KSÜ Tarım ve Doğa Derg 29 (2), 475-486, 2026
KSU J. Agric Nat 29 (2), 475-486, 2026
https://doi.org/10.18016/ksutarimdoga.vi.1740494

Determining the Attitudes of Agricultural Engineer Candidates Towards Digitalization in Agriculture with Factor Analysis: The Case of Tokat Gaziosmanpasa University

Asena ERTÜRK[1], Didem DOĞAR[2]✉, Adnan ÇİÇEK[3]
[1,2,3]Tokat Gaziosmanpaşa University, Faculty of Agriculture, Department of Agricultural Economics, 60240, Tokat, Türkiye.
[1]https://orcid.org/0000-0002-7435-6822, [2]https://orcid.org/0000-0003-0330-255X, [3]https://orcid.org/0000-0002-2671-1439
✉: dogardidem@gmail.com

ABSTRACT
The aim of this research is to determine the attitudes of Tokat Gaziosmanpaşa University Faculty of Agriculture students towards digitalization in agriculture and to analyze the factors affecting these attitudes. The data of the study were collected from 208 third and fourth-grade students in the 2024-2025 academic year by survey. A Likert-type scale consisting of 23 items was used as a data collection tool, and exploratory factor analysis was applied to the obtained data. As a result of the analysis, the scale was divided into three main dimensions. These are: "Perception of the Benefits and Education of Digital Agriculture", "Economic and Environmental Benefits of Digital Agriculture" and "Concerns and Support Needs for Digital Agriculture". While students largely expressed positive opinions on issues such as increasing productivity, reducing costs, and contributing to environmental sustainability in digital agriculture, they also expressed their concerns about risks such as dependence on technology, high investment costs, and the decrease in agricultural employment. The KMO value was calculated as 0.950, and Cronbach's Alpha coefficient as 0.971, and these results showed that the data set was extremely suitable for factor analysis and the scale was highly reliable. The findings reveal that theoretical and applied training on digital agricultural technologies should be increased in agricultural faculties. It is also emphasized that not only technological advantages but also education, support, and adaptation dimensions should be taken into consideration in the digitalization dissemination process. In this context, it is recommended to adopt holistic approaches that include socio-cultural and educational components, not technology-based ones.

Agricultural Economics

Research Article

Article History
Received : 11.07.2025
Accepted : 18.09.2025

Keywords
Digitalization in agriculture
Use of technology in agriculture
Smart agriculture
Exploratory factor analysis(EFA)
Agricultural engineer candidate

Ziraat Mühendisi Adaylarının Tarımda Dijitalleşmeye Yönelik Tutumlarının Faktör Analizi ile Belirlenmesi: Tokat Gaziosmanpaşa Üniversitesi Örneği

ÖZET
Bu araştırmanın amacı, Tokat Gaziosmanpaşa Üniversitesi Ziraat Fakültesi öğrencilerinin tarımda dijitalleşmeye yönelik tutumlarını belirlemek ve bu tutumları etkileyen faktörleri analiz etmektir. Çalışmanın verileri, 2024-2025 akademik yılında 208 adet üçüncü ve dördüncü sınıf öğrencilerinden anket yoluyla toplanmıştır. Veri toplama aracı olarak 23 maddeden oluşan Likert tipi bir ölçek kullanılmış ve elde edilen veriler üzerinde keşfedici faktör analizi uygulanmıştır. Analiz sonucunda ölçek üç ana boyuta ayrılmıştır. Bunlar; "Dijital Tarımın Faydaları ve Eğitimine Yönelik Algı", "Dijital Tarımın Ekonomik ve Çevresel Faydaları" ve "Dijital Tarıma Yönelik Endişeler ve Destek İhtiyacı" şeklindedir. Öğrenciler, dijital tarımın verimlilik artışı, maliyetlerin azaltılması ve çevresel sürdürülebilirliğe katkısı gibi konularda büyük ölçüde olumlu görüş bildirirken; teknolojiye bağımlılık, yüksek yatırım maliyetleri ve tarımsal istihdamın azalması gibi risklere yönelik kaygılarını da ifade etmişlerdir. KMO değeri 0.950 ve Cronbach's Alpha katsayısı 0.971 olarak hesaplanmış, bu sonuçlar veri setinin faktör analizine son derece uygun ve ölçeğin yüksek derecede güvenilir

Tarım Ekonomisi

Araştırma Makalesi

Makale Tarihçesi
Geliş Tarihi : 11.07.2025
Kabul Tarihi : 18.09.2025

Anahtar Kelimeler
Tarımda dijitalleşme
Tarımda teknoloji kullanımı
Akıllı Tarım
Keşfedici faktör analizi (KFA)
Ziraat mühendisi adayı

olduğunu göstermiştir. Elde edilen bulgular, ziraat fakültelerinde dijital tarım teknolojilerine yönelik hem teorik hem de uygulamalı eğitimlerin artırılması gerektiğini ortaya koymaktadır. Ayrıca dijitalleşmenin yaygınlaştırılması sürecinde yalnızca teknolojik avantajların değil eğitim, destek ve adaptasyon boyutlarının da dikkate alınması gerektiği vurgulanmaktadır. Bu bağlamda, teknoloji temelli değil, sosyo-kültürel ve eğitimsel bileşenleri içeren bütüncül yaklaşımlar benimsenmesi önerilmektedir.

