Agri Articles
(e-Magazine for Agricultural Articles)
Volume: 05, Issue: 02 (MAR-APR, 2025)
Available online at http://www.agriarticles.com
©Agri Articles, ISSN: 2582-9882

Drone Application: A Game Changer in Agricultural Sector

(Sarthak Pattanayak[1], Priyanka Das[2], *K.R. Hemasree[3], Nori Maheswari[3] and Roman Kumar Mahto[3])

[1]Krishi Vigyan Kendra, OUAT, Puri, Odisha-752014, India

[2]Assistant Horticulture Officer, Department of Agriculture and Farmers' Empowerment, Govt. of Odisha

[3]Department of Agronomy and Agroforestry, M. S. Swaminathan School of Agriculture, Centurion University of Technology and Management, Paralakhemundi, Odisha, India

*Corresponding Author's email: 230805190025@centurionuniv.edu.in

Agriculture creates millions of rural livelihoods in India, but it suffers from unpredictable weather patterns, pest infestations, and a total dependency on traditional farming practices. The combination of smart farming and precision agriculture particularly through the use of agricultural drones is the disruptive solution. Drones mounted with high-resolution cameras, multispectral sensors, and thermal imagining enable airborne surveillance, soil analysis, precision crop planting, nutrient management, and targeted watering, thus improving agricultural productivity. They optimize chemical use while helping in pest management, crop health monitoring, and assessment of damages. They also assist with livestock management and geofencing, as well as crop insurance assessment and weather forecasting leaving decisions more data-driven in favour of increased production and sustainability. Initial capital investments, regulations, climate dependency, and need for technical skills restrict the advantages of these services. Additionally, Data security privacy concerns are among the hurdles to the implementation process. Overcoming them would require empowerment through regulations, financial incentives, and farmer programs.

Keywords: Agriculture, Drone, Precision Agriculture, Smart farming.

Introduction

India is primarily an agrarian economy, where agriculture is the main source of income for a large portion of rural households. The economy heavily depends on agricultural products, which constitute a significant share of its exports. However, despite the increasing importance of agriculture, the sector is hindered by a lack of technological advancement. Crop failures, often caused by unfavourable weather and pest issues, have significantly contributed to this predicament (Hossain et al., 2022). Furthermore, many farmers in India still depend on monsoon rains for irrigation and utilize traditional farming methods. Additionally, the shrinking arable land, contaminated groundwater and growing population adds up to this issue (Pramanick et al., 2022; Mukesh et al., 2024; Ray et al., 2024; Maitra et al., 2024; Santosh et al., 2024). Consequently, the quality and quantity of agricultural production may suffer, despite the relentless efforts of farmers. To tackle these issues, practices like intercropping (Maitra et al., 2000; Sarkar et al., 2000), nutrient management practices like (Mwadalu et al., 2022; Mirriam et al., 2022; Sairam et at., 2024), mulching (Peera et al., 2020), water management practices (Ray et al., 2021) , new advance technologies like integration of innovative technologies such as smart farming and precision agriculture has garnered attention (Nduwimana et al., 2020; Bhattacharya et al., 2020; Tang et al., 2021; Krishna et al., 2024;).

