APPLICATION OF UAV FOR SUSTAINABLE AGRICULTURE IN HILLY REGIONS

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INTRODUCTION:

Throughout history, humans have developed various agricultural methods to sustain their communities. This has led to the creation of agricultural systems tailored to specific geographic conditions, emphasizing the balance between meeting demands and sustainable resource use. Traditional farming practices, particularly in hilly regions like India's Himalayas, have supported entire communities, highlighting the importance of resilience in adapting to environmental and social changes. These areas, inhabited by millions, rely heavily on subsistence farming despite facing challenges such as rugged terrain, unpredictable weather, and limited accessibility. Sustainable agriculture and agro-biodiversity maintenance offer solutions to these challenges, contributing to food diversity, farmer earnings, and ecosystem preservation. However, achieving sustainable agriculture requires the adoption of new technologies and practices, including Information and Communication Technologies (ICT), which play a crucial role in addressing the unique challenges faced by farmers. ICT tools, such as weather forecasting applications and Geographic Information System (GIS) technology, enable informed decision-making and optimized land use. Unmanned Aerial Vehicles (UAVs) have also found applications in agriculture, aiding in crop monitoring, spraying, and disease detection.

APPLICATION OF UAV

UAV has huge scope of application in agriculture and some of the major implementation areas are discussed in the following section.

1. **UAV as a farmer:** One of the significant advantages of drones in hill agriculture is their ability to survey and map the land. By using UAVs, farmers can keep a watch on their crops from above, giving them a bird's eye perspective of the whole agricultural area. The observations made from sky offer valuable new perspectives on pest infestations, soil fluctuations, and irrigation problems. With regard to livestock, UAVs assist in animal counting and conduct in-depth analyses of their eating patterns. The data gathered from the sky levels assists farmers in identifying issues in a priority manner so they may make the best decisions possible to control production and increase profit margins. The farmers face significant hurdles due to the size of the crop fields, which makes them challenging to oversee. The issues are made worse by the unpredictable weather, which raises the labor and risk costs associated with field maintenance. These difficulties are mitigated in part by UAVs fitted with cameras based on RGB or thermal imaging sensors. Hexacopter, quadcopters, and fixed-wing monocopter cameras equipped with multispectral or hyperspectral sensors are commonly utilized for agricultural surveillance. They're also used for efficient chemical spraying, safeguarding farmers from dangerous chemical exposure. In this instance, infrared thermal imaging sensors are crucial to the assessment of

droplet deposition, helping to guarantee field homogeneity throughout the spraying process.

2. **UAV for crop health monitoring:** In hill areas, where access to crops can be challenging, this aerial perspective allows farmers to monitor their crops without physically reaching every corner of the field. Throughout the crop season, drones can be used to monitor crop conditions, enabling prompt and necessary action to be made. According to the reflection pattern at different wavelengths, various multispectral indices can be calculated by utilizing various types of sensors related to visible, near-infrared, and thermal infrared radiation. These indices can be used to evaluate various agricultural situations, such as nutrient stress, insect-pest attack, diseases, and water stress. Even before symptoms become apparent, the sensors installed on the drones can detect the prevalence of diseases or deficiencies. As a result, they are a tool for early disease identification. Drones can be utilized as an early warning system in this way, allowing preventative measures to be applied in a timely manner according to the severity of the stress. UAVs may observe crops using different indices. In a single flight, the UAVs can cover up to hectares of fields. The quadcopter is equipped with thermal and multispectral cameras to record the reflectance of the vegetation canopy for this observation. The camera records one image every second, saves it in memory, and transmits it via telemetry to the ground station.
3. **UAV for spraying:** Traditionally, the farmers in the hill areas had to rely on

manual spraying, which were not only time-consuming but also posed risks to their health and safety. Depending on how differently the crops and field are arranged in space, drones can be used to spray chemicals such as insecticides, fertilizers, etc. Depending on the crop conditions or the intensity of the insect-pest attack, the quantity of chemicals to be sprayed might be changed. Researcher proposed the Quad copter (QC) system which is low cost, and lightweight. Compared to tractors, drones can spray fields much more precisely since they can carry tanks full of insecticides and fertilizers. By doing this, expenses are reduced as well as the possibility of worker exposure to pesticides when such crops were sprayed manually. Throughout the irrigation season, ground equipment application is utilized in addition to aerial spraying to maintain a constant crop nutrient status. Studies show that monitoring can be done using unmanned aerial vehicles (UAVs), specific camera sensors (like thermal and optical cameras), and specialist optical filters (like Red Edge or hyper spectral cameras). Fertilizer and pesticides were sprayed using accelerometer and gyroscope sensors, which can save time and labor.

4. **UAV for soil and field analysis:** When the agricultural cycle starts, drones can be quite helpful in which they create accurate three-dimensional maps that are helpful in planning seed planting patterns for early soil analysis. Drone-based soil analysis after planting gives information for controlling nitrogen levels and irrigation.
5. **UAV for nutrient status and deficiency monitoring:** For plants to grow and yield heavily, the right amounts of nutrients are required. Appropriate amounts of nitrogen will guarantee

robust foliage and vegetation growth; appropriate amounts of phosphorous are needed for robust root and stem growth; and appropriate amounts of potassium are needed to improve disease resistance and guarantee higher-quality crop production. Any deficiency in these nutrients in the soil can cause stress to the plant, making it difficult for it to grow. Using NDVI Index mosaics, it is able to determine the precise crccop areas that are under stress or having difficulties developing and to directly focus on these areas. Long before the problem is apparent to the unaided eye, these management zones can be identified using the NIR/ multispectral imaging that the UAVs offer. This implies that it is possible to target these management zones prior to crop development and yield being affected. Because of its relationship to yield and biomass, nitrogen has been the nutrient that has been investigated the most. Sodium and potassium have also drawn considerable interest.

6. **UAV for slope and erosion monitoring:** UAVs equipped with high-resolution cameras and LiDAR technology can be used to assess slope stability and erosion rates in hilly regions. This information is crucial for implementing soil conservation measures and preventing landslides
7. **UAV for irrigation:** In hill areas, irrigation management is crucial due to limited water availability and challenging terrain. Drones equipped with thermal sensors can identify areas of excess moisture or water stress in fields, aiding farmers in optimizing their irrigation practices. Through specifying areas needing different water levels, farmers can curtail water wastage, enhance water-use efficiency, and promote optimal crop health and growth. This precision irrigation method not only conserves water resources but also fosters sustainable farming practices.

CONCLUSION:

UAVs offer transformative opportunities for sustainable agriculture across diverse landscapes, including hilly and mountainous regions. These aerial platforms equipped with various sensors and cameras enable farmers to gather valuable data with precision and efficiency. In such challenging terrains, UAVs provide crucial insights into crop

health, soil conditions, and pest infestations, allowing for targeted interventions and resource optimization. High-resolution imagery captured by drones aids in the early detection of erosion-prone areas and facilitates the implementation of erosion control measures like reforestation and contour farming. Additionally, UAVs equipped with thermal sensors can monitor microclimates and assist in irrigation management, conserving water resources in water-stressed regions. Moreover, drones support precision agriculture practices by delivering inputs such as seeds, fertilizers, and pesticides precisely where needed, minimizing wastage and environmental impact. By integrating UAV technology into agricultural operations, hilly and mountainous regions can enhance productivity, reduce costs, and promote sustainable land management practices for long-term resilience and prosperity.