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Analysing the Adoption of Drones in Agriculture at Khargone District

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Abstract: *The purpose of this paper is to analyse the adoption of drones in agriculture as the newest tool added to the set of precision agriculture technologies using a new application of the trans-theoretical model of behavioural change by analysing a sample of 167 large-scale German farmers collected in 2019. This model gives a gradual measure of farmers' decision making regarding the adoption of drones, giving more detailed insight into the farmers' adoption processes than the more common approach of applied binary classifications. Results of ordinal logit regression indicate that, among other determinants, age, precision agriculture technology literacy and farm size of farmers determine the farmers' adoption process. Therefore, this paper contributes to literature by identifying key determinants of the drone adoption process in agriculture. Additionally, this research furnished information about the areas of application of drones as well as reasons opposing the usage of drones by farmers. Results: Of interest to the policy makers and suppliers of drones.*

Keywords: Fertilizer and Pesticide Spraying System, Unmanned Aerial Vehicle (UAV), Time and Cost Saving

I. INTRODUCTION

In 2021, the Massachusetts Institute of Technology classified "agricultural drones" at the first position out of ten breakthrough technologies [1]. Such primacy is a consequence of a general growing interest in Unmanned Aerial Vehicles (UAV) for environmental and agricultural applications. Indeed, many researchers and scientists agree on the substantial role agriculture can play as the largest user of such systems [2; 3]. The exponential growth in the field can be underlined by the number of worldwide patents indexed in the European Patent Office search engine, reporting "unmanned aerial vehicle innovation" in the title. Similarly, scientific papers indexed by Scopus that discuss UAVs and agriculture are under constant growth (Fig. 1). On the other hand, mainly due to the recency of Such growth, several lacks of knowledge can be recognized, mainly dealing with the cost effectiveness and performance analyses.

Technological solutions for development and their dissemination are significant to achieve SDGs, which were emphasized during the UN Rio+20 conference [1]. However, adoption of technology in agrarian rural areas is restricted for various reasons that slow down the achievement of SDGs [2]. Though traditional farming practices have many benefits, most of them have become ineffective due to climate change, population explosion, and increased food demand. These technologies demand modification, upgradation, and replacement, and/or adoption in many countries. The adoption of modern technologies like UAVs, robotics, the Internet of Things can help increase the productivity, sustainability, and efficiency of agriculture. Referred to as precision agriculture, it exploits modern technologies for getting data about soil, weather, crops, and applies this information making informed decisions on plantations, irrigations, fertilizer applications, and pest control.

Among these technologies, the use of UAVs, popularly known as drones, is gaining traction around the world. The capabilities of UAVs offer flexibility to the farmers in analysing the crops at a desired spatial and temporal resolutions enabling them to take timely decisions [3]. Most of the currently available agricultural drones are semi-automatic devices that are edging towards complete automation [4]. These unmanned devices have significant potential in collecting various spatial attributes to assist in agricultural planning. Recent developments in this technology offer safe,

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reliable, and affordable solutions for various activities involved in agriculture [5]. Fig. 1 presents the typical UAVs being used in the agricultural domain.

Fixed wing drones are designed using a fixed wing system and are nearly identical to traditional manned aircrafts [6]. They have well known advantages including longer flight time duration, higher range of speed, payload capacity, and stability during flight. However, they require a considerable amount of runway space for landing and take-off. Also, due to the design restrictions, they cannot deliver missions with agile and complex manoeuvres. On the other hand, Monocopter drones enable VTOL and do not require a runway or operational space [7]. It provides higher maneuver flexibility through control of the propeller speed, which enables agile movements during missions. However, they cannot provide sufficient stability and control during missions, particularly at higher and payloads.

There is a growing need for food and raw materials that agriculture needs to supply, and concerns over sustainability and resource efficiency have become increasingly important aspects of agricultural production because agriculture is expected to contribute significantly to environmental and climate protection (EU SCAR, 2012; Valin et al., 2014). Precision agriculture (PA) is a management strategy that bases its implementation on the use of data from multiple sources to improve the decision-making skills of farmers (Candiago et al., 2015). It focuses on tailoring management practices to the need of the crop, by taking into consideration spatial and temporal information regarding the crop, soil, and environment (Mesas- Carrascosa et al., 2015; Puig et al., 2018). With the application of precision agricultural technologies (PAT), farmers can increase farm productivity by improving yields while at the same time reducing inputs and external environmental impacts (Pierpaoli et al., 2013; Tey and Brindal, 2012). Thus, PAT can contribute to farmers' well-being by improving the economic status of the farmer, which is also of great importance for the rural living. In many countries, rural areas are still to a great extent characterized economically and culturally by agriculture because farmers represent the core group of rural communities in providing jobs and maintaining traditions (Jeffcoat et al., 2012; Morris et al., 2017). Therefore, PAT do not only contribute to challenges of environmental protection and security of food supplies but also in the maintenance of liveable rural areas.

