BANGABANDHU SHEIKH MUJIBUR RAHMAN AVIATION AND AEROSPACE UNIVERSITY

UTILIZATION OF UNMANNED AERIAL VEHICLES (UAV) IN BANGLADESH: PROSPECTS AND CHALLENGES

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31 March 2022

Bangabandhu Sheikh Mujibur Rahman Aviation and Aerospace University

Statement of Original Authorship

I, **TANVIR EHSAN** certify that the thesis paper "**UTILIZATION OF UNMANNED AERIAL VEHICLES (UAV) IN BANGLADESH: PROSPECTS AND CHALLENGES"** is my own work and that use of material from other sources in this paper has been properly and fully acknowledged in the text following the **BSMRAAU** referencing conventions. I am fully aware of the ethical behaviour in academic works, definition of plagiarism and the department's advice on good academic practice.

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LETTER OF ACCEPTANCE

This isto certify that the thesis on "**Utilization of Unmanned Aerial Vehicles (UAV) in Bangladesh: prospects and challenges" is done by TANVIR EHSAN as a partial fulfillment of the requirement of Masters of Business Administration (MBA) from the** Department of Aviation Operation Management (BSMRAAU). I believe that the report has been prepared by him under my guidance and is a record of bona fide work carried out successfully.

I wish him success in every stage of life.

_____

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ABSTRACT

Pre-programmed schedules or automation systems allow less dependency on humans. There will be a huge development in the UAV sector during the 4th industrial revolution in Bangladesh benefiting the lives of 160 million people. The uses of UAV technology in diversified activities such as Agricultural Management, Climate change monitoring, public health management, wildlife observation, protection forestry surveillance, Disaster Risk Reduction Management, and so on.

The objective of the research is to identify the prospects of the utilization of the UAV for socio-economic as well as environmental sustainability in Bangladesh; to explore the main barriers for the expansion of the use of UAVs towards sustainable development that includes socio-economic as well as environmental sustainability in Bangladesh, and to propose some viable recommendations which can expand the UAV industry in Bangladesh. This study has been initiated by collecting and reviewing primary and secondary data. Mixed-method research methodology has been used which includes both quantitative and qualitative approaches. From benefits and cost analysis, it has been observed that by using UAVs, agricultural productivity can be increased significantly. One of the challenges is the balance between the UAV cost and the performance.

To expand this lubricative industry, financial support through government incentives, foreign investment, and public-private partnerships is essential.

Keywords: UAV, Utilization, Prospect, Challenges

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CHAPTER 1: INTRODUCTION

1.1. Introduction

Unmanned Aerial Vehicle (UAV), or drones are aircraft that can be operated remotely by a pilot or by pre-programmed schedules or automation systems, allowing them to fly autonomously.

Social, economic, environmental, and industrial as well as recreational users deploy this technology across the globe. Leveraging the Fourth industrial revolution for strengthening competitiveness as well as creating high-income, future work opportunities will lead to the prosperity of Bangladesh. For instance, the benefits of UAV technology have the potential to touch the lives of 160 million Bangladeshi citizens (Perspective Plan, 2021). Uses of UAV technology in diversified activities such as delivery of goods, aerial survey, aerial photography, socio-economic and resettlement survey, agricultural farming, Disaster Risk Reduction and Management (DRRM), Health management, Climate change monitoring, Marin time Surveillance**,** wildlife observation and protection, forestry surveillance, and so on.

Now it's time for the authorities of Bangladesh to take a proactive role in catalyzing the growth of UAV start-ups for service innovation through liberal regulations, research, and development (R&D) supports as well as lead usages.

1.2. Background of the Study

While drones have had a long history in military deployment, their increasingly widespread use in non-military roles requires consideration. Though current usage is limited, whilst the technology is in the development phase, as they

possess significant potential versatility, drones may transform the way that logistics services are provided such as maritime survey as well as rescue operations, border surveillance, air space management as well as surveillance, surveillance in the hilly areas, in the environment by spraying pesticide on insects on farmland in many countries, climate change monitoring, DRRM, aerial photography and so on. As a result, it acts not only as an economic booster but also helps to purify the environment.

The use of drones for different purposes have been gaining popularity in Bangladesh too as well as news reports, covered stories on the seizure of drone components from terrorist, use of a drone by the South African Cricket team during their practice session(*Drone in Bangladesh: Safety Concerns and Regulation | The Daily Star*, n.d.), an inspection of Padma Bridge and seizure of drones, with or without owners, in different occasions even though the present Import Policy does not contain specific provisions on drone import in the country.

As drone technology advances, these aircrafts are expected to become more popular as well as affordable. Rising adoption of UAV in a civil and commercial applications, increasing deployment of UAV in border patrolling and combating terrorism, and regulations to permit the use of UAV in several industries are the key factors driving the growth of the unmanned aerial vehicle (UAV) market.

1.3 Problem Statement

UAV is a valuable as well as a growing industry in Bangladesh. Its development has been accompanied by social, economic, and environmental

impacts. For instance, in agriculture, Rice is the most beneficial product and cash crop in many areas of Bangladesh. However, many reasons have affected this culture which is not being addressed adequately, especially- the challenges of cultivators. The government, industrial and scientific communities have encouraged industrial expansion while at the same time, the sustainability of the traditional farms is threatened by a combination of poor management practices, pollution by farm effluents, climate change, pest management, viral diseases, and so on.

The visionary Government of Bangladesh under the leadership of Prime Minister Sheikh Hasina has already taken several robust initiatives to recover the loss in focusing the environmental sustainability as well. Relevant ministries, public and private agencies, research, and academic institutions need to implement the planned activities and develop further plans to address the challenges faced by the farmers in Bangladesh. Subsequently, coordinated approach among the public and private entities including all relevant stakeholders is essential.

The use of UAVs will undoubtedly lead to the achievement of new business, social, environmental, and other goals. However, it also creates a potentially disruptive scenario as their usage expands out of control and causes problems for other parts of the economic system.

The prime objective of the study is to identify the prospects of the utilization of the UAV for socio-economic as well as environmental sustainability in Bangladesh, explore the main Barriers for the expansion of the use of UAVs towards sustainable development that includes socio-economic as well as environmental sustainability

in Bangladesh and recommend some possible ways for the expansion of the UAV industry in Bangladesh.

1.4. Research Questions

The research work will find the answer to the following questions.

i. What are the potential use of UAVs for socio-economic and environmental sustainability in Bangladesh? and
ii. What are the major constraints for the significant use of UAVs towards the socio-economic as well as environmental sustainability in Bangladesh?

1.5. Research Objectives

The purpose of this research proposal is

i. To identify the prospects of the utilization of the UAV for the socio-economic as well as environmental sustainability in Bangladesh;
ii. To explore the main barriers for the expansion of the use of UAVs towards sustainable development that includes socio-economic as well as environmental sustainability in Bangladesh; and
iii. To propose some viable recommendations which can expand the UAV industry in Bangladesh.

1.6. Rationale and Significance of the Study

Bangladesh is at the cusp of the fourth industrial revolution (4IR), which is likely to have a transformational impact in every sphere of our life. Although start-ups, Artificial Intelligence (AI), or UAVs have roots in advanced countries, they are showing potential in developing countries such as Bangladesh as well. Due to

the commodification of hardware component technologies, software-centric innovations around them are also opening up new opportunities for promising start-ups in these countries.

