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Evaluation of Information and Communication Technology Utilisation in Turkish Agriculture

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Abstract

This paper aims to reflect on the current state of digital transformation in Turkish agriculture and to evaluate the ICT data published by the Turkish Statistical Institute and the Agricultural Outlook Field Surveys published by the Credit Registry Office. One of the important objectives of this study is to measure the level of digital literacy among farmers and to identify the needs and opportunities in this area for agricultural enterprises and present them to relevant stakeholders. In addition, the article discusses the development of digital technologies in agriculture, barriers to the use of ICT, activities, and ongoing initiatives related to the use of ICT. As a result, Turkey has made significant progress in digitalization in the agricultural sector in recent years, with higher-income agricultural enterprises tending to use more ICT. The main barriers to ICT utilization are farmers' technology acceptance dynamics, lack of ICT knowledge, and technology cost. With 91% of farmers owning smartphones and 85% using the internet—numbers that continue to rise—increasing digital literacy enables agricultural enterprises to develop products and services that support participation, efficiency, and sustainability. The most common uses of ICT by farmers are 78% agricultural weather/meteorological information services, 66% agricultural news, and 34% crop/input prices. Digital services that farmers may be interested in, in addition to the existing ones are 35% satellite monitoring of their land, 35% asking agricultural questions via mobile/internet, 17% information about diseases and pests, and 11% agricultural technologies. The integration of young people in the agricultural sector offers an excellent opportunity for the effective use of agricultural technologies. Digitalization of agriculture will ensure global food security, environmental sustainability, combating climate change, creating a more efficient and sustainable agricultural system, as well as economic gain and competitive advantage.

Keywords: ICT, ICT adoption, Digitalization, Turkish agriculture, ICT in agriculture

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INTRODUCTION

According to World Bank data, the world population is projected to reach 9.7 billion in 2050 and 10.8 billion in 2080. In this case, a farmer needs to feed approximately 200 people in 2050, considering only population growth without considering factors and trends such as increase in height and body mass index, etc. While the number of people fed by a farmer increases, the number of farmers decreases and the average age increases. The only way out in this inverse proportion is the use of state-of-the-art agricultural mechanization tools and precision/intelligent agricultural technologies supported by biotechnological innovation (Tarmakbir, 2024).

ICT is defined as “the tools used to collect, process, modify, store, access and share information through hardware and software application” (Chavula, 2014; Gül and Demiryurek, 2020).

Innovations and digital technologies have great potential to improve economic development, food security, farmer incomes, and labor productivity in agriculture. However, these technologies cannot be rapidly adopted by all farmers (Maertens and Barrett, 2013). Digital technologies reduce chemical use and greenhouse gas emissions, offer all farmers opportunities to manage their businesses more efficiently, reduce manual labor, and enable them to use their time wisely (Easy4Digit, 2025).

The adoption of information technology is a process determined by farmers' characteristics such as age, personality, education, experience, and goals. Because of these characteristics, there may be significant differences between farmers in system configuration and ICT selection (Alvarez and Nuthall, 2006).

The use of ICT in agricultural production plays an important role in increasing sustainability and productivity (Kılıç, 2024). ICTs are the basis for economic growth (Spasi´c and Georgijevski, 2013). The more countries invest in information and communication technologies in agriculture, the higher the production value. This growth leads to an increase in agricultural production as a proportion of GDP at the national level (Kountios et al., 2023).

The solution to uneven development between urban and rural areas or between regions is digitalization and the further development of ICT penetration (Arion et al., 2024). According to World Bank and FAO reports, digital transformation can be used to solve the problems encountered in rural areas and agriculture (WB 2019; Trendov et al., 2019).

ICT integration in agriculture increases the sustainability of technology use (Heyl et al., 2022). With the development of ICT in agriculture, digital tools and techniques improve feasibility (Kountios et al., 2023). ICT adoption is one of the tools of social development and economic growth and enables the development of rural areas. IT in agriculture supports decision-making by researchers, policymakers, and managers (FAO and ITU, 2020).

Farmers need more effective and efficient information with the development of ICT (Sachitra et al., 2016). Knowledge and innovation are the new driving forces of economies (Tekin and Sındır, 2002). This leads to the agricultural revolution, firstly called smart agriculture and more recently Agriculture 4.0 (Tekin, 2019). Developments in the Internet of Things, robotics, and artificial intelligence pave the way for innovation for Agriculture 4.0 or in some cases Agriculture 5.0. All of these terms combine research areas such as smart agriculture, precision agriculture, and animal husbandry, all driven by technological developments in the ICT sector (Mallinger and Baeza-Yates, 2024). Developments and advances in different areas of ICT, combined with the need to increase production efficiency, have led to significant innovations in agriculture (Kiani and Seyyedabbasi, 2018). UAVs combine IoT, robots, ICTs, big data, and artificial intelligence (Kim et al., 2019).

ICT-related research and recent developments have identified Artificial Intelligence and the Internet of Things as technologies that will revolutionize modern agricultural practices. With the use of these technologies, data obtained from the field can be better analyzed, allowing agricultural practices to be planned with minimum manual labor.

In recent years, smart agriculture has made significant progress with ICT (Nehrey, 2023). It has been proven to increase crop yield, minimise crop losses, reduce input costs and increase productivity. The Smart Agriculture market is expected to experience significant growth in the coming years. Its market capitalisation is estimated to increase to USD 42.92 billion by 2031 (Global Smart Farming Market—Industry Trends and Forecast to 2031, 2024).

“Communication technologies in Turkey account for more than half of the sector's size (17 billion US dollars), but the share of information technologies is increasing day by day. Software development has contributed to approximately two-thirds of the sector's overall growth” (Deloitte and TÜBİSAD, 2022).

