**Sky-Farming: Evaluating the Role of Drone Technology in Enhancing Agricultural Sustainability**

**Abstract**—Climate change and local weather conditions have posed significant challenges in the farming sector. To secure food and water supplies, precision agriculture and smart farming have become essential. Unmanned aerial vehicles (UAVs), commonly known as drones, play a crucial role in this context. They offer various benefits in agriculture, including counting plants, visual inspection of crop fields, water management, erosion analysis, soil moisture assessment, crop health evaluation, and yield forecasting. Beyond agriculture, drones also contribute to rural development by collecting data related to land boundaries, water resources, village boundaries, forest monitoring, and soil conditions. Detecting problems associated with rural development promptly is crucial to prevent further degradation of soil and water resources. This paper explores the opportunities and challenges of sustainable rural development through the application of UAVs, allowing significant advancements in human life support.

**Index Terms**—Drones, Internet of Things (IoT), sustainability, optimal data collection, precision agriculture.

**I. Introduction**

Drones, the futuristic marvels once confined to military operations, have swiftly infiltrated various facets of our lives. These Unmanned Aerial Vehicles (UAVs), with their ability to soar above landscapes, have transcended boundaries, spanning continents and countries. According to dronedeploy.com, they now command the skies over 7 continents and have left their mark in 160 countries, covering an expansive 25 million acres. From military reconnaissance to breathtaking aerial photography, drones have evolved into indispensable tools across diverse sectors.

One of the most notable domains to embrace drone technology is agriculture. In the midst of labour shortages and the pressing need for precision farming, drones have emerged as saviours for farmers. Once deemed a luxury beyond the reach of the farming community, drones are now within grasp, offering a pathway to enhanced efficiency and productivity. This technological leap has transformed the agricultural landscape, offering solutions to age-old challenges and ushering in a new era of farming.

As we delve into the realm of drones, it becomes evident that their impact transcends mere convenience; it is a catalyst for economic growth. Studies project that between 2015 and 2025, the global economy stands to gain over 70 billion Euros from the proliferation of drone technology. This staggering figure underscores the transformative power of drones, not just as tools of innovation but also as engines of economic progress.

In this ever-evolving narrative of technological advancement, drones stand as emblematic symbols of human ingenuity. Their ascent from military bunkers to farmland skies symbolizes our relentless pursuit of progress and our unwavering commitment to harnessing technology for the betterment of society. Join us as we soar through the skies of innovation, exploring the boundless possibilities that drones offer in shaping our future.

**Types of Drones**

In this study, drones have been classified into seven categories ie: Micro Air Vehicles (MAV), Vertical take-off and landing (VTOL), Low Altitude- Short Endurance (LASE), Low Altitude- Short Endurance Close, Low Altitude low endurance, Medium Altitude and High Altitude Long Endurance (HALE).

**Micro Air Vehicles (MAV**): Because of their scale, they are very often called as Nano-Air aircraft, which usually allows military variants of these air craft to be carried in backpacks of soldiers and enables unobtrusive monitoring ability in cramped spaces. Such aircrafts usually operate at lower altitudes (<330 m), with battery life constraints contributing to shorter flight times near 5-30 minutes. But, their development on commercial scale is still in infant stage.

**Vertical take-off and landing (VTOL)**: These aircrafts do not entail a take-off and landing flight, and therefore are usually used in instances where terrain constraints demand this advanced ability. They fly at different heights, based on the mission profile but mostly at lower altitudes and high battery power demands for flight hovering restricts flight timeframes. VTOLs have major advantage of remote area network portability, without any need for pathway complexes.

**Low Altitude-Short Endurance (LASE)**: Mini unmanned aerial systems often eliminate necessity of aircraft runways designed for fast zone deployment and conveyance. Typically it has a weight of 2 to 5 kg and less than three metre length of wingspans to launch the aircraft from catapult configuration. Weight-capacity sacrifices tend to reduce the range of strength and connectivity to 1-2 hours, but within a few kilometres of ground stations.

**LASE Close**: This group defines tiny unmanned aircraft which requires runways of greater weight and size with enhanced capabilities. They have relatively high flight time which can operate to an altitude of 1500 m and these constraints were addressed through explicitly modified "record- breaker" aircraft substantially.

**Low Altitude - Long Endurance (LALE)**: United States Federal Aviation Administration gave a designation to this type of drones based on their capability to carry input payloads to an extreme upper end with a high weight (kg) at relatively higher altitude for prolonged period of time.

**Medium Altitude Long Endurance (MALE)**: Usually these aircrafts are much bigger than low-altitude UAV groups, flying at altitudes up to 9,000 m through hundreds of kilometres of flights from their base stations which last several hours. These have magnificent role in taking strategic decisions for military defence services and inflated usage are seen in some areas of civil applications.

