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An Extensive Analysis of Unmanned Aerial Vehicle Technology and Its Effect on Agriculture

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ABSTRACT

In recent years, the agriculture industry has witnessed a significant transformation with the integration of cutting-edge technologies to enhance productivity, efficiency, and sustainability. Among these technologies, sensors have emerged as indispensable tools for monitoring various agricultural parameters and optimizing farming practices. Current advancements and technological improvement in the sector of agriculture requires modern day machineries-drones. Drones technologies proved to save the water, pesticides, and herbicides, maintain the soil fertility also helps to cut excess implication of man power along with increase the output and raise the standard of quality. Robots, artificial intelligence, big data, robotics, and the internet of things are all combined in UAVs. Agricultural UAVs have shown to be quite effective when in use, and they are now extensively employed in many facets of agriculture, such as seed sowing, growth evaluation, and mapping, as well as the application of pesticides and fertilizers. It is becoming essential in the field of agronomical research, they are quite susceptible to variation in soil, climate and alteration to physico-chemical changes. The aim of this paper is to review the usage of Drones, UAVs and remote sensing in agriculture applications. On the basis of literature, we found that a lot of advantages are witnessed in agriculture in using Drone, UAV and remote sensing. This paper summarizes the current state of three technologies for agricultural uses, including crop health monitoring and farm operations like, weed management, evapotranspiration estimation, spraying etc. In order to improve their agricultural production, more farmers should invest in contemporary equipment and technology, according to the research article's conclusion.

***Key words**: Drones, UAVs, Remote sensing, Artificial intelligence*

Introduction

The demand of food is increasing day by day tremendously as population is increasing. The ancient methods of agricultural practices acquired by the farmers were not enough in order to fulfil the requirements of the upcoming generation. To fulfil the futuristic demand, few modern technologies are in demand for precision agriculture. These are automated methods (Drone technology), application of unmanned aerial vehicles (UAV) and remote sensing, which showed many benefits in the field of agriculture. These novel techniques are adequate for the need for nutritional requirements and further supplied opportunity of job to thousands of people. As, India mainly based on the agriculture for food, still it is far behind from adopting modern technologies for betterment in agriculture. Most of the developed nations have begun utilizing UAVs in their modern agriculture system, photogrammetric and remote sensing. Many countries like, Europe union (Italy, Greece), United Kingdom, sub-Sahara Africa, Asian countries (Israel and China) and Australia have already adopted UAV for various purposes (Chamola *et al*., 2021). Due to the miniaturization and cost reduction of GPS receivers, inertial navigation systems, computers, and, most importantly, remote sensing sensors, unmanned aerial vehicles (UAVs) or over the past ten years, technologies for remotely piloted aircraft have grown in popularity in Europe and hence adopted by them. In the regions of Zimbabwe and Kenya (Africa) UAVs are utilized in crop breeding advancements and conservation of agriculture management.Unmanned aerial vehicle (UAV) can be flown autonomously or with the assistance of the global positioning system with preprogrammed instructions (GPS). The UAVs are very fast in performance and it can reduce manpower cost and work load to the farmers. Generally, UAVs remain fitted with cameras and sensors for crop monitoring and sprayers for pesticide spraying. The technical support of UAVs in precision agriculture is to determine their usefulness in modern agriculture operations is crop height estimations, spraying of pesticides monitoring of crop and soil analysis. The condition of the monitored vegetation is measured using multispectral cameras inside the UAV in regards of (i) The quantity of chlorophyll (ii) The quantity of water in the leaves (iii) The quantity of ground cover and Leaf Area Index (LAI) (iv) The Normalized Difference Vegetation Index (NDVI). Because of the elevated temperature of the stressed plant, thermal cameras have demonstrated to have a substantial potential in order to identify water stress in crops (Daponte *et al*., 2019).