Turkey has a growing, robust software development sector, and the environment for digital transformation in rural areas is well developed. While ICT hardware is mostly imported, IT software and services are generally provided by local suppliers. “Turkey ranks high among upper-middle-income countries in international indices examining digital transformation capabilities, but ranks lower than European Union countries.” Internet access and mobile connectivity are at the same level as the European and Central Asian averages. Turkey is on par with regional averages in terms of satellite coverage, physical infrastructure, and mobile connectivity. Although rural areas lag behind cities in smartphone usage, the rate is high. Internet and smartphone usage increase with education level and decrease with age. “The percentage of farmers with adequate internet access provides a solid foundation for widespread access to digital technologies. The Ministry of Agriculture and Forestry has digitized its systems and offers various e-government services, hosting comprehensive databases, but interoperability remains limited, and data quality issues persist” (Höllinger and Sener, 2025).

The sector policy document for Agricultural Machinery and Technologies sets out the following objectives for the 2023-2027 period: planning and managing the technological transformation process in agriculture under the leadership of the Ministry of Agriculture and Forestry with the support of all stakeholders; accelerating efforts to address issues encountered in digitalization and to track, store, preserve, and make usable data collected from the field or similar studies from a single center (TAGEM, 2023).

ICT indicators are useful for assessing agricultural potential and population (World development indicators, 2016). A limited number of studies were found on ICT adoption, development, dissemination, and applications of digital technologies in agriculture in Turkey. Information and communication technologies contribute to the development of rural areas and bring about significant innovations by increasing efficiency, so new studies are needed in this area. Due to the lack of studies conducted on the application of information and communication technologies in agriculture in the current literature, there are significant gaps in this area, and advanced studies need to be conducted. Therefore, this article will pioneer the implementation of ICT in Turkish agriculture by analyzing the state of information technology penetration of Turkish agriculture with ICT indicators, the barriers to ICT utilization, and the proposed solutions to these barriers. One of the important objectives of this study is to measure the level of digital literacy among farmers and to identify the needs and opportunities in this area for agricultural enterprises and present them to relevant stakeholders.

This article addresses the following research questions:

*What is the status and applications of information technology penetration in Turkish agriculture with ICT indicators?

*What are the advantages of using ICT in Agriculture?

*What are the Barriers to the Use of ICT in Agriculture?

Chapter 2 includes Materials and Methods. In Section 3, the Results (Agricultural Structure, Labor and Income, Digitalization in the Agricultural Sector, ICT Adoption, Barriers to ICT Use) are presented. Section 4 discusses the results. Finally, Section 5 summarizes the results and provides recommendations.

MATERIALS AND METHODS

To evaluate Turkish agriculture, data on the TURKSTAT Agricultural Holding Structure Survey, TURKSTAT Regional Statistics, TURKSTAT Labour Force Statistics, and TURKSTAT Plant and Animal Production Values were analyzed. To evaluate the use of information and communication technology in Turkish agriculture and the current status of digital transformation, the TURKSTAT Household and Individual Information and Communication Technologies (ICT) Use Survey, the World Telecommunication/ICT Indicators database, Credit Registry Bureau Agricultural Outlook Field Research Reports, and FAO's "Digital Technologies in Agriculture in Türkiye" report were utilized.

In the first of the data collection methods, TURKSTAT applied a computer-assisted telephone interview. TURKSTAT uses the National Address Database, which matches the Address Based Population Registration System records for Household Information Technology Usage Statistics. All settlements in Turkey were included in the sample selection. The sample consists of individuals aged 16-74 in households. The Household Information Technology Usage Survey, which has been conducted in Turkey since 2004, is the primary data source that provides information on the use of ICTs to compile information on the use of ICTs in households.

In the second data collection method, surveys were conducted via telephone interviews by agricultural experts with field experience from the Frankfurt School of Finance and Management on behalf of the Credit Registry Office. The 2024 Agricultural Outlook Field Research was conducted with a “simple random sampling” method among people who are “actual” and “active” farmers in 28 provinces, and the number of farmers interviewed was 1,098. When selecting provinces, two groupings were used. The first consists of seven geographical regions. The second consists of four provinces: those with the highest and lowest agricultural production values in each region. The identified provinces were compared based on production patterns, product diversity, and location in the same basin. A final selection was then made. This approach ensures that all geographical and climatic structures, as well as production patterns in Turkey, are represented in this study. More farmers were included in the research in provinces with intensive agricultural activity. There are 2 319 426 farmers registered in the Farmer Registration System in Turkey. Accordingly, the sample size represents the target population with a margin of error of ±3.89% at a 99% confidence interval.

RESULTS

Agricultural Structure, Labor and Income

The cultivated agricultural areas in Turkey are decreasing day by day. Agricultural lands in Turkey are generally scattered and consist of small parcels. This makes it difficult to announce, use, and adopt technologies (Karabak and Taşcı, 2015). The structure of farm size in Turkey is a significant challenge to the widespread adoption of digital technologies (Höllinger and Sener, 2025). According to the Agricultural Enterprise Structure Survey conducted by TurkStat in 2016, 80.7% of agricultural enterprises are in enterprise size groups smaller than 10 ha, and the land at the disposal of these enterprises constitutes 29.1% of the total land. The average size of agricultural holdings is on the rise. 25.9% of the enterprises with land are in the 2-4.9 ha enterprise size group, while 24.5% are in the 20-49.9 ha enterprise size group. The average farm size increased to 7.63 ha (TURKSTAT Agricultural Holding Structure Survey, 2016). This value is 32.4 hectares in the United Kingdom, 42.9 in Germany, and 40.3 in France. Small and fragmented land settlement is a major obstacle to benefiting from economies of scale and are a serious hindrance to investment (Tarmakbir, 2024).

Agricultural production areas (cultivated area + perennial plants area) in Turkey decreased by 2.06 million ha (9.2%) from 2005 to 2023, from 26.03 million ha to 23.97 million ha (TURKSTAT Regional Statistics, 2025).

The number of people employed in agriculture in the world is approximately one billion, accounting for approximately 28% of the total population. Approximately 450 million people are wage workers employed in plantation agriculture. Although the share of employment in agriculture has decreased with economic changes and technological developments, it continues to be important for rural development, food security, and livelihoods (ILO, 2025). Although there is no clear information on the average age of the world's farmers, the "60 years" estimate is often made (Tarmakbir, 2024).

