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# Measuring the Level of Digitalization in Agriculture: Identification Indicators and Scaling to Determine the Digitalization Level of Farmers

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ABSTRACT

Technological developments have accelerated the use of information and communication technologies in the agricultural sector as in all other sectors. However, there is still a lack of information in the literature on measuring the level of digital technology usage by farmers. This study will help to eliminate the lack of information on the indicators and their weights that can be used to determine the level of digitalisation of farmers. The aim of the study is to determine the indicators to be used in measuring the level of digital technology use, the sub-dimensions of these indicators, and the weights of these indicators. The constant-sum scale and expert opinions were used to determine the indicators and their weights to be used in measuring the level of digitalisation. The level of agreement of the opinions expressed by different experts about different digitalisation level indicators and their weights was revealed with the help of Kendall's Coefficient of Concordance. The study results showed that the indicators of internet access facilities, internet speed, smartphone ownership, mobile internet usage, and the ability to use office programs are important variables in measuring the level of digitalisation. The study determined eight main indicators to measure the level of digitalisation and 96 indicators under them, and their weights were put forward. By using the digitalisation indicators and their weights, it will be possible to measure the level of digitalisation in agricultural enterprises reliably.

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## Introduction

Technological developments until today have affected agriculture and agricultural production systems, albeit relatively late. At the point reached today, although it is possible to use technologies that allow obtaining more products from much less area, there are important concerns about sustainability. Especially in recent years, negativities such as drought caused by climate change, destructive natural disasters, biodiversity destruction and natural resource erosion, agricultural migration, aging in agricultural population, and global epidemics deepen these concerns.

In addition to the negativities in the food supply, the demand pressure created by the increasing world population forces countries to seek new policies. At this point, one of the most prominent approaches is integrating the new generation of digital Technologies into the agricultural system, ensuring maximum benefit from the power of information and data. At this point, another important point is to focus on the correct and most suitable technological methods for geography by effectively processing ancient knowledge in agriculture.

The use of technology in agriculture has been developing since the existence of humanity. The transition to settled life took a certain process, and human beings started to focus on developing new techniques to meet their nutritional needs. With this process, in parallel with the development of the industry, the transition from labor-intensive production to technology-intensive production accelerated.

This process is schematized as a process shaped by the impact of industrial development, extending from Agriculture 1.0 to Agriculture 4.0. The period from when farmers used tools such as sickle, hoe, and pitchfork, which were largely ancient practices, until the end of the 19th century, when they started using agricultural machinery, is called Agriculture 1.0 (Liu Y. et al., 2021) .

The most basic feature of the period in which the first transformation, called Agriculture 1.0, was experienced is that it had a labor-intensive mode of production with low productivity. By the late 1950s, synthetic pesticides, fertilizers, and more effective machinery had reduced production costs and thus entered the era of Agriculture

2.0, called the Green Revolution. Efficiency increased thanks to cheap inputs and new tools. The Agriculture 3.0 process, which started in the 1990s with the use of GPS signals by everyone, is now more commonly referred to as "Precision Agriculture". Thanks to GPS technology, manual guidance, variable rate systems applied to the harvesting machines and especially the tracking of the fertilization process are the main technologies applied in this period. With precision farming methods, tracking and solutions specific to each parcel of the land or each animal in the herd are offered, and the process is managed more effectively by reducing production costs (Anonymous 2020).

Finally, since the 2010s, developing sensor technologies, high bandwidth in cell communication, cloud-based systems, and big data analytics have pioneered agricultural applications. The Internet of Things (IoT), one of the most important technologies of Industry 4.0, is the main component of agricultural applications within the scope of Agriculture 4.0. The raw data collected by various sensors is transmitted to the cloud placed in the product area. With sensor technology, information such as the type of fertilizer they need to use, soil condition, irrigation and mineral amount, estimated harvest time, and weather conditions are provided to the farmer, helping them to take optimum decisions for production, thus both resource management is optimized and productivity advantages are provided (Ateş and Şahin, 2021).

