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COMCEC

ACCELERATION OF DIGITAL TRANSFORMATION IN AGRICULTURE SECTOR FOR ENSURING SUSTAINABLE FOOD SECURITY

This needs assessment report was prepared under the COMCEC COVID Response

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Executive summary

The world has been facing numerous environmental changes during the outbreak of the COVID-19 pandemic. Webb et al. (2021) point out: "international supply chains and global food systems continued to feed most of the world, but with varying levels of damage and disruption, and with impacts on food security being felt most acutely by the poor" (p.1) at the United Nations Food Systems Summit 2021. They highlighted the fragile current food systems and emphasized on the need for resilience to combat in ever-challenging time.

The food systems crises started before the COVD-19 pandemic, and the event caused a shock to food demand and supply such as disruptions to food supply chains, decreased or loss of income of consumers which affect the affordability of food. This rapidly changing environment also

leads to uncertainty and future threats to food security and nutrition. A sustainable food system is a complex and systemic challenge which is one of the United Nations' Sustainable Development Goals (SDGs) required for urgent transformation in agriculture and food systems at the local, national, regional as well as at global levels.

The concept of sustainable food system agenda includes; food supply chains and trade, affordability of healthy diets, farmers and food production, jobs, incomes and food insecurity, food environment such as impacts on dietary preference. Governments all over the world are taking the initiative by providing resources to cope with events.

Farmers play an important role in driving economic development, especially in rural areas. There is a need to modernize the food system for a more productive, inclusive, sustainable, and resilient to end hunger while improving nutrition, and achieving food security by 2030. It has been 2 years that the world is facing the COVID-19 pandemic which accelerated the need for improvements for the food supply chains with consumers' access to food and shifts in demand while dealing with several restrictions and challenges such as new regulations for trade and lockdowns and labor shortages.

To achieve these goals requires changes and transformation in the current agri-food system (FAO, 2017) by emphasizing on Agriculture 4.0 approach towards farm management, promoting the use of technology, such as agricultural digital technologies, and innovations including the application of Blockchain, Artificial Intelligence (AI), Internet of Things (IoT), and Virtual Reality (VR), and so on (Trendov et al., 2019). Digital use in agriculture can contribute to achieving at least 6 Sustainable Development Goals (SDGs) including; 1. No Poverty, 2. Zero hunger, 8 Decent work, and economic growth,9. Industry, Innovation and Infrastructure, 12. Responsible consumption and production and 15. Life on land.

In Türkiye, Agriculture has always played a crucial role in its national economy which has approximately 20% share in agricultural employment. Digitization in the agriculture sector makes big changes in every part of the agri-food chain, accelerating the process in the management of resources across the system and offering the opportunity to predict future conditions which are necessary for sustainable optimization of agricultural production.

This study, carried out in partnership with the Standing Committee for Economic and Commercial Cooperation of the Organization of Islamic Cooperation (COMCEC) and the Ministry of Agriculture and Forestry of the Republic of Türkiye, aims to provide information about the development of digital transformation and smart agriculture applications in agriculture and e-commerce in agriculture. This study will be revealed how effective the digital transformation in agriculture is in terms of economic, social, and cultural aspects, especially in the COVID-19 pandemic process. The pandemic forced all businesses to be more innovative and to adapt to technologies to support the acceleration of the digital transformation.

Therefore, this project aims to provide information about the development of digital transformation, smart applications, and e-commerce in agriculture and the effectiveness of agriculture in the COVID-19 pandemic era. This research focuses on one of the trends in the field highlighting the importance of acceleration of the digital transformation in agriculture concerning food security to combat the COVID – 19 pandemic crises. It also considers the accessibility to farmers and all other stakeholders examining the existing policies and frameworks and their implications.

This new normal situation forced all businesses to be more innovative and the need to adapt to technologies as nowadays, agriculture is one of the most demanded sectors worldwide. According to the literature, the effects of the pandemic period on agricultural production were observed as follows; The occurrence of environmental variability (climate), Economic variability (input costs, reduced revenues), Importance of food safety (risk of contamination, desire for healthy products), Excessive demand for food, Problems in mass transportation of people (risk of contamination), Problems occurring in collective work (risk of contamination), and Difficulty of producers due to travel restrictions.
Among 125 relevant articles, 10 articles were identified as important sources, investigating the current situation on the impact of COVID–19 and the digital agricultural market analysis in different countries such as China, the USA, Australia, and England. All articles highlighted the policy implications and recommendations for improvements according to their research findings at regional levels.

The report follows the same approach following on identifying the current situation and the effectiveness of the digital transformation in agriculture economically, socially, and considering cultural aspects in the COVID-19 pandemic process in the Republic of Türkiye.

The report is divided into three phases, starting with phase I - assessment of the current situation, providing detailed information of the concepts through the literature. It starts with the introduction of the study topic, justifying the need for this research. This section provides the step-by-step need assessment process as follows; 1. Material and Method, 2. Key Indicators of Agriculture in Türkiye, 3. Digital Agriculture Concept and its Development, 4. Digital Agriculture Components, 5. Importance of Smart Agricultural Practices and Applications Around the World in the COVID-19 era, 6. The Situation of Smart Agriculture in Türkiye, 7. E-Commerce Term Components in Agriculture, and 8. E-Commerce Effects and Contributions to Agriculture.

Over 6000 articles on digitalization during the COVID – 19 pandemics were identified, and the relevant literature was examined between the year 2020 to 2021. The visual maps were created by using the software tool "VOSviewer" to demonstrate different clusters and the most common terms found related to digital transformation and security.

Food security was identified as one of the most important topics during the Covid era, in the area of the digital transformation in agriculture. The application of digital tools for e-commerce clearly creates a positive impact on how food systems operate, to become more agile and resilient to respond to unforeseen events during this challenging period.

The shift to e-business became a must for all to survive in the market under the current situation. A good example of such a digital tool from Türkiye, the Digital Market Place / Farming Market (DİTAP) for agri-food products is explained in the chapter as one of the quick actions taken by the government. It is a Digital Agricultural Market which brings together buyers and sellers online which can accelerate production and trade in agriculture. This digital marketplace approach is believed to be useful and enable producers to generate more income, access to financial benefits such as the loan packages of banks created within the scope of contract agriculture.

Although the employment share in agriculture in Türkiye decreased in the last 20 years, there are still 20% which is a large part of the national economy. Therefore, the application of DİTAP is expected to great a great impact if it can be used by all stakeholders.

Some of the examples of smart agriculture applications in the world and in Türkiye are as follow; Sensor-based herbicide application (Felton et al., 1991), Weed control in maize (Williams et al., 2000), Variable level herbicide application (Mohammadzamani et al., 2009 ; Timmermann et al., 2001), Variable level herbicide application (Green et al., 1997), Variable nitrogen application (Koch et al., 2004; Türker et al., 2003; Wang et al., 2003). The results of all the researchers demonstrated the reduction in their resources which increases productivity. In addition, there is some research on the adoption of the technology and the business profitability.

For instance, Khanna et al. (1999) conducted research on factors affecting the adoption of new agricultural technologies in crop production practices and identified that producers adopting precision agriculture have higher land widths, more educated and younger producers. Similarly, Fountas et al. (2005) studied identifying producers' precision farming experience in Denmark and the eastern United States. They identified the main problems of producers in precision agriculture applications are the time requirement and high data-processing costs, which shows the same result as the study conducted by Reichardt and Jürgens (2009), determining the adaptation of farmers to precision farming practices in Germany.

There is a new area of study that recently attracted the attention of researchers which is concerning the ethical issues related to the application. For example, Çokuysal (2021) a very interesting study was recently presented on Ethical Problem Issues in Agriculture, Digitalization and Sustainability Triangle, which illustrates that the socio-ethical problems caused by digital farming systems affect efficiency and productivity. His research shows that there is a need to have a common agreement standard on the ethical ground applicable for all stakeholders.

In line with the increasing interest in the research topic on the digital transformation process, in Türkiye, there has been a lot of improvements in terms of access to digital technologies and services within the last decade. The country is now ranked 5th out of 150 countries for improvements for 3G and 4G coverage, network performance, and spectrum availability according to the GSMA Mobile Connectivity Index. Not only the accessibility but also the physical infrastructure has been improved especially between the years 2015 and 2017. Such improvements include the increased speed for download by 300%, and 4G network coverage reached 90% of the country's population. As a result, Türkiye is ready for the acceleration of digital transformation with the already established infrastructure available nationwide.

In addition, there are many highly skilled individuals in the digital sector in Türkiye. However, the digital workforce is mainly based in the largest cities and there are still opportunities to grow in rural areas in the agricultural sector. Especially, e-commerce should be introduced to more people as this is a basic practice in, easily accessible for all stakeholders easily. Many researchers from different countries have studied the impact of e-commerce with a specific emphasis on COVID-19. Such studies include the assessment of the current situation in different countries or regions that are now in high demand by policymakers and practitioners, which makes this report valuable to introduce the case of Türkiye.

Phase II – Data gathering and analysis is the most important contribution to this study collecting valuable data from the field research of a total of 85 people (35 institutions/organizations and

50 producers) covering 14 provinces in Türkiye. The questionnaire used in the interviews targeting producers and the related stakeholders contributes to the most important element of the study.

In order to prevent false data entry, a coding system was developed in line with the application of the appropriate statistical analyses of the data recording. Then, both the results obtained from the analysis of the quantitative data and the results obtained from the qualitative data were re-evaluated. Those interviews conducted among 50 producers were in different provinces of Türkiye, 20 producers from Ankara, 4 producers from Ordu, Samsun, Adana, Aydın and Gaziantep provinces, 3 producers from Tekirdağ province, and 1 producer from Amasya, İzmir, Kırklareli, and Kırşehir provinces. Some rules were introduced by the Ministry of Health for the face-to-face interviews during the pandemic, such as to use open-air spaces considering the social distance.

92% of the producers who participated in the survey are men and 8% were women and the average age was 49 years. Among them, the ratio of university and high school graduates was the highest at 26%, followed by primary school graduates and associate degree graduates at 16%, secondary school graduates at 10%, and the lowest rate was the postgraduate graduates which were at 6%. 76% of them carry out plant production activities, only 2% carry out animal production activities. The remaining 22% perform both plant and animal production activities. According to the findings, most producers (62%) do not plan to expand their agricultural lands in the future, 50% answered that they are not able to do so as they do not have a relative who will continue their agricultural activities. The average year of experience of the producers in the agricultural sector was identified as 22 years.

The research findings show the interesting reality that although most of the producers are using smartphones and the internet, they are reluctant to use them. This is due to the high investments especially for small farmers who do not have the knowledge to do so and require extra support and assistance to set up e-commerce. In addition, people are hesitant to learn and accept new things due to the norm believing that technology is not applicable for elder people. The most common use of their smartphones was identified as to access basic information such as agricultural weather conditions and product prices and the use of well-established applications such as İşbank "İmece" application, "E-government" application, "Hepsiburada" applications.

Despite the high expectation of the spread of "DİTAP" application, is still not widely used among producers especially those over 60 years who believe they cannot benefit from the application. The findings also discovered the gender differences that more women's cooperatives use technology compared to men for their marketing. The common applications used during the COVID-19 pandemic by these women are Instagram, Hepsiburada.com, and trendyol.com. Although such producers are actively using the technology for marketing their products and services, the level of knowledge on smart agriculture remains low and there is a need for more support to encourage them to use it.

The research findings show that the main reason slowing down the advancement of technological developments is the lack of capital in the agricultural sector. It is also important to mention those producers are not open to innovations and this is one of the obstacles to overcome especially among elders in rural areas. However, it was also discovered that more producers in Türkiye are using drone technology for pesticides in paddy, corn, and sunflower as many producers find drones accessible and efficient.

And finally, phase III – Policy recommendation and implications to contribute to the need for a rapidly changing environment during the crises as such digital agricultural advancements have never been based on a national strategy or plan in Türkiye. The COVID-19 pandemic reinforced all the nations to tackle these global issues and work towards the 17 SDGs as well as to act on the economic response and recovery in line with the Covid-19 response. Some of the goals relevant to the agriculture sector include; Job retention and job creation for vulnerable groups, Rural interventions to increase the resilience of producers and improve supply chains in the agri-food system, 3. Recovery actions for business continuity in the private sector, 4. Business transformation for adaptation to the post-Covid-19 economy, 5. Effective public sector response for an economy resilient to shocks and hazards, and 6. Protection of natural habitats.

In Türkiye, agricultural policies evolved since 2006 when the Turkish policies aligned with European Unions for harmonization to create the Common Agricultural Policy (Diakosavvas, 2011). Türkiye's digital agriculture advancements are seen only in recent years as it was not reflected in a national strategy or plan in the country. It is planned to be included for the first time in the forthcoming 5-Year Development Plan concerning the digital transformation and digitization for various sectors, including agriculture.

Currently, all-digital agricultural programs in Türkiye are under the supervision of the Digital Transformation Office. The office was established as part of the presidential governance system and across all ministries and sectors, working towards the develop national digital solutions and raising awareness, conducting big data analyses in priority areas, and improving cybersecurity and information security. Likewise, the Science, Technology, and Innovation Board is a part of the presidential office, providing recommendations to digital agricultural solutions. Key recommendations include; providing opportunities for regional and global competition, entrepreneurial culture, digital solutions, and catalyzing research and development of new technologies, creating infrastructure, human resource, and other development projects to improve economic, social, and national security, segmenting the areas of strategic technology opportunity, introducing the medium- and long-term national technology strategies and policy plans, developing programs to reduce import dependency and increase the competitiveness of Turkish industry and most importantly to revise policy and strategy for promoting effective and accessible digital solutions in the fields of economy, commerce, recreation, science, education, and culture which is in line with this research.

The Ministry of Agriculture and Forestry is the primary government actor in terms of agricultural production, and the most prominent investor in Turkish digital agricultural solutions. Among the total budget of USD4,5 billion, around USD884 million was allocated for investments. Out of the total investment, USD26,5 million which is 3% of the overall investment fund is to be allocated for digital agriculture solutions.

The General Directorate of Agricultural Research and Policies which is the part of the Ministry is responsible for conducting research and it was in the year 2002 when the digital agriculture research programs started. These programs include: Determination of Variables Affecting the Yield in Cereal Cultivation Areas Using Precision Agricultural Techniques; Field Specific Variable Rate Fertilizer Application in Maize Production in the Çukurova Region Using Information Technologies Supported by Satellite Images; and the Integrated Project for Planning, Development, and Dissemination of Precision Agricultural Applications in Crop Production.

The ministry is not only providing support for their related offices but also to some companies, for instance to ASELSAN which is the largest defense electronics company in Türkiye. Their projects include: Automatic Tractor Steering and Control System Development; Farm Management Systems Development; Image Processing Based Precision Agricultural Applications with Unmanned Aerial Vehicles; System Development for Monitoring and Tracking Wheat Losses During Harvest; and Development of the Intelligent Measurement Platform Prototype for Sheep and Goat Breeding (Anonymous 2020).

The government is under increased pressure to act quickly and build digital resilience, which is the key for the economy, especially in the current pandemic conditions. In Türkiye, the government eased the restrictions imposed on export items based on the market demand to keep the businesses running. Then, the digital solutions "DITAP" was introduced in 2020 to connect producers and consumers in the virtual agriculture market platform. The platform offers the opportunity for financial support, as well as providing an up-to-date information-sharing place to help prevent market fluctuations for sustainability. The country also modified the mechanism for customs clearance (Agriculture sector exempt from COVID-19 pandemic restrictions) to facilitate regional agri-food trade for sustainable food supply chains during the crises.

The accelerated improvements in digital infrastructure along with the introduction of DITAP seems to be a great solution in Türkiye. However, as mentioned earlier, it is not used as planned and especially among elder farmers and producers, there are less interested in utilizing this tool. In order to make the best use of useful tools, educational and training programs should be organized on a larger scale targeting rural areas as well as we less-advantaged group including elder users.

The research leads to a better understanding of the current situation in a specific context Türkiye with contextual details, which makes this report more credible and useful for readers. The method applied for this project is a mixed method of primary and secondary research, as quantitative or qualitative data alone will not be sufficient to meet the research purpose of this study.

The Ministry of Agriculture and Forestry is a prominent investor in digital agricultural solutions in the country and therefore these research findings could be directly reflected in the action plan to tackle the identified and analyzed needs within the country. Although Türkiye's digital infrastructure is satisfactory, the country needs to respond quickly to increase the awareness of value-added services and opportunities to improve the existing infrastructure and ecosystems. The primary research data collected during this research will serve as the important need analysis to proprieties the uncovered and unreached segments among the relevant stakeholders such as government officers, elder producers, and small agricultural enterprises in Türkiye.

Introduction

The world has been in a constant state of change and transformation, the increase in the human population and the curiosity of human beings in every subject has accelerated this change, and adaptation has become more visible with each passing day. In today's world, economic growth, advancing technologies, technical developments, population growth, globalization, urbanization, increasing food needs, and many other similar variables lead up to a set of changes,

transformations, and developments in every field. Along with those changes, the environmental effects and factors brought by industrialization also affect the ecological system of the world. Current research and studies reveal that the said conditions will affect the changes even more and in an accelerated manner. The increase in the world population will enhance the rate of consumption, especially that of food, in many areas in the near future. Therefore, the scarcity of resources will cause profound changes in every field, and the correct use of those resources will become more of an issue.

Nowadays, in many different parts of the world, digital transformation becoming prevalent is witnessed day by day. This maturing digital transformation constitutes the essence of the main source of sustainable and long-term economic growth. This, in fact, is called the digital revolution and has embraced all industries and social areas. It is needless to say that one of those areas is the agricultural sector (Victorovich et al., 2020).

According to the report prepared by the United Nations (UN) Economic and Social Affairs Unit revealing the world population growth expectations and which was formerly revised in 2019, the world population is expected to be between 8.5 billion and 8.6 billion by the year 2030 with a probability of 95%. According to the same report, the world population is expected to be between 9.4 billion and 10.01 billion by the year 2050. The report also forecasts the world population to be between 9.4 billion and 12.7 billion by the year 2100 (UN DESA, 2019).

Likewise, in the 2018 revision of the UN Economic and Social Affairs Unit's World Urbanization Report, it was stated that 30% of the world's population dwelled in urban areas in 1950. According to the same report, it is stated that 55% of the population dwelt in the urban areas as of 2018, while it was forecasted that 68% of the population would dwell in cities by the year 2050 (UN DESA, 2018). According to UN reports and studies of the said institutions, it is obvious that the need for food supply will become intense more than ever with the current population growth and urbanization rates.

Climate change is an important variable that imposes both implicit and explicit impacts on a wide basis on agriculture. Therefore, changes in the climate affect agriculture and the sectors related to it (Singh et al., 2021). Hence climate change can bring about several problems such as difficulties in food availability, difficulties in food access, and negative changes in the quality of the food. Moreover, variability in temperatures, variations in precipitation patterns, sudden changes in weather events and significant reductions in water availability can lead productivity in agriculture to decrease (EC, 2021).

More productive, efficient, sustainable, inclusive, transparent, and durable food systems will be needed to reach the goal of a "zero hunger world", which is one of the sustainable development goals that the United Nations emphasizes, until 2030. This requires an urgent change and transformation in the current agri-food system (FAO, 2017). Digital technologies and digital innovations can be a solution for this change and transformation. These technologies, including Blockchain, Artificial Intelligence (AI), Internet of Things (IoT), and Virtual Reality (VR), are rapidly changing all sectors under the name of the fourth industrial revolution (Industry 4.0) (Trendov et al., 2019). It is observed that the progress of mobile technologies, the development of remote sensing systems, and distributed computer systems have begun to improve the access of small businesses operating in the agriculture and food sector to many areas such as information, data, markets, finance, and education.

These emerging digital technologies will create new opportunities to integrate farmers into the digitally managed agri-food system (USAID, 2018). Digitization will change every part of the agri-food chain and make the management of resources across the system more optimized and more personalized. Thanks to this situation, instant data flow will be achieved, so everything will become more predictable. In addition to this, a structure that can take more effective and faster decisions will be achieved. While the entire production chain can be monitored and coordinated at the most detailed level, different gardens, different fields, different poultry houses, and different barns will become accurately managed in their own optimal recipes. In addition to these, systems that can produce compatible solutions against the changes caused by climate change will be developed thanks to digital systems (Trendov et al., 2019). All these processes will lead to greater productivity, profitability, sustainability, and food safety.

This study, carried out in partnership with the Standing Committee for Economic and Commercial Cooperation of the Organization of Islamic Cooperation (COMCEC) and the Ministry of Agriculture and Forestry of the Republic of Türkiye, aims to provide information about the development of digital transformation and smart agriculture applications in agriculture and e-commerce in agriculture. This study will be revealed how effective the digital transformation in agriculture is in terms of economic, social, and cultural aspects, especially in the COVID-19 pandemic process.

Phase I - Assessing the Current Situation

1. Material and Method

1.1. Material

The questionnaire used in the interviews with the "producers and the related stakeholders" constitutes the most important element of the study. The forms were filled out with utmost attention. Aside from filling out forms, additional information was obtained on interviews and this information will be utilized at the stage of report writing. Importance is given to conducting interviews at the yards and fields of the producers and this policy will be followed thus. This practice served to form personal relations with the interviewees and helped to obtain clear information. Regarding the topics involved in numerical answers, precise information could not be obtained at the first instance but attempts to derive correct answers to these questions were made in relation to the other questions. Hence, with this method, clear and precise results were aimed to be gathered.

In the planning stage of the study, separate evaluations of the stakeholders were aimed but as the interviews were furthered, most of the stakeholders were determined to belong to different categories at the same time, hence showing a mutual pattern.

A database was formed to store the data obtained both from the field surveys and office searches. A coding system was developed to prevent false data entry as well as facilitate it. To apply the appropriate statistical analyses the data recording was initiated. As this process gets completed quantitative data analysis and use of qualitative data evaluations shall be carried out together.

1.2. The Method

Basically, the method of the study is composed of the following stages: preparation, developing the means for data collection, data collection, data sorting, and analysis. The first field visits of the study commenced in the districts of Evren and Şereflikoçhisar of Ankara province on 12 July 2021 and continued in other districts of the same province during 12-16 July 2021. Online meetings were held with the relevant stakeholders. In the meantime, the necessary information was obtained from the director of the Hatay Agriculture and Forestry Provincial Office. Activities performed during the first round of field visits and office work are acknowledged in detail under relevant headings.

	Month				
	1	2	3	4	5
Stages					
Preparation stage (Literature Review /Online meetings)					
Developing the means for data collection (Questionnaire)					
Data collection (as indicated in the below Map of Türkiye)					
Data sorting					
Analysis					

Table 1. The timescale for Method Stages

Preparation stage

The preparation stage comprised the office work and developing the means for data collection. At this stage, the available information set and information needs were reviewed primarily. Then the approach for obtaining the needed information was decided. In addition, meetings with the representatives of the supporting institutions for the project were held in order to evaluate the operability of the questions placed on the questionnaire and to revise them. In this respect, by the end of the first field visits the formats of the questions had been finalized by the participatory actions of experts and the representatives. By that time some of the questions had been discarded while some were newly placed on the questionnaire.