When the data on “Sector Shares and Employment” in Turkey are analyzed, 4.9 million of 32.7 million people are employed in the agricultural sector. The share of those employed in the agricultural sector in total is 15 percent (Table 1) (TURKSTAT Labour Force Statistics, 2024a).

The fact that agricultural employment has remained almost the same in the face of the fact that the country's population has increased by 21 percent from 2007 to 2023 can be attributed to the fact that the land/land resource in production is limited and decreasing due to its use for non-agricultural purposes (housing, industry, mining, etc.) and that the economic and financial difficulties experienced by agricultural production are forcing the agricultural population to migrate from rural to urban areas (Sındır et al., 2025). Approximately one in every 6.7 people in Turkey is engaged in agriculture. Due to high economic uncertainties in agriculture, the young population moves to other sectors. The decreasing proportional share of the agricultural sector has mostly shifted to the services sector.

The average age of farmers engaged in agricultural production in Turkey is 53.2 years. The rate of young farmers (18-39 years old) is 15 percent (KKB, 2025). Although there is no official statistic that regularly presents the average age of farmers in Turkey, the average age of 5 million 162 thousand farmers registered in the system of the Union of Chambers of Agriculture (TZOB), where all farmers are registered, was 58.1 as of June 2023 (TZOB, 2023). Usually, the average age is calculated higher in TZOB records than in this field survey because farmer registrations in agricultural chambers are mostly

based on land ownership. In the selection of farmers for field research, the criterion of 'actively' managing a farm, whether or not they own land, is taken into consideration (KKB, 2024). Although the population engaged in agriculture in Turkey remains below the world average, it can be said that it is old and as a solution to this problem, projects for 'Rejuvenation of Agricultural Population' have been included in the scope of rural development support (Sındır et al., 2025).

Table 1. Employment by sector

Years	(Thousand person)	Agriculture (%)	Industry (%)	Services (%)
2010	21 810	23.3	27.7	49
2015	26 501	20.2	27.4	52.4
2020	26 695	17.7	26.3	55.9
2023	31 632	14.8	27.5	57.6
2024	32 620	14.8	27.3	57.9

Source: (TURKSTAT Labour Force Statistics, 2024a).

The ratio between "production value" and "marketed product value", which is the measure of the market accessibility of agricultural products, decreased to 67% in 2021 (TURKSTAT Plant and Animal Production Values, 2024b). This rate remained at 83% in plant products in 2021 and 52% in animal products in 2020. The share of Animal Production in Total Production Value increased to 55.3% and its share in Marketed Agricultural Production Value increased to 43.3%. This development shows that there is an increase in agricultural mechanization tools to meet the needs of animal production (Sındır et al., 2025).

The necessity of agriculture in areas that cannot be expanded, the necessity to protect these areas, and the necessity to utilize these areas most efficiently are inevitable. In today's world, where concepts such as Precision / Smart Agriculture, Agriculture 4.0, and Industry 4.0 come to the fore, it is clear that the experiences to be combined with the right planning and implementation by taking advantage of the facilities brought by technology will take agriculture even further (Sındır et al., 2025).

Digitalization in the Agricultural Sector

Digitalization is expected to be one of the most important levers for sustainability and productivity in agriculture. The main goal has become to process big data in the agricultural sector and teach machines, thereby developing more advanced artificial intelligence and robot technologies (KKB, 2025).

The use of mobile technologies in agriculture enables farmers to make informed decisions on issues such as weather conditions, plant growth, and soil moisture levels. These applications enable farmers to make informed decisions about weather, plant growth, and soil moisture levels. Thus, operations such as fertilization and irrigation can be carried out more optimally and precision agriculture practices can be expanded. Mobile applications are an effective tool to support agricultural activities to be more sustainable, more efficient, and less costly (Hacıyusufoğlu and Güler, 2016).

Turkey has experienced significant developments related to the Digital Transformation in Agriculture Project, which started in 2019. Within the scope of this project, various trainings were provided for farmers to make informed decisions on input use and product management, digital resources were provided, and a mobile application was created where they can access data on government support, climate data, and product prices.

In Turkey, a center for collecting and analyzing data on agricultural production, the national digital agricultural platform 'Agriculture Information System' has been established. Farmers were provided with insights into consumer preferences and market trends, enabling them to optimize their practices.

Turkey has made great progress in digital technology services and access in the last 10 years and ranks 5th in the world in terms of 3G/4G coverage, spectrum availability, and network performance. Digital professionals are generally concentrated in big cities, slowing growth in rural areas (Easy4Digit, 2025).

The Turkish Ministry of Agriculture and Forestry (TarımBulut, TarımCebimde) applications aim to inform farmers about smart agriculture and to popularise the use of these applications (Ministry of Agriculture and Forestry, 2025).

In partnership with the Ministry of Agriculture and Forestry and Turkcell, machine-to-machine communication (Smart Agriculture Solutions application) was launched. Turkcell supports the Agriculture Sector Integrated Management Information System project. Savings and efficiency projects have been developed under the leadership of the Ministry (Star, 2015).

Turkcell Filiz is a mobile application that provides users with real-time data about their fields, along with a soil-weather station. This application helps farmers increase their productivity by enabling them to make irrigation and spraying decisions based on soil and weather conditions (TAGEM, 2023).

Turkcell's smart agriculture solutions include greenhouse monitoring solutions, cattle step and location tracking, milk measurement and tracking solutions, poultry monitoring applications, fish farm monitoring systems, and solutions for business management (Kılavuz and Erdem, 2019).

Turk Telekom offers BuluTT business solutions to its corporate customers. M2M services provide convenience to farmers engaged in plant and animal production. Disease prevention alarm and observation systems, entrance and feeding monitoring, temperature control and monitoring, controlled lighting, and "Animal Shelter Control and Monitoring Solutions" developed for enterprises provide producers with remote, smart management opportunities. Producers can get more efficiency with applications such as temperature monitoring systems, intrusion and drought warning tracking, frost warning, planting area management, and irrigation management (Turk Telekom, 2025).

