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Bangladesh is an agriculture-based country. With the advancement of technology and modernization, the impact of globalization and urbanization, influence of industrialization, agriculture experienced a multi-dimensional global change and will continue to do so in the future. With that, drone culture has been introduced globally in agriculture. Bangladesh is not far behind in deploying drones instead of human resources to the field with the world as the country has already experienced growing drone usage in some areas. This paper will focus on helping indecisive farmers with scientific suggestions about suitable drones and their interest in drone use by practically testing them in our agricultural field, accelerating overall agricultural strategies country-wide. The test result of each observation helped us to reach a generalized conclusion on the drawing of the research and future of agriculture with drone technology in Bangladesh.

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In this study, we sought to answer the farmer's question, "Which drone should we start with for better and efficient yield in farming?"

Bangladesh is an agriculture-based country. With the advancement of technology and modernization, the impact of globalization and urbanization, influence of industrialization, agriculture experienced a multi-dimensional global change and will continue to do so in the future. With that, drone culture has been introduced globally in agriculture. Bangladesh is not far behind in deploying drones instead of human resources to the field with the world as the country has already experienced growing drone usage in some areas. This paper will focus on helping indecisive farmers with scientific suggestions about suitable drones and their interest in drone use by practically testing them in our agricultural field, accelerating overall agricultural strategies country-wide. The test result of each observation helped us to reach a generalized conclusion on the drawing of the research and future of agriculture with drone technology in Bangladesh.

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I. INTRODUCTION

Bangladesh is a small country with 147570 sq. km area[1]. It has agricultural land of 143000 sq. km, of which about 59.8% is available for cultivation. The land is categorized in such a manner depending on the flooding depth: highland (20%), medium highland (39%), medium lowland (15%), lowland (8%), and very lowland (2%) [2]. According to the Labor Force Survey by BBS, 22.7 million people in Bangladesh are directly involved in agriculture [3] out of 164.7 million (2020) population[4]. Agriculture is the largest employment sector in Bangladesh, making up 14.2 percent of Bangladesh's GDP in 2017 and employing about 42.7 percent of the workforce[5].

But, even after the allocation of Tk 33,698 crore BDT (353 crore USD) for food, fisheries, and agriculture for the 2022-2023 fiscal year, which is 6.2 percent of the total national budget[6], drone technology's usage has not been noticeably wide-spread here, one of the main reasons for that being the lack of agricultural automation direction or knowledge in the mediocrely educated farmers. Therefore, Drone technology is a relatively recent addition in agriculture, compared to traditional harvesting methods, and provided that it comes with proper directions and support, it is destined to be popular among the farmers in no time and the reasons being many. Moreover, the growing use of drones in some areas of the country is not negligible as their use is gaining popularity for efficient farming strategies among farmers. But there is no one to show the way to them. And hence, the real problem is not farmers' lack of tech knowledge but our failure to bring out the best possible probability in front of them that we were supposed to do in the first place long ago.

Although the known use of drones in agriculture began in 2000 when Yamaha came out with the unmanned helicopter R-50, which was designed for crop mapping and field analysis[7], later, they were equipped with spraying equipment and a

urface area km

pesticide tank to spray crop fields in Japan. But in Bangladesh, drone technology was introduced in 2015 by the international non-government organization CIMMYT (International Maize and Wheat Improvement Centre) in association with Bangladesh Agricultural Research Institute and Bangladesh Agricultural Research Council with the approval of the country's defense ministry[8]. The Civil Aviation Authority of Bangladesh (CAAB) approved a regulation for operating remotely piloted aircraft systems in 2016. The progressive trend of the multi-purpose use of drones attracts and encourages more and more people to consider their use for the modernization of our agriculture.

Two drones were bought from Germany under the 20-month project that began in November 2015 and were used to collect data from 23 acres of land in four villages for the first time in the country. Agriculturalists have started using drones to monitor farmlands in the southern districts of Barisal and Patuakhali. Maize, wheat, and mung beans are being cultivated in the land. The project's prime objective is to analyze farming conditions and improve them in the southern part of the country as per a master plan of the government[9].