The world population has increases day by day and projected to reach 9 billion people by 2050, so the experts expect that the demand for food production will also increase in the same proportion. In order to feed the ever increasing urban and richer population, food production must be increased by 70 per cent (Ahirwar et al., 2019). Frequently, the agriculture field faces destruction losses due to the diseases in crops. The pesticides are crucial ingredients to kill insects. Hand spraying of the pesticides influences humans and causes cancer, hypersensitivity, asthma and other diseases (Devi et al., 2020). India and other developing countries are facing many issues in agriculture field like labor scarcity, health problems. According to WHO survey there are 3 million or more cases of pesticide poisoning in every year. Children and new born babies are at high risk To exposure of pesticides because they are not having strong immune system (Kedari etal., 2016).

In India, nearly 65% of the workforce derives livelihood from agriculture and it contributes 18% to the GDP. In the crop production process the pesticides and other agrochemicals play an important role in Indian agriculture and it has shown a steady increase from the mid-fifties, both in the quantum of consumption and in coverage. Globally, India is the fourth largest producer of agrochemicals, after the United States, Japan and China. Plant protection coverage increased to 200+ million hectares in 2019 and the sales of pesticides rose to 200,000+ tonnes. Pesticides are used more specifically in commercial and industrial agriculture to grow food and crops. Internationally big effort is made to the safe use of chemicals for the sound management of the chemicals. It is widely accepted and Bureau of Industrial Costs and Prices (BICP)'s analysis also confirms that cotton and rice are the two main pesticides using crops in India. Pesticide safety, its use, application technologies and integrated pest management are some of the important strategies to minimize human exposure to pesticides (NIIR Project Consultancy Services (NPCS)).

II. REVIEW OF LITERATURES

• Prof. P. P. Mone, Chavhan Priyanka Shivaji, Jagtap Komal Tanaji, Nimbalkar Aishwarya Satish, "Agriculture Drone for Spraying fertilizer and Pesticides", This work quotes the authors who have provided information about implementation of Agriculture drone for the automatic spraying mechanism. In this paper, they have provided with the problem statement of World Health Organization where it states, that there are 3 million cases of pesticide poisions in

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every year and up to 220,000 deaths, mainly from developing countries. They have explained in this paper that which type of precautions the farmer needs to be taken for the avoidance of harming effects of pesticides and fertilizing effects as well as cost-effective technology with PIC microcontroller, for control agriculture robots. IJRTI published the research paper, and the link to access it can be found below Volume 2, Issue 6, 2017 [1]. 2017.

• Title of the paper: "Quadcopter UAV based Fertilizer and Pesticide Spraying System" Prof. S. Meivel M.E., Dr. R. Maguteeswaran Ph.D., N. Gandhiraj B.E., G. Srinivasan Ph.D. has published a paper. That paper is about the implementation of Agriculture wonder drone, the authors have provided detail information of the Quadcopter UAV with sprayer module and also discuss pesticide content to the areas that can't easily accessible for human beings. They discussed the use of multispectral cameras, which is used to capture remote sensing images to identify the green field as well as the edges of crop areas. Their quad copter can carry a total pay load lift of 8 kg. They applied QGIS software for the purpose of analyzing the remote sensing images. This paper can be downloaded from International Academic Research, Journal of Engineering Sciences, Volume 1, Issue 1, February 2016.