Atıf Şekli: Ertürk, A., Doğar, D. & Çiçek, A. (2026). Ziraat Mühendisi Adaylarının Tarımda Dijitalleşmeye Yönelik Tutumlarının Faktör Analizi ile Belirlenmesi: Tokat Gaziosmanpaşa Üniversitesi Örneği. *KSÜ Tarım ve Doğa Derg 29* (2), 475-486. https://doi.org/10.18016/ksutarimdoga.vi.1740494

To Cite : Ertürk, A., Doğar, D. & Çiçek, A. (2026). Determining the Attitudes of Agricultural Engineer Candidates Towards Digitalization in Agriculture with Factor Analysis: The Case of Tokat Gaziosmanpasa University. *KSU J. Agric Nat 29* (2), 475-486. https://doi.org/10.18016/ksutarimdoga.vi.1740494

INTRODUCTION

Digital agriculture (smart agriculture, precision agriculture), which is one of the modern agricultural production approaches, has developed with the integration of information and communication technologies into agricultural processes (Zhang, 2016). This approach comprises basic components, including Geographic Information Systems (GIS), Global Positioning Systems (GPS), remote sensing techniques, and data analytics processes (Demirel Atasoy, 2019; Göl & Tarhan, 2024). The application area of digital technologies is quite wide. These technologies, which are used effectively in many processes from agricultural production to marketing, increase efficiency in activities such as production planning, processing of raw materials, transportation, and storage of products. In addition, the sale of products and their promotion to consumers become more effective through digital tools. These technologies improve decision-making processes, reduce costs, increase product quality, and contribute to the more efficient use of labor. Thus, the competitiveness of businesses increases, production losses decrease, and income levels increase (Nezamova & Olentsova, 2022).

Today, digital agricultural technologies are spreading rapidly on a global scale. The digital agriculture market, which is 14.98 billion USD as of 2024, is expected to reach 16.25 billion USD in 2025 and 26.94 billion USD in 2029. The realization of this growth with an annual compound growth rate of 13.5% clearly reveals the economic potential of digital agriculture and its importance in the sector (TBRC, 2024). This development is also supported by the increasing food demand, the effects of climate change, and the need for efficiency in resource utilization (Wolfert et al., 2017).

In Türkiye, the digitalization process is increasingly coming to the fore in the agricultural sector, and innovative applications are being implemented (Demiryürek et al., 2021; Koçyiğit et al., 2024). Drones, one of these applications, are used to evaluate plant health through geographical data by being equipped with multispectral and Red-Green-Blue (RGB) cameras (Reinecke & Prinsloo, 2017; Daponte et al., 2019). However, blockchain technology, another important component of digital agriculture, enables the tracking of products from production to consumption by providing transparent data management and contributes to food safety (Xiong et al., 2020). Similarly, sensors integrated with the Internet of Things (IoT) provide support to farmers in decision-making processes by measuring environmental factors such as soil pH, humidity, temperature, and precipitation in real time (Aydın, 2022). In addition, online agricultural consultancy services provide expert support to producers, increasing both efficiency and supporting a sustainable production approach (Abdulai et al., 2022; Koçyiğit et al., 2024). When these technologies are considered together, it is seen that digital agriculture creates transformation not only in production stages but also in a wide range such as food safety and supply chain management (Kamilaris et al., 2019).

Although digital agriculture offers many opportunities, there are socio-technical obstacles to its widespread adoption. These include infrastructure deficiencies, high costs, low levels of digital literacy among producers, and technological adaptation problems (Anitei et al., 2020). In particular, limited internet access and the digital divide in rural areas are among the most important obstacles to the spread of digital agricultural technologies (Eastwood et al., 2019). In developing countries, the lack of education and technical support, as well as economic constraints, slow down the integration of digital technologies into agriculture (Dibbern et al., 2024). In Türkiye, despite Ministry-supported projects, the use of imported and high-cost technologies and the low digital literacy level of farmers limit proliferation (Baran et al., 2023).

In order to effectively realize the digital transformation, a suitable digital infrastructure must first be established. Determining the most appropriate solutions for the enterprise and developing the appropriate infrastructure will

facilitate the adaptation of employees to new technologies. The training to be provided in this process will contribute to the development of agricultural production by ensuring a better understanding and effective use of digital tools (Lazebnyk et al., 2021). In addition, it is of great importance to train qualified human resources that will contribute to the digital transformation process. Agricultural faculties are not only institutions that teach the technical aspects of agricultural production; they are also strategic structures that train individuals equipped with the knowledge, skills, and vision to support sustainable agricultural development. These institutions play a critical role in the integration of modern agricultural technologies into the sector. Therefore, determining the attitudes of agricultural faculty students towards digital agricultural technologies will contribute both to the restructuring of agricultural education policies and to the effective management of the digital transformation process. The positive approaches of these students, who will have a say in the future of the sector, to digitalization will facilitate the adoption of digital technologies and significantly contribute to their widespread use in the agricultural sector.

In this context, the main objective of the research is to determine the attitudes of students at Tokat Gaziosmanpaşa University, Faculty of Agriculture, towards digitalization in agriculture and to examine the factors affecting these attitudes. In line with this objective, the study aims to reveal students' overall attitudes toward digital agriculture, to evaluate how they perceive both the benefits and risks of digitalization, and to develop implications for the integration of digital agricultural technologies into agricultural education programs and policy practices based on the findings.

MATERIAL and METHOD

The main material of the research consists of the data obtained from the questionnaire study applied to the third and fourth-grade students studying at Tokat Gaziosmanpaşa University Faculty of Agriculture. The questionnaire application was carried out in March of the 2024-2025 academic year, and was carried out meticulously with the necessary ethical approval in line with the decision numbered 01-68 of the Tokat Gaziosmanpaşa University Ethics Committee.

Method Used in Obtaining Data

The target audience of the research consists of third and fourth-grade students studying in seven departments (Horticulture, Plant Protection, Biosystems Engineering, Agricultural Economics, Field Crops, Soil Science and Plant Nutrition, Animal Science) within the Faculty of Agriculture of Tokat Gaziosmanpaşa University. The reason for choosing these classes is that the students have completed a large part of their professional education, and their awareness, attitudes, and professional orientations towards agricultural technologies can be observed more clearly. In addition, the fact that these students, who are about to graduate, will be included in the sector in a short time allows the findings to present more meaningful results in terms of the future of the agricultural sector. In the study, a full count was made with the students in question, and a questionnaire was conducted with a total of 208 active students. In the data collection process, the questionnaire form was transferred to the digital environment via Google Forms; then, the online link address was sent to the students through the faculty members, and the questionnaires were filled out. The SPSS 18.0 package program was used in data analysis (IBM, 2009).