Role of UAVs in Agriculture

Drones are equipment that can fly autonomously with specialized software which allows it to fly in programmed plan by deploying the GPS system with a range of parameters, including speed, altitude, ROI (Region of interest), geo-fence and failsafe modes. Use of aerial vehicle is possible only because of its smaller and compact cameras and other sensors like infrared and sonar. Numerous technical difficulties have become hindrance in the UAVs usage in agriculture, which still have to be conquered. Crop monitoring for pest and diseases, fertilizer application, water-stress, and overall plant health is a vital aspect for a good agriculture practice. Remote sensing is a monitoring tool in agriculture utilizing both ground-based observations and space technology for increased accuracy. Data from Remote sensing helps in monitoring the objects on the earth surface by providing timely, synoptic, economical and recurring information regarding the objectives on the earth surface. Data from remote sensing can be in conjunction with models of crop simulation for a very useful crop yield forecasting. By 2050, there will be approximately 10 billion people on the planet (https://www.worldbank.org/en/topic/agriculture/overview). With increase in population food production will have increment of 70% of current production. Old agriculture practices are not adequate to increase the production of food rate, and current agriculture system requires some modern thoughts like automation, robotics, information services, and intelligence that combines information and communication technologies (ICT), robotics, artificial intelligence (AI), big data, and the internet of things. Precision agriculture system is an active field that produces new opportunities for the future. Nowadays the UAVs are significantly reduced working hours, resulting in increased stability, measurement accuracy, and productivity in agriculture sector. UAVs and its usage have contributed to the expansion of many new areas in agriculture field, including insecticide and fertilizer application, seed sowing, weed identification, fertility assessment, mapping, and crop forecasting. So, in this current review we focus on the application and types of drones in agriculture.

Sensors used in agriculture

Sensors play a pivotal role in providing real-time data, enabling farmers to make informed decisions and adopt precision agriculture techniques. This work aims to comprehensively explore the variety of sensors used in agriculture, their effects on agricultural practices, benefits, limitations, emerging trends, future directions, case studies, challenges, and recommendations for the successful implementation of sensor-based agriculture systems (Talaviya *et al.,* 2020).

Different kinds of agriculture sensors: (i)Optical Sensors (ii) Electromagnetic Sensors (iii)Location Sensors (iv) Airflow Sensors (v) Acoustic Sensors (vi) Electrochemical Sensor

Crop health surveillance

Health condition of plants can be monitored by drones throughout the cropping season, and accordingly decision will be taken for improvement of plant health on need-based basis. Drone has different kinds of sensors compatible to visible, NIR (Near Infrared Rays) and thermal infrared rays. On the basis of reflection pattern of objectives at various wavelengths, several multispectral indices can be estimated with the application of these techniques. These indices mainly used to assess different aspects in fields of agriculture like, water stress, nutrient stress, pest-insect attack, diseases, etc. Incidence and presence of diseases and pests or nutrient deficiency symptoms can be detected by the sensors available in the drones, which cannot be detected with human eyes prior to the onset of discernible symptoms. Thus, drone serves as an effective instrument for early monitoring in detection of the insect-pest and diseases. These drones can be used as early warning system so that timely action can be taken without economic loss. Likewise, UAVs (Drone) are able to observe the crop situation with different indices. Thermal and multi spectral cameras are fitted to drone to record reflectance of vegetation canopy (Colomina *et al.,* 2014).

The effectiveness of drones in capturing the reflectivity of the canopy above vineyards has already been established. Aerial photographs can be accessed at the beginning throughout the season, at set times throughout the season, and just before harvest to show the expansion throughout the field and highlight any rows that exhibit signs of stunted growth due to low initial nitrogen content or inadequate irrigation (Simelli *et al.,* 2015).

