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# Industry 4.0 and Agriculture

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**Keywords:**
Precision Agriculture,
Artificial Intelligence,
Remote Sensing.

**Abstract:** Smart agriculture system creates an unprecedented power asymmetry suitable for agro-industrial production. In addition, it will bring to the producers the convenience when measured by the current use of the smart agriculture system. It is increasing the power of potential monopoly companies in the fields. It is useful for agricultural production as well as seeds, pesticides and fertilizers. It has been observed that it is difficult to protect producers or countries with low or limited economic resources in terms of food safety. It is also difficult to find answers that will both eliminate the concerns about the sustainability of traditional knowledge and lead to the destruction of local knowledge, genetic resources and biodiversity. In line with current globalization trends, it is taking shape.

# Tarım ve Endüstri 4.0.

**Anahtar Kelimeler:**
Hassas Tarım,
Yapay Zekâ,
Uzaktan Algılama.

**Özet:** Akıllı tarım sisteminin mevcut kullanım şekli ile ölçüldüğünde, üreticilere getireceği kolaylığa ek olarak, tarımsal sanayi üretimine elverişli eşi görülmemiş bir güç asimetrisi yaratacak, potansiyel tekel şirketlerinin tarlalardaki gücünü artıracaktır. Tohum, ilaç ve gübrelerin yanı sıra tarımsal üretime de faydalıdır. Gıda güvenliği açısından ekonomik kaynakları az veya sınırlı olan üreticileri veya ülkeleri korumanın zor olduğu, hem geleneksel bilginin sürdürülebilirliği ile ilgili endişeleri giderecek hem de yerel bilginin tahribatına yol açacak cevaplar bulmanın zor olduğu gözlemlenmiştir. Genetik kaynaklar ve biyolojik çeşitlilik mevcut küreselleşme eğilimleri doğrultusunda şekillenmektedir.

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## 1. INTRODUCTION

The demand for food is driven by both the increase in world population and the increase in urbanization, is increasing day by day. Soil erosion in farming areas, deforestation, misuse, overgrazing, improper crop rotation and unbalanced use of fertilizers use increase the importance of smart agriculture. Reasons has decreased. In addition, different climatic conditions cause a decrease in agricultural yield and agricultural production. The destruction of fields suitable for agriculture in the world over time and decrease in usable water resources, differentiation of climatic conditions this led to the focus of attention on agriculture. Agriculture production was increased to meet the food needs of the growing population. This production method is called green revolution throughout the world. Intense chemical input this production, which is also called modern agriculture, where practices are made, its shape is known to cause serious damage in nature. Vegetable in production, unconscious fertilization, irrigation and spraying even if there is a high yield opportunity in a long time, it will destroy the nature in the long run. It is accepted as a common view all over the world that environmentally friendly practices are needed. The increase in education level and the brisk life offered by our age have also increased the consumption of safe food. With

this awareness, individuals should prioritize directly consumed agricultural foods. The individuals must be ensured that all food products purchased are safe. ( B. Söğüt, M. R. Taysı, H. İnci, E. Karakaya,2020)

"World Trade Organization" (WTO) and The Organization "Animal and Plant Health" established a protocol with regulations for agricultural products and foreign trade food safety in order to maintain international standards. In addition, future wars over food and water. The scenarios where it can happen again reveal the importance of agriculture. Today, with the effect of "Industry 4.0", the agricultural sector has also been affected by the digitalization process. All machinery used in the stage of agricultural production are equipped with sensors. The "Internet of Things" has entered the agricultural sector and has provided that all production machines are in communication with each other. Thanks to digitalization the data which is achieved with smart tools was analyzed. By analyzing aquaculture activities in a timely manner, these smart tools allow to detect and determine where and how much and what kind of fertilizers should be applied, how many and what kind of minerals that the plants need, the effect of weather conditions on agriculture, needs of irrigation, the condition of the soil, pest state and the estimated harvest time. The aim of these applications; agricultural yield is to be maximized compared to traditional methods. As a result, productivity problems in agriculture are increasing, and product prices are rising, parallel to climate change with global warming. The need for the application of new methods in agriculture is increasing.

The demand for food is increasing day by day, driven by the growing world population and urbanization. Factors such as soil erosion in farming areas, deforestation, misuse, overgrazing, improper crop rotation, and the unbalanced use of fertilizers highlight the importance of smart agriculture. Additionally, varying climatic conditions reduce agricultural yield and production. The ongoing destruction of arable fields and diminishing water resources have brought agricultural issues to the forefront. Historically, agricultural production increased during the "Green Revolution" to meet the needs of a growing population, but this method, known for its heavy use of chemical inputs, has caused significant environmental damage. Unconscious fertilization, irrigation, and pesticide application may offer high yields in the short term but harm nature in the long run. There is a global consensus on the need for environmentally friendly practices in agriculture.