Method Used to Analyze Data

The survey form used in the data analysis phase consists of two sections. The first section includes questions to determine the demographic characteristics of the participants, while the second section includes 5-point Likert-type questions to measure attitudes towards digitalization in agriculture. The scale expressions used in this study were adapted from the study developed by Koçyiğit et al. (2024) on Ondokuz Mayıs University students, but were revised in accordance with the context of Tokat Gaziosmanpaşa University students. Thus, the scale was applied in a different university and student group, allowing the results to be evaluated in a comparative manner. This contributes to the testing of the scale's validity in different samples and the generalizability of the findings. In addition, expert academicians were consulted to ensure content validity, and 13 items with less than 90% consensus were removed from the scale; a 23-item scale was used in its final form. In the Likert scale, the answer options are: "I completely agree (5)", "I agree (4)", "I am undecided (3)", "I disagree (2)", and "I definitely disagree (1)". According to the content analysis of the items, 17 items measure thoughts and 6 items measure concerns.

The data obtained through the survey were subjected to exploratory factor analysis (EFA) and reliability analysis to determine the structural and factorial validity of the scale. Factor analysis is one of the multivariate statistical methods that enables the presentation of data in a more meaningful and concise manner by basing it on the relationships between variables (Kurtuluş, 2004; Tekinarslan, 2008; Karpati & Szakal, 2009). The aim of this method is to collect similar variables under fewer factors by explaining the relationships between variables with the least loss of information. Thus, dimension reduction is achieved in the data set, and the data becomes easier

to interpret (Brown, 2009).

Not every data set may be directly suitable for factor analysis. Therefore, various statistical evaluations are needed to test the suitability of the data before analysis. Factor analysis generally consists of four basic stages (Çakır, 2014).

1. Evaluation of the suitability of the data set for factor analysis,
2. Obtaining factors,
3. Rotation of factors,
4. Naming the factors.

Before starting the analysis, in order to determine the suitability of the data set for the analysis, the normality of the data was evaluated by examining the skewness and kurtosis values, and it was observed that the values were in the range of ±2; this finding indicates that the data is suitable for normal distribution (Mallery & George, 2000). In addition, the correlation values between factors were found to be low ($r<0.30$). For this reason, it was assumed that the factors were independent of each other, and Varimax, which is a vertical (Orthogonal) rotation technique, was preferred (Tabachnick & Fidell, 2007; Hair et al., 2009). In the next stage, the Correlation Matrix, Kaiser-Meyer-Olkin (KMO) Sampling Adequacy Test, and Bartlett's Sphericity Test were applied. The KMO test is an index that compares the magnitude of observed correlation coefficients with partial correlation coefficients, and the greater the ratio, the more suitable it is for factor analysis (Topçu, 2006). KMO values vary between 0.00 and 1.00, and according to the generally accepted classification; 0.00–0.49 is "unacceptable", 0.50–0.69 is "moderate", 0.70–0.79 is "good", 0.80–0.89 is "very good", 0.90 and above indicates "excellent" level of sample adequacy, and it is desired that this value is ≥70 (Izquierdo et al., 2014; Lloret et al., 2017; Nikkhah et al., 2018; Watkins, 2018; Marofi et al., 2020). However, if this value is below 0.50, the data set is considered unsuitable for factor analysis (Kaiser, 1974; Watkins, 2018).

In addition, with Bartlett's Sphericity Test, it was tested whether there was a sufficient level of correlation between the variables. A significant p-value ($p< .05$) obtained as a result of the Bartlett test indicates that the data exhibits a suitable structure for factor analysis (Bartlett, 1954; Howard, 2016; Shrestha, 2020). Thus, the suitability of the data for factor analysis was evaluated by considering both the KMO test and Bartlett's Sphericity Test results.

The criterion of an eigenvalue greater than 1 was taken as the basis for determining the factors. This approach is based on the assumption that the explanatory power of a factor should carry as much information as at least one variable, and it was proposed by Kaiser (1960). In this context, factors with an eigenvalue greater than 1 were included in the factor structure, and others were excluded from the evaluation. In order to make the factors easier to interpret, the Varimax rotation method was used, and the value of 0.40 was taken as the lower limit of the factor loadings in order to evaluate whether the items were significantly loaded on a particular factor. This threshold is a criterion that is widely accepted in the literature that factor loadings between 0.30–0.40 can be considered as threshold values (Hinkin, 1995; Costello & Osborne, 2005; Hair et al., 2009; Tabachnick & Fidell, 2007; Howard, 2016).

Cronbach's Alpha coefficient was calculated to determine the reliability of the data set. Cronbach's Alpha (α) is a widely used reliability measure to determine the overall internal consistency of scales created with items containing continuous, ordinal, or multiple-choice responses (Cronbach, 1951; Bonett & Wright, 2015; Özdamar, 2017). This coefficient varies between 0 and 1, and while it is understood that the items measure the same structure as the value increases, it shows that some or all of the items do not measure the same dimension when it approaches 0 (Bujang et al., 2018). It is accepted that this value indicates "acceptable" reliability between 0.70–0.79, "good" between 0.80–0.89, and "excellent" reliability between 0.90–1.00 (Sarmento & Costa, 2019). In the final stage, the factors are named. In this process, the content and semantic integrity of the items are taken into account by considering the items concentrated in each factor, and meaningful names are given to the factors.

RESULTS and DISCUSSION

Information on the demographic characteristics of the students participating in the study is presented in Table 1. Men constitute 61.1% of the total 208 students, and women constitute 38.9%. When the age groups of the participants were examined, it was determined that 35.6% were in the 18–21 age range, 33.2% were in the 22–24 age range, and 31.3% were 25 years and older. The average age of the participants was calculated as 26.45. When the distribution of fathers' occupations was examined, it was seen that 26.4% of the students' fathers were retired, 23.1% were private sector employees, 22.6% were farmers, and 22.6% were civil servants; 5.3% were workers. This distribution shows that rural and urban occupational groups are represented in a balanced way. When the distribution of students by departments was examined, it was determined that 26.0% were studying in the Department of Agricultural Economics, 24.0% in the Department of Horticulture and Field Crops, 14.4% in the

Department of Plant Protection, 13.0% in the Department of Biosystems Engineering, 12.5% in the Department of Soil Science and Plant Nutrition, and 10.1% in the Department of Animal Science.