• Prof. K. B. Korlahalli, Mr. Mazhar Ahmed Hangal, Mr. Nitin Jituri, Mr. Prakash Frances Rego, Mr. sachin M.\tRaykar published a paper entitled "An Automatically Controlled Drone based Aerial Pesticide Sprayer". In this paper authors has given detail about implementation of Agriculture Wonder Drone System. This paper proposes the development of a wireless drone system, incorporating components like FCB (Flight Controlled Board), GPS, Brushless DC motor, ESC (Electronic Speed Control), wireless transceiver, frame, propellers, and a battery. Here, FCB was utilized in controlling the operation of a drone in relation to its movements, lifting, and positioning. The authors in this project programmed the FCB in order to interface different sensors including GPS, Barometer, Accelerometer, Gyroscope, etc., as well as different motor components. This drone was designed for two modes that include manual mode and autonomous mode. The paper was presented by K. L. E. Institute of Technology, Hubballi, Project reference no.:39S_BE_0564.[3].

• Maddikunta Reddy P.K. et al (2021) studied applications, requirements and challenges of UAVs (drones) in smart agriculture. Their study list that primarily fixed wing and multi rotor UAVs are used for agricultural purposes among the different categories of UAVs like fixed wing, multi rotor, single rotor and hybrid vertical take-off and landing UAVs. Multi rotor UAVs are simpler to build and inexpensive compared to all types of UAVs and fixed wing are excellent for long-range operations and provide maximum flying time. They have also developed different types of agricultural sensors like optical sensors, temperature-based sensors, location-based sensors etc, and recognized possibilities of using UAVs in smart agriculture. They are enlisted as follows:

• UAVs as sky farmers, allowing an entire view of cultivation field or livestock herd from above UAV application in precision agriculture and capturing imageswith superior quality from hyper spectral and multispectral cameras for obtaining indices such as NDVI • UAV in Irrigation Monitoring

•UAV in Aerial Mustering •UAV in Artificial PollinationThe research discovers that essential enabling needs ofUAVs for smartagriculture consist o f availability of network, storage capacity for data, acceptability of technology from the farmers' end, accuracy of output and UAV regulations, etc. Maddikunta Reddy P.K. et al (2021) have analyzed applications, needs and challenges of UAVs (drones) in smart agriculture. Their work mentions that above all, primarily fixed wing and multi rotor UAVs are used for agricultural purposes in the different types of UAVs like fixed wing, multi rotor, single rotor and hybrid vertical take-off and landing UAVs. Multi rotor UAVs are easy to manufacture and the cheapest of all kinds of UAVs and fixed wing are ideal for long distance operations and more flying time. They have also explored various types of agricultural sensors such as optical sensors, temperature-based sensors, location-based sensors etc and identified potential applications of UAVs in smart agriculture. They are mentioned below: • UAVs as sky farmers, which enable one to have an aerial view of the entire cultivation field or livestock herd • Precision agriculture using UAVs, where superior quality images are obtained using hyperspectral and multispectral cameras, which help obtain vegetation indices such as NDVI • UAV in Irrigation Monitoring • UAV in Aerial Mustering • UAV in Artificial Pollination. The study identified key enabling requirements of UAVs in smart agriculture, including availability of network, data storage, acceptance of technology by farmers, accuracy of results, and regulation of UAVs etc.

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• Rahman M.F.F et al (2021) have compared the application of UAV Systems in Agriculture. They claim that with low cost and small size, UAVs can aid agriculture in developing countries to gain economic prosperity mainly by reducing health related risks associated with manual pesticide spraying and the number of workers. Farmers can use UAVs for agricultural spraying, pest control, aerial mapping, irrigation, and livestock farming. Their review also finds that fixed-wing UAVs are already being implemented for field mapping and livestock activities; and multi rotor Agriculture is best suited with UAVs, specifically with a quadcopter due to excellent
aeronautics. With UAVs, such an immense wastage of fertilizer and pesticides is being lessened and helps in keeping laborers aside from chemical effects, thus making the job comfortable and fast. Some prime examples of disadvantages are provided in the subsequent points. A few limitations of UAVs for agriculture are there. For example, proper data interpretation, privacy risks, complicated spraying environmentand long distancedpositioning can be registered as some of the disadvantages.

• Mogili U.M.R. and Deepak B.B.V.L. (2018) have reviewed Application of Drone Systems in Precision Agriculture. They state that drones are used to spray the pesticides to avoid the health problems of humans when they (humans) spray manually. Drones also can operate in areas that may be challenging for human beings to operate. They describe crop monitoring through a multispectral camera mounted on a drone. Pictures would be captured one flight, hence it is easily determined where one should spray with the pesticides to be used basing on t he analytical pictures. Further, the pesticide sprinkling system auto navigates with the determined GPS coordinates meant to spray to the infected places but no vegetation of any sort to crop up from an NDVI image. They conclude that these are early developments of drones in precision agriculture and there is scope for further development in both the technology as well as the agriculture applications.