By this study, the researcher will identify the prospects of the utilization of UAV in the potentiality of UAV in Bangladesh in geomorphological studies, in biogeography studies, Disaster Risk Reduction and Management (DRRM), maritime surveillance, Climate change monitoring, wildlife observation and protection, and so on. The researcher has taken initiative to conduct this study with the hope that this study will add value to the existing literature concerning the existing challenges to explore the UAV as well. Furthermore, the researcher expects that this study will play a key role to motivate the authorities in the sector to undertake possible actions to expand the UAV industries in Bangladesh.

1.7. Conceptual Framework

The study would first attempt to assess the current scenario of utilization of the Unmanned Aerial Vehicle in Bangladesh. Then the research work will ascertain sustainable development by using Unmanned Aerial Vehicle. Meanwhile, the researcher would gather necessary information from primary and secondary sources as well. Simultaneously, the study will examine the main barriers for the expansion of the use of unmanned Aerial Vehicles towards sustainable development that includes socio-economic as well as environmental sustainability in Bangladesh. Eventually, the study will propose viable recommendations regarding institutional as well as policy supports for expanding this lucrative industry.

For clear understanding the conceptual framework is shown in the diagram below:

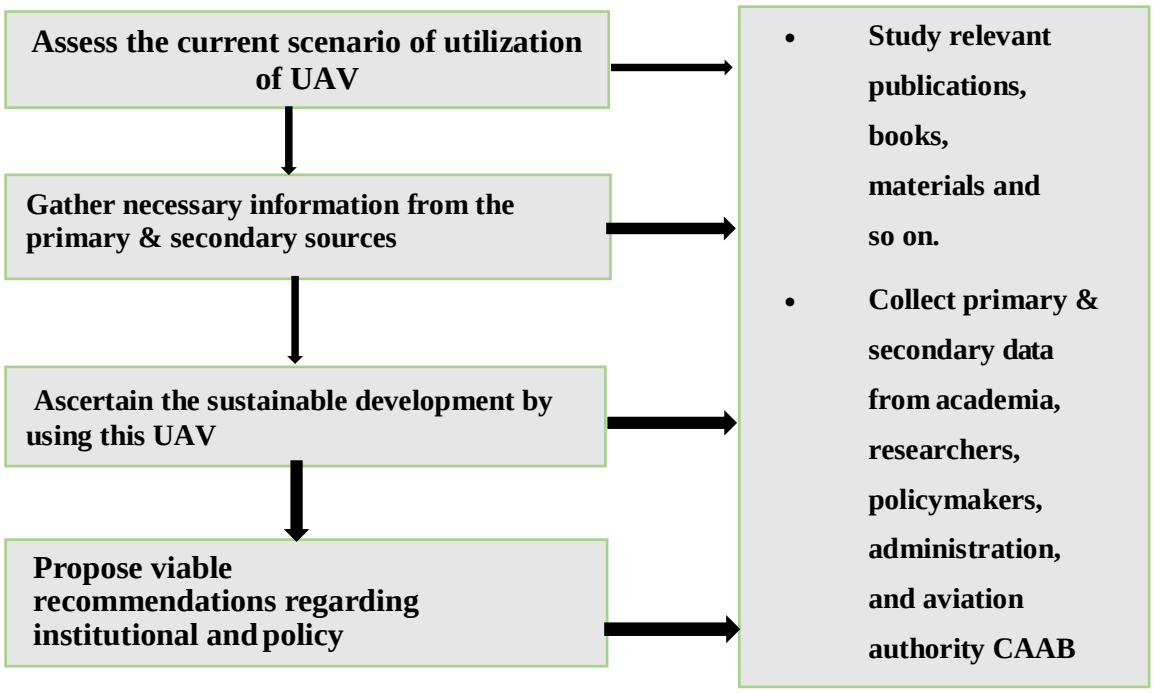

Figure 1: Conceptual framework

1.8. Structure of the thesis

The present thesis comprises five chapters. Chapter one titled '**Introduction**' gives an introduction of the study along with the objectives of the research work.

Chapter two titled '**Literature Review**' contains brief & selective review of the literature.

Chapter three titled '**Methodology**' presents a methodology for carrying out the work.

Chapter four titled '**Data Analysis and Findings'** studies and analyze the data collected through the primary as well as secondary sources.

Eventually, chapter five titled '**Conclusion** 'attempts to bring the major findings of the study together in the form of conclusion and outlines recommendations for the studies to be required in the future.

1.9. Hypothesis of the Study

The study has been conducted on the basis of the following hypothesis.

Null Hypothesis: H0: There are no Significant barriers towards the use Of UAV in Bangladesh

Alternative Hypothesis: H1: There are Significant barriers towards the use of UAV in Bangladesh

CHAPTER-2: LITERATURE REVIEW

2.1. Introduction

A literature review has seemed like the internal part of the research. There are several research works regarding the utility of UAVs all across the world, however, no significant research has been published regarding challenges and prospects in Bangladesh. Relevant works of literature have been reviewed by the researchers.

2.2. An Overview and Analysis of related Literature

The findings of the review of the works of literature are appended below:

(Gallay, 2013) states that in experiments, SfM (Structure-from-Motion) utilizes algorithms to reconstruct the three-dimensional structure of objects from two-dimensional overlapping digital imagery(Gallay, 2013).

(Candigo et al., 2015) argued that Traditional topography maps, as well as satellite-derived DEMs, are not enough to demonstrate subtle variations between multiple terraces (Candiago et al., 2015).

Drones in Biogeography to bring precision the o agriculture, drones can be used in biogeographical studies. In agriculture, three jobs are done precisely by using drones. They are: - Crop monitoring and height estimations - soil and field analysis pesticide spraying. Candiago et al., (2015), have mentioned about three indexes to be used in crop monitoring as well as vegetation health(Candiago et al., 2015). Luppicini and So, (2016), mentioned that While there have been earlier reviews the commercial use of drones is yet to be written about in any significant volume in the management literature(Luppicini & So, 2016).

(Ramadan et al., 2017) stated that the technological aspects of drones have been identified to form a relationship with consumers through changing perceptions of risk, functional benefits, and relational attributes(Ramadan et al., 2017).

Bamford et al., (2017) mentioned that including monitoring stockpiles of ore and leeching pads for maintenance issues as well as analyzing blast ore before its processing(Bamford et al., 2017).

Farming has had a recent history of using satellite information to identify crop health issues, using data collected to more efficiently target the application of fertilizers as well as pesticides.

Na et al., (2017) stated that Farming has had a recent history of using satellite information to identify crop health issues, using data collected to more efficiently target the application of fertilizers as well as pesticides(Na et al., 2017).

(Daly, 2017; Aydin, 2019) stated that Privacy issues remain a concern, particularly from drones that can capture imagery, particularly those that are used close to private personal space such as homes and apartments(Daly, 2017).

Honjo et al., 2017) mentioned that SfM techniques to obtain a mosaic of larger areas. The technique was successfully used in obtaining climatic data in Japanese cities(Honjo et al., 2017).