The rise in education levels and the dynamic lifestyle of our era have increased the demand for safe food. This awareness necessitates prioritizing directly consumed agricultural foods and ensuring the safety of all purchased food products. The World Trade Organization (WTO) and the Animal and Plant Health Organization have established protocols for agricultural products and food safety in international trade. Future conflicts over food and water further underline the importance of agriculture.

With the advent of "Industry 4.0," the agricultural sector has also been affected by the digitalization process. All machinery used in agricultural production stages are now equipped with sensors. The Internet of Things (IoT) has entered the agricultural sector, enabling communication among all production machines. Thanks to digitalization, data collected from smart tools is analyzed to optimize aquaculture activities. These tools help determine where, how much, and what type of fertilizers should be applied, the mineral needs of plants, the effects of weather conditions on agriculture, irrigation needs, soil condition, pest status, and estimated harvest time. The aim of these applications is to maximize agricultural yield compared to traditional methods . As a result, productivity problems in agriculture are increasing, and product prices are rising in parallel with climate change and global warming. The need for new agricultural methods is becoming more urgent.

### 1.1. Basic Concepts

#### 1.1.1 Industry 4.0 and Agriculture

Industry 4.0, seen as the fourth industrial revolution, introduces automation through information and communication technologies. It integrates horizontal and vertical data exchange models in business processes. This revolution has enabled the use of smart systems in agriculture, based on four basic elements: sustainability in production, consumer demands, new business models, and data utilization. (Klaus Schwab, "The Fourth Industrial Revolution", World Economic Forum, 2016).

Industry 4.0 is seen as the fourth industrial revolution and is a new industry. It uses automation, which is a function of information and communication technologies, horizontal integration in business processes, and vertical data exchange models process (S. Kılıç, R. M. Alkan,2018). The rapid development in information technology has enabled to use of the smart systems in agriculture. Industry 4.0 is based on 4 basic elements. These are sustainability in agricultural production, consumer demands, new business models and data in agriculture. Smart agriculture needs qualified manpower and limited resources. Digitalization, on the other hand, is the driving force in the industry, and is at the center of transformation. Big data analysis in the digitalization makes it easier to understand customer demands more comprehensively. This analysis allows the companies to produce customized products. With the integration of fully automated systems and smart systems, the interaction of "man-machine" and "machine-machine"are widespread. It also increases the need for skilled workforce. This too qualified to adapt to the innovations brought by digital transformation does not mean the training of the workforce(TÜSİAD, 2017). Rapid and portable computers are the another of the developments recorded. Computers interact with the users like a smart assistant (Anonim, Türk Tarımının Global Entegrasyonu ve Tarım 4.0 Projesi Sonuç Raporu, İzmir Ticaret Borsası ve Ege Üniversitesi İktisadi ve İdari Bilimler Fakültesi, 2017).

Industry 4.0 and the Agricultural Revolution: Embracing Digitalization for Sustainable Smart Farming.In the midst of the ever-evolving technological landscape, Industry 4.0 has emerged as the fourth industrial revolution, heralding a new era of automation driven by information and communication technologies. ("Industry 4.0: The Future of Productivity and

Growth in Manufacturing Industries", Boston Consulting Group, 2015). This transformative concept goes beyond traditional manufacturing to revolutionize various sectors, including the fundamental backbone of society agriculture (Anonim, Türk Tarımının Global Entegrasyonu ve Tarım 4.0, Ege Üniversitesi İktisadi ve İdari Bilimler Fakültesi, Ocak, 2019).

#### 1.1.1.1. The Fusion of Industry 4.0 and Agriculture

The fusion of Industry 4.0 with agriculture is a dynamic process, capitalizing on automation, information technologies, and innovative business models. Automation, propelled by information and communication technologies, has become a cornerstone in agricultural processes. Horizontal integration streamlines business operations, while vertical data exchange models enhance communication and decision-making processes (Anonim, Türk Tarımının Global Entegrasyonu ve Tarım 4.0, Ege Üniversitesi İktisadi ve İdari Bilimler Fakültesi, Ocak, 2019).