Water stress monitoring

To identify and characterize stress due to water on crops is a challenging task due to the impacts of drought affect several factors. Variables generated using thermal pictures, which are frequently sensitive to even minute temperature changes, to identify strains and other issues. Due to this reason, cutoff and regression equations that are generated under specific circumstances typically don't match in even slightly different situations. As an illustration, different cultivars of a certain crop may show substantial variations in canopy temperatures under same circumstances because of innate variations in transpiration rates and stomatal conductance. In the experiments conducted by, employed canopy temperature traits acquired from UAV thermal pictures to follow the status of cotton water. With a coefficient of determination (R2) of 0.88 ranging from canopy temperature standard deviation (CTSD) and stomatal conductance, the findings revealed that CTSD was responsive to crop water stress. In a field of commercial sugar beet(Martinez *et al.,* 2017) evaluated the possibility of UAV Utilizing thermal imaging to track plant water stress.

Nutrient status and deficiency monitoring

Adequate amount of nutrients is essential to plants in order to survive and produce an expected yield. Adequate levels of nitrogen ensure strong growth of plant, for strong root and stem growth optimum levels of phosphorous is needed likewise appropriate levels of potassium are essential for development of resistance capacity to pest and diseases and also to produce a better quality of crop. If the soil becomes deficient in any of these nutrients, the plant comes under stress and will have to struggle to survive. Presently, direct visual technique is common method adopted to determine the nutritional status, which is indicated by plant colour and appearance, which do not guide assessments quantitatively.For more accurate result laboratorial leaf analyses method is adopted may take a lot of time and call for particular techniques to properly understand the data. There are various indirect substitute tech-

Table 1. Drone classification for use in Agriculture

UAV	Rotary wings	Fixed wings
Duration of Flight	Fly uptotwenty minutes	Flown for one hour
Wind Pressure	Able to be flown from in brisk winds of 20 to 50 mph	Fly between the wind and itself for satisfactory images
Flexibility in changing direction	Give a fresh direction during flight for re-direction	Allow new direction upload while in flight for redirection
Price range	500 to 100,000 dollars	500 to 100,000 dollars
Deployable option	Highly deployable	Deployable

niques available for some nutrients *viz.,* Use of chlorophyll meter for nitrogen deficiency analysis (Balasubramaniam *et al.*, 2016), but this is also a time-consuming process, which is likewise dependent upon various conditions and the approximations aren't always precise. Thus, a novel technique has been created for the identification and calculation of plant nutritional characteristics (Ali *et al.,* 2017). Potassium and sodium are also two important nutrients for plant growth. Traditionally, multispectral pictures have been used to extract significant features and indices (Gabriel *et al.,* 2017) but RGB (Maimaitijiang *et al.,* 2017) and hyper spectral images (Gabriel *et al.,* 2017) are also widely embraced. Investigations have also been conducted on combining more than two sensor types (Thermal, RGB, and multispectral) (Maimaitijiang *et al.,* 2017). With the exception of the colour features, which are determined from RGB photos, all of these are computed from hyperspectral images.

Diseases monitoring

Pest and diseases are two devastating factors in agriculture crop. Infrared cameras are fitted in drones, which can see the plants to inside. With the aid of drones a pest or disease can be detected before time and preventive measure can be adopted in advance. Thus, drone can be a significant factor in identification of pest and diseases. From the experiments conducted by scientist and researchers yellow stripe rust in wheat (Zhang *et al*., 2019), yellow leaf disease of Arecanut (Lei *et al.,* 2021) and white leaf disease in sugarcane (Narmilan *et al*., 2022) could be monitored with the assistance of UAVs Multispectral image system in detection of pest and diseases are a preferred methods to learn more about the subject being studied areas. For detection of disease intensity hyper spectraland thermal images have additionally been examined and in practice. The thermal image system is generally used in order to identify water stress symptoms maybe brought on by the particular disease.

Weed control

Weeds are undesirable vegetation grow along with agricultural crops and can cause problems to cultivated crop. The main problem with weed is they are vying with each other for nourishment and water available or even space, resulting crop loss and effect growth. Yield losses due to weed in India in rice (10-100%), wheat (10-60%), maize (30-40%), sugarcane (25-50%), vegetables (30-40%), jute (30-70%) and potato (20-30%) etc. (Gharde *et al.,* 2015). Drone has been in use for weed control by way of using spectral pictures to distinguish spectral signatures between different glyphosate resistances in weeds. Use of RGB sensors is very effective to identify different weed species (Huang *etal*., 2018). Hyperspectral sensors are employed in weed monitoring to identify leaf density and chlorophyll content (Malenovsky *et al.,* 2017). For controlling weeds spraying herbicides is a common practice. From various researches conducted, many selective weeds could be identified such as morning glory, Palmer amaranth, cocklebur and waterhemp with the help of weed infestation mapping done by the imagery data collected from UAVs.