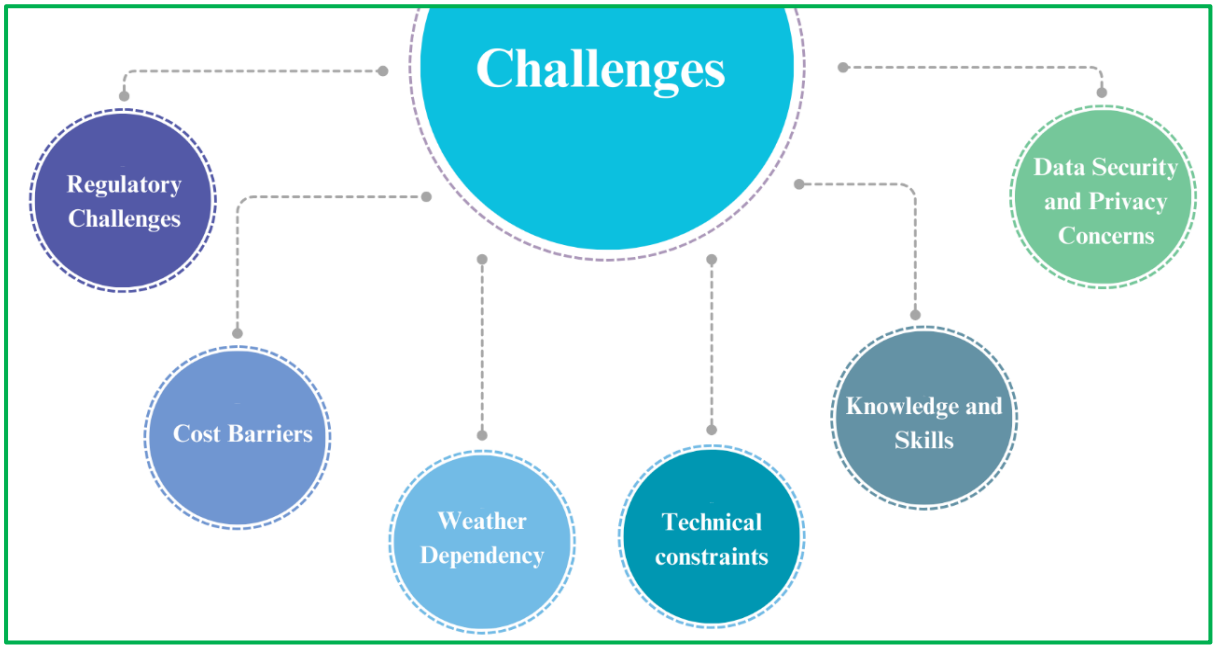
Smart farming entails the use of advanced innovations, including information, communication technologies and to improve farming efficiency (Haque et al., 2021). Precision agriculture emphasizes site-specific management through technologies like, Wireless Sensor Networks, artificial intelligence etc. Remote sensing technologies, such as satellites, manned aircraft, and drones (Unmanned Aerial Vehicles or UAVs), play a vital role in advancing smart and precision agriculture (Tsouros et al., 2019). An agricultural drone is a type of unmanned aerial vehicle designed for use in agricultural practices, primarily focusing on enhancing yield and monitoring the growth and production of crops. These drones offer valuable insights into various aspects of agriculture, such as the stages of crop development, overall crop health, and variations in soil conditions. Equipped with multispectral sensors, agricultural drones can capture images of electromagnetic radiation that extends beyond the visible spectrum, including near-infrared and short-wave infrared wavelengths. Drones provide benefits like high-quality imaging in overcast conditions, cost-effectiveness, ease of setup and maintenance, and swift data transmission (Radoglou-Grammatikis et al., 2020).

Use of Drones in Agriculture

1. **Aerial Surveillance:** An important use of drone in agriculture is aerial monitoring and crop surveillance. Use of high-resolution cameras and multispectral sensors, drones enable them to capture intricate images of crops from an elevated viewpoint that empowers farmers to assess crop health, recognize stress indicators and identify disease, pests, water and nutrient shortages. The ability to gather real-time data facilitates prompt actions, promoting optimal growth and maximizing yield. Crop surveillance also helps in understanding and planning for the succeeding farming season.
2. **Soil and field analysis:** Agricultural drones play a crucial role in effective field planning by conducting soil and field analyses. These drones, outfitted with advanced sensors like electromagnetic induction and ground-penetrating radar, are capable of generating comprehensive topographical maps and gathering soil samples. The data obtained enhances the understanding of soil variability, moisture content, and nutrient levels, enabling farmers to make well-informed decisions regarding soil management strategies. Additionally, accurate photogrammetry and 3D mapping allow for an in-depth examination of soil conditions.
3. **Crop sowing and plantation:** Drones are increasingly playing a crucial role in the cultivation of crops and plants, a responsibility that has historically fallen to farmers. This cutting-edge technology minimizes labour demands and promotes fuel conservation. It is expected that cost-effective drones will eventually take the place of large tractors, which are known to pollute the environment with harmful emissions. In India, innovative drone startups have created sophisticated planting systems that allow drones to distribute pods filled with seeds and vital nutrients directly into the ground. This method not only reduces expenses by approximately 85% but also improves the consistency and efficiency of agricultural operations.
4. **Nutrient Management:** Through the examination of soil data gathered by drones, farmers are able to adopt precise nutrient management techniques. This approach involves customized fertilization strategies that guarantee crops obtain the appropriate nutrients at the optimal time and in the correct locations, promoting ideal growth conditions.
5. **Irrigation scheduling of crops:** Drones equipped with optical, multispectral, and thermal imaging sensors can accurately identify heat and water stress in crops at designated locations. This technology allows for targeted irrigation based on the specific needs of the crops, thereby minimizing water waste and promoting the efficient use of irrigation resources.
6. **Crop damage assessment:** Agricultural drones equipped with multispectral and RGB sensors are capable of identifying areas in fields affected by weeds, diseases, and pests. This information allows for precise calculations of the necessary chemical treatments, ultimately reducing the financial burden on farmers.

