# THE REVOLUTION OF TRADITIONAL AGRICULTURE TOWARD INTELLIGENT AGRICULTURE WITH THE HELP OF AGRICULTURAL DRONES

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**Abstract**

The growing interest of farmers in agricultural drones is due to the increasing technology of agriculture, the expansion of crops and the pooling of the land that will be reached in the near future, with traditional agriculture leaving the place of smart agriculture of the future. Drone applications in agriculture are unlimited in such a way that farmers will be able to see the evolution of crops and will be able to monitor their agricultural crops in ways that were not possible until these agricultural drones were introduced. Farmers can use agricultural drones to adapt the intelligent use of pesticides, herbicides and fertilizers using technological applications to ensure the need for agricultural cultivation at all stages of development, ensuring the exact supply of nutrients as well as the protection needs of the crop, saving money by reducing waste. In this work I will study the factors and trends in the use of drones in agriculture as well as the progress of this branch of intelligent agriculture in Romanian agriculture.

**Key words**: Drone, sensor, NDVI (Normalized Difference Vegetation Index), UAV (unmanned aerial vehicle), multispectral camera

The growing popularity of agricultural drones is also due to the increasing technological development of agriculture, the expansion of crops and the land consolidation that will take place in the near future, with traditional agriculture giving way to the intelligent agriculture of the future. Agricultural drones will have a significant and long-lasting impact in the agriculture of the future, which need to be upgraded with additional devices to collect more information, such as thermal sensors to identify plant stress situations early on, which can then be run, analysed and used by farmers as shown in (*figure 1*). Farmers can use agricultural drones to tailor the intelligent use of pesticides, herbicides, fertilizers using technological applications to ensure the needs of the agricultural crop at all stages of development, accurately ensuring nutrient supply as well as crop protection needs, saving growers money by reducing wastage (Stiri Agricole magazine, 2014). At first drones were used to capture images - a simple aerial view of farmland adds great value.

Basically, farmers could "fly" over their fields and observe potential problems: variation in plant density, leaf colour, problems with irrigation systems, pest attacks, etc. These images helped farmers better plan their future farm work. Very soon after this came programmes producing 'health' maps of crops to identify areas of potential yield loss (Ghise G., 2020).

Figure 1 **Multirotor agricultural drone**
Source: Revista Stiri Agricole, 2014

The range of the use of agricultural drones can also be extended to carry out verifications and compliance checks carried out on area subsidies granted under the CAP (Common Agricultural Policy), by payment agencies, public institutions at the level of each Member State of the European Union, using imaging technologies from which it can obtain a huge range of useful information for the development of farms as can be seen in figure 2. In Denmark, payment agency inspectors use drones to check areas with difficult access, reducing the risks to their health and safety and the time it takes to carry out checks. Paying agencies most often mention autonomy limited and

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regulatory restrictions to explain why they do not use drones more widely (European Court of Auditors, 2020) (*figure 2*).

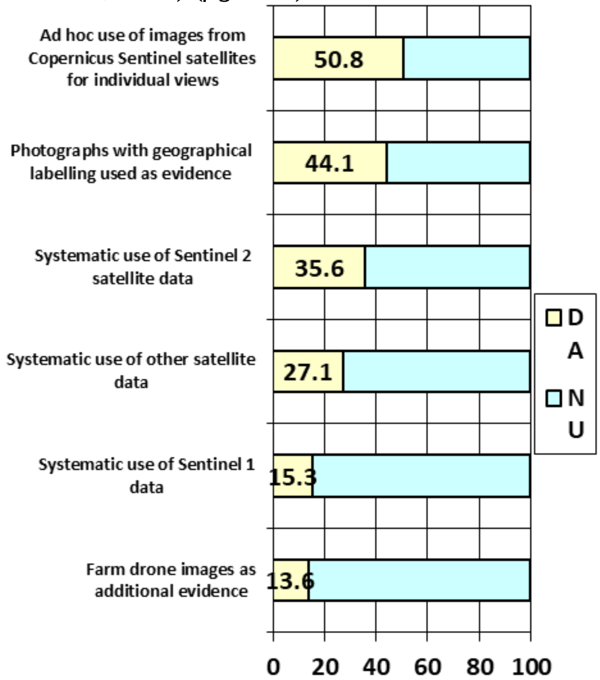


Figure 2 **Use of imaging technologies for compliance checks on CAP area subsidies**
Source: European Court of Auditors, 2020

## MATERIAL AND METHOD

For my research study, as material, I opted for the DJI PHANTOM 4 Multispectral drone - a high precision drone with a perfectly integrated multispectral imaging system, designed for agricultural missions, environmental monitoring and more. P4 Multispectral, as shown in figure 3, reinforces the data capture process that provides insight into crop health and vegetation management. DJI has created this platform with the same strong performance standards for which it is known. The drone has a maximum flight time of 27 minutes and a transmission range of up to 7 km with the OcuSync system.