As of the period we are in today, the above-mentioned technological development stages have evolved to a completely different point. In the 1950s, agricultural mechanization was understood by the expression of agricultural technology. Nowadays, we encounter many issues such as information and communication technologies, digitalization, smart agriculture, the internet of things, variable rate systems, sensor Technologies, and even business management over mobile phones. This situation imposes the responsibility of catching up with the times by developing a new perspective and producing the right policies for the countries that have an important place in agriculture in their economy. Developing the right policies is to present the current situation with correct and scientific foundations. In this respect, it is extremely important to determine the digitalization level of an agricultural producer and the areas open to development. Despite this importance, there are not enough academic studies in the context of measuring the level of digitalization of farmers who produce agricultural products. To date, some studies have been carried out to reveal the level of digitalization in the production of agricultural products in the world (Kumar, R. 2013 Olaniyi E. 2018, Zhan, A., Jakku E. 2018). However, there is still a significant knowledge gap in this area. There is not yet a scale that can be used everywhere to measure farmers' digitalization level, especially considering smart and precision agriculture technologies. The few studies conducted so far have used different indicators and weights, and it has not yet been tested whether they can be used in other places. The same is valid for Turkey. Although there are some studies (Erdal and Çallı, 2013, Gülter et al., 2018) to reveal the digitalization level of farmers in terms of some indicators, no study has been found to date that addresses the level of digitalization in all its aspects and measures the level of digitalization. For this purpose, there is no scale that can be used in Turkey with proven validity and reliability. The knowledge gap on this subject has led this study to focus on measuring the level of digitization in agriculture. For this reason, the aim of this study is to reveal the indicators to be used in the measurement of the level of digital technology use in agricultural enterprises, together with their sub-dimensions, and to determine the weights of these indicators. The study was carried out within the scope of the doctoral project titled "Determination of Digital Technology Usage Level of Farmers within the Scope of E-agriculture and Developing Policy Suggestions (Example of Konya Province)" and the findings will be used in field studies and analyzes.

## Material and Method

The material of the study consists of the data obtained through a questionnaire from a group of 40 experts, which was formed by considering the topics within the scope of digitalization in agriculture. While determining the experts, digitalization indicators (Table 1) compiled from the literature were taken into account. There are multiple definitions for digitalization in agriculture, and detailed information is available for each in the literature. While determining the indicators, digital technologies and applications focused on Digital Agriculture, Precision Agriculture, Smart Agriculture, Agriculture 4.0 and E-agriculture approaches were taken into account. In addition to the information gathered from the literature, aspects such as the participation of farmers in online meetings, their knowledge of risks originating from the internet, and their application to public institutions online or via telephone were included in the evaluation and 96 indicators were used.

While determining the experts, the previously determined indicators were taken into account. In this context, an informatics expert from the Information Technologies and Communication Presidency, the institution responsible for the internet infrastructure, has been included in the list of experts. In addition, experts from the General Directorate of Information Technologies affiliated with the Ministry of Agriculture and Forestry were included in the list. The opinions of experts from the Education and Publication Department of the Ministry of Agriculture and Forestry, which works on accessing information with digital means, were consulted. In terms of agricultural electronic commerce, which is an important topic for the level of digitalization, the experts' evaluations were taken from the Ministry of Agriculture and Forestry Marketing Department.

Digitalization manifests itself in many sub-activity branches of agricultural production. These areas can be summarized as irrigation, fertilization, plant protection, mechanization and cultivation. Considering these activities, public administrators and researchers in field crops, horticultural crops, animal husbandry, beekeeping, phytosanitary, irrigation, plant nutrition and mechanization were included in the list. On the other hand, many experts from universities, research institutes, the private sector, and public institutions in smart and precision agriculture technologies have been involved in the process.

Table 1. Indicators Used in Determining the Digitization Level of Farmers

| Indicators | Source |
|---|---|
| Smartphone ownership<br>Classic phone ownership<br>Computer ownership<br>Tablet ownership<br>Have an active internet subscription<br>Ability to make basic adjustments to the computer (sound, screen, etc.)<br>Creating folders and sorting files<br>File compression or decompression<br>Being a member of discussion sites and participating in discussions<br>Deciding on the computer and hardware needed<br>Ability to download files or applications from the Internet<br>Follow-up of social media accounts such as Facebook, Instagram for agricultural purposes<br>Following TV channels operating in the field of agriculture | (Gülter et al., 2018) |
| Ability to transfer files between mobile phone and digital technologies (such as smartphone-computer)<br>Cell phone, camera, etc. the ability to connect and use devices to a computer<br>Ability to use external storage devices (cd, harddisk, flashdisk, floppy disk etc.)<br>Ability to video chat<br>Ability to use instant messaging technologies (such as Whatsapp, Line, Skype)<br>Ability to use social networking tools (such as Facebook, Twitter)<br>Applying to Google, Youtube and similar websites<br>Ability to use search engines (such as Google, Yandex)<br>Watching movies/series with mobile phone<br>Ability to play online games<br>Ability to set up and adjust equipment such as scanners and printers<br>Ability to use office programs (Word, Excel, PPT)<br>Online shopping<br>Ability to listen to music from mobile phone<br>Ability to use e-mail<br>Navigating web pages | (Sulak, 2019) |
| Use of an application that monitors irrigation / fertilization, etc. via smartphone<br>Downloading apps to mobile phone<br>Ability to use mobile phone application in accordance with its purpose | (Hacıyusufoğlu and Güler, 2015) |
| Using the calculator on my mobile phone<br>Capable of taking videos/photos with a mobile phone<br>Ability to send SMS<br>Ability to read SMS<br>Making calls with my mobile phone<br>Following internet-based agricultural TV channels (Agricultural TV etc.)<br>Home phone ownership<br>Laptop ownership<br>Obtaining technical information via e-mail<br>Ability to perform online transactions such as hospital, banking and hotel reservations<br>Communicating with experts with Whatsapp etc applications<br>Obtaining agricultural information via SMS via mobile phone<br>Ability to monitor the market over the Internet<br>Ability to market products online<br>Purchasing agricultural inputs via the internet<br>Applying to Google, Youtube and similar sites | (Awol, 2020) |
| TV ownership<br>Radio ownership | (Altın and Demiryürek, 2016) |
| Use of tablets for agricultural purposes | (Klavuz and Erdem, 2019) |
| Use of drones for security and other monitoring purposes<br>Use of drones for precision agriculture (supply of visual/phenological data) | (Panday, 2017) |
| Use of robots for agricultural purposes (irrigation, fertilization, planting, etc.) | (Nedumaran and Manida, 2020) |
| Sensor usage (humidity sensor, light sensor, color sensor) | (Santha Sheela, 2019) |
| Use of sensor mechanization | (Bach, 2018) |
| Using GPS | (Andrade and Heun, 2010) |
| Use of autonomous tractors<br>Computer aided spraying (variable ratio spraying equipment)<br>Computer aided fertilization (variable rate fertilization equipment)<br>Use of ISO-BUS | (Türker et al., 2015) |
| Using a smart irrigation system | (Radhi, 2017) |
| Use of smart greenhouse systems | (Oz et al., 2008) |
| Use of computerized weighing systems | (Yıldız and Ozgüven, 2018) |
| Software usage (production planning, product recipes, waste tracking, accounting etc.) | (Schönfeld et al., 2018) |
| Use of phytosanitary early warning system | (Canhilal and Tiryaki., 2010) |
| Use of pedometer<br>Use of herd tracking software<br>Using the milking robot | (Gündüz and Akyüz, 2017) |
| Adequacy of access to home internet service<br>Adequacy of access to mobile internet service<br>Satisfaction with home internet speed<br>Satisfaction with mobile Internet speed<br>Use of applications that provide consultancy services via mobile phone | (Saçtı et al., 2019) |
| Ability to make transactions from mobile via e-government | (Tunç et al., 2017) |

In order to include the farmers' evaluations regarding the indicators, the farmers, the managers of the leading farmer associations, the Agricultural Credit Cooperatives and Chambers of Agriculture representatives were also included in the list. On the other hand, the opinions of experts involved in the management and implementation stages of the "National E-Agriculture Strategy within the Scope of Agriculture 4.0" prepared in 2021 were consulted.

In the study, a list of indicators to be used to measure the digitalization level of farmers was sent to the experts and they were asked to allocate one hundred points among the indicators. Experts punctuated eight main dimensions and sub-indicators respectively. The weights of each indicator were calculated using the Constant-Sum scale (Altunışık R. et al., 2022) with the data obtained from the experts. Then, Kendall's coefficient of concordance (W) was used to determine the agreement between the experts scores. Kendall's coefficient of concordance (W), proposed by Maurice G. Kendall and Bernard Babington Smith, is a measure of fit between several (m) quantitative or semi-quantitative variables that evaluate a set of objects of interest. In the social sciences, the variables are usually subject experts who evaluate different topics or situations (Jeevanand 2020). Kendall's coefficient of concordance (W) is a non-parametric statistic. It is used to evaluate the agreement between experts and ranges from 0 to 1. Zero indicates no agreement among experts, and 1 indicates excellent agreement. The SPSS package program was used to calculate Kendall's coefficient of concordance (W). Whether Kendall's coefficient of concordance (W) is statistically significant was determined by hypothesis testing and the following initial and alternative hypotheses were used.

$H_0$: W = 0 (no agreement among experts' opinions)
$H_1$ W ≠ 0 (there is agreement among experts' opinions).

The results of the analysis showed that Kendall's coefficient of concordance (W) was 0.26 and was statistically significant ($P<0.01$). Kendall's coefficient of concordance (W) indicates an acceptable level of agreement between expert opinions.

## Research Findings

For digitalization in agriculture, there are many references to information communication technologies under the headings of precision agriculture, agriculture 4.0, smart agriculture, digital agriculture and e-agriculture. In the study, the technologies that each approach focuses on were taken into account and the indicators that are descriptive of the digitalization level of farmers engaged in crop production were collected under eight main headings. As a result of the evaluations of the experts, it has been determined that the most prominent digitalization dimension in revealing the digitalization level of the farmers is the use of the internet via mobile phones (Table 2).

### *Internet Access Opportunities*

One of the most important indicators of digitalization in agriculture is access to the internet. At this point, it is necessary to consider two issues separately. First of all, the existence of internet infrastructure in production areas is very important. Issues such as access to information, access to public services over the internet, electronic commerce and the use of smart/precise agricultural technologies are directly dependent on internet infrastructure in agricultural production regions.

It is very important to consider the internet infrastructure not only in terms of cable internet but also mobile internet. As a matter of fact, mobile internet infrastructure is needed for early warning systems, decision support systems and variable rate applications. On the other hand, internet infrastructure alone is not sufficient for digital agriculture. Internet speed and stability are also extremely important in both home internet service and mobile internet service. In this respect, satisfaction with the internet infrastructure and internet speed was taken into account in scaling the digitalization levels of farmers. As a result of the study, the experts evaluated the adequacy of access to mobile internet service as the most important parameter under this title (Table 3).

### *Ownership of Communication Tools*

One of the prominent issues when evaluating the level of digitalization in agriculture is the ownership of information and communication tools. When the evaluations of the experts on these parameters, which are important in terms of access to information, are examined, it is seen that the status of having a smart phone stands out, while the farmers' having a radio, classical mobile phone and the home phone remained at a lower level. As a matter of fact, the increasing habit of using smartphones in recent years highlights the use of smartphones in terms of access to information (Table 4).

### *Mobile Phone (smart/classic) use*

Mobile phones play an important role in accessing information in agriculture. This field, expressed as m-agriculture in the literature and a sub-branch of e-agriculture, covers all portable devices, such as tablet devices, smart phones and mobile phones, which provide agricultural services through mobile communication technologies (Hacıyusufoğlu AF, Güler E., 2015).

Table 2. Indicators and Weights Used in Determining the Digitization Level of Farmers

| Digitization Level Basic Dimensions | Weight (%) |
|---|---|
| Internet use via mobile phone | 15.80 |
| Mobile Phone (smart/classic) Usage | 14.70 |
| Use of Smart Agriculture Applications | 13.55 |
| Internet Access Opportunities | 13.50 |
| Use of Information and Communication Technologies for Agricultural Purposes | 12.85 |
| Ownership of Communication Tools | 11.53 |
| Computer Usage Skill | 9.50 |
| Internet Usage from Computer | 8.57 |
| Total | 100.00 |

Table 3. Sub-Indicators and Weights of Basic Dimension of Internet Access Facilities

| Sub indicators | Weight (%) |
|---|---|
| Adequacy of Access to Mobile Internet Service | 5.03 |
| Satisfaction with Mobile Internet Speed | 3.57 |
| Adequacy of Access to Home Internet Service | 2.92 |
| Satisfaction with Home Internet Speed | 1.98 |

Table 4. Sub-Indicators and Weights of the Basic Dimension of Ownership of Communication Tools

| Sub indicators | Weight (%) |
|---|---|
| Smartphone ownership | 2.90 |
| TV ownership | 1.80 |
| Have an active internet subscription | 1.77 |
| Laptop ownership | 1.41 |
| Computer ownership | 1.32 |
| Tablet ownership | 0.83 |
| Radio ownership | 0.69 |
| Classic phone ownership | 0.45 |
| Home phone ownership | 0.36 |

Table 5. Sub-Indicators and Weights of Cell Phone Usage Baseline Dimension

| Sub indicators | Weight (%) |
|---|---|
| Making calls with my mobile phone | 2.29 |
| Ability to use mobile phone application in accordance with its purpose | 1.71 |
| Ability to use instant messaging technologies (whatsapp etc.) | 1.61 |
| Ability to video chat | 1.34 |
| Capable of taking videos/photos with a mobile phone | 1.28 |
| Ability to add contacts to mobile phone | 1.08 |
| Ability to transfer files between mobile phone and digital technologies (such as smartphone-computer) | 0.99 |
| Ability to read sms | 0.95 |
| Downloading apps to mobile phone | 0.86 |
| Ability to send sms | 0.76 |
| Using the calculator on my mobile phone | 0.70 |
| Ability to listen to music from mobile phone | 0.63 |
| Watching movies/series with mobile phone | 0.50 |

On the other hand, sms, whatsapp and similar instant messaging technologies, which are sub-service forms of mobile phones, are very important in terms of delivering information to the masses quickly. In this context, when we look at the expert evaluations, the ability to make calls with a mobile phone, to use a mobile phone application in accordance with its purpose, to use instant messaging technologies (such as whatsapp, line, skype) and to make video calls were evaluated by the experts as important sub-indicators in revealing the digitalization levels of the farmers. Table 5).

***Use of Computer***

As an economic sector, agriculture is information-intensive in the production, logistics processes and marketing phases. The computer skills of the farmers are very important in terms of both accessing information and using the information in decision-making processes. In this respect, as in all other business lines, computer technologies provide a competitive advantage in agriculture. In particular, it will provide important gains in the digital age for farmers to improve themselves in the use of computers in order to collect, store and process production records in the digital environment.

In the agricultural sector, where the education level is relatively low in Turkey, it is important to take action to increase the use of computers in terms of increasing productivity and quality and in terms of the efficiency of production decisions. Farmers' knowledge of computer use in terms of software and hardware, as well as their internet usage habits in general, was considered important in terms of measuring the level of digitalization and was presented to experts for evaluation. In the evaluation made by experts, the ability to use office programs (Word, Excel, PPT) was important, while skills such as creating folders and sorting files and compressing or opening files were found to be relatively less important (Table 6).

***Using Internet***

Another topic that can be used to measure digitalization in agriculture is the use of the internet. It is important to address internet use not only in agricultural areas but also in non-agricultural areas. As a matter of fact, the capacity of a farmer in general internet use will accelerate the adaptation process to internet use in agricultural areas. At this point, one of the most important issues is the changing internet usage habits with the widespread use of smart phones. In this respect, in this study, internet usage habits over the computer and mobile phone were handled separately, and access to the internet with these two methods was examined with separate parameters in terms of the level of digitalization. In the evaluation by the experts, internet use via mobile phone was more important than internet use via computer (Table 7).

***Use of Information and Communication Technologies (ICT) for Agricultural Purposes***

In parallel with the developments in information and communication technologies, some digital services have started to be used in agricultural areas. Internet use is one of the prominent topics, especially in terms of accessing information on agricultural issues. In this context, the use cases of google, youtube, social media platforms, and internet-based agricultural television channels are discussed. The digitalization habits of farmers were evaluated on issues such as using applications that provide consultancy services over mobile phones, obtaining agricultural information through virtual classrooms, and participating in agricultural online discussion platforms. On the other hand, topics such as agricultural electronic commerce, obtaining information via e-mail/whatsapp/sms, obtaining information from public institutions via telephone and internet, and obtaining information from non-internet-based TV channels were evaluated by experts. In the evaluations by experts, while marketing products over the internet, the use of applications that provide consultancy services over the mobile phone, the supply of inputs over the internet and the monitoring of agricultural social media platforms were seen as important parameters for the evaluation of digitalization, obtaining agricultural information via sms via mobile phone was seen as less important (Table 8).

***Smart Agricultural Practices***

The developments in the industry have had a significant impact on the agricultural technologies used in the agricultural sector. Especially the developments in precision agriculture technologies have enabled the use of sensors in agriculture, the use of drones, the use of robotic applications, and the spread of IoT technologies.

Table 6. Sub-Indicators and Weights of the Computer Use Baseline Dimension

| Sub indicators | Weight (%) |
|---|---|
| Ability to use office programs (word, excel, ppt) | 1.92 |
| Cell phone, camera, etc. the ability to connect and use devices to a computer | 1.19 |
| Ability to make basic computer adjustments (sound, screen, etc.) | 1.14 |
| Ability to use external storage devices (cd, harddisk, flashdisk, floppy disk etc.) | 1.09 |
| Ability to set privacy and security settings | 1.03 |
| Deciding on the computer and hardware needed | 0.93 |
| Ability to set up and adjust equipment such as scanners and printers | 0.84 |
| Creating folders and sorting files | 0.83 |
| File compression or decompression | 0.53 |

Table 7. Sub-Indicators and Weights of the Internet Usage Baseline Dimension

| Sub indicators | Weight (%) |
|---|---|
| Ability to use search engines (google, yandex, etc.) via mobile phone | 2.07 |
| Navigating web pages via mobile phone | 1.50 |
| Making e-government transactions via mobile phone | 1.41 |
| Ability to use social networking tools (facebook, twitter, etc.) via mobile phone | 1.41 |
| Participating in meetings with zoom, skype and similar applications via mobile phone | 1.24 |
| Ability to choose an internet service provider that suits their expectations and conditions while using the internet via a mobile phone. | 1.21 |
| Ability to make online transactions such as hospital, banking and hotel reservations via mobile phone | 1.10 |
| Ability to use e-mail via mobile phone | 1.10 |
| Online shopping via mobile phone | 1.07 |
| Ability to download files or applications via mobile phone | 1.02 |
| Ability to perform e-government transactions via computer | 0.97 |
| Ability to play online games via mobile phone | 0.94 |
| Ability to use search engines (such as google, yandex) via computer | 0.91 |
| Being informed about the risks originating from the internet while using the internet via mobile phone | 0.90 |
| Membership and participation in discussion lists via mobile phone | 0.83 |
| Participating in meetings with zoom, skype and similar applications via computer | 0.73 |
| Browsing web pages via computer | 0.70 |
| Ability to make online transactions such as hospital, banking and hotel reservations via computer | 0.68 |
| Ability to download files or applications from the Internet via a computer | 0.68 |
| Ability to use e-mail via computer | 0.66 |
| Ability to use social networking tools (such as facebook, twitter) via computer | 0.65 |
| Ability to shop online via computer | 0.63 |
| Being informed about the risks originating from the internet while using the internet via a computer | 0.58 |
| Being able to become a member of discussion sites and participate in discussions via computer | 0.51 |
| Ability to choose an internet service provider according to their own conditions while using the internet via a computer | 0.50 |
| Ability to play online games via computer | 0.40 |

Table 8. Sub-Indicators and Weights of the Basic Dimension of ICT Use in Agriculture

| Sub indicators | Weight (%) |
|---|---|
| Ability to market products online | 1.11 |
| The use of applications that provide consultancy services via mobile phone (imece mobile, hektaş smart assistant, field my mobile, field work etc.) | 1.10 |
| Purchasing agricultural inputs via the internet | 1.03 |
| Following social media accounts such as facebook and instagram for agricultural purposes | 1.00 |
| Ability to monitor the market over the Internet | 0.95 |
| Communicating with experts with Whatsapp etc applications | 0.94 |
| Asking the ministry units via digital or phone applications | 0.83 |
| Following internet-based agricultural TV channels (agricultural TV etc.) | 0.80 |
| Obtaining information through virtual classes such as zoom, skype etc. | 0.79 |
| Applying to google, youtube and similar sites | 0.78 |
| Obtaining technical information via e-mail | 0.76 |
| Making video calls with experts in agricultural matters | 0.75 |
| Following TV channels operating in the field of agriculture (Bereket TV, Farmer TV, etc.) | 0.73 |
| Taking part in online discussion platforms for agricultural purposes | 0.67 |
| Obtaining agricultural information via sms via mobile phone | 0.62 |

Table 9. Sub-Indicators and Weights of the Basic Dimension of the Use of Smart Agricultural Practices

| Sub indicators | Weight (%) |
|---|---|
| Irrigation/fertilization etc. via smartphone. tracking app usage | 0.88 |
| Use of phytosanitary early warning system | 0.83 |
| Using a smart irrigation system | 0.80 |
| Use of sensor mechanization | 0.78 |
| Use of robots for agricultural purposes (irrigation, fertilization, planting, etc.) | 0.77 |
| Use of computer aided fertilization technologies | 0.76 |
| Use of smart greenhouse systems | 0.74 |
| Sensor usage (humidity sensor, light sensor, color sensor) | 0.74 |
| Gps usage | 0.73 |
| Software usage (production planning, product recipes, waste tracking, accounting etc.) | 0.73 |
| Use of computer aided spraying technologies | 0.72 |
| Use of herd tracking software | 0.68 |
| Use of drones for precision agriculture (supply of visual/phenological data) | 0.63 |
| Use of tablets for agricultural purposes | 0.57 |
| Use of computerized weighing systems | 0.56 |
| Use of autonomous tractors | 0.56 |
| Use of drones for security and other monitoring purposes | 0.54 |
| Using the milking robot | 0.54 |
| Using iso-bus | 0.53 |
| Use of pedometer | 0.47 |

In the study, the use of smart agriculture applications specified by experts in measuring the digitalization of farmers has been examined. Although the study concentrates on the field of plant production, the technologies used by the farmers, apart from the plant production activities within the enterprise, may be an indicator of the digital predisposition of the farmers. In this respect, some smart technologies used outside of plant production have been included in the evaluation. In the evaluation made by the experts, irrigation/fertilization etc. The use of applications that monitor, the use of phytosanitary early warning systems and the use of smart irrigation systems are among the most important parameters in terms of determining the level of digitalization (Table 9).

## Conclusion and Discussion

In the study, it is seen that the use of mobile phones and the use of the internet via mobile phones stand out in terms of the main parameters in determining the digitalization levels of farmers. In the study conducted by Olaniyi (2018), it was stated that mobile phones and the internet play an important role in agricultural development. On the other hand, smart agricultural technologies emerge as prominent topics in terms of the digitalization level of farmers. In a study conducted by Himes et al. (2018), the role of big data, digital revolution, Internet of Things and sensor technologies in the agricultural sector was discussed. In this study, it is stated that next generation farm equipment with GPS and sensors, e-tablets, android-based tools that can measure and monitor crop and soil health will contribute to the growth of digital agriculture and precision agriculture.

When the situation is evaluated in terms of sub-parameters, especially the adequacy of the mobile communication infrastructure was considered important and the internet speed was also evaluated as important. In the study conducted by Himes et al (2018); It has been stated that there are some major bottlenecks to take full advantage of digital agriculture driven by big data in the developing world and these are digital literacy, Internet access and speed. In addition, in the study conducted by Kumar (2013), mobile phones were expressed as a frequently used information and communication tool in agriculture. Findings from the study and other studies in the literature show that mobile devices will gain more and more importance in agricultural production processes in the new age.

With the change in technology, some technologies have become less important and especially the developments in smart phone technology have made having a home phone and a classic mobile phone very insignificant in terms of digitalization indicators. With digitalization, new doors have been opened in accessing information, and areas such as social media platforms and discussion sites, especially instant messaging technologies, have begun to facilitate the information process of farmers. On the other hand, the habit of making agricultural trade on the internet is also an important topic for digitalization. In the study conducted by Sulak (2019), the ability to shop online was determined as an indicator for digital literacy.