A drone or UAV [10] (Unmanned Aerial Vehicle) is a technology capable of making a flight autonomously, working with GPS and other embedded features; until recently the drone technology has been widely used for military surveillance, marking, or other purposes. But recently, due to the development of the sophisticated chip, more powerful motors, and substantial radio control, this drone technology has been introduced in agriculture too.

Fixed-wing drones and multirotors are very different technologies from aircraft and helicopters. A quadcopter[11]; a multirotor sometimes known as a quadrotor, is a helicopter with four rotors, whereas fixed-wing UAVs are controlled by a human operator or by an autonomous system via onboard computers with attached one or two rotors. But these technologies are used interchangeably. Approximately 50 percent of Bangladesh's population is primarily employed in agriculture, with more than 70 percent of its land dedicated to growing crops[12]. Besides, Drone Deploy[13] an agricultural drone supplier and programming company, suggests starting small and incorporating drone data into an organization slowly for the best results (in a word: an experiment). The experiment will compare the need for aircraft or a quadcopter based on natural and geographical factors in our agricultural activities. Moreover, the study's findings can be used to determine which parts of the drones need to be improved to boost the overall performance or yield of the annual production in Bangladesh.

Compared to agriculture, Bangladesh's industrial sector has been more automated, requiring less physical labor, ending with farmers' exit from their fields. The switch from farm to non-farm is on the rise. Adding drone culture in agriculture would do the same as what Industry did before its revolution. The introduction of drone culture will serve to minimize the cost of walking the fields or airplane fly-over filming, saving time scouting acres and acres of crops by foot; imaging can be used to see crop health accurately, and monitoring crops via drone is much more efficient than by foot, reducing crop damage with frequent and efficient monitoring and much more. All these help in reducing physical labor and increasing production efficiency. It is rational to explore which is adequate for agriculture production.

The research question is "Which drone would be more suitable as a leading step in automation of Bangladesh agriculture? Quadcopter or fixed wing drone?"

The aim of this study is to determine which drone type is more compatible with agriculture by testing them in the field.

Specific Objectives:

- To specify the operational capability of the drones.
- To underline the average performance speed of the drones.

- To explore the benefits of drone technology.
- To draw up a recommendation for drone practice in Bangladesh perspective.

II. LITERATURE REVIEW

Agricultural drones are Unmanned Aerial Vehicles designed, manufactured and equipped with the elements, systems, tools and techniques necessary to perform specific functions to conduct and improve agricultural activities and research. More than 60 countries around the world are developing and operating agricultural drones including The USA, UK, Germany, China, India, Israel, Japan, France, Australia, Belarus, Belgium, Brazil, Canada, Finland, Greece, Indonesia, Iran, Malaysia, Netherlands, Philippines, Russia, South Korea, Spain. It has been proven to be very effective and useful for agricultural research and development in the agricultural areas[14].

The ultimate fate of this revolution will show self-outcasted farmers their way back to agriculture. Consulting and market research firm BlueWeave Consulting's recent study states Indian Agriculture Drones market will experience a four-fold increase by 2028, with a projected CAGR of more than 25% during 2022 – 2028[15]. Uganda's agriculture sector employs about 80% of its population and the Ugandan farmers lost 30 to 40 percent of their harvests to pests, insects, diseases or storage problems, inefficient production methods, processing, rudimentary handling and transportation. Ugandan farmers even failed to identify pests and diseases, let alone treat them. A service called Fapp, introduced by Hansu Mobile Innovations, which is a startup team of three Ugandan developers from a farming community, has already started achieving noticeable ground in the efficiency of agricultural drones in the service's initial stage. With the help of drones and smart devices working offline and online, with built-in machine learning solely for image recognition, large-sized fields were mapped out to identify affected areas. Later in development, this service will fruit sustainable pesticides to Ugandan farmers, ensuring that the solution is environmentally healthy and maintains the nutritional integrity of crops[16]. And the findings are not new.