Table 1. General information about the participants
Çizelge 1. Katılımcılara ait genel bilgiler

Gender		**N**	**%**
Male		127	61,1
Female		81	38,9
Total		208	100,0
Age group	**Average Age**	**N**	**%**
18-21	20,49	74	35,6
22-24	22,84	69	33,2
25 and over	37,08	65	31,3
Total	26,45	208	100,0
Father Occupation		**N**	**%**
Farmer		47	22,6
Civil servant		47	22,6
Private sector		48	23,1
Retired		55	26,4
Worker		11	5,3
Total		208	100,0
Department		**N**	**%**
Garden-Field		50	24,0
Plant protection		30	14,4
Agricultural economics		54	26,0
Biosystems		27	13,0
Soil science and plant nutrition		26	12,5
Animal science		21	10,1
Total		208	100,0

In this study, which aims to analyze students' attitudes towards digitalization in agriculture and the factors affecting these attitudes, the suitability of the data set for factor analysis was evaluated first. In this context, the Kaiser-Meyer-Olkin (KMO) test to measure the adequacy of the sample size and Bartlett's Sphericity Test, which tests the level of relationship between the variables, were applied. According to the results of the analysis, the scale was found to be suitable in terms of structural validity, and the relevant findings are given in Table 2.

Table 2. Kaiser-Meyer-Olkin test
Çizelge 2. Kaiser-Meyer-Olkin testi

Kaiser-Meyer-Olkin measure of sampling adequacy	,950
Bartlett's test of sphericity	
Approx. Chi-Square	10339,407
Degrees of freedom	630
Significance level	,000

According to the analysis results, the KMO value was found to be 0.950. According to the criteria developed by Kaiser (1974) (KMO ≥ 0.90), this value expresses a "perfect" level of sample adequacy. The fact that the KMO value is so high indicates that the common variance between the items is sufficiently high and that the data have a very suitable structure for factor analysis. In other words, the relationships between the variables are strong, and this supports the fact that meaningful factors can be obtained as a result of factor analysis (Kaiser, 1974; Field, 2009). On the other hand, Bartlett's Sphericity Test results also reveal that the necessary preconditions for the analysis are met. As a result of the Bartlett test, $\chi^2 = 10339.407$, df = 630, and $p < .001$ were found, and these values indicate that the correlation matrix is not a unit matrix (there is no relationship between the variables) and that there are statistically significant relationships between the variables (Bartlett, 1954). In other words, it has been confirmed that there is a sufficient level of correlation between the variables in order to perform factor analysis. Similar findings are also compatible with previous studies. Costello and Osborne (2005) emphasized that a KMO value of at least 0.60 and a significant Bartlett test are a prerequisite before factor analysis. In addition, Tabachnick and Fidell (2007) stated that KMO ≥ 0.80 values indicate a "very good" and ≥ 0.90 values indicate an "excellent" level of data structure. In this context, the high KMO value and significant Bartlett test result obtained in the study

show that it constitutes an ideal basis for scaling the scale with factor analysis. Cronbach's Alpha coefficient was calculated to evaluate the reliability of the scale, and information on this is given in Table 3.

Table 3. Cronbach's Alpha Reliability Analysis Results
Çizelge 3. Cronbach Alfa Güvenilirlik Analizi Sonuçları

Cronbach's Alpha	N of Items
,971	23

As a result of the analysis, the Cronbach's Alpha coefficient calculated for the 23-item scale (α = 0.971) indicates that the scale has an excellent level of internal consistency. Mallery & George (2000) classified α ≥ 0.90 values as "excellent" level of reliability. Similarly, Nunnally (1978) and Hair et al. (2009) stated in applied studies that α ≥ 0.90 values should be preferred for high reliability. These results support that the scale used is a strong measurement tool suitable for research purposes.

A 23x23 correlation matrix consisting of 23 questions was created for factor analysis. In the analysis, three factors with eigenvalues above 1 were obtained. According to the Kaiser criterion (eigenvalue > 1), these three factors were considered significant in explaining the structure of the scale. Therefore, the results of the factor analysis were examined considering three factors. Information on this is given in Table 4.

Table 4. Determining the number of factors with eigenvalues and variance explained
Çizelge 4. Özdeğerle faktör sayısının belirlenmesi ve açıklanan varyans

Factors	Initial eigenvalues			Sum of squares			Sum of rotated squares		
	Total	Explained Variance (%)	Cumulative (%)	Total	Explained Variance (%)	Cumulative (%)	Total	Explained Variance (%)	Cumulative (%)
1	14,327	62,292	62,292	14,327	62,292	62,292	6,691	29,092	29,092
2	2,222	9,660	71,952	2,222	9,660	71,952	6,455	28,065	57,156
3	1,569	6,821	78,773	1,569	6,821	78,773	4,972	21,617	78,773
4	,852	3,706	82,479						
5	,777	3,380	85,859						
6	,443	1,928	87,787						
7	,409	1,777	89,564						
8	,351	1,527	91,090						
9	,306	1,329	92,419						
10	,254	1,106	93,526						
11	,232	1,007	94,533						
12	,180	,783	95,316						
13	,171	,744	96,060						
14	,137	,596	96,656						
15	,132	,572	97,228						
16	,123	,534	97,762						
17	,109	,475	98,237						
18	,097	,421	98,658						
19	,076	,332	98,991						
20	,071	,310	99,301						
21	,063	,274	99,575						
22	,057	,250	99,824						
23	,040	,176	100,000						

The initial eigenvalue of the first factor is 14.327, explaining 62.292% of the total variance. The eigenvalue of the second factor is 2.222, explaining 9.660% variance. The third factor explains 6.821% variance with an eigenvalue of 1.569. The contribution of the three factors to the total variance is 78.773%, which is well above the 50% threshold accepted in social sciences. In the literature, it is accepted that a total variance of 50% and above is sufficient for validity in exploratory factor analyses (Tabachnick & Fidell, 2007; Hair et al., 2009). In this context, it is understood that the scale items are strongly represented within the determined factor structure. The Varimax rotation method was applied to make the factors easier to interpret. According to the variance ratios obtained after rotation, the first factor explains 29.092%, the second factor 28.065%, and the third factor 21.617% of the variance. The rotated results show that there is no dominant factor among the factors, and the variance is distributed in a balanced way. As stated by Costello and Osborne (2005) and Hinkin (1995), the balanced rotated factor loadings

are an important indicator of structural validity. In addition, the 0.40 value was taken as the cut-off point for factor loadings, and factors were created by considering the loadings above this limit value. It is also stated in the literature that the loadings in the 0.30-0.40 range are the limit value (Hair et al., 2009; Tabachnick & Fidell, 2007).