The study shows that for the effective realization of digitalization in agriculture, increasing digital literacy skills, especially mobile technologies, in agricultural trade, using mechanization and access to information is a very important policy area.

## References

Altın Ö, Demiryürek K. 2016. Analysis of the Use of Information and Communication Technologies in Agricultural Extension by Members of Tokat Agricultural Growers' Associations: The Case of Tokat Province MAS Journal of Applied Sciences6(4): 844–859, DOİ: http://dx.doi.org/10.52520/masjaps.132 (Date of access: 13.03.2023)

Altunışık R, Boz H, Gegez E, Koc E, Sığrı Ü, Yıldız E, Yuksel A. 2022. Research Methods in Social Sciences - New Perspectives 1st Edition, October 2022 Page 202

Andrade P, Heun, J. 2010. Understanding Technical Terms and Acronyms Used in Precision Agriculture. The University of Arizona collage of Agriculture and Life Sciences, https://extension.arizona.edu/sites/extension.arizona.edu/files/pubs/az1534.pdf (Date of access: 13.03.2023)

Anonymous 2020. Information Technologies and Communication Institution-Smart Agriculture Report https://www.btk.gov.tr/uploads/pages/arastirma-raporlari/akilli-tarim.pdf (Date of access: 13.03.2023)

Ateş MG, Şahin Y. 2021. Evaluation of Industry 4.0 Applications for Agriculture using AHP Methodology. DOİ: https://doi.org/10.34088/kojose.768344 (Date of access: 13.03.2023)

Awol YA. 2020. Use of Mobile Technologies in Agriculture The Example of Amhara Region, Ethiopia Bursa Uludağ University Graduate School of Science Thesis. https://acikerisim.uludag.edu.tr/bitstream/11452/11604/1/10324747. pdf (Date of access: 13.03.2023)

Bach H. 2018.Sustainable Agriculture and Smart Farming.Earth Observation Open Science and https://www.researchgate.net/publication/322659995_Sustainable_Agriculture_and_Smart_Farming (Date of access: 13.03.2023)

Canhilal R, Tiryaki O. 2010. Plant protection practices in and around Kayseri: problems and solutions. Kayseri Erciyes University Journal of Science Institute 26 (2): 88-101 https://dergipark.org.tr/en/download/article-file/236257 (Date of access: 13.03.2023)

Erdal G, Çallı A. 2013. Study on Farmers' Computer and Internet Usage: The Case of Civril District of Denizli Province. Journal of Gaziosmanpaşa Scientific Research Issue 8, 71 - 81, 01.12.2013 https://dergipark.org.tr/en/pub/gbad/issue/29702/319592 (Date of access: 13.03.2023)

Gülter S, Yıldız Ö, Boyacı M. 2018. The Tendency of Farmers to Use Information and Communication Technologies: The Case of Menderes District of İzmir Province DOO: https://doi.org/10.24181/tarekoder.446332 (Date of access: 13.03.2023)

Gündüz KA, Akyüz ET. 2017. Internet of Things and Applications in the Field of Animal Husbandry Selçuk University Journal of Social and Technical Research Issue: 14, 2017, pp. 232-246 http://sosyoteknik.selcuk.edu.tr/sustad/article/view/138/111 (Date of access: 13.03.2023)

Hacıyusufoğlu AF, Güler E. 2010. Mobile Applications in Agriculture. 18th academic informatics conference proceedings book page 211. https://ab.org.tr/ab16/bildiri/77.pdf (Date of access: 13.03.2023)

Himes S, Rao P, Gouda KC, Rames KV, Rakesh R, Mohaptra GN, Roa BK, Sahoo SK, Ajilesh P. 2018 Digital revolution and Big Data: a new revolution in agriculture. Reviews Perspectives in Agriculture Veterinary Science Nutrition and Natural Resources 13(21):1-7 https://www.researchgate.net/publication/327572166_Digital_revolution_and_Big_Data_a_new_revolution_in_agriculture Erişim Tarihi: 13.03.2023 https://dergipark.org.tr/en/pub/nwsaso cial/issue/49791/511386 Access: 05.03.2023

Jeevanand 2020. Kendall's Coefficient of Concordance Dr.E.S.Jeevanand, Associate Professor Union Christian College. Aluva https://esjeevanand.uccollege.edu.in/wp-content/uploads/sites/114/2020/08/NON-PARAMTERIC-TEST-8.pdf (Date of access: 13.03.2023)

Klavuz E, Erdem İ. 2019 - Agricultural 4.0 Practices in the World and the Transformation of Turkish Agriculture 2019; 14(4):133-157.