From a Bangladeshi perspective, the idea remains the same. Farmers share the same experience. Pest attacks, diseases, inefficiency in production, improper harvesting, and most importantly, the problems being unresolved for a long time are the core sources of discouragement in agriculture for farmers. Development hardly touched this sector in Bangladesh, while industrialization saw massive modernization and automation. Innovative measures in Bangladesh agriculture are not only important but necessary, for which we need to first borderline the best way to reach our objective and comparing the already available prevalent agricultural drones in the market is the way to do so. That's why this study is relevant now more than ever. According to Future Farming, the agricultural drone market is expected to grow from a $1.2 billion (USD) in 2019 to $4.8 billion in 2024[17]. This finding is interesting because Bangladesh's economy massively depends on agriculture and by using drone technology, more profitable harvesting can be multi-folded.

Benefits of Drone Technology over Traditional Agriculture Methods:

- A lot of factors needed to be considered simultaneously in the process of producing bumper crops. And the use of drones will make a lot of hassles cleared from the shoulder of farmers by just making all-round surveillance over the crops throughout the whole season most effectively[18].
- By using the NVDI [19] (Normalized Difference Vegetation Index) and NIR [20] (Near Infrared Sensors) generated by drones, the farmers can keep track of their crops' soundness by checking the satellite images, i.e., colour textures, paleness, sharpness, dullness of crops generated by the drones[21].
- The high level of spectroscopy and thermography sensors of drones enable farmers to measure their lands' moisture condition and irrigation quantity effectively.
- There has been a long debate about whether drones are more effective in artificial pollination than mechanical insects. But a recent study of AERMATICA3D [22] has provided the effectiveness of drones in pollination in walnuts, and certain other types

of plants are more than any other technology to the extent that it even beats natural pollination capability.

- Drone culture will introduce a revolution in Bangladesh agriculture through Scouting / Monitoring Plant Health, Monitoring Field Conditions, Planting & Seeding, Spray Application, Security, Drone Pollination and Drone Irrigation.

III. METHODOLOGY, PROCESS AND PROCEDURE

A definitive research experiment will be carried out by making an instructive table using information on the benefits and drawbacks based on the characteristics of drones from different review sources and using the parameter table as a guide.

Time	1pm-6pm
Temperature	28°C-35°C
Wind speed	4mph-6mph
Gusts	8mph-12mph

Four drones on the 100 m straight side of land are flown five times for the fixed operating period. The drones were passed in the following average parameters for all four days (March 8-12).

First, we take a method that combines pragmatism with virtual research. The first-hand practical experiment will aid in producing the most reliable and valuable results. If there are doubts or encounters of systematic or random mistakes in the output results, various reputable sources can be consulted to verify. Though this procedure would be considerably more difficult and time-consuming in this manner, the implications of the outcome would be more efficient.

*The steps of the method to find the best suitable drone for Bangladesh Agriculture Area***:**

1. Doing initial background research on the average climatic and weather condition – through UAV forecast application [23] of the region where the test would be done.
2. Deciding the best time to experiment with the tests (the time of the day) and considering the situation, the temperature, wind speed, and wind direction.
3. Taking the UAVs and considering the best samples out of them to test.
4. Determining the factors which are testable for the data collection (i.e., controlling range, monitoring capacity, image quality, etc.). Then, making up the final strands.
5. Collecting the open-source data by testing them practically and comparing them with other dependable sources.
6. Drawing the conclusion.

Step 1: Looking for available drones:

Several shops and organizations involved in drone rental and commerce were requested to inquire about the types of drones available. Online drone rental organizations, like AmarSheba [24] and SkyHigh BD [25] were checked too. Unfortunately, the probable sources didn't have drones at that time. According to their responses, the DJI series [26] and senseFly series [27] drones are the most demandable, and that's why they were out of stock. Later, BADC [28] (Bangladesh Agricultural Development Corporation) agreed to lend the drones for the study under the supervision of Mr. Al-Mahumud, an instructor from BADC.

