# Advancements in Drone Technology for Fruit Crop Management


## Abstract

The evolving role of drone technology in fruit crop management, providing a comprehensive overview of its applications, benefits, and existing challenges. Drones, or Unmanned Aerial Vehicles (UAVs), equipped with advanced sensors and imaging capabilities, have revolutionized the way farmers monitor and manage fruit crops. Aerial surveillance enables high-resolution imaging of orchards and vineyards, allowing for early detection of diseases, pests, and other stress factors that can impact crop health. The data collected by drones facilitate precise and targeted interventions, optimizing resource use and enhancing overall crop productivity. Additionally, drones contribute to yield estimation, canopy management, and post-harvest monitoring. While the technology offers significant advantages, challenges such as payload limitations, weather sensitivity, and regulatory compliance must be addressed. Ongoing research and technological advancements are expected to overcome these limitations, further establishing drones as indispensable tools for sustainable and efficient fruit crop management. This review consolidates current knowledge, highlights emerging trends, and outlines future prospects for the integration of drone technology in fruit agriculture.



Keywords: drones, productivity, fruit, weather, research


## Introduction

Drone technology, also known as Unmanned Aerial Vehicle (UAV) technology, has rapidly evolved into a transformative force across various industries, offering innovative solutions and reshaping traditional practices[1]. Drones are unmanned, remotely operated aircraft equipped with cameras, sensors, and other payloads, enabling them to collect valuable data and perform a range of tasks. In agriculture, particularly in fruit crop management, drones have become indispensable tools[2]. They provide farmers with a bird's-eye view of their fields, offering high-resolution imagery and data on crop health, pest infestations, and overall field conditions. This aerial perspective facilitates precision agriculture, allowing farmers to make data-driven decisions regarding irrigation, fertilization, and pest control. Drones contribute to increased efficiency, reduced resource use, and improved crop yields[3]. Beyond agriculture, drone technology has applications in mapping, surveying, search and rescue operations, environmental monitoring, and more. As the technology continues to advance, the potential applications of drones in various industries are likely to expand, ushering in a new era of data-driven, efficient, and sustainable practices[4]. Drone imagery has grown in popularity over the last ten years as a means of gathering data to support orchard management. Miniaturized sensors intended for drones can gather information on-demand with extremely high spatial resolution, covering orchard scales (less than 10 km2)[5]. However, since different combinations of flight variables affect the final products' quality and usability, choosing the right setting for flight planning is crucial. Numerous studies have found that various flight planning parameters, including flying altitude and image overlap, affect the radiometric quality and the estimation of tree structure variables[6].

Some people believe that drones are the best invention ever made by humans. It has broad applications in a variety of fields, including industry, agriculture, and defense. Currently, the military uses about 85% of drone technology, with the remaining 15% being used by civilians for a variety of purposes[7]. However, there are some countries, like India, where flying drones over public spaces and government buildings is prohibited, albeit with some restrictions. It can be effectively applied in agriculture for a variety of tasks, including fertility of the land, disease and pest infestation on crops, weather phenomena, and water management. Drone technology has recently been shown to cover an area that is roughly 10 to 15 times larger than that which can be covered by conventional land-based methods[8].

Plant diseases cause significant yield losses and pose a threat to the world's food supply; therefore, early detection and accurate diagnostic techniques for determining the disease's etiological agents are crucial for preventing or minimizing crop damages and saving time and money[9]. In the past, diseases were diagnosed using conventional techniques, which were labor-intensive overall but frequently subjective, reliant on the observer, and inaccurate. Furthermore, due to human error and/or the occurrence of cryptic symptoms that are not mild, human scouting is costly and frequently impractical, making early diagnosis impossible. Thus, it will take a technologically driven agricultural revolution to permanently solve the aforementioned issues at a reasonable cost with minimal negative effects on the environment[10].

Agriculture has changed as a result of the ongoing adoption of recent, cutting-edge technologies like sophisticated sensors, Internet of Things devices, intelligent algorithms, and modern machinery. Currently, intelligent agricultural machinery and robots are replacing human labour in this task[11]. Intelligent agricultural devices and robotics have been created that can simultaneously track the long-distance movement of plants and identify plant diseases at an early stage. The irrigation industry uses the most water, accounting for nearly 80% of India's water resources and providing 25–40% of the country's water use efficiency (WUE). Therefore, reaching maximum yield is required to improve WUE. Modern information and communication technology (ICT) is essential for increasing WUE[12].