In this regard, factor naming was carried out by considering the content and semantic integrity of the items loaded on the factors. In factor naming, the conceptual structures represented by the items were taken into account. Information on this is given in Table 5.

Table 5. Obtaining factors
Çizelge 5. Faktörlerin elde edilmesi

	Reasons for Preference	1st Factor	2nd Factor	3rd Factor
S20	Practical training on digital agriculture applications should be provided in agricultural faculties.	,845		
S19	Courses on digital agricultural technologies should be increased in universities.	,832		
S21	Learning to use digital agricultural technologies is important for my professional future.	,797		
S11	Farmers should be trained to use digital agriculture applications.	,768	,428	
S8	Farmers should be encouraged to use digital agricultural technologies.	,750	,481	
S23	If I am considering working in the agricultural sector, I have to learn to use digital agricultural technologies.	,743		
S10	The government needs to increase incentives for digitalization in agriculture.	,731	,493	
S9	Small farmers' access to digital agricultural technologies should be facilitated.	,730	,445	
S12	Agricultural policies should prioritize the widespread adoption of digital technologies.	,719	,449	
S2	Digital agriculture reduces input costs and increases profitability.		,858	
S1	Digital agricultural technologies increase agricultural productivity.		,836	
S3	Precision agriculture practices support environmental sustainability.		,835	
S6	Data analytics and artificial intelligence play a critical role in agriculture for production forecasting and disease detection.		,823	
S5	Digital irrigation systems enable more efficient use of water resources.	,429	,820	
S7	Digital agriculture technologies reduce agricultural production forecast errors and losses.		,815	
S4	The use of drones in agriculture (aerial spraying, mapping, etc.) makes agricultural production more efficient.		,753	
S15	The use of digital agricultural technologies may increase farmers' dependence on technology.			,879
S17	Digital agriculture may reduce agricultural employment and lead to unemployment problems.			,810
S16	Data sharing and digital systems in agriculture may carry security risks.			,807
S14	Digitalization in agriculture may lead to the abandonment of traditional farming methods.			,759
S18	Food security may be threatened in the future if investments are not made in digital agricultural technologies.			,730
S13	The high cost of digital agricultural technologies may put small-scale farmers at a disadvantage.			,645
S22	My university provides sufficient training in digital agricultural technologies.			,474

When the factor loading values of the items are examined, it is understood that they generally have high levels of factor loadings, and this situation supports the construct validity of the scale. The items in the first factor (S20, S19, S21, S11, S8, S23, S10, S9, S12) focus on the benefits of digital agriculture and the necessity of education and incentives. The factor loadings vary between 0.719 and 0.845, and the fact that all items take values above 0.70 indicates that the factor has high internal consistency. In particular, the expressions "Practical training on digital agriculture applications should be given in agricultural faculties" (S20, 0.845) and "Courses on digital agriculture technologies should be increased in universities" (S19, 0.832) reveal that students see digital agriculture technologies as an integral part of their professional competence and the need for applied content in education programs.

The second factor includes issues such as agricultural productivity, reducing input costs, and environmental sustainability (S2, S1, S3, S6, S5, S7, S4). The factor loadings vary between 0.753 and 0.858, and the items "Digital agriculture reduces input costs and increases profitability" (S2, 0.858) and "Digital agriculture technologies increase agricultural productivity" (S1, 0.836) stand out in particular. These findings reflect the student perception that digital technologies provide economic benefits in agricultural production and support environmental sustainability.

The third factor covers the risks and support needs regarding digital agriculture (S15, S17, S16, S14, S18, S13). Factor loadings range from 0.645 to 0.879. In particular, the statements "The use of digital agricultural technologies may increase farmers' dependence on technology" (S15, 0.879) and "Digital agriculture may reduce agricultural employment and lead to unemployment problems" (S17, 0.810) are remarkable with their high loads. Students' perception of both opportunities and threats regarding digitalization indicates that their approach to this issue is multidimensional. It is noteworthy that especially the risks of high cost, job loss, and technological dependence stand out, since digital agriculture is mostly on the agenda with its positive aspects such as production efficiency, cost reduction, and sustainability (Wolfert et al., 2017; Eryılmaz & Kılıç, 2018). However, in this study, the students' strong emphasis on risks as well as benefits reveals that the perception of digitalization is two-way. This finding is in line with Bronson (2018)'s observation that digital agriculture offers both opportunities and creates new concerns. In addition, concerns about job loss and technological dependence also reflect students' uncertainties about their professional future. The naming of the factors is clearly stated in Table 6.

Table 6. Naming of factors
Çizelge 6. Faktörlerin isimlendirilmesi

Perception of the Benefits and Training of Digital Agriculture	**Economic and Environmental Benefits of Digital Agriculture**	**Concerns About and Need for Support for Digital Agriculture**
1st Factor	**2nd Factor**	**3rd Factor**
Practical training on digital agriculture applications should be provided in agricultural faculties.	Digital agriculture reduces input costs and increases profitability.	The use of digital agriculture technologies may increase farmers' dependence on technology.
Courses on digital agriculture technologies in universities should be increased.	Digital agriculture technologies increase agricultural productivity.	Digital agriculture may reduce agricultural employment and lead to unemployment problems.
Learning to use digital agriculture technologies is important for my professional future.	Precision agriculture practices support environmental sustainability.	Data sharing and digital systems in agriculture may carry security risks.
Farmers should be trained to use digital agriculture applications.	Data analytics and artificial intelligence play a critical role in agriculture for production forecasting and disease detection.	Digitalization in agriculture may lead to the abandonment of traditional farming methods.
Farmers should be encouraged to use digital agriculture technologies.	Digital irrigation systems ensure more efficient use of water resources.	Food security may be threatened in the future if investments are not made in digital agriculture technologies.
If I am considering working in the agricultural sector, I have to learn how to use digital agriculture technologies.	Digital agriculture technologies reduce agricultural production forecast errors and losses.	The high cost of digital agriculture technologies may put small-scale farmers at a disadvantage.
The government needs to increase incentives for digitalization in agriculture.	The use of drones in agriculture (aerial spraying, mapping, etc.) makes agricultural production more efficient.	My university provides sufficient training in digital agriculture technologies.
Small farmers' access to digital agriculture technologies should be facilitated.		
Agricultural policies should prioritize the dissemination of digital technologies.		

