ID: 532

Use of Digital Technologies in Agriculture: Comparative Analysis in terms of Production and Marketing

Nebi Seren[1]

[1]Computer Technologies, Orhangazi Yeniköy Asil Çelik Vocational School, Bursa Uludağ University, Bursa, Turkiye

Abstract

This study first analyses the use of digital technologies in agriculture from two different perspectives. Then, correlation analyses using these data aim to show which countries that focus on which of the two perspectives are ahead in agricultural exports. In the study, publications containing the word 'agriculture' in the title, abstract or keywords section of the Scopus database and the keywords 'digital technology' and 'production' in the all fields section were selected and recorded as publications in which digital technologies in agricultural production were investigated. Then, in the Scopus database, publications containing the word 'agriculture' in the title, abstract or keywords section and the words 'digital technology' and 'marketing' in the all fields section were kept in a separate category and recorded as publications in which digital technologies in marketing of agricultural products were investigated. These two data sets were subjected to correlation analysis with export data obtained from OECD databases, and interactions on the axis of agriculture, digital technologies, production and marketing were revealed. After selecting the OECD member countries with export data from all the data obtained, the number of academic publications of these countries with the specified conditions is given in separate tables. The correlation analysis carried out on OECD member countries revealed a statistically significant and strong positive relationship between the average agricultural export volumes for 2020-2024 and the number of scientific publications containing the terms agriculture, digital technologies and production indexed in the Scopus database. The Pearson correlation coefficient was calculated as $r = 0.813$, and the significance level was $p = 0.004$. When a similar correlation analysis was conducted with publications containing agriculture, digital technologies and marketing terms, the Pearson correlation coefficient was $r = 0.958$ with a significance level of $p < 0.001$. This finding indicates that countries that produce higher levels of academic output in agriculture (publications containing both production and marketing terms) tend to have higher export performance in the agricultural sector. The results suggest that there may be a significant relationship between academic productivity and economic output in international agricultural trade.

Key Words: *Digital Agriculture Technologies, Agricultural Production, Agricultural Marketing, Agricultural Exports, Correlation Analysis*

Introduction

Nowadays, when digital technologies have taken a prominent place in all areas of life, the agricultural sector is also experiencing its share of transformation. This transformation manifests itself both in production processes and marketing processes. On the other hand, businesses that internalise digital technologies in supply chain management and consumer relations have an advantageous position in the competitive market. Digitalisation plays an important role in changing the traditional understanding of agriculture by directly affecting food safety, environmental sustainability and rural development (MacPherson et al., 2022; Lin et al., 2020).

The contributions of digital technologies to the agricultural sector are emphasised at many different points. In their study, Prashanth et al. (2025) emphasise that digital technologies are widely used to increase production efficiency, optimise the use of resources, reduce environmental impacts and improve marketing strategies (Prashanth et al., 2025). In other case studies, it is emphasised that artificial intelligence, Internet of Things (Iot), blockchain, big data analytics and remote sensing technologies contribute to the transformation and development of agriculture (Wolfert et al., 2017; Lin et al., 2020). When all these comprehensive areas are evaluated, the increase in technology-based agricultural practices in developing and developed countries shows that digital agricultural practices have become a global research topic.

This study aims to analyse the effects of digital technologies on agricultural production and marketing processes comparatively. It also reveals the interaction of the use of these technologies with the agricultural export performance of countries. Thus, it tries to show how agricultural digital transformation contributes to production, marketing, foreign trade and global competitiveness.

Turkish Science and Technology Publishing (TURSTEP)
www.turstep.com.tr

In the context of production, Iot-based innovative agricultural applications strengthen decision support processes in areas such as crop management, irrigation systems, crop monitoring and environmental control through data processing (Prashanth et al., 2025). In addition, soil condition and weather conditions can be monitored through sensors and satellite data, making it possible to intervene at the right time (Wolfert et al., 2017). Artificial intelligence and machine learning algorithms facilitate operations in areas such as disease detection, crop recommendation, yield estimation and management of automated agricultural machinery (MacPherson et al., 2022).

In marketing, digital technologies can significantly contribute to delivering agricultural products to the target audience, increasing brand value and making market analyses more accurate (Zhang et al., 2021). Thanks to digital channels such as email marketing, social media, SEO, mobile applications and e-commerce platforms, producers can provide direct access to consumers, thus reducing traditional intermediary structures and improving profit margins (Zhang et al., 2021). In addition, digital marketing has facilitated the opening of agricultural products to global markets.