Drones in Climatic Research For the last 10 years, drones are in use of climatic research acquiring data as well as relevant information over areas under investigation in Australia and the US. (Honjo et al., 2017) mentioned that there are four ways that drones can help scientific researchers in obtaining climatic data. -

Drones help farmers to reduce costs as well as increase resilience - Drones help communities to manage water during the drought period - Drones help to track wildlife movement and protect key habitat - Drones help scientists to monitor ever-changing coastal areas(Honjo et al., 2017).

Solodov et al., (2018) argued that power stations have the potential to and do cause costly disruption (e.g. the near-total closure of Gatwick Airport and disruption to fire and emergency services work in Tasmania in (2018)(Solodov et al., 2018).

Chang and Li, (2018) argued that other amenity issues, such as the impact of noise, are also under consideration(Chang & Li, 2018).

Weersink et al., (2018) argued that Agricultural (and related) industries are inquisitive when it comes to learning more regarding the land they manage as well as naturally have looked at drone technology to capture new information (Weersink et al., 2018).

(Nelson and Gorichanaz, 2019) stated that drones require societal trust (Nelson & Gorichanaz, 2019).

(Hwang et al., 2019a) mentioned that Drones provide a psychological benefit to consumers as well as generate positive intentions to use drones (Hwang et al., 2019).

(Hwang et al., 2019b) argued that Perceptions of environmental benefits suggest favorable consumer perceptions of drone use(Hwang et al., 2019).

(Hwang et al., 2019c) studies that motivated consumer innovations to suggest that dimensions of functional, hedonic, and social motivated ness are key drivers of attitudes towards consumption using drones(Hwang et al., 2019).

Hwang et al., (2019) state that innovativeness is noted as an attraction of drone food delivery services for consumers, with younger as well as female consumers more likely to be attracted by drones(Hwang & Choe, 2019).

Hwang et al., (2019) mentioned that managing perceived risks associated with drone deliveries is a necessary task for foodservice delivery operators(Hwang et al., 2019).

Stankov et al., (2019) mentioned that the use of drone imagery in this manner is, therefore expanding(Stankov et al., 2019)

2.3. Research Gap

There are several research works regarding the utilization of Unmanned Aerial Vehicle (UAV) all across the world, however comprehensive, as well as significant study, has been found hardly regarding this matter in Bangladesh.

This research has been focused to explore the tremendous prospects to use the UAV for sustainable development such as socio-economic as well as environmental sustainability in Bangladesh. Furthermore, this research has the potential to motivate the policymakers for undertaking further actions to address the challenges of exploring the UAV industry in Bangladesh.

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CHAPTER-3: METHODOLOGY

3.1. Introduction

This study has been initiated by collecting primary data from Researchers and government and private employee from relevant sectors and associated organization reviewing previous research reports, newspaper articles, and online document reports from the Civil Aviation Authority of Bangladesh.

3.2. Research Approach and Types of Data

This study has been initiated by reviewing previous research reports, newspaper articles, online documents, reports of Govt.

Mixed-method research methodology has been used which includes both quantitative and qualitative approaches.

Quantitative data shows the numerical presentation of data along with necessary tables & charts. On the other hand, qualitative data has been illustrated through the descriptive presentation. Information has been collected from secondary sources and also has been collected from cross-sectional data from the primary sources as well.

Primary Data. Primary source information has been gathered from the farmers from the selected regions. Researchers, Private and govt. officers of relevant sectors and associated organizations have also been consulted for their expert opinion.

Secondary Data. Secondary data of the related issues have been collected from various books, policies, journal articles, newspaper articles and presentations. Relevant content will be analyzed to critically and objectively review published and printed facts, opinions and observations too.

3.3. Data Collection Period

The data collection period for the study has been considered from May to November 2021.

3.4. Selection of Target Group

The target group was the professionals engaged in the agricultural sector, Government, Private organizations, Academia, Business, research and so on.

3.5. Sampling Frameworks and Data Collection

Both primary and secondary data have been used in this study and findings would have been developed on the basis of collected data. Primary cross-sectional data would have been collected in different sampling methods, including-direct/telephonic interview, emailing by using semi-structured questionnaire, FGDs. Qualitative data have been gathered by informal discussion/interview conducted on farmers, govt. officers, researchers, and so on.

3.6. Questionnaire Design

The questionnaire for the survey is comprised of two parts; the first part includes name, designation and organization about respondents' age and profession. All the questions are **multiple-choice and close-ended questions.** Because of being closed- ended and multiple-choice in nature. The results of the questions are easy to compare, tabulate and analyze. In the questions **5-point Likert-scale** was used where the respondents are asked to select the most appropriate number those correspondents to extent to which they agree with a statement. The scales in our survey questions are 1 to 5 with "1" denoting "strongly disagree" and "5" denoting "strongly agree". A five-point Likert scale is used to determine the importance and acceptance of each question.

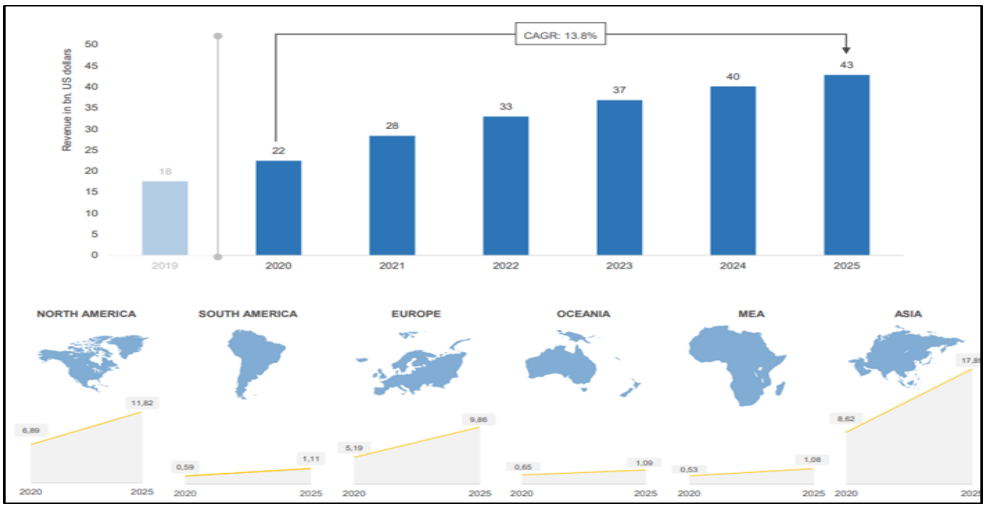
3.7. Processing and Analysis of Data

Data collected from primary as well as secondary sources will be analyzed to understand the present condition, challenges, and prospects of UAVs in terms of socio-economic and environmental perspectives. Different figures, tables will be produced through various analytical tools, techniques. Furthermore, statistic software SPSS software has been used to analyses the data.

CHAPTER-4: ANALYSIS AND FINDINGS

4.1. Introduction

An unmanned aerial vehicle (UAV) or drone, is an aircraft without any human pilot, crew, or passenger on board. UAVs are a component of an unmanned aircraft system (UAS), which includes a ground-based controller and a system of communications with the UAV. The flight of UAVs may operate under remote control by a human operator, as remotely-piloted aircraft (RPA), or with various degrees of autonomy, such as autopilot assistance, up to fully autonomous aircraft that have no provision for human intervention.4.2. Global scenario of Unmanned Aerial Vehicles (UAVs).