The main objective of the preparation stage was determining the target group. To this end, a list of the relevant parties operating in the province and districts of main concern such as public institutions, non-governmental organizations, agricultural cooperatives and unions, firms selling or buying agricultural products, and Agriculture and Forestry Provincial/District Offices, was prepared. In addition, persons and firms to be visited were enlisted.

Developing the means for data collection

In this stage, it was aimed to combine and evaluate the qualitative and quantitative aspects together whenever necessary in order to reveal the results of the study on an institutional and settlements basis. To this end, an establishment-based questionnaire form related to the stakeholders was devised. The questionnaire preparation study adopted an approach combining the advantages of both quantitative and qualitative methods.
During the fieldwork, information was gathered under the following headings.

General information about the producers / Structural characteristics of establishments /Smart and Digital Agriculture

- Socio-economic characteristics,
- Agricultural establishment characteristics,
- Employed smart agriculture applications
- Employed digital agriculture applications
- Change of used technology during COVID-19 period,
- Future expectations and attitudes
-

Institutional characteristics of stakeholders/ structural feature / Smart and digital Agriculture

- Institutional information,
- Information related to employment practices during the pre-and post-COVID-19 periods
- Employed smart agriculture practices
- Employed digital agriculture practices
- Change of used technology during COVID-19 period,
- Future expectations and attitudes

After gathering data for the needs assessment in the first stage, the environmental scanning was performed followed by the below steps outlined for a better understanding of emerging trends, opportunities, and challenges, which impact the agriculture sector, specifically relevant to food security in the Turkish context. Environmental scanning also provides early warnings of external changes that can impact the sector and/or organizations. Several driving forces were identified especially in the COVID 19 Pandemic era, which is important for the development of the future Agricultural Policy Framework.

Figure 1. A step-by-step process

2. Key Indicators of Agriculture in Türkiye

Agriculture has always held a crucial role in Türkiye's national economy. Today, agriculture accounts for approximately 6.5% of Turkish GDP, currently valued at USD851,6 billion. Agricultural employment peaked at nearly 48% of the total population in 1991 and now stands at approximately 20%.

Türkiye's 785.350 km^2 landmass connects eastern Europe to western Asia and has three distinct climatic regions. The Aegean and Mediterranean coastal areas feature a Mediterranean climate with mild, wet winters and hot, dry summers. The Black Sea coastal areas have an Oceanic climate with warm, wet winters and cool, wet summers. The Oceanic climate areas are the only regions of Türkiye that receive high precipitation throughout the year. The interior of Türkiye has a continental climate with sharply contrasting seasons, hot summers, and severe winters.

Agricultural land comprises approximately 50% of the total land area. This figure has remained quite constant, varying only from 47.4% to 53.6% over the past several decades. Nearly 70% of farmers hold less than 5 ha of land, and the average farm size is 6 ha. As of 2020, the primary crops according to quantity were wheat (20,5 million tonnes/ year), sugar beet (23,0 million tonnes/year), tomatoes (13,2 million tonnes/year), barley (8,3 million tonnes/year), and corn (6,5 million tonnes/year). Türkiye is the world's largest producer of both fresh and dried apricots and about 833,4 thousand tonnes of apricots are grown throughout the country every year.

Crops, legumes, and industrial plants stand out among the cultivated plants in Türkiye. Effects of the changes in the climate, commodity prices, and subsidies have been causing volatility in production. From 1990 to 2018, the size of lands was used for cultivating wheat, barley, and rye has decreased while the lands where corn is grown have expanded. From among the legumes, the rise in lentil and chickpea cultivation reversed during the post-1990 period.

With the advancement of intensive agriculture in Türkiye, pomiculture and olericulture activities scaled up. Türkiye has an opulence of globally high-ranking products in this field. Grown on a remarkable number of fruit trees and cultivated as part of major production between 1990 and 2018; hazelnut, apple, orange, pistachio, and fig are among these high-

ranking products. Of these products, major surges were experienced in orange and pistachio cultivation.

Good agricultural practices and organic agriculture have also significantly stepped up, especially as of 2002 (Demiryürek, 2016). Whereas in 2002, good agricultural practices were underway on a land of 535 thousand decares overall, they had spread across an area of 772 thousand decares by 2018. The size of production almost doubled in 2018 compared to 2002 figures, reaching more than 8 million tons. Whereas 12.428 farmers cultivated 310 thousand tons of organic products across a land of 89 thousand hectares in 2002, 79.563 farmers cultivated 2,3 million tons of organic products across a land of 626 thousand hectares in 2018.

Wheat is essential for meeting the nutritional needs of many people around the world. In Türkiye, the consumption of wheat and wheat products ranks at the top of the list. Although wheat productivity in Türkiye has been on the rise over the years, the average figure remains below that of the world and EU countries. While wheat was cultivated on a total land of 9,2 hectares back in 2000, the figure from 2020 was reduced by one-fifth of the number recorded in 2000, amounting recently to 6,9 million hectares of land.

Corn is known to be a plant that is used for human consumption, and as forage and industrial raw material. Since it can be cultivated across tropical, subtropical, and temperate climate zones, corn is grown in almost all parts of the world, except Antarctica. Cultivated across the third largest land among the cereals grown in our country, just Türkiye beneath wheat and barley on the list, corn is used both as a primary and secondary product. While corn was grown on a total land of 705 thousand hectares in 1961 and 646 thousand hectares in 1970, this figure dropped as low as 583 thousand hectares in 1980. In the 2000s, on the other hand, corn was cultivated across a total land of 600 thousand hectares on average and in 2020 it reached to about 692 thousand hectares. Türkiye's corn productivity rate is above the EU and global average, thanks to the practice of contemporary corn production methods, greater use of hybrid seeds, and relocation of corn cultivation to irrigated areas.

A glance at the history of cotton cultivation lands in Türkiye would show that the size of lands peaked in 1984/85 and 1998/99 reaching 760 thousand hectares. However, this period was followed by a downward trend in the size of cotton cultivation lands due to the increasing input costs associated with corn and its weakened competitiveness against alternative products, and the total land size hit rock bottom in 2009/10, dropping to 420 thousand hectares. In parallel with the skyrocketing cotton prices in 2011, the size of cotton cultivation lands ascended to 542 thousand hectares in 2011/12. Cotton cultivation lands have expanded as large as 350-500 thousand hectares between 2017 and 2020. Nevertheless, Türkiye's cotton production was not strongly affected by the fluctuations in the size of cotton cultivation lands. This is indeed linked to how cotton productivity rose from 770 kg/ha (1980/81) to 1.830kg/ha (2020).

Name of the product	2017			2020		
	Cultivation Area (ha)	**Production Amount (tons)**	**Yield (kg/da)**	**Cultivation Area (ha)**	**Production Amount (tons)**	**Yield (kg/da)**
Barley	2,424,737	7,100,000	293	3,097,163	8,300,000	268
Wheat	7,668,879	21,500,000	280	6,922,236	20,500,000	296
Corn	639,084	5,900,000	923	691,632	6,500,000	940
Sugar beet	339,274	21,149,020	6,234	338,108	23,025,738	6,810
Cotton (fiber)	501,853	882,000	176	359,220	656,251	183
Apricot (fresh)	125,048	985,000	788	132,748	833,398	628
Tomato	177,474	12,750,000	7,184	174,437	13,204,015	7,570

Table 2. Source: Data from Statistics TÜİK 2017 / 2020

According to FAO data, average cow milk productivity in 2017 was 2,430kg/head globally, 10,457 kg/head in the USA, and 8,587 kg/head in the Netherlands. In Türkiye, cow milk productivity was recorded as 1.351 kg per head in 1990 whereas it was estimated to be around 3.161 kg/head in 2018, with an increase of 6.4% over the past 5 years.

Nevertheless, this figure is rather low compared to the figures from other countries around the world and EU member states (EU average being 6.000kg/heads).

Türkiye is also a large producer of livestock and livestock products. The country had 1.38 million registered cattle farms as of 2018. Small farms (with less than 5 head of cattle) represent about 60% of the total. As of 2017, sheep for meat and milk dominated the market at 20.800.000 and 175.000 head, respectively. Goats for meat (4.500.000 head) and milk (4.964.000 head), beef cattle (3.602.000 head), and dairy cows (5.969.000 head) were also widely produced. Chicken production was relatively limited by comparison (1,228,000 head). The country produced about 25 million MT of feed in 2017, including that produced on-farm. About half of the feed ingredients (12 million MT) were imported, including soybeans, sunflower seeds, corn products, and additives.

The population of Türkiye has increased more than six-fold since the proclamation of the Republic. While the total number of people living in the country was around 13,6 million back in 1927, the population of Türkiye was estimated to be 82,3 million as of 2018. In 1927, 75,8% of the population was living in rural areas and 24.2% in urban ones whereas the figures recorded in 2018 were 7,7% and 92,3%, respectively. In particular, the decline in rural population gained momentum from 1990 to 2018. Enactment of a law widely known as the "Greater City Act" in 2011 also played a part in the growth of the urban population as it granted the status of the neighborhood to the villages and sub-districts which lied within the boundaries of metropolitan municipalities although they were indeed located in rural areas.

According to TurkStat's gross domestic product (GDP) results for 2018 calculated based on the production method, compared to the previous year, Türkiye's economy grew by,.6% in 2018 in terms of chained volume index (2009=100). A glance at the activities constituting the Gross Domestic Product shows that, in 2018, there was a 1,3% increase in the added value of

agriculture in terms of chained volume index, a 1,1% increase in industry, and a 5,6% increase in the service sector. Within agriculture, the share of the gross product was dominated by plant production. While the share of husbandry within gross agricultural production in the EU is 49%, the figure in Türkiye is 36%. According to the Turkish Exporters Assembly's Agriculture Report (2016), in terms of agricultural added value, Türkiye ranked 5th in 1997 and 9th in 2014. The same report indicates that although it ranked 17th inland productivity (agricultural added value/hectares), Türkiye descended to 21st place in the world ranking in 2014.

3. Digital Agriculture Concept and its Development

Technological developments occurring in recent years have driven all sectors into rapid change. As in other sectors, agriculture has been affected by these technological developments and has entered a process of change and development. Many institutions, organizations, and universities in different countries of the world conduct different studies under the name of smart agriculture by using developing technologies. As a result of these studies, many new terms and definitions are emerging. Different forms of digitalization in agriculture have been stated, so "Digital Agriculture", "Precision Agriculture" "Precision Farming", "Smart Agriculture" "Smart Farming" are the concepts that have emerged. These terms used in the digitalization of agriculture were sometimes used alone in the studies in the literature, and sometimes two or three different terms were used together at the same time. While Wolfert et al. (2017), Blok and Gremmen (2018), Rose and Chilvers (2018) use the term of smart farming in their studies; Gondchawar and Kawitkar (2016), Kaya (2019), Kırkaya (2020) used the term of smart agriculture in their studies, Keogh and Henry (2016), Shepherd, et al. (2020) used the term of digital agriculture in their studies as well.

While Eastwood et al. (2017) used the term of precision farming in their studies, Kaya and Örs (2015), Burunkaya (2018), Özcan et al. (2020) used the term of precision agriculture in their studies. Klerkx et al. (2019) used the term of digital agriculture and smart agriculture in their studies, as Wolf and Buttel (1996) used the term of precision agriculture and precision farming simultaneously in their studies.

Similar situations are encountered in the articles and reports of many institutions and organizations on the digitalization of agriculture topic. To give some examples about this issue; While the term "Digital Farming" is used in the report of the Food and Agriculture Organization (FAO) titled Digital Technologies in Agriculture and Rural Areas, it is seen that the term "Precision Farming" is also used in the same study (Trendov et al., 2019). It is seen that the terms "Smart Farming" and "Precision Farming" are used together in the report of the European Agricultural Machinery Association (CEMA) titled "Smart Farming for All Farms" (Dryancour, 2017).

Smart agriculture is a modern agricultural production technology based on the use of advanced information technologies and control systems in an agricultural enterprise, which is based on the needs that differ spatially and temporally in the production area, considering these location and time criteria (Ministry of Agriculture and forestry, 2021). The number of studies related to Smart agriculture started to get the attention of many researchers especially after 2008 and it became one of the popular trends since 2019. The recent studies focus on agriculture through digital innovation (Muangprathub et al., 2019; Khanna and Abhishek., 2019; Klerkx et al., 2019).

3.1. Industry 4.0 and Agriculture 4.0

It is seen that the first revolution in the development of the industry is the first industrial revolution called Industry 1.0. This revolution, which started in the middle of the 18th century and gained momentum at the beginning of the 19th century, was realized when the production activities carried out with human power were replaced by machine power. The most important factor in the realization of the first industrial revolution was the invention of the steam engine in 1712. In this period, there were various developments in metallurgy, and steel production was increased. In addition to this, the first mechanical weaving process was carried out in 1784 and important developments emerged in the weaving industry (Alçın, 2016; Akben & Avşar, 2018; Bulut & Akçacı, 2017; Duman & Özsoy, 2019; Fırat & Fırat, 2017; Kagermann et al., 2013; Şekkeli & Bakan, 2018). The second industrial revolution, also called **Industry 2.0,** was started after the 1850s. The important factor in the realization of the second industrial revolution was mass production based on electricity and division of labor. In 1870, the first production line was put into operation at the Cincinnati Slaughterhouse. In this period, the efficiency of oil in the industry was discovered and it started to be used more intensively. At the same time, the effect of oil on transportation also accelerated the progress in transportation. Besides, the development of railways has brought along the ease of access to raw materials and product marketing. The production line technology initiated by Ford company in 1913 affected other sectors and caused an increase in production efficiency. Many inventions such as the telegraph (in 1840), the telephone (in 1880), and the first electrically fired and water-cooled internal combustion engine (in 1860) were invented during this period (Bulut & Akçacı, 2017; Ertuğrul & Deniz, 2018; Fırat & Fırat, 2017; Jänicke & Jacob, 2009; Kagermann et al., 2013; Şekkeli & Bakan, 2018 Tunzelmann, 2003).

The third industrial revolution, called **Industry 3.0**, started in the early 1970s with the first programmable production system called automation. In this period, manufacturing with the improvements on the use of electronic and information technologies In the third industrial revolution, revolutionary developments were experienced in many fields such as nuclear energy, fiber optic systems, chip technology, biotechnology, nanotechnology, semiconductor technology, and communication technologies and inventions were brought into open (Tunzelmann, 2003; Yücel, 2004; Kagermann, Wahlster and Helbig, 2013; Dombrowsi and Wagner, 2014; Fırat and Fırat, 2017; Şekkeli and Bakan, 2018; Duman and Özsoy, 2019). The pioneer of the term of **Industry 4.0** has been a technology project developed by the German federal government that develops a computer and internet supported production model, and this term was used for the first time in 2011 at the Hannover Fair. It was mentioned at the fair that the information age revolutionized the field of production by bringing production technology to a higher level. Industry 4.0 is a complex system that includes many components and terms such as computers, robots, 3D printers, UAVs (Drones), artificial intelligence, the internet, digital production, and automation technologies. Technological developments that emerged in the fourth industrial revolution are intertwined and continue to develop by influencing each other. In addition to this, developments in different disciplines are progressing in conjunction with each other. The Industry 4.0 understanding is focused on building smart production processes that include physical and virtual components. These production processes, called smart factories, are value chains that can be managed and directed by computers, can make autonomous decisions, and have the capacity to organize themselves. With all these realized developments, it is aimed to enable faster, more efficient and lower cost productions (Akben & Avşar, 2018; Bulut & Akçacı, 2017; Kılıç & Alkan, 2018; Soylu, 2018 ; Şekkeli & Bakan, 2018).

Today, the relationship between agriculture and industry is becoming tighter than ever. As in other sectors, it is aimed to make agriculture more productive and efficient with the use of information technologies. While moving towards this goal, a transition to a production process based on information technologies has begun to take place. The process in which many technological components such as computers, robots, UAVs, artificial intelligence, augmented reality, the internet, and automation are now used in agriculture in parallel with the revolution in the industry with Industry 4.0 is called Agriculture 4.0. It is seen that the agriculture 4.0 process has been given names such as Digital Agriculture, Precision Agriculture or Smart Agriculture (Ercan et al., 2019; Gökkur, 2019; Güldal et al., 2019; Kirmikil & Ertaş, 2020).

With its many technologies and smart applications, Smart Agriculture offers solutions to producers at many points such as land cultivation, planting and planting, fertilization, spraying, irrigation, disease and pest detection, soil analysis, humidity and temperature control, plant and animal growth monitoring, product tracking, harvesting, storage, logistics, marketing, and sales, in the process from the beginning of production to the last moment when the product reaches the final consumer (i.e. from farm to fork). Following the whole process by technology and smart applications will make significant contributions to collect data from every point of the field, storing the collected data, and obtain projections which will be able to help make decisions in the future by analyzing the stored data (Ercan et al., 2019; Gökkur, 2019; Güldal, et al., 2019; Kirmikil & Ertaş, 2020; Kılavuz & Erdem, 2019; Pakdemirli, et al., 2021).

- **Agriculture 1.0:** Low productivity, Labor Intensive.
- **Agriculture 2.0:** (Green Revolution) (1950) Synthetic Pesticides, Fertilizers, Cheap inputs, New Instruments ➔ Low Cost
- **Agriculture 3.0:** (Precision Agriculture) (1990) Manual Guidance with GPS, Variable Rate Application in Harvesters (VRA), Fertilization Process Tracking, Plot Specific Tracking, Animal Specific Tracking, Herd Tracking ➔ Cost Reduction and Effective Process Management (Saygılı et al., 2019:P.12).
- **Agriculture 4.0:** (2010) In parallel with the revolution in the industry with Industry 4.0, many technological components such as computers, robots, UAVs (Drones), artificial intelligence, augmented reality, internet of things, sensors, internet, and automation have been used in agriculture. It is seen that the agriculture 4.0 process has been given names such as Digital Agriculture, Precision Agriculture (1990), and Smart Agriculture (Ercan, et al., 2019; Gökkur, 2019; Güldal et al., 2019; Kirmikil & Ertaş, 2020).

3.2. Smart Agriculture Applications

Today, various agricultural applications are developed and implemented using smart agriculture components. Various research and development activities are carried out in this field not only in the academic field but also by many government institutions and the private sector. It can be observed that there are applications in many subjects such as IoT-based greenhouse systems, harvest detection with multispectral cameras, remote sensing irrigation systems, artificial intelligence supported pest detection, barn, and poultry monitoring systems, spraying and fertilization with the drone, harvesting with autonomous vehicles, meteorological data analysis with cloud data, frost tracking with cyber-physical systems and blockchain-based agricultural logistics security. Before explaining the situation of Smart Agriculture Applications in the world and in Türkiye in the following sections, it is possible to give some examples of academic studies related to this as follows.

	Title of study	Author	The topic of the research	Key findings
PESTICIDE AND HERBICIDE APPLICATIONS	A microprocessor-controlled technology to selectively spot sprayer weeds	Felton et al. (1991)	Sensor-based herbicide application	90% reduction in sprayed area, 95% of weeds becoming ineffective
	Spatially selective application of herbicide to cereal crops	Stafford and Miller (1993)	Applying herbicide only to the part affected by weed damage	35% reduction in the amount of herbicide applied
	Automatic spray control for airblast sprayers: first results	Balsari and Tamagno ne (1997)	Variable level pesticide application	10-35% pesticide savings
	Precision management of spatially variable weeds	Green et al. (1997)	Variable level herbicide application	70-86% herbicide savings
	Two-year weed seedling population responses to a post-emergent method of site-specific weed management	Williams et al. (2000)	Weed control in maize	11.5% reduction in the amount of pesticide applied
	The economical and ecological impact of the site-specific weed control	Timmerm ann et al. (2001)	Variable level herbicide application	Reduction in herbicide application 54%, saving 33 Euros per hectare
	Variable-rate herbicide application using the global positioning system for generating a digital management map	Mohamm adzamani et al. (2009)	Variable level herbicide application	13% herbicide savings
	Production Economy of Precision Agricultural Technologies and Possibilities of Using	Özgüven and Türker (2010)	Variable level drug administration	55.84% pesticide savings

	them in Corn Production in Our Country			
	Assessing the impact of site-specific spraying on control of Eurygaster integriceps (Hemiptera: Scutelleridae) damage and natural enemies	Karimzadeh et al. (2011)	Variable level insecticide application	Insecticide savings of 40-50%
CHEMICAL FERTILIZER APPLICATIONS	Soil specific anhydrous ammonia management system	Robert et al. (1991)	Variable application of ammonia	Savings of $3-9 per hectare
	Precision farming in a tomato production system	Rosa, U.A et al. (2000)	Variable nitrogen application	35% cost reduction, 40-50% efficiency increase
	Economics of variable rate lime in Indiana	Bongiova et al. (2000)	Variable level lime application	Profit between $ 7-20 per hectare
	Economic and environmental evaluation of variable? rate nitrogen and lime application for claypan soil fields	Wang et al. (2003)	Variable nitrogen and lime application	Reduction are 75%
	Variable rate nitrogen fertilisation of winter wheat based on a crop density sensor	Ehlert et al. (2004)	Variable nitrogen application	10-12% decrease in the amount of fertilizer used
	Economic feasibility of variable-rate nitrogen application utilizing site-specific management zones	Koch et al. (2004)	Variable nitrogen application	Fertilizer savings of 46%, profit between $18.2-$29.6 per hectare

STUDIES ON BUSINESS PROFITABILITY	Investing in precision agriculture(PA)	Moss and Schmitz (1999)	Determining the cost and benefits of PA	PA investment is not profitable since the profitability per decare ranges from $1.02 to $5.77 on average, and the PA investment cost is between $5.71-7.69 per decare.
	Precision farming of cereals crops, a five-year experiment to develop management guidelines, Home Grown Cereals Authority	Godwin et al. (2002)	Determining the cost and benefits of HT	Not profitable because variable rate implementation costs more than inputs
	Applications of Precision Agricultural Technologies in Türkiye	Güçdemir et al. (2004)	Comparison of traditional practices and precision farming practices	64% increase in crop yield
ADAPTATION OF TECHNOLOGICAL APPLICATIONS	Site-specific crop management: adoption patterns and incentives	Khanna et al. (1999)	Factors affecting the adoption of new agricultural technologies in crop production practices	It has been determined that only 20% of producers adopt PA applications. It has been determined that the producers adopting precision agriculture have higher land widths, more educated and younger producers.
	Farmer experience with precision agriculture in Denmark and the US Eastern Corn Belt	Fountas et al. (2005)	Identifying producers' precision farming experience in Denmark and the eastern United States	The main problems of producers in precision agriculture applications are the time requirement and high data processing costs. It has also been determined that 80%

				of the producers want to collect their data themselves.
	Adoption and future perspective of precision farming in Germany: results of several surveys among different agricultural target groups	Reichardt and Jürgens (2009)	Determining the adaptation of farmers to precision farming practices in Germany	It has been determined that the most important problem in adopting precision agriculture practices among producers is high-cost systems.
	IT as an enabler of sustainable farming: An empirical analysis of farmers' adoption decision of precision agriculture technology	Aubert et al. (2012)	This study tests a model explaining the difficulties of PA technology adoption.	Producers' knowledge of PA technologies claims to have the highest impact on the perception of the use of these applications.
	Adoption of precision agriculture technologies by German crop farmers	Paustian and Theuvsen (2017)	Evaluation of German agricultural producers' adaptation to precision agriculture technologies from different aspects	It has been determined that the producers having 16-20 years of experience and owning more than 500 hectares of land have a positive effect on the adoption of precision agriculture practices.