Vodafone Digital Agriculture Solutions offers a decision and support system that maximizes yield while helping to reduce production costs such as electricity, fertilizer, and pesticides (TAGEM, 2023). The 'Vodafone Smart Village' project,

the first smart village equipped with digital technologies, develops and improves agricultural practices, ensures economic development, and sets a good example by encouraging sustainability, productivity, and efficiency. There are drones for crop monitoring and mapping, automated irrigation systems, and sensor-based monitoring systems to track soil nutrient levels and moisture. Farmers use mobile and internet connectivity to provide data to aid decision-making, such as real-time market values, weather updates, etc. (Dünya gazetesi, 2017). It analyzes air and soil data through sensors and modules within the system and helps avoid crop loss and equipment damage with early warnings while recommending the best timing for agricultural operations (TAGEM, 2023).

In 2018, the Smart Agriculture Platform was established under the Ministry of Agriculture and Forestry. This voluntary organization promotes and adopts smart agriculture practices among relevant stakeholders and provides implementation examples (Easy4Digit, 2025).

Training aimed at increasing the digital literacy of rural residents has been implemented. Easy4digit is a project that aims to close the gap in digital education in agriculture by focusing on Decision Support Systems. It aims to overcome the lack of knowledge of adult and young farmers and trainers who can be considered intermediaries (Easy4Digit, 2025).

ICT Adoption

Although there has been progress in ICT adoption in rural areas, it remains a major challenge today. Some of these barriers are: lack of training, traditional nature of farmers, lack of technological infrastructure, personal barriers, cost of technology, difficult-to-use systems that are not user-friendly, inability to understand the benefits, time constraints, poor integration with other agricultural systems, fear of technology, lack of useful information, no one to consult, security problems, other farmers not using, inability to access reliable information, inadequacies in extension work.

Factors that facilitate and/or hinder Internet access include region of residence, income, education level, and gender (Flores, 2003).

There is no direct indicator developed to measure the level of ICT penetration in agricultural enterprises (Tekin, 2019).

Internet use and access are considered key determinants of digital penetration. The internet access rate in households in Turkey for 2024 is 96.4% (Table 2).

Table 2. "The proportion of households accessing the Internet by Statistical Regions Level 1, 2011-2024" (TURKSTAT, 2024c)

	Internet users													
Years	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**
Turkey	42.9	47.2	49.1	60.2	69.5	76.3	80.7	83.8	88.3	90.7	92.0	94.1	95.5	96.4

Source: (TURKSTAT Survey on Information and Communication Technology (ICT) Usage in Households and by Individuals, 2024c).

In the 15-24 age group, 97.4% of internet users are male and 95.6% are female. In the 25-74 age group, 89.3% are male and 81.7% are female (Table 3).

Table 3. Individuals using the Internet (from any location), by age and gender (%) 2024 year

		Age 15-24			Age 25-74		
Economy name	**Year**	**Total**	**Male**	**Female**	**Total**	**Male**	**Female**
Turkey	2024	96.5	97.4	95.6	85.4	89.3	81.7

Source: ITU, 2025. World Telecommunication/ICT Indicators database

The internet usage rate of skilled agricultural, forestry, and aquaculture workers increased by 416% from 2013 to 2024 and reached 79.1% (Table 4).

Table 4. The proportion of individuals using the Internet by occupation group, 2013-2024

	Internet users											
Years	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**
Skilled agricultural, forestry, and fishery workers	19.0	22.7	34.5	34.4	38.6	47.9	53.1	58.2	62.0	71.0	76.1	79.1

Source: (TURKSTAT Survey on Information and Communication Technology (ICT) Usage in Households and by Individuals, 2024c)

Mobile phones play an important role in facilitating cooperation and improving relationships in the market (Srinivasan et al., 2013).

Digital literacy is important for all segments of society, as well as for agricultural businesses, in terms of sustainability, efficiency, and participation. Farmers were asked which technological devices they use in order to measure their level of digital literacy and identify needs and opportunities in this area for agricultural businesses.

Farmers' ownership of "smartphones" has increased every year and was measured at 91% as of 2024. In other words, 9 out of 10 farmers now own a smartphone. Conversely, the percentage of farmers who own a "classic (non-internet-enabled) mobile phone" has fallen to 9% (Figure 1) (KKB, 2025).

It is not surprising that 85% of farmers access the internet via "smartphones." Some farmers also access the internet via a desktop computer/laptop (14%) or tablet (1%) in addition to their mobile phones. However, the fact that 15% of farmers still say they do not use the internet indicates that there are opportunities for deepening existing internet services and developing new ones (Figure 2) (KKB, 2025).