7. **Pest Control:** Drones play a crucial role in the early detection and monitoring of agricultural issues. With advanced sensors, these drones can assist in identifying and tracking pest infestations at an early stage. By conducting regular field surveys, farmers are able to pinpoint vulnerable areas and implement targeted measures, thereby decreasing reliance on broad-spectrum pesticides and lessening their environmental footprint
8. **Crop spraying:** Agricultural drones are equipped with reservoirs that allow for the rapid application of fertilizers and pesticides on crops, significantly reducing the time required compared to conventional methods. Consequently, drone technology has the potential to revolutionize precision agriculture.
9. **Avoid overuse of chemicals:** Drones have the potential to significantly minimize the excessive application of pesticides, insecticides, and other chemicals. While these substances are essential for safeguarding crops, their overapplication can have harmful effects. Drones are capable of identifying subtle indicators of pest infestations and delivering precise information about the extent and severity of the attack. This enables farmers to determine the appropriate quantity of chemicals needed, ensuring that they protect their crops without causing additional harm.
10. **Check crop health:** Agriculture encompasses a broad range of activities across extensive land areas. Regular evaluations are crucial for assessing soil quality and crop health. Manual assessments can be time-consuming, often taking several days and being susceptible to human error. In contrast, drones can perform these evaluations in a matter of hours. By employing infrared mapping technology, drones gather data on the condition of both soil and crops, delivering detailed insights throughout the growth cycle and identifying issues before they escalate. Additionally, multispectral imaging can reveal subtle distinctions between healthy and unhealthy crops that might not be visible to the naked eye.
11. **Livestock management:** Drones are increasingly being utilized for the oversight and management of large livestock herds, equipped with high-resolution infrared cameras that can identify sick animals and enable prompt intervention. Consequently, the role of drones in precision dairy farming is poised to become standard practice. Through drone surveys, farmers can not only monitor their crops but also track the movements of their cattle. The use of thermal sensor technology aids in locating lost animals and identifying injuries or illnesses. This capability of drones significantly enhances agricultural productivity.
12. **Geo fencing:** Drones equipped with thermal cameras are capable of effectively identifying both animals and humans. This technology enables drones to protect agricultural fields from potential harm inflicted by wildlife, particularly during night time hours.
13. **Crop insurance:** Drones serve as a valuable tool for accurately assessing and tracking crop failures. This capability benefits both farmers and insurance companies by facilitating the evaluation of insurance claims in relation to the extent of damage incurred. The technology holds significant promise for the precise and efficient execution of crop insurance programs, such as the Pradhan Mantri Fasal Bima Yojana in India, ensuring impartiality in the process.
14. **Anticipation of potential weather disruptions:** Weather conditions can significantly impact a farmer's success, acting as both a valuable ally and a formidable adversary. The unpredictability of these conditions complicates preparation for any changes in weather patterns. However, drones have emerged as a useful tool for monitoring impending weather events. Storm drones are currently employed to enhance forecasting accuracy. This data can empower farmers to make informed decisions, allowing them to prepare effectively. Early warnings of storms or drought can guide farmers in selecting the most appropriate crops for the season and in managing the care of existing crops as they grow.