Table 3. Subject-based review of the literature

While there is much literature on the application of such smart agriculture, the adoption of the technology, and the business profitability, there are new studies concerning the ethical issues related to the application. For instance, International Congress on Agricultural and Food Ethics are organized in Turkey in the last few years. Çokuysal (2021) recently presented his study on Ethical Problem Issues in Agriculture, Digitalization and Sustainability Triangle at the 3rd congress in November 2021. The socio-ethical problems caused by digital farming systems affect efficiency and productivity. Therefore, he highlighted that a common agreement standard on the ethical ground should be introduced for all stakeholders such as digital service providers, farmers, agricultural engineers, software and hardware engineers, involved in the food supply chain, and the industry.

4. Digital Agriculture Components

In order to understand the development of smart farm practices and their current state, one must know about the components and the tools used along with the components of such practices. Smart agriculture components show similarities with the components of the Industry 4.0 concept and with the factors complementing those components. However, despite the existence of similarities, literature studies also indicate a number of dissimilarities in this regard. It is possible to summarize the examples of the components cited in the literature studies. In the 2016 study by Hermann et al. entitled "*Design Principles for Industrie 4.0 Scenarios*" main headings of Industry 4.0 components are enlisted as;

- Cyber-Physical Systems
- Internet of Things
- Smart Factory
- Internet of Services
- Smart Product
- M2M/Machine-to-Machine
- Big Data
- Cloud (Hermann et al., 2016).

On the other hand, Bulut and Akçacı, in their 2017 study entitled "*Analysis of Türkiye In the Context of Industry 4.0 and Innovation Indicators*" mentions;

- 3D Printers
- Internet of Things (IoT)
- Smart Factories
- Augmented Reality (AR)
- Artificila Intelligence (AI)
- Cyber Physical Systems (CPS)
- Cyber Security (CS)
- Big Data
- Autonomous Robots
- Simulation
- System Integration
- Cloud Computing Systems (Bulut & Akçacı, 2017).

Four most widely used components in Industry 4.0 studies are listed by Fırat and Fırat'ın in their 2017 study entitled "Trends and Robots in Industry 4.0 Journey" as;

- Cyber Physical Systems
- Internet of Things
- Smart Factory
- Internet of Services
- Smart Products
- M2M / Machine-to-Machine
- Big Data
- Cloud Technology (Fırat & Fırat, 2017).

On the other hand, Akben and Avşar, in their 2018 study entitled "Industry 4.0 ve Dark Production: A General Overview " lists the Industry 4.0 components as;

- Cyber Security
- Cyber Physical Systems
- Cloud Technology
- Smart Factory
- Internet of Things
- Internet of Services
- Learning Robots
- Big Data
- Virtual Reality
- 3D Printers (Akben & Avşar, 2018).

In their 2018 study entitled "*Logistics 4.0 Under the Effect of Industry 4.0*" Şekkeli and Bakan *lists components as;*

- Internet of Things (IoT)
- Internet of Services
- Cyber Physical Systems (CPS)
- 3D Printers
- Smart Objects
- Cloud Computing
- Augmented Reality
- Artificial Intelligence
- Simulation
- Big Data
- Autonomuos Robots
- Vertical and Horizontal System Integration (Şekkeli & Bakan, 2018).

In their 2019 study entitled "*Smart Agriculture with the Perspective of Industry 4.0*" the components of Industry 4.0 is enlisted as;

- 3D Printing Technologies
- Internet of Things (IoT)
- Smart Factory
- Cyber Physical Systems (CPS)
- Big Data
- Autonomous Robots
- Simulation
- System Integration
- Cloud Computing System (Duman & Özsoy, 2019).

When a literature survey on Smart Agriculture is performed similarities between Agriculture 4.0 and Industry 4.0 are detected. The article entitled *"Agriculture 4.0 and Assessment of its Applicability in Türkiye"* written by Ercan, et al. in 2019 components of Agriculture 4.0 are enlisted as ;

- Big Data
- Internet of Things
- Cloud Computing
- Satellite and Airborn Vehicles
- Drone
- Autonomous Vehicles and Robotic Systems
- Machine Vision Systems (Ercan et al., 2019).

In the 2020 study of Arvanitis ve Symeonaki'nin entitled "*Agriculture 4.0: The Role of Innovative Smart Technologies Towards Sustainable Farm Management*" Agriculture 4.0 and its components are enlisted as;

- Agricultural Cyber-Physical Systems (ACPSs)
- Cloud Computing
- Agricultural Internet of Things (AIoT)
- Artificial Intelligence (AI)
- Machine Learning (ML)
- Big Data and Analytics
- Agricultural Robots
- Agricultural Autonomous Systems (Arvanitis & Symnenaki, 2020).

Once more, Kirmikil & Ertaş study of the year 2020 entitled "A Sustainable Future with Agriculture 4.0" enlists the components of Agriculture 4.0 as;

- Cloud Informatics/Computing
- Internet of Things (Iot)
- Big Data
- Satellite and Airborne Vehicles
- Autonomous Vehicles and Robotic Systems
- Machine Vision Systems (Kirmikil & Ertaş, 2020).

In the 2021 study of Liu et al. entitled "*From Industry 4.0 to Agriculture 4.0: Current Status, Enabling Technologies, and Research Challenges*", apart from previous studies, it is seen that the component list included Blockchain. The list of components of the said study might be revealed as;

- Internet of Things (IoT)
- Robotic and Autonomous Systems (RAS)
- Artificial Intelligence (AI)
- Big Data Analytics
- Blockchain (Liu et al., 2021).

When the change brought to affect many other sectors in relation with Industry 4.0 studies the prevailing components in regards to Agriculture 4.0 might be listed as;

- Internet of Things
- Cyber Physical Systems
- Artificial Intelligence (Simulation and Machine Learning)
- Robotics and Autonomous Systems

- Big Data
- Cloud Computing
- Drone
- Blockchain.

Internet of Things (IoT)

Technologically well-equipped units' having an interactive quality with each other using the internet as the medium might be termed as the Internet of Things. In this system of communication, units are able to interact with each other without needing any human intervention. The term Internet of Things was first introduced by a number of academics who monitored the behavior of a coffee machine from a distance. Internet of Things is made used in various fields such as logistics, health sector, energy, production and manufacturing, trade, agriculture, and smart homes (Duman & Özsoy, 2019; Gökrem & Bozuklu, 2016; Liu et al., 2021).

Nowadays internet of things is practiced frequently in the field of agriculture. Farmers are able to monitor distant operations on their farms by means of computers, i-pad or cellular phones. With the help of the internet of things distant irrigation and fertilization activities might be carried out, climate conditions might be followed momentarily, the herd might be watched at the barn or coop, fishing activities might be carried as well as conditions of greenhouses are checked. In this respect, increases in productivity and quality in the production process, as well as cost reductions, are realized easily (Ercan et al., 2019; Kirmikil & Ertaş, 2020; Lezoche et al., 2020; Liu et al., 2021).

Cyber-Physical Systems (CPS)

The whole structure which has an informatics infrastructure and maintains the movements, communication, and coordination of objects between the physical and virtual media with the help of sensors as well as transferring this information to a system using the internet is named CPS. Cyber-physical systems work using the internet of things. The use of CPS helps model the productive stages by transferring the productive activities into a virtual medium and hence make the whole production process be followed virtually (Duman & Özsoy, 2019; Kamber & Sönmeztürk Bolatan, 2019; Soylu., 2018). Tools connected to cyber-physical systems acquire the ability to collect information via a control system that is based on digital sensing. CPS uses the collected feedback to convert them into continuous control cycles. Employing this principal CPS, checks the production process and contributes enhanced transparency and productivity (Duman & Özsoy, 2019; Toker, 2018). Cyber-physical systems are employed at various phases of the activities such as energy, health, agriculture, car building, manufacturing, aviation, and transportation (Soylu, 2018; Stojmenovic & Zhang, 2015).

Agricultural Cyber-Physical System (ACPS) is the application of cyber-physical systems to the agricultural sector. In ACPS technologies such as robotics and sensors are used. Using robots and sensors integrated farm management systems are established. By the use of the system parameters such as plant growth, soil values, heat and humidity can be followed. Collected information helps take correct actions at the appropriate time regarding the activities of plant condition, irrigation, fertilization, and harvesting. Hence possible losses are covered by obtaining the chance of early intervention (Dusadeerungsikula et al., 2019; Selmani et al., 2019).

Artificial Intelligence (AI)

Artificial intelligence (AI) might be defined as the technological ability of machines to imitate human behavioral traits such as sensing, seeing, thinking, learning, decision making (Bakan, 2018; Şekkeli & Uzun et al., 2018). AI systems, unlike classical computer technologies, are able to develop themselves through interpretation of the stored information by adding new capacities and functions by means of a trial-and-error process. AI's self-development process by applying a trial-and-error method is called machine learning. An AI software can perform calculations and analyses, which are difficult or impossible for the human brain, easily. AI which was a common use in robotics previously has been introduced in almost every field of life today thanks to the rapidly changing Technologies (Bulut & Akçacı, 2017; Liu et al., 2021; Şekkeli & Bakan, 2018). AI is used in gathering data, processing the data gathered, forming simulations, helping decision-making by performing analyses, and making various calculations in agriculture. Although it seems that AI is employed less frequently in the field of agriculture compared to other sectors recently the number of studies in this regard is on the rise.

Robotics and Autonomous Systems

Robots are devices that work autonomously in parallel with the loaded software with no human intervention. Robots have the ability to sense physical variables such as heat, light, speed, and current within the working areas, through the built-in sensors. Hence robots, using the loaded software, move the mechanical applicators and realize the defined tasks by converting the parameter values in the location into electrical impulses (Özsoylu, 2017; Şekkeli & Bakan, 2018).

Autonomous systems and smart robots are used in the field of agriculture as they are used in other areas. Examples of that are autonomous tractors, autonomous harvesters, crop harvest robots, insecticide robots, autonomous mowing robots, and similar others (Ercan et al., 2019; Kirmikil & Ertaş, 2020; Uzun et al., 2018).

Those vehicles having the capacity of sensing, navigating, and directing without human intervention are called "Autonomous Vehicles". In Industry 4.0 period, many producers of tractor and agricultural vehicles started producing tractors, harvesters, and similar autonomous vehicles compatible with smart agriculture practices having no need of a driver as being equipped with techniques and technologies such as radar, GPS, odometry, sensor, computer vision. Vehicles that are driven by computers within the context of smart agriculture need no drivers. Using automatic steering systems activities such as the following might be realized; planting or harvesting the crop day or night without being affected by the weather conditions, planting seeds with proper distance, causing less pressure in the soil, skipping the problem of driver carelessness, catching zero percent error, having ease at harvesting stage, realizing savings in fuel-insecticide-fertilizer-labor such systems help to remove drivers' errors in agricultural activities. Automatic steering systems, receiving from satellite different types of signals at differing levels, perform steering (driving) functions by themselves and thus increase productivity. Application of those systems in raising plants that need a certain distance in row, such as corn, cotton, and sunflower, help correct use of inputs such as seeds, insecticide, and fertilizer and thus drop costs. Scientific studies reveal that using automatic steering helps reach savings rates of 9% in fuel, 17% in time spent, and 10% on the whole operation. It is now possible by applying smart agriculture techniques, which work on data transfer through a common protocol built-in on a tractor and related equipment, reaching zero rates of error and maximum rate of productivity (regardless of conditions of nature).

It has been determined by the Harvester Productivity/Harvest Tracking Log System that during a harvest machine are unable to realize the duly action or leave the product out by 40%. This costs Türkiye a loss of USD 2 billion each year. Using 9 different sensors and a locally modified main computer board for harvesting systems information at the time of the harvest such as yield of the land, crop area, slope, type of crop, humidity, heat, length of front cutter, coordinates are compiled momentarily by the operational center. In this respect, all 300 harvesters reached satisfactory results.

System of Harvester Productivity Monitor and Crop Yield Augmentation (Instant) serves to produce information for years to come by interpreting the data on yield, speed, humidity, temperature, height, slope, and mappings which are compiled on the parcel basis through harvesters and to make simulations regarding the time of harvest by making comparisons between the parameter values of the yearly average values over districts, provinces, and Türkiye in general.

Big Data

Big Data is defined as the huge data sets which cannot be processed with the available information systems. In other words, the volume of data that is impossible to be collected, stored, processed, and analyzed by the currently available software tools and traditional database management systems is called big data. Processing the big data is not only made to reach the data or store it but it is also made to analyze the solutions yielded by such data and to use it properly. As a result of processing and interpreting big data with the right analysis methods it will be possible for businesses to make innovative decisions with the right strategies, minimize risks and reduce costs. Hence, it will be easier for establishments to improve their competitive power and create value with the goods and services they produce by processing the big data (Akben & Avşar, 2018; Ercan et al., 2019; Hermann et al., 2015; Özsoylu, 2017).
With data-based production sustainability in agriculture can be maintained. Big data is as important for Agriculture 4.0 as it is for Industry 4.0. Using big data applications, it is possible to make accurate decisions in the agricultural production process. Collecting data and analyzing it continuously during each phase of production such as growing the crop, harvesting, storing and, transportation, will be effective on production and consumption decisions. In addition, this will reduce the losses incurred throughout the whole production chain to a minimum. It is observed that big data in the agricultural sector is used in many instances such as modeling the harvesting risks, creating feeding in livestock production, making price comparisons, and modeling such differences, defining marketing targets, and making logistics modeling (Akben & Avşar, 2018; Demiryürek, 2001; Liu et al., 2021; Özsoylu, 2017).

Cloud Computing Technologies

An increase in internet use created a number of changes and developments in informatics infrastructure. One of those developments is cloud computing Technologies. Cloud computing technology is the online sharing of information between information and technology devices via the internet. In this technology, data is stored on a remote internet server and access to that data is provided momentarily and is operable at any time. Cloud Computing Technologies have improved and new companies to serve in this field have been formed. The technology whose use and importance are rising every day creates novelties in various areas. By the application of

cloud technology new transformations are expected in the areas of information, telecommunications, education, health, agriculture, and manufacturing (Kirmikil & Ertaş, 2020; Özsoylu 2017; Şekkeli & Bakan, 2018).

Owing to the internet of things, the use of cloud computing technologies in agriculture is increasing every day. In this technology, the data is obtained using the equipment, robots, sensors, systems, and agricultural software to a remote server. The data hence collected on a server is stored, classified, and analyzed according to the needs. Cloud computing technologies give way to the formation of a mutual platform to share knowledge on a real-time basis between multiple users. It gives the opportunity to create virtual scenarios helping make real-time decisions by employing virtualization and visualization. With the help of newly developing cloud computing technologies many results are produced in the areas of collecting data with sensors, data management in farms, analysis of plant diseases, monitoring herd development, production management, marketing management, and analysis of input costs (Foughali et al., 2018; Ojha et al., 2017; Singh et al., 2020; Ünal & Toprakçı, 2013).

Drone

An unmanned aerial vehicle is defined as a straight-wing aircraft or helicopter having no human pilot and is controlled remotely from centers on the land using radio net connections. As the result of technological developments equipment that has propellers, has a high degree of motility, and is relatively small in size have been created and are called "the drone" In the early stages of their development drones were used for military purposes but then were started to be used in different sectors where the agricultural sector is being one. Especially ability to control the flight patterns and flight speed of those drones via cellular phones, i-pads, or by own control boards expanded their use (Ercan et al., 2019; Kirmikil & Ertaş, 2020; Krishna, 2018: P4-8; Uzun et al., 2018).

Agricultural drones have started to gain popularity in recent years as a result of the imaging systems as well as sensors that are capable of overcoming obstacles. Drones are used in many activities such as seed planting, casting insecticides, harvest detection, field control, pest detection, weed detection, and fire extinguishing owing to the functions of momentarily image transfer, computer-based decision-making systems, portable tanks, and spraying (Ercan et al., 2019; Kirmikil & Ertaş, 2020; Krishna, 2018: P4-8; Uzun et al., 2018).

Blockchain

The origin of the blockchain concept is based on the article titled "Bitcoin: A Peer-to-Peer Electronic Payment System" written by Satoshi Nakamoto, a name considered to be (Nakamoto, 2008). The author(s) of the article aimed to create a stateless currency that cannot be controlled by any government institution and does not need central financial intermediaries (Gerdan et al., 2020; Morkunas, Paschen & Boon, 2019). Concepts of blockchain and bitcoin are often confused with each other. While bitcoin is defined as virtual crypto money, blockchain technology is defined as a recording method (or a ledger) used in bitcoin transfers (Kırbaş, 2018ccc). The infrastructure of blockchain is not created for only the transfer of virtual cryptocurrencies. The purpose of blockchain technology is, in addition, to allow tracking the ownership of any physical or digital asset(s) tracking (Kırbaş, 2018; Yıldızbaşı & Üstünyer, 2019). In blockchain technology, the users recorded in the system hold digital ledgers and each transaction is recorded in those

ledgers. The blockchain system uses interconnected block structures in order to verify the data and store them. Each transaction forms a block and this newly formed block, to create a linear and chronological chain, integrates itself into the chain system. Owing to this chain system transactions are recorded in an irreversible manner. Irreversibility of those records allows a settlement system which is distributed independently of a consenting (Cankül & Kızıltaş, 2020; Gerdan et al., 2020; Tunca & Sezen, 2020).

One of the applications of blockchain technology in agriculture is blockchain-based smart contracts for agricultural food supply chains. Using the internet of things technology all contracts (production, storage, distribution, and marketing) are recorded with smart contracts in a decentralized manner along the blockchain supply chain. Hence a fixed transaction log might be created beginning by the raw material supplier to the final consumer. Owing to the transaction logs food safety, quality, and traceability might be enhanced which in turn helps to build a transparent and credible system. The ability to track the history of each transaction helps buyers to follow the stages and thus prooves the authenticity of the transactions. In addition, contrary to the complexity of the traditional contracts blockchain system allows safer and rapid settlement of contracts (Yıldızbaşı & Üstünyer, 2019; İrak & Topçu, 2020; Cankül & Kızıltaş, 2020; Gerdan et al., 2020; Liu et al., 2021).

5. Importance of Smart Agricultural Practices and Applications Around the World in the COVID-19 era

In 2020, The United Nation of Türkiye has published a report on COVID-19 Socioeconomic Impact Assessment, presenting the updated situation on the crises and responses under 5 pillars which are: Health First; Protecting People; Economic Response and Recovery; Macroeconomic Response and Multilateral Cooperation, and Social Cohesion and Community Resilience. The importance of acceleration of the transformation of digitalization in agriculture was heightened in Pillar 3 (Economic Response and Recovery) and food insecurity in Türkiye was discussed as one of the risks due to the disruptions caused by the crises.

Then the government took and quick action by introducing a Digital Market Place / Farming Market (DİTAP) for agri-food products which are explained in detail in chapter 7. Despite this efficient response, the necessary training, and related activities such as field visits and pest monitoring and surveillance were terminated for some period due to the covid 19 restriction. The crises obviously negatively affected the working conditions of workers in the agriculture sector.

Similarly, Apostolopoulos et al. (2021) conducted research on the impact of COVID-19 on agri-food entrepreneurship, highlighting that governments have been forced to take such restrictive measures in food supply chains worldwide to reduce the spread of disease (Mishra et al., 2021) The pandemic became the trigger for all business to be more innovative and to adapt to technologies. The same applies to food security which needs this adaption throughout the production, processing, and consumption stages (Di Vaio & Varriale, 2020). There is a number of challenges in Smart Agricultural Practices, however, this crisis also generates opportunities and accelerates the digital transformation.

Therefore, this project aims to provide information about the development of digital transformation, smart applications, and e-commerce in agriculture. More specifically it focuses on the effectiveness of the digital transformation in agriculture, especially in the COVID-19 pandemic era. Between the years 2020 to 2021, 6122 articles were identified in a web of science list journals, containing the keywords "Covid" and "Digital" as shown in Visualisation Map 1: "Covid" and "Digital". The software tool "VOSviewer" was used to create the below maps based on text data. Key terms were divided into 4 clusters and the most common terms used in all the fields of research were fields related to Digital Transformation and Security, followed by Healthcare, Medical treatments, and online education. Among them, only 36 articles were in the area of Agriculture which were divided into 5 different clusters as shown in Visualisation Map 2. The biggest cluster includes the general key terms such as Innovation, Opportunity, Internet, and Technology most relevant to the Digital Transformation. The terms such as Food Security and Food Insecurity were in the 2nd largest cluster in green.

There were only 4 publications in Agriculture Multidisciplinary and/or Economy in different contexts. For instance, Lopez-Ridaura et al. (2021) conducted research on the impact of COVID-19 on farming systems in Central America and Mexico. Similarly, Aseeva & Budanov (2020) discussed the potential risks caused by the rapid digital transformation process in Russia. Both articles highlighted the accelerated digital transformation process as a result of the pandemic. And therefore, the mechanism or a system should be introduced for the smooth implementation of actions, while concerning the security issues in agriculture.

According to this reliable database collected, food security is one of the most important topics during the Covid era, connected to the digital transformation in agriculture. There are very few studies conducted worldwide and it clearly demonstrates the need for this project to contribute to a better understanding of the current situation and to provide a road map in the Turkish context.

