Agricultural Technologies

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Introduction

The concept of "agriculture", known in its most general sense, means the production of vegetable and animal products. It is a branch of science that deals not only with their production, but also with improving their quality and efficiency, preserving products under appropriate conditions, processing and evaluating them efficiently, and marketing them. In other words, the care, cultivation, nutrition, protection of all plant and animal products that have nutritional and economic value for the benefit of people and the mechanization necessary for them are all activities. Agriculture even includes fishing activities carried out in private areas or in still waters.

We don't stop and think about the stages at which any food we eat every day comes from the field or from the farm to our table. In fact, these foods come across as a result of a worldwide network of many people involved in the food business, such as farmers, merchants, food manufacturers and retailers. Humanity has faced many problems throughout its history. In addition to problems such as natural disasters, drought, global warming, the global food system is also one of the problems that will greatly affect humanity. Due to the rapid growth of the world's population, the world population is expected to be 10 billion, up from 7.5 billion in 2050. Therefore, it is important that the worldwide food system in the world provides reliable and nutritious foods against this food demand. For this reason, it is estimated that global food production should increase by 70 percent to prevent a major famine that may occur in the future (Zhang & Kovacs, 2012).

Due to the fact that the need for food is increasing day by day, it is necessary for producers to learn how to deal with problems such as climate change, floods, droughts and resource depletion. It is necessary to overcome these great difficulties in order to meet the upcoming food demand (Lindblom et al., 2017).

Today, technologies are being developed to overcome these challenges and agriculture precision farming precision agriculture be sustainable for centuries to technological innovations to change the understanding of people the main aim of Agriculture is to offer their service. In this way, increase its productivity and hence profitability of precision agriculture, sustainable agriculture, improving the quality of the product with the environment and the reduction of harmful effects to nature, agriculture dealing with individuals who are enhancing their quality of life, natural and safe the convenience of access to food, rural life and economy, such as the development of new agricultural innovations and related benefit that will provide many approaches have been developed (Liaghat & Balasundram, 2010). When we look at the rapid development of technology, we see that investments for research and technology development have increased rapidly in this regard significantly in the last decade (Schellberg et al., 2008).

Precision agricultural applications have continued to develop in a different way with the advent of GPS (GPS: Global Positioning System) and GNSS (GNSS: Global Navigation Satellite System). Researchers, farmers in a field by finding the precise location many measurable variable (e.g., crop yield, land features/topography, organic matter content, moisture levels, nitrogen levels, Ph, EC, Mg, K, and others) allows the creation of maps of the spatial variability (McBratney & Pringle, 1999). In addition to these measured variables, for example, GPS data can be collected thanks to a GPS-equipped harvester. In the same way, a series of real-time data can be obtained with sensors and multispectral images that can measure the water state of the plant and the water stress at the chlorophyll level. However, recent technological developments have enabled the use of real-time sensors directly in the ground with wireless data technology that eliminates the human factor (Reyns et al., 2002; Sophocleous, 2016).

The technologies used in the field of agriculture are increasing day by day and are aimed at providing the maximum benefit. Agriculture is currently undergoing a process of transition from low-tech mechanization to high-tech mechanization. Briefly, we can list the points of origin of these developments and the solution suggestions as follows (Technology Development Foundation of Turkey, 2020);

- Using sensors, cameras, IoT (IoT: Internet of Things), satellite and drone technologies for remote monitoring of garden and field products, it is able to detect risks such as plant health, irrigation needs, disease and pest detection.

- Blockchain technology stands out in providing technological integration at all stages of the supply chain to ensure food safety and traceability.

- Biotechnological developments should be used for quality and efficient products that will adapt to changing environmental conditions with climate change.

- Vertical farming should be encouraged in order to minimize space and input costs.

- Artificial intelligence, machine learning, autonomous and robotic systems should be brought to the forefront for low-cost and data-based agricultural production with optimal parameters.