Step 2: Gathering drones:

Two fixed-wing drones and two quadcopters based on the models provided by BADC were tested. BADC lent the drones and also introduced us to one of their drone instructors, who trained us to fly those four drones named;

(a) Agras MG-1-DJI [29]
(b) DJI T600 Inspire 1 [30]
(c) EBEE SQ-SenseFly [31]
(d) Lancaster 5 PrecisionHawk [32]

Step 3: Fixing the experimental location and agriculture dependent variables:

A predominantly agricultural area (with or without crops) with no obstruction to aerial flight to operate the drones was required. We have selected the same crop fields for both experiments in Kishoreganj and Mymensingh. Farmers were

asked about the procedures of the whole harvesting season.

The most frequent answers were:

1. Speediness of the working procedure.
2. Season-specific forecasts.
3. Pesticide spraying and irrigation.
4. Monitoring of crops based on the color texture.
5. Monitoring the livestock.

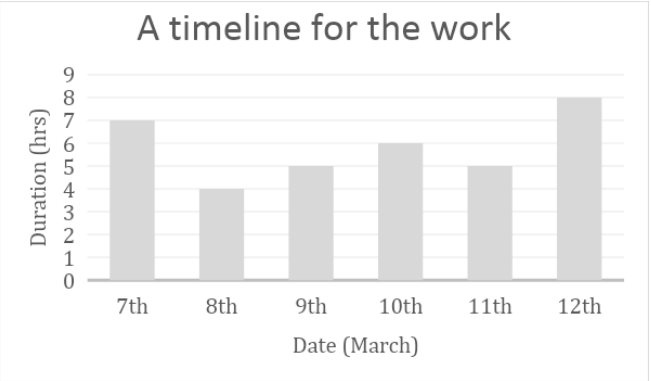
Strands for which data collection would be done were adjusted on their comments. During this step, we focused on performing these activities using our Drones to compare possible outcomes with ongoing methods.

Step 4: Experimentation and gathering of sample data:

All four drones were flown after the adjustment of the location and data recording. We divided into groups of two – one focusing on quadcopters and the other on fixed-wing drones. Trials of each of the four drones were done on the first day (March 7th) to make sure everything was working correctly; then, collection of results of the quadcopters (Agras MG1- DJI, DJI T600 Inspire1 on March 8th and 9th, respectively) and fixed-wing drones (EBEE SQ Sense Fly, Lancaster 5 PrecisionHawk on 10th and 11th March respectively) was carried out. Finally, on March 12th, we combined the collected data of our two teams.

Step 5: Double-checking and documentation of findings:

The findings were noted down and later put on the table. Revisions were done, and then the data were finalized.



IV. RESULT AND DISCUSSION

- *The average performance speed of the drones:*

Drone name	Flight no	Time recorded (100m) in sec	Average time= (total time/ total trial)	Speed= (total distance/ total time)
Agras MG1- DJI	1	14	13.5 seconds	7.4 m/s
	2	12		
	3	15		
	4	12.3		
	5	14.5		
DJI T600 Inspire 1	1	7	8.1 seconds	12.34 m/s
	2	8.5		
	3	9		
	4	8.2		
	5	8		
EBEE SQ Sense Fly	1	5.1	5.34 seconds	18.7 m/s
	2	5		
	3	5.6		
	4	6.1		
	5	4.9		
Lancaster 5 Precision Hawk	1	7	7.68 seconds	13 m/s
	2	7.5		
	3	8		
	4	8.1		
	5	7.8		

- *The performances output according to the observation:*

The performance output by the Quadcopters and Fixed Wing Drones.					
Drones (Model Names)	Average performing speed(m/s)	Vertical controlling range.	Pesticide spraying capacity	Spectroscopic and thermographic image quality	Flight duration form single charge.
(a) Agras MG1- DJI	7.4 m/s	1 kilometer	2 acres can be sprayed in 15 minutes.	Extraneous camera frame needed to be customized for getting the images. Not specialized in this field.	24 minutes
(b)DJI T600 Inspire 1	12.34 m/s	3.5 kilometers	Extraneous frame needed to be customized for pesticide spraying. Not specialized in this field	UHD (4K): 4096x2160p24/25, 3840x2160p24/25/30 FHD: 1920x1080p24/25/30/48/50/ 1280x720p24/25/30/48/50/6	18 minutes
(c)EBEE SQ Sense Fly	18.7 m/s	35 kilometers	N/A	3D flight planning and NVDI (Normalized Difference Vegetation Index) technology.	Up-to 90 minutes
(d)Lancaster 5 Precision Hawk	13 m/s	2 kilometers	N/A	3D mapping technology with NDVI available which helps inspecting over crops throughout the season	Up-to 45 minutes

A thorough analysis of the different types of drones' performance output can reveal whether the quadcopters (a,b) are more compatible than the fixed-wing drones (c,d).