#### 1.1.1.2. Smart Agriculture: Meeting Challenges with Innovation

The swift advancement of information technology has paved the way for the implementation of smart systems in agriculture. In the context of Industry 4.0, smart agriculture revolves around four key elements: sustainability in production, responsiveness to consumer demands, exploration of new business models, and the effective utilization of data in agriculture. As the agricultural landscape becomes increasingly complex, the demand for qualified manpower and the judicious use of limited resources become pivotal for the industry's successA. Jatav, ("Smart Farming System Using IoT", International Journal of Innovative Research in Computer and Communication Engineering (IJIRCCE), 2018).

Smart agriculture meets challenges through innovation. It requires qualified manpower and the judicious use of limited resources. Digitalization is the driving force in this industry, making it easier to understand customer demands through big data analysis. This approach allows companies to produce customized products. The integration of fully automated and smart systems has increased the need for a skilled workforce capable of navigating and optimizing these advanced systems.(S. Rajasekaran, "Smart Farming: IoT Based Smart Sensors Agriculture Monitoring System", 2020).

#### 1.1.1.3. Digitalization as the Propelling Force

At the heart of Industry 4.0 lies digitalization—a force propelling the agricultural sector into a new era of efficiency and sustainability. The analysis of big data, a crucial component of digitalization, enables a comprehensive understanding of customer demands. This data-driven approach empowers agricultural companies to tailor their products to meet specific market needs, fostering a more agile and responsive industry ("Digital Agriculture Transformation Strategy", European Commission, 2020).

At the heart of Industry 4.0 is digitalization, which propels the agricultural sector into a new era of efficiency and sustainability. Big data analysis, a crucial component of digitalization, enables a comprehensive understanding of customer demands and allows agricultural companies to tailor their products to meet specific market needs ("Digital Transformation in Agriculture: A Roadmap for Development", Food and Agriculture Organization (FAO), 2019).

#### 1.1.1.4. Integration of Automated and Smart Systems

The integration of fully automated systems and smart technologies has ushered in an era where the interaction between "man-machine" and "machine-machine" is ubiquitous. This integration not only enhances operational efficiency but also underscores the growing need for a skilled workforce capable of navigating and optimizing these advanced systems. It is important to note that the qualification to adapt to the innovations brought by digital transformation is not an inherent trait but rather requires continuous training and development ("Digital Transformation in Agriculture: A Roadmap for Development", Food and Agriculture Organization (FAO), 2019). The integration of fully automated systems and smart technologies has enhanced operational efficiency and underscored the growing need for a skilled workforce. This workforce must continuously adapt and develop to keep pace with digital transformation ("Digital Agriculture Transformation Strategy", European Commission, 2020).

#### 1.1.1.5. The Rise of Rapid and Portable Computers

In this dynamic agricultural landscape, the evolution of computers has played a pivotal role. Rapid and portable computers have become indispensable tools, seamlessly interacting with users and functioning as smart assistants (Anonim, Türk Tarımının Global Entegrasyonu ve Tarım 4.0 Projesi Sonuç Raporu, İzmir Ticaret Borsası ve Ege Üniversitesi İktisadi ve İdari Bilimler Fakültesi, 2017). This development has further contributed to the integration of technology into various aspects of agriculture, simplifying processes and enhancing the overall user experience (K. Kumar, "Integration of Smart Farming and IoT for Enhanced Agriculture", Journal of the Indian Society of Remote Sensing, 2020).

#### 1.1.1.6. The Future of Agriculture in the Hands of Innovation

As Industry 4.0 continues to unfold, it becomes increasingly evident that the synergy between automation, smart systems, and digitalization is reshaping agriculture on a fundamental level (D. A. Benton, "The Role of Portable Computers in Agricultural Development", Journal of Agricultural Engineering Research, 2021). This transformation not only addresses the challenges of sustainability and resource limitations but also opens up new avenues for innovation and customized solutions (M. S. Holthaus, "Mobile and Embedded Systems: The New Face of Modern Agriculture", Embedded Computing Design, 2019). The future of agriculture lies in the hands of those who can adapt, learn, and harness the power of Industry 4.0 to cultivate a more sustainable and technologically advanced landscape. It is a call for the agricultural sector to embrace the digital age

and chart a course towards a future defined by efficiency, innovation, and environmental responsibility (A. A. Balsiger, "Automation in Agriculture", Automation World, 2018).

### 1.2. Leading Competition in Digital Transformation Status of Countries in the Industry

Digital transformation has become a decisive factor in competition among industries in today's world. The adoption of digital technologies plays a critical role in influencing the economic and industrial successes of countries. In this article, we will focus on understanding how competition in the industry is shaped by examining the status of countries leading in digital transformation ("Digital Economy and Society Index (DESI) 2023", European Commission, 2023).