(Sources: Drone II.com)

Figure 2: Drone Market Size and Forecast 2020-2025

From the above figure, it has been observed that The Drone market size will grow to 42.8 billion USD by 2025. From generating 22.5 billion USD in 2020 it will grow at a CAGR (Compound Annual Growth Rate) of 13.8% to almost double that in 2025. While back in 2018 North America was generating slightly more revenue compared to Asia. Furthermore, Asia pulled ahead already by the end of

2019. Moreover, the region will continue to build on this growth and be the leading regional market by some margin in 2025.

Surveying of construction sites will enable building managers to fulfill project deliverables efficiently in a short period.

With climate change having a devastating impact on wildlife, conservationists are using innovative drone technology to monitor and track endangered species as well as collect samples.

The progressive automation of agricultural processes has significantly improved the productivity of agriculture labor, shifting masses of workers into other productive industrial areas. In effect, in recent years agricultural production has increased substantially.

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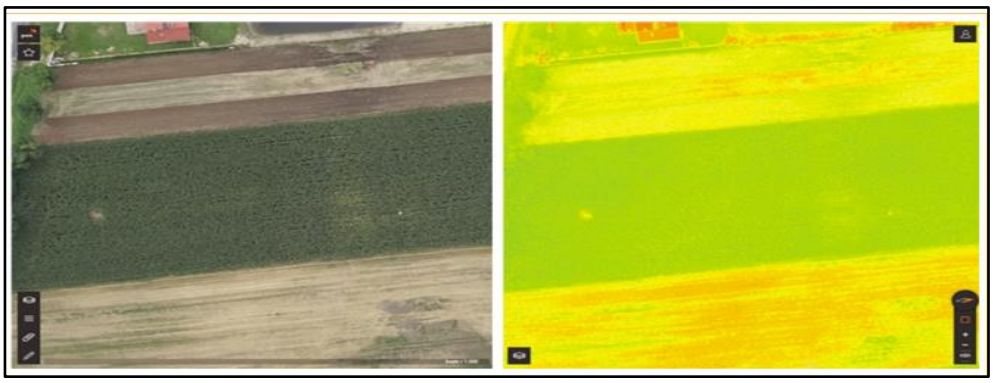


(Source: PwC commercial drone consulting project)

Figure 3: Analysis of the NDVI index output enables monitoring of corn crops condition

Nowadays, drone technology is employed in insurance, with agriculture claims management. Another, rather non-obvious application of drone imaging and mapping capabilities is counting and taking stock of herds of animals.

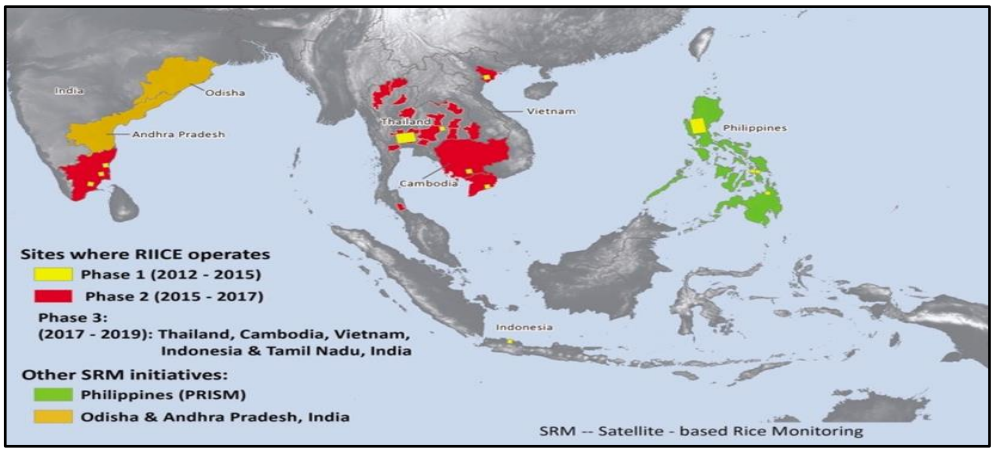
Mapping and imaging capabilities of drone platforms with a range of sensors can be used throughout the whole production process to plan production better and therefore in many business activities, drones can substitute traditional methods of operation.

4.2. USA, North America Europe, Africa, Asia Scenario of Unmanned Aerial Vehicles (UAVs)

(Source: https://news.marketersmedia.com)

Figure 4: Europe UAV Market Size 2017 and 2024

From the above figure, it has been observed that the Europe Commercial Drone Market size in 2017 was estimated to be over 27 thousand units. Furthermore, it is anticipated to grow at a CAGR of 24% with the market value of more than USD 500 million and is anticipated to grow at a CAGR of around 21% over 2024 (*Europe Commercial Drone/Unmanned Aerial Vehicle (UAV) Market 2019 | Rising Growth, Business Analysis and 2024 Forecast Study*, n.d.).



(Source: https://www.fao.org /06.04.2018)

Figure 5: SRM- Satellite-based Rice Monitoring in recent years

These satellite-based rice monitoring (SRM) initiatives integrated remote sensing, crop modeling, and ICT tools to generate and provide near-real-time and accurate information on rice growth, yield, as well as damage caused by abiotic and biotic stresses.

4.3. Bangladesh Scenario of Unmanned Aerial Vehicles (UAVs)

Recent media reports show that the use of drones has been increasing day by day in many government and private sector projects as well as for making dramas, movies, advertisements, documentaries, for instance, movie Aynabaji, documentaries of Kushiara power plant, Mohipal flyover project, mapping of Sundarbans oil spills, and so on. Drone selling as well as renting businesses have also been going on in Bangladesh.

4.4. Potentiality of UAV uses in Bangladesh from Socio-economic perspectives

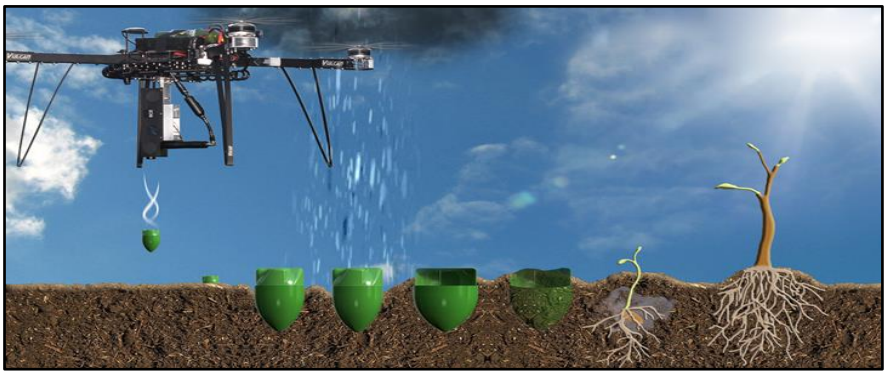
4.4.1. Geomorphological studies

In geomorphological studies, a high-resolution representation of the Earth's surface is a significant requirement. Topographical data is generally derived from digital topography maps or satellite-based digital elevation models (DEM) achieved with terrestrial laser scanning (TLS) as well as aerial laser scanning (ALS) Scanning is done, on a very limited scale. Therefore, Bangladesh has limited knowledge regarding the uses of these electronic devices.