Average performing speed: One hundred feet above the 100 meters of the ground crop the drones were flown by, repeating five times the time were recorded. Although there is no huge difference, the performing time disparity will ultimately widen when implemented in more extensive areas. Quadcopters 'a' and 'b' covered 7.4 meters and 12.34 meters in 1 second, whereas fixed-wing drones covered 18.7 meters and 13 meters in 1 second. In this case, fixed-wing drones outperform quadcopters in terms of operating time.

Controlling range: Regarding the control range, quadcopters in the experiment could be controlled from 1 to 3 kilometers, whereas fixed-wing UAVs could be controlled from 2 to 35 kilometers. In the selected site, we stretched the flight of EBEE SQ Sense Fly up to 5 kilometers; did not do more as advised by Mr. Al- Mahmud (in the site, after 5 kilometers, there were deep forests with tall trees on two sides). We later learned this drone could be operated from even 35 plus kilometers. Finally, Fixed Wing drones used in the experiment have the farthest control capabilities.

Pesticide spraying capability: One of the experimental sample quadcopters (Agras MG1-DJI) was explicitly built for pesticide spraying and irrigation. The nozzles had to be changed in a demo situation where there were no crops for spraying. Instead of pesticides, Water was used (not fresh Water) in the spray tank. At the same time, the fixed-wing drones used in the experiment were useless in this thread. Quadcopters, therefore, outperform in this regard.

Captured image quality: While quadcopter an (Agras MG1- DJI) is unsuitable for scanning because it has no capturing device, quadcopter 'b' has an ultra-high-definition feature. Looking at the fixed-wing drones, the scanning capabilities were phenomenal; they were designed specifically for scanning. While staying on the experiment site, a considerable difference wasn't found in image quality. But later, indoors, checking the images for judgment, it could be easily found out the sharper and clearer images taken by both of the fixed-wing drones. For scanning and

monitoring related tasks, fixed-wing drones outperform quadcopters.

Flight duration for efficient livestock farming: In cattle husbandry monitoring, the longer the flight time, the more efficient the operation. The quadcopters in the experiment could fly for 24 minutes and 18 minutes on a single charge, respectively, while the fixed-wing drones could fly for 90 minutes and 45 minutes at a stretch. Finally, fixed-wing drones were found better at livestock tracking.

Undoubtedly, drone technology is an addition to Bangladesh agriculture that will achieve altitudes in no time. It will continue to gain popularity among farmers while maximizing its capacity to produce more, saving time and labor. But more constructive work has yet to be done to help farmers advance with drone technology. The first step for anyone working on the farm with the drone for the first time would be choosing the drone. That's why confused farmers keep asking, "Which drone to use?" When the first one is answered, the following question arises – "For what purposes to use this drone exactly?"

Primarily, we chose newly introduced drones that are already in use. Fixed wing and quadcopters are two popular drones flying over crops worldwide. Each of the two comes with limitations, while they have their unique capabilities. We ran the drones in the field to test their performances practically. While we compared each drone with the other in five significant farm jobs, we did not only award one over the other eventually after the experiment was done. We specifically mentioned which drone is best for what job. The interested farmers trying to use drones on their farms for the first time will be helped by our recommendation. Furthermore, our drawn limitations for each of them will let farmers know the correct use of their purchases. After the experiment, we found raw data about each drone's performance to analyze its capabilities. Fixed-wing drones seemed to do a better job than quadcopters in every step except one. Quadcopters outperformed fixed-wing drones in only pesticide spraying capability, and fixed-wing drones beat quadcopters in all other four sectors: average performing speed, controlling range, captured image quality, and flight duration for efficient livestock farming. Thus, we found that fixed-wing drones are more efficient than quadcopters for a leading step in automation of Bangladesh agriculture.