Spraying

For high productivity agriculture needed protection from pest and diseases. In agriculture fertilizer and pesticides are very much needed to manage insect pest / diseases and for the growth of crops. UAV with sprayer system perhaps a good option for better and quick management of pest and diseases. For spraying of a large area heavy lift UAVs are required. Scientist has recommended the Quad copter (QC) system which is having low cost, lightweight, and additionally referred to as UAV (Kediri *et al.,* 2016). Quadcopters are small in size, and it's usable for indoor crops as well as outdoor crops. Quadcopter is a small flight for spraying pesticides and fertilizer, which is operative autonomously using the android device. A quad copter aerial automated pesticide sprayer (AAPS) was developed for pesticide spraying, which is predicated on the GPS coordinates in lower altitude environment. To reduce the wastage of pesticides a hexa rotor UAV designed on electrostatic spray technology. To avoid humans from pesticide, poison a remote-controlled UAV is accustomed to spray the pesticide as well as fertilizer. Use and impact of UAV (UAV N3) spraying the prevention of powdery mildew in Asian countries were studied at different working height and with different concentrations of pesticides on the wheat canopy (Qin *et al.,* 2018). Generally, in traditional agriculture system fertilizer was applied by tractor powered sprayers or pressurized irrigation systemsor by manned aircraft. The manned aircraft is the most preferred one and used for long time. Estimation of requirement of nutrient deficiency with thermal cameras along with specialized optical filters such as Red Edge or hyper spectral cameras is considered as perfect tool for the purpose. In this kind of UAVs accelerometer and Gyroscope Sensors are employed in spraying fertilizer and pesticide; which can reduce time and human efforts. Various pesticides are spray drifted on pineapples in China with assistance from UAVs (Wang *et al.*, 2018). China also uses UAVs to spray pesticides in the fields of corn, paddy, cotton, tea and apples while in America It's employed in almond fields (Li *et al.*, 2021).

Forecasting crop yield and production

Prediction influencing the growth of crops before to harvest and actual quantification is crucial for the design of national food policy. The yield of crops basically depends on a number of variables, including crop variety, the field's water and nutrient status, weed effect, pest and disease infestation, and meteorological conditions. Crop production forecasting relies heavily on consistent crop yield. Prediction of yields mostly determined by statistically significant correlations between vegetation indices and yield. Yield of various crops, for example, potato, cotton (Xu *et al*., 2021), olive tree, sugarcane and wheat could be predicted with the assistance of UAVs.

Conclusion

Drones have the potential to significantly change agriculture in India. Future technological advancements are anticipated to make drone manufacture more affordable. The arduous labour and tedium associated with farming deter the next generation from pursuing this career path. Drones may intrigue young people and inspire them to pursue careers in agriculture. When it comes to aerial imagery over agricultural areas, drones offer superior quality and real-time data over satellite imagery. Furthermore, drones can currently be used for applications such as weed and disease localization, soil property determination, vegetation detection, and the creation of precise elevation models. Farmers will be able to learn more about their farms thanks to drones. As a result, farmers will receive assistance in growing more food with fewer chemicals. Almost all farmers who have used drones have benefited in some way. They can utilize their property more effectively, get rid of pests before they wipe out entire crops, improve the quality of the soil to encourage better growth in trouble spots, enhance irrigation for plants experiencing heat stress, and put out fires before they spread. Drones could therefore play a major role in agriculture in the future by assisting farmers in more sustainable and effective management of their land and resources.

Conflict of interest: The authors declare no conflict of interest

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