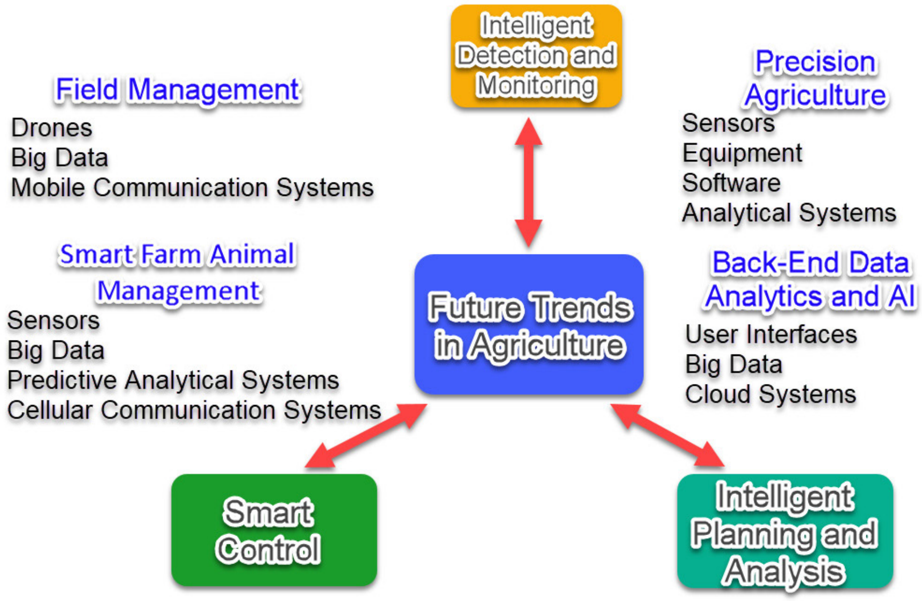

Figure 1. Future Trends in Agriculture

The emergence of this kind of technology in agriculture has been around for more than half a century, though today we have seen significant progress in this area, to facilitate sensor technology, computer vision, cost-effective computing power and recent development in the field of artificial intelligence, has made progress.

Looking at the world as a whole, countries that are advanced in technology for sustainable and efficient agricultural production are creating intelligent agriculture and agriculture 4.0 research centers. Venture capital and angel investors who want to invest in companies that want to enable farm applications of the developed technologies and develop technology in these areas have an accelerating role in the development of agricultural technologies.

The most basic goal of agricultural technologies is to improve crop production by understanding the soil. At the same time, it aims to reduce the impact of environmental pollution by enabling farmers to use fewer pesticides (pesticides) in their products. Monitoring soil and weather conditions is significantly effective for reducing water waste. Digital agriculture contributes to the economic development of farmers by obtaining maximum production from their land. The use of technology by farmers with digital agriculture allows them to work together as well as collect and share data.

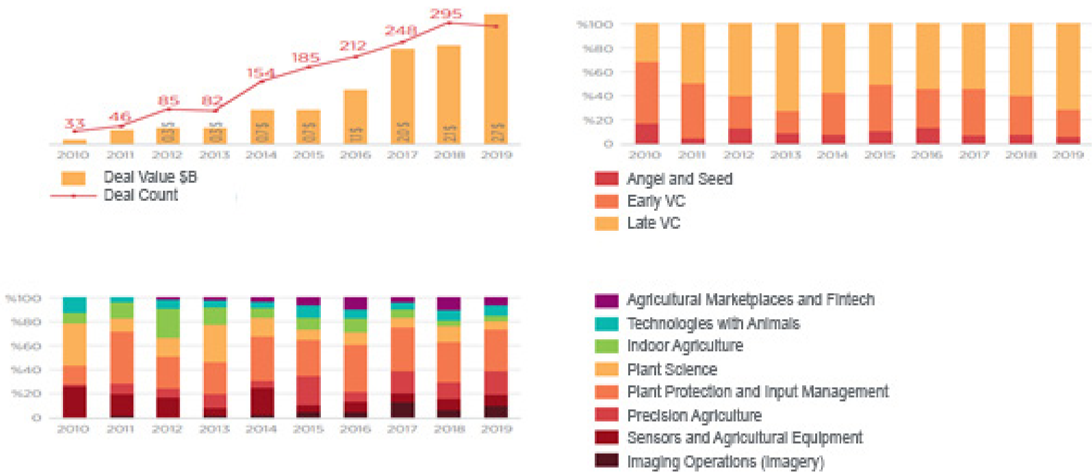

Figure 2. Global Investment in Agricultural Technologies (Source: PitchBook)

The Importance of Agricultural Technologies

Thanks to the rapid development and change of technology, sensors, autonomous devices, machines and information technologies, today's modern farms and agricultural operations work more efficiently than a decade ago. Robots, various sensors, ground imaging systems, GPS and related agriculture-facilitating systems are often used routinely in precision agriculture, which have replaced classical agriculture.

With the use of technological facilities, applications such as water, fertilizers and pesticides are applied not only to the entire area of the land, but also to the areas where they are needed. Thanks to such agricultural improvements, the agricultural operations performed by enterprises become profitable, efficient, safe and environmentally friendly. In parallel with technological developments, new methods applied in agriculture aim to provide maximum profit with minimum inputs. For example, the areas needed for fertilizer application are targeted, and only the plant that needs fertilizer can be detected. In this way, it can be applied to the required points to the required extent. If we look at the advantages in this way, we will:

- Increasing product efficiency
- Reducing the use of water, fertilizers and pesticides and reducing costs
- An approach that protects nature
- Fewer chemical mixtures to nature
- Protection of the health of working personnel

In addition, sensor technologies provide reliable monitoring and management of natural resources such as water.

It provides traceability and control in processes such as processing, distribution and storage of plant and animal production. This gives us the advantages that we will list below:

- Increasing productivity and, accordingly, reducing prices
- The cultivation process is reliable and healthy foods are produced
- Reduction of the negative impact on the environment

Vertical Farming

Vertical farming can be defined as the practice of growing crops stacked on top of each other in a closed and controlled environment. Vertically mounted racks, using layers, significantly reduce the amount of land required for growing crops compared to traditional farming methods (Saygin, 2017).

Vertical farming can be of different shapes and sizes - from simple two-level or wall-mounted systems to large areas with several floors. To provide plants with nutrients, one of three hydroponic systems is used (hydroponic, aeroponic or aquaponic).

Hydroponics (hydroponics): Hydroponics, the most common cultivation system used in vertical agriculture, is to grow plants growing in nutrient solutions in hydroponic water. The plant roots are located in a water whose correct mineral and necessary compositions are constantly in circulation (Velazquez et al., 2020).

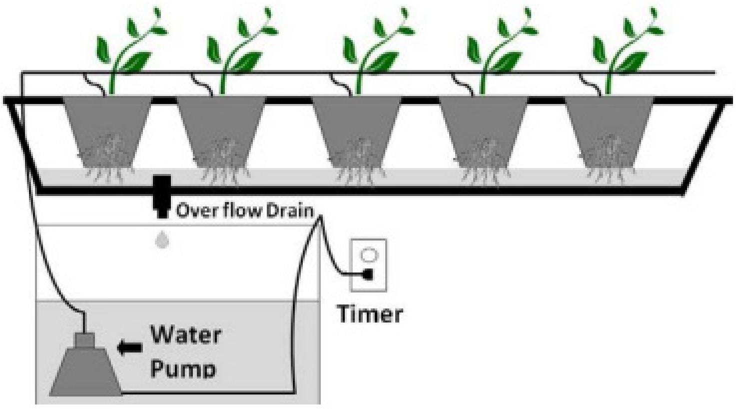

Figure 3. Hydroponic Plant Cultivation (Source:NCAT)

Aeroponics: Aeroponics is actually a subset of the hydroponic system. in the 1990s, he developed the concept of "aeroponics", which was called "farming in an air/fog environment with a small amount of water without using soil" by NASA to farm in space. The aeroponic system is the most efficient agricultural system that can be used on vertical farms and uses close to 90% less water than the hydroponic systems known as the most efficient. It has been shown that plants grown in these aeroponic systems receive more minerals and vitamins, making plants healthier and potentially more nutritious (Eldridge et al., 2020).