**Aerial Imaging and Mapping**

Aerial imaging and mapping, facilitated by advancements in drone technology, have revolutionized the way we perceive and understand our surroundings. Drones equipped with high-resolution cameras and sophisticated sensors enable the capture of detailed aerial imagery over large areas with remarkable precision. In fields such as urban planning, environmental monitoring, and agriculture, aerial imaging provides a comprehensive overview of landscapes, infrastructure, and natural resources[13]. The data collected through aerial mapping is crucial for creating accurate maps, assessing changes in land use, and identifying potential areas of concern such as environmental degradation or urban expansion. This technology has proven particularly valuable in disaster response, where rapid and detailed mapping can aid in assessing damage and planning relief efforts[14]. Aerial imaging and mapping not only enhance our ability to comprehend complex spatial relationships but also empower decision-makers across various sectors to make informed choices based on real-time, high-quality geospatial information. As drone technology continues to advance, the applications of aerial imaging and mapping are likely to expand, contributing to more effective and sustainable resource management practices[15].

Unmanned aerial vehicles have a lot of potential for mapping and can produce very accurate data. The market is filled with a wide variety of UAV models and designs.UAVs are capable of gathering images at a broad range of flight altitudes, from 0 to 2000 kilometers. The UAV's visibility (line of sight) and altitude are restricted by aviation regulations in numerous countries. Similar to manned flight, UAVs provide the same concept of image acquisition, but they don't need a pilot on board to carry out their mission[16]. UAVs can be quickly deployed and provide high-resolution images for areas with limited space. UAVs have the potential to be used in a range of applications and surveillance missions, including aerial tracking.

Fixed-wing UAVs can be radio-controlled by the operator or run independently. Because UAV turbulence is influenced by wind direction, autonomous flight control may occasionally perform the flight plan less accurately[17]. One benefit of autonomous flight missions, though, is that they can be utilized for large study areas without worrying about the limitations of human vision. Nevertheless, one must take into account the regional aviation laws.

Both manual and autonomous flight require an equal level of control, which includes monitoring the path being taken and looking for any anomalies in the UAV's instrumentation from the start of the mission until its conclusion. The operator's skill during the flight mission determines the UAV's level of safety[18].

## Precision Agriculture

Precision agriculture, empowered by drone technology, has emerged as a transformative approach to modern farming practices. Drones equipped with advanced sensors, cameras, and GPS technology provide farmers with a level of precision and efficiency previously unimaginable. In the realm of agriculture, these unmanned aerial vehicles enable detailed and real-time monitoring of fields, offering insights into crop health, nutrient levels, and pest infestations[19]. By capturing high-resolution aerial imagery, drones help identify and address issues at an early stage, allowing for targeted interventions and optimizing the use of resources such as water, fertilizers, and pesticides. This not only enhances crop yields but also minimizes environmental impact and reduces production costs. The ability to create precise maps of fields and analyze data at a granular level enables farmers to make informed decisions tailored to specific areas of their land. Precision agriculture through drones is not merely a technological advancement; it represents a paradigm shift in farming practices, promoting sustainability, resource efficiency, and increased profitability for farmers[20]. As the technology continues to evolve, the integration of drones into precision agriculture holds the promise of revolutionizing the way we cultivate and manage crops on a global scale.

The concept of site-specific management, or SSM, is acting appropriately in the appropriate location at the appropriate time. Although this concept predates agriculture, there was significant financial pressure to treat large fields using uniform agronomic practises during the 20th century agricultural mechanization [21]. By utilising information technology to automate SSM, precision farming makes SSM feasible in commercial agriculture. PA refers to all agricultural production techniques that use information technology, such as yield monitors, variable rate application (VRA), and remote sensing, to either monitor or customise the use of inputs to achieve desired results. Input management for temporal SSM must be based on knowledge of the life cycles of pests, livestock, and agricultural crops. Developmental stage (DS) information is a common term used to describe this temporal information[22].

Orange orchards in Florida developed applications for oranges. Orange orchard yield mapping system that is automated. Large bins were used to collect the fruits. A system of load cells mounted on the truck was used to weigh the bins as they were loaded onto the vehicles[23].

Using a DGPS system, the truck's location was determined. Maps of yield were produced using the data. a less complicated way to gauge the height of the fruit-filled bags. Weighed the workers' filled small plastic bins, which weighed about 20 kg, and used a DGPS system to track their location in order to create yield maps for apples and vines[24].