Considering all these effects, the relationship between academic publication outputs and the agricultural export performance of countries will be evaluated comparatively through the production and marketing perspectives of digital technologies. This evaluation aims to provide guiding information to policymakers, agricultural sector producers, and those who want to market these products by revealing which digitalisation approach is more closely related to agricultural export success.

Materials and Methods

Conceptual Framework

Digital technologies offer support that can provide intensive contributions in the short term in terms of productivity, sustainability and marketing strategies in agriculture to producers and those who want to market agricultural products. At this point, it is important to detail how digital technologies are used in agriculture and to reveal how they are examined in the literature. How digital technologies are used in production and marketing processes in agriculture will be analysed under two main categories. Digital technologies in production and marketing are examined in the literature, respectively.

Digital Technologies in Agriculture Production

Information technologies enable agricultural data storage, transmission and reuse through hardware and software systems. Birt et al. (2012) state that these systems improve data flow in agricultural activities and contribute to decision-making processes. Producers manage resources more effectively by providing accurate and timely access to data; thus, agricultural productivity can increase. In the study by Yechin et al. (2021), business technology contributes to efficiency and coordination in agricultural supply chains.

Communication technologies enable the connection between users and devices through digital networks. Kiambi (2018) states that these technologies facilitate farmers' information sharing in regions such as Africa and increase market access. In production processes, these tools help drive efficient workflows and stronger coordination along the value chain.

Operational technologies secure agricultural systems and support field operations by combining software and hardware. Wei et al. (2024) emphasise that these technologies enable the execution of autonomous processes in large-scale agricultural areas and reduce the need for manual labour. Thus, productivity is increased and cost control is facilitated.

Artificial intelligence technologies enable agricultural processes to be carried out more efficiently from planting to distribution through real-time data and learning algorithms. Akintuyi (2024) states that artificial intelligence increases operational efficiency and contributes to sustainable production choices. Thanks to artificial intelligence technologies, applications that can go beyond autonomy, make their own decisions, and determine their next steps by making inferences from past data add value to agricultural production.

Digital Technologies in Agricultural Marketing

The importance of digital marketing applications in agriculture is addressed from various perspectives. In their analysis, Leng and Tong emphasise the role of digital technologies in supporting the sustainable development of agriculture-related industries (Leng & Tong, 2022). Leng and Tong's research shows that aligning digital marketing with sustainable practices can positively impact producers (Leng & Tong, 2022).

Addressing the regional dimensions of digital technologies in agriculture, Nemchenko et al. emphasise that adopting an innovative approach to agricultural production is essential for the competitive advantage of digitalisation and the change of technological structures (Nemchenko et al., 2020). Beksultanova et al. discuss the comprehensive restructuring required for the agricultural sector to adapt to digital innovations, stating that it increases productivity and enables reaching broader audiences (Beksultanova et al., 2023).

In addition to these studies, some look at the phenomenon from different perspectives and examine the challenges and opportunities sustainable digital marketing can offer in agriculture. Kosior discusses how digital technologies such as big data and Iot can effectively increase productivity and ensure sustainable use of resources in the agri-food sector (Kosior, 2018). Moreover, the role of e-commerce in agricultural wholesale markets should not be ignored. Luo and Wang state that e-commerce platforms can significantly increase farmers' access to broader markets, thus reducing information complexity and minimising agricultural waste (Lou & Wang, 2024).
E-WOM (electronic word-of-mouth marketing) is an important tool in marketing agricultural products, as it is effective in all other sectors. Arslan and Güven's study investigates the effect of online comments on consumers' purchasing behaviour. The role of electronic word-of-mouth communication in shaping consumers' product preferences provides guiding information on the marketing of agricultural products (Arslan & Güven, 2020).
Blockchain technology offers a secure, web-based financial system with encrypted data to ensure the traceability and security of agricultural products. Chiaraluce et al. (2024) state that blockchain technology increases security in agricultural supply chains and prevents fraud (Chiaraluce et al., 2024). This technology is an important tool for providing reliability and transparency in marketing agricultural products.