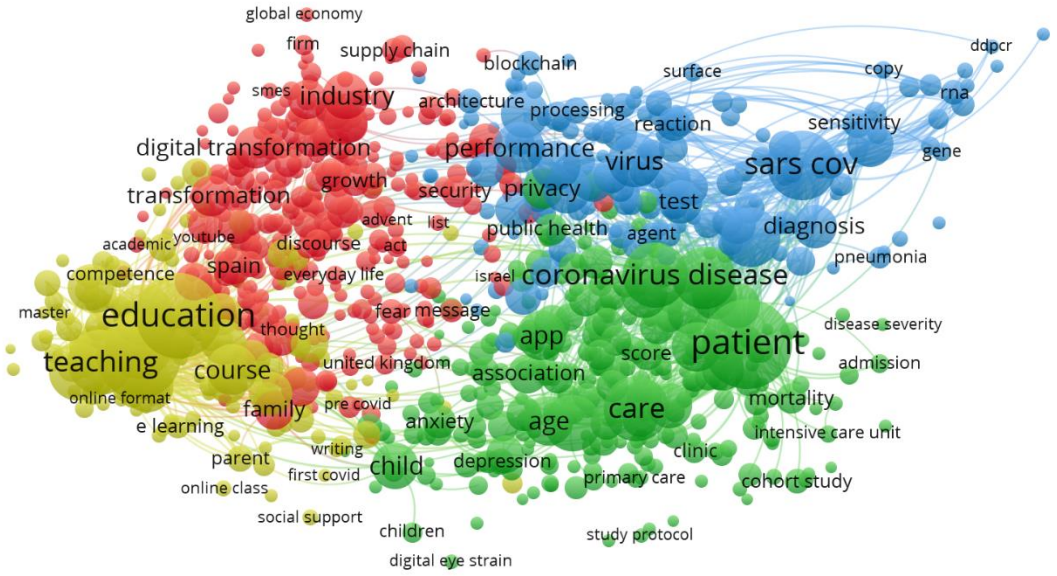

Figure 2. Visualization Map "Covid" and "Digital"

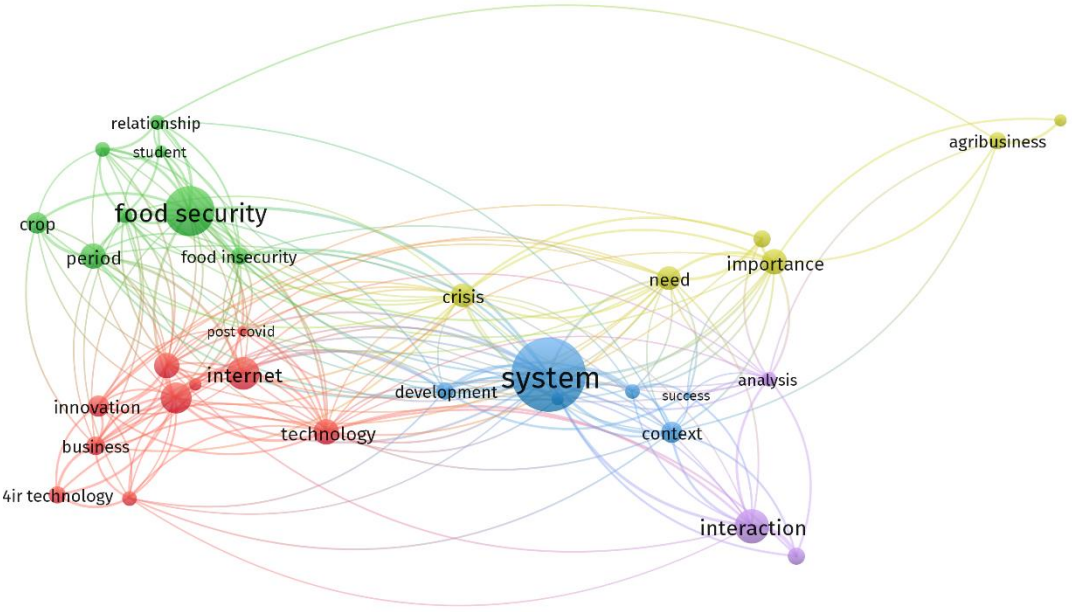

Figure 3. Visualization Map "Covid" , "Digital" and "Agriculture"

When agricultural practices are examined, it can be observed that they contain several measures and targets. If it is desired to mention these measures and goals, they can be listed as follows;

- Reducing costs,
- Obtaining maximum product with minimum cost,

- Increasing product quality,
- Environmentally-friendly production with minimum input usage,
- Control of chemicals such as pesticides and fertilizers used,
- Control of production equipment,
- To be able to control the emission,
- Making business decisions effectively and efficiently,
- Product selection
- Market follow-up,
- Rapid pricing decisions can be made due to simultaneous costs,
- Ensuring the flow of information within the enterprise,
- Minimizing problems and disruptions related to workmanship,
- Supporting entrepreneurship.

The COVID-19 pandemic process, the symptoms of which began to be seen at the end of 2019 and became more widespread as of 2020, affected agricultural activities as well as affecting every field. Especially with the increase in the need for food, the importance of agriculture has increased even more. While the announced pandemic rules bring some difficulties, the importance of smart agriculture has come to the fore. From this point of view, the effects of the pandemic period on agricultural production were observed as follows;

- The occurrence of environmental variability (climate),
- Economic variability (input costs, reduced revenues),
- Importance of food safety (risk of contamination, desire for healthy products),
- Excessive demand for food,
- Problems in mass transportation of people (risk of contamination),
- Problems occurring in collective work (risk of contamination),
- Difficulty of producers due to travel restrictions (Yıldızbaşı & Üstünyer, 2019; İrak & Topçu, 2020; Cankül & Kızıltaş, 2020; Gerdan et al., 2020; Liu et al., 2021).

Regarding smart agriculture, many projects and studies are conducted at universities, institutes, institutions, establishments companies both in the World and in Türkiye. Many of those ongoing studies are observed to intensify in countries such as China, Taiwan, Japan, the Netherlands, the United States, and Israel. Countries that focus on such studies invest heavily in agricultural Technologies and carry R&D activities. According to the 2017 "*Smart Agriculture Market Research*" report of Huawei company, the volume of the smart agriculture market reached USD 13,7 billion globally in 2015. The report forecasts the volume of the market to reach USD 26,8 billion in 2020 and double this latter volume in 2025 (Atasoy Demirel, 2019).

China, to defend and improve its share in the global markets, is taking aggressive steps toward digital transformation in all sectors. Owing to her investments China is today a leader in digital transformation. The country assigned special importance to modern agriculture technologies as of 2007. In addition, the country provided an incentive scheme amounting to Yuan 2,6 billion in 2014 with the aim of developing agricultural technologies. The government extends incentives for fertilization, spraying, performing soil tests under the light of scientific rules as well as breeding healthy herds using animal farming technologies. With the technological breakthrough in 2014, China contributed to 56% of the whole agricultural growth. Research made in 2016 revealed that only 3% of the Chinese firms were unprepared for digital transformation (Atasoy Demirel, 2019).

The USA is one of the leading countries in the use of technology in agriculture. The country has become the largest agricultural product exporter as the result of the developments realized. Perhaps the most important secrets in the agricultural success of the USA are investing both in creating technology and teaching how to use this newly created technology. Many organizations and institutes affiliated with the US Federal Department of Agriculture (USDA) work on issues such as increasing production, reducing costs, economizing on spraying and fertilization, reducing environmental hazards, improving irrigation efficiency, and guaranteeing food safety.

While carrying out such studies they support computer science research, development of high technology products, research in the fields of engineering and physics, production of agricultural tools, and software creation in many fields. According to the report published by the US National Science and Technology Council in 2016, in order to support advanced production Technologies, a separate strategy and action plan on artificial intelligence were prepared. NASA sent an observation satellite to space to monitor climatic events. A group of farmers received incentives from the state to use integrated systems aimed to combine humidity, temperature, and control of harmful substances online in their areas of production. Many farmers started forming productivity maps using GPS systems (Atasoy Demirel, 2019; Güldal, Özçelik & Şahinli, 2019; Kirmikil & Ertaş, 2020).

The role of private companies producing both machinery/equipment and software in the developments in the field of agricultural technology in the USA is so great to be underestimated. Using a mobile application called Scoutpro, a farmer can monitor his land life while getting information about the land conditions, at the same time. John Deere company, one of the major agricultural equipment producers in the world, using APEX TM JDLink software provides online access to farms, agricultural data, and machinery. The company, in addition, has recorded improvements in reducing fuel costs by integrating GPS sensors into the tractors produced. With the web-based service and mobile application called Cropio, remote real-time monitoring of the land and crop conditions as well as yield forecasts are realized. In Green Sense, the largest indoor vertical farm in the USA, production is carried out by controlling light, humidity, temperature, and water flow employing computer systems (Atasoy Demirel, 2019; Kirmikil & Ertaş, 2020; Saiz-Rubio & Rovira-Mas, 2020; Yuksel, 2020).

The Netherlands is an example of success in the creation and application of agricultural technologies. The most important motivation yielding this result is the importance attaches to digital transformation. Ranking 4th in the 2017 Global Competitiveness Index, the Netherlands is most successful in technological readiness, innovation, and education. One of the most important factors in the agricultural development of the Netherlands is the agricultural universities established in the country. At the same time, important studies are carried out within the scope of the smart industry through the innovation centers called "Field Labs", the number of which reached 32 as of 2018. Despite the relatively small size of the agricultural area, the country ranks second in the world's agricultural product exports. While the total size of agricultural exports realized in 2017 was Euro 100,8 billion of this volume Euro 9,1 billion constituted by technological agricultural exports (Erdem, 2017; Atasoy Demirel, 2019; Lider & Erdem, 2019; Kirmikil & Ertaş, 2020).

The Government of the Netherlands has purchased satellite data for Euro 1,4 billion in order to increase agricultural productivity and ensure sustainability in the sector. The government then shared this data with the producers online. Producers have realized productivity increase and sustainability in agriculture by using this data, which included information such as plant

development, soil condition, weather conditions. The Netherlands has made remarkable progress in many areas such as high-tech supported irrigation systems, renewable energy systems, automation systems, robot technologies, big data analysis, artificial intelligence, and smart agriculture software (Atasoy Demirel, 2019; Guide & Erdem, 2019; Kirmikil & Ertaş, 2020).

As **Japan**'s arable land is only 11% of the total amount of land it owns, the population working in the agricultural sector is low, and the average age is relatively old, the country, to mitigate those disadvantages, has made significant investments in agricultural technologies, thus making significant developments in the agricultural sector. The country has produced robots that harvest fruit in a short time of 8 seconds. In the bionic farms established production is carried out by controlling light, heat, and humidity using computers. Harvest controls are employed by using vision and sensor technologies. A 2000 m^2 vegetable greenhouse was established by Osaka Prefecture University. In this greenhouse, which is commonly known as the vegetable factory, rapid product development was achieved by using artificial light technology.

The Fukushima Agricultural Technology Center provides technical support to producers along with providing opportunities for farmers regarding technology creation and application that is free of charge. The company named Kubota provides cloud-based agricultural management support services to producers using the software it has developed. A company named Topcon has developed a cloud-based data management software that provides data management for farmers, data analysis for agronomists, and multi-user data management services. This software has been developed in a way that it can be monitored and connected in harmony with both its own equipment and equipment of the other companies (Güldal et al., 2019; Kirmikil & Ertaş, 2020; Saiz-Rubio & Rovira-Mas, 2020).

Agriculture constitutes the largest share of **Taiwan**'s economy. 25% of the country's land inventory consists of cultivated land. Since the beginning of the 1960s, the country started important investments in the agricultural sector. The country has made serious progress by giving due importance to innovations, mechanization, and digital farming systems. It has become an important manufacturer in the field of agricultural machinery and machine components. Taiwan manufactures and markets globally components of the internet of things, drones, robots, solar panels, and LED technologies. It is one of the leading countries, especially in LED technologies. It produces, in greenhouses, using special LED lights that imitate sunlight yet not give harmful rays to plants. The country is also in the number 1 position in the world especially related to solar cell production. The company named Advantech has developed a remote-control system in the field of digital agriculture and is working on the applicability of the system to the whole country. The company called YesHealth iFarm has established a 14-story smart farm where vertical farming is applied with temperature, humidity, and airflow controls (Erdem, 2017; Guide & Erdem, 2019; Kirmikil & Ertaş, 2020).

The UK is one of the countries that most successfully implement smart agricultural practices with the cooperation of universities, industry, and government. The country started the process by educating young scientists and establishing research centers in this regard. The most important reason for the success of the UK in Agriculture 4.0 might be named the support given to agricultural research and training. Just in the 2011-2012 period, the government spent Euro 450 million on research and development activities in the agriculture and food sector.

There are many institutions and organizations performing in the field of agriculture in the UK. Among them is DEFRA (Ministry of Environment, Food and Rural Affairs), which works under

the government, comes first. In 2016, DEFRA, the Ministry of Economy, Environment and Rural Affairs of Northern Ireland, theMinistry of Rural Affairs of the Welsh Assembly Government, and the Scottish Government jointly published the "Agriculture in the UK" report describing the agricultural data and state of agriculture in the UK. This report contains striking data. According to the report, Sterling 250 million was spent on agricultural technologies in 2015. This, in turn, caused an increase in, wheat production per hectare from 7 tons to 8 tons. The revenue from the agricultural market in 2015 was Sterling 96 billion, equivalent to 0.7% of GDP (Gross Domestic Product) of the UK. 3,8 million people are employed in the agriculture and food sector. This constitutes 1.2% of the total workforce.

Another major agricultural institution in the UK is the Rothamsted Institute. Celebrating its 175th anniversary this year the main field of study of the institute is environmentally friendly agricultural technologies. The Institute carries out successful projects with a budget of Sterling 37 million and with 450 researchers. The cumulative contribution of the institute's studies to the UK economy amounts up to Sterling 3 billion per year. The institution's researchers contribute to the dissemination of knowledge worldwide by publishing nearly 300 publications each year of which 70% are free of charge. The institute currently conducts projects on food safety, genetic studies to increase productivity, and future agriculture and food technologies. In 2015, the institute established the world's first field crops analysis facility. The facility, which operates 24 hours a day, has a scanner that can scan an area of 15mx120m with the sensors and cameras on it. In this way, the development and health of plants can be analyzed by scanning the field surface.

One of the most important cooperation experiences in agricultural and food technologies in the UK is the N8 Agrifood platform which was constituted by the eight leading universities of the country (Universities of Newcastle, Lancaster, Manchester, Durham, Liverpool, York, Leeds, and Sheffield). On this platform, more than 450 researchers and more than 150 doctoral students work platform with a fund amounting to Sterling 269 million. The cooperation platform, through research conducted, also supports more than 40 establishments. The main areas of interest of the studies run on this platform are sustainable food production, a safe food supply chain, and phytosanitary and food health. In this context, the studies focus on precision agriculture and Agriculture 4.0 technologies and gene studies.

6. The Situation of Smart Agriculture in the Türkiye

Agriculture plays a critical role in the global economy. As the COVID-19 pandemic continues, more and more challenges are seen in agricultural activities such as the disruption of supply and demand for food in particular. Many new rules and regulations are introduced which affect the global supply chain in the rapidly changing environment. For instance, Lioutas et al (2021) emphasized related issues in smart technology and big data and suggested how farmers can overcome those challenges. Graham et al. (2021) conducted a comparative study (before and after the Covid 19 pandemic) on emissions from livestock in Northern Kenya. Their findings show that the current pandemic leads to unexpected results depending on the environmental conditions.

To respond to those unexpected challenges including food shortage and inflation, the integration of digital support and digital transformation in agriculture became invaluable. Implementation of smart agricultural practices helps to improve the production and sale process to drive future market growth.

In Türkiye, there have been enormous improvements in terms of access to digital technologies and services within the last decade. Out of 150 countries, Türkiye was ranked 5th globally for improvements made to 3G and 4G coverage, network performance, and spectrum availability according to the GSMA Mobile Connectivity Index. The most significant improvements were the physical infrastructure. Between 2015 and 2017, download speeds increased by 300% to an average of 28Mbps, and 4G network coverage reached 90% of the population. Within the same period, Türkiye climbed five places on the ICT Development Index, from 72nd to 67th.

The International Telecommunications Union reported that over 97% of surveyed inhabitants had mobile cellular subscriptions, whereas only 14% had fixed telephone subscriptions. The latest census data from the Ministry of Transport and Infrastructure shows over 80 million mobile telephone subscriptions in the country. Mobile technologies are also the preferred and dominant means of internet access.

As of 2018, 81% of Turkish households have internet access. Approximately 74% of surveyed inhabitants were mobile broadband subscribers, and 16% had fixed broadband subscriptions. Only 57% of households own a computer, although 71% of individuals actively use the Internet. Nevertheless, the Information and Communication Technologies Authority reports full market competition for wireless broadband, DSL, and cable modem Internet services. As of late 2017, the country had over 450 ICT service operators. Turkcell is the largest mobile service provider, covering nearly 44% of the market, followed by Vodafone and Türk Telekom. Türkiye also has three Internet exchange points: IST-IX, TNAP, and DEC-IX.

Türkiye ranks “high” on the E-Government Development Index (53rd globally) and “very high” on the E-Participation Index (37th globally), both of which measure the degree to which public services are available digitally. For example, the Turkish Presidency’s Communication Center, originally launched in 2006, is an electronic tool to facilitate civic engagement and public information requests.

In the last decade, Türkiye has also increased its access to and use of EO resources, which play a significant role in information extraction. With the launch of the RASAT satellite in 2011, Türkiye began offering EO data through the open GEZGIN online portal. A second EO data platform, GEOPORTAL, was established as part of the national initiative to strengthen economic development and environmental monitoring through EO services, followed by the European Union FP7-funded EMPOWER. In June 2016, the European Space Center launched Türkiye’s Göktürk-1 satellite, which is equipped with remote sensing technology to monitor pollution, natural disasters, and law enforcement. In 2020, Türkiye will expand its satellite capabilities by deploying Göktürk-3 to capture high-resolution imagery using a synthetic aperture radar.

Currently, Türkiye is preparing for the deployment of 5G technologies, which will allow for machine-machine and machine-human connections. The country has also been working with

the United States' Open Networking Foundation to develop the next generation of ICT technologies, including enhanced mobile broadband, enhanced machine-type communications, and ultralow latency communications. Following Information and Communication Technologies Authority approval, Turkcell, Vodafone, and TT Mobil have begun piloting 5G technologies in Istanbul, Izmir, and Ankara, giving Türkiye a leading position in the international race to 5G.

Digital agriculture end users may be generally grouped into four hubs. Each hub has unique resources and needs in terms of digital agriculture, and each hub faces unique challenges for which digital agriculture could offer solutions. The hubs are not mutually exclusive; any given individual may function within multiple end-user hubs.

The Input hub includes all actors providing agricultural inputs, such as seeds, feeds, agrochemicals, machinery, and finance. The main challenges faced in this hub include small farm size, limited farmer financing, and limited decision support mechanisms for selecting inputs. Most farmers rely on what they have traditionally used or simply what local retailers offer. A large percentage of farmers purchase inputs on credit provided by local retailers. Regional and national supplier networks employ market and supply chain forecasting technology; local establishments rely on low-tech information sources.

The Production hub fundamentally consists of farmers and livestock keepers. A survey of more than 3.000 farmers across 81 regions in Türkiye indicates that only 39% of the farmers have access to the internet using computers. Of these, 25% use it for surfing on social media, 12% use it to view weather forecasts, and only 3% use it to acquire agricultural information. Almost half (44%) of farmers use smartphones; of those, 33% have access to social media, 2% use agriculture-oriented apps, and 3% use banking services. Additionally, many farmers currently receive climate information via SMS. Another study run over 114 farmers around Izmir found that internet usage increases with the education level. Of the farmers that seek out agricultural information on the internet, most have only a moderate level of confidence in the information they find. In the last five years, about 54% of farmers who sought out agricultural information online applied the information they had sought.

High-profit farmers (generally large-scale livestock and cereal producers, smaller scale fruit and nut farmers, and greenhouse farmers) compose about 2,5% of all farmers. This group is most likely to use digital technologies for farming. They possess the highest levels of digital solutions, including weather stations, soil/livestock sensors, Internet of things, and decision support tools providing information on e.g. markets, weather, pests, and diseases. These data suggest that farmers who trust the information source are willing to use digital resources.

The Distribution hub includes all actors in the value chain between farmers and consumers, such as traders, transporters, and processors, among others. Distribution hub end users are most often constrained by limited access to financial solutions, poor traceability, and a lack of communication with other value chain stakeholders. Large regional, national, and international distributor networks have strong digital solutions, including high connectivity, information access, and forecasting systems. Local retailers, markets, and farmer organizations operate with low-tech solutions.

In Türkiye, farmer organizations (e.g. cooperatives, unions) fall into the Input, Production, and Distribution hubs. Producer organizations are particularly important in areas with a large number of small farms; the organization mitigates potential small-scale issues that would

otherwise increase average production and transaction costs. Some of the more advanced producer organizations, such as those with regional and national reach, have already started using digital technologies in their operations, including harvest, processing, and marketing. Some are even using drones and sensors to help track production for their members.

The Consumer hub consists of consumers of both raw and processed agricultural produce—in effect, the entire population. Consumers are subdivided by income and geographic proximity over large cities. All consumers have similar rates of connectivity but those with higher income and greater urban proximity have much higher access to smartphones and are more interested in the nutritional value of food. This results in an increased ability to make informed purchasing decisions and utilize traceability technologies when buying agricultural goods.

Although the need for technological advancement is necessary, many agricultural producers in Türkiye do not invest in innovative farming technology. As a result, the country is currently facing a lack the contemporary technologies and decision support tools for boosting yields and sustainable agricultural practices. This challenge is exacerbated by regional water shortages and recent currency devaluation. Other stakeholders along agricultural value chains, including input providers, distributors, and consumers also face substantial challenges, including powerful regional distributor networks and subsidy systems based on regional averages.
On the contrary, there are more investments in agricultural credit systems, which reflect countries' political, economic, and structural properties such as the predictable annual input costs. Financial literacy education would prepare farmers for the up-front investments necessary for many digital solutions. The current gender power dynamics in the agricultural sector may also hinder the scale-up of innovations and technologies.

The Turkish educational system is relatively advanced in terms of computer science and there are many highly skilled individuals in the digital sector. Nevertheless, the digital workforce available to develop and manage digital solutions is lower per capita than the global average and is highly centralized in the largest cities. As such, there is a significant opportunity for the growth of the digital workforce, particularly in rural areas and the agricultural sector.

Studies on smart agriculture and related fields have gained momentum in recent years. The interest of the Ministry of Agriculture and Forestry, as well as that of the private sector toward this topic, is on rising every day. Especially, information technologies companies' interest in this area and their related research and development investments increased. Universities have initiated cooperation efforts on both a national and international scale in this regard. A number of projects and academic research are conducted related to Agriculture 4.0. Examples of such studies and research might be enlisted;

- TÜBİTAK Space Technologies Institute has started working with the Presidency of GAP (Southeastern Anatolian Project) Regional Development Administration in order to support agriculture via space Technologies within the scope of the Southeastern Anatolian Project.
- Under the partnership of TÜBİTAK and Ankara University a smart agriculture feasibility project has been realized. Within the scope of the project, data were collected both from the air and from the ground. The collected data were processed and analyzed.