#### 1.2.1. Status of Leading Countries in Digital Transformation

Many countries worldwide are striving to improve their economic and industrial processes by embracing digital transformation. However, some countries stand out with their leadership in digitization. The success of these countries in digital transformation is turning into a competitive advantage, positioning them as leaders in the global market.

##### 1.2.1.1. Digital Skills and Infrastructure

Leading countries in digital transformation possess a robust digital infrastructure and a skilled workforce. High-speed internet access, broadband infrastructure, and advanced digital education programs make these countries pioneers in digitization.

##### 1.2.1.2. Investment and Innovation

Countries leading in digital transformation make significant investments in Research and Development (R&D) and focus on innovation. By rapidly adapting to technological innovations, these countries set industry standards and gain a competitive advantage in the global market.

##### 1.2.1.3. Effective Use of Digital Strategies

Leading countries in digital transformation excel in developing and implementing effective digital strategies. Collaboration between the public and private sectors is a critical factor in accelerating and sustaining the digitization process.

Sustainable gain in almost every field around the world, new digital technologies within the framework of digital transformation in the industry It is known that it is related to developing and adopting. International Telecommunication Union's "Information Society" According to the book with the content of "Measurement", "Information and Communication Technologies". It included the "Development Index". The index with 176 countries according to the statistics, Iceland ranked first in 2017, followed by South Korea and Switzerland. Among 176 countries, Turkey is in the 67th place with its index value 6.08 (Anonim, Türk Tarımının Global Entegrasyonu ve Tarım 4.0, Ege Üniversitesi İktisadi ve İdari Bilimler Fakültesi, Ocak, 2019). China has taken important steps in the digital transformation in the industry. The country in question is making efforts to preserve its current share in the global value chain. It is acting with foresight in order to raise it even more. Considering these, China; it has the status of a country that should be taken as an example for Turkey (B. A. Topcu,2005). USA: In addition to the identification and development of digital technology, it demonstrates a strategic approach in public support by taking acompetency and opportunity-based strategic approach. In addition, the USA has determined its technological priorities in terms of advanced production and is preparing a separate strategic action plan on artificial intelligence technologies. England: It has positioned "artificial intelligence" as one of the building blocks of its industrial strategy. South Korea: It has adopted the concept of smart factories as the digital transformation process of the manufacturing industry. It allocates huge budgets for R&D studies within the state policy for these areas. France: Focused on featured products such as robotics, big data, and internet of things, high performance programming, energy efficient cars, and cloud computing and electric airplanes. Netherlands: It is taking concrete steps in the digital transformation of the manufacturing industry within the scope of innovation centers they call "Field Labs". Germany: Contrary to other European countries, it is among the leading countries, especially in the manufacturing industry, due to the developments in digital transformation (T.C. Tarım ve Orman Bakanlığı, Erişim Tarihi:30.05.2021 https://www.kesantb.org.tr/docs/atprapor-2019).

With the introduction of "Industry 4.0" into our lives and technological developments, artificial intelligence, which has become a part of our daily life together, wireless communication networks, cloud system, machine-to-machine communication and with concepts such as the internet of things, mobile devices have become more as a result of intensive and effective use, in all areas of our lives as well as the use of relevant technologies in the agricultural sector. Efficiency, sustainability, speed, food safety, competitiveness, environmentally friendly practices, and input cost started to show itself with the pressures to reduce it. Many new techniques by combining agriculture and information technologies the term has also been used. Including smart agriculture digital farming, precision farming, driverless vehicles and farm management software can be counted (Anonim, Türk Tarımının Global Entegrasyonu ve Tarım 4.0, Ege Üniversitesi İktisadi ve İdari Bilimler Fakültesi, Ocak, 2019). Environmental effects of inputs used in agricultural production, and the pressures to reduce costs, are increasing with developing technology day by day. Not particularly uniform soil, geographical and physical variables of agricultural land, inputs environmental impact, environmental and product factors, and increasing cost, show an increasing intensity. Precision agriculture is of importance for reducing environmental pollution, effectively using of products, and ensuring uniformity in product quality. For this reason, establishment of registration order in agriculture, obtaining quality product and reduction of chemical inputs (such as pesticides and fertilizers) are among the targets of precision agriculture. In the technological development process of Agriculture 4.0, the data acquisition

process has started quite comprehensively, and the data analyzed implementation of business decisions depending on the results point has been reached. At this point, what the farmers are curious about and the question they ask the experts is that precision-applied agriculture technology whether it is economical or not and how it affects profitability. Size of agricultural lands, production pattern, status of enterprises, adaptation of enterprises to current problems and intensive applications of technology are the most important factors. They effect on the economics of precision farming practices. The increase in the world's population has led to the problem of nutrition, which is a basic need, and has led to the search for solutions for sustainability. This has led people to turn to smart agriculture. Green With the intense chemical input called revolution, this problem has a certain has been resolved up to this stage, but this solution comes with it. It also brought some fundamental environmental problems. Greenhouse gas in the world between 11% and 15% of its emissions are due to industrial agriculture applications. Considering that it occurs as a result of the uncontrolled production increase, The negative impact of climate change is now an indisputable problem. Appears. In addition, with urbanization, agriculture It has also caused a decrease in agricultural areas and agricultural workforce.

All Use of Global Positioning System (GPS) in agriculture with the beginning of the 1990s, the agriculture 3.0 process started. This agriculture, which is also called “Precision Agriculture”, “manual guidance” thanks to GPS technology, harvesting with the "Variable Rate Applications" system applied to the machines technologies such as monitoring the fertilization process in particular has been applied. Industry 4.0 in the 2010s Parallel to these developments, developments have also occurred in the agricultural sector. Named as Digital Agriculture, E-Agriculture, and Smart agriculture, this microprocessors, sensors, cloud-based information and to the smart agriculture sector, which includes communication technologies and sensors.is the implementation. Smart Agriculture Application Areas Smart agriculture, “product and soil management to increase agricultural production to increase product yield and to increase the resources in this process at an optimum level. It is a technique that minimizes the damage to the environment by using It In this context, “conventional agriculture is abandoned, and the land is homogeneous. of a form of practice that deals with a non-variable approach. The main element aimed here is, when inputs applied in agricultural production are needed, it is used in place and amount”. The global market size of smart agriculture in the world is approximately It is around 9.58 billion dollars and is 23.14 in a 5-year period Billion dollars (Statista, https://www.statista.com/statistics/720062/market-value-smart-agricultureworldwide ,ErişimTarihi:31.05.2021,Online).Especially the EU member states that the development of this application is politically member country development policies work programs (Ş. Ercan, R. Öztep, D. Güler, G. Saner, 2019). The main Smart Agriculture application areas are as follows grouping is possible. Land Classification For the precision agriculture application to be carried out, the cultivated product in the field It's important to know. However, with multiple images Although it is a prerequisite for high success in classification, different characteristics of plants/objects such as multiple sensors and SAR. They can offer higher classification accuracy because they carry (M. Teke, H. S. Deveci, F. Öztoprak, M. Efendioğlu, R. Küpçü, C. Demirkesen ve E. Yıldırım;2016). Fertilization Map systems-based applications used to make it happen.

With the help of GPS data determination of the composition of nutrients in the soil and accordingly, in addition to the preparation of re-fertilization programs, smart tillage tools to be used in tillage Can be used with the help of GPS signal Irrigation With smart irrigation, the amount of water consumption of farmers can be significantly reduced. Can be reduced so that agricultural practices can affect the environment. It will make you more sensitive. However, especially smart significant water savings with the sprinkler system (U. Türker, B. Akdemir, M. Topakcı, B. Tekin, İ. Ü. A. Aydın, G. Özoğul, ve M.Evrenosoğlu,2015)

#### 1.2.1.3.1. Yield Mapping

Timely and accurate yield forecasts for agricultural production and agricultural It is a very important issue for all industry stakeholders connected to production. It forecasts are financial and strategic both locally and globally. There is a long chain from producers to politicians in making decisions. Provides significant advantages (M. Teke, H. S. Deveci, F. Öztoprak, M. Efendioğlu, R. Küpçü, C. Demirkesen ve E. Yıldırım, 2016).

#### 1.2.1.3.2. Livestock Practices

The fully automated "monitoring and control systems” with regard to the reproduction, production, health and environment of animals.to the development of animal husbandry, as it will make the interaction with will make a great contribution. However, smart farming technology with this, producers can monitor animals one by one and production and cultivation with the most appropriate cultural techniques develop their techniques. Greenhouse Application Areas Vertical, which has become popular especially in recent years, with greenhouse cultivation. Smart agriculture applications have started in agricultural applications. With this In addition to greenhouse automation, in parallel with environmental data applications such as ventilation of greenhouses, irrigation and lighting, etc. Can be done automatically.

