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Navigation Challenges: Integrating Agri-drones in hilly agriculture

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Introduction

Given the perpetually increasing demand for food, agriculture is the only industry that will consistently thrive. The sector is witnessing a continuous influx of technologically advanced and fast farm implements, greatly enhancing efficiency in agriculture. Various farm implements have been put to use or are being introduced, from sowing to harvest, effectively reducing the time required for various farming operations. A recent advancement, especially in India, is the integration of Agri-drones. Drone technology reduces the time for certain farm operations and increases overall efficiency for farmers. The Government of India is actively promoting drone usage in agriculture, providing Agri drones to ICAR institutes, SAUs, and KVKs since 2022 to encourage their adoption for agricultural purposes. The government has also initiated the certification process for agricultural drones.

They have significantly contributed to modern agriculture by offering time-saving and innovative solutions in diverse agricultural operations. In India, hexacopters with six propellers or rotors are currently the most popular type of drone in agriculture, extensively used for pesticide spraying and precision agriculture tasks. The higher number of propellers enhances stability and payload capacity. Octocopters with eight propellers offer similar advantages. Other types of drones, such as fixed-wing drones resembling small airplanes, single-propeller helicopter drones, quadcopters with four propellers, and vertical takeoff and landing drones with a combined advantage of fixed wing and multirotor drones, cater to specific requirements in the agriculture sector.

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Drones find applications in various activities, including surveying, monitoring, agrochemical spraying, and broadcasting seeds in inaccessible areas. Farmers often face challenges in assessing crop health and determining suitable management strategies. These modern farm machines offer numerous advantages, including enhanced precision due to GPS integration, enabling accurate crop health assessment. Drones can be equipped with advanced imaging techniques like infrared radiation to evaluate crop health. Drones equipped with thermal sensors can assist in determining irrigation requirements for the fields. Drones equipped with tanks and sprayers streamline the usage of drones for pesticide and fertilizer spraying. This allows stakeholders to care for crops by spraying agrochemicals while minimizing direct contact and inhalation risks associated with different chemicals.

Drones come with an array of advantages. They facilitate rapid and efficient data collection over large agricultural areas. Drones with high-resolution cameras and sensors provide detailed images and data, enabling a closer look at crop health, disease detection, and nutrient deficiencies. This early detection allows farmers to address pest outbreaks or water stress promptly through targeted interventions, such as variable-rate fertilizer application. However, alongside these advantages, certain drawbacks need to be considered, including the high cost leading to a substantial initial investment, coupled with various regulatory and legal challenges. Weather conditions can also restrict drone operations, and the requirement of specific software and knowledge for data processing poses limitations. The pros and cons should be carefully weighed depending on the specific conditions and utilization.

One such unique condition is the application of drones in states with hilly terrain. Using drones in hilly areas presents challenges different from those in plain areas of the country. Himachal Pradesh is one such state divided into four agroclimatic zones: (i) Sub tropical, sub mountain and low hills, (ii) Sub temperate, sub-humid mid hills, (iii) Wet temperate high hills, and (iv) cold deserts. The agriculture in the state is mostly rainfed, with rice, wheat and maize grown as main cereal crops, and soyabean, sunflower and mustard as key oilseed crops. The state has diverse agroclimatic conditions, making it suitable for producing temperate and tropical fruits. The area under horticultural crops has increased from 792 ha in 1950-51 to 2,35,785 ha in 2021-22. Apple, mango, orange, pear, plum, peach, galgal and apricot are the major horticulture crops in the state. Vegetable production, including the off-season vegetables, is the major cash crop of the state.

The farmers have small land holdings. As per the economic survey (2022-23) of Himachal Pradesh, the total number of operational holdings in the state is 9.97 lakh, covering an area of 9.44 lakh ha and the average size of land holding is 0.95 hectares. Amongst them, 71.45 % of farmers have

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marginal holdings, with less than 1 ha of land, and 17.45 % have small holdings, with 1-2 ha land. In hilly states like Himachal Pradesh, where a significant proportion of farmers have small landholdings and limited income, the adoption of drones has yet to gain popularity.

The cost of drones in India remains prohibitively high for small and marginal farmers. Moreover, the hilly terrain and small, terraced farms pose practical challenges for drone usage, impacting flight efficiency and necessitating additional battery sets. The current guidelines issued by DGCA do not adequately address the specific requirements of flying drones in such terrains where visibility and maneuverability are compromised.

In orchards with uneven tree heights, drones with height-adjusting sensors face the risk of collisions with taller adjacent trees during spraying. Even without these sensors, pilots must manually adjust the height, increasing the risk of crashes.

Utilizing drones in hilly regions presents unique challenges due to the distinctive topography and environmental conditions. Some of the primary difficulties of drone applications in the hilly areas include:

1. **Terrain complexity:** Hilly areas have rugged and uneven terrain, making it challenging for drones to maintain stability and navigate smoothly. The abrupt elevation changes can result in loss of communication and control, risking the safety and integrity of the drone.
2. **Limited line of sight (LOS):** Visual line of sight is crucial for safe drone operation, but in hilly regions, the undulating landscape can obstruct the operator's line of sight, making it difficult to maintain control and comply with safety regulations.