• The application of UAV technology in modern agriculture has been the hot spot of home and abroad research. With the continuous advancement of UAV technology, its application potential in the agricultural field is more and more manifest. The UAV has the advantages of high maneuverability, low cost, and flexible deployment, with which it can effectively improve the efficiency of agricultural production, reduce labor intensity, and realize precision agricultural management. Domestic and foreign studies have indicated that the application of UAVs in agricultural monitoring and information acquisition, precision agriculture, agricultural disaster prevention and rescue has achieved remarkable results. Especially in crop growth monitoring, soil moisture and nutrition monitoring, pest and disease monitoring, etc., the high-resolution cameras and sensors carried by UAVs can provide real-time and accurate data support. More significantly, the utilization of UAVs in precision fertilization, pesticide application and irrigation, as well as the exercise in the distribution of emergency rescue material, post-earthquake assessment and reconstruction have demonstrated its potential significance in agriculture production.

• The conceptualization of CE has been widely debated since the last decade (Murray et al., 2017), which resulted in several definitions of CE. In general, a CE model can be referred to as a non- linear, regenerative and restorative by design practices aiming to detach consumption of non-renewable resources from growth, opposing the conventional 'take-make-waste' economy model (MacArthur et al., 2016). Although there is no unified definition, definition, the CE's 3Rs principles have been applied widely across, macro and micro levels, including cleaner production contexts (Sousa-Zomer et al., 2018). For example, the concept of 'reduce' was used by Su et al. (2013) and Winans et al. (2017) in their research, 'reuse' concept in Castellani et al. (2015), and recycle in Birat's (2015) research.

• Critical Role of Drones in Agriculture: A Review Authors: C. Bala Vivin Sundar and M. Asokhan 2023 It gives a glimpse into how drones as part of sustainable agriculture practices are being integrated in Indian farming towards the solution of the issue of labor scarcity and low productivity. It examines the different uses of drones in agriculture, encouraged by government efforts.Source: Asian Journal of Agricultural Extension, Economics & Sociology.

• Quadcopters in Smart Agriculture: Applications and Modelling Authors: Mohamad Khaldi, Benoit Clement, Mohammad Ammad-Uddin, 2024 This review is focused on the role of quadcopters in smart agriculture, detailing their specific advantages over other UAV types, and their usage in crop monitoring, irrigation, and precision farming. It also discusses modeling and real-world system simulations for future research improvements.

• Drone Technology in Sustainable Agriculture: Precision Agriculture and Mapping to the Future of Farming Authors: G. Lazzeri, W. Frodella, G. Rossi, S. Moretti 2021 This paper explores the use of UAVs in multitemporal

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mapping for agricultural purposes, which include precision farming, post-fire land cover and monitoring, and environmental monitoring. This has indicated the advantages of using UAVs for resource management through detailed spatial data collection.

• Li, L., Zhang, S., & Wang, B. (2024) - This paper is based on the use of deep learning in plant disease recognition using drones. It describes how the problem of manually identifying features of disease in plants can be overcome and shows how the deep learning algorithms used by drones enhance the detection process. The authors concentrate on how these technologies reduce human error and speed up research to show insights into the use of drones for objective and high- precision disease monitoring in agricultural settings.

• Pagonis, K, Zacharia, P, Kantaros, A, Ganetsos, T, & Brachos, K. (2024) -This research discusses the development of integration of drones with robotic arms for advanced agricultural operations, such as object identification, thereby indicating the potential to be expected from machine vision when combined with the mobility of a drone to undertake complex operations related to crop harvesting and inspection into future trends in autonomous systems for agriculture.

• Shamshiri, R., Weltzien, C., Hameed, I. A., et al. (2023) - The authors provide an overview of the development of agricultural robotics with a focus on drone applications in crop monitoring, multi-robot systems, and swarm robotics. The authors describe how drones are being used increasingly together with ground-based robots to automate tasks in agriculture, focusing on the future role of aerial drones in digital farming systems.