Figure 3 **DJI Phantom 4 drone with multispectral camera**
Source: DJI.com, 2021

Farm image collection is now simpler and more efficient than ever, with a built-in stabilised image system that collects comprehensive data sets right out of the box. Access information collected by 1 RGB camera and a 5-camera multispectral camera array covering blue, green, red, red edge and near infrared bands - all at 2 MP with global shutter, on a 3-axis stabilized gimbal, as shown in figure 4. Accurate real-time positioning data will be obtained from images captured by all six cameras with DJI's TimeSync system, providing accurate measurements to the centimeter level. The TimeSync system continuously aligns the flight controller, RGB and NB cameras and the RTK module, fixing the data positioning at the CMOS center and ensuring that each photo uses the most accurate metadata. All cameras go through a rigorous calibration process in which radial and tangential lens distortions are measured. The gathered distortion parameters are stored in the metadata of each image, allowing the post-processing program to adjust uniquely for each user.

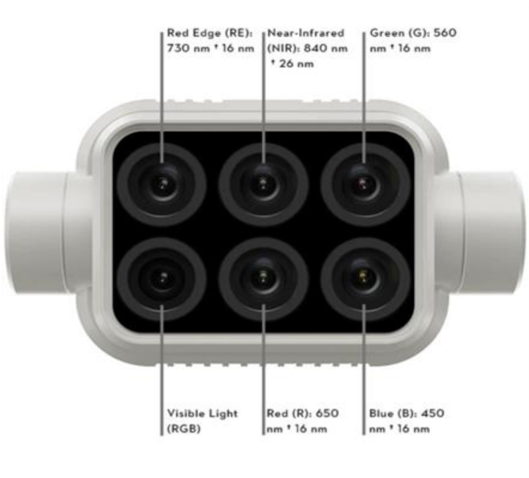


Figure 4 **DJI multispectral camera**
Source: DJI.com, 2021

The collected data can be easily imported into DJI Terra or other software, including Pix4D Mapper and DroneDeploy, for analysis and generation of additional vegetation index maps. DJI Terra is an intuitive and easy-to-use software for capturing, analysing and visualising the environment with DJI drones. It allows the execution of the work from the design phase to the final delivery – figure 5, going through all four important steps: Mission Planning, Data Acquisition, Data Processing and Data Analysis. It can be used in areas such as construction, infrastructure, agriculture and surveying, as well as for filming and improving road safety.

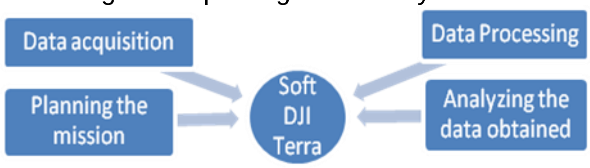


Figure 5 **Stages of use of DJI Terra Soft**

Integrated image processing and analysis saves time. In about 10 minutes, hundreds of images taken from the drone flight can be uploaded. No need for complex software, special computing power or expensive upgrades. The cloud-based service is always up to date. Processing only takes a few hours of work and the results are intuitive for the farmer to understand.

The range of agricultural drones that can achieve all these requirements are equipped from the start with multispectral cameras. Multispectral cameras mounted on a drone are high-precision equipment with a perfectly integrated multispectral imaging system designed for agricultural missions, environmental monitoring and more. Remote Sensing and Agrochemical and Soil Mapping services help farmers to know their land better and understand its needs in order to produce richer crops. If in the case of Agrochemical and Soil Mapping the technology and benefits are already known by most farmers, Remote Sensing by Multispectral Aerial Photography is less known in Romania. As a technology, multispectral aerial photography remote sensing is based on capturing electromagnetic radiation emitted by plants through sensors capable of receiving light in bands beyond the visible spectrum. Basically, the technology is similar to that used by APIA (Agentia de Plati si interventie in Agricultura) for the verification of area payment claims, with the difference that satellite imagery is used to verify claims, while remote sensing by multispectral aerial photography uses much more detailed images, which are taken from an altitude of about 150 m using drones. This produces maps showing not only crop type, but also plant health indicators, types of pests present in the crop or nitrogen requirements within the monitored plots. Agricultural producers can request these services for:

-developing the fertilization plan;

-classifying the type and degree of crop infestation;

-determining the degree of plant development of the crop;

- monitoring crops and agricultural work (Ghise G., 2014).

## RESULTS AND DISCUSSIONS

### Trends in smart farming

*Identifying diseases and pests*

Current practices for diagnosing diseases in agricultural crops are mainly based on human inspection of symptoms as shown in figure 6. In most cases, diseases show a number of visual signs such as coloured spots and general variations in foliage colour. Direct visual observation of the appearance of disease symptoms in agricultural crops is very costly and time consuming, especially for large areas. Machine learning helps to detect diseases early.

Basically, special software processes aerial images (captured by drone-mounted cameras) and analyses and compares the photos with an archive of images in the cloud, providing an immediate diagnosis.

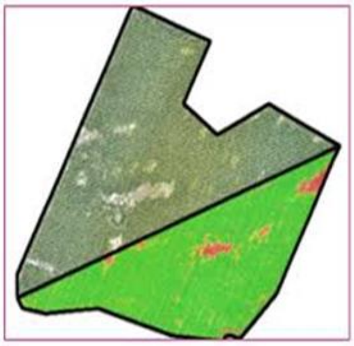

Figure 6 **Identification of diseases and pests**

Automated programs allow faster prediction and better management of disease outbreaks. At the same time, data processing and variable-rate prescription maps allow disease outbreaks to be isolated quickly and costs to be reduced as less plant protection product is used. After that, herbicides are applied only where they are needed.

*Weed control*

Weeds can be effectively combated by various activities: One of the most effective methods of weed control is crop rotation. It is also cost-effective. Respecting the sequentiality of crop cultivation prevents the spread of diseases, pests and reduces the weed stock in the soil. In addition to respecting the crop spacing, it is important to cultivate dusty crops (with larger row spacing) after those sown compactly (15 cm) and vice versa. Thanks to the precision offered by drone technologies, pest and weed control helps farmers save important resources and better protect their crops. Accurate identification of weed infested areas then allows variable application of herbicides, thus reducing active substance consumption and resource allocation.

Figure 7 **Weed control**
Source: Laorizont.ro, 2021

*Harvesting crops*

Traditional methods of analysis are time consuming and prone to human error. With drones in precision agriculture, farmers get accurate data on the state of the crop with a given area is feasible and fast, simpler and more accurate than traditional estimates!

Figure 8 **Crop harvesting**
**Source: Laorizont.ro, 2021**

Plant counting can be performed as a result of image recognition technology and thus eliminates plants not subject to analysis from the algorithm. the possibility to take early action to improve the yield of the whole farm. With the help of UAVs, the plant count on the crop can also highlight areas of possible loss which allows timely replanting as shown in figure 8. All these analyses directly help the crop harvesting process which leads to an increased yield of the plant type efficiency.

*Soil analysis*

This application gives farmers the opportunity to apply so-called precision farming, where every plant is used to its full potential. If a nutrient deficiency is found in a certain area of the crop, fertiliser is applied there so that the plant produces a good yield.

The app can also identify plant diseases and provide a diagnosis of their health status. The app uses artificial intelligence and machine learning to broaden its scope of knowledge.

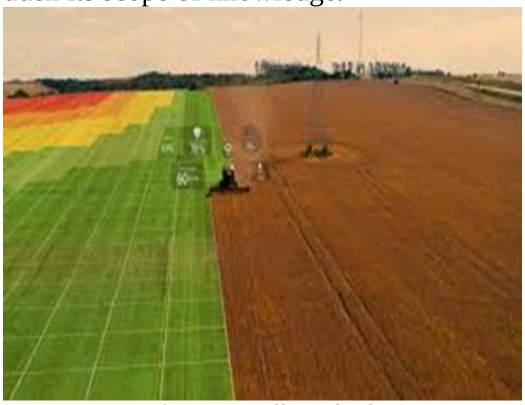

Figure 9 **Soil analysis**
Source: Agrobussines, 2020

*Weather forecast*

It is also artificial intelligence that helps the farmer to be better informed about the weather forecast. Estimates of soil water requirements help farmers to take early action so that plants are not affected by drought or too much water. These applications of the amount of rainfall and the estimated amount of rainfall in the short and medium term lead to higher yields for farmers and lower risks of crop losses due to drought. Technology is advancing at a dizzying pace, moving from software and hardware technologies to technology capable of interpreting all the data collected (e.g. data entered into the management system, data transmitted by weather stations, various sensors or drones). In addition to this, there is also the knowledge passed down from previous generations, information that may be unique to each individual farm and which relates to the geology and microclimate of the area. All this, put together and interpreted properly, can form the basis of a 'recipe' for farming efficiently, using resources optimally for maximum results. The data gathered is used to make forecasts and 'predict the future of farming'. As with weather forecasts, the farmer can make decisions to reduce risk - what treatments are needed and when to apply them or when to harvest for best crop yield. (Jurnalul de afaceri, 2020). Equipped with technological capabilities and connectivity, drones are one of the cutting-edge technologies incorporated into the smart factory at various stages of the processes. Currently, drones are not widely used in manufacturing as shown in figure 10. According to the Federal Aviation Administration (FAA), manufacturing uses only 1.5% of the US market. The main reasons for the low use of drones in production are related to the complexity of the site

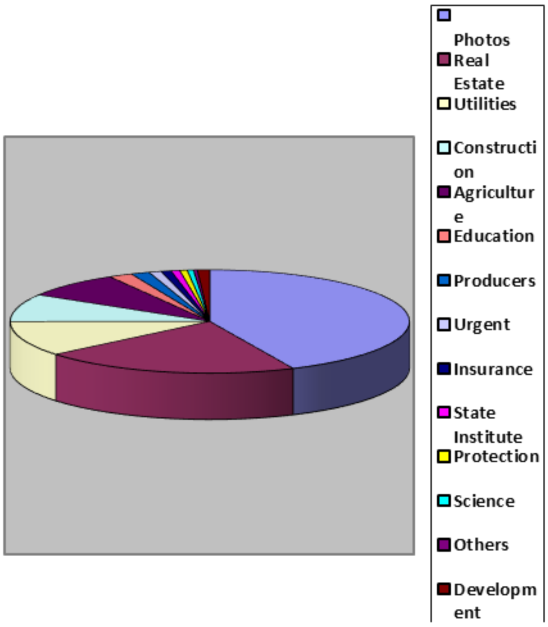


Figure 10 **Fields of activity using drones**
Source: Edudrone.ro, 2018

*Factors and benefits of using agricultural drones*

One of the main benefits of drones is that they can increase the productivity of the agricultural sector. Drones meet the needs of the growing agricultural industry. For example, they offer much more advanced forms of crop monitoring, faster inspections, accuracy and advanced measurement tactics that help payment agency inspectors determine which crops will receive direct area payments and help farmers save water and chemicals. Industrial drones increase the accuracy and efficiency of any farming operation. If equipped with advanced thermal and geographic sensors, drones can provide information that human inspectors cannot obtain by conventional means (European Court of Auditors, 2020). Drone surveillance services can be used from the beginning of March until October or November and when the average temperature is at least 5-6°C (KPMG, 2021). Useful information in the use of drones for inspectors carrying out checks required for the monitoring requirements of the Common Agricultural Policy as well as for farmers as shown in figure 11. Factors that support and may influence the use of drones are as follows in figure 12:

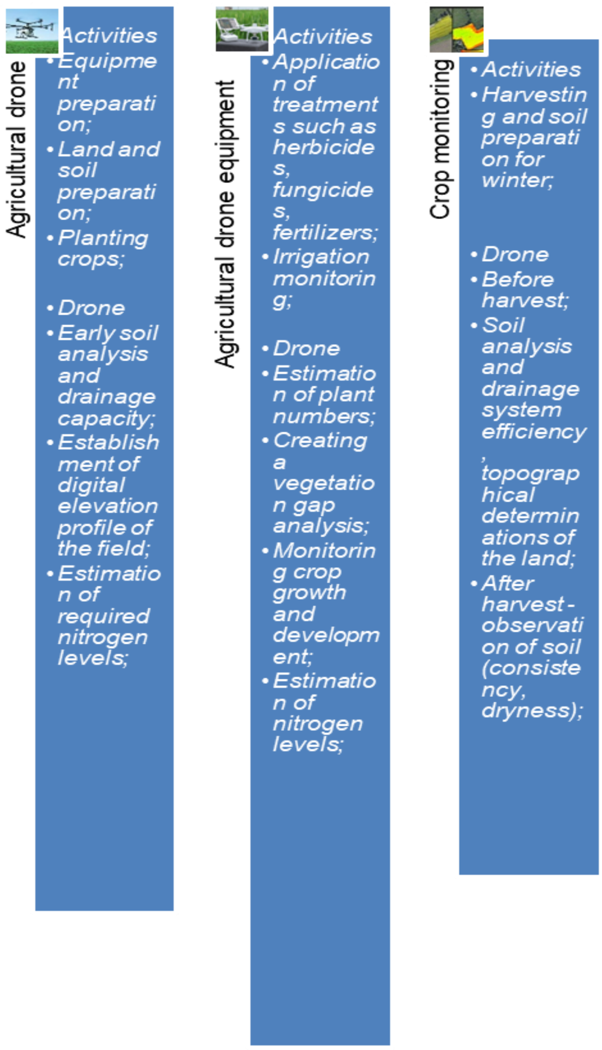


Figure 11 **Drone activities at different times of the calendar year**

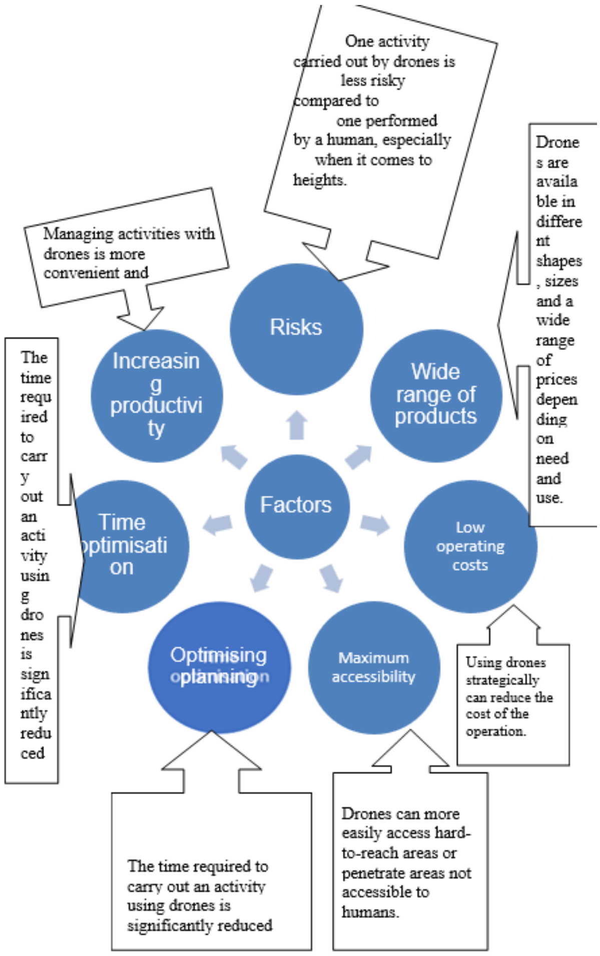


Figure 12 **Factors that support and may influence the use of drones**

## CONCLUSIONS

UAVs are now seen as a safer option for mapping difficult areas, such as uneven or expansive fields, which can be dangerous for operators - especially compared to ground techniques, which must be done on foot. Where satellites and manned aircraft have traditionally been used to monitor agriculture, UAVs are fast becoming recognised as a more accurate and cost-effective replacement. Drone imagery offers a higher rate of accuracy and resolution – even on cloudy days. While using traditional ground-based approaches to collect data in difficult weather conditions could delay projects by days, accurate crop health assessments can be made year-round using UAVs. The ultimate goal is to provide practical detection tools that can help farmers improve crop productivity, product composition and quality, environmental sustainability and business profitability. To determine whether or not plants have specific nutrients and whether they need more or less water, the system installed on the drone uses non-visible light (newsbreak.com), which is different from the visible spectrum (also called the optical spectrum), which is the domain of the visible electromagnetic spectrum (cannot be detected by the human eye without auxiliary equipment or devices) and whose electromagnetic radiation (in this wavelength range) is called visible light. Drones have been used for decades in the private sector, but have only recently started to gain popularity in the agricultural world. Agriculture is one of the most promising industries for drones. Drones are poised to tackle significant challenges and streamline many aspects of the industry. As the population grows, so does agricultural consumption. To cope with this growth, we need a modern approach to agriculture that can meet the new demands and challenges. Either through their own funding or through the use of funding provided by national farmer support programmes or those provided by the European Union, covering both restructuring and conversion of plantations, promotion, crop insurance, but also various investments including IT solutions for agriculture.

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