V. RECOMMENDATIONS

In the Bangladeshi agricultural environment, the farmers needing full features from a single drone can use fixed-wing drones as their primary farming and monitoring technology. For the implications in the broader agricultural perspective, the quadcopters need to be developed more in terms of performance speed, remote controlling distance, and flight duration. On operational handiness, the application software for running and operating those drones was tough to manage as they were complex. And no option is in the software to translate the apps' language into Bangla. These are the sectors that remain to be improved.

VI. CONCLUSION

The time efficiency and the higher yield of agricultural production are not only affordable but also already in practice in different countries. So, to follow up on the advancement of technology and modernization, the impact of globalization, influence of industrialization, it can be concluded that for an agriculture-based developing country like Bangladesh, if the farmers start using fixed-wing drones for their primary farming and monitoring, it will be possible to boost up the country's economy by bolstering higher production yield in the agricultural area.

To draw conclusion, fixed-wing drones were found to be more compatible in four of the five working sectors whilst quadcopters in one. So, any farmer can start using fixed-wing drones for farming and later upgrade to the more advanced future quadcopters for higher yields.

REFERENCES

1. https://www.macrotrends.net/countries/BGD/bangladesh/surface-area-km

2. https://en.banglapedia.org/index.php/Agriculture#:~:text=Agricultural%20land%20The%20total%20land,and%20very%20lowland%20(2%25)
3. https://www.thedailystar.net/supplements/celebrating-50-years-bangladesh/news/agriculture-bangladesh-the-last-and-the-next-fifty-years-2066689
4. https://statisticstimes.com/demographics/country/bangladesh-demographics.php
5. https://en.wikipedia.org/wiki/Agriculture_in_Bangladesh
6. https://www.thedailystar.net/business/economy/national-budget/news/food-agriculture-lot-hype-little-promised-3043881
7. https://timesagriculture.com/drone-technology-in-agriculture/#:~:text=In%202000%2C%20the%20Japanese%20company,crop%20mapping%20and%20field%20analysis.
8. https://www.observerbd.com/news.php?id=209798
9. https://www.thedailystar.net/backpage/drones-used-first-time-bangladesh-4956
10. https://www.sciencedirect.com/topics/engineering/unmanned-aerial-vehicle
11. https://droneomega.com/what-is-a-quadcopter/
12. https://www.fao.org/asiapacific/perspectives/agricultural-statistics/global-strategy/results-in-the-region/bangladesh/en/
13. https://www.dronedeploy.com/solutions/agriculture/
14. https://www.observerbd.com/news.php?id=209798
15. https://www.globenewswire.com/en/news-release/2022/05/27/2452057/0/en/India-Agriculture-Drones-Market-to-Witness-Four-Fold-Increase-by-2028-BlueWeave-Consulting.html
16. https://www.fao.org/e-agriculture/news/hack-harvests-how-drones-and-smartphones-are-helping-ugandan-farmers-save-their-crops-pests-and.
17. https://www.futurefarming.com/smart-farming/tools-data/agricultural-drone-market-to-grow-to-usd-4-8-billion/
18. https://www.jouav.com/
19. https://gisgeography.com/ndvi-normalized-difference-vegetation-index/
20. https://www.infinitioptics.com/technology/nir-near-infrared
21. https://blog.mapbox.com/visualizing-ndvi-for-agriculture-ad35d7c5f27e
22. https://www.aermatica.com/en/aermatica3d-realizes-the-drone-solution-for-artificial-pollination/
23. https://play.google.com/store/apps/details?id=com.uavforecast&hl=en&gl=US
24. https://amarsheba.com/
25. https://web.facebook.com/skyhigh1377/?_rdc=1&_rdr
26. https://www.dji.com/mproducts/mavic
27. https://www.sensefly.com/
28. http://www.badc.gov.bd/
29. https://www.dji.com/mg-1
30. https://www.dji.com/inspire-1/info
31. https://www.dronefly.com/sensefly-ebee-sq.html
32. https://www.precisionhawk.com/blog/media/topic/lancaster-5