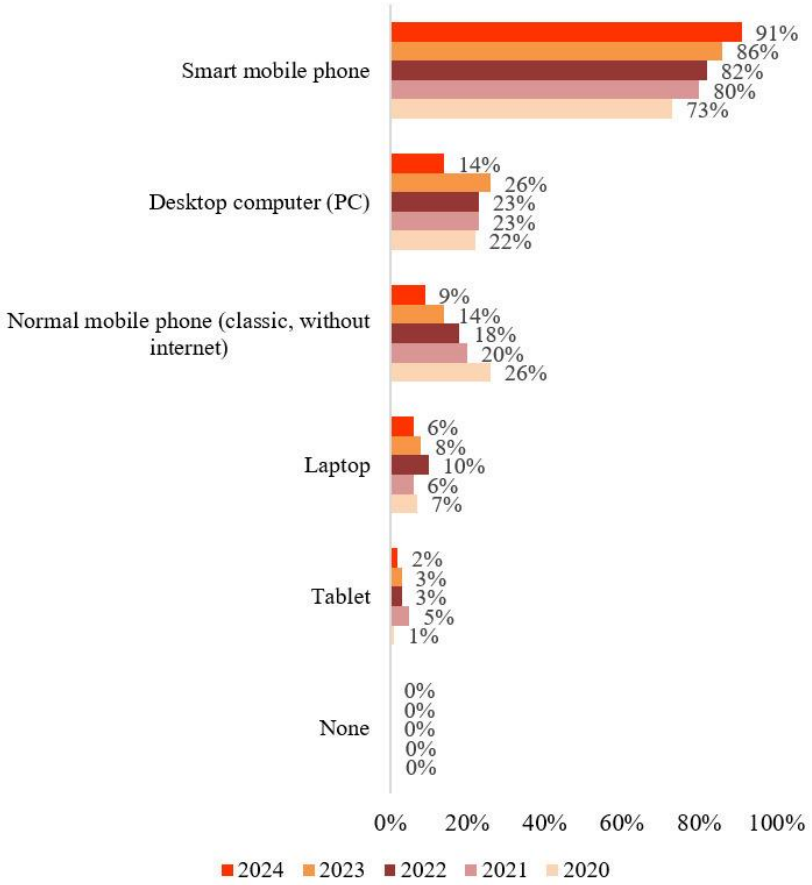

Figure 1. Technology devices used by farmers

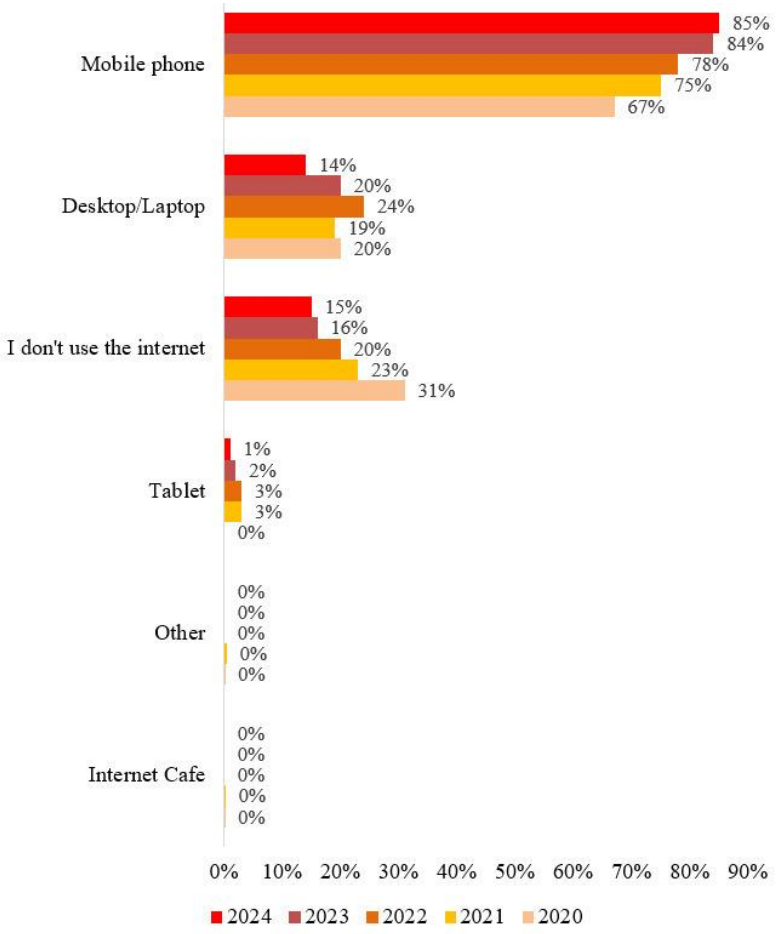

Figure 2. Farmers' access technologies to the internet

"Although the use of social media and the internet is widespread among farmers to access e-government services, price and weather information, only a small portion have purchased specific smart farming technologies and paid for related services". Early adopters are typically large-scale agricultural businesses with access to information about new technologies and a high level of education. While these businesses have begun digitizing raw material procurement, traceability systems, field operations, and quality management, they are still in the early stages (Höllinger and Sener, 2025).

The topics of interest of farmers in agriculture in the digital world were measured. Farmers were asked about the digital information services they "currently use" and those they "might want to use in addition" to the existing ones (KKB, 2024). In 2024, the areas of digital information services that farmers are most interested in are: 78% agricultural weather/meteorological information services, 66% agricultural news, and 34% product/input prices and stock market prices. 16% of farmers sell their products online/on social media, and 4% purchase inputs. 18% do not use or follow any digital services. The "asking questions online" service, which unexpectedly rose to 16% in 2023, has seen a noticeable decline of 2% in 2024. In 2024, most of the increase reported by farmers as "other" in the 5% option comes from "social media product groups/communities." Participants noted that agricultural product-based groups have become popular on platforms such as Facebook, X, and WhatsApp, and that farmers share their experiences and knowledge with each other in these groups (Figure 3), (KKB, 2025).