4.4.2. UAV in Biogeography studies

4.4.2.1. Planting Seeds and Seedlings

Planting seeds, as well as seedlings, can be made more efficient by using UAVs. effective use UAVs can be used in a large area of uneven rice paddies. A UAV-based system to distribute seeds as well as plant nutrients by accessing conditions for plant growth. The drones shoot seeds with nutrients in the soil with an average uptake of 75 percent, thus bringing down costs for planting.



(Source: https://internationalforestindustries.com/2019/04/26/)

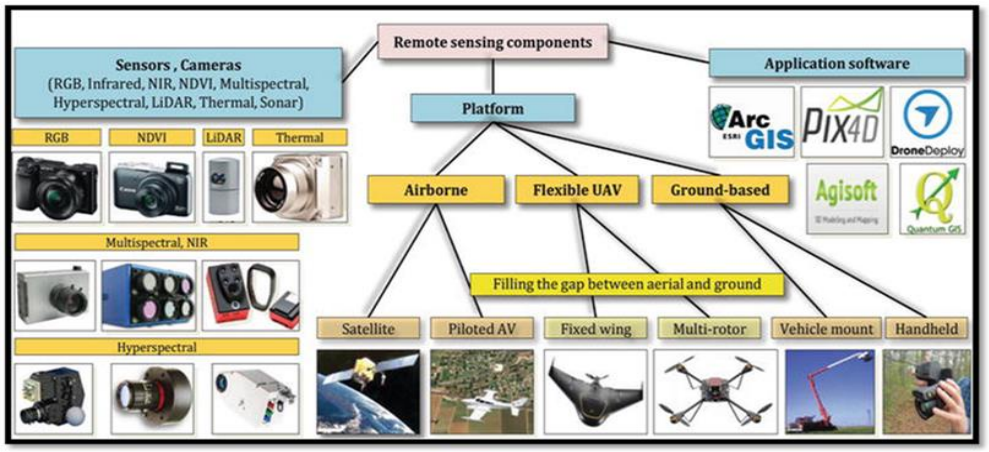
Figure 6: Planting Seeds and Seedlings

4.4.2.2. Crop Health Monitoring

One of the latest developments helps to assess a plant's health as well as spot bacteria or fungal infections on trees. in the case of crop failure, the farmer will be able to document losses for insurance claims much faster.

The most common smart farming application is to assess plant health by using remote sensing as well as image analytics. One of the most applied remote sensing methods is aerial monitoring by using images captured by satellites and unmanned and manned aircraft. However, satellite imagery is very expensive for developing country farmers. Furthermore, the resolution, as well as quality of satellite data, are not practical as well as satisfactory due to the weather conditions. Accordingly, aerial data captured by manned aircraft present a better quality compared to the satellite data, however, this method is also costly. Conversely, small unmanned aerial vehicles (UAVs), also known as drones, can provide high-quality data more economically.

The national agriculture policy-2018 (Jatio Krishi Niti-2018) stressed adopting the Precision Agriculture concept (Krishi Niti-2018 clause 10.9) in Bangladesh so that farmers could increase their crop production. Furthermore, Climate change is a huge issue for future food production. The climate-smart agriculture techniques are now discussed at the policy level in this context. Wide-scale use of drones in our next generation. Precision Agriculture could be a driving force to accurately monitor, assess and forecast crop health, food production, and food deficit as well as surplus, respectively.



(Source: Copyright 2018, license Intech Open)

Figure 7: Typical components of a remote sensing platform for smart farming

4.4.2.3. Pest Management

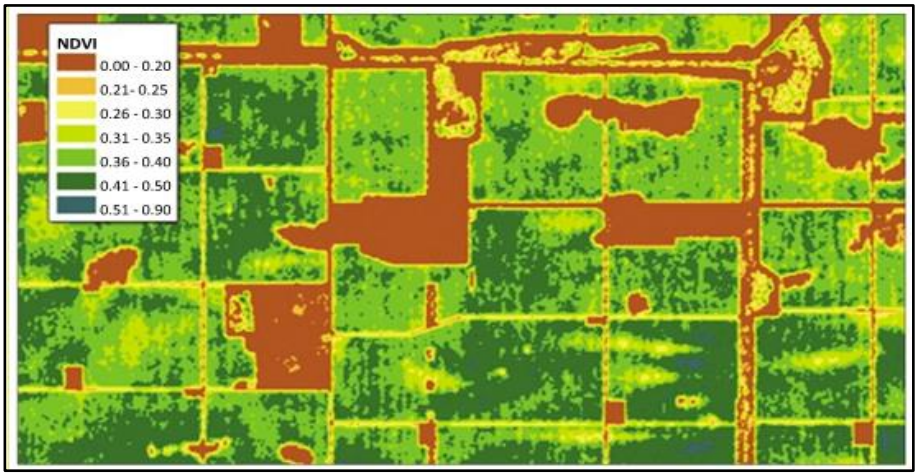
Aerial photography, multispectral imagery, pests, and diseases of crop monitoring, as well as forecasting, are the major implications of drones in Agriculture. Multispectral (true color) images are widely used to determine soil and crop health so that it is possible to estimate the crop yield, weed, pest, and pathogen infestation as well as future prediction of yield.

Typical spraying drones have a tank capacity of about ten liters of liquid pesticide having a discharge rate of one liter per minute, can cover one hectare in ten minutes.

The drone-based spraying platform synchronized can be with an aerial crop monitoring process, thus providing accurate as well as efficient use of the agrochemical products.

The spraying can be paired and synchronized with precision imaging, processing, and automated analytical capabilities to address the affected areas or plants

perfectly. It helps to ameliorate the required dosage in the affected areas and thus reduce the overall use of chemicals within the area. It ensures spraying in real-time for even coverage.



(Source: Drone Deploy)

Figure 8: NDVI map depicting crop health

Drones can carry suitably sized reservoirs, which can be filled with fertilizers, herbicides, or pesticides for crop spraying on large areas in less time. Smart farms use drones for agriculture spraying, which reduces the contact of humans with fertilizers, pesticides, and other harmful chemicals. Drones enhance spraying capacity up to five times faster than traditional machinery.

4.4.2.4. Irrigation Management

Drones with hyperspectral, multispectral, or thermal sensors can identify which parts of a field are dry or need improvements. Furthermore, it helps to make precise irrigation scheduling: when to irrigate as well as how to irrigate. Drone survey helps improve water efficiency and disclose potential pooling as well as leaks in

irrigation by providing Irrigation monitoring yields calculations of the vegetation index to help realize the health of crops and emitted heat and energy.

The application of drones in the Precision Agriculture of Bangladesh is minimal. Only a few drones are currently operating just for research purposes. In Bangladesh, the drone was first used in Agriculture in 2015 by International Maize and Wheat Improvement Centre (CIMMYT) in collaboration with Bangladesh Agriculture Research Institute (BARI). The project's objectives include determining the irrigation requirement as well as assessing the crop damage from floods or cyclones.