**Water Management**

Water management in agriculture has undergone a remarkable transformation with the integration of drone technology. Drones equipped with advanced sensors and imaging capabilities have become instrumental in assessing and optimizing water usage in fields. Aerial surveys conducted by drones provide farmers with valuable insights into soil moisture levels, irrigation efficiency, and overall crop health. These unmanned aerial vehicles can quickly and accurately identify areas with water stress or over-irrigation, allowing for precise adjustments in irrigation practices[25]. By delivering real-time data, drones assist farmers in making informed decisions about when, where, and how much water to apply. This targeted approach not only conserves water resources but also contributes to increased crop yields and improved quality. Additionally, drones aid in identifying leaks or inefficiencies in irrigation systems, further enhancing overall water management practices. The integration of drone technology into water management strategies exemplifies a sustainable and data-driven approach, ensuring the judicious use of water resources while promoting agricultural productivity[26]. As the technology continues to advance, the role of drones in water management is likely to expand, offering even more sophisticated solutions to address the challenges of water scarcity and efficient agricultural practices.

Water is frequently absorbed by land unevenly. Equipment used for watering may overlook certain parts or operate faster than others. The dry point at which crops wilt can be found using thermography and spectroscopy. Leaks in irrigation channels and equipment can also be found using imaging[27]. More importantly, farmers can evaluate the topography of their land by using software or airborne laser scanning technology that stitches thousands of high-quality aerial photographs into 3D maps. These maps show catchments, the direction of water flow at the base of each tree in the orchard, and other topographical characteristics that could have an impact on soil erosion and crop health[28].

Monitoring water stress: Characterising the effects of drought on crops is a challenging task due to the multiple factors that can influence and be affected by the effects of drought. Thermal image-derived variables frequently use minute temperature changes to identify stresses and other phenomena. Therefore, regression equations and thresholds that are derived under specific conditions typically do not hold under even slightly different conditions. For instance, due to innate variations in stomatal conductance and transpiration rates, different genotypes of a given crop may present significantly different canopy temperatures under the same conditions[29].

**Pollination Assistance**

Pollination assistance through drones represents a cutting-edge application of technology to address challenges in agriculture. With the decline of natural pollinators and concerns about pollination efficiency, drones have emerged as potential allies in ensuring successful fertilization of crops[30]. Equipped with specialized devices, these unmanned aerial vehicles can transport and distribute pollen over crops, mimicking the role of bees and other pollinators. The use of drone technology in pollination offers several advantages, including the ability to cover large areas efficiently and mitigate the impact of declining bee populations. Drones can navigate through fields with precision, delivering pollen to specific plants and optimizing the pollination process[31]. While the technology is still in its early stages and faces challenges such as developing efficient pollen-carrying mechanisms, the concept holds promise for sustaining agricultural productivity. As researchers and engineers continue to refine and innovate droneassisted pollination, it could become an integral part of future agricultural practices, contributing to food security in the face of pollinator declines and environmental changes[32].

Drones may eventually aid real bees in pollination, but bee robots might not contribute significantly. A startup out of New York has created a pollen dump drone to aid in the pollination of fruits like apples, cherries, and almonds. The company stated that it could increase drone rates from 25% to 65%; however, independent analysis confirmed that these numbers have not been reached. In spite of this, some fruit growers think drones could be helpful in orchards[33].

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**Canopy Management**

Canopy management is a critical aspect of optimizing fruit crops, and drones have emerged as invaluable tools for this purpose. Equipped with advanced imaging technology, drones provide a bird's-eye view of orchards and vineyards, enabling farmers to assess and manage the density and structure of the plant canopy[34]. Drones can capture high-resolution imagery, allowing for detailed analysis of the foliage, identifying areas of overgrowth, disease, or stress. This data aids in strategic pruning, thinning, and overall canopy manipulation to enhance sunlight exposure, air circulation, and fruit quality. The real-time and precise information provided by drones facilitates informed decision-making, ensuring that canopy management strategies are tailored to the specific needs of different sections within the crop. This targeted approach not only improves fruit quality and yield but also contributes to resource efficiency by minimizing unnecessary interventions[35]. As a result, canopy management through drones represents a transformative approach in horticulture, promoting sustainable practices and optimizing the balance between crop growth and environmental conditions. As technology continues to evolve, the integration of drones into canopy management practices is likely to become even more sophisticated, offering farmers precise insights for enhanced crop health and productivity[36].

A drone is used to drop seeds, and once the seeds reach their designated locations, they are dispersed. The drone can drop up to 60 seeds per minute and up to 28800 seed balls in eight hours. Startups have created drone planting systems that reduce planting costs by 85% and achieve a 75% uptake rate. In fact, experts predict that using drones for aerial spraying can complete the task up to five times faster than using traditional machinery. A human charges between 100 and 200 rupees a day to spray pesticides; in contrast, a drone uses 3 watts of power and only costs 10 rupees for electricity[37].

Compared to ground spraying, praying the pesticide with a drone at a height of 3.5 metres results in a higher droplet coverage rate and uniformity on the heated canopy. Approximately 80% of operating time, 90% of water consumption, and 50% of pesticide use can be reduced by using drones to spray pesticides[38].

**Inventory and Yield Estimation**

Yield estimation through drones has emerged as a transformative tool in horticulture, revolutionizing how farmers assess and manage their crops. Drones equipped with high-resolution cameras and sensors provide a unique aerial perspective that allows for detailed monitoring of horticultural fields[39]. These unmanned aerial vehicles can capture comprehensive data on plant health, canopy density, and fruit development, enabling accurate yield estimations. The ability to survey large areas quickly and efficiently allows farmers to identify variations in crop health and productivity across the field. The data collected by drones is processed through advanced analytics software, generating detailed maps and reports that aid in decision-making[40]. This information is invaluable for optimizing irrigation, fertilization, and pest control strategies to enhance overall crop yield. By integrating drone technology into horticultural practices, farmers gain a real-time understanding of their crops, enabling proactive measures and precise interventions. Ultimately, yield estimation through drones in horticulture not only improves the efficiency of crop management but also contributes to sustainable farming practices by minimizing resource inputs and maximizing output[41]. As technology continues to advance, the role of drones in horticultural yield estimation is likely to expand, offering increasingly sophisticated solutions for precision agriculture.

Because they are done by hand, the harvesting of oranges for the fresh market is one of the most costly activities related to Spanish citrus crops. At the moment, fruit size and yield data are only accessible following fruit harvesting, weighing, and sorting in processing facilities using automated commercial graders[42]. Fruit trait measurements done by hand take a lot of time and are prone to measurement and recording errors. Owing to developments in computers, cameras, and image processing techniques, numerous approaches based on counting the number of fruits have been developed recently to estimate crop yields[43].

For instance, guava, apples, and citrus fruits were the subjects of some past research on fruit recognition. To identify and count fruits, the majority of these methods, however, rely on algorithms that use the spectral response between pixels as a distinctive characteristic. Using such algorithms can decrease the accuracy of fruit detection because image pixels are highly sensitive to changes in illumination under unstructured light conditions[44].

Artificial intelligence (AI) methods, particularly artificial neural networks (ANNs), have been used recently for yield estimation based on fruit detection as an alternative to the aforementioned techniques. Thanks to developments in computer technology, these techniques have significantly improved over the past ten years, producing amazing outcomes in a variety of fields, including agriculture[45]. For example, ANNs have been used to estimate yields for apples, citrus, and mangos that have proven to be very successful. Experts define machine learning (ML), a non-linear information processing method based on feature extraction and pattern analysis, as a subset of deep learning (DL), which includes all of these tools. Scientists believe that in this case, technology will be able to take the place of farmers' innate wisdom and intuition[46].



## **Disease and Pest Surveillance**

Drones equipped with advanced sensors and imaging technology have proven to be invaluable tools in disease and pest surveillance in fruit crops. The aerial capabilities of drones allow for efficient and comprehensive monitoring of large orchards or vineyards, providing farmers with a detailed perspective on the health of their crops[47]. These unmanned aerial vehicles can capture high-resolution images and thermal data, enabling the early detection of potential disease outbreaks and pest infestations that may not be immediately apparent from ground-level observations. The ability to quickly and precisely survey the entire crop area facilitates timely interventions, such as targeted pesticide application or disease management strategies[48]. Drones can cover large areas in a relatively short time, making them particularly effective in identifying patterns of disease spread or pest movement. The data collected by drones is processed using specialized software, allowing for the creation of detailed maps that highlight areas of concern[49]. By incorporating drone technology into disease and pest surveillance practices, farmers can implement proactive measures to mitigate the impact of these threats, ultimately contributing to improved crop yields and the overall health of fruit crops. As drone technology continues to evolve, its role in enhancing the efficiency and effectiveness of disease and pest management in fruit agriculture is likely to expand[50].