Method

This study was created with a quantitative research design to comparatively examine the use of digital technologies in production and marketing processes in agriculture. The data in this study were obtained from Bursa Uludağ University, Scopus database and OECD databases between April 5 and April 10, 2025. Within the scope of the research, publications containing the term "agriculture" in the title, abstract or keywords section and the keywords "digital technology" and "production" in the all fields section were identified in the Scopus database. Similarly, to identify the literature on the use of digital technologies in the marketing of agricultural products, publications containing the term "agriculture" and the keywords "digital technology" and "marketing" were searched.
The two data sets obtained were analysed on a country basis to examine the level of adoption of digital technologies in production and marketing processes in agriculture. These data were matched with OECD agricultural export data and used in a correlation analysis. The correlation analysis was conducted to determine how agricultural production and marketing-oriented use of digital technologies relate to export performance.
In the analyses, Pearson correlation analysis was performed using SPSS 26.0 software to determine the interaction between the research of digital technologies in agricultural production and marketing and countries' export performance. The results are visualised and interpreted in order to comparatively assess the effectiveness of digital technologies in the context of agricultural production and marketing.

Results and Discussion

Results

Studies where agriculture and digital technologies intersect with the concept of production

When the publications in the Scopus database containing the term "agriculture" in the title, abstract or keywords section and the keywords "digital technology" and "production" in the all fields section are filtered with the date restriction of 2020-2024, a total of 2370 academic publications appear in the Scopus database. When these publications are analysed bibliometrically, the scientific fields in which the most publications are produced are shown in Table 1 for the Scopus database.
As a result of the query in the Scopus database, the top three scientific fields with the highest number of publications related to the use of digital technologies in agricultural production processes are Agricultural and Biological Sciences (769 publications), Computer Sciences (692 publications) and Environmental Sciences (681 publications). This spatial distribution reveals the interdisciplinary nature of digital agriculture studies. It reveals that technological applications are widely researched and analysed in the agricultural field and different scientific fields.

Table 1: Scientific fields and number of publications obtained in the Production Cluster

	Scientific fields	# of Publications
1	Agricultural and Biological Sciences	769
2	Computer Science	692
3	Environmental Science	681
4	Engineering	551
5	Social Sciences	531
6	Business, Management and Accounting	326
7	Energy	279
8	Economics, Econometrics and Finance	266
9	Earth and Planetary Sciences	219
10	Decision Sciences	153

Table 2: Number of publications by country in the Production Cluster

	Countries	# of Publications
1	China	400
2	Russian Federation	345
3	India	273
4	United States	209
5	Germany	140
6	Italy	137
7	United Kingdom	133
8	Australia	93
9	Canada	79
10	France	77

When the number of academic studies conducted in the context of digital agricultural technologies and production is analysed by countries, China (400 publications) ranks first, followed by Russia (345 publications) and India (273 publications). The academic productivity of these countries in digital agriculture is linked to both their agricultural potential and their interest in technological development. Moreover, this finding reveals that Asian countries make many scientific contributions to digital agriculture.

Table 3: Universities and research institutions producing the most publications in the Production Cluster

	Universities and research organizations	# of Publications
1	Wageningen University	42
2	INRAE	34
3	Russian Academy of Sciences	32
4	University of Guelph	28
5	Northwest University	28
6	Universität Hohenheim	27
7	Russian State Agrarian University - Moscow Timiryazev Agricultural Academy	27
8	University of Johannesburg	21
9	Kuban State Agrarian University	20
10	Université de Montpellier	20

When the universities and research institutions producing the highest number of publications are analysed, Wageningen University ranks first with 42 publications. This institution is followed by INRAE (34 publications) and the Russian Academy of Sciences (32 publications). This situation shows that academic institutions, especially in Europe and Russia, carry out intensive research activities in digital agriculture and are in a leading position.

Studies where agriculture and digital technologies intersect with the concept of marketing

In Scopus databases, when the publications containing the term "agriculture" in the title, abstract or keywords section and the keywords "digital technology" and "marketing" in the all fields section are restricted to 2020-2024, a total of 698 academic publications are obtained in the Scopus database. When these publications are analysed bibliometrically, the scientific fields in which the most publications are produced are shown in Table 4 for the Scopus database.

In the Scopus database, the top three scientific fields with the highest number of publications were Agricultural and Biological Sciences (223 publications), Social Sciences (196 publications) and Computer Sciences (188 publications). This distribution shows that the technical and social aspects of digital marketing are intensively addressed academically. The high ranking of social sciences, in particular, indicates that digital agricultural marketing also focuses on consumer behaviour, communication, and social interaction.