The drone technology is being used for the first time under Cumilla-Chandpur-Brahmanbaria District Irrigation Area Development Project under BADC. Through the use of this technology, the current status of the project area and the progress of the project area after implementation can be considered.

The project stakeholders are working for a sustainable solution to the problem by identifying the amount of waterlogged area as well as its causes through drones. CEGIS, a trust under the Ministry of Water Resources, has provided technical assistance regarding this matter.

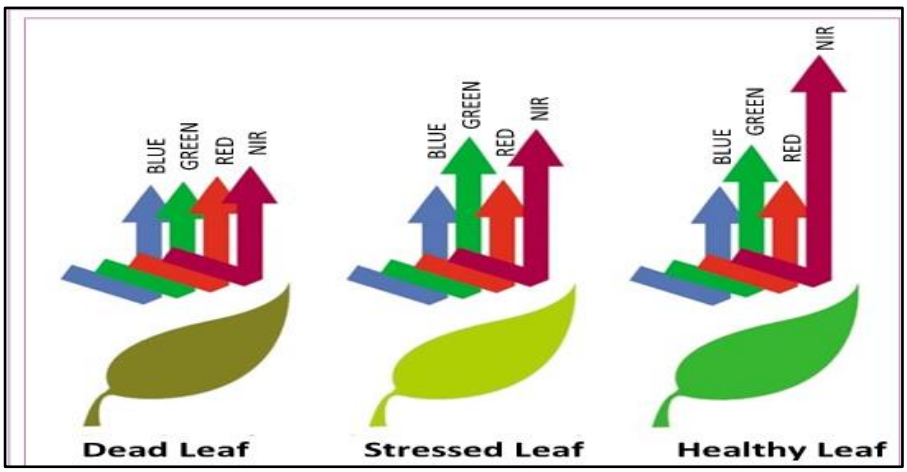
4.4.2.5. Monitoring and management of agricultural productivity

Agricultural drones are Unmanned Aerial Vehicles designed, manufactured, and equipped with essential elements, systems, tools, and technologies required to perform specific functions for the accomplishment and improvement of agricultural

activities and research. It has been proved to be very effective and helpful for the research and development of agriculture.

Many organizations are working for the development of agriculture in Bangladesh that can take the responsibility of utilizing this unique technology, for instance, the Bangladesh Agricultural Development Corporation which has had a longstanding experience of dealing with various agricultural technologies may consider such a project for the interest of our country.

The drones can survey the crops for the farmers periodically as they wish daily, weekly, or even hourly to observe the changes in the crops over time, identify any trouble spots and take appropriate actions on time to improve crop management and production. It is capable of surveying every inch of hundreds of hectares in just a few hours. Drone-enabled NDVI (Normalised Difference Vegetation Index) values analysis helps to indicate the precise timing for harvesting.



(Source: agribotix.com)

Figure 9: NDVI and Plant Health

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 its use for the modernization of our agriculture.

In Bangladesh, drones can help researchers in all of the above areas such as farmers to reduce costs as well as increase resilience that help communities to manage water during the drought period.

For the first time in Bangladesh, agriculturalists have started using drones to monitor farmlands in the southern districts of Barisal and Patuakhali. In Bangladesh, the drone was introduced in agriculture in 2015 by an international non-government organization CIMMYT (International Maize and Wheat Improvement Centre) in association with Bangladesh Agricultural Research Institute and Bangladesh Agricultural Research Council with approval from the defense ministry. The objectives of the project include:

- Collection of data from 23 acres of land in four villages of Patuakhali and Barisal,
- Analyze data to determine when and how to irrigate, apply fertilizers or pesticides,
- Ascertain crop damage from flood or cyclone, and
- To find out the requirements of the farmlands to increase crop production.

The farmers are also very cheerful as well as fascinated by the stunning performances of this new device. The radio-controlled unmanned aerial vehicles or UAVs equipped with a set of cameras, take high-resolution photos of the soil as well as crops.

(Source: https://www.thedailystar.net)

Figure 10: A drone built for collecting farm data is in operation at Jain Kathi of Patuakhali Sadar Upazila

By using the images taken by the octocopters, scientists can rapidly assess the condition of crops on a large scale without going through tedious and time-consuming manual sampling. Issues such as crop growth, nutrient deficiency, water abundance, disease attacks, and insect infestation can easily be quantified after analyzing the UAV images.

International NGO CIMMYT is implementing the project -- Spurring a Transformation for Agriculture through Remote Sensing (STARS) -- in association with Bangladesh Agricultural Research Institute and Bangladesh Agricultural Research Council with approval from the defense ministry.

Two drones have been bought from Germany under the 20-month project that began in November last year and is now being used to collect data from 23 acres of land in four villages of Patuakhali and Barisal. Maize, wheat, and mung bean are being cultivated in the land. The project's prime objective is to analyze farming conditions as well as ameliorate them in the southern part of the country as per a master plan of the government.

The data obtained through the drone images would help farmers decide when and how to best irrigate as well as apply fertilizers. Gradually, data on crop damage from floods as well as cyclones will also be collected by the drones, The farmers in the project areas are upbeat about the new technology. Furthermore, farms productivity can be achieved.

4.4.2.6. Benefits, Costs, and Saving in Using UAV in Agricultural Sector

4.4.2.6.1. High field capacity and efficiency:

Drones have very little turnaround time and other field operational delays. The drone can spray 50-100 acres per day depending upon the capacity of the drone which is 30 times more than the traditional knapsack sprayer.

4.4.2.6.2. Wastage reduction:

Due to a high degree of atomization while spraying, 30% of pesticide is saved. Pesticides in the form of chemical fog can be sprayed at all levels of the crop.

(Source: https://www.indiamart.com)

Figure 11: Agriculture Pesticide Spraying by Drone in India

4.4.2.6.3. Water-saving:

Drone utilizes ultra-low volume spraying technology, thus saving 90% of water in comparison to traditional spraying methods.

(Source:

https://www.indiamart.com)

Figure 12: Watering by Drone in India

4.4.2.6.4. Lower cost:

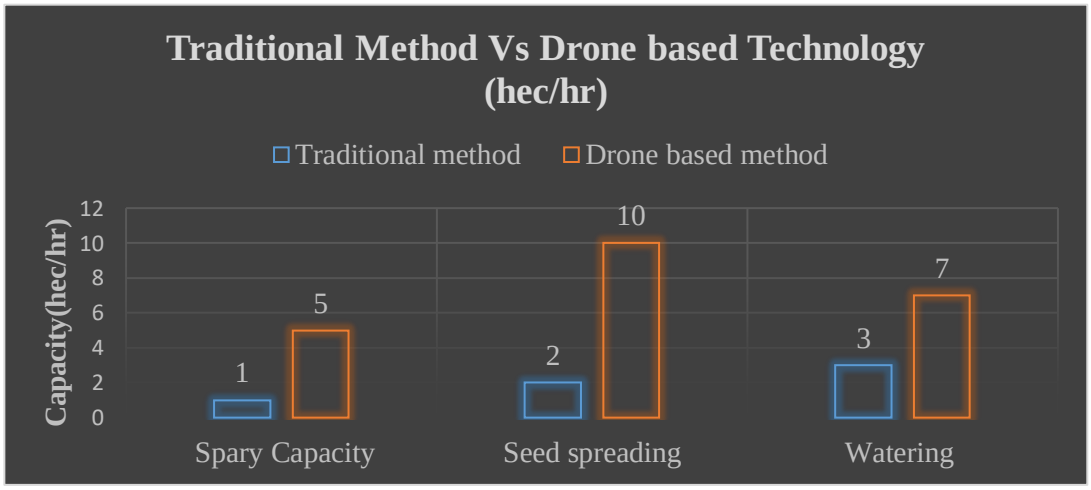
In comparison to conventional spraying methods, the cost of drone spaying is reduced by 97%.