Accordingly, the first factor was named "Perception of the Benefits and Education of Digital Agriculture." The items concentrated in this factor reveal that students have a strong perception that digital agricultural technologies should be integrated into education processes. The statements "Practical training on digital agriculture applications should be given in agricultural faculties" and "Courses on digital agriculture technologies should be increased in universities" support this trend with high factor loadings. This finding is in line with the current literature that agricultural education curricula should adapt to the digitalization process (Demirel Atasoy, 2019; Koçyiğit et al., 2024).

The second factor was named "Economic and Environmental Benefits of Digital Agriculture." The items here reflect students' perceptions that digital technologies increase agricultural productivity, reduce input costs, and support environmental sustainability. In particular, the items "Digital agricultural technologies increase agricultural productivity" and "Precision agriculture practices support environmental sustainability" stand out with high factor loadings. These findings are in line with the results emphasized by Bronson (2018) and Wolfert et al. (2017) regarding the economic and environmental contributions of digital agricultural technologies.

The third factor is grouped under the title "Concerns About Digital Agriculture and Need for Support". The items in this factor express students' concerns about the potential negative impacts of digital agriculture. Expressions such as "Digital agriculture may reduce agricultural employment and lead to unemployment problems" and "The high cost of digital agricultural technologies may put small-scale farmers at a disadvantage" show that students are aware that agricultural digitalization includes not only opportunities but also social and economic risks. These findings coincide with Koçyiğit et al. (2024)'s emphasis on socio-economic inequality risks, Xiong et al. (2020)'s emphasis on employment impacts, Nezamova & Olentsova (2022)'s emphasis on data security issues, and Baran et al. (2023)'s emphasis on cost disadvantages. In addition, the low factor loading of the statement "Our university provides sufficient training on digital agricultural technologies" is remarkable. This situation shows that the current education does not meet student expectations and indicates that innovative revisions are needed at the curriculum level.

When Tokat Gaziosmanpasa University students' risk perception is compared with the findings in the study conducted by Koçyiğit et al. (2024) in Samsun, it shows similarities, and in both studies, students strongly emphasized the risks while accepting the benefits. However, while the demands for education and applied courses are more prominent in the Tokat sample, it is seen that the economic dimension and cost factors are more dominant in the Samsun sample. This difference shows that regional conditions and curriculum differences may be effective on student perceptions. On the other hand, in the qualitative research conducted by Boz Yılmazer & Tunalıoğlu (2024) with farmers and agricultural technical personnel, similarly, high costs, infrastructure problems, and lack of education were reported as the main obstacles to the widespread adoption of digital agriculture. This situation reveals that the findings obtained through different actors (students, farmers, technical personnel) complement each other and that digital agriculture should be addressed not only with its technical but also with its socio-economic and educational dimensions. As a result, it is seen that not only technological advantages but also education, support, and adaptation dimensions should be taken into account in the digitalization dissemination process. In this context, holistic approaches that include socio-cultural and educational components, not technology-based ones, should be adopted (Reinecke & Prinsloo, 2017; Abdulai et al., 2022).

CONCLUSION

In this study, the attitudes of Tokat Gaziosmanpasa University Faculty of Agriculture students towards digitalization in agriculture were examined, and a three-dimensional structure was revealed as a result of exploratory factor analysis. The findings show that students evaluate digital agriculture together with its benefits and risks. The determination of three basic factors, namely "benefits of digital agriculture and perception towards education", "economic and environmental benefits of digital agriculture", and "concerns about digital agriculture and need for support", reveals that the perception on this issue is multidimensional. The results show that students are aware that digital agriculture technologies offer significant opportunities in terms of production efficiency, resource utilization, and environmental sustainability. However, concerns such as high costs, technological dependence, and the risk of small-scale producers falling into a disadvantaged position have also been expressed by the students. This situation indicates that socio-cultural dimensions, as well as technical and economic factors, should be taken into account in the process of adopting digital agriculture.

One of the most important findings of the study is that students strongly emphasize the need for training on digital agriculture applications. In this context, more practical courses and content on digital agriculture technologies should be added to the curricula of agricultural faculties. In this way, students' professional competencies will increase, and they will be able to contribute more effectively to the digitalization process in the sector. In addition, the joint role of public policies, universities, and the private sector is of great importance in the dissemination of

digitalization. The Ministry of Agriculture should strengthen the internet infrastructure in rural areas and provide financial support and digital literacy programs to small producers. Universities should add applied digital agriculture content to their curricula and provide students with field and laboratory experiences. The private sector, on the other hand, should develop cost-effective solutions for small and medium-sized enterprises and offer internship and application opportunities to students in cooperation with universities.

In order for digitalization to take place more effectively in the agricultural sector in the future, a strong cooperation must be established between educational institutions, public policies, and sector stakeholders. Thanks to this cooperation, the technological infrastructure in agricultural production will be strengthened, and producers' access to digital solutions will be facilitated. Students' positive attitudes towards digital agriculture will contribute to the faster and more effective adoption of these technologies in the sector. However, possible difficulties such as high investment costs, dependence on technology, and the reshaping of employment should not be ignored. At this point, financial support mechanisms and consultancy services for small-scale producers, as well as quality education to be provided in universities, will contribute to the realization of digital transformation in a more inclusive and sustainable way. Thus, institutional and sectoral support combined with students' innovative perspectives will accelerate the digitalization process of agriculture and increase the competitiveness of the country's agriculture. In addition, when compared with a similar study conducted in Samsun before, while the economic and cost dimension of digital agriculture came to the fore in the Samsun sample, demands for education and applied courses were more clearly revealed in the Tokat sample. This difference shows that regional conditions and curriculum diversity may be effective on student perceptions.