When the publications on digital agricultural marketing are analysed by country, China (115 publications) leads the way, followed by India (87 publications) and the United States (61 publications). This result shows that Asian countries invest in digitalisation not only in production but also in marketing processes. At the same time, the academic productivity of developing countries in this field has been observed at a high level.

Wageningen University (11 publications) ranks first among the institutions with the highest number of publications on digital agricultural marketing, followed by the University of Johannesburg (10 publications) and Northwest University (9 publications). Table 6 shows that universities in Europe and Africa have pioneered digital agricultural marketing research. The fact that universities in South Africa are particularly prominent in this field reveals that regional innovation and digitalisation are also reflected in the academic field.

Table 4: Scientific fields and number of publications obtained in the Marketing Cluster

	Scientific fields	# of Publications
1	Agricultural and Biological Sciences	223
2	Social Sciences	196
3	Computer Science	188
4	Environmental Science	170
5	Business, Management and Accounting	162
6	Engineering	134
7	Economics, Econometrics and Finance	104
8	Energy	83
9	Decision Sciences	53
10	Earth and Planetary Sciences	27

Table 5: Number of publications by country in the Marketing Cluster

	Countries	# of Publications
1	China	115
2	India	87
3	United States	61
4	Russian Federation	45
5	Italy	44
6	United Kingdom	42
7	Germany	41
8	Indonesia	35
9	South Africa	34
10	Australia	29

Table 6: Universities and research institutions producing the most publications in the Marketing Cluster

	Universities and research organisations	#of Publications
1	Wageningen University	11
2	University of Johannesburg	10
3	Northwest University	9
4	Universität Bonn	8
5	South China Agricultural University	8
6	Zentrum für Entwicklungsforschung	7
7	Aristotle University of Thessaloniki	7
8	University of Guelph	7
9	Sichuan Agricultural University	7
10	School of Agriculture	7

Correlation analyses

The correlation analyses conducted in the study were carried out in two different categories, as in the previous sections. The purpose of the correlations in the context of production and marketing is to observe whether there is a correlation between the number of academic research papers and the agricultural export figures of countries.

Table 7 shows the relationship between average agricultural export volumes and the number of academic publications on digital agricultural production in selected OECD countries for 2020-2024. While the United States has the highest number of publications (210 publications), it also has the highest average export volume (28,276.6 tonnes). Countries such as the United Kingdom, Australia and Canada stand out with both high publication productivity and high export figures. This supports a strong positive relationship between academic productivity and export performance. In addition to this finding, another finding that should be noted is that although the number of publications is high in countries such as New Zealand, Colombia and Norway, export volumes are pretty low.

Table 7. Number of Academic Publications on Digital Agricultural Production and Average Agricultural Export Volumes (2020-2024) in Selected OECD Countries

Countries	# of Publications	Agricultural Export data 2020 -2024 Average
United States	210	28276.6
United Kingdom	134	1332.6
Australia	93	16131.7
Canada	79	16906.6
Switzerland	29	89.1
Mexico	19	1053.0
New Zealand	17	0.5
Colombia	17	3.06
Norway	14	1.3
Chile	12	8.6

