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Digitalization with the Use of Unmanned Aerial Vehicle (UAV) in Agriculture

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Abstract: In this research, attention is drawn to the effective use of Unmanned Aerial Vehicle Technology in many business lines today and in the future. The digitalization wave that comes from Industry 4.0 and after affects almost every sector and drives the sectors to a change. Both civilian and military fields benefit from these technologies. Drones, also known as UAVs, can work very effectively, especially in agricultural areas, minimizing labor need. Studies on drone systems in the UAV and agriculture sector shed light on the new digital system to be implemented in the future.

Keywords: UAV, Unmanned Aerial Vehicle, Drone, Digital Agriculture

1. Introduction

The concept used as crewless agriculture is agriculture applied using smart agricultural software, drones, and unmanned aerial vehicles. Drones, one of the latest developments globally, is widely used in agriculture, and their use is increasing rapidly. Remotely controlled aircraft that are not human pilots, known as uncrewed aerial vehicles (UAVs), are also active in agriculture. This satellite-based information has great potential in supporting evidence-based planning in agriculture and spatial data collection. Despite some inherent limitations, these tools and technologies can provide valuable data that can then be used to influence policies and decisions (Yuksel, 2020). Literature Review method was used in this study.

2. Unmanned Aerial Vehicle (UAV)

Unmanned aerial vehicles (UAVs) are electronic devices that can be controlled with remote control, with different functions according to their intended use, and can fly. In other words, these vehicles are called "drones."

Although it was formerly called "Unmanned Aerial Vehicle System," today it is used as "Unmanned Aerial Vehicle." The reason for this is that the unmanned aerial vehicle is mostly preferred as an aircraft.

Unmanned aerial vehicles are classified according to their usage patterns. This classification is also divided into civilian and military uses and performances such as weight, altitude, wing load, range, and speed (Çoban, 2018).

When classified according to performance characteristics, designers determine classifications according to the needs of their customers. The most important performance characteristics of UAVs:

- Weight
- Durability and Range
- Maximum Altitude
- Wing Loading
- Engine Type
- Power / Thrust Loading

Table 1. UAV Classification by Weight

Category	**Weight**	**Example UAV**
Very heavy	>2000 kg	Global Hawk
Heavy	200-2000 kg	A-160
Medium	50-200 kg	Raven
Light	5-50 kg	RPO Midget
Very Light	>5 kg	Dragon Eye

Source: (Arjomandi, 2007)

Table 1 shows unmanned air vehicle levels by weight.

Table 2. UAV Classification According to Their Durability and Range

Category	**Durability**	**Range**	**Example UAV**
High	>24 hours	>1500 km	Predator B
Medium	5-24 hours	100-400 km	Silver Fox
Low	<5 hours	<100 km	Pointer

Source: (Arjomandi, 2007)

Table 2 shows unmanned air vehicles classification over durability and range.

Table 3. UAV Classification According to its Maximum Altitude

Category	Maximum Altitude	Example UAV
Low	<1000 m	Pointer
Medium	1000-10000 m	Finder
High	>10000 m	Darkstar

Source: (Arjomandi, 2007)

Table 3 shows unmanned air vehicle classes on maximum altitude.

Table 4. UAV Classification According to Wing Loading

Category	Wing Loading	Example UAV
Low	<50	Seeker
Medium	50-100	X-45
High	>100	Global Hawk

Source: (Arjomandi, 2007)

Table 4 shows unmanned air vehicle classes on wing loading capacity.

3. Use of UAVs in Agriculture

Agriculture faces many economic challenges in terms of production and cost-effectiveness. The decreases in rural areas and the population engaged in agriculture partially bring about labor shortages. In the face of such difficulties, there are increasing urban populations, deteriorating environments, aging populations, variations in food preferences caused by migration, and climate shift (Gnip, 2008), (Carpenter, 1998).

Furthermore, pathogens and other factors affecting both plants and animal health must be correctly identified, appropriate quantitation, economic expenses can be made correctly and controlled to reduce human health risks.

To be able to intervene in all these factors and fulfill its requirements, it is important to utilize technology, follow scientific progress, and establish a much more comprehensive agricultural system, which is characterized by the adoption of technologies and tools derived from R&D activities (Pasquale, 2019).

In light of these developments, the transition to digital agriculture becomes a necessity. Digital agriculture is already setting paradigms for improving working conditions by reducing manual labor and increasing productivity and farm quality.

All of these factors play an essential role in the sustainability of agriculture. Moreover, many modern farmers are also using high-tech solutions such as digitally controlled agricultural facilities and unmanned aerial vehicles (UAVs) for their farm monitoring and data prediction. Drones can now display relevant geographic locations and location data.