4.4.2.6.5. Easy to use and maintain:

The agricultural drones are made rugged. It has low maintenance a long productive lifespan, and its parts replacement is simple, as and when required for the company offering drone services.

4.4.2.6.6. Security:

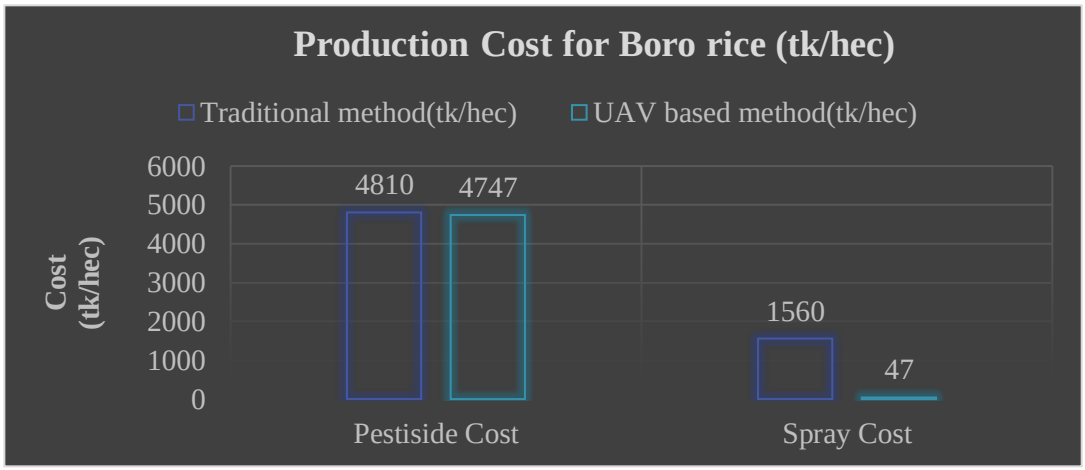
The agriculture sprayer drones are controlled from a distance by trained pilots. This process eradicates the involvement of farmers or farm laborers in direct contact with poisonous chemicals as well as adverse operational conditions.



`. ***(Source**: https://www.fao.org /06.04.2018)*

Figure 13: Traditional Method Vs Drone-based technology

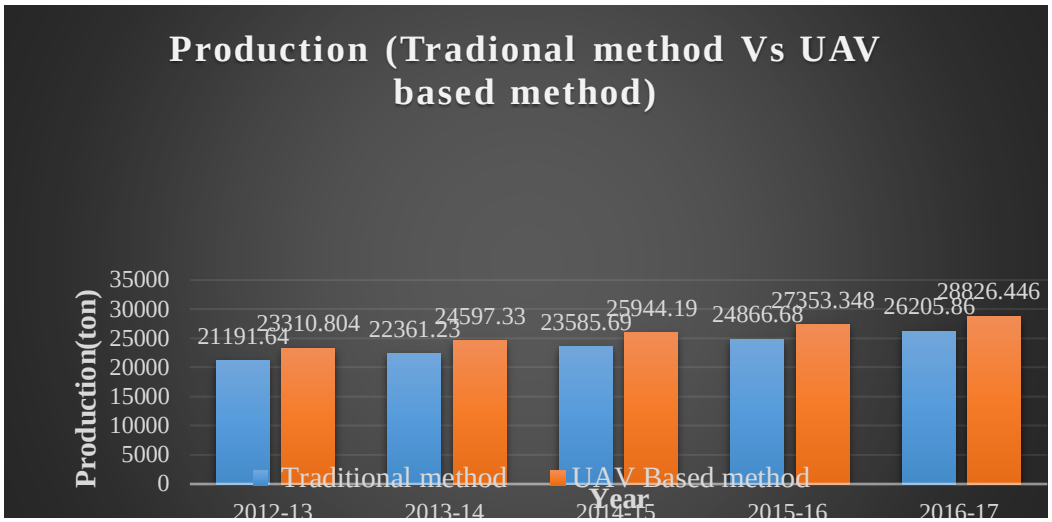
According to the above figure, drones enhance spraying capacity up to five times faster than with traditional machinery(Giacomo & David, 2018). Furthermore, in the case of seed spreading drones enhance capacity up to five times compared to traditional machinery. In addition, in the case of watering, drones enhance watering capacity that is more than double in contrast with traditional machinery.



(Source: https://www.researchgate.net)

Figure 14: Production cost for Boro rice (Tk/hec)

According to the above figure, drones reduce Boro rice pesticide cost by approximately 1.3 percent by comparison with traditional machinery. Furthermore, in the case of Boro rice production drones reduce spray cost is approximately 97 percent in comparison with traditional machinery(Maikaensarn & Chantharat, 2020)



(Source: https://www.researchgate.net)

Figure 15: Yearly rice (Boro) production in the agricultural sector

According to the above figure if it could be possible to use drone technology instead of traditional machinery boro rice production would be increased significantly from the year 2012 to 2017(Maikaensarn & Chantharat, 2020).

(Source: https://mdpi-res.com)

4.4.2.6.7. RIICE technology for food security and crop insurance policies

By implementing RIICE technology in Bangladesh rice monitoring, mapping, and forecasting can be achieved. Moreover, Farm productivity can be increased substantially.

4.4.2.6.8. Soil Survey

Drone technology is being used to assess soil condition, soil health scan, soil variation, and soil quality as well as moisture and water flow precisely to plan crop cultivation in farmland in Bangladesh. It enables the preparation of precise soil

maps even in areas difficult to access and remote areas such as mountainous regions, terrace areas, etc. for making proper land-use plans. The nutrient status of the soil can also be analyzed for further operations.

4.4.2.6.9. Field Soil Analysis

The drone survey allows farmers to obtain information regarding their land's soil conditions. Multispectral sensors allow seizing data useful for seed planting patterns, thorough field soil analysis, irrigation as well as nitrogen-level management. Precise Photogrammetry/ 3D mapping permits farmers to analyze their soil conditions thoroughly.

4.4.2.6.10. Controlling weed, insect, pest, and diseases

Apart from soil conditions, drones can also detect as well as inform farmers regarding field areas inflicted by weeds, disease as well as insect pests. Based on this information, farmers can optimize the use of chemicals needed to fight infestations, hence reducing the expenses. Furthermore, contributes to better field health.

4.5.3. Fisheries

In the fisheries sector, drones have been used to detect illegal fishing and aid in the prosecution of offenders.