Since the study is limited to only third and fourth-grade students, the generalizability of the results is limited. Collecting data from larger samples from different universities in future studies, examining the change in students' attitudes over time with longitudinal studies, and including farmers, consultants, and policy makers in the scope of the research will contribute to the development of holistic strategies for the dissemination of digital agriculture.

ACKNOWLEDGMENTS

This study was presented as an oral presentation at the 6th International Statistics Congress held on May 14-16, 2025, and was published as an abstract in the congress proceedings.

Contribution Rate Statement Summary of Researchers

The authors declare that they have contributed equally to the article.

Conflict of Interest

The authors of the articles declare that they have no conflicts of interest.

REFERENCES

Abdulai, A.R., KC, K.B. & Fraser, E. (2022). What factors influence the likelihood of rural farmer participation in digital agricultural services? Experience from smallholder digitalization in Northern Ghana. *Outlook on Agriculture, 52*(1), 57-66. https://doi.org/10.1177/00307270221144641.

Anitei, M., Veres, C. & Pisla, A. (2020). Research on challenges and prospects of digital agriculture. *Proceedings*, *63*(1), 67. https://doi.org/10.3390/proceedings2020063067.

Aydın, N. (2022). The place of informatıon technologıes in the agrıcultural sector. *Balkan and Near Eastern Journal of Social Sciences. 8*(Special Issue), 129-135.

Baran, F.O., Kara, E., & Sürmen, M. (2023). Türkiye'de tarımda dijitalleşme sürecinde yaşanan gelişmeler. A.B. Uçak & S. Güneş Şen (Ed.), *Tarım, orman ve su bilimlerinde yenilikçi çalışmalar içinde* (s. 151-177). Duvar Yayınevi.

Bartlett, M.S. (1954). A note on the multiplying factors for various χ2 approximations. *Journal of the Royal Statistical Society. Series B (Methodological), 16*(2), 296-298. https://www.jstor.org/stable/2984057.

Bonett, D.G. & Wright, T.A. (2015). Cronbach's alpha reliability: Interval estimation, hypothesis testing, and sample size planning. *Journal of Organizational Behavior, 36*(1), 3-15. https://doi.org/10.1002/job.1960.

Boz Yılmazer, E. & Tunalıoğlu, R. (2024). Akıllı tarım uygulamalarının sektörel bakış açısıyla değerlendirilmesi. *ÇOMÜ Ziraat Fakültesi Dergisi*, *12*(1), 55-66. https://doi.org/10.33202/comuagri.1469974.

Bronson, K. (2018). Smart farming: Including rights holders for responsible agricultural innovation. *Technology Innovation Management Review, 8*(2), 7-14. http://doi.org/10.22215/timreview/1133.

Brown, J.D. (2009). Principal components analysis and exploratory factor analysis-Definitions, differences and choices. *Shiken: JALT Testing & Evaluation SIG Newsletter, 13*(1), 26-30.

Bujang, M.A., Omar, E.D. & Baharum, N.A. (2018). A review on sample size determination for Cronbach's alpha

test: a simple guide for researchers. *The Malaysian Journal of Medical Sciences: MJMS, 25*(6), 85-99. https://doi.org/10.21315/mjms2018.25.6.9.

Cronbach, L.J. (1951). Coefficient alpha and the interval structure of tests. *Psychometrika, 16*(3), 297-334. https://doi.org/10.1007/BF02310555.

Costello, A.B. & Osborne, J.W. (2005). Best practices in exploratory factor analysis: Four recommendations for getting the most from your analysis. *Practical Assessment, Research & Evaluation, 10*(7), 1-9. https://doi.org/10.7275/jyj1-4868.

Çakır, A. (2014). *Faktör Analizi*, İstanbul Ticaret Üniversitesi Sosyal Bilimler Enstitüsü (Doctoral dissertation, Doktora Tezi).

Daponte, P., De Vito, L., Glielmo, L., Iannelli, L., Liuzza, D., Picariello, F. & Silano, G. (2019). A review on the use of drones for precision agriculture. *IOP Conference Series: Earth and Environmental Science, 275*(1), 012022. https://doi.org/10.1088/1755-1315/275/1/012022.

Demirel Atasoy, Z., Velioğlu, H., İlter, S., Gez, M. & Koç, C. (2019*). Türkiye'de akıllı tarımın mevcut durum raporu*. Tarım ve Orman Bakanlığı, Bitkisel Üretim Genel Müdürlüğü. https://tarmakbir.org/wp-content/uploads/2022/07/akillitarimrapor01.pdf.

Demiryürek, K., Köksal, Ö. & Kawamorita, H. (2021). *Acceleration of digital transformation in agriculture sector for ensuring sustainable food security* (p. 93). Ankara: COMCEC and Ministry of Agriculture and Forestry.

Dibbern, T., Romani, L.A.S. & Massruhá, S.M.F.S. (2024). Main drivers and barriers to the adoption of Digital Agriculture technologies. *Smart Agricultural Technology*, *8*, 100459. https://doi.org/10.1016/j.atech.2024.100459.

Eastwood, C., Klerkx, L., Ayre, M. & Dela Rue, B. (2019). Managing socio-ethical challenges in the development of smart farming: from a fragmented to a comprehensive approach for responsible research and innovation. *Journal of agricultural and environmental ethics*, *32*(5), 741-768. https://doi.org/10.1007/s10806-017-9704-5.

Eryılmaz, G.A., & Kılıç, O. (2018). Türkiye'de sürdürülebilir tarım ve iyi tarım uygulamaları. *Kahramanmaraş Sütçü İmam Üniversitesi Tarım ve Doğa Dergisi, 21*(4), 624-631.

Field, A. (2009). *Discovering Statistics Using SPSS.* 3rd Edition, Sage Publications Ltd., London.

Göl, B. & Tarhan, Ç. (2024). The challenges of digitalization in agriculture and digital agriculture in the EU climate policy. *Journal of Information Systems and Management Research*. *6*(1), 127-134. https://doi.org/10.59940/jismar.1504821.