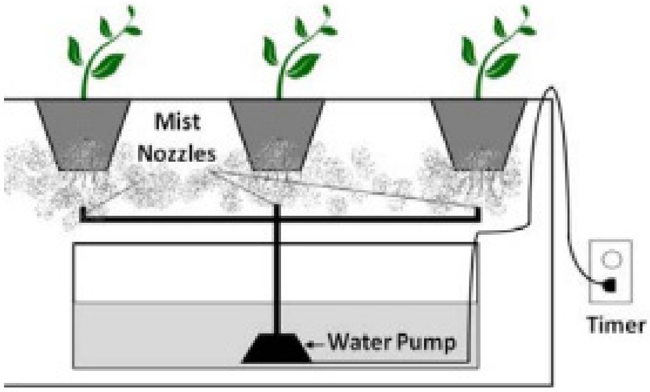

Figure 4. Aeroponic System (Source:NCAT)

Aquaponics: An aquaponic system takes the hydroponic system one step further, combining plants and fish in the same ecosystem. The fish are raised in closed systems (aquarium-style but in large waters) and produce nutrient-rich waste that is used as a feed source for vertical agricultural crops. On the other hand, plants reach the necessary vitamins and minerals by using these rich wastes (Nesterova, 2019).

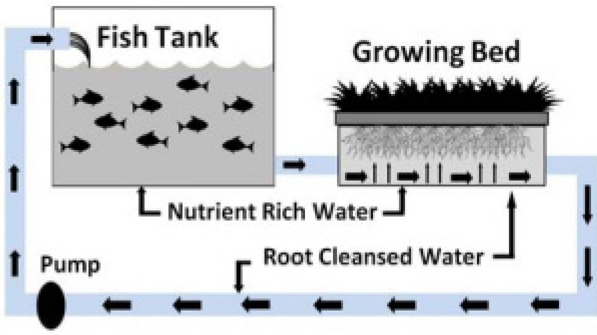

Figure 5. Aquaponic System (Source:NCAT)

These vertical farming variations that excite the world will increase the energy efficiency and profit margins of these farms in the near future with new technologies. Innovative vertical agricultural areas currently under construction or already under construction are closely monitored by urban planners and the sustainable agriculture community. It is considered to be available to people at certain points of cities (Birkby, 2016).

Figure 6. Example of Vertical Farming

Farm Automations

Farm automation includes intelligent systems with automatic systems that are associated with ”smart agriculture”, aimed at bringing the human factor to the least likes, which allows farms to be more efficient and transform the production of life. Today, companies working in the field of agriculture are working to develop many technologies, such as drones, autonomous tractors, robot harvesters, automatic irrigation and seeding robots. Despite the fact that the developed technologies are still new, it seems that agricultural companies that carry out their business with the help of incoming methods are being included in farm automation processes day by day.

IoT (internet of things) is a network-device technology that allows devices to communicate with each other using common communication protocols. Its most important feature is that it is the systems created by devices that provide data exchange over wireless networks without human intervention. In smart agricultural applications, the fact that it allows wireless data exchange and that different devices communicate with each other has allowed the development of technologies in this direction. For example, in an automatic irrigation system, thanks to modern technology, it makes it possible to find out the humidity and temperature values of the soil from different parts of the agricultural land using affordable and affordable wireless sensor network technology. The irrigation system can automatically turn on and off the pump system to ensure that the plant receives the optimal amount of water it needs (Abdurrahman et al., 2015; Maureira et al., 2011).

To say a few automation systems that we may encounter in agricultural fields;

- Automatic Harvesting Automation
- Autonomous Tractors
- Automatic Seed Sorting Systems
- Flying Drones

Figure 7. An Autonomous Spraying Machine (Source:Web)

Today's consumer habits indicate an increasing interest in organic and sustainable agricultural products. On the other hand, manufacturers incorporate developing automation systems into their production processes to ensure that the products demanded by consumers are faster, fresher and the products are sustainable. The positive effect of the use of automation on the manufacturer's side is that increasing productivity and reducing costs increase earnings. At the same time, automating the process helps to reduce costs by minimizing the labor force needed by doing the work that manpower routinely does with the help of autonomous systems (Ahmed et al., 2018).

Livestock Technology

Animal production, or animal husbandry as it is commonly called, is the branch of agriculture that covers the care, nutrition, production and breeding of domestic animals useful to humans with their products and powers. Livestock farming includes poultry farms, dairy farms, cattle farms or other agricultural enterprises related to livestock in general. Accurate financial records should be kept in animal husbandry, workers should be supervised, and animals should be properly cared for and fed. As technology has affected many areas, it has also been effective in changing the traditional understanding of livestock and livestock management issues. The developments over the last ten years have provided great improvements for data-oriented and quick decision-making systems on many livestock-related issues, such as livestock tracking and management (Annosi et al., 2019).

Livestock technology provides producers with various systems for increasing animal and animal productivity, facilitating the welfare and management of animals. Today, the concept of "Connected cow" is used for cows with sensors aimed at increasing productivity by monitoring the health of herds on large farms. Data-oriented tracking of each cattle in the herd is provided with the help of sensors that can be worn on the cattle, or worn on their bodies, as well as tracking data related to daily activity and health of the cattle. All the data obtained can be converted into meaningful and actionable information for manufacturers, from which they can make quick and healthy decisions at the same time (Zin et al., 2018).

Figure 8. Thanks to the Intelligent Sensor Installed on the Cows, the Condition of the Cows can be Monitored (Source:Tarnet)

Sensor and data technologies have great benefits for the current livestock industry. It can increase the productivity and well-being of livestock by detecting sick animals and taking measures against it early. The data collected by computer vision can be translated into action by making sense of it and allows us to have all kinds of unbiased data in the future. Data-driven decision-making systems enable better, more efficient and timely decision-making that will increase the productivity of animal herds.

In addition to the use of facial recognition in various systems, another area of use is the surveillance of livestock with the help of drones. This technology allows farmers to register their cattle's identities and information in a database. These counted features can then be easily accessed by facial recognition with the help of drones to recognize each animal, detect where it is located in the pasture and track vital health information such as weight, size, facial features and physical activity. This allows not only to identify the disease quickly, but also to reduce the work of farmers, in addition to the fact that the health of cattle can be constantly monitored as an example. It is possible to find out the location of any cattle outside in the pasture and manually monitor its health, which is done at that moment through the heart rate and GPS locators (Zin et al., 2018).

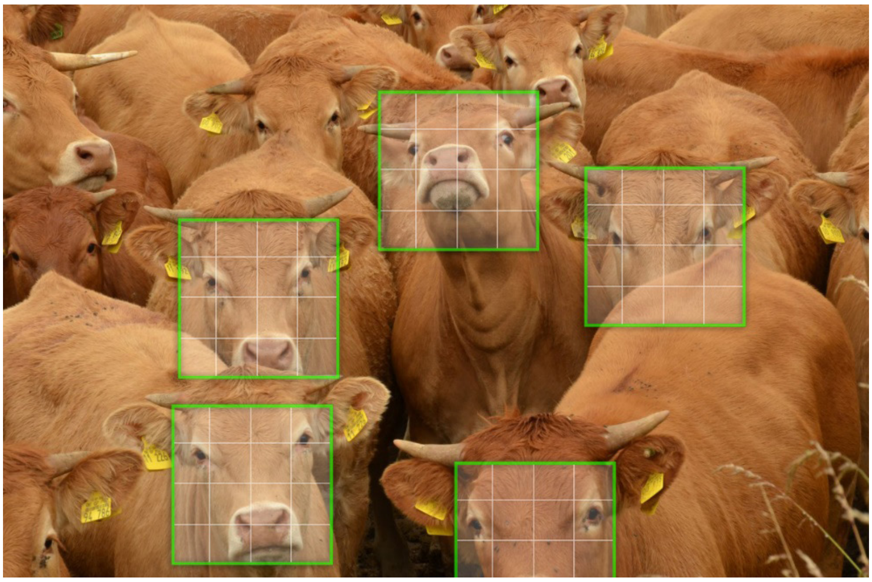

Figure 9. A System that can Receive Data from Cattle with the Help of Facial Recognition and Sensors (Source:Web)

Precision Agriculture

Agriculture is becoming an indispensable part of every farmer with a continuous process of change and development with the development of technology. New precision agricultural companies are developing technologies that allow maximizing yield by tracking all kinds of variables such as soil moisture level, pest stress of the plant, soil conditions and microclimates. Precision october provides more accurate techniques for october and growing crops, allowing farmers to increase productivity and manage costs (Kent Shannon et al., 2018).