Secures the user to have a complete and clear picture of the land information. For example, drones equipped with multispectral and RGB cameras can provide sanitary conditions for crops by offering the advantage of viewing the near-infrared part of the electromagnetic spectrum compared to crops (Reinecke, 2017).

A much-cited drone report published by the Association for Unmanned Vehicle Systems International also known as AUVSI predicts that the legalization of commercial drones will create an economic impact of more than € 70 billion (such as revenue, job creation) between 2015 and 2025.

Digital farming will provide the majority of this growth. There are five agricultural drone applications that are currently being deployed in the field (Veroustrate, 2015).

3.1. Mid-Season Crop Health Monitoring

The ability to examine continuous crops from a height of about 100 meters using normalized vegetation index (NDVI) or near infrared (NIR) sensors are by far the leading practice for drones in agriculture. Current generation drones allow the capture of data that cannot be seen by the unaided eye (such as NDVI or near infrared), as well as allowing to cover more surface area in a much shorter period of time. Besides, it minimizes human error in within of conventional inventorization. However physical examination of an area of interest after viewing the image is still recommended.

3.2. Irrigation Equipment Monitoring

Managing multiple irrigation pivots is useful, especially problematic for large growers with many fields spread across a county or region. Mid-season inspection of the nozzles and sprinklers of the irrigation equipment that supplies much-needed water becomes a truly arduous exercise when crops like corn begin to reach certain heights.

3.3. Weed Identification in Mid-Field

By using NDVI sensor data and post-flight image processing to generate a weed map, farmers and their agronomists can easily distinguish areas of high-density weed growth from areas of healthy crops growing alongside them. Historically, many farmers did not realize the severity of weed problems until they were harvested.”

3.4. Variable Rate Fertility

While many will argue that satellite imagery ground inspections are more practical for refining nitrogen, phosphorus and potassium applications in agriculture, along with a dedicated grid soil sampling program, drones have their own unique suitability. A start-up drone services company in the US used NDVI maps to guide seasonal fertilizer applications to corn and other crops. Using variable rate application maps (VRA) created by the drone to determine the strength of nutrient intake in a single field, the farmer can apply 300 kg / ha of fertilizer in vulnerable areas, 200 kg / ha in quality areas average and 150 kg / ha in healthy areas, to reduce fertilizer costs and increase efficiency.

3.5.Cattle Herd Monitoring

During times of falling commodity prices, many farmers called for diversification by adding livestock. Drones are solid option for monitoring flocks from above, tracking the number and activity level of animals in fields. It is particularly useful for night viewing since the unaided eye cannot see it in the dark (Veroustrate, 2015).

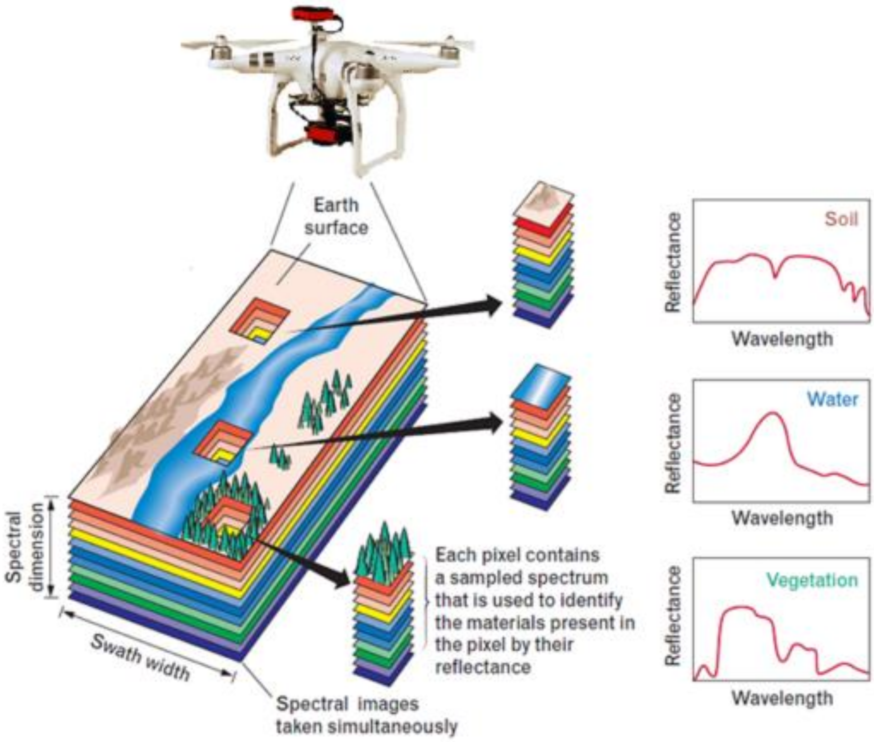

Figure 1. Monitoring of a crop with a multispectral camera placed on the drone

Unmanned aerial vehicles; Apart from the defense and security areas, it is also used in civilian areas, such as agriculture, fire fighting, transportation, natural life surveillance, aerial shooting, post-earthquake damage, and radiation detection (Koger, 2003), (De Castro, 2012).