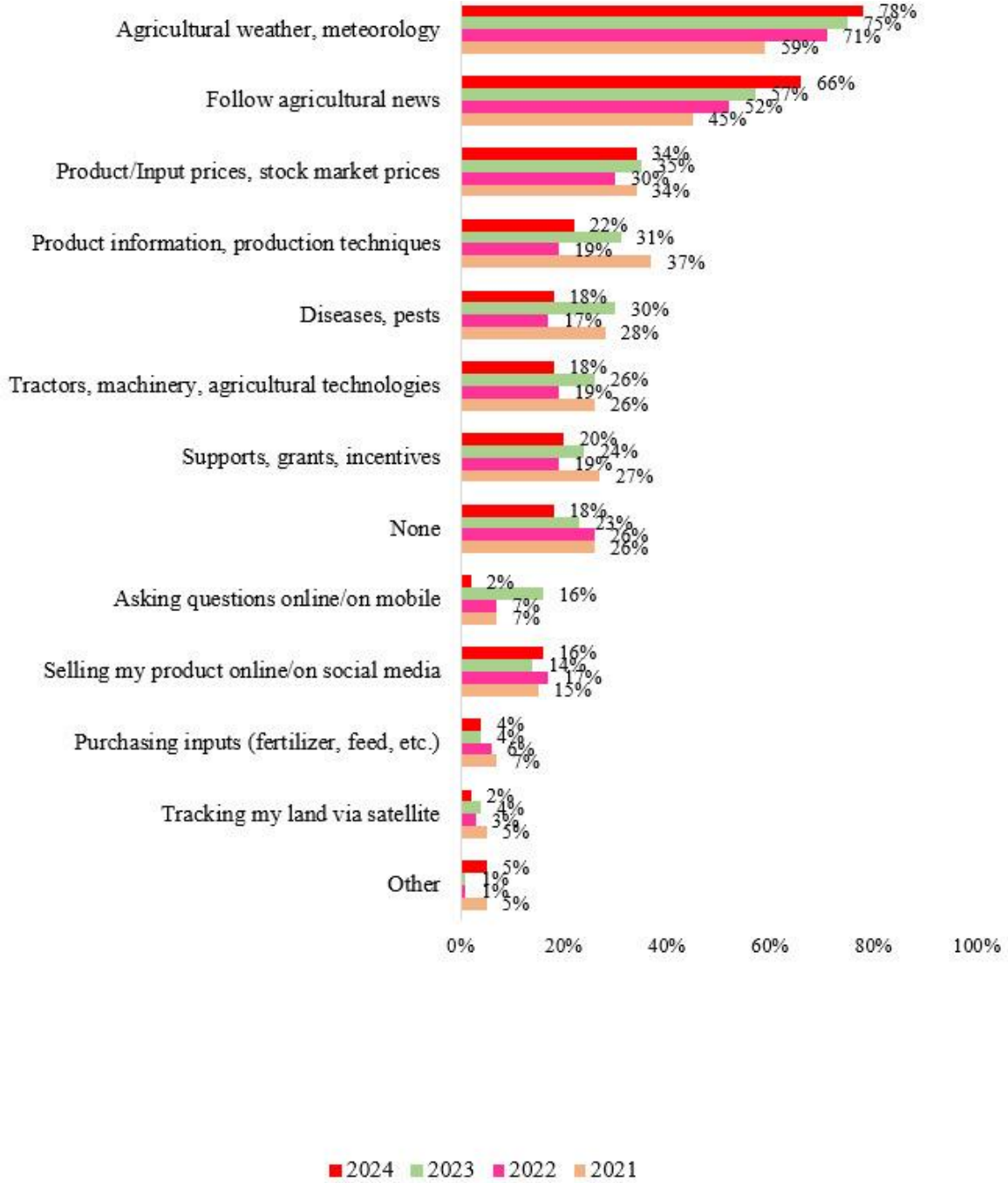

Figure 3. Digital services used by farmers

In addition to the existing ones, 35% of the farmers stated that they would be interested in digital services such as monitoring their land via satellite, 35% asking agricultural questions via mobile/internet, and 11% agricultural technology, tractors, and machinery. It was evaluated that digital service providers operating in agriculture are proportional to their marketing efforts and visibility. It is believed that the amount of data accumulated over time in field research for additional digital services of interest will provide important outputs for new ventures (Figure 4) (KKB, 2025).

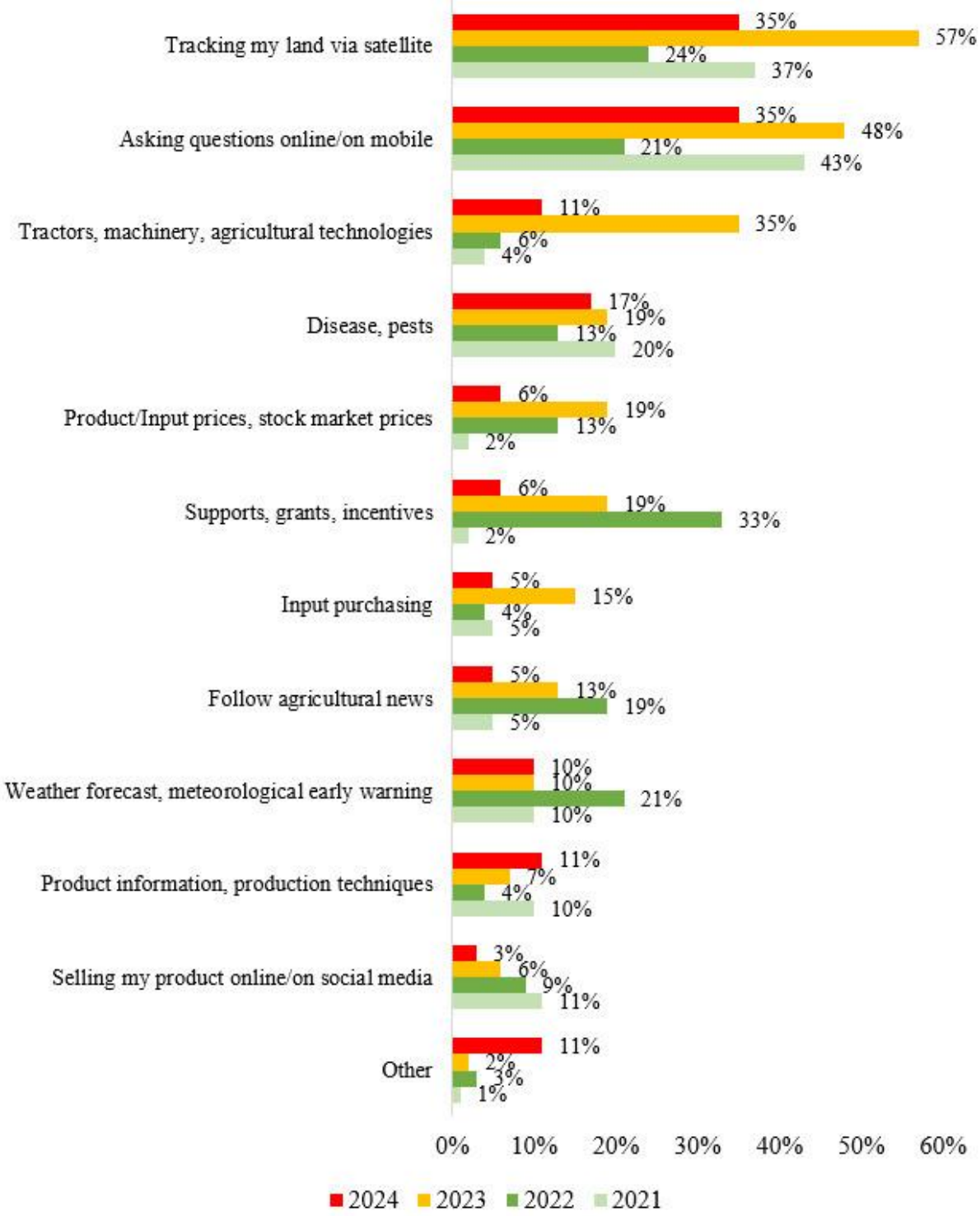

Figure 4. Digital service topics that farmers would like to use as 'additional'