#### 1.2.1.3.3. Smart Agriculture and Technologies in Türkiye Status

Smart agriculture, farmers, private sector, public institutions in Turkey, a joint organization consisting of cooperatives and unions and universities. Sector area. Farmers Weather forecasting and weather forecasting via warning systems and satellites in smart agriculture agricultural struggle, decrease in agricultural inputs, workers and production reduction in costs, technological materials In addition to increasing the amount and efficiency, it is beneficial for human health and nature. Production, which is important, is included in these concepts.

#### 1.2.1.3.4. Private Sector

Technological applications in agriculture, increasing productivity and efficiency, the use of technology in this application, automation, digitalization and ensuring synchronization, reducing input costs, etc. Institutions and organizations that deal with applications.

#### 1.2.1.3.5. Cooperatives and Unions

Harvesting and processing starting from the early stages of agricultural production. Technologies and at almost every stage from the marketing process. Using appropriate sensor, drone and computer technologies. Have been included in the field of smart agriculture application.

#### 1.2.1.3.6. University and Other Public Institutions

Unlike traditional agricultural production and practices, smart agriculture environment-friendly practices and nature's variability management, production planning, final product has gone through all the stages it has gone through until its use traceability, sustainability, use of sensors, cost estimation, quality management, protective on agriculture and the use and protection of its resources. Included in the smart agriculture application in the form of directing its activities have been developed.

### 1.2.2. Existing Smart Agriculture in Türkiye Applications

Turkey, its population, area, ecological features, agricultural areas and the leading countries in the world in terms of arable land are among. However, the country's agricultural product export when we look at the values of these resources, our country has not yet does not appear to be used effectively. Such as the Netherlands and Israel. Used the achievements of countries in agriculture and agricultural products. It seems possible with their technology. smart agriculture Agricultural product export and import of the countries that have adapted the process When we look at the values of the countries in question in this area, appear to have values. With the developments in the field of smart agriculture in the world, has accelerated its work in this field. agricultural product In Turkey, which has a high potential in the production of R&D studies in the field of agricultural technology in years; state policies, research centers, universities and private sectors developed with the support of "Ankara university “and “Aegean University” with its national and international studies.

These collaborations have increased. In addition, agricultural equipment, R&D, especially GSM companies and the number of software producing companies and patent applications are increasing day by day. Support for rural development in cooperation with Vodafone Turkey and TABİT for this purpose, they started the Smart Village projects. Turk cell Filiz, providing instant data about its cultivated area to its user, a mobile device for use with an air-earth station is the application. Türk Telekom works on smart agriculture with IoT and M2M carries out. Cultivation Area/Greenhouse Control and Management, Intelligent Irrigation, Animal Tracking and Coop/Shelter Monitoring, Flow and Depth Measurement It offers solutions with applications.

### 1.3. Digital Agricultural Applications and Country Samples

The current called Agriculture 4.0 or digital agriculture is the evolution of agricultural engineering based on the precision farm production system and its main purpose is to automate sustainable production in agriculture (CEMA, Erişim Tarihi: 20.01.2023.https://www.cema-agri.org/images/publications/position-papers/CEMA_Digital_Farming_-_Agriculture_4.0 13_02_2017_0pdf).

The vehicles used at every stage of agricultural production are equipped with sensors, ensuring that the machines are in communication with each other during the entire production period. With agricultural tools and fields equipped with sensors, it is aimed to maximize the yield by giving detailed information to the farmers on what field and what kind of fertilizer they should use, weather conditions, the amount of mineral and irrigation needed by the plant, the condition of the soil, and the estimated harvest time. In this way, producers have the opportunity to manage and monitor the entire cultivation area with smart technology devices, minimize labor power and production input costs, and have the opportunity to obtain high-quality and high-quality products (H. Kahraman, “Endüstri 4.0’la Birlikte Gelen Akıllı Tarım”, Erişim Tarihi: 20.01.2023). The point reached in digital agriculture is not the result of a process that develops all of a sudden. These phases

Agriculture 1.0: Combined use of animal power and mechanization,

Agriculture 2.0; The start of the use of engines and tractors in agriculture,

Agriculture 3.0; Switching to guidance systems and precision farming practices and

Agriculture 4.0; Connected farming practices.

Changes in agriculture to meet the food demand of the growing population in the mid- 1600s in England paved the way for the 1st Industrial Revolution. These changes in agriculture were known as the "Agricultural Revolution". Many historians have concluded that without these changes there would be no industrialization (University of Stellenbosch Business School Agriculture Report, “The future of the Western Cape agricultural sector in the context of The Fourth Industrial Revolution”, Erişim Tarihi: 18.01.2023).

As a result of the consolidation of agricultural lands into large farms in England, production began to be managed better, and productivity and profitability increased with the emergence of agricultural machinery. In the 1840s, productivity increased even more with the use of fertilizers. With the 2nd Industrial Revolution (1870-1914), the transition to electricity and mass production led to mass production, chemical fertilizers, and pesticides to combat agricultural pests were used in agriculture, and mechanization (such as sorting, collection) in agriculture increased. The third industrial revolution, called the computer and digital revolution, started in the 1960s, and the changes in agriculture

with new products, irrigation, fertilization, pesticides, mechanization, transfer of technological knowledge were called the "Green Revolution". Although all the developments made are to feed the increasing world population, environmental problems have emerged as production costs have increased and it has become ecologically unsustainable. The rapid change in agricultural technologies, the use of tractors, the emergence of genetically modified products that are claimed to be resistant to agricultural pests have changed the face of agriculture ("Global Innovation Index (GII) 2023", World Intellectual Property Organization (WIPO), 2023). The agricultural sector was introduced to satellite technologies in 1994 in order to better monitor and plan farms. In the 2000s, software and mobile devices started to help farmers to increase yields. In 2011, the German Federal Government explained its advanced technology strategy with the term Industry 4.0. Along with this industrialization process, the use of technology in agriculture has also increased and the emergence of the use of large amounts of data (Big Data) in 2015 has led to significant developments in agriculture. Farmers have started to use the power of information to make more informed decisions and to use their resources more effectively. The use of digital technologies in agriculture such as smartphones, tablets, field sensors, drones and satellites has become widespread, offering a range of agricultural solutions such as remote measurement of soil conditions, better water management and monitoring of livestock and crops. While digitalization increases profitability with cost minimization, it also helps to reduce the environmental impact of agriculture (University of Stellenbosch Business School Agriculture Report, "The future of the Western Cape agricultural sector in the context of The Fourth Industrial Revolution", Erişim Tarihi: 18.01.2023).It is aimed to maximize the productivity in agriculture with smart agriculture applications made using information and communication technologies solutions, which is called Agriculture 4.0 in short.

As a result of the sensors and every part of the smart system working in harmony with each other, the system administrator can work and intervene effectively (İ. H. İnan, B. Gülçubuk, C. Ertuğrul, E. Kantürer, E. A. Baran ve Ö. Dilmen,2000) One of the implemented examples in this regard is John Deere tractors. In these tractors, an automation has been prepared in which the internet of things will be used, and the farmers can observe the product efficiency. With this automation, it has become possible to observe factors such as the performance of the tractor and the estimated time of the area to be planted (Ş. Topal, "Atos'tan Yenilikçi Endüstri 4.0 Uygulamaları", Erişim Tarihi: 19.01.2023. https://www.endustri40.com/endustri-4-0-uygulamada-atostan-yenilikci-endustri-4-0-ugulama-ornekleri). However, in order to maximize efficiency and output with the Internet of Things (IoT), all machines/animals in a farm must be equipped with a smart system. The system integrated into the farm analyzes all the factors required for production and presents the appropriate conditions for the producer in a report. Therefore, the producer has instant access to the information he wants and has the opportunity to intervene remotely with devices such as phones/tablets if he deems it necessary. BI Intelligence, one of the Business Insider (BI) premium research services, revealed that IoT devices in agriculture in 2015.It is estimated that this figure will increase to 75 million in 2020, while it was 30 million in 2017. It is predicted that this will provide a growth increase of approximately 20 percent to the country's economy. In addition, On farm, which makes a farm IoT platform with the internet of things, determined in its study that with the application of Industry 4.0 solutions to agriculture, the efficiency will increase by 1.75 percent, the energy cost can decrease by $ 7-13 per acre and the water use rate will decrease by 8 percent (B. Kesayak, "Endüstri 4.0 Tarım Sektörünü Nasıl Etkileyecek", Erişim Tarihi:19.01.2023).

Major developments with Agriculture 4.0 include cheap and advanced sensors, low-cost microprocessors, high-bandwidth cellular communication and cloud-based ICT systems and big data analytics (CEMA, Erişim Tarihi:20.01.2023.https://www.cema-agri.org/images/publications/position-papers/CEMA_Digital_Farming_-Agriculture_4.0 13_02_2017_0.pdf).

Increasing the efficiency of the value chain (Direct delivery to the consumer, meal kits, food e-commerce, etc.),

Drones, robots, big data and sharing platforms as well as irrigation, soil and crop technologies,

Innovations in agrochemicals, biomaterials, and bioenergy to reduce the ecological footprint.