• Khaldi, M., Clement, B., & Ammad-Uddin, M. (2024) have provided a detailed overview of how drones, specifically quadcopters, are becoming an essential component of smart agriculture. The authors pointed out the role of UAVs in various applications for agriculture, including disease detection, precision pesticide spraying, and environmental monitoring. They emphasized the quadcopter's ability to uniquely optimize the agricultural process and how it can potentially be used to counter desertification and resource scarcity.

III. OBJECTIVES

1. To examine the innovation of drones in agriculture.
2. To assess the effectiveness of drones.
3. To analyse the cost benefits.
4. To propose strategies for enhancing drones adoption.

IV. CONCLUSION

Drones in Agriculture at Khargone District is a promising advancement in modern farming practice. The research outcome shows that precision farming, efficient application of pesticides and fertilizer, and better crop monitoring through drones are increasing the acceptance level of farmers towards the technology, but specific constraints such as high initial investment, lack of technical skills, and regulatory issues prevent its wider use.

The integration of government policies, technical knowledge, and education can ensure increasing awareness and availability. While developing the agriculture sector, inclusion of drones into farm activities would allow for efficient and productive work to be performed and reduce waste. This is something that Khargone District might need as the district has developed and become important in India. Thus, a facilitative environment at the policy and financial levels will be crucially required to successfully adopt drone technology in agriculture by developing skills of the farmers as well.

REFERANCES

[1]. Ronin, M. R. S. (2020). Souvenir (Doctoral dissertation, Suresh Gyan Vihar University).
[2]. Gupta, B. K., Mishra, D., Ojha, P. K., Verma, A. P., & Mishra, B. P. (2022). e-READING MANUAL.
[3]. Dixit, S., Bhatia, V., Khanganba, S. P., & Agrawal, A. (2022). 6G: Sustainable Development for Rural and Remote Communities. Springer.

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[4]. Madaswamy, M. (2023). Spices Informatics Network and Value Chain for Open Innovation and Value Creation Network. In Handbook of Spices in India: 75 Years of Research and Development (pp. 1147-1191). Singapore: Springer Nature Singapore.

[5]. Zuo, A., Wheeler, S. A., & Sun, H. (2021). Flying over the farm: Understanding drone adoption by Australian irrigators. Precision agriculture, 22(6), 1973-1991.

[6]. Marinello, F., Pezzuolo, A., Chiumenti, A., & Sartori, L. (2016). Technical analysis of unmanned aerial vehicles (drones) for agricultural applications. Engineering for rural development, 15(2), 870-875.

[7]. Michels, M., von Hobe, C. F., & Musshoff, O. (2020). A trans-theoretical model for the adoption of drones by large-scale German farmers. Journal of rural studies, 75, 80-88.

[8]. Bai, A., Kovách, I., Czibere, I., Megyesi, B., & Balogh, P. (2022). Examining the adoption of drones and categorisation of precision elements among Hungarian precision farmers using a trans- theoretical model. Drones, 6(8), 200.

[9]. Puppala, H., Peddinti, P. R., Tamvada, J. P., Ahuja, J., & Kim, B. (2023). Barriers to the adoption of new technologies in rural areas: The case of unmanned aerial vehicles for precision agriculture in India. Technology in Society, 74, 102335.

[10]. Brunetti, S. (2021). The agricultural innovation in the Italian landscape: drones adoption.

[11]. Chandel, A., Verma, R., Sood, K., & Grima, S. (2024). A bibliometric analysis of drones- mediated precision farming. International Journal of Sustainable Agricultural Management and Informatics, 10(4), 347-377.

[12]. von Hobe, C. F. (2021). 21st Century Challenges in Arable Farming-Essays on the Agricultural Land Market and Drone Adoption in Germany (Doctoral dissertation, Georg-August- Universität Göttingen).

[13]. Iagăru, P., Pavel, P., Iagăru, R., & Șipoș, A. (2021). Using drone technology for preserving the economic sustainability of the agricultural holdings. International Journal of Advanced Statistics and IT&C for Economics and Life Sciences, 11(1), 85-90.

[14]. Trappey, A. J., Lin, G. B., Chen, H. K., & Chen, M. C. (2023). A comprehensive analysis of global patent landscape for recent R&D in agricultural drone technologies. World Patent Information, 74, 102216.

[15]. Trappey, A. J., Lin, G. B., Chen, H. K., & Chen, M. C. (2023). A comprehensive

[16]. analysis of global patent landscape for recent R&D in agricultural drone technologies. World Patent Information, 74, 102216.

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