- In 2012 with the support of TÜBİTAK "Doktar Agriculture and Livestock Information Systems Research and Development Inc.", which is called the Doctor of Agriculture, was established within Ege University. The company creates technologies using various components of smart

agriculture such as the internet of things, big data management and analysis, remote sensing, geographical information systems (GIS), image processing and analysis, modeling, sensor Technologies, agricultural control technologies, production, and planning software, greenhouse systems as well as processing the data obtained using the said technologies and serving clients needing those technologies. In addition, the company provides services such as intervention to plant disease and surveillance of plant health via satellite, digital soil analysis.

- The project named "Global Integration of Turkish Agriculture: Agriculture 4.0" was started under the partnership of Ege University and İzmir Commodity Exchange.

- In the project run by the Faculty of Agriculture of Ankara University over an area of 400 hectares in Haymana Research and Application Farm practices related to 16 agricultural crops were conducted using remote sensing systems. The Project aimed at productivity mapping, irrigation, fertilization, disease, and pest detection, and performing analyses.

- The company named Farm.io, which was established in 2014 provides information services to producers and clients related to agriculture using meteorological services, soil sensors, satellites, and digital mechanization Technologies. The company which used to provide services to clients within Türkiye also started in 2019 in the European market.

- Tabit Smart Agricultural Technologies Inc., the first İstanbul based company to work on agricultural technologies, started a smart village in Koçarlı, Aydın with the partnership of Vodafone with the aim of supporting the agricultural development. This village is about to become the first smart village equipped with digital technologies.

- With the help of M2M services of BuluTT business solutions program, Turkcell provides smart remote management services to clients related to agriculture and livestock business. Using the internet of things and M2M solutions harvesting area management, greenhouse surveillance, animal monitoring, coop, and barn monitoring, flow and depth measurement services made available to the clients.

- Turkcell has started Turkcell Filiz Project to provide instant data services to farmers. The application, with the help of a soil-weather station placed on the farm, provides data on soil and weather conditions to producers helping them in their decisions of irrigation, fertilizing, and spraying pesticides. In addition, with the help of the information integrated into the application regarding 117 different plants, tips on how to raise the crop, how to irrigate according to weather and soil conditions, how to prevent fungus risks, when to spray insecticides, local weather conditions, heavy rainfall/frost conditions are provided.

- Vodafone Digital Agriculture Decision Support System consists of four stages: instant moisture monitoring and irrigation planning, early diagnosis and early warning of diseases, pest tracking, and warning systems, information on changes in climatic conditions independent of meteorology. Also using the mobile laboratory additional services such as instantaneous measurement of nitrate, potassium, ammonium, and sulfate values of the soil as well as monitoring PH-EC values and occupancy rates of fertilizer tanks are given.

- A third-generation farmer family established a firm named Tarsens to develop multispectral cameras sensing plant health. The company is the only agricultural company that takes part in Türkiye Artificial Intelligence Initiative. With the help of enhanced intelligence, the firm, using

the images obtained from multispectral and modified cameras is able to perform plant health calculations better than the classical methods at the rate of 25%-35%.

- DOKTAR helps farmers, input (seed, pesticide, etc.) producers, and food companies by offering innovative service models such as call centers operated by agricultural engineers, mobile applications, phenology engines, satellite monitoring, IoT sensor centers, and deep machine learning.

- TarsenFs, the Agricultural Sensor Systems company, started its activities to develop multispectral (an image that captures image data at certain wavelength ranges along the electromagnetic spectrum) cameras used to detect plant health. In addition to the multispectral cameras it has developed, the company also develops wireless sensor networks (IoT) for the monitoring and monitoring of agricultural production areas, and today, with the development of artificial intelligence, phytosanitary calculations from multispectral and modified camera images can be made 25%-35% healthier than the classical methods. Plants that look green to the human eye reflect infrared if they are healthy, and border-red (redge) if they are unhealthy. Such data are collected and analyzed with modified or multispectral cameras, so that plant fertilization and spraying maps can be created. By using far-infrared and thermal cameras, irrigation need maps of plants can be drawn and irrigation maps can be created accordingly. By using cameras with artificial intelligence, the use of herbicides used in plant production can be reduced by up to 99%. Owing to the production and use of such technologies, Türkiye's dependence on substances, some of which are imported, such as fertilizers and pesticides, which are the raw materials of agricultural production, will decrease.

- The first farm in Türkiye using robot technologies has started operation with the cooperation of the Levy firm of the Netherlands and Onet firm of Balıkesir, Türkiye. Robots are employed for many activities on the farm, including feeding and milking the cows. Using robots increased milk productivity by 15%, enhanced quality, and reduced costs.

- The program conducted by the General Directorate of Agricultural Reform of Ministry of Agriculture and Forestry has established Farm Accounting Data Net and, up to now, integrated structural, physical, and financial data of more than 6.000 establishments (Ercan et al., 2019; Demirel Tatsoy, 2019; Güldal et al., 2019; Kaya, 2019; Kılavuz & Erdem, 2019; Kirmikil & Bektaş, 2020; Özdoğan et al., 2017; Yüksel 2020).

The above examples of good practices in Türkiye clearly demonstrate that the country is moving in the right direction of accelerating the digital transformation process considering the impact of COVID-19. Below are the key findings of Smart Agriculture in Türkiye and the suggestions on how farmers and/or agribusinesses can improve their situation.

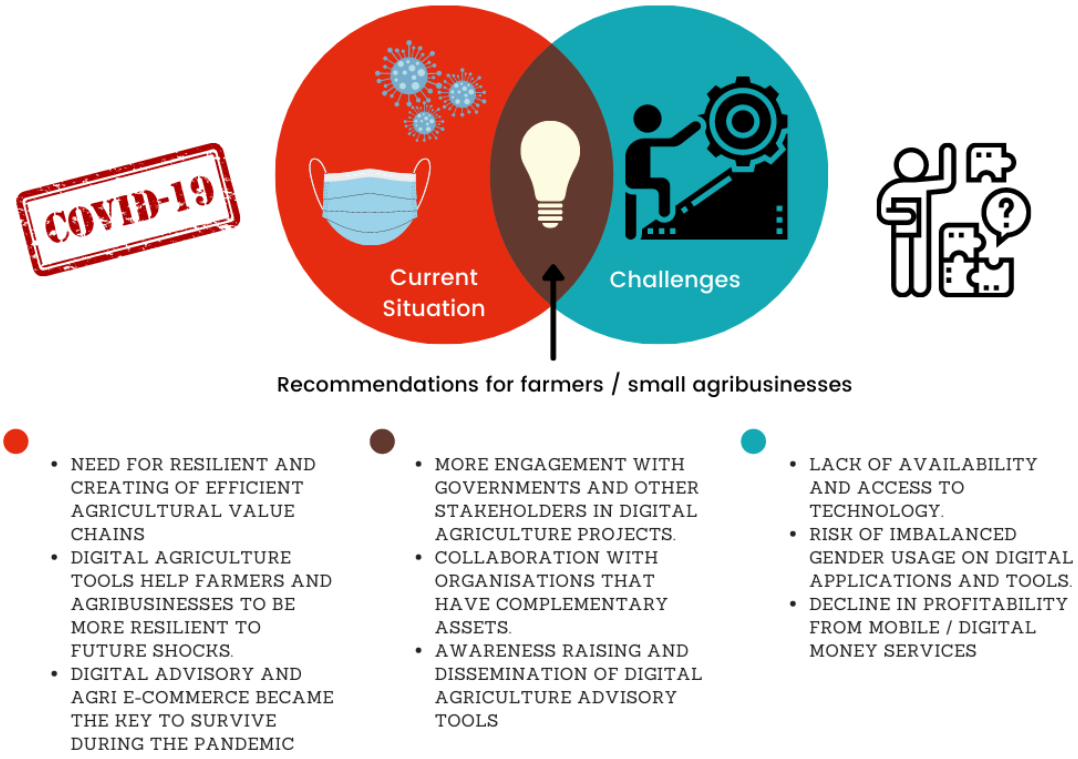

Figure 4. Suggestions for improvements

This project was financed especially under the COVID program to tackle one of the most needed and challenging issues in the endless pandemic era. The results of this report will be significant to the existing knowledge by providing the field research of the effectiveness of the digital transformation in agriculture. This project was proposed for COMCEC and the Ministry of Agriculture and Forestry who are the pioneers in organizing and coordinating digitalization in Türkiye.

7. E-Commerce Term Components in Agriculture

7.1. Digitalization of Commerce

Internet and information technologies, which record rapid improvement and development on daily basis, not only affect many areas of the economy but also the existing commercial system. Especially the internet of things (IoT), the development of mobile devices related to it, and the increase in the number of users of such technologies exert pressure on commercial activities to change rapidly and transform. Each and every day, traditional commercial activities are witnessed to cease routine methods to adapt themselves to the novel electronic character. It is detected that different institutions assign different meanings to the concept of electronic

commerce (e-commerce). Several definitions of e-commerce by different international organizations are presented below.

E-commerce is defined by the World Trade Organization (WTO) as: “the production, advertisement, sale and distribution of goods and services through telecommunication networks” (Gürleyen, 2019: P26). On the other hand, the Organization for Economic Co-operation and Development (OECD) defines e-commerce as: “all commercial activities based on the processing and transmission of digitized written text, voice and appearance of individuals and organizations, in general” (Öztürk, 2020: P7). According to the United Nations Center for Trade Facilitation and Electronic Business (UN-CEFACT), e-commerce is: “the exchange of all business information used in the process of management and consumption activities, between producers, consumers and public institutions and other organizations via electronic means” (Elitaş et al., 2007: P197). E-commerce is defined by the European Commission (EC) as: "enterprises’ carrying out their transactions via electronic means instead of by traditional methods".

In short, e-commerce is defined as the promotion, sale, distribution, and payment transactions of goods and services made utilizing the internet and information technologies.

When E-Commerce was introduced back in the 1960s, many business owners were hesitant to use them as they had to make advanced payments without actuallyactuallythe products. In line with the great development of the digital transformation, the E-Commerce industry now offers faster and safer online transactions. Therefore, the use of such digital technologies for any industry became the key to success.

Zeng et al. (2017) conducted a systematic literature review on 64 papers between 2000 to 2015 in the area of Agri-food E-commerce (AE) and proposed directions for future research based on the gaps identified in their study. According to their findings, AE research has attracted many interests among scholars from different countries in disciplines. Most of the research was from developed countries such as China and the USA and very few were from developing countries. It is suggested that more emphasis should be on the regional development modes of AE and its impact which is directly affecting the rural economic development and the policy implications for the developing countries.

Below is the updated information on the literature, 125 articles identified in multiple databases on the Web of Science platform with the relevant keywords “food* Agri* and e-commerce*” between the years 2016 to 2021. Among them, 10 articles focusing on policy implications were selected for systematic literature review for analysis. The result was very similar to the systematic literature review data between 2000 to 2015 conducted by Zeng et al. (2017). However, more studies were seen at the regional level, as a result of changing environment. The number of publications has raised dramatically after 2019, and more countries from the emerging economy are working on need assessment of the current situation to foresee the future. Türkiye is also one of the countries that require such study and therefore, this project is important, and it can serve as the guidebook for practisionnairs and policymakers to act on ongoing challenges accordingly.

No	Author	Year	Country	Method	Title
1	Guo et al	2020	China	Case study	The role of e-commerce in the urban food system under COVID-19: lessons from China
2	Hao and Wang	2020	China	Survey	The impact of online grocery shopping on stockpile behavior in COVID-19
3	Li et al	2021	China	Survey	Do farmers gain internet dividends from E-commerce adoption? Evidence from China
4	Chanti, and Qiu	2019	China	Conceptual	A Nonlinear Empirical Analysis On Influence Factor Of Circulation Efficiency
5	Zheng et al	2020	USA	Survey	What factors affect Chinese consumers' online grocery shopping? Product attributes, e-vendor characteristics, and consumer perceptions
6	Reardon et al	2021	USA	Conceptual	Pivoting" by food industry firms to cope with COVID-19 in developing regions: E-commerce and "copivoting" delivery intermediaries
7	Reardon et al	2021	USA	Conceptual	E-commerce's fast-tracking diffusion and adaptation in developing countries
8	Wang et al	2019	China	Conceptual	Mapping the value chain of imported shellfish in China
9	Wittwer et al	2021	Australia	Conceptual	COVID-19's impact on Australian wine markets and regions
10	Martindale	2021	England	Conceptual	From Land Consolidation and Food Safety to Taobao Villages and Alternative Food Networks: Four Components of China's Dynamic Agri-Rural Innovation System

Table 4. Selected literature between 2019 to 2021 with specific emphasis on COVID-19

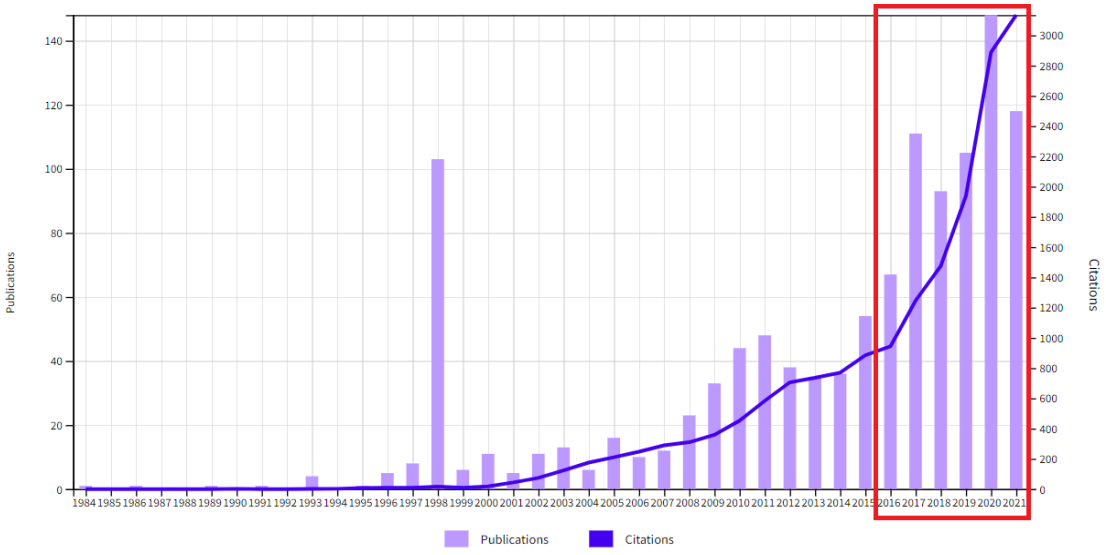

Figure 5. Time Cited and Publication Over Time

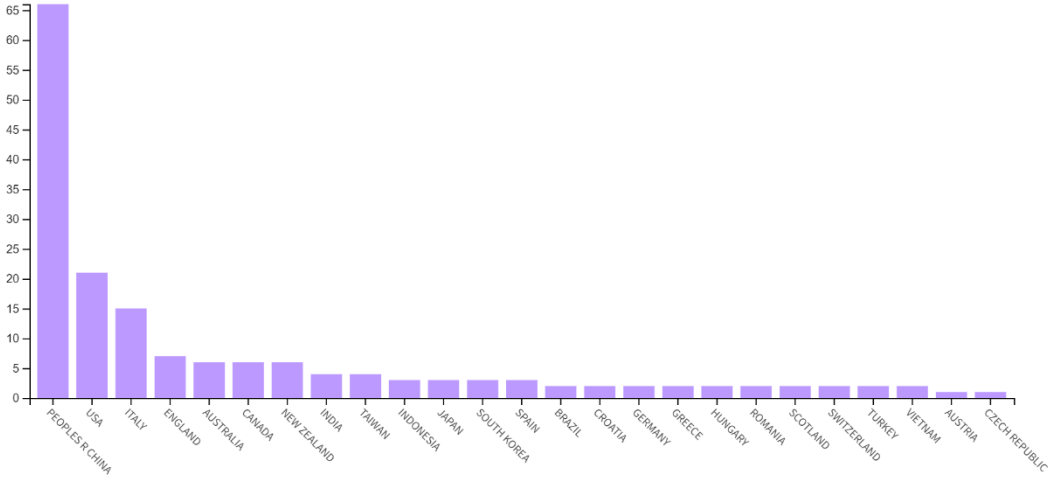

Figure 6. Distribution of publications across countries

To facilitate e-commerce, it is important to introduce the holistic approach to create the ecosystem. The digitalization of commerce requires changes in policy, as well as in practices to improve the whole infrastructure to facilitate digital payments, to set up the legal and regulatory frameworks for online transactions and security. The application of digital tools for e-commerce in agriculture is transforming the way how food systems operate, to become more agile and resilient to respond to unforeseen events during the pandemic. The COVID-19 pandemic

accelerated the adaption of technology worldwide, especially in the emerging economy. Türkiye also has been experiencing a shift to e-business to meet the demand for new normal in a continuously changing environment. The pandemic demonstrated the potential and necessity of digitalization in all sectors as it enables efficient solutions considering social distancing required, which can not be ignored under the current situation.

7.2. Digital Agriculture Market

Digital agriculture is driven by private firms not only from the agricultural sector but also from input firms, software firms as well as startups (Birner et al., 2021) Digital agriculture market has great potential as it creates multiplier effects on Sustainable Development Goals (SDG's) not only to increase the productivity and incomes but also strengthening food security.

In addition, the digital transformation in agriculture offers new opportunities to improve policy which was recently discussed at OECD Global Forum on Agriculture 2021: Policies for a more resilient agro-food sector. Meanwhile, there are some critics of digital divides between urban and rural areas, the size of the firms as well as the gender of farmers. Despite the high number of research interests in the availability of digital technologies, adoption, and the impact, few studies were on incentives to supply such technologies to farmers at different levels. One of the innovative start-up companies provides a tool called "Uber for Tractors" enabling traditional small-scale farmers to access tractor hire services (Duam et al., 2020). According to the research conducted by Duam et al. (2020), the tool has the potential to reduce transaction costs by enabling the monitoring of tractors and operators through GPS devices.

During COVID-19, there is a shift in consumer preferences towards food safety and quality which creates more opportunities in the digital agriculture market. Moreover, it affects both food supply and demands directly with uncertain effects on food prices worldwide. In 2020, a number of reports on COVID-19 Impact on the Digital Agriculture Market were published by market research companies to provide insights on COVID-19 impact, and key strategies associated.

Food prices are determined by supply and demand, as well as policy actions are taken to mitigate effects (Schmidhuber et al., 2020). In order to deal with this global crisis, governments need to adopt comprehensive and holistic approaches to improve the availability, accessibility, and affordability of food projects during the COVID 19 era. Policy measures must be taken seriously in both domestic and international distribution channels for the smooth operation of agribusiness.

The size of the Digital Agriculture Market depends on the demand by the farmers, influenced by different factors (Kırkaya, 2020) as listed below:

- Level of mechanization and economies of scale
- Input prices, including labor costs and output prices
- Environmental regulations and public pressure
- Possibility to transfer the digital technology across regions and farming systems

The technologies of Agriculture 4.0, which were developed under the influence of Industry 4.0, shortly named the digital industrial revolution, do not only be taken as the technologies pertaining to the production process or are limited to the referred process but they are beyond

that. Those technologies also deeply affect, change, and develop various other stages following the production process.

E-commerce, which increasingly is being used by different sectors, has become an inevitable option for the marketing and sale of agricultural and food products. Business-to-business (B2B) e-commerce, business-to-consumer (B2C) e-commerce, business-to-government (B2G) e-commerce and government-to-consumer (G2C) e-commerce options, as well as human-to-human communication, human-to-object communication help an immense network of object-to-object communication possibilities emerge. The formation of such a network minimizes the effects of borders between countries, cities, businesses, and people, thus creating a marketplace that almost everyone would have access to (Alpaslan & Delibalta, 2018; Kızılaslan & Ünal, 2015; Turhan et al., 2010).

	Business	Consumer	Government
Business	B2B Wholesalers, software, and service provider	B2C Retailers	B2G Private sector suppliers Web-based applications and databases
	Alibaba Group Holdings Limited, TradeFord, TradeB2B, Farmlead, ExportsManager, Farmer's Business Network, Inc., Korea Agro-Fisheries & Food Trade Corp, FoodDirectories.com, ThomasNet and EC21	eBay n11.com, Trendyol.com (Türkiye) 	
Consumer	C2B An individual who has something to offer	C2C Action website	C2G Public Government Actions
Government	G2B Online collection of taxes and fees	G2C Online collection of taxes and fees	G2G Document exchange, sharing public administration registers
	Digital Farming Market (DITAP) in Türkiye		

Table 5. E-Commerce Matrix for Agriculture Sector

Developments in e-commerce have become important in terms of rural development. Although there is no direct effect of e-commerce on rural development, indirect positive effects are determined. Although the producers do not involve yet selling directly using an e-commerce facility, they could work B2B with e-commerce companies by eliminating the intermediaries.

Some producers are successful enough to engage in e-commerce activities with their own efforts. The number of enterprises dealing with social media applications such as whatsapp, instagram and facebook or marketplace applications such as hepsiburada, n11, gittigidiyor, trendyol, pttavm, Amazon is on the rise every day. Examples of Agricultural e-commerce applications might be given as:

- Using own e-commerce websites,
- Using the services provided by social networks,
- Using e-commerce sites,
- Using advertisement sites,
-Using internet advertisements (Kara, 2018; Kızılaslan & Gönültaş, 2011; Kızılaslan & Ünal, 2015; Tuncer & Gündüz, 2017).

Many producers sell their own products using social media, internet sites, and internet marketplaces using the labels of organic, natural, farm, lady, homemade, garden, village, agriculture, field, dairy products, village products, hometown, your, our, fresh, freshest, direct, etc. (Kara, 2018; Tuncer & Gündüz, 2017).

Contributions of e-commerce to the agricultural sector might be listed as:

- Market and price advantages for producers,
- Opportunity to trade without the time and work-space limitations,
- Having access to numerous consumers and buyer firms,
- Having access to new markets (Çakmaklı, 2004; Kızılaslan & Gönültaş, 2011).

The Digital Farming Market (DITAP/DFM), being implemented by the Ministry of Agriculture and Forestry (MAF), was started as an important project to cover various key components for digitalization in agriculture such as production on contract system, price stability, removal of intermediaries and cost reduction. Agriculture has been the only sector in Türkiye expanding the capacity and production since the outbreak of COVID-19 pandemic.

In the Digital Farming Market, stakeholders in the agricultural sector, producers, industrialists, input suppliers, exporters, transporters, cooperatives, citizens, individuals, and institutions come together and interact. As a result of this extended network, all actors have benefited each other and are eneble to meet effective and efficient solutions to their supply and demand needs.

Figure 7. Stakeholders of Digital Farming Market

Through implementation of the Digital Farming Market, it is aimed that the producers who are disadvantageous in determining the market price would sell their products at a price suitable for them and thus, derive profit out of this opportunity. Producers can market their products directly through DITAP and so they become able to enhance their market opportunities. In addition, DITAP narrows the gap between production and consumption phases and marketing channels, supposed to decrease price differences between producers and consumers and so, the farmers can obtain higher prices, and the consumers can pay relatively cheaper prices for the agricultural products. In the digital agriculture market, matching the quantity produced with the quantity demanded may also help the reduction of food waste by following the effective production plan. In addition, DITAP keeps expanding the network and providing enhanced marketing capabilities to the disadvantaged group such as farmers in rural area which were not possible before.