Another important issue in the case of hilly areas is that the fields are small and terrace farming is practised. The Remote Pilot certificate issued by DGCA is either VLOS (Visual line-of-Sight) or BVLOS (Beyond visual line-of-Sight). It is essential to understand this terminology. VLOS means that the Pilot, i.e., person with a valid Remote pilot certificate (License) can fly a drone in an area where the drone is clearly visible to the Pilot. In case of the Agri-drones, the Remote pilot certificate (RPC) issued is of VLOS type. The person having this type of RPC is supposed to fly the drone uptill the time the drone is in front of his or her eyes. But in terrace farming, when the Pilot stands at the bottom of the hill and launches the drone from the bottom, the drone will not be visible after three or four steps. The Pilot will have to land the drone after two or three steps, climb the steps, look out again for a suitable place for launching the drone and then fly the drone and spray the crop. This process will be repeated several times, which may lead to the battery's drainage due to the drone repeatedly launching and landing. Thus, the efficiency of battery and drone will be reduced and the time taken for spraying

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one payload will be more than in the plain farms. In Himachal Pradesh, apple is the main crop which accounts for the more than 80 % of total fruit production of the state. In an orchard to spray any input using drone, the drone will not be in front of the eyes of the Pilot. After taking the flight, when the drone crosses a few trees, it will not be visible to the pilot from between the canopy.

Uptill now DGCA has no guidelines regarding what type of RPC will be required while flying an Agri-drone in such conditions. As per the prevalent guidelines in such conditions, a BVLOS type of RPC is required as the drone will not always be in front of eyes/ visible to the Pilot.

In the orchards, the trees are not of uniform height. The drone equipped with the sensor at the bottom will automatically adjust the height during spraying. While changing the height, it may come in contact with the adjacent trees with more height and chances of crash will always be there. Even if the drone is not equipped with a sensor and the option of adjusting the height during spray is not given, the pilot will also have to adjust the height for the spray. The risk of a crash will also prevail in that condition.

3. **Weather variability:** Hilly areas often experience unpredictable and rapidly changing weather patterns, including strong winds, fog, and rain. Adverse weather conditions can disrupt drone flights, leading to unsafe operations and data inaccuracies.
4. **GPS inaccuracy and signal loss:** The steep terrain and dense vegetation in hilly regions can interfere with GPS signals, causing inaccuracies in positioning and navigation. Signal loss can pose a significant challenge, especially when relying on GPS for safe and precise drone operation.
5. **Limited flight time and battery life:** Drones typically have a limited flight time due to battery constraints. In hilly areas, the constant adjustments in altitude and the need for higher power consumption can reduce the drone's flight time, limiting the area that can be covered in a single flight.
6. **Landing and takeoff challenges:** Finding suitable and safe takeoff and landing spots can be difficult in hilly terrains. Trees, rocks, and uneven surfaces may hinder smooth takeoffs and landings, potentially damaging the drone.
7. **Payload capacity constraints:** The limited payload capacity of drones becomes more pronounced in hilly regions, where additional equipment or sensors might be required for specific tasks. This constraint affects the drone's ability to carry necessary payloads for various applications.

8. **Cost constraints**: The initial investment required for drones is relatively high, and this cost can be a significant barrier to adoption, particularly for farmers or small businesses in hilly regions with limited financial resources.
9. **Regulatory Compliance and Permissions:** Complying with aviation regulations and obtaining necessary permissions for drone operations can be complex and time-consuming. Additional clearances might be needed in hilly areas due to environmental sensitivities and protected regions.

a. Use of drone in Terrace farming situations

b. Hindered view of drone due to trees

Addressing these challenges requires tailored solutions, specialized training, improved technology, and a thorough understanding of the specific demands of operating drones in hilly terrains. Considering its potential benefits and limitations, a thoughtful approach to adopting drone technology is required.

Conclusions

Agri-drones are gaining prominence in India, offering the potential to reduce operation time and amplify overall productivity for farmers. Drones have proven effective in modern agriculture, delivering time-saving and innovative solutions across diverse operations. Drones find application in surveys, monitoring, agrochemical spraying, and seed broadcasting, presenting a array of advantages, including precision enhancement through GPS integration and various imaging techniques for crop health assessment. However, alongside drones' remarkable advantages, there are considerations to weigh, including the substantial initial investment and regulatory challenges. In hilly terrains like those in Himachal Pradesh, unique challenges arise, ranging from the cost barrier for small farmers to the

complexities of flight operations in rugged landscapes and orchards with uneven tree heights. In such challenging terrains, addressing the complexity of the landscape, ensuring clear communication and control, and maneuvering within unpredictable weather patterns is paramount. As the application of drones in agriculture continues to evolve, it must be carefully tailored to suit the distinctive needs and challenges of hilly regions, emphasizing safety, efficiency, and sustainable agricultural practices.