Although there are some studies in Turkey within the scope of public-university-industry cooperation projects on precision agriculture technologies, only a few of them have yet been able to turn into commercial products. It has been observed that the number of start-ups has increased in recent years. While these initiatives mostly provide evaluation and data collection services, studies are also carried out in many segments, from soilless agriculture technologies to variable rate spraying, from artificial intelligence agricultural forecasting systems to artificial intelligence-supported early warning systems for animal health (Tarmakbir, 2024).

There has been an increase in the use of digital technologies such as early warning systems and remote advisory services in agricultural enterprises in Turkey to combat extreme weather events, pests, and diseases (Höllinger and Sener, 2025).

Applications that have room for development among the initiatives are climatic early warning systems, agricultural decision support systems, field stations and sensor applications, digital soil analysis, telematics applications, variable rate spraying applications, robotic systems, precision agriculture applications for livestock (Tarmakbir, 2024).

In smart agriculture, the most common applications on a farmer basis are service applications, and on a machine basis are Automatic Steering (AS) systems. AS systems are the smart agricultural systems that attract the most attention from agricultural machinery manufacturers and the number of companies is constantly increasing. AS systems can be embedded in tractors offered for sale, or they can be installed later. It is estimated that approximately 30 thousand AS tractors are used in agricultural production. The cities where AS tractors are used most are Adana, Aydın, Konya, İzmir, Tekirdağ, Mardin and Şanlıurfa (Tarmakbir, 2024).

Barriers to ICT Use

The relationship between ICT and income inequality depends on political and economic characteristics (Richmond and Triplett, 2018). The socio-economic characteristics of the region where farmers live affect their use of and access to information and communication technologies. These differences create a digital divide in agricultural businesses. Therefore, the problems are related to different social groups (Tekin, 2011). Lack of technical expertise, limited access to technology, and poor internet connectivity limit farmers' ability to adopt and apply advanced agricultural techniques (Bolfe et al., 2020). “The existence of the digital divide exacerbates these inequalities in agricultural productivity and income” (Padhiary, 2025).

Factors affecting the faster adoption and growth of digital technologies on farms in Turkey: the issue of scale; the cost of technologies; limited knowledge, skills, and awareness; and the varying quality of digital technologies (Höllinger and Sener, 2025).

“The use of digital technologies is much lower at the field and farm level. Medium and small-scale farmers rarely purchase digital technologies or pay for related services”. A recent study confirmed that digital technologies are used very limitedly by small-scale elderly farmers who need support and additional advisory services (MoAF and COMCEC, 2021).

The low use of digital technologies in Turkish agriculture is linked to its structural characteristics. These include: the large number of farmers, the low average size of farms, the fragmentation of land, the age profile of farmers, their low levels of digital literacy, the diversity of agroecological regions, microclimate, and topography (Höllinger and Sener, 2025).

In Turkey, drought as a result of climate change, decreased yields due to the decrease in natural resources such as water, cyclones and floods, economic crises, and global market fluctuations have caused a decrease in farmer incomes (Özgüven et al., 2025). The unstable and limited income of most farmers creates additional constraints on their investment in new technologies (Höllinger and Sener, 2025). The ability to use one or more of the digital agriculture applications is directly related to qualified manpower and technical and economic opportunities. The barriers to the use of digital applications are the increase in the elderly population in the villages as a result of the migration of the young population from the villages to the cities (Özgüven et al., 2025). The adoption of new technologies is related to age and cultural factors. Farmers in Turkey have low levels of technical literacy, and some regions are more open to technical innovations than others (Höllinger and Sener, 2025).

Another obstacle to smart agricultural machinery is environmental conditions, such as temperature, humidity, and corrosive factors in agricultural areas and technical difficulties such as communication problems over long distances (Özgüven et al., 2025). The rapid evolution of the digital environment creates challenges in keeping up with new use cases, suppliers, and technologies. “A lack of knowledge and trust in new technologies limits farmers' willingness to invest in them”. Because most agricultural technology providers are located in major cities, product information is often available online, making accessibility difficult for farmers. Even if technology providers provide training during installation and technical support afterward, this support is often insufficient (Höllinger and Sener, 2025).

Most of the technological challenges in agriculture are due to a lack of standards, security issues, hardware and software limitations, and lack of interoperability (Birkel and Hartmann, 2019). The risks and main challenges are related to the methodology, with the design aspect identified as a technological problem and the political and social challenges neglected (Ben-Daya et al., 2019).

In rural areas, network coverage is not sufficient due to long distances (Vaezi et al., 2022). The aim to utilize all arable land in Agriculture 5.0 has recently been a problem in deployed networks due to the density of sensors, delays, problems, amount of data exchanged, required network capacity, and reliability (Saiz-Rubio et al., 2020; Azari et al., 2022).

DISCUSSION

Although Turkey has taken significant steps in implementing government-led education initiatives and access to digital technologies, more education is needed in rural areas to ensure the versatile use of technologies. In addition, educational activities are very important to raise awareness about the benefits of smart agricultural technologies, to gain the support of individuals who do not know or do not apply this technology, who show resistance, and to attract the interest of those who do not use it (Easy4Digit, 2025).

Remote sensing satellite imagery has not been used adequately, and some field-level quality issues have been reported. There is significant potential for advancements and additional uses beyond farming for government agencies, banks, insurance companies, and agribusinesses (Höllinger and Sener, 2025).

Precision livestock farming is currently limited to medium and large-scale dairy producers, but the entry of new suppliers and low-cost technologies into the market could facilitate its expansion. Automation is limited to large-scale poultry farming, modern greenhouses, dairy farming, and tractor use; there is also some potential in irrigation. “Although interest in the use

of drones for spraying is growing, the potential for expansion is moderate and limited to specific products (Höllinger and Sener, 2025)".