It is possible for pathogens that cause plants to wither and otherwise ruin crops to go undetected. Despite the fact that green plants can have yellowing plants visible through spectral imaging technology, Schale of Virginia Tech is employing drones to find pathogens that have not yet settled in vacant spaces[51].

Crop diseases are categorized as bacterial, viral, or fungal and can be extremely destructive. Drones with infrared cameras are able to see inside plants, providing a clear picture of their state. When an infection is discovered early on, a farmer can take action to stop it from spreading to nearby plants, such as pulling the offending plant. Thus, when human assessment is inappropriate, unreliable, or unavailable, image-based tools can be crucial in identifying and diagnosing plant diseases, especially given the increased coverage that unmanned aerial vehicles (UAVs) provide[52]. While hyperspectral and thermal images have also been tested, RGB and multispectral images have been the most popular ways to gather data about the areas under study.

drone-based high-resolution aerial imaging for the detection of citrus greening disease, also known as Huanglongbing (HLB). Drones were equipped with a multi-band imaging sensor, and the flying altitude used to capture images was adjusted to achieve the required resolution. Next, the outcomes from drone-based sensors were contrasted with those from aircraft-based sensors that had less spatial resolution[53]. The seven vegetation indices (Vis) and six spectral bands, ranging in wavelength from 530 to 900 nm, made up the data. Relevant features were extracted from the spectral images captured by drones and aircraft using regression analysis. The findings showed that a dependable technique for identifying citrus trees infected with HLB is high-resolution aerial sensing[54].

Grapevine Trunk Disease (GTD) and Flavescence dorée (FD) are two diseases that affect grapevines in European vineyards. Vineyards are harmed by these diseases. Multispectral drone imagery can be an effective tool for identifying symptomatic vines. But as the aforementioned diseases in red vine cultivars demonstrate, different diseases can cause similar leaf discolorations[55]. The ability of drones to differentiate between symptomatic and asymptomatic vines was assessed by the authors. The study was carried out in France's southern regions. Five distinct red vine cultivars and seven vineyards were chosen. Drones equipped with the MicaSenseRedEdge® sensor captured multispectral images. Surface reflectance mosaics with a 0.10 m ground spatial resolution were produced by processing the images[56].

## Limitation of drone technology

While drone technology has brought significant advancements to fruit crop management, it is not without its limitations. One notable constraint is the limited payload capacity of most drones. As fruit crops vary in size, shape, and density, the payload capacity may restrict the types of sensors or equipment that can be carried[57]. This limitation can impact the range and depth of data collected, potentially hindering the comprehensiveness of surveys and analyses. Additionally, drones are sensitive to weather conditions, and adverse weather, such as strong winds or heavy rainfall, can impede their ability to operate effectively. The need for skilled operators is another limitation; individuals must be trained to pilot drones and interpret the data they collect accurately[58]. Furthermore, the initial cost of acquiring and maintaining drone technology, along with the expenses associated with software and data processing, can be a barrier for smaller-scale farmers with limited resources. Privacy concerns and compliance with regulations also pose challenges, as the use of drones in agriculture may raise issues related to data ownership, security, and adherence to airspace regulations. Despite these limitations, ongoing technological advancements and continued research are likely to address some of these challenges, making drone technology increasingly accessible and beneficial for fruit crop management[59].

The numerous shortcomings of current image sensor technology preclude its application in the early detection of illness. Integrating data from various sensors can improve predictions of crop growth and health. This clarifies the increased emphasis on multimodal data fusion for crop disease detection among researchers. In agriculture, data fusion can take many different forms, but the most popular ones are the combinations of data from several drone sensors and satellite and drone imagery[60]. Such data fusion approaches can improve the detection procedure for tasks like plant categorization and crop monitoring. In modern agriculture, the development of accurate, dependable, autonomous, real-time drone-based plant disease detection systems has become increasingly important[61].

## Conclusion

Drones have the potential to significantly change agriculture in India. Future technological advancements are anticipated to make drone production more affordable. Due to the arduous labour and drudgery involved, farming does not appeal to today's youth. Drones have the potential to intrigue and inspire young people to pursue careers in agriculture.

When it comes to high-quality, real-time aerial imagery over agricultural areas, drones outperform satellite imagery. Drones can also 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 fields thanks to drones. As a result, farmers will receive help in growing more food with fewer chemicals. Almost all farmers who have used drones have benefited in some way. They can use their land more effectively by tracking fires before they spread, improving irrigation for plants experiencing heat stress, removing pests before they destroy entire crops, and adjusting the quality of the soil to improve growth in trouble areas. Drones could therefore play a major role in agriculture in the future by assisting farmers in more sustainable and effective management of their fields and resources.



## References

1. A.M. Cunliffe et al., Ultra-fine grain landscape-scale quantification of dryland vegetation structure with drone-acquired structure-from-motion photogrammetry,(2016).
2. L. Deng et al., UAV-based multispectral remote sensing for precision agriculture: a comparison between different cameras, (2018)
3. P.J. Zarco-Tejada et al., Tree height quantification using very high resolution imagery acquired from an unmanned aerial vehicle (UAV) and automatic 3D photo-reconstruction methods(2014)
4. H. Aasen et al., Quantitative remote sensing at ultra-high resolution with UAV spectroscopy: a review of sensor technology, measurement procedures, and data correction workflows, (2018)
5. Agisoft LLC, 2019. AgisoftMetashape User Manual: Professional Edition, Version 1.5, G.P.
6. Bureau of Meteorology, Commonwealth of Australia Climate Data Online
7. S. Candiago et al., Evaluating multispectral images and vegetation indices for precision farming applications from UAV images, (2015)

8. Davies, F.T., Bowman, J.E., 2016. Horticulture, food security, and the challenge of feeding the world, 1128 ed, (2015)
9. E. Honkavaara et al., Radiometric correction of close-range spectral image blocks captured using an unmanned aerial vehicle with a radiometric block adjustmen, (2018)
10. J.R. Jensen, Introductory Digital Image Processing: A Remote Sensing Perspective, (2016)
11. F.M. Jiménez-Brenes et al., Quantifying pruning impacts on olive tree architecture and annual canopy growth by using UAV-based 3D modelling, (2017)
12. K. Johansen et al., Using multi-spectral UAV imagery to extract tree crop structural properties and assess pruning effects, (2018)
13. AERIAL TERRAIN MAPPING USING UNMANNED AERIAL VEHICLE APPROACH by K. N. Tahar,
14. Rejesus, R. M. and Hornbaker, R. H. 1999. Economic and environmental evaluation of alternative pollution-reducing nitrogen management practices in central illinois. Agriculture, Ecosystems and Environment 75, 41–53.
15. Wang, D., Prato, T., Qiu, Z., Kitchen, N. and Sudduth, K. 2003. Economic and environmental evaluation of variable rate nitrogen and lime application for claypan soil fields. Precision Agriculture 4, 35–52.
16. Whitley, K. M., Davenport, J. R. and Manley, S. R. 2000. Differences in nitrate leaching under variable and conventional nitrogen fertilizer management in irrigated potato systems. Proceedings of the 5th International Conference on Precision Agriculture, edited by P. C. Robert, R. H. Rust and W. E. Larson. (ASA-CSSA-SSSA. Madison, WI, USA).
17. Molin, J.P., Mascarin, L.S., Povh, F.P., Amaral, J.R., Oliveira, A.S. Proceedings of the 6th European Conference on Precision Agriculture, Skiathos, Greece. Poster Abstracts in CD; 2007.
18. Aggelopoulou, K. D., Fountas, S., Gemtos, T. A., Nanos, G. D., Wulfsohn, D. Precision farming in small apple fields of Greece. In: Proceedings of the 8th International Conference on Precision Agriculture. July 23-26, (Minneapolis, USA), CD-ROM; 2006.
19. Ben-Gal A., N.t Agam, V. Alchanatis. Y. Cohen, U. Yermiyahu, I. Zipori, E. Presnov, M. Sprintsin, A. Dag. Evaluating water stress in irrigated olives: correlation of soil water status, tree water status, and thermal imagery Irrig Sci 2009;27:367-376.