**Literature survey**

Prof. P. P. Mone, Chavhan Priyanka Shivaji, Jagtap Komal Tanaji, Nimbalkar Aishwarya Satish has published a paper entitled “Agriculture Drone for Spraying fertilizer and Pesticides”. In this paper authors has given detail about implementation of Agriculture drone for automatic spraying mechanism. In this paper, they gave problem statement of World Health Organization where it estimates that there are 3 million cases of pesticide poisions in each year and upto 220,000 deaths, primarily in developing countries. In this paper they also explain what precautions the farmer should have to use to avoid harmful effects of pesticides and fertilizing effects as well as cost effective technology using components such as PIC microcontroller for the control of agriculture robots. The published paper is available at IJRTI, Volume 2, Issue 6, 2017.[1]

Prof. S. Meivel M.E., Dr. R. Maguteeswaran Ph.D., N. Gandhiraj B.E., G. Srinivasan Ph.D. has published a paper entitled “Quadcopter UAV based Fertilizer and Pesticide Spraying System”. In this paper authors has given detail about implementation of Agriculture wonder drone. They gave detail about Quadcopter UAV and sprayer module and also discuss pesticide content to the areas that can’t easily accessible for human beings. They discussed used of multispectral cameras which is used to capture remote sensing images to identify the green field as well as the edges of crop area. Total pay load lift of their quad copter is 8 kg. They used QGIS software for the purposed of analyzing the remote sensing images. The published paper is available at International Academic Research, Journal of Engineering Sciences, Volume 1, Issue 1, February 2016.[2]

**Methodology**

An ever-increasing global labour force does not match plant growth proportionately; thus there is widespread concern about food production sustainability. In such an effort to address this task, growers all over the world nave to acclimate for the advanced and computerised solutions to maintain the world's human population farming needs, which are in constant state of flux. At present, drones are used in agricultural fields to determine crop biomass, growth and production pattern in determining precision application of input resources, aid in harvesting the produce and optimization of logistics.

**Field and soil assessment:** Before the start of the season and after crop planting, data collected by drones regarding soil analysis is instrumental in planning the crop species to be sown, pattern of planting and determining the amount and time of irrigation and nutrient application. These management decisions taken at farm level can enhance overall productivity of the farm. This kind of approach in agriculture fetches scope to adapt site specific management practices ie. precision farming.

**Plant establishment:** Due to labour scarcity, now-a-days sowing of crops has become an expensive and burdensome endeavour which traditionally requires a great deal of human labour. Drones have simplified planting of crops on large scale with utmost exactness and accuracy in short time of span. This method of planting using drones has brought down the cost of planting up to 85 per cent and reduces the strenuous work through on-the-ground-planting.

**Precision crop spraying:** Site specific crop spraying can be done using drones equipped with sensors where it scans the cropped area on real time basis and ensures precise quantity of liquid (like pesticides and nutrients) is sprayed on that target place. Indeed, experts estimated that drones can complete aerial spraying up to five times faster than those of conventional spraying. It enhances accuracy in spraying, saves time and input costs of farmers. It indirectly reduces pesticide pollution in groundwater.

**Crop monitoring:** Crop production challenges i.e. unpredictable weather extremes create biggest obstacle in monitoring crop at field level. The greatest benefits of using unmanned drones are its simplicity and efficiency of massive-scale surveillance of crops and agricultural land. Well into the earlier days, satellite imagery had been used to get a view.

**Conclusion:**

In conclusion, the integration of machine learning with drones represents a transformative paradigm in agriculture, offering unparalleled capabilities for plant health monitoring and data collection. By harnessing the power of advanced sensors, cameras, and ML algorithms, farmers can make informed decisions in real-time, leading to improved crop management practices and sustainable agriculture. This synergy between ML and drones not only enhances efficiency and accuracy but also fosters precision agriculture, ultimately contributing to increased crop yields, reduced environmental impact, and food security for future generations. As technology continues to evolve, the potential for ML-enabled drones to revolutionize agriculture remains promising, paving the way for a more resilient and productive agricultural sector.

**References:**

[1] Prof. P. P. Mone, Chavhan Priyanka Shivaji, Jagtap Komal Tanaji, Nimbalkar Aishwarya Satish “Agriculture Drone for Spraying Fertilizer and Pesticides”, International Journal of Research Trends and Innovation, (ISSN 2456-3315, Volume 2, Issue 6). September 2017.

[2] S. Meivel M.E, Dr. R. Maguteeswaran Ph.D., N. Gandhiraj B.E, G. Sreenivasan Ph.D., “Quadcopter UAV Based Fertilizer and Pesticides Spraying System”, International Academic Research Journal of Engineering Sciences, ISSN No. 2414-6242, Volume 1,Issue 1, February 2016.

[3] https://youtu.be/wagjFXb\_uz4?si=GI7CkPCwID0A8jM6.

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