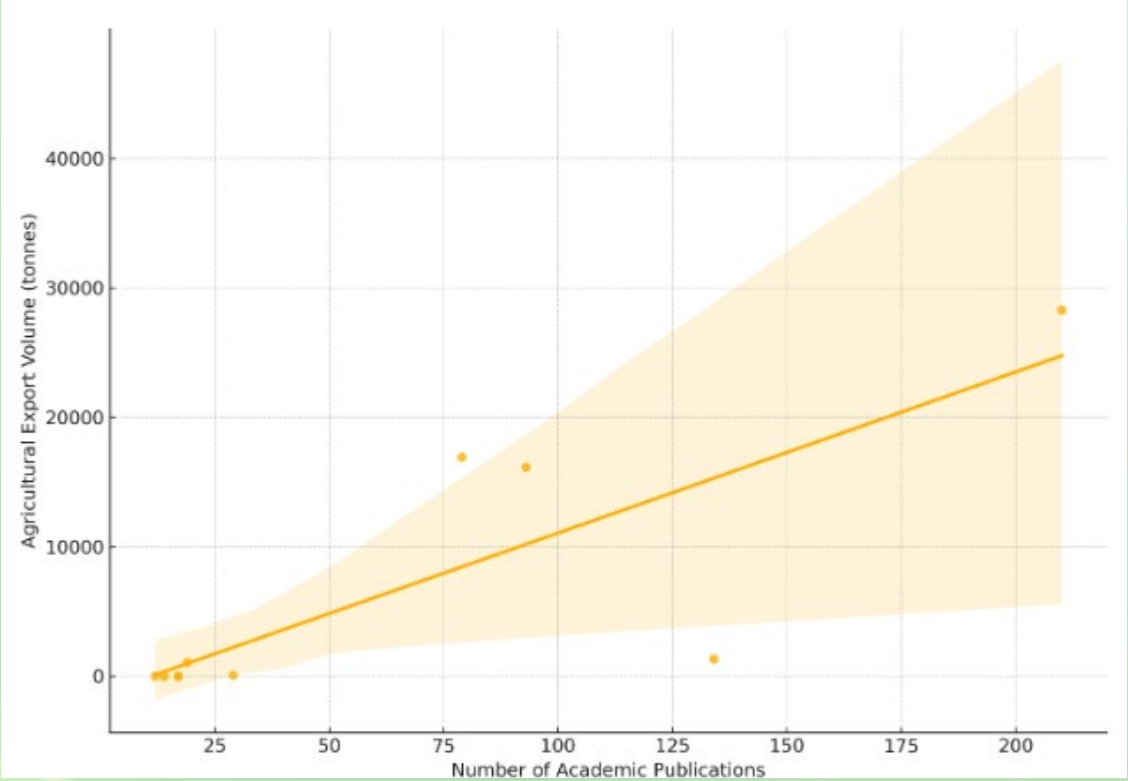

Figure 1. Correlation between Academic Publications on Digital Agricultural Production and Export Volume

The scatter plot in Figure 1 shows the relationship between the average agricultural export volumes in OECD member countries between 2020 and 2024 and the number of academic publications on digital agricultural production. As a result of the correlation analysis, the Pearson correlation coefficient r = 0.813 and the significance level p = 0.004. This strong and statistically significant positive relationship shows that countries that produce more academic publications in digital agricultural production also tend to have higher agricultural export performance.

Table 8 compares the number of academic publications on digital agricultural marketing with the average agricultural export volumes of OECD countries for 2020-2024. The country with the highest number of academic publications is the United States of America (61 publications), which also has the highest export volume (104,526 tonnes). The United States is followed by Canada (19 publications, 53,978 tonnes) and Australia (29 publications, 34,591 tonnes). Turkey is on the list with 11 publications, with an average export volume of 7,644 tonnes. This table provides a numerical result that there may be a strong relationship between the number of academic publications in digital marketing and agricultural export performance.

Table 8. Academic Publications on Digital Agricultural Marketing and Agricultural Export Volumes among OECD Countries (2020-2024)

Countries	# of Publications	Agricultural Export data 2020 -2024 Average
United States	61	104526.38
Canada	19	53978.72
Turkiye	11	7644.79
Australia	29	34591.71
Japan	4	381.57
South Korea	3	613.05
Mexico	5	1223.22
New Zealand	5	117.45
Norway	7	5.01
Switzerland	6	174.92