20. Aggelopoulou, K., Pateras, D., Fountas, S., Gemtos, T., Nanos, G. Soil spatial variability and site-specific fertilization maps in an apple orchard. Precision Agriculture 2010;12:118-129.
21. Alchanatis, V., Ostrovsky, V., Levi, O. Detection of green apples in hyperspectral images of apple-tree foliage using machine vision. Transactions of the ASABE 2007;50(6):2303-2313.
22. Wang Xianping. Advantages of UAV flying defense operations and techniques during operation Qiao [J]. Science and Technology Economics Guide, 2018, 26 (4): 57-58.
23. Ren Yaowu, Zhou Wei, Gong Jiwei, et al. Development of plant protection drones in Hubei Province.
24. Xiong Liping. Design of Vehicle Detector Based on Internet of Things Technology [J]. Internet of Things Technology, 2018, 8 (9): 92-95.
25. Aditya S Natu, Kulkarni SC. Adoption and Utilization of Drones for Advanced Precision Farming: A Review. published in International Journal on Recent and Innovation Trends in Computing and Communication, ISSN: 2321-8169. 2016; 4(5):563-565.
26. Zhang C, Kovacs JM. The application of small unmanned aerial systems for precision agriculture: a review. Precision agriculture, Springer. 2012; 13(6):693-712.
27. Everaerts J. The use of unmanned aerial vehicles (UAVs) for remote sensing and mapping. The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences. 2008; 37:1187-1192.
28. Colomina I, Molina P. “Unmanned aerial systems for photogrammetry and remote sensing: A review.”ISPRS Journal of Photogrammetry and Remote Sensing. 2014; 92:79-97.
29. Bendig J, Bolten A, Bareth G. Introducing a low-cost mini-UAV for thermal-and multispectral-imaging. Int. Arch. Photogramm. Remote Sens. Spat. Inf. Sci. 2012; 39:345-349.
30. Huang Y, Hoffmann WC, LAN Y, Wu W, Fritz BK. Development of a spray system for an unmanned aerial vehicle platform. Applied Engineering in Agriculture. 2009; 25(6):803-809.

31. Primicerio J, Di Gennaro SF, Fiorillo E, Genesio L, Lugato E, Matese A et al. A flexible unmanned aerial vehicle for precision agriculture. Precision Agriculture. 2012; 13(4):517-523.
32. Nonami K. Prospect and recent research & development for civil use autonomous unmanned aircraft as UAV and MAV.Journal of system Design and Dynamics. 2007; 1(2):120-128.
33. Colomina I, Molina P. “Unmanned aerial systems for photogrammetry and remote sensing: A review.” ISPRS Journal of Photogrammetry and Remote Sensing. 2014; 92:79-97.
34. Berni JAJ, Zarco-Tejada PJ, Suarez L, Fereres E. Thermal and Narrowband Multispectral Remote Sensing for Vegetation Monitoring From An Unmanned Aerial Vehicle. IEEE Trans. Geosci. Remote Sens. 2009; 47:722-738.
35. Suryawanshi, S., Baraskar, T., Umbrani, K., & Chitnis, A. (2022, August). Using Drone Technology for Fruit Orchard Management and Waste Reduction. In *2022 6th International Conference On Computing, Communication, Control And Automation (ICCUBEA* (pp. 1-9). IEEE.
36. Vandermaeseri, J., Rombouts, B., Delalieux, S., Bylemans, D., & Remy, S. (2021, July). Drone-acquired data in support of Belgian fruit production. In *2021 IEEE International Geoscience and Remote Sensing Symposium IGARSS* (pp. 6292-6295). IEEE.
37. Chen, C. J., Huang, Y. Y., Li, Y. S., Chen, Y. C., Chang, C. Y., & Huang, Y. M. (2021). Identification of fruit tree pests with deep learning on embedded drone to achieve accurate pesticide spraying. *IEEE Access*, *9*, 21986-21997.
38. Gulzar, U., Gulzar, U., Jamwal, M., Singh, P., Kour, K., & ji Bhai, D. (2022). PRECISION FARMING IN FRUIT CROPS. *Sustainable Development for Society, Industrial*, 167.
39. Ren, Q., Zhang, R., Cai, W., Sun, X., & Cao, L. (2020, February). Application and development of new drones in agriculture. In *IOP conference series: earth and environmental science* (Vol. 440, No. 5, p. 052041). IOP Publishing.
40. Saha, A. K., Saha, J., Ray, R., Sircar, S., Dutta, S., Chattopadhyay, S. P., & Saha, H. N. (2018, January). IOT-based drone for improvement of crop quality in agricultural field. In *2018 IEEE 8th Annual Computing and Communication Workshop and Conference (CCWC)* (pp. 612-615). IEEE.

41. Egi, Y., Hajyzadeh, M., &Eyceyurt, E. (2022). Drone-computer communication based tomato generative organ counting model using YOLO V5 and deep-sort. *Agriculture*, *12*(9), 1290.
42. Nonami, K. (2016). Drone technology, cutting-edge drone business, and future prospects. *Journal of Robotics and Mechatronics*, *28*(3), 262-272.
43. Reinecke, M., & Prinsloo, T. (2017, July). The influence of drone monitoring on crop health and harvest size. In *2017 1st International conference on next generation computing applications (NextComp)* (pp. 5-10). IEEE.
44. Rieder, R., Pavan, W., Carré Maciel, J. M., Cunha Fernandes, J. M., &Sarroglia Pinho, M. (2014). A virtual reality system to monitor and control diseases in strawberry with drones: A project.
45. Rehna, V. J., & Inamdar, M. N. (2022). Impact of Autonomous Drone Pollination in Date Palms. *International Journal of Innovative Research and Scientific Studies*, *5*(4), 297-305.
46. Roslim, M. H. M., Juraimi, A. S., Che'Ya, N. N., Sulaiman, N., Manaf, M. N. H. A., Ramli, Z., &Motmainna, M. (2021). Using remote sensing and an unmanned aerial system for weed management in agricultural crops: A review. *Agronomy*, *11*(9), 1809.
47. UPADHYAYA, A., JEET, P., SUNDARAM, P. K., SINGH, A. K., SAURABH, K., & DEO, M. (2022). Efficacy of drone technology in agriculture: A review: Drone technology in agriculture. *Journal of AgriSearch*, *9*(3), 189-195.
48. Surekha, P., Venu, N., Shetty, A. N., & Sachan, O. (2020, December). An automatic drone to survey orchards using image processing and solar energy. In *2020 IEEE 17th India Council International Conference (INDICON)* (pp. 1-7). IEEE.
49. Alam, A., Chauhan, A., Khan, M. T., & Jaffery, Z. A. (2022). Drone-Based Crop Product Quality Monitoring System: An Application of Smart Agriculture. In *Agri-Food 4.0* (Vol. 27, pp. 97-110). Emerald Publishing Limited.
50. Basri, R., Islam, F., Shorif, S. B., & Uddin, M. S. (2021). Robots and drones in agriculture—a survey. *Computer vision and machine learning in agriculture*, 9-29.
51. Gupta, R., Kataria, D., & Tripathi, B. S. (2023). Drone Harvester: Detect and Collect Ripen Fruit and Vegetables. In *Applying Drone Technologies and Robotics for Agricultural Sustainability* (pp. 108-123). IGI Global.

52. Bansod, B., Singh, R., Thakur, R., & Singhal, G. (2017). A comparision between satellite based and drone based remote sensing technology to achieve sustainable development: A review. *Journal of Agriculture and Environment for International Development (JAEID)*, *111*(2), 383-407.
53. Ilyas, M. (2020). Drones at our Service. *The Journal of Systemics, Cybernetics, and Informatics*, *18*(7), 126-131.
54. Romero, A., Sánchez-DelaCruz, E., & Ochoa, A. (2022). Implementation of an intelligent model based on Convolutional Neural Network for the detection of diseases in citrus crops caused by bird pests using an intelligent drone. *Technological and Industrial Applications Associated With Industry 4.0*, 3-22.
55. Ali, Z. A., Yang, C., Israr, A., & Zhu, Q. (2023). A Comprehensive Review of Scab Disease Detection on Rosaceae Family Fruits via UAV Imagery. *Drones*, *7*(2), 97.
56. Potts, S. G., Neumann, P., Vaissière, B., & Vereecken, N. J. (2018). Robotic bees for crop pollination: Why drones cannot replace biodiversity. *Science of the total environment*, *642*, 665-667.
57. Alyafei, M. A., Al Dakheel, A., Almoosa, M., & Ahmed, Z. F. (2022). Innovative and Effective Spray Method for Artificial Pollination of Date Palm Using Drone. *HortScience*, *57*(10), 1298-1305.
58. Mandla, V. R., Chokkavarapu, N., &Peddinti, V. S. S. (2021, April). Role of Drone Technology in Sustainable Rural Development: Opportunities and Challenges. In *International Conference on Unmanned Aerial System in Geomatics* (pp. 301-318). Cham: Springer International Publishing.
59. Hensh, S. Application of Drone in Agriculture: An Overview.
60. Thongnim, P., Yuvanatemiya, V., Charoenwanit, E., &Srinil, P. (2023, June). Design and Testing of Spraying Drones on Durian Farms. In *2023 International Technical Conference on Circuits/Systems, Computers, and Communications (ITC-CSCC)* (pp. 1-6). IEEE.
61. Kumar, A., Ahamad, S., Kumar, M., Bihari, C., Singh, S., Pandey, V., ... & Gautam, P. (2022). An innovative drones technology in agriculture: A.