The use of this efficient agricultural marketing system gathers data more frequently and accurately to optimize resources for effective output management to support income generation. Digital agriculture has the potential to improve the market product life cycle. However, there are barriers such as high costs and unpredictable long-term outcomes. To overcome these challenges, the adaption of digitalization must be done with the collaboration of different actors involved in the value chain.

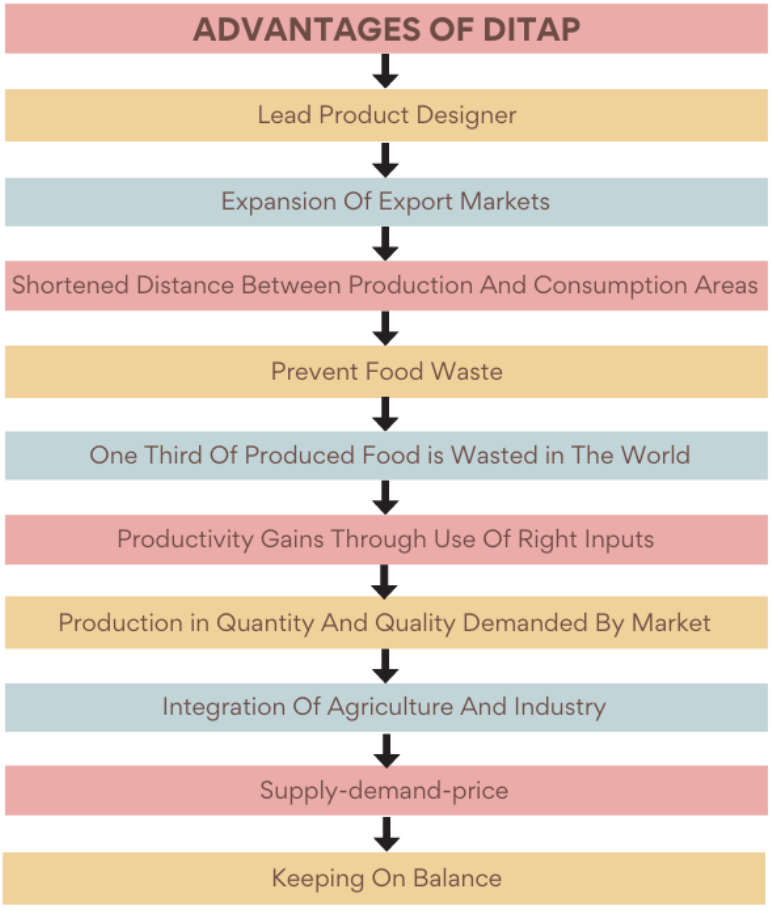

Figure 8. Advantages of Digital Farming Market

Figure 9. Advantages of DITAP for the crop demanding sectors

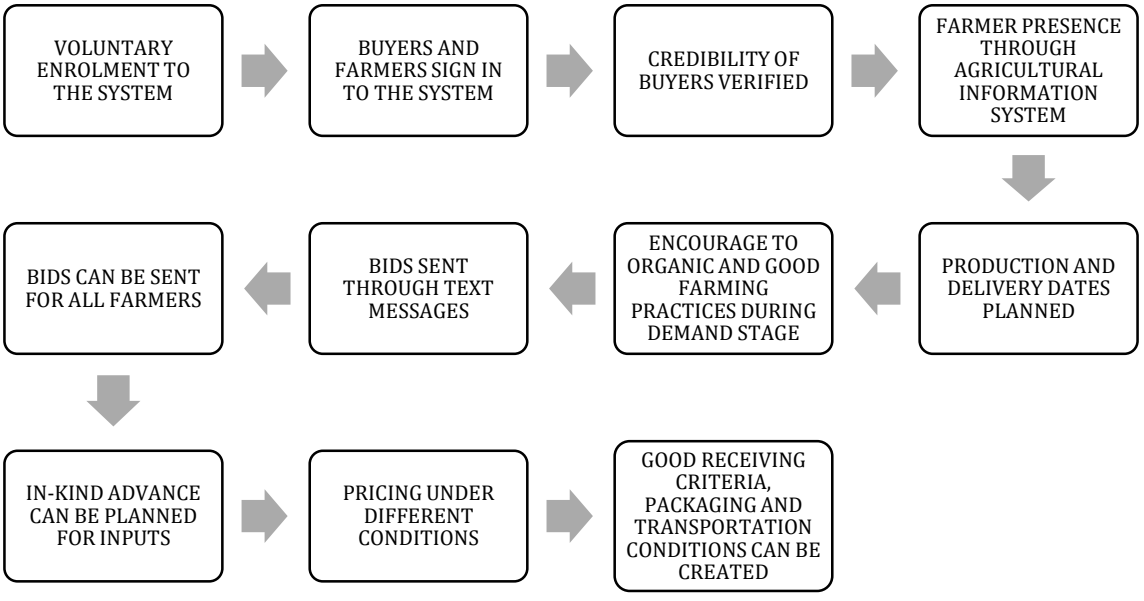

Figure 10. DITAP Application Stage

Since the outbreak of the COVID-19, it is highlighted that the need for resilient and efficient agricultural value chains became the key to survive in the complexed agriculture market. The digitalization in agriculture have become a key driver for rural transformation. DITAP is a good example of such a tool creating new opportunities, especially for small farmers and agribusinesses to be more resilient and provide a useful mechanism. This official application prevents from the risk of misinformation often happing on social media and other platforms. Digitalization in agriculture has positive impacts on economic, social, and environmental in the COVID-19 pandemic recovery process.

8. E-Commerce Effects and Contributions to Agriculture

The digital economy is developing very fast globally. And innovation is the driver and the key to success in a digital business environment. E-commerce appears as a potential strategic tool as it allows farmers to directly get connected with buyers which helps any business to reduce the cost and time to increase incomes (Reardon et al., 2021). In this way, it also reduces food waste especially necessary during the COVID-19 pandemic.

Digital technologies face important policy challenges including data ownership and user rights which need to be introduced with guidelines and regulations. E-commerce has the effect of increasing the transparency of the market at both macro and micro levels, which leads to more productivity. Evidently, E-commerce has a positive impact on all business sectors, hence the impact on macroeconomic growth on society is often discussed.

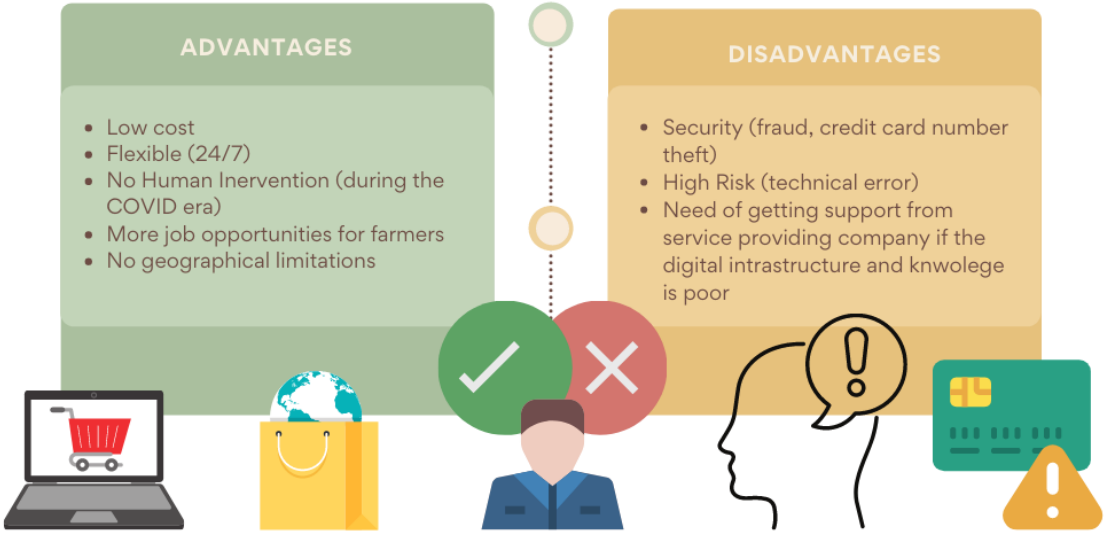

Figure 11. E-Commerce: Advantages and Disadvantages

E-commerce increased the use of mobile devices worldwide along with the access and improvements in the infrastructure such as Internet connectivity. Electronic commerce or e-commerce is defined as doing business in the electronic environment. It is conducting the activities of production, promotion, sales, insurance, distribution, and payment for marketable goods and services via computer networks. In e-commerce, which can be realized in the form of

Business to Business (B2B), Business to Consumer (B2C), and Consumer to Consumer (C2C) payment options such as eft, credit card, and payment at the door. The volume of e-commerce has increased immensely due to the ease of access and utilization rate of the internet.

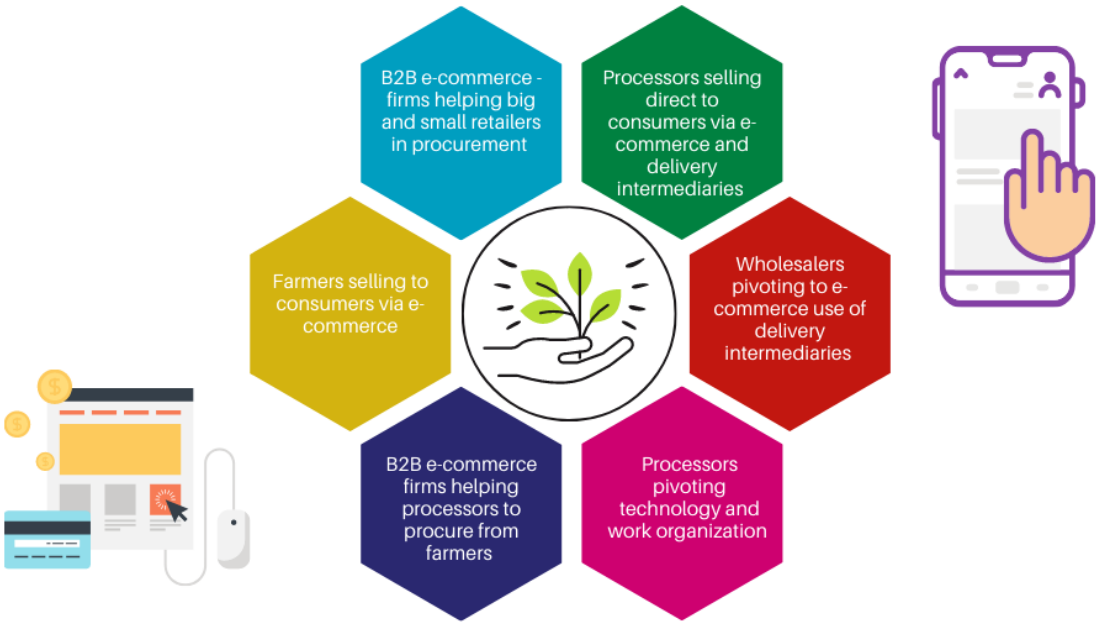

Figure 12. E-Commerce: Contributions to Agriculture

The online shopping industry has changed the retail world completely in Türkiye and globally. And this situation contributed to the volume and variability of e-commerce sales. In Türkiye, according to e-commerce data, expenditures rank respectively as a voyage, electronic products, fashion and beauty products, toys, and hobby products. In addition to the sales made through the marketplace platforms, companies and individuals have also started sales through their own e-commerce sites and social media networks.

The development of e-commerce strategy in agriculture is highly influenced by the national environment and its supporting policies. A better understanding of the user needs and customer value can improve customer satisfaction and promote the development of agricultural e-commerce. For instance, the development e-commerce strategy for fresh agricultural products is about the industry chain process including production, sales, procurement, finance, marketing, warehousing, logistics, and soon. It is especially important to consider seasonal products. Innovation in business operation models can be the key fact or sustainable development. The rapid growth of e-commerce contributions to the development

The agricultural sector as the governments and digital service providers constantly need to keep improving the business environment. For example, the field research data collection can enrich the Agricultural information useful for producers and buyers. And based on the accurate information, improved mechanism and legislation can be created.

While E-Commerces has the effect of increasing the transparency of the market at both macro and micro levels contributing to improved productivity, issues and challenges remain. The level of security is crucial as cybercrime is one of the most common problems raised all over the world.

The digital infrastructure in Türkiye is satisfactory and the country is working on creating a digital ecosystem in the agriculture sector. However, there are challenges in terms of the digital mechanisms, lack of value-added services such as accessing and analyzing data from multiple sources to respond to the need of the end-users.

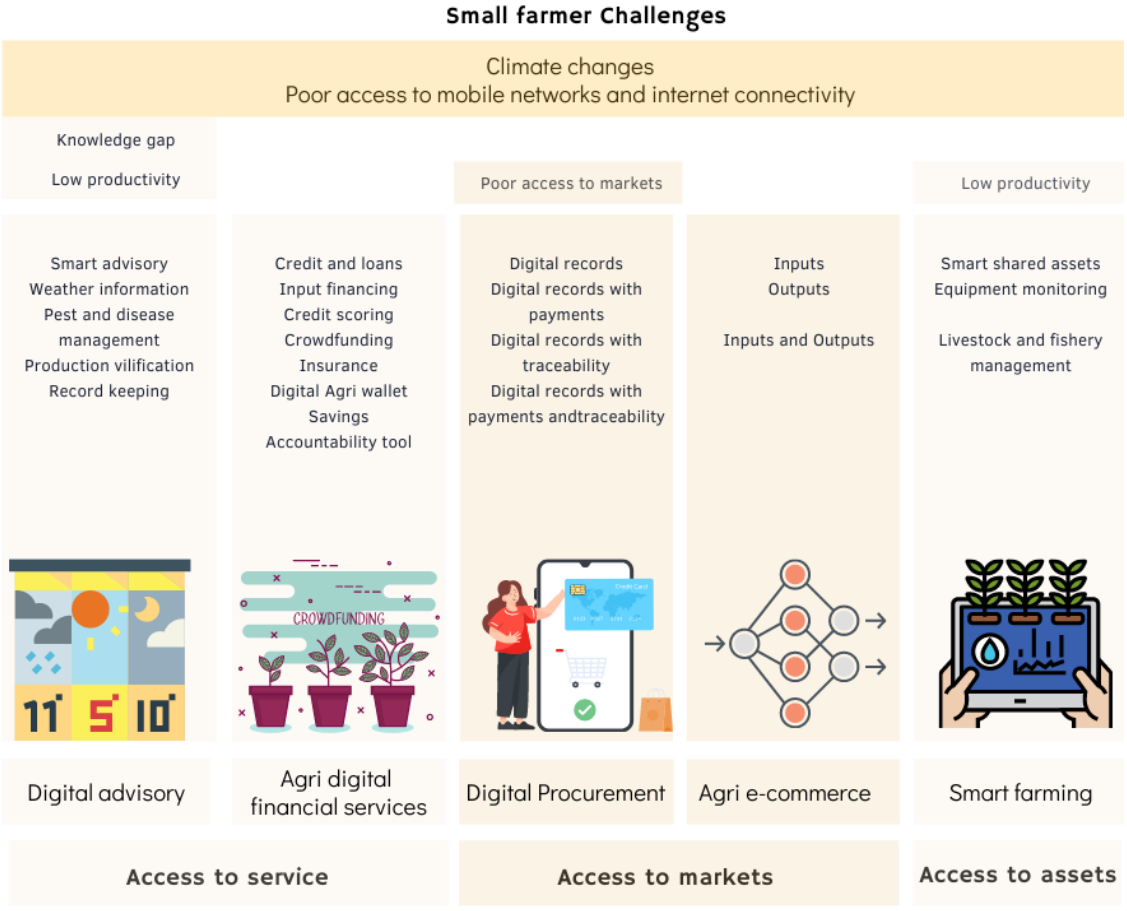

Table 6. Contributions of e-commerce and challenges in agriculture in Türkiye

During the COVID-19 pandemic, the whole world was focused to fill the gap in food supplies. Digital applications in logistics contributions to the efficiency in transport as it allows real-time up to date information of the number of available stock and the product tracking throughout the supply chain in agriculture. Through E-commerce, it is predicted that the GDP of Türkiye will be increase and more jobs in agriculture could be created in the near future. The e-commerce

market in Türkiye has been successful and it exceeded ₺350 billion (Anonymous, 2021c). The outcome of e-commerce affects more investment in the creation of digital platforms and agriculture is also one of the primary sectors sectoring from the service, obtaining accurate information in real-time. The use of e-commerce in agriculture enhanced the need for improved information flows and access to agricultural services and information. The great outcome of the effect of e-commerce in agriculture is the development of the national e-agriculture vision which lead to the creation of DITAP.

While there are many studies and reports on digital transformation and infrastructure, some focusing on the "usage" identifying how digital literacy impacts economic improvements. Based on the theory of asymmetric information, the imbalance in the information to both the buyer and the seller is one of the biggest challenges affecting the e-commerce failure in markets. For instance, Kawamorita et al. (2020) identified that "media literacy positively impacts entrepreneurship among women in rural areas by increasing information asymmetry for the whom with increased access to media and can analyze the media content and news for a better understanding of market needs and response to the opportunities". Demiryürek (2006) highlighted that in Türkiye, agricultural television programs have been bridging this gap to support rural women entrepreneurs. The necessary education and/or training to adapt to the use of digital technology will increase opportunities created by e-commerce in agriculture.

Phase II - Gathering and Analyzing Data

The most important material of the study is the questionnaires used in the interviews with "farmers and relevant stakeholders". While the interviews were held in the garden, in front of the house, greenhouse, and field of the farmers, the stakeholder meetings were held in the open air. During the field study, great importance was attached to the rules published by the Ministry of Health regarding the pandemic period. On the other hand, in the settlements where the open-air survey is not possible, the front of the village rooms, the gardens of the headman's buildings, the entrance sections of the house (without entering the farmer's house), the large meeting rooms of the stakeholders were used.

The purpose of the field studies; access to primary data. One of the one-to-one interview methods to be used for this purpose is questionnaires, which is one of the quantitative research methods.

In determining the farmers and stakeholders to be included in the survey, some priorities and approaches have been developed. In the interviews with key people in the region, farmers/stakeholders were determined according to their level of use of smart and digital agriculture and their knowledge. In the study, a sampling methodology was not applied due to the duration of the project and a large number of provinces it covers. As stated in the scope of the study, since field interviews should be conducted in all geographical regions of Türkiye, one-to-one (face-to-face, telephone, online) interviews were conducted with a certain number of farmers, public, private sector, and producer organizations representatives in each region (quick impact assessment method).

While the results of the survey conducted with the farmers in the study were evaluated quantitatively, the data obtained from the interviews with the stakeholders were evaluated and presented qualitatively.

In the study, the number of farmers and stakeholder persons interviewed according to the provinces is given in the table.

Provinces	Number of Stakeholders
Adana	MoAF 2 Producer Union, 2 Input Providers 4 Farmers
Amasya	1 Farmer
Ankara	5 Producer Union, 4 Input Providers 20 Farmers
Aydın	Vodofone Smart village 4 Farmers
Çanakkale	1 Producer Union
Edirne	1 Farmer
Gaziantep	MoAF 2 Producer Union, 1 Input Providers 1 Chamber of Agriculture 1 Industry 4 Farmers
Giresun	2 Farmers
İzmir	2 institutions/organizations 1 Farmer
Kahramanmaraş	1 Producer Union 1 Input Provider
Kırklareli	1 Farmer
Kırşehir	1 Farmer
Konya	1 Producer Union
Manisa	1 institutions/organizations
Ordu	1 Producer Union 4 Farmers
Samsun	MoAF Black Sea Agricultural Research Institute 1 Input Provider 1 Organic Farming Business 4 Farmers
Şanlıurfa	1 Producer Union
Tekirdağ	Leading farmer association (Tekirdağ and Hayrabolu) 3 Farmers

Table 7. List of farmers and stakeholders

The study was prepared by evaluating the data obtained as a result of the questionnaire and telephone interviews with a total of 85 people, 35 institutions/organizations, and 50 producers. Within the scope of the study, a database was created in order to transfer the data collected through desk studies and field studies to electronic media. A coding system has been developed to facilitate data entry and prevent erroneous data entry. The data were transferred to the computer environment to perform the appropriate statistical analysis. Then, both the results obtained from the analysis of the quantitative data and the results obtained from the qualitative data were re-evaluated.

Figure 13. Map of Türkiye: Data Collection

Considering that many different crops are grown in the agricultural sector in Türkiye, there are many different production systems, both in terms of the type, intensity, and method of production, and due to environmental differences in the area where the production is carried out. Although there are significant differences between these production systems, they are similar to each other in terms of some basic elements and smart/digital farming systems. Therefore, the effects of the use of smart and digital agriculture systems, which are similar in different product groups, will be discussed under this title, and the effects experienced in production groups will be given in detail. It has been explained in detail under this heading as a result of survey data and field observations that there are different reflections in terms of technology use in sub-branches of agricultural production and stakeholder groups, especially during the COVID-19pandemic process.

Within the scope of the research, a survey was conducted with 50 producers. In the study conducted in different provinces of Türkiye, a survey was conducted with 20 producers from Ankara, 4 producers from Ordu, Samsun, Adana, Aydın and Gaziantep provinces, 3 producers from Tekirdağ province, and 1 producer from Amasya, İzmir, Kırklareli, and Kırşehir provinces.

Table 8. Distribution by provinces participating in the survey

İl	n	%
Adana	4	8,00
Amasya	1	2,00
Ankara	20	40,00
Aydın	4	8,00
Edirne	1	2,00
Gaziantep	4	8,00
Giresun	2	4,00
İzmir	1	2,00
Kırklareli	1	2,00
Kırşehir	1	2,00
Ordu	4	8,00
Samsun	4	8,00
Tekirdağ	3	6,00
Toplam	50	100,00

92.00% of the producers participating in the survey are men and 8.00% are women.

Figure 14. Gender of producers

The average age of the producers participating in the survey is 49 years. However, 38.00% of the producers are between the ages of 26-40, 38.00% are between the ages of 41-60 and 24.00% are aged 60 and over.

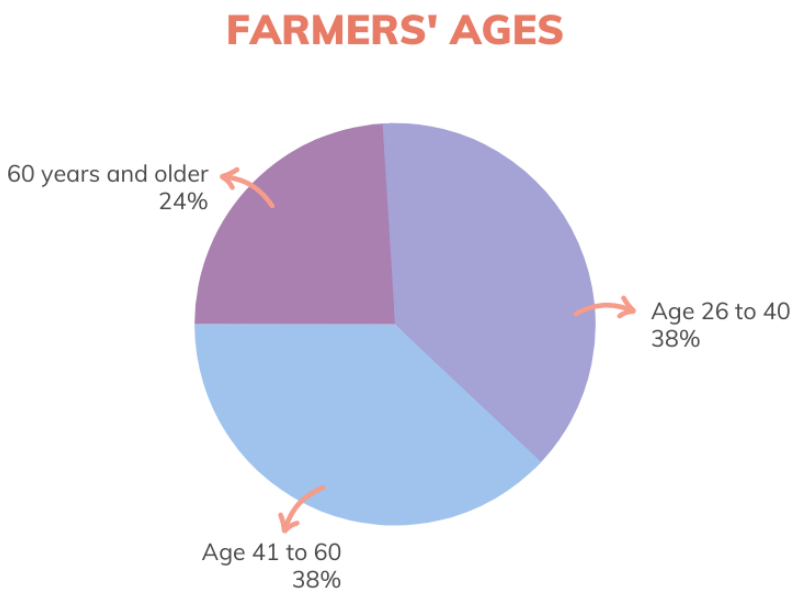

Figure 15. Age distribution of producers (%)

Among the producers, the ratio of university and high school graduates is 26.00%. However, the rate of primary school graduates is 16.00%, the rate of secondary school graduates is 10.00%, the rate of associate degree graduates is 16.00% and the rate of postgraduate graduates is 6.00%.

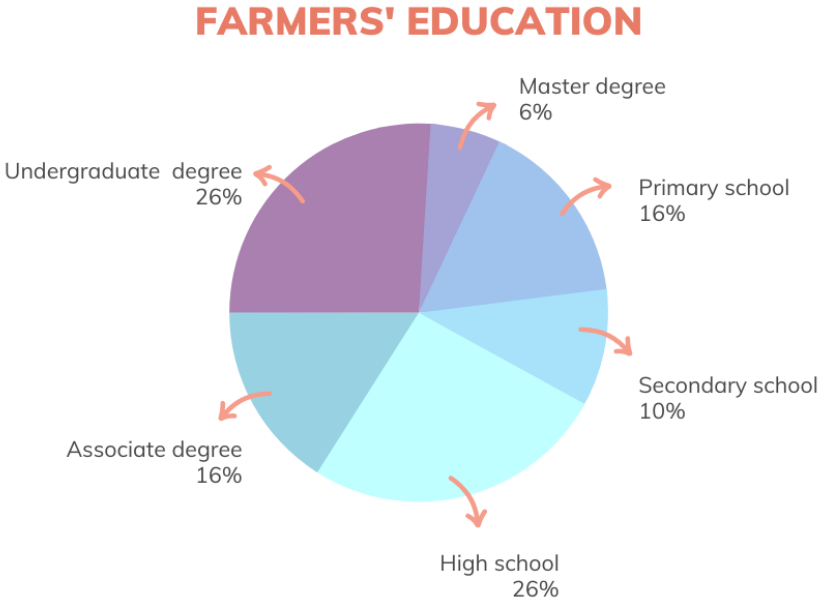

Figure 16. Educational status of producers

While 76.00% of the producers carry out plant production activities, the rate of those who carry out animal production activities is 2.00%, and the ratio of those who perform both plant and animal production activities is 22.00%.

Table 9. Information on the production activities of the producers

Production Activity	n	%
Plant Production	38	76,00
Animal Production	1	2,00
Plant and Animal Production	11	22,00
Total	50	100,00

In the enterprises examined, the average property land width of the producers was 235.76 decares, 31.52 decares of land held for rent and partner, and 10.00 decares of land given to rent and partner. However, the average number of cattle is 69 heads and the number of sheep and goats is 97.

Table 10. Average land widths of producers

Average land width	da
Property land	235,76
Leased and partnered	31,52
Rented and given to partner	10,00

62.00% of the producers stated that they do not plan to expand their agricultural lands in the future, and 50.00% stated that they do not have a relative who will continue their agricultural activities in the future. While the rate of producers with non-agricultural income was determined as 78.00%, it was determined that 80.00% of the producers were members of any cooperative or union. It has been determined that the average period of experience of the producers in the agricultural sector is 22 years.

Table 11. Information on producers

	n	%
Does it consider expanding farmland in the future?		
Yes	19	38,00
No	31	62,00
Total	50	100,00
Do you have relatives who will continue their agricultural activities in the future?		
Yes	25	50,00
No	25	50,00
Total	50	100,00
Do producers have non-farm income?		
Yes	39	78,00
No	11	22,00
Total	50	100,00
Are the producers a member of any cooperative or union?		
Yes	40	80,00

No	10	20,00
Total	50	100,00

64.51% of the producers market their products through traders, 9.68% producer organizations/cooperatives, 9.68% contracted production, 9.68% wholesale market, 3.23% e-commerce It was determined that 1.61% of them marketed their products through relatives and 1.61% of them by their own means.

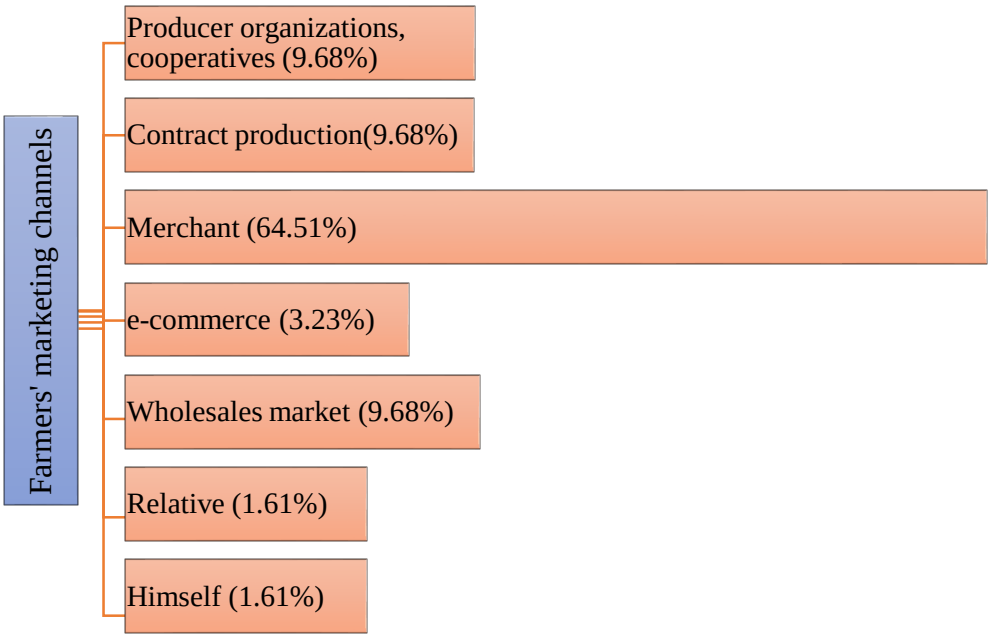

Figure 17. Marketing channels of producers

While it was determined that 90.00% of the producers use the internet, the rate of smartphone users was determined as 94.00%.

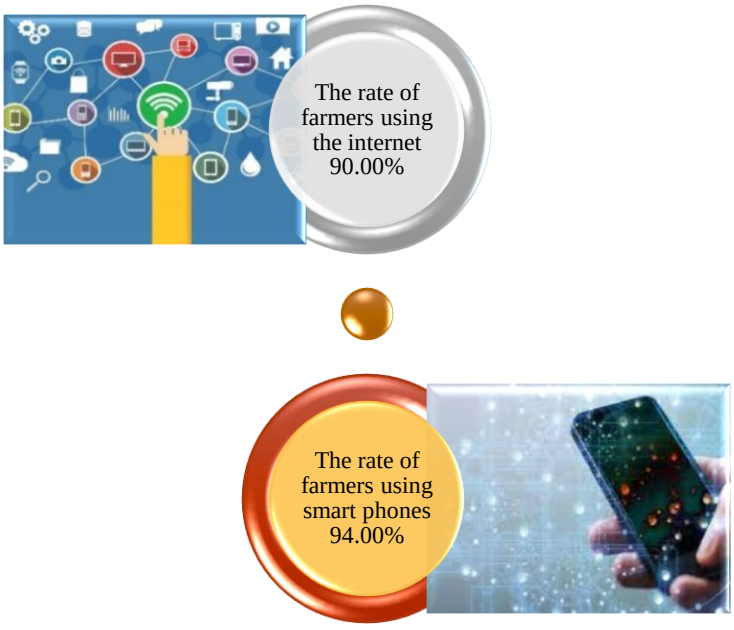

Figure 18. Smartphone and internet usage status of producers

Among the stakeholders other than the producers, especially the Provincial/District Directorates of the Ministry of Agriculture and Forestry, producer organizations and companies selling inputs in agriculture, holding their meetings via remote access are in a more advantageous position compared to other institutions/organizations and producers due to both infrastructure and technological opportunities. It has also been determined that these organizations are in contact with producers through various internet channels during the pandemic process.

In particular, agricultural input-selling and producer organizations adopted new technologies more easily, moved their marketing strategies to digital media, and delivered their advertising campaigns to their customers through digital media. Some small family businesses stated that they bought the pesticides they needed online during the COVID-19 period.

Producers mostly monitor the weather (39.50%) on their smartphones, along with product prices (24.37%), fertilizing time (10.92%), spraying time (10.08%), and irrigation time (10%). ,08) were found to follow.

Figure 19. Applications followed by producers on their smartphones (%)

Among the phone applications used by the producers, the e-government application comes first with 19.35%. In addition, meteorology status (16.59%), Çiftçi TV (14.29%), Tarsim Mobile (9.68%), and Land Registry and Cadastre Parcel Query application (8.29%) are among the most used applications.

Table 12. Phone applications used by producers

	n	%
E-devlet	42	19,35
Çiftçi TV	31	14,29
Meteoroloji Durumu	36	16,59
Tapu Kadastro Parsel Sorgu	18	8,29
Tarsim Mobil	21	9,68
Tarım TV	15	6,91
Küpe Sorgulama	5	2,30
BAYER Tarım	3	1,38
Denizden Toprağa	14	6,45
Tarım Türk TV	12	5,53
Tüccarım	2	0,92
GÜBRETAŞ	5	2,30
DOKTAR	4	1,84
İş Bankası İmece	3	1,38
Tarbil	3	1,38
Toros Çiftçi	1	0,49
Zirai Pazar	2	0,92
Toplam	217	100,00

Among the producers participating in the survey, the number of producers using any technological application in their enterprises is low. It has been determined that there are producers who use only one of the applications, as well as producers who use more than one technological application at the same time in their businesses. Herd management software (17.86%) comes first among the most used technological applications, followed by smart irrigation systems with 14.29% and drone, automatic steering tractor, sensored machines, and smart greenhouse systems with 10.71%.

Smart irrigation systems (19.15%) were determined as the most preferred application by the producers who use or do not use any technological application.
When a general evaluation of the interviews is made;

• It has been determined that most of the producers use smartphones and the internet. Agricultural weather conditions and product prices are frequently followed on their smartphones. In addition, it has been determined that they use İşbank "İmece" application, "E-government" application, "Hepsiburada" applications. It has also been determined that some producers have knowledge about "DİTAP". Although it is noteworthy that the producers do not use agricultural applications too much, it was determined that all of the respondents supported the widespread use of technological applications in agriculture. It is an important finding that especially producers over the age of 60 stated that they do not benefit from applications such as "DITAP", but that they can be included in similar systems when a system such as a face recognition system is developed.

• It is noteworthy that women's cooperatives use technology more in the marketing phase of their products during the COVID process. It has been determined that among the internet sales sites that women's cooperatives use in marketing their products, they sell on "Instagram" as well as sites such as Hepsiburada.com and trendyol.com.
It is noteworthy that the producers who have knowledge about smart agriculture remain at a low rate.

• It has been determined that the biggest obstacle to the advancement of technological developments in agriculture is the lack of capital in the agricultural sector. In addition, it has been determined that the producers are not open to innovations, small and fragmented agricultural lands, low-profit margin in agriculture, high agricultural loan interests.

• It has been determined that during the COVID-19 pandemic period, the demand for agriculture increased more among the producers compared to the pre-pandemic period. In addition, it was determined that the production paused a little, but the production continued. It has been determined that the need for the agricultural sector has increased even more during the pandemic period. It has been determined that there are problems in the processing of livestock due to the lack of timely delivery of imported animal vaccines during the COVID-19 period, and it has been determined that the price increases in medical supplies during the pandemic period have adversely affected livestock.

•It has been stated that there are meteorology stations belonging to Agricultural Credit Cooperatives. At these stations, it is possible to report all operational systems in the production process. With the rapid increase in greenhouse installation in the country, this information is needed. A station to be established on uneven lands, 5 km. It can produce data that is vital for greenhouses in an area within its radius. Since each greenhouse contains separate climate

dynamics, studies should be carried out to establish a digital infrastructure that will provide these data for each.

•Investments in digital products usually start with 10 decares. It is stated that the investment cost in digital tools is the same for 10 decares and 50 decares. However, due to the fragmented land structure, the investment cost of digitalization can be seen as higher in relatively small agricultural areas. It can be suggested that small producers should come together and ensure the use of technology in order to minimize the cost items of this digitalization.

• For effective data use in agriculture, it is necessary to work in the same field for at least 10 years.

• Some of the results of the study to date are that systems for disease detection, yield estimation, and water stress measurement of plants are requested by cotton and corn producers.

• The stock market prices of all products in Türkiye are sent to the Leader Farmer Association by the software company and it has been determined that they are shared with all its members via the phone application of the association.

Table 13. Technological applications that producers use or want to use

	Kullanıyor		Kullanmak istiyor	
	n	%	n	%
Smart irrigation system	4	14,29	9	19,15
Computer-assisted milking systems	1	3,57	1	2,13
Variable-rate fertilizer or pesticide	2	7,14	6	12,77
Drone	3	10,71	7	14,89
Automatic steering tractor	3	10,71	6	12,77
Machines with sensors	3	10,71	4	8,51
Herd management software	5	17,86	1	2,13
Water temperature, pH, salinity, conductivity sensors	3	10,71	8	17,02
Smart greenhouse systems	1	3,57	0	0,00
Pedometer	1	3,57	1	2,13
Water quality measuring devices	2	7,14	0	0,00
Combine harvester with yield meter kit	0	0,00	4	8,51
Total	28	100,00	47	100,00

Smart irrigation systems

Users (4 farmers)

Want to use (9 farmers)

Automated steering system

Users (3 farmersi)

Want to use (6 farmers)

Smart greenhouses system

Users (1 farmers)

Want to use (0 farmers)

Automatic milking systems

Users (1 farmers)

Want to use (1 farmers)

Sensor machines

Users (3 farmers)

Want to use (4 farmers)

Pedometer

Users (1 farmers)

Want to use (1 farmers)

Variable rate application

Users (2 farmers)

Want to use (6 farmers)

Herd management system

Users (5 farmers)

Want to use (1 farmers)

Water quality test equipment

Users (2 farmers)

Want to use (0 farmers)

Drone

Users (3 farmers)

Want to use (7 farmers)

Water temperature, pH, salinity, conductivity sensors

Users (3 farmers)

Want to use (8 farmers)

Combine harvester with yield mapping

Users (0 farmers)

Want to use (4 farmers)

It can be said that producers are using drone technology more and more widely. Drone use is mainly used for pesticides in paddy, corn, and sunflower. A rice producer that carries out spraying, fertilization, and planting activities with a drone in Bafra District of Samsun Province; In one of the two different and adjacent 75 decare parcels, paddy cultivation, fertilization and spraying were carried out with drone technology, while the same activities were carried out using traditional methods in the other parcel. While an average yield of 850 kg/decare was achieved in the parcel processed using drone technology, an average yield of 800 kg/decare was obtained in the parcel processed without using drone technology. It has been stated that there is a 70-80% reduction in spraying, 40-50% in planting and 35-50% in fertilization in the labor costs of the activities carried out with drone technology, apart from the efficiency.

It has been reported by the producers that spraying with the drone at night that spraying can be done with a drone at night, allowing the plant to take the drug better.

Drones are also available to producers who use or purchase services for locating trees and saplings and drawing sketches. It can be said that this type of work, which the manufacturer can do in a day, can be done with a drone in 1 hour, providing an advantage to the producers in terms of both time and labor cost.

It can be argued that 450 thousand decares of paddy land in the Thrace Region is one of the most striking results obtained from the interviews, where spraying was done with a drone in the 2020-2021 production season.

It has been determined that the Leader Farmer Association, which uses the field tracking system, receives the data of the lands belonging to the software companies they have contracted with and the agricultural enterprises of which it is a member, from the satellite on a weekly basis and follows their lands. It has been determined that the lands of the producers in the Thrace Region, which uses the field tracking system, are approximately 300.00 decares. The data pertaining to the lands of the members are delivered to the members of the association on a field and parcel basis via a phone application belonging to the Leader Farmer Association.

There are 150 producers benefiting from this technological service and these members pay a fee of 3 TL per decare to the association in return for this service. The association provides 3 basic services from the software company: buying software, images, and image processing. Images from the software company; It is demanded and purchased because it gives the best results at 3*3 pixels for sugar beet and corn, and 10*10 pixels for canola, wheat, and sunflower.

Leader Farmer's Association also monitors the lands of its members with rain gauge sensors on their lands. They also monitor the lands with the technological system they have created so that 25 farmers have 1 observer and 1 engineer. It also shares the land prices with the member monthly, with a 20 km diameter arc on the lands of its members.

With the “Climate Change Research Center”, which the Leader Farmer Association has further developed its infrastructure during the pandemic process.
• Research of drought tolerance,
• Resistance to cold (-20 degrees),
• To create an accreditation center,
• It has been observed that they use technological opportunities too much and intensively in order to develop varieties resistant to cold and climate change.

The aim of establishing Hayrabolu Leader Çiftçi Production and Marketing Cooperative is another remarkable finding in the research; “Digitizing the Cooperative”. Hayrabolu Leader Farmer's Association is a capital-based cooperative with a participation of 5,000 TL for the children of its partners. 50% of the cooperative partners are university graduates. By making an agreement with a cooperative bank, it offers all post-harvest inputs to its partners interest-free for 6 months. Cooperative members also offer the manual steering system to their partners at affordable prices. The steering system is a system that allows the operator of the tractor to self-align in the field, thanks to the precise positioning information it obtains.

Thanks to this system, it is used by the producers in the Thrace Region as a system that both saves money, prevents unnecessary residues in the products, and increases the yield by guiding the producer in the process from soil fertilizer to harvest (except planting) throughout the production season. As a result of the data obtained by the cooperative managers from their partners; They found that an average of 17% savings in fertilizer costs and an average increase of 10-12% in wheat yield from 1 decare of the wheat field, in other words, an average of 120 TL was provided to the producer per decare. The cost to be incurred by the manufacturer for the manual steering system is foreseen as a result of the calculations, that it will pay for itself at the end of only one season in 500 decares and above Canola or 800 decares and above Wheat.

It has been determined that the producers using the Field Analysis System technology have an average of 1600-1700 decares and a single parcel of agricultural production. The products that are produced are based on the remote sensing system; wheat, barley, canola, and corn. The field analysis system maximizes the potential of each decare. The field analysis engineer examines the crop's plant health, calculates how much fertilizer is needed, and the available sprays and scattering are applied in real-time. In the system, the amount of fertilizer calculated per decare is applied with tools and equipment using a new generation passive sensor, 4K camera system, multiple light sensors, and an advanced virtual intelligence engine. Thanks to this system, problems that cannot be seen with the biological eye can be seen and determined by the digital eye. Due to the high investment costs (average 9-10 thousand Euros), it has been determined that it is used by producers of certain scales. The fact that the tractors and equipment owned are suitable for smart farming systems is another factor in the use of such systems.

Automatic steering can provide 2 cm, manual steering systems can provide 10-16 cm alignment. Another area where digital technology is used by producers is to monitor the productivity of tractors by installing monitoring systems on tractors. It has been determined that producers using permanent or temporary labor in tractors have installed a tractor monitoring system. In this way, the producers stated that the performance of the people working on the tractors increased by 20% and they saved about 40% from the diesel fuel. For example, while there was 1 to 1.2 liters of diesel consumption per decare before installing the tractor monitoring system, it has been reported that the person working on the tractor performs the work more consciously as they know that they are being watched with the monitoring tool placed on the tractors, and the diesel consumption per decare drops to 0.7-0.8 liters.

While 92.00% of the producers support the spread of technological applications in agriculture, 50.00% of those do not support them because they are not suitable for small agricultural enterprises and 50.00% do not support them because they are not suitable for the elderly producers.

It has been determined that 60,00% of the producers participating in the survey are knowledgeable about smart agricultural practices.

Table 14. Knowledge of producers about smart farming practices

	n	**%**
Yes	30	60,00
No	20	40,00
Total	50	100,00

It was determined that 22.00% of the producers participated in the training on smart agriculture practices. 90.91% of the producers participating in the training stated that these training were given face-to-face, and 45.44% stated that this training was given by private sector personnel.

Table 15. Information on the participation of producers in any training on smart agriculture practices, the way the training is given, and by whom it is given

Status of participation in training	**n**	**%**
Yes	11	22,00
No	39	78,00
Total	50	100,00
The way the training is delivered		
Online	1	9,09
Face to face	10	90,91
Total	11	100,00
Given by whom		
Agricultural engineers	1	9,09
Consultants	3	27,27
University staff	2	18,18
Private sector personnel	5	45,44
Total	11	100,00

If smart agriculture applications are found in enterprises, the problems that may be experienced during the use phase are a matter of discussion. As a result of the research, it was determined that 50.00% of the producers could use these systems alone if they were in their enterprises, while it was determined that 50.00% of them could not use them.

It has been determined that 86.00% of the producers will not be bothered by the fact that their businesses are followed 24 hours a day, 7 days a week, while 72.00% of them will allow the information of their businesses to be shared with third parties.

Among the producers participating in the survey, it was determined that the biggest obstacle to technological developments in agriculture was the lack of capital (17.58%), while the thought that smart agricultural practices were not economically profitable (15.58%), high loan interest rates (15.58%) and agricultural Insufficient supports (13,07%) were identified among other obstacles.

Table 16. Barriers to the advancement of technological developments in agriculture

	n	**%**
Lack of capital	35	17,58
Legal and political provisions	11	5,53
Lack of an effective organization	18	9,05
Smart farming practices are not economically profitable	31	15,58

High loan interest rates	31	15,58
Low-profit margin in agriculture	23	11,56
The fluctuation of agricultural product prices	9	4,52
Insufficient workforce	13	6,53
Insufficient agricultural support	26	13,07
Small plots of land	1	0,50
Familial reasons	1	0,50
Toplam	199	100,00

Changes in the activities of producers during the Covid 19 pandemic period are indicated in Table 17. It has been determined that there is no change compared to the pre-pandemic period in product sales (92.00%) and e-commerce sales (88.00%) on DİTAP, for the manufacturers, sales over the social platform (26.00%), and the use of new inputs or techniques (30.00%) increased.