15. **Cost-Effectiveness:** In contrast to conventional aerial surveys or manual methods, drones provide a more economical option for data gathering. Their deployment is straightforward, allowing them to efficiently survey extensive agricultural regions in a brief period, which lowers labor expenses and enhances operational productivity (Rejeb et al., 2020)



Challenges in use of agricultural drones

1. **Regulatory Challenges:** Regulatory laws vary significantly within regions and country. Farmers must be aware of permissions, licensing, and operational restrictions related to drone usage for seamless integration of drones into routine agricultural practices (Ayamga et al., 2021)
2. **Cost Barriers:** Although expenses related to drone technology is diminishing over time, the initial investment remains a considerable hurdle for many farmers, particularly those with smaller operations. For acquiring high quality drone with advanced sensors, imaging capabilities, ongoing maintenance cost, insurances and time to time potential upgrade add overall financial burden in adaptation of drone technology.
3. **Weather Dependency:** Drones are significantly affected by weather conditions. It is not advisable to operate them during rain or strong winds.
4. **Knowledge and Skills:** While, adopting new technology is beneficial, daily use necessitates specific skills and knowledge. Many farmers may find it challenging to operate drones effectively and may need to either learn the necessary skills or rely on someone with experience.
5. **Data Security and Privacy Concerns:** Extensive data collection by drones raises a concern over privacy and data security. Farmers should be very much aware regarding protection of sensitive information related to their fields, crop health, and farming practices. There is necessity of clear guidelines and regulatory act for data ownership and usage to protect farmers' interests and prevent potential misuse.
6. **Technical constraints:** Technical constraints like limited flight time, inadequate payload capacity, and susceptibility to unfavorable weather conditions and necessary infrastructure for processing and analyzing the data gathered by drones acts as a strain to farmers for successful use of drones in agriculture.

Conclusion

Agricultural drones are revolutionizing farming by increasing efficiency, lowering input costs, and strengthening climate resilience. They have diverse applications across agricultural monitoring, precision spraying, irrigation management, and pest control to make data-driven

decisions for better yield and sustainability. High initial costs, regulatory limitations, and the required technical competency further block wider implementation. Supporting legislation, financial incentives, and farmer training are all vital to overcoming these challenges. The right investments and infrastructure could indeed reinvent Indian agriculture and make it smart, efficient, and climate-resilient.

References

1. Ayamga, M., Tekinerdogan, B., and Kassahun, A. (2021). Exploring thechallenges posed by regulations for the use of drones in agriculture in the African context. *Land*, **10**(2): 164.
2. Bhattacharyay, D., Maitra, S., Pine, S., Shankar, T., Pedda Ghouse Peera, S.K (2020). Future of Precision Agriculture in India, In: Protected Cultivation and Smart Agriculture; Maitra, S., Gaikwad, D. J. and Shankar, T.(*Eds*) New Delhi, India, pp. 289−299.
3. Haque, A., Islam, N., Samrat, N.H., Dey, S. and Ray, B. (2021). Smart farming through responsible leadership in bangladesh: possibilities, opportunities, and beyond. *Sustainability*, **13** (8) : 4511.
4. Hossain, A., Maitra, S., Pramanick, B., Bhutia, K.L., Ahmad, Z., Moulik, D., Syed, M. A., Shankar, T., Adeel, M., Hassan, M. M. and Aftab, T. (2022). Wild relatives of plants as sources for the development of abiotic stress tolerance in plants. In: *Plant Perspectives to Global Climate Changes*, Roychoudhury, A. and Aftab, T. (Eds.), Academic Press, pp. 471−518.
5. Krishna, T.G., Maitra, S., R.S. Kalasare, Ray, S., Mahto, R.K. and Sairam, M. (2024). Influence of location-specific nutrient management and plant stand on the growth, productivity, and nutrient uptake of irrigated rabi maize (Zea mays L.). *Research on. Crop*. **25**: 560-569.
6. Maitra, S., Ghosh, D. C., Sounda, G. Jana, P.K. and Roy, D.K. 2000. Productivity, competition and economics of intercropping legumes in finger millet (*Eleusine coracana*) at different fertility levels. *Indian Journal of Agricultural Sciences***, 70 (**12**)**: 824-828.
7. Maitra, S., Sairam, M., Ray, S., Santosh, D.T., Gaikwad, D.J., Gitari, H.I., Mukesh, G. and Maheswari, N. (2024). Applauding soil quality improvement through legume-based intercropping system: A Review. *International Journal of Bioresource Science.* **11**: 59-69.
8. Mirriam, A., Mugwe, J., and Raza, M. A., Seleiman, M. F., Maitra, S. and Gitari, H.I. (2022). Aggrandizing soybean yield, phosphorus use efficiency and economic returns under phosphatic fertilizer application and inoculation with *Bradyrhizobium*, *Journal of Soil Science and Plant Nutrition.* **22**: 5086–5098, https://doi.org/10.1007/s42729-022-00985-8.
9. Mukesh, G., Sairam, M., Maitra, S., Gaikwad, D.J., Sagar, L. and Ray, S., 2024. Agrometeorological Indices, Physiological Growth Parameters and Performance of Finger Millet as Influenced by Different Cultivars Under Hot and Sub-Humid Region of Odisha. *International Journal of Experimental Research and Review* **42**: 148-161.
10. Mwadalu, R., Mochoge, B., Mwangi, M., Maitra, S. and Gitari, H.I. (2022). Response of Gadam sorghum (*Sorghum bicolor*) to farmyard manure and inorganic fertilizer application, *International Journal of Agriculture Environment & Biotechnology*, **15** (1) : 51−60.
11. Nduwimana, D., Mochoge, B., Danga, B, Masso, C., Maitra, S. and Gitari, H. (2020). Optimizing nitrogen use efficiency and maize yield under varying fertilizer rates in Kenya. *International Journal of. Bioresource Sciences.* **7** (2) : 63-73.
12. Peera, P.G., S. K., Debnath, S. and Maitra, S. (2020). Mulching: Materials, advantages and crop production, In: Protected cultivation and smart agriculture, Maitra, S., Gaikwad, D. J. and Shankar, T. (*Eds*.), New Delhi Publishers, pp. 55−66.
13. Pramanick, B., Kumar, M., Naik, B.M., Kumar, M., Singh, S.K., Maitra, S., Naik, B.S.S.S., Rajput, V.D. and Minkina, T. (2022). Long-term conservation tillage and

precision nutrient management in maize–wheat cropping system: effect on soil properties, crop production, and economics. *Agronomy*, **12**: 2766.

14. Radoglou-Grammatikis, P., Sarigiannidis, P., Lagkas, T. and Moscholios, I. (2020). A compilation of UAV applications for precision agriculture. *Computer Networks*, **172**: 107148 https://doi.org/10.1016/j.comnet.2020.107148.
15. Ray, S., Maitra, S., Sairam, M., Sravya, M., Priyadarshini, A., Shubhadarshi, S. and Padhi, D.P., (2024). An unravelled potential of foliar application of micro and beneficial nutrients in cereals for ensuring food and nutritional security. *International Journal of Experimental Research and Review*, **41**: 19-42.
16. Ray, S., Umesha, C., Meshram, M.R. and Sanodiya, L.K., 2021. The Influence of irrigation and hydrogel application on yield and economics of pearl millet (*Pennisetum glaucum* L.) under Eastern UP condition. *Environment Conservation Journal*. **22**:31-36.
17. Sairam, M., Maitra, S., Sain, S., Gaikwad, D.J. and Sagar, L. (2024). Dry Matter Accumulation and Physiological Growth Parameters of Maize as Influenced by Different Nutrient Management Practices. *Agricultural Science Digest*. **44**(2) : 219-225.
18. Santosh, D. T., Debnath, S., Maitra, S., Sairam, M., Sagar, L., Hossain, A., and Moulick, D. (2024). Alleviation of Climate Catastrophe in Agriculture Through Adoption of Climate-Smart Technologies. In: *Climate Crisis: Adaptive Approaches and Sustainability*, Springer Nature, pp. 307-332
19. Sarkar, R.K., Shit, D. and Maitra, S. (2000). Competition functions, productivity and economics of chickpea (Cicer arietinum)-based intercropping system under rainfed conditions of Bihar plateau. *Indian Journal of Agronomy*, **45**: 681-686.
20. Tang, Y., Dananjayan, S., Hou, C., Guo, Q., Luo, S. and He, Y. (2021). A survey on the 5G network and its impact on agriculture: challenges and opportunities. *Computer and Electronics in Agriculture*. **180**: 105895 https://doi.org/10.1016/j.compag.2020.105895.
21. Tsouros, D.C., Bibi, S. and Sarigiannidis, P.G. (2019). A review on UAV-based applications for precision agriculture. *Information* (Switzerland) **10** (11). https://doi.org/10.3390/ info10110349.