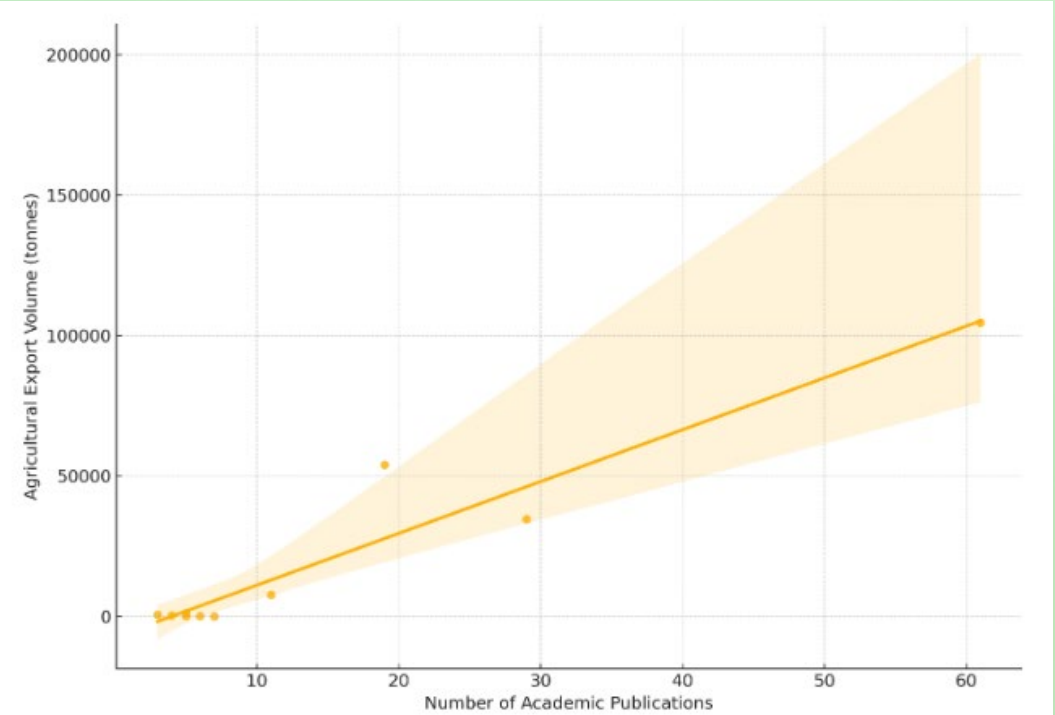

Figure 2. Correlation between Academic Publications on Digital Agricultural Marketing and Export Volume

The correlation analysis conducted on OECD member countries revealed a statistically significant and strong positive relationship between the average agricultural export volumes for 2020-2024 and the number of scientific publications indexed in the Scopus database. The Pearson correlation coefficient was calculated as $r = 0.958$, and the significance level was $p = 0.001$. This result shows a powerful and significant positive statistical relationship between the number of publications related to digital technologies in agricultural marketing and the amount of agricultural exports among OECD members and the 10 highest exporting countries.

Discussion

This study emphasises the power of digital agricultural technologies to improve agricultural production and marketing. The findings obtained from analysing the data draw attention to the positive effects of researching these technologies on the country's export figures by examining how digital technologies are involved in marketing and production areas. The results obtained coincide with the achievements emphasised in the literature. This is in line with previous findings showing that digital technologies can increase production and productivity and are a method of opening up to new markets (Yaman, 2021; Gedik, 2023).

Technologies such as artificial intelligence, remote sensing, and digital sales platforms within the scope of digital agricultural technologies have an important place in changing agricultural production and marketing structures. Digital agricultural technologies reduce production costs in decision-making processes and add value to the product in all processes from the field to the market. While production-oriented innovations contribute to efficient production, they also help sustainable resource utilisation. On the other hand, marketing technologies increase the value of agricultural products by increasing brand visibility and consumer access. The importance of digital technologies for competitive agriculture, emphasised by Yaman et. al (2021) in their study, is also supported in this study.

While this study emphasises the impact of digital technologies in agricultural production through two different phenomena, it has some shortcomings. The first can be summarised as focusing only on countries where agricultural export data are available in OECD databases. Some countries outside these datasets that have a voice in digital agricultural technologies and can actively apply these technologies are not included in the study due to a lack of data. In addition, inconsistencies in the representation of European Union member countries in academic and statistical databases led to their exclusion from the study. This deficiency can be overcome by accessing the export figures of the European Union member countries one by one.

Similar future studies can be repeated using datasets that include export data from alternative sources such as FAO, UN Comtrade, or national statistical agencies. Thus, the mentioned limitations can be overcome. Expanding the scope to include more countries and a more extended time period would allow for a more comprehensive conclusion and evaluation of how digitalisation shapes agricultural trade on a global scale.

This study supports the literature by indicating that digital technologies can be used to improve economic performance in agricultural systems in addition to being facilitative tools. Gedik (2023) emphasises that digital platforms have changed how producers interact with consumers. In their study, Yaman et al. (2021) argue that technological specialisation can significantly affect regional economic outcomes. In this context, it seems possible for researchers and policymakers to maximise regional and global gains by keeping sustainable digital transformation in agriculture more on their agenda.