The word "Precision" used in precision agriculture is used because it aims to make the right intervention possible at the right time, in the right place, at the right time by responding with superior levels of sensitivity to the special conditions and situations of crops and land areas thanks to the state-of-the-art tools used.

Nowadays, the term Agriculture 4.0, which is the evolution of the concept of precision agriculture, refers to: all tools and strategies that use the latest technologies, starting with the use of data to improve and optimize production.

Figure 10. Precision Agricultural System (Source: Agricultural Credit)

Soil Sampling with the Help of GPS**:** It is important to test the soil of an area, to know the pH level along with the available minerals and vitamins contained in the soil, to make informed and profitable decisions. At the core of this technology is soil sampling, which allows growers to take into account differences in productivity in an area and create a plan that takes these differences into account. As a result, it creates an infrastructure for variable rate applications to optimize seeding and fertilizer in the light of these data (Huuskonen & Oksanen, 2018).

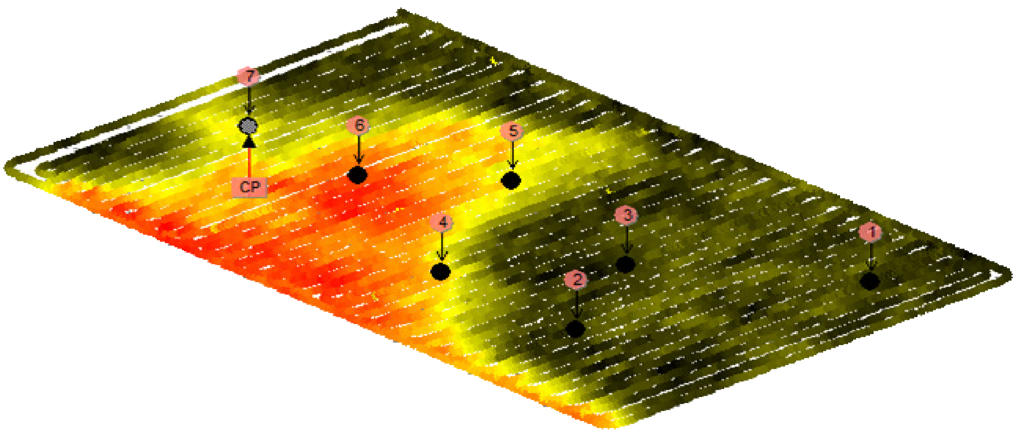

Figure 11. A Representative Picture of the Different Structure of the Land (Source: Web)

Computer-based Applications: Computer applications can be used to create precise farm plans, field maps, crop exploration and yield maps. This in turn allows for more precise application of inputs such as pesticides, herbicides and fertilizers, so that it can help reduce expenses, produce higher yields and create more environmentally friendly work. The difficulty of these software systems is that they sometimes offer a narrow value, which does not allow using data to make larger farm decisions, especially with the support of a specialist. But many software applications are able to draw accurate results for farmers from large datasets using techniques such as deep learning, artificial intelligence, and machine learning (Razmjooy & Estrela, 2019).

Figure 12. Computer-Based Precision Agriculture Applications (Source: Web)

Remote Sensing Technology: It is a technology used in agriculture since the early 1970s. Remote sensing technology is a unique tool for monitoring, managing and using water and other resources depending on the current state of the land. This technology, which allows you to predict for what reason the crop will be stressed, up to the amount of water and moisture in the soil, helps determine the cause of many problems. This data can come from a variety of sources, including drones and satellites, making it easier for farmers to make decisions.

In addition to protecting the environment, critical issues such as sustainability of agriculture, profitability and productivity constitute the primary purpose of precision agriculture. The use of remote sensing technology ensures that the chemical drug, fertilizer and seed that will be used optimally at the best time will give results that will guide decisions both at that time and for years to come as a result of analyzing the large-scale data collected.