Table 17. Changes in the pandemic process compared to pre-Covid 19 (%)

	Not at all Decreased	Slightly decreased	Unchanged	Increased	Definitely increased
Application of new knowledge	0,00	6,00	68,00	24,00	2,00
Doing e-commerce	0,00	0,00	88,00	8,00	4,00
Online sales	0,00	0,00	62,00	30,00	8,00
Selling on the social platform	0,00	0,00	66,00	26,00	8,00
Use of new input or technique	0,00	2,00	66,00	30,00	2,00
Product sales via DİTAP	2,00	0,00	92,00	4,00	2,00
Participation in distance education programs	0,00	0,00	78,00	14,00	8,00

Phase III – Policy Recommendations

The COVID-19 pandemic has impacted negatively on the 2030 Agenda, starting with the SDG3 (Good Health and Well-Being) which led to the global socio-economic challenge, linking with SDG8 (Decent Work and Economic Growth), SDG1 (No Poverty), SDG2 (Zero Hunger) and SDG10 (Reduced Inequalities), as well as SDG9 (Industry, Innovation and Infrastructure). Moreover, these crises made us all realize the importance of this agenda and the need to tackle all the 17 SDGs not as an individual nation but as they all united, towards the same direction.

Figure 20. THE 17 GOALS | Sustainable Development (un.org)

Based on the UN Türkiye COVID-19 Socio-Economic Impact Assessment (SEIA) Report discussed in an earlier chapter, the United Nations has offered to support developing partner countries including Türkiye, focusing on priorities outlined in both SDGs and the 11th National Development Plan (2019- 2023). More specifically, the relevant support was listed below under Pillar 3 which is the Economic Response and Recovery in line with the COVID-19 response.

1. Job retention and job creation for vulnerable groups
2. Rural interventions to increase the resilience of producers and improve supply chains in the agrifood system
3. Recovery actions for business continuity in the private sector
4. Business transformation for adaptation to the post- COVID-19 economy
5. Effective public sector response for an economy resilient to shocks and hazards
6. Protection of natural habitats
7. Business practices upholding child rights and wellbeing and the work-life balance

In Türkiye, agricultural policies evolved since 2006 when the Turkish policies aligned with European Unions for harmonization to create the Common Agricultural Policy (Diakosavvas, 2011). In this section, emerging challenges for Turkish agricultural policies related to the transformation process of digitalization related to the COVID-19 pandemic are discussed, and key policy recommendations are provided. It is necessary to narrow the gaps between the city and the countryside in terms of connectivity, information, technology, and internet access.

Apart from the increased food demand owing to the factors such as adverse effects of globalization, urbanization, population growth, climate change works as an intensifying hostile agent on agricultural production. Hence, various institutions, private establishments, and scientists seek a way out of the intensifying food need. This aim has become a main motive in the studies to be conducted. IoT, CPS, Big Data, Cloud Computing Technologies, AI, M2M, and many similar technologies have become indispensable to agricultural applications. Needs of cost reduction and green-sensitive mode of production as well as difficulties that arose from COVID-19 conditions have all made digital support and digital transformation integrated part of agriculture.

Until recently, Türkiye's digital agriculture advancements were not based on a national strategy or plan. The soon-to-be-released 5-Year Development Plan includes, for the first time, objectives related to digital transformation and digitization for various sectors, including agriculture. Implementing modern agricultural practices is also underscored in the climate commitments of Türkiye's Intended Nationally Determined Contributions. As such, a major push for digital agricultural solutions is expected in the coming years. All new and current digital agricultural programs conducted in Türkiye fall under the supervision of the Digital Transformation Office, which was established as part of the presidential governance system and across all ministries and sectors.

The primary responsibilities of this office include coordinating e-government development, undertaking the necessary projects to develop national digital solutions and raise awareness, conducting big data analyses in priority areas, and improving cybersecurity and information security. The Science, Technology, and Innovation Board also falls under the presidential office and is tasked with making recommendations in terms of multiple areas directly relevant to digital agricultural solutions, including:

• Opportunities for regional and global competition, entrepreneurial culture, digital solutions, and catalyzing research and development of new technologies

• Infrastructure, human resource, and other development projects to improve economic, social, and national security

• Areas of strategic technology opportunity

• Medium- and long-term national technology strategies and policy plans

• Programs to reduce import dependency and increase the competitiveness of Turkish industry

• Policy and strategy for promoting effective and accessible digital solutions in the fields of economy, commerce, recreation, science, education, and culture.

The Ministry of Agriculture and Forestry is the primary government actor in terms of agricultural production, and the most prominent investor in Turkish digital agricultural solutions. The Ministry's 2019 budget is approximately USD4,5 billion, of which approximately USD884 million is allocated for investments. An estimated 3% of the investment fund (USD26,5 million) will be allocated solely to digital agriculture solutions.

Within the Ministry, the General Directorate of Agricultural Research and Policies is responsible for conducting research; the General Directorate began digital agriculture research programs in 2002. Some of these programs include: Determination of Variables Affecting the Yield in Cereal Cultivation Areas Using Precision Agricultural Techniques; Field Specific Variable Rate Fertilizer Application in Maize Production in the Çukurova Region Using Information Technologies Supported by Satellite Images; and the Integrated Project for Planning, Development, and Dissemination of Precision Agricultural Applications in Crop Production.

The Ministry also supports research programs conducted by ASELSAN, the largest defense electronics company in Türkiye, with the aim of transferring the use of unmanned aerial devices, communication platforms, and traffic and automation systems to the field of agriculture. Some of ASELSAN's projects to date include: Automatic Tractor Steering and Control System Development; Farm Management Systems Development; Image Processing Based Precision Agricultural Applications with Unmanned Aerial Vehicles; System Development for Monitoring and Tracking Wheat Losses During Harvest; and Development of the Intelligent Measurement Platform Prototype for Sheep and Goat Breeding (Anonymous 2020).

The government in Türkiye has already been working on improving the Economic Recovery in line with the Covid-19 response as explained above. The future digital transformation predictions emphasize that those small farmers who are currently not involved in e-commerce will be forced to adapt to digitalization to survive in the market. To do so, the government is expected to introduce policies to support it, and higher education institutions will play a significant role in contributing to accelerating the progression by working together with the government and industries, offering relevant education and training as listed in table 18.
The updated gaps which need changespoliciescies are also identified as shown in table 19. The ability to use the developed and changing technologies, applications and tools are considered the important skills required by all users not only for farmers but also for government officers.

Ecosystems and Infrastructure should be driven by the core value propositions in digital agriculture. This report's findings provide valuable information for policymakers and practitioners to identify the value proposition for investment and to tackle priorities especially in response to the changing environment during the Covid 19 Pandemic.

Both literature and our findings in Türkiye show that there are more men working in the agriculture sector. Surprisingly, women are adapting to this digital transformation process better than men especially for marketing their products online. Although the number of smartphones and internet users among producers is high as over 90% (figure 18), Only 3.24% of them are using the technology for their marketing channels (Figure 17).

This is due to the low rate of producers having knowledge about "smart agriculture" as they are reluctant towards the innovation, not easily open to changes such as the use of technology. Evidently, there is a large space for improvements. Although the lack of capital in the agriculture sector was identified as one of the biggest challenges, much more should be done to introduce the advantages of the use of smart agriculture and digitalization, and to provide sufficient information and training which could be done with the help of educators and trainers.

Drivers of growth -Private companies	According to the report prepared by Markets and Markets (2020), it is predicted that there will be an annual growth of 9.9% due to the COVID-19. As a result of better infrastructure such as the reduced costs of high-speed internet, cloud services, satellites, computers, cellphones, and smartphones. In addition, the actions related to the reduction of labor as well as more consciousness on resources contributed to the improvement in performance. More start-up companies supplying digital agricultural technology help especially traditional small farmers to get into the online business to reach more customers efficiently.
Government policies to create a business-friendly environment	Governments can provide more support to agribusinesses by introducing policies affecting the overall business operations (simple and user-friendly registration procedures, access to credit, protection of intellectual property rights. And more importantly, it is they need to act proactively to facilitate international trade during the COVID 19 pandemic.
Promoting skills development at all levels	More investment in human capacity such as offering skills development program is necessary for digital agriculture at different levels. -Farmers for digital literacy -Government employees - training programs -IT specialists- skills development
Growth of communication infrastructure	It is necessary to make sure the sufficient communication infrastructure in rural areas is provided as telephone and internet access are a must in a digital environment. Getting investments and fundings from multiple actors is the key the success.
Research to support digital agriculture	Updated data collection will be relevant, for example when developing new apps to meet the demand from the user. Base on the infrastructure available in a particular country or area, the developer can create the app according to the access to the usage.
Policies related to the agricultural input industries	Laws and regulations such as antitrust regulation

Table 18. List of suggestions for improvements in agricultural infrastructure

The report can be utilized as a roadmap for policy change and/or adoption for Türkiye. The COVID-19 pandemic is an ongoing global pandemic, constantly changing which affects the rules and regulations of international trade. As a result, economic multiplier impacts are massive, as these indirect impacts influence greater through the national economy.

And therefore, we must consider the possible negative effects which could be caused by the crises and act proactively, increasing the number of awareness-raising activities on food loss and waste through digitalization. Digital transformation clearly helps achieve this goal within the agricultural industry by improving the food supply chain management system. Food and nutrition security during COVID-19 is the going challenge we are facing constantly.

Activities implemented in Türkiye especially in rural areas could be one of the good examples and practices which create a big impact on sustainability to ensure there is enough resource to support the future global population. The COVID-19 pandemic situation created more demand and concerns for food in line with the shift in consumer behavior towards healthy products. The application of Smart agriculture can accelerate the process at every stage to meet this highly demanded and important sector worldwide.

According to our research findings, although the number of producers supporting the spread of technological applications is high as 92%, they have concerns about the implementation of such technology as it has a low-profit rate compared to the among of investments they have to take.

As a result, half of them find it not suitable for small agricultural enterprises, and the remaining half believe it is not applicable for elder producers. However, this could be overcome by providing appropriate support and guidance for elder producers just like the example of the elder women in rural areas in Japan, who received such support and now leading the economy in the village as described in the case study written by Kawamorita et al (2021).

Table 19. Policy Recommendations for Türkiye

Adaption Needs	Existing Government initiatives	Gaps
Smallholders, 40% of whom are over 50 years old, need support in adopting costly new hygiene and handling practices as well as selling their products through novel channels in response to the more stringent standards of the retailing sector in the post-pandemic period. This would also support diversified food supply by articulating local and regional short food supply chains to strengthen the agri-food system.	Farmers' credit repayments and the collection of rent on state lands under agricultural production were postponed.	Lack of supporting mechanism to deal with the crises.
	DİTAP has been introduced for agri-food products with the aim of matching producers and processors/retailers through contract farming, to be supported by special credit lines.	Training or external service provider is still needed especially for farmers in the rural area.
Product and target group-specific good hygiene and handling guidance are needed for the harvest season when physical contact among farmers/producers, workers, and others intensifies. It is necessary to deal with rapidly changing business environments during the Covid 19 pandemic.	Restrictions on the movement of persons were relaxed earlier for farmers and agricultural workers than for other citizens. Information campaigns have been launched on Covid-19 related hygiene and handling practices.	Lack of sufficient regulations.
	Fertilizer stocks are being monitored to avoid any shortages.	
The positive shift in consumer behavior towards foods with long shelf lives provides an opportunity for the Turkish agri-food industry to supply more such foods both in the domestic market and to export markets.	Support has been extended to aquaculture, campaigns such as "eat fish at home".	Lack of sufficient awareness-raising practices especially in rural areas.
There is a need to clear any surplus products in the markets in order to sustain the incomes of farmers/producers.	This can be done by distributing them through food banks or – particularly for fruits, vegetables, and dairy products – processing them into products with long shelf lives.	Lack of sufficient actions to prevent food loss and waste.

Policy Recommendations

There is a need and opportunity to accelerate efforts to reduce food loss and waste. A policy framework and greater capacity for implementation are needed. The measures are taken to avoid the spread of the pandemic at wholesalers and retailers – notably, the pre-packing of products – can help to reduce the loss with more concrete awareness-raising. And to strengthen the coping capacity of the agri-food sector towards the achievement of the Sustainable Development Goals.

In response to the COVID-19 conditions, the Turkish government eased the restrictions imposed on export items based on the market demand. In 2020, the Digital solutions DITAP have been adopted and introduced in Türkiye to connect producers and consumers in the virtual agriculture market platform. This up-to-date information-sharing place helps to prevent market fluctuations and enables them to set the price for sustainability as explained in Chapter 7. The platform also offers the opportunity for producers to access preferential credit for contract farming by banks. According to the latest report on the policy response to the COVID-19 pandemic by FAO (2020), Türkiye has strengthened the mechanism for customs clearance (Agriculture sector exempt from COVID-19 pandemic restrictions) to facilitate regional agri-food trade, "green corridors" during the lockdown period to keep food supply chains ongoing

since 2020. Special movement permissions for farmers, traders, and cargo have been given to support the Agricultural Business Cycle.

The government is under increased pressure to act quickly and build digital resilience, which is the key for the economy, especially in the current pandemic conditions.

The improvements in digital infrastructure in Türkiye in line with the implementation of DITAP are narrowing the current gap in the agricultural economy. To make the best use of the existing tools, more education and training program should be introduced especially for producers such as farmers who have fewer competencies in the use of technology in rural areas. The project-based bottom-up approach is contributing to the enhancement of the current situation.

Nevertheless, the government policy and agricultural supply require in-depth analysis on multiple levels, and the specific need of the target group should be linking the policy to tackle issues and challenges. Therefore, this research report will serve as necessary data collection for policymakers to better understand the current demand in the digital transformation process in agriculture.

Conclusions

The COVID-19 days, which are tried to be spent in great anxiety and uncertainty, have clearly revealed the value of some economic activities and the people working in these activities that were never cared for. The pandemic process has highlighted the importance of the agriculture sector and sub-sectors connected to the agricultural sector among all economic activities in Türkiye as well as in the rest of the world.

It has been almost 2 years since the outbreak of the COVID-19 pandemic in Türkiye. Since then, the country has been responding to the continuously changing business environment and a series of economic precautionary measures were taken by the government to alleviate the negative economic effects of the pandemic in Türkiye as well as on the whole world.

The government has been providing support and trying to keep businesses open by reducing restrictions for trade and allowing companies to set their own guidelines for employers during the crises. Institutions and organizations in the agricultural sector and producers were also allowed to apply for these supports. At the beginning of these supports are part-time working allowance, low-interest loan facilities of public banks, credit debt delays of public banks, low-interest loans offered by private banks within the scope of the loan guarantee fund, and municipal supports.
The use of digital technologies because a must in all industries to survive during crises while many restrictions are required such as social distance, closure of country borders as we as the temporary export restrictions for certain products to avoid the shortage within the country.

Under such conditions, the role of technology and related systems such as IoT, and Drones are helpful while dealing with the pandemic. It is the key to success during the pandemic and the acceleration of digital transformation is required everywhere, not depending on the size of the organizations or the age of the users.

There are many different production systems exit in Türkiye and among all the differences, there are similarities in basic elements and smart/digital farming systems. This research focuses on the similarities related to the effects of the use of smart and digital agriculture systems during the COVID-19 pandemic process.

The use of this modern agricultural production technology based on the use of advanced information technologies and control systems received great attention from many researchers in the last few years. By 2019, it became one of the most important trends focusing on digital innovation in agriculture.

The literature review findings show the need for such digital transformation in different contexts, and our conducted primary research offers added value to the existing literature by providing the case of Türkiye in the agriculture field. It addresses the changes in the use of technology by the stakeholders in agriculture during the pandemic process and the level of use of digital/smart agriculture systems, rather than focusing on only the economic impact of the pandemic in the target provinces.

This report covers a wide range of topics that are explored and investigated by theories and field research in agriculture, which provide more contextual, and updated findings in the Turkish context. Meanwhile, ethical problem issues in Agriculture were examined as a new area of research that is expected to grow in the new future considering the continuous demands of the use of smart agriculture technologies. Detailed information on the digital agricultural components is listed in chapter 4.

One of the leading countries in the use of technology in agriculture is identified as the USA, the largest agricultural product exporter in the world. The reasons for their success are believed to be the level of investment in both creating technologies and teaching how to use this newly created technology.

In many countries including Türkiye, there is a lack of training on how to use the existing technology among practitioners such as farmers and producers. The application of smart agriculture technology help increase production, reduce costs, economize on spraying and fertilization, reduce environmental hazards, improve irrigation efficiency, and guarantee food safety. And it's important the users utilize such available technology in the field.

Although Türkiye has shown great improvements in accessing digital technologies and services, and the created educational training initiatives by the government, more and more training should be provided for full use of the technology especially in rural areas. At the same time, it is important to raise awareness of the impact of smart agriculture technology and promote it among nonusers and nonsupporters.

In line with the application of smart agriculture technology, digitalization of commerce is necessary especially during the COVID-19 pandemic as the method of promotion, sale, distribution, and payment transactions of goods and services via the internet and information technologies.

The agricultural digital infrastructure in Türkiye is satisfactory however, the lack of developments in digital mechanisms to access and analyze data from multiple sources was raised as one of the challenges to overcome. Also, introducing a holistic approach is the appropriate method to create the ecosystem for facilitating e-commerce. Changes in policy are required to accommodate the digitalization of commerce and to improve the infrastructure for digital payments, to set up the legal and regulatory frameworks for online transactions and security.

During the pandemic, the ability to act and adapt quickly and flexibly to changing internal and external conditions on food systems operation is required to respond to unexpected future. The COVID-19 pandemic accelerated the adaption of technology worldwide and Türkiye has been experiencing the shift to e-business.

The purpose of the field studies was to have access to primary data which is valuable for a better understanding of the current situation. To do so, this study followed the research process which includes preparation, developing the means for data collection, data collection, data sorting, and analysis. The needs assessment was completed, the target group was identified during the first stage of the preparation, and the means for data collection were organized accordingly.

The most important material used was the questionnaire interview which is one of the quantitative research methods. These one-to-one interviews were conducted with a total of 85 people, 35 institutions/organizations, and 50 producers targeting the farmers and relevant stakeholders in person or by telephone.

The face-to-face interviews were arranged according to the rules introduced by the Ministry of Health during the pandemic, such as to use open-air spaces considering the social distance. The key people in the region were prioritized as the target group and the level of use of smart and digital agriculture and their knowledge among those farmers/stakeholders were examined. The collected data were analyzed and evaluated to enrich the result by demonstrating quantitatively (data from Farmers) while extracting the qualitative descriptive phenomenon (data from stakeholders). The creation of the database was performed to avoid errors during the data entry process.

As discussed in Phase II – Gathering and Analysing Data, although several challenges in the application of smart agriculture are highlighted, so far there are not many changes in the pandemic process before and after the outbreak of the COVID – 19 pandemic (Table 17). While there is less increase in the use of DITAP for sales, the use of social platforms and online tools/applications have improved significantly. The result shows that individuals have responded to the changes after the crises efficiently. However, although there is a slight increase in the number of doing e-commerce and participation in distance education programs, more could be done with the help of the government and the policymakers.

Although most of the producers use smartphones and the internet and the high number of producers supporting the spread of technological applications, most of them are reluctant to use them due to the high investments as well as the norm that this technology is not applicable for elder people. Most of them are using their smartphones for accessing basic information such as

agricultural weather conditions and product prices and the most commonly used applications are İşbank “İmece” application, “E-government” application, “Hepsiburada” applications.

Unfortunatly the research finding discovered that the “DİTAP” application is less used and especially producers over the age of 60 stated that they do not benefit from the application. Meanwhile, there are differences in gender that women's cooperatives use technology more than men for their marketing such as via "Instagram", Hepsiburada.com, and trendyol.com during the COVID-19 pandemic. Although the producers are actively using the technology for marketing their products and services, the level of knowledge on smart agriculture remains low.

The lack of capital in the agricultural sector was identified as the main reason slowing down the advancement of technological developments. Also, it was discovered that producers are not open to innovations.

The demand for agriculture has massively increased during the COVID-19 pandemic period, however, many challenges were seen such as the obstacles while processing livestock due to the lack of timely delivery of imported animal vaccines. There has been an increase in greenhouse installation in Türkiye and as a result, all operational systems in the production process must be controlled through the process. meteorology stations established by Agricultural Credit Cooperatives are one of the useful resources available to obtain the needed information. Digital infrastructure should be created to meet different conditions as each greenhouse are different.

According to the research finding, at least 10 years of experience is believed to be required for effective data use in agriculture. One of the phone applications is used for the stock market prices of all products in Türkiye, and the member of the Leader Farmer Association has the privilege to access the shared information. The association also monitors the conditions among its member such as the rain gauge sensors on their lands and provide a technological system by offering 1 observer and 1 engineer for 25 farmers.

More producers in Türkiye are using drone technology for pesticides in paddy, corn, and sunflower. A rice producer that carries out spraying, fertilization, and planting activities with a drone in Bafra District of Samsun Province was mentioned as one of the good examples. The use of drones resulted in a 70-80% reduction in spraying, 40-50% in planting, and 35-50% in fertilization in the labor costs of the activities. Many producers find drones accessible and efficient. For instance, the work done by the manufacturer in a day is equivalent to the work done by a drone in 1 hour. This clearly shows the advantage to the producers in terms of both time and labor cost and the increase in the application of drones is expected to grow.

Educators and training providers could help more to accelerate the transformation of digitalization in the agriculture sector to reach a larger number of stakeholders, changes the prospectives of anti-technology users, especially in rural areas to make a bigger impact in short term as the gap in untouched segments (elder producers, small agricultural enterprises, etc).

The finding of this research in Türkiye support previous studies around the world (Table 4) and reveal how effective the digital transformation in agriculture is applied considering its socio-economic impacts during the COVID -19 pandemics.

This report can be useful as a roadmap for the policymakers and all practitioners in Türkiye to update the existing supporting mechanisms and to create innovative solutions by collaboration among all stakeholders. The government plays an important role as the leader of the country and policymakers should take the most suitable approach to support each actor.

This report also can be used for educators and trainers to better understand the importance of the high demand for awareness and skill development training programs in the agriculture sector. More activities should be initiated through national and international projects to narrow the gap between the available technology and the ability to use them.

The study has a limitation for reaching farmers for data collection due to restrictions during the COVID 19 pandemic. Therefore, further research with a wider sample size may provide contributions to the existing literature as this type of research really matters, providing value research analysis and forecasts.

As described in the report, the COVID-19 pandemic has negative impacts on the global economy. In Türkiye, the input prices increased due to inflation and foreign currency which affected farmers, not being able to use enough inputs. As a result, it is expected to have a negative effect on the 2022 yield. Therefore, it is suggested that smart farming is the key to reducing costs and accessing optimum input use with digital technologies.

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