Although investments in Agriculture 4.0 in small and medium-sized enterprises in Turkey have been at lower limits recently, there have been significant developments in the use of digital technologies in agriculture. Households that tend to use more ICT have higher incomes. This result is consistent with the research of Arion et al., Höllinger, and Sener (Arion et al., 2024; Höllinger and Sener, 2025).

Although the digital infrastructure is sufficient in Turkish agriculture, the lack of development in the establishment of digital systems for accessing and analyzing data from different sources is an issue that needs to be taken into consideration. There is significant support for technology applications in Turkey, and most farmers have smartphones and internet access. However, the perception that these technologies may not be suitable for older ages and the high costs make farmers reluctant to use these tools. The main factor that prevents the advancement of technological innovations in agriculture is the lack of capital. Farmers are resistant to accepting innovations and new ideas (Easy4Digit, 2025).

ICT development has a positive relationship with economic growth. Efforts should be made to increase the accessibility and availability of ICT, such as improving Internet access and quality, reducing the price of digital devices, etc. (Arion et al., 2024).

Educators and training providers can play a vital role in engaging all stakeholders, including those resistant to technology in rural areas, and accelerating digital transformation. These stakeholders can change the views of those who have not yet utilized these opportunities, such as small farmers and older farmers, and can have significant impacts (Easy4Digit, 2025).

CONCLUSIONS and RECOMMENDATIONS

This article addressed the status of information technology penetration in Turkish agriculture through ICT indicators. It evaluated the ICT data published by the Turkish Statistical Institute, the Agricultural Outlook Field Surveys published by the Credit Bureau, and FAO's review report on digital technologies in agriculture in Türkiye. The article discusses the development of digital technologies in agriculture, obstacles to using ICT, activities carried out, and ongoing initiatives related to using ICT. The results and recommendations of the study are as follows:

Although digital technologies are used by agricultural enterprises, farmers, public institutions, financial institutions, and input suppliers in Turkey, their overall adoption levels are low. Remote sensing is used in monitoring and management of field crops, pesticide applications with drones, and GPS-assisted guidance systems. Nearly half of dairy farms with more than 100 cows use precision animal husbandry, combining manure management, animal feeding, and milking with robotic technology. Automation is standardized in modern greenhouses (Höllinger and Sener, 2025).

"While the use of precision agriculture technologies in Turkey is limited to guided systems for large-scale field crop farmers, the use of variable rate applications is still in its infancy" (Höllinger and Sener, 2025).

The adoption of digital technologies has made greater progress in greenhouse production, orchards, and field crops. IoT devices such as digital field climate stations, soil moisture sensors, and insect traps have shown rapid growth due to their proven benefits in terms of advanced production management, reduced input use, and various applications (Höllinger and Sener, 2025).

The internet, mobile phones, and digital platforms offering online services are among the most important tools enabling small-scale agricultural businesses to participate in the economy. With lower costs, small farmers can directly access market information, better manage their businesses, and participate in commercial activities (Easy4Digit, 2025).

Increasing the population of young farmers in rural areas will contribute positively to the adoption, dissemination, and use of ICTs. In order to increase employment in rural areas, policies can be developed for young people to return to their hometowns (Kılıç, 2024).

As farmers get older, their willingness to adopt and use ICT decreases. The use of smartphone-based technologies in farm management has been increasing in recent years. For these technologies to be sustainable in farm management, they must be user-friendly.

Technology companies can simplify application software and interfaces for older farmers, making them easier to use (Kılıç, 2024).

The stability of research institutions and the policies developed in Turkey show that digital technologies help increase the competitiveness and sustainability of agricultural enterprises and that there is great interest in digital technologies. The trend in this regard should be towards increasing the use of digital technologies in agriculture by small and medium-sized enterprises and directing young farmers towards professional agriculture (Easy4Digit, 2025).

The level of use of digital technologies and devices depends on the user's income, the development of digital literacy, infrastructure, and accessibility. Consequently, the acquisition and use of ICT entails costs. In agricultural policies, incentives and supports that will reduce the costs of farmers should be increased.

Older farmers do not adapt to ICT as quickly as younger ones. The way forward would be to implement a comprehensive training program to meet the needs of such farmers. Farmers should be provided with information on how to utilize new technologies to reduce physical workload, save time, and increase economic benefits.

Establishing an appropriate legal infrastructure is essential for the development of the digital ecosystem (Arion et al., 2024).

The Information and Communication Technologies Authority can be used to ensure traceability in agriculture (Prashar et al., 2020; Chryssochoidis et al., 2009).

Applications such as Agriculture in My Pocket and Digital Agricultural Market, which are among the applications developed by the Ministry of Agriculture and Forestry to help farmers in the production and post-production process, should be developed and increased.

As in the rest of the world, digitalization in agriculture is in the development phase in Turkey. International companies are usually the main suppliers. Although the number of domestic manufacturers is increasing day by day, our level of technology production is not yet at the desired level in this field.

In order to disseminate digital agricultural technologies, infrastructure investments need to be increased, medium and large-scale incentive programs need to be developed and local producers need to be supported. The integration of the young population into the agricultural sector offers a great opportunity in terms of the effective use of technologies. Strong collaboration between the public, academia, and private sectors is required to overcome economic and existing technological barriers (Özgüven et al., 2025).

Public-private partnerships are essential for promoting the adoption of digital technologies and innovation in agriculture in Turkey.

Although significant progress has been made in information and communication technologies in Turkey, continued investment and focus on the development of new technologies in agriculture, research, and education are essential (Easy4Digit, 2025).

When we evaluate Turkey in terms of ICT usage in the global market, we see promising developments. However, it is important that these efforts continue.

Compliance with Ethical Standards

Peer Review

This article has been peer-reviewed by independent experts in the field using a double-blind review process.

Conflict of Interest

The author declares that there is no conflict of interest.

Author Contribution

The author solely conceived, designed, and conducted the study, analyzed the data, and wrote the manuscript.

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