Kumar R. 2013. İmpact of İnformation and Communation Technologies (İCTs) on Agriculture in Haryana https://krishikosh.egranth.ac.in/handle/1/5810010991 (Date of access: 13.03.2023)

Liu Y, Ma X, Shu L, Hancke GP. 2021. From Industry 4.0 to Agriculture 4.0 Current Status Enabling Technologies and_Research Challenges. IEEE Transactıons On Industrıal Informatıcs, Vol. 17, NO. 6, June 2021, https://www.researchgate.net/publication/342368607 (Date of access: 13.03.2023)

Nedumaran G, Manida M. 2020. E-Agriculture and Rural Development in India. A Journal of Composition Theory January 2020 https://www.researchgate.net/publication/338422120_EAgriculture_and_Rural_Development_in_India (Date of access: 13.03.2023)

Olaniyi E. 2018. Digital Agriculture: Mobile Phones, Internet and Agricultural Development in Africa. Actual Problems of Economics page 205-206 https://www.researchgate.net/publication/328517883_Digital_Agriculture_Mobile_Phones_Internet_and_Agricultural_Development_in_Africa (Date of access: 13.03.2023)

Öz S, Cellatoglu A, Küren E. 2008. Internet and Mobile Supported Smart Greenhouse Automation Control System Vocational Education Symposium https://www.researchgate.net/profile/Eren-Kuren (Date of access: 13.03.2023)

Panday D. 2017. Digital Farming: Fostering Young People in Agricultural Landscape World Farmers' Organization Digital Farming https://www.researchgate.net/publication/320188634 _Digital_Farming_ (Date of access: 13.03.2023)

Radhi AA. 2017. Design and Implementation of a Smart Farm System. Article in Journal of the Association of Arab Universities for Basic and Applied Sciences 24(3):227-241 December 2017 with 194 Reads https://www.researchgate.net/publication/328887603_Design_and_ Implementation_of_a_Smart_Farm_System (Date of access: 13.03.2023)

Saçtı H, Ar H, Akay M, Dellal İ, Gezici M, Aras İ, Treinen S, Selışık A, Gürbüz Ş, Sylvester G. 2019. Fao/Tur/3703 Supporting the Development of the National E-Agriculture Strategy Project Documents - Turkish National E-Agriculture Strategy Preparatory Workshop Report. https://www.tarimorman.gov.tr/tagem/belgeler/yayin/t%c3%9crk%c3%87e_ulusal%20e-tarim%20stratej%c4%b0s%c4%b0%20hazirlik%20%c3%87ali% c5%9etayi_raporu.pdf (Date of access: 13.03.2023)

Santha Sheela K. 2019. Smart farming with e: Technology. International Journal of Engineering in Computer Science (1st issue) pages 32-35 https://www.researchgate.net/publication/333566461_Smart_farming_with_e_Technology Access (Date of access: 13.03.2023)

Schönfeld M, Heil R, Bittner L. 2018. Big Data on a Farm—Smart Farming DOI: https://doi.org/10.1007/978-3-319-62461-7_12 (Date of access: 13.03.2023)

Sulak SE. 2019. Instructor Prof. Süleyman Erkam- Sulak Development of Digital Literacy Scale: Validity and Reliability Study- International Social Sciences Studies Journal SSSjournal (ISSN:2587-1587) DOI: 10.26449/sssj.1345 (Date of access: 13.03.2023)

Tunç A, Belli A, Aydoğdu Y. 2017. An Evaluation of the Ministry of Food, Agriculture and Livestock in terms of Digitalized Public Services. Süleyman Demirel University Faculty of Economics and Administrative Sciences Journal Y.2017, C.22, Kayfor15 Special Issue, p.1921-1931. https://dergipark.org.tr/en/download/article-file/1025594 (Date of access: 13.03.2023)

Türker U, Akdemir B, Topakçı M, Tekin B, Ünal İ, Aydın A, Özoğul G, Evrenosoğlu M. 2015. Advances in Precision Agricultural Technologies. Turkish Agricultural Engineering VIII. Technical Congress-2015 Page 295 https://www.researchgate.net/profile/HayrettinOkut/publication/335025628_ Tarimsal_verilerin_degerlendirlmesinde_kullanilan_veri_madenciligi_teknikleri/links/603f98f9299bf1e07854140e/Tarimsal-verilerin-degerlendirlmesinde-kullanilan-veri-madenciligi-teknikleri.pdf#page=295 (Date of access: 13.03.2023)

Yıldız AK, Özgüven MM. 2018. Precision Animal Production Practices and Applicability in Yozgat Livestock. https://www.researchgate.net/profile/Adil-Koray-Yildiz/publication/329444105 (Date of access: 13.03.2023)

Zhan A, Jakku E. 2018. Surveying the Needs and Drivers for Digital Agriculture in Australia. Farm Policy Journal | Vol. No. 15 1 | Autumn Quarter 2018 https://www.researchgate.net/publication/324486222_Surveying_the_needs_and_drivers_for_digital_agriculture_in_Australia (Date of access: 13.03.2023)