Today, digital technologies such as smartphones, tablets, in-field sensors, satellites, and drones are common in agriculture. A range of solutions can be explored, such as measuring soil conditions remotely, managing water more intelligently, and monitoring livestock and crops. That empowers farmers to plan and be efficient in a more efficient Figure. After all, crop yields, livestock, optimization of process inputs, labor reduction, etc. Digitalization also helps ensure working conditions for farmers and reduce the environmental impact of agriculture (EIP-Agri Agriculture & Innovation, 2018).

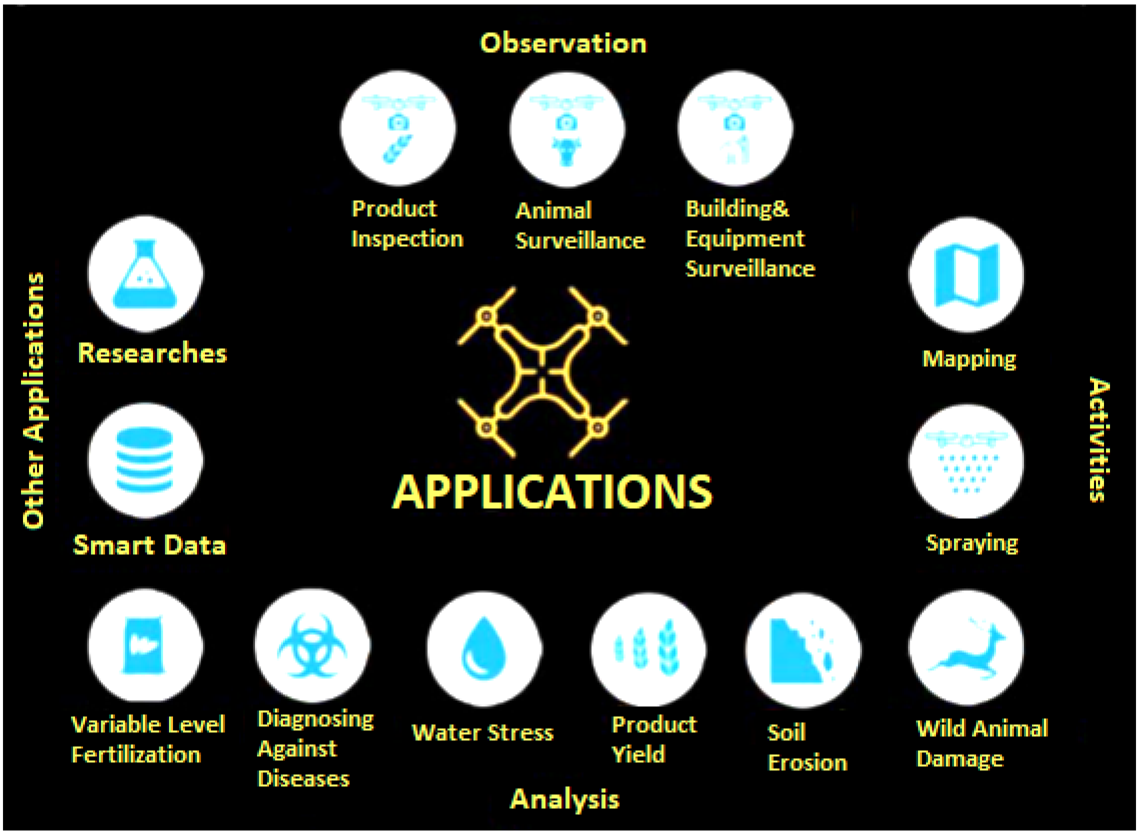

Figure 2. Subjects where UAVs are used in agriculture

Drone use in agriculture is increasing rapidly in crop production and early warning systems, reducing the risk of disaster, forestry, fishing, and wildlife protection. Drones are increasingly used in the agricultural insurance and assessment industry, including forensic analysis of insurance claims. Drone imaging is also useful for predicting crop losses in an accurate figure (Sylvester, 2018).