Although the principles of precision agriculture have been around for many years, they have become more widespread in the last decade with the contribution of technological advances and other technologies. The adoption of mobile devices, high-speed internet access, low cost and reliable satellite - positioning and images - optimized for precision agriculture and farm equipment by the manufacturer, are some of the important technologies that characterize the trend of precision agriculture (Pallavi et al., 2017).

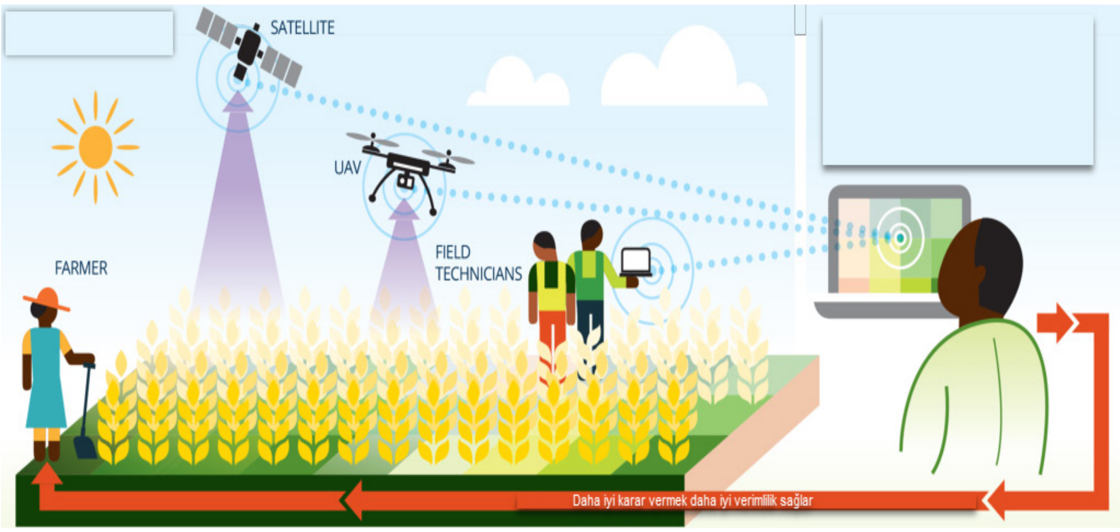

Figure 13. Use of Remote Sensing Technology (Popović et al., 2017)

Blockchain

A blockchain is a shared, immutable large registry for recording transactions, tracking assets, and building trust. For this reason, the blockchain infrastructure can be used in critical situations such as food fraud, food recall processes for security reasons, food supply chain disruptions, and traceability of food during the supply process. Sundays Decoy's unique decentralized structure ensures that these products create a reliable market in the entire process between the production and consumption stages, as well as the fact that high-quality products are real and verified (Bermeo-Almeida et al., 2018).

Food traceability is at the center of food safety discussions. Especially new developments in blockchain applications come across with different applications regarding food safety. The food industry remains extremely vulnerable in the processes of production, preservation, transportation and supply of perishable foods to the consumer against making mistakes that will affect human health. Therefore, when foodborne diseases threaten public health, there is no tolerance for uncertainty in the process of food, from farm to table, to find the source of the problem as the first step in the cause-and-effect analysis.

As a result, it is critically important to monitor this process until the food arrives from the farm to the table. Given the current communication used in the food ecosystem, the relevant people of the process cannot save the time-consuming and complex process of traceability on paper, which they use as a classic technique. In order to create an accountable and traceable system at every stage of the food chain, each recorded data point and the sharing of these points are required by the structure of the blockchain. Step by step with the help of well-known tags, each data point is saved instantly without modification. Thanks to the recorded data points, the journey of a food leaving the farm until it reaches the consumer is made traceable in real time and without error.

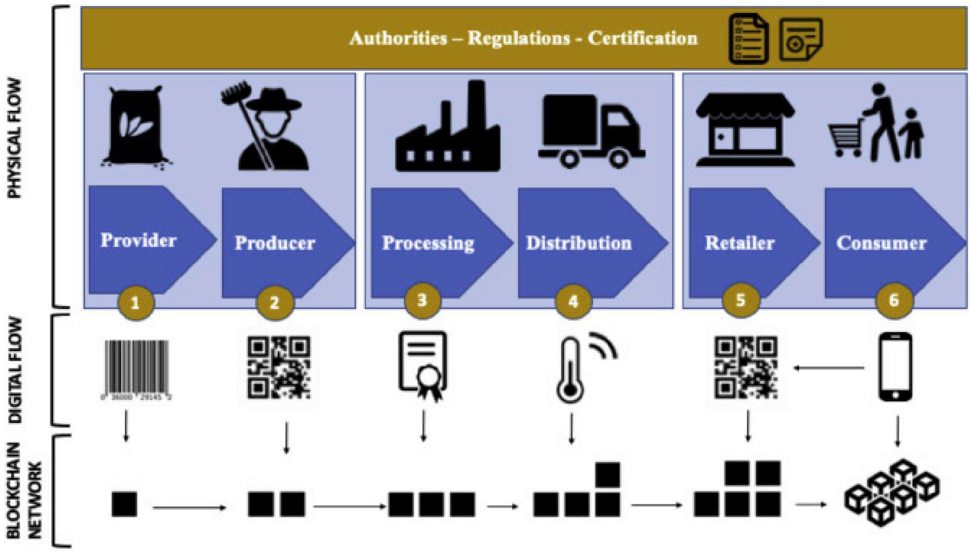

Figure 14. Application of Blockchain in Agriculture (Source: Web)

Artificial Intelligence

The rise of digital agriculture and its related technologies has opened up a lot of new data opportunities. It is possible to collect information 24/7 in all desired areas with remote sensors, satellites and drones. These data include plant health, soil condition, temperature, humidity, etc. it contains information. The analysis of the results of the collected data is much more than the human mind can make sense of.

Thanks to high-tech sensors that contain more data than the human eye can see, this data makes it easier to better understand the situation about the land or a farm. Thanks to technologies such as remote sensing, many situations can be detected until the lack of minerals and water in the soil is reached (Eli-Chukwu, 2019).

This collected data, thanks to software containing artificial intelligence algorithms, allows any environment to interpret its values as statistical data that can be understood and useful to farmers for making decisions. These developed algorithms process the data according to the received data, adapt it and learn it for later data. Making the right decision is the result of a multifaceted process. For this, a lot of input and statistical data will be processed thanks to a number of algorithms, which will be effective in making the right decision for the farmer. It is here that artificial intelligence allows farmers to make better decisions and achieve the goal of a better harvest through a series of data retrieval and processing processes (Ku, 2021).

Figure 15. The use of Artificial Intelligence in the Agricultural Field (Source: Web)

Harvest Quality Detection

Image processing based systems developed for the detection of harvest quality are a new technology that simplifies the harvesting process of fruits and vegetables by eliminating the need for manual inspection (Tian et al., 2020).

At the heart of the system are a wide range of various and technological image acquisition tools for determining the quality and quantity of products. It ensures that high volumes of products harvested at once are graded before being placed in storage. Using a camera to rate products is superior to the selectivity of the human eye. Thanks to the developed software, growers can be informed about and take precautions against diseases, defects and lack of yield early in the period from the beginning to the end of the harvesting process. In this way, it helps farmers to produce the same type of products with high quality with the measures and improvements taken, which ensures that their income increases. Looking at the literature, although this technology is currently only available for grading and sorting apples, it is an example for its use in other agricultural products.

Figure 16. Harvest Detection System [(*Harvest Quality Vision*, 2021)]

Spectral Cameras

Remote sensing by unmanned aerial vehicles is a technology that disrupts memorization in precision agriculture. Spectral cameras, on the other hand, provide spatial and temporal resolution, as well as provide detailed vegetation height data and versatile observations. They are spectral cameras that provide a picture of the wavelength of light that the human eye cannot see. These images are processed and interpreted in special image processing programs. With the combination of both technologies, it can be used in drought stress, weed and pathogen detection, soil mineral status and growth viability assessment and yield estimation (Daponte et al., 2019).

Figure 17. Multispectral Camera Image (Source: Web)

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