Plant-based foods for sustainable protein needs,

Indoor and vertical farming, Smart greenhouses

Today, European countries have started a digital revolution in the agriculture sector by supporting special plans and offering financial incentives to farms with Agriculture 4.0. It is estimated that the trends affecting agricultural practices and structures will be implemented in developed economies until 2030. By this year, the integration of precision agriculture and digital technology will become the most influential trend in Europe as the growing number of farmers begin to adopt digital technologies to run their businesses. The European Joint Research Center has estimated that precision agriculture could save a great deal of carbon dioxide in European agriculture by 2030. The storage and processing of this information depends on the development of the internet network (A. Lamborelle and L. F. Álvarez, "Farming 4.0: The Future of Agriculture", Erişim Tarihi: 20 .01.2023 https://www.euractiv.com/section/agriculture-food/infographic/farming-4-0-the-future-of-agriculture/).

## 2. CONCLUSION

The integration of Industry 4.0 into agriculture is transforming the sector, addressing sustainability and efficiency challenges while opening new avenues for innovation. Digitalization, automation, and smart systems are essential for modern agriculture, requiring continuous adaptation and development of a skilled workforce. Leading countries in digital transformation set examples for integrating these technologies into agriculture, positioning

themselves competitively in the global market. Smart agriculture practices, such as precision farming and smart irrigation, play crucial roles in reducing environmental impact and enhancing productivity. The future of agriculture lies in embracing these digital advancements to create a more sustainable and efficient agricultural landscape.

The agricultural sector is undergoing a significant transformation with digitalization, making traditional methods more efficient and offering farmers the potential for better production management and sustainability. In this article, we will explore the advantages brought by digitalization in agriculture and how it is reshaping the industry.

### 2.1. Precision Farming

At the core of digital agriculture is precision farming, aiming to optimize agricultural processes using technologies such as sensors, GPS, and data analysis. Farmers can make more informed decisions by analyzing a range of data, from soil moisture to weather conditions. This can reduce input costs and increase efficiency.

### 2.2. Smart Agricultural Equipment

Agricultural machinery is also adapting to the trend of digitalization. Smart tractors, drones, and robots offer farmers the opportunity to automate challenging and time-consuming tasks. These devices can make farming operations faster and more effective, resulting in labor savings.

### 2.3. Data Analysis and Big Data

Agriculture generates vast amounts of data. Through digitalization, analyzing and understanding this data becomes more accessible. Farmers can use data on soil characteristics, climate conditions, and crop growth to better plan future harvests. This optimizes resource use and supports sustainable farming practices.

### 2.4. Internet of Things (IoT)

Agriculture is becoming a sector supported by the Internet of Things (IoT). Sensors and connected devices continuously monitor conditions on agricultural land, providing farmers with real-time information. This allows farmers to make quick decisions and intervene as needed.

Digitalization in Agriculture is making the agricultural sector more sustainable, efficient, and competitive. These technologies empower farmers with more control and information, shaping the future of agriculture to meet the global demand for food. Digitalization transforms agriculture from merely a production process into a data-driven industry. This anticipates more innovation and sustainability in agriculture in the future.

In addition to agricultural production and arable agricultural land, a suitable has a say in the field of agricultural production in our country, which is in an ecological position. The resources it has in order to compete in the same lane with the countries for the sustainability of the production in question, as well as the effective use of technological progress and progress technologies to be integrated into agricultural production as soon as possible must be provided addition, general determinations about the current situation of Turkey and solution proposals can be summarized briefly as follows.

In order not to encounter any problems in digital transformation good planning is essential. The shortest possible time to address the inadequacies of domestic technology supplier companies. Remediation in time. In order for the investments to reach the target, the stakeholder institutions determine their strategies well and choose an appropriate way accordingly map needs to be drawn. An effective and fast way of digitization in the public and private sectors needs to be followed. In addition, institutions and organizations related to digitalization organizations should be supported by the government. Need for qualified human resources in digitalization has. This area should be compensated as soon as possible required. Priority to domestic technology suppliers and solution partners should be given. The age level of individuals engaged in agriculture in Turkey is high technology-based approach to the young population engaged in agriculture. Adopting the data and in this process, the young population with smart agriculture must be brought into agriculture. Smart agriculture or digital agriculture for farmers and producer association awareness training should be given, especially pioneering farmers should be equipped.

**Declaration Of Ethical Code**

In this study, the authors undertake that they comply with all the rules within the scope of "Higher Educati on Institutions Scientific Research and Publication Ethics Directive" and that they do not perform any of the actions under the heading "Actions Contrary to Scientific Research and Publication Ethics" of the relevant directive.

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