Acknowledgements

References

Akintuyi, A. (2024). Adaptive AI in agriculture: Enhancing productivity and sustainability. *Agricultural Systems*, 58(1), 67-80. https://doi.org/10.1007/s43069-025-00434-z

Arslan, A. and Güven, Ö. Z. (2020). Gtkm kapsamında akademisyenlerin çevrimiçi tatil satın alma davranışlarında ewom un etkisi (the effect of ewom on the online holiday purchase behaviors of academics within of etam). Journal of Business Research - Turk, 12(1), 43-64. https://doi.org/10.20491/isarder.2020.827

Beksultanova, R., Zhang, Y., & Li, M. (2023). Digital technologies adoption and economic benefits in agriculture. *Sustainability, 16*(11), 4431. https://doi.org/10.3390/su16114431

Birt, J., Lee, S., & Smith, K. (2012). Information technology in agricultural production: Improving data flow and decision support. *Computers and Electronics in Agriculture*, 78(3), 45-56. https://doi.org/10.1016/j.compag.2012.04.005

Chiaraluce, F., Rossi, M., & Bianchi, P. (2024). Blockchain technology in agricultural supply chains: Enhancing security and transparency. *Journal of Agricultural Economics*, 65(4), 89-102. https://doi.org/10.1007/s13593-022-00792-6

Gedik, A. (2023). Impact of digital transformation in agribusinesses on total factor productivity. *International Food and Agribusiness Management Review, 27*(5), 843–860. https://doi.org/10.22434/IFAMR2023.0056

Kiambi, D. (2018). Communication technology in African agriculture: Improving information exchange and marketing. *African Journal of Agricultural Research*, 13(5), 234-245. https://doi.org/10.5897/AJAR2018.13045

Kosior, K. (2018). Towards a Common Agricultural Data Space in the European Union. *Institute of Agricultural and Food Economics – National Research Institute*. https://ageconsearch.umn.edu/record/344672/files/Kosior.pdf

Leng, X., & Tong, G. (2022). The digital economy empowers the sustainable development of China's agriculture-related industries. *Sustainability, 14*(17), 10967. https://doi.org/10.3390/su141710967

Lin, J., Wang, Y., Wang, Y., & Wang, J. (2020). Applications of blockchain technology to the sustainable food supply chain: The role of information transparency. *Technological Forecasting and Social Change, 161*, 120287. https://doi.org/10.1016/j.techfore.2020.120287

Luo, Q., & Wang, Y. (2024). Strategies selection for building e-commerce platforms for agricultural wholesale markets: A tripartite evolutionary game perspective. *PLOS ONE, 19*(1), e0297360. https://doi.org/10.1371/journal.pone.0297360

MacPherson, J., Voglhuber-Slavinsky, A., Olbrisch, M., Schöbel, P., Dönitz, E., Mouratiadou, I., & Helming, K. (2022). Future agricultural systems and the role of digitalization for achieving sustainability goals. *Agronomy for Sustainable Development*, 42, 70. https://doi.org/10.1007/s13593-022-00792-6

Nemchenko, A. S., Alekseeva, N. A., & Lyashenko, V. I. (2020). Digital transformation of agricultural production: Regional aspect. *Scientific Horizons, 23*(1), 12–19.

Prashanth, J. S., Krishna, G. B., Prasad, A. V. K., & Rao, P. R. (2025). Smart Farming Revolution: A Cutting-Edge Review of Deep Learning and IoT Innovations in Agriculture. *Operations Research Forum*, 6, 35. https://doi.org/10.1007/s43069-025-00434-z

Wei, W., Xiao, M., Duan, W., Wang, H., Zhu, Y., Zhai, C., & Geng, G. (2024). Research progress on autonomous operation technology for agricultural equipment in large fields. *Agriculture, 14*(9), 1473. https://doi.org/10.3390/agriculture14091473

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

Yaman, H. (2021). The impact of digitalization on export of high technology products: A panel data approach. *The Journal of International Trade & Economic Development, 31*(2), 1–20. https://doi.org/10.1080/09638199.2021.1965645

Yaman, H., Sungur, O., & Dulupçu, M. A. (2021). Dünyada tarım ve hayvancılığın dönüşümü: Teknolojiye dayalı uygulamalar ve devrimler. *Tarım Ekonomisi Dergisi*, 27(2), 123–133

Yechin, N., Kitayov, Y., Kravchenko, D., Pak, Z., & Chovgan, N. (2021). Features of the digitalization impact on the functioning of agricultural enterprises. BIO Web of Conferences, 39, 09004. https://doi.org/10.1051/bioconf/20213909004

Zhang, Y., Wang, C., & Liu, Y. (2021). The role of e-commerce in the agricultural supply chain: Evidence from China. *Electronic Commerce Research and Applications, 45*, 101015. https://doi.org/10.1016/j.elerap.2020.101015