Table 5. 5 Areas Where Drone Systems Are Used Effectively

Monitoring product status	– Farmers can quickly examine their products with infrared (NIR) or Normalized Difference Vegetation Index (NDVI) sensors.
Monitoring irrigation systems	– Irrigation systems are examined according to the needs of the crops, especially in large agricultural lands.
Identifying weed flora	– With the help of NDVI sensors and using post-flight image processing data, farmers are able to easily distinguish and detect weeds.
Variable rate applications	– NDVI maps, created with satellite and ground-based images, are produced with drones in a fast and practical figure, allowing to reduce fertilizer costs and increase efficiency.
Herd management and monitoring	– In particular, it is possible to monitor freely raised ovine or bovine animals / herds, their quantities and activity levels.

Source: (Özgüven, 2015)

In Table 5, (Özgüven, 2015) states that drone systems are effectively used in 5 areas in digital agriculture.

There are some benefits to using UAVs in agriculture. Some of these benefits are; disease and pest detection in plants, yield estimation, water stress detection, productivity, maturity prediction, weed flora detection, water resources control, and employee monitoring.

These benefits can direct farmers to produce with an entirely new perspective. The goal of digital agriculture is variability management. More diverse and detailed data on agricultural production areas can be obtained by using appropriate technologies. In this context, data on sub-areas varying according to the level of heterogeneity can be used to apply agricultural inputs depending on spatial differences.

Inputs are minimized, and income is increased with heterogeneity management that allows optimal use of inputs, fertilizers, chemicals, and water needed in agricultural production (Tekin, 2016).

The sectoral benefits of using unmanned aerial vehicles (UAVs) in agricultural production are as follows:

- Ease of judgment and mapping by using drone technologies in large agricultural lands
- Agricultural spraying and fertilizing via drones
- To examine the condition of the plant, to determine its diseases
- Easy to control weather, soil, crop and humidity
- Control of unwanted living things (pest, wild animal, etc.)
- Border security
- Data analysis
- Detection of plants damaged by natural events with simultaneous control with meteorology
- Yield estimation
- Time savings with mapping
- Preparation of the soil for the next growing period
- Controlling the physiological development of the plant
- Plant water stress detection

4. Application

Leading countries in digital agriculture such as the USA, Germany, the Netherlands, and Israel have been actively using UAVs in agriculture in recent years.

Flight data and analysis from the drone are essential for a farmer. The most common use case for drone data and analytics is the early detection of weeds and diseases that preserve crop yields and reduce herbicide use. Farmers are also looking for crop count analysis that can improve yields and better predict yields by improving re-planting at the beginning of the season in the data they seek from a drone system. These use cases and others also have a valuable labor-saving component because farm staff or a paid agronomist potentially reduce the human tracking of crops.

In this context, American Robotics Scout System, a fully automatic drone system developed in the United States, deals with mission planning, flight, charging, data processing, and data analysis. Their back customers need to focus solely on what to do with that information (Claver, 2020).

Figure 3. American Robotics Scout System

Figure 3 shows the UAV Scout in Figure "parked" in an air quality-proof enclosed center or station in a field. A turnkey package can be realized from an autonomous UAV with central, visual, and multispectral cameras.

The device center houses the UAV and deals with charging, data processing, and data transfer.

In Turkey, operating at the OYAK-site and pesticides producing HEKTAŞ firm, 2.5 meters wingspan with UAV-2 status in Turkey's first and SHGM (Civil Aviation Authority) registered "only agricultural spraying drone" HEKTAŞ was presented to Crane Services. HEKTAŞ Turna aims to protect the soil and the crop by preventing the needs of the plant such as irrigation, pesticide, and fertilization, and to pave the way for a healthier and more sustainable agricultural production in terms of environment and human health (Milliyet, 2020).

Figure 4. HEKTAŞ Turna Drone System in Action

5. Conclusion

Thanks to the development of digital agriculture technologies in recent years, high-resolution images of hundreds of land areas can be taken with a single flight from the air with UAVs. These studies can be completed in a shorter time without the need for personnel and workers. It also provides the opportunity to receive images even in cloudy weather conditions where satellite images cannot be taken. Due to the numerous advantages of the UAVs, usage of UAVs in agriculture spreading rapidly among farmers (Tekin, 2016).

The perception that digital agriculture with UAVs can be done on large-scale agricultural land is not accurate. There is a wide range of products in terms of cost. Therefore, the product can be determined and used according to the need in small lands.

In the future, within the scope of "Agriculture 4.0", digitalization in agricultural activities will be inevitable, and the use of drones will make life easier and provide minimum labor and maximum product yield.

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