Hair, J.F., Black, W.C., Babin, B.J. & Anderson, R.E. (2009). *Multivariate data analysis* (7th ed.). Prentice-Hall.

Hinkin, T.R. (1995). A review of scale development practices in the study of organizations. *Journal of Management, 21*(5), 967-988. https://doi.org/10.1177/014920639502100509.

Howard, M.C. (2016). A review of exploratory factor analysis decisions and overview of current practices: What we are doing and how can we improve? *International Journal of Human-Computer Interaction, 32*(1), 51-62. https://doi.org/10.1080/10447318.2015.1087664.

IBM Corp, (2009). *IBM SPSS Statistics for Windows, Version 18.0*. Armonk, NY: IBM Corp.

Izquierdo, I., Olea, J. & Abad, F.J. (2014). Exploratory factor analysis in validation studies: Uses and recommendations. *Psicothema, 26*(3), 395-400. https://doi.org/10.7334/psicothema2013.349.

Kaiser, H.F. (1960). The application of electronic computers to factor analysis. *Educational and Psychological Measurement, 20*(1), 141-151. https://doi.org/10.1177/001316446002000116.

Kaiser, H.F. (1974). An index of factorial simplicity. *Psychometrika*, *39*(1), 31-36. https://doi.org/10.1007/BF02291575.

Kamilaris, A., Fonts, A. & Prenafeta-Boldύ, F. X. (2019). The rise of blockchain technology in agriculture and food supply chains. *Trends in food science & technology*, *91*, 640-652. https://doi.org/10.1016/j.tifs.2019.07.034.

Karpati, L., & Szakal, Z. (2009). Marketing characteristics of Tokaj wine specialities based on factor and cluster analyses. *Applied Studies in Agribusiness and Commerce, 3*(3-4), 93-101. https://doi.org/10.19041/APSTRACT/2009/3-4/20.

Koçyiğit, A.Y., Abacı, N.İ., Demiryürek, K. & Demir, H. (2024). A research on determining the attitudes of Ondokuz Mayıs University Faculty of Agriculture students towards digitalization in agriculture. *Tarım Ekonomisi Araştırmaları Dergisi (TEAD), 10*(2), 186-200. https://doi.org/10.61513/tead.1573312.

Kurtuluş, K. (2004). Pazarlama Araştırmaları (Genişletilmiş 7. Baskı, s. 397-418), Literatür Yayınları, İstanbul.

Lazebnyk, L.L. & Voitenko, V.O. (2021). Digital technologies in agricultural enterprise management. *Financial and Credit Activity: Problems of Theory and Practice, 6*(41), 203-210. https://doi.org/10.18371/fcaptp.v6i41.251440.

Lloret, S., Ferreres, A., Hernandez, A. & Tomas, I. (2017). The exploratory factor analysis ofitems: Guided analysis based on empirical data and software. *Anales de Psicologia, 33*(2), 417-432. http://dx.doi.org/10.6018/analesps.33.2.270211.

Mallery, P. & George, D. (2000). SPSS for windows step by step. Allyn & Bacon, Inc.

Marofi, Z., Bandari, R., Heravi-Karimooi, M., Rejeh, N. & Montazeri, A. (2020). Cultural adoption, and validation of the Persian version of the coronary artery disease education questionnaire (CADE-Q):a second-order confirmatory factor analysis. *BMC Cardiovascular Disorders, 20*(1), 1-9. https://doi.org/10.1186/s12872-020-01628-5.

Nezamova, O.A. & Olentsova, J.A. (2022). The main trends of digitalization in agriculture. *IOP Conference Series: Earth and Environmental Science, 981*(3), 032018. https://doi.org/10.1088/1755-1315/981/3/032018.

Nikkhah, M., Heravi-Karimooi, M., Montazeri, A., Rejeh, N. & Sharif Nia, H. (2018). Psychometric properties the Iranian version of older People's quality of life questionnaire (OPQOL). *Health and Quality of Life Outcomes, 16*(1), 1-10. https://doi.org/10.1186/s12955-018-1002-z.

Nunnally, J.C. (1978). *Psychometric theory* (2nd ed.). New York: McGraw-Hill.

Özdamar, K. (2017). *Statistiksel veri analizi: SPSS ile uygulamalar*. Nobel Yayıncılık.

Reinecke, M. & Prinsloo, T. (2017). The influence of drone monitoring on crop health and harvest size. *In 2017 1st International Conference on Next Generation Computing Applications* (p. 5-10). https://doi.org/10.1109/NEXTCOMP.2017.8016168.

Sarmento, R.P. & Costa, V. (2019). Confirmatory factor analysis-a case study. (arXiv preprint arXiv:1905.05598). https://doi.org/10.48550/arXiv.1905.05598.

Shrestha, N. (2020). Detecting multicollinearity in regression analysis. *American Journal of Applied Mathematics and Statistics, 8*(2), 39-42. https://doi.org/10.48550/arXiv.1905.05598.

Tabachnick, B.G. & Fidell, L.S. (2007). Using multivariate statistics (5th ed.). *New York: Allyn and Bacon.*

TBRC, (2024). Digital agriculture global market report 2024. The Business Research Company. https://www.thebusinessresearchcompany.com/report/digital-agriculture-global-market-report. (Accessed 03 Mar 2025)

Tekinarslan, E. (2008). Faculty of education students' attitudes toward internet and implications for online learning. *Abant İzzet Baysal Üniversitesi Eğitim Fakültesi Dergisi*, *8*(1), 69-85.

Zhang, Q. (2016). Precision agriculture technology for crop farming (p. 374). Taylor & Francis. https://doi.org/10.1201/b19336.

Xiong, H., Dalhaus, T., Wang, P. & Huang, J. (2020). Blockchain technology for agriculture: Applications and rationale. *Frontiers in Blockchain, 3.* https://doi.org/10.3389/fbloc.2020.00007.

Watkins, M.W. (2018). Exploratory factor analysis: A guide to best practice. *Journal of Black Psychology*, *44*(3), 201-246. https://doi.org/10.1177/0095798418771807.

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.