Today, drones have been successful in collecting environmental data and fish behavior at the aquaculture site for monitoring an autonomous drone performs visual surveillance to monitor fish feeding activities, detect nets, moorings, cages, and detect suspicious objects (e.g., people, ships). UAV technology can be used for

visual surveillance to monitor fish feeding activities, detect nets, moorings, cages, and detect suspicious or illicit activities in Bangladesh coastal regions such as Coxes Bazar.

4.5.4. Disaster Risk Reduction and Management (DRRM)

Drones are used for data collection that assists in disaster risk reduction efforts. These data are fed into modeling systems that provide valuable insights which can be used to provide rural communities with reliable advice and can also assist the government in better planning of disaster relief management as well as response services. Modern geospatial technology is used to enhance disaster preparedness as well as response activities.

Bangladesh has been coping with the inflow of 1.1 million Displaced Rohingya People (DRP) in Cox's Bazar, which is vulnerable to extreme climate events as well as under immense strain on the existing resources. As part of the World Bank's Emergency Multi-Sector Rohingya Crisis Response Project (EMCRP), the

(Source: https://www.worldbank.org/en/news/feature/2021/06/20/)

Figure 16: World Bank's Emergency Multi-Sector Rohingya Crisis Response Project (EMCRP)

Local Government Engineering Department (LGED), will construct climate-resilient multi-purpose disaster shelters inside the DRP camps.

(Source: https://drnepal.org May 7, 2015)

Figure 17: Nepal Earthquake Relief and The Urgent Boost from Drones

4.5.5. River and floodplain management

In Bangladesh, Geological surveys reveal that Bangladesh itself is lying over as well as surrounded by three faults. The important Rajmahal fault is stretched under the alluvium bed as well as extends from southwest to northeast and joins the Assam fault. Major river systems of the country are distributed over the fault and have been subject to various tectonic changes in the past and to be in the future as well. In Bangladesh, SfM as a tool can be used for mapping fault zone topography. Furthermore, can make a comparative assessment with airborne LIDAR (Light Detection and Ranging).

4.5.6. Landslides

Landslides constitute a substantial problem in the hilly regions such as Sylhet and Chittagong and Hill Tracts of Bangladesh and monitoring them is significant for preventing human casualties as well as economic loss. In these regions, highly detailed 3D models of landslides can be achieved using drones.

4.5.7. Monitoring and management of forest

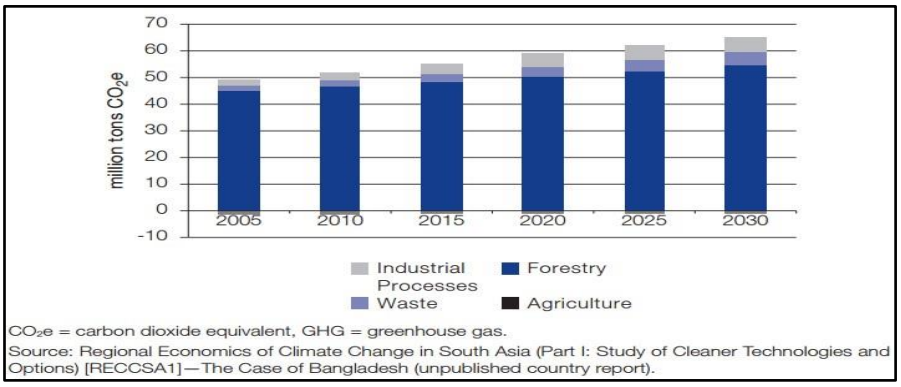
Drones are used for forest and landscape mapping to provide precise pictures for valuation, monitoring as well as research. The ortho maps help to improve forest management as well as operational planning, including the monitoring of illegal activities, poaching of endangered species, unsustainable uses of forest resources, land occupancy as well as encroachment. It also assists in collecting various forest metrics such as carbon sequestration, tree canopy analysis, conservation features, tracking native species, monitoring biodiversity as well as ecological landscape features. It is very useful for Forest Inventories including adaptive planning, high project customization, and rapid implementation, even under challenging weather conditions.

(Source: https://www.observerbd.com)

Figure 18: Forest monitoring and management

4.5.8. Climate change monitoring

In Bangladesh, drones can be used in climatic studies both in the ountryside as well as in densely populated areas or industrial sites to measure levels air



(Source: Regional Economics of Climate Change in South Asia)

Figure 19: Carbon dioxide equivalent emission from various industries in Bangladesh

pollution and to find ways for reducing the levels of danger as well as improving public health. Air pollution, at present, is one of the main reasons that kills thousands of people annually in Bangladesh.

To control and mitigate the impact of the emission of greenhouse gases, monitoring the environment is an essential activity.

A smart environment monitoring (Smart EM) method can be used by using an unmanned aerial vehicle (UAV) to collect and process the data. UAV-based data acquisition is an effective solution for retrieving sensor data, even from inaccessible locations.

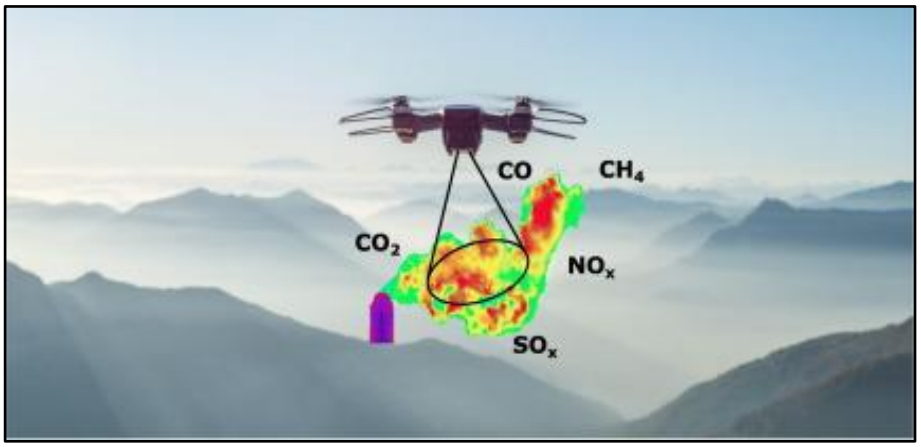
In the future, in the event of a major earthquake in Bangladeshi city areas, drones can be used for inspection of building damage assessment. The technique used is

known as ‘facade modeling’, where, a set of multi-view drone imagery is used and high-quality results are obtained.

Since 2000, the surface temperature in major cities of Bangladesh is on increased as well as the collection of surface temperature data is very significant for researching urban climatic changes. Such data can be obtained through using Drones as well as collecting satellite imagery. Measuring Surface temperature is significant data for urban climatology studies as well as has been widely obtained with satellite imagery. More detailed urban climate studies, however, can be achieved using drones. For instance, Drones can collect the surface temperature of Dhaka city. In cities such as Dhaka or Chittagong, one can find many closed street canyons where relatively high and long rows of buildings are standing parallel to the street. These are the street canyons where the highest concentrations of fine particles are found and causing a very high level of air pollution. Vertical profiles of urban pollutant concentrations can be measured by using a modified drone.

4.5.8.1. Aerosol Detection in the Air

Detection of Aerosol in Air Presence of aerosol in a vertical distribution is also detected in the Bangladeshