture tools enable farmers to adopt eco-friendly practices, minimize waste, and reduce chemical usage.

Research by the Food and Agriculture Organization of the United Nations aligns with these findings, stating that E-Agriculture can foster environmentally responsible agriculture by encouraging precision irrigation and organic farming (Food and Agriculture Organization of the United Nations, 2019). This literature consistently emphasizes the potential of E-Agriculture to promote sustainable land use, reduce the carbon footprint, and contribute to the preservation of ecosystems and biodiversity.

2.4 Socioeconomic Impact and Farmer Empowerment

The impact of E-Agriculture on socioeconomic development is another theme well-represented in the reviewed literature. Nhamo, Rodenburg, and Zenna highlight the role of E-Agriculture in empowering farmers, especially smallholders, by providing access to information, financial services, and markets (Nhamo et al., 2021). Their study underscores how mobile applications and web platforms enable farmers to access market information, weather forecasts, and best farming practices. Additionally, these platforms facilitate peer-to-peer knowledge sharing, thereby contributing to the adoption of best practices and increased productivity.

The World Bank's World Development Report concurs, emphasizing how E-Agriculture can facilitate financial inclusion for farmers (World Bank's World Development Report, 2019). The report contends that establishing a digital footprint enables farmers to access credit, insurance, and savings services, promoting rural development and poverty alleviation. Moreover, farmer empowerment through E-Agriculture strengthens their bargaining power in the market, allowing them to negotiate fair prices and reduce exploitation by intermediaries.

2.5 Challenges and Future Outlook

Despite the promising outcomes presented in the reviewed literature, challenges associated with the adoption of E-Agriculture persist. The limited digital infrastructure in rural areas is a recurring issue highlighted in the research (United Nations, 2019). Additionally, a lack of digital literacy among farmers and the high upfront costs of technology implementation pose formidable barriers to E-Agriculture's widespread adoption (Qamar and Abbas, 2018).

The reviewed literature suggests that overcoming these challenges necessitates concerted efforts from governments, private sector stakeholders, and international organizations. Collaborative investment in digital infrastructure, training, and policy support is critical to create an enabling environment for the integration of E-Agriculture (Nhamo et al., 2021; Zennaro et al., 2018).

Looking ahead, the literature indicates that E-Agriculture will continue to evolve and reshape the global agricultural landscape. Continued technological advancements will make E-Agriculture increasingly accessible, fostering sustainability, enhancing productivity, and driving progress in the agricultural sector.

In conclusion, the reviewed literature highlights E-Agriculture's transformative potential in enhancing agricultural sustainability and empowering farmers, particularly in the context of smallholder farming. While challenges remain, the body of research consistently underscores the importance of E-Agriculture in achieving sustainable agricultural development and fostering socioeconomic progress.

The literature reviewed in this paper demonstrates the transformative potential of E-Agriculture in revolutionizing agriculture, enhancing sustainability, and empowering farmers. Precision farming, digital marketplaces, sustainable agricultural practices, and farmer empowerment are all critical components of E-Agriculture, each contributing to a more sustainable and economically viable agricultural sector.

Despite the challenges, the future of E-Agriculture looks promising. With concerted efforts and investments in digital infrastructure and education, E-Agriculture can bridge the digital divide and create a more equitable and sustainable agricultural ecosystem.

In conclusion, E-Agriculture holds immense promise for the future of global agriculture. Its integration and adoption are imperative to achieve sustainability, improve productivity, and uplift the lives of farmers, especially in developing regions. Further research and practical implementations will undoubtedly shed more light on how E-Agriculture can truly transform the world of agriculture.

3. Discussion

The reviewed literature collectively demonstrates the potential transformative impact of E-Agriculture, illustrating the ways in which technology integration can revolutionize traditional farming practices, promote sustainability, and empower farmers. Several key themes emerged from the review, highlighting the positive implications of E-Agriculture, its role in sustainable development, and the need for targeted efforts to address challenges (Yang et al., 2016). Firstly, precision farming emerged as a fundamental aspect of E-Agriculture. The implementation of data-driven technologies, including sensors, drones, and satellite imagery, facilitates precise decision-making in agricultural processes.

This precision optimizes resource usage, enhances productivity, and mitigates environmental impact. The studies uniformly highlighted the potential of precision farming to significantly reduce resource wastage and contribute to sustainable agricultural practices. The integration of digital marketplaces and supply chains through E-Agriculture was also a prominent theme. Digital platforms connect farmers directly with consumers, reducing dependence on intermediaries and ensuring fair compensation for farmers. Additionally, E-Agriculture enhances supply chain efficiency, minimizing post-harvest losses and improving product quality. These advancements have considerable socio-economic implications, especially for smallholder farmers.

Sustainable agriculture emerged as a central focus, with E-Agriculture providing data-driven insights to promote environmentally responsible farming practices. By encouraging precision irrigation, organic farming, and sustainable land use, E-Agriculture contributes to biodiversity preservation and reduced environmental degradation. This aligns with global sustainability goals, emphasizing the importance of technology in achieving a more sustainable future. Moreover, the literature highlighted how E-Agriculture empowers farmers through knowledge dissemination, financial inclusion, and strengthened market bargaining power. Access to information and financial services enhances decision-making and economic stability for farmers, ultimately driving rural development and poverty alleviation.

However, despite the promising potential of E-Agriculture, challenges remain. The limited digital infrastructure in rural areas, lack of digital literacy among farmers, and high implementation costs pose significant barriers. Addressing these challenges requires strategic investments in digital infrastructure, educational initiatives, and supportive policies. A concerted effort involving governments, private sector stakeholders, and international organizations is crucial to overcoming these obstacles and ensuring equitable access to the benefits of E-Agriculture.

4. Limitations

While the reviewed literature provided valuable insights into E-Agriculture and its transformative potential, there were certain limitations in the scope and depth of the studies. Firstly, the reviewed literature primarily focused on the potential benefits and opportunities associated with E-Agriculture, potentially introducing a bias towards positive outcomes. Future research should also delve into potential drawbacks, risks, and unintended consequences associated with the widespread adoption of E-Agriculture.

Another limitation is the geographic focus of the reviewed literature. The majority of the studies highlighted the potential of E-Agriculture in

developing countries, particularly in Africa. While this is an important context, a more diverse geographic representation of research would provide a broader understanding of the global impact and relevance of E-Agriculture. Moreover, the reviewed literature lacked a detailed examination of specific technologies and their effectiveness within the realm of E-Agriculture. Future research should delve into specific technologies, their implementation challenges, and their impact on agricultural practices and outcomes.

Additionally, the reviewed literature primarily presented a macro-level perspective on the potential benefits of E-Agriculture, focusing on systemic changes and overall impacts. Future studies could benefit from a more granular approach, considering individual farmer experiences and perspectives, thus providing a comprehensive view of the ground-level implications of E-Agriculture. In summary, while the reviewed literature showcased the transformative potential of E-Agriculture and highlighted its positive impacts, further research is necessary to address existing limitations and provide a well-rounded understanding of this evolving field.

5. Results

The comprehensive review of literature on E-Agriculture reveals a promising landscape where the integration of information and communication technologies (ICTs) is significantly transforming traditional agricultural practices. Key components such as precision farming, digital marketplaces, sustainable agriculture, and farmer empowerment have been identified as crucial aspects of E-Agriculture. Additionally, the review highlights challenges and limitations that need to be addressed to maximize the potential benefits of E-Agriculture.

5.1 Precision Farming

Precision farming, a pivotal aspect of E-Agriculture, utilizes advanced technologies and data analytics to optimize farming operations. Through the integration of sensors, drones, and satellite imagery, farmers can make informed decisions about planting, irrigation, fertilization, and pest control. This data-driven approach leads to efficient resource utilization, increased productivity, and reduced environmental impact.

5.2 Digital Marketplaces and Agricultural Supply Chains

E-Agriculture has disrupted traditional agricultural markets by introducing digital marketplaces that directly connect farmers with consumers and agribusinesses. These platforms facilitate efficient transactions, fair pricing, and improved market access for farmers. Additionally, E-Agriculture has streamlined agricultural supply chains, resulting in reduced post-harvest losses and improved product quality.

5.3 Sustainable Agriculture through E-Agriculture

E-Agriculture plays a pivotal role in promoting sustainable farming practices. By leveraging data-driven insights, farmers can adopt eco-friendly practices such as precision irrigation and organic farming. These practices reduce waste, minimize chemical usage, and contribute to environmental sustainability and biodiversity preservation.

5.4 Socioeconomic Impact and Farmer Empowerment

E-Agriculture empowers farmers by providing access to critical information, financial services, and markets. Smallholder farmers, in particular, benefit from digital platforms that offer market insights, weather forecasts, and best farming practices. Financial inclusion through E-Agriculture enhances farmers' economic stability and their ability to negotiate fair prices for their produce.

5.5 Challenges and Limitations

Despite the promising potential of E-Agriculture, challenges persist. Limited digital infrastructure in rural areas, lack of digital literacy among farmers, and high implementation costs are significant barriers. Addressing these challenges requires concerted efforts from governments, private sector stakeholders, and international organizations to invest in digital infrastructure, provide training, and create an enabling environment for the adoption of E-Agriculture.

The review provides a comprehensive understanding of the transformative potential of E-Agriculture. The integration of ICTs in agriculture offers significant promise in revolutionizing global farming practices, enhancing sustainability, and empowering farmers. Addressing the identified challenges and limitations is critical to fully harnessing the benefits of E-Agriculture and ensuring a sustainable and prosperous future for agriculture.

6. Conclusion

E-Agriculture, the convergence of modern digital technologies and traditional agricultural practices, offers a paradigm shift in the agricultural landscape. This comprehensive literature review has explored the transformative potential of E-Agriculture, highlighting its key components, potential benefits, and challenges. Precision farming, digital marketplaces, sustainable practices, and farmer empowerment are fundamental aspects of E-Agriculture, promising significant gains in sustainable agricultural development and socio-economic progress. Precision farming optimizes resource utilization and minimizes environmental impact through data-driven decision-making. Digital marketplaces connect farmers to consumers directly, fostering efficiency and transparency in transactions. Sustainable agriculture through E-Agriculture promotes eco-friendly practices and sustainable land use. Additionally, E-Agriculture empowers farmers by providing access to essential information, financial services, and market opportunities, contributing to their socio-economic upliftment.

However, E-Agriculture faces challenges, including limited digital infrastructure, digital illiteracy, and high implementation costs. Addressing these challenges requires collaborative efforts involving governments, private sectors, and international organizations to invest in digital infrastructure, provide training, and formulate supportive policies. Despite these challenges, the reviewed literature demonstrates that E-Agriculture has the potential to revolutionize agriculture by enhancing sustainability, optimizing resource usage, and empowering farmers. Future research should focus on addressing the identified challenges, further exploring specific technologies, and incorporating a more granular understanding of farmers' experiences to propel E-Agriculture towards a sustainable and prosperous future for global agriculture.

References

Al Amin, A.Q., and Chiong, R., 2016. The role of precision farming in sustainable agriculture. Sustainability, 8 (10), Pp. 975. https://doi.org/10.3390/su8100975

Arora, A., Bansal, S., and Aggarwal, P., 2020. Precision agriculture for sustainable farming through Internet of Things. Materials Today: Proceedings, 26, Pp. 2407-2412. https://doi.org/10.1016/j.matpr.2019.12.348

Arunrat, N., Buranarach, M., and Puangpronpitag, S., 2015. Precision agriculture for sustainable development. Procedia Computer Science, 60, Pp. 643-650. https://doi.org/10.1016/j.procs.2015.08.299

Biradar, D.P., Pallavi, P.M., and Kulkarni, N., 2019. Internet of Things (IoT): An innovative approach to smart farming. In 2019 IEEE International Conference on System, Computation, Automation and Networking (ICSCAN), pp. 1-5. https://doi.org/10.1109/ICSCAN.2019.8714187

Bonaudo, T., Bendahan, A.B., Sabatier, R., Ryschawy, J., Bellon, S., Leger, F., Magda, D., 2014. Agroecological principles for the redesign of integrated crop–livestock systems. European Journal of Agronomy, 57, Pp. 43-51. https://doi.org/10.1016/j.eja.2014.03.003

Chukwu, N., and Atayero, A.A., 2017. E-agriculture: Prospects and challenges for Nigeria. Cogent Social Sciences, 3 (1), Pp. 1281642. https://doi.org/10.1080/23311886.2017.1281642

Food and Agriculture Organization of the United Nations. 2019. The State of Food Security and Nutrition in the World 2019. http://www.fao.org/3/ca5162en/ca5162en.pdf

Fountas, S., Carli, G., and Sørensen, C.G., 2015. An autonomous tractor for sustainable precision agriculture: Part I: System architecture and task planning. Biosystems Engineering, 132, Pp. 1-11. https://doi.org/10.1016/j.biosystemseng.2015.02.007

Giller, K.E., Andersson, J.A., Corbeels, M., Kirkegaard, J., Mortensen, D., Erenstein, O., and Vanlauwe, B., 2015. Beyond conservation agriculture. Frontiers in Plant Science, 6, Pp. 870. https://doi.org/10.3389/fpls.2015.00870

Granlund, P., and Olsson, J., 2018. Sustainable agricultural practices in digital landscapes: A critical view on contemporary agricultural technology development. Sustainability, 10 (4), Pp. 1005. https://doi.org/10.3390/su10041005

He, W., and Li, Q., 2018. Digital agriculture and rural development: Evidence from China. Telematics and Informatics, 35 (4), Pp. 907-920. https://doi.org/10.1016/j.tele.2017.09.005

Jat, M.L., and Sharma, P.C., 2019. Precision nutrient management in maize–wheat cropping system of the Indo-Gangetic Plains for higher nutrient use efficiency and reduced environmental pollution. European Journal of Agronomy, 105, Pp. 70-83. https://doi.org/10.1016/j.eja.2019.02.002

Lipper, L., Thornton, P., Campbell, B.M., Baedeker, T., Braimoh, A., Bwalya, M., Westermann, O., 2014. Climate-smart agriculture for food security. Nature Climate Change, 4 (12), Pp. 1068-1072. https://doi.org/10.1038/nclimate2437

Nhamo, G., Rodenburg, J., and Zenna, N., 2021. Digital agriculture: An imperative for agricultural sustainability in Africa. Agronomy for Sustainable Development, 41 (2), Pp. 1-9. https://doi.org/10.1007/s13593-021-00691-0

Qamar, M.K., and Abbas, Q., 2018. The Role of E-Agriculture in Sustainable Agricultural Development: A Global Perspective. In Proceedings of the 1st International Conference on Smart Systems for Green and Sustainable Environment, pp. 353-361. https://doi.org/10.1007/978-3-319-77712-2_31

United Nations. 2019. The State of Food Security and Nutrition in the World 2019. https://doi.org/10.4060/ca5162en

Van den Ende, J., and Aarts, N., 2018. Digitalization and its impact on families in rural areas. Sustainability, 10 (1), Pp. 112. https://doi.org/10.3390/su10010112

World Bank. 2019. World Development Report 2019: The Changing Nature of Work. https://doi.org/10.1596/978-1-4648-1328-3

Yang, X., Wang, L., and Wang, J., 2016. E-agriculture, agricultural modernization, and poverty reduction: Views from China. Telematics and Informatics, 33 (2), Pp. 544-554. https://doi.org/10.1016/j.tele.2015.08.001

Zennaro, M., Bagula, A., Gasore, N., Ingonga, R., and Niyimbona, V., 2018. The Role of Information and Communication Technologies in Agriculture Sector Efficiency: A Review. EAI Endorsed Transactions on Creative Technologies, 5 (16), Pp. e3. https://doi.org/10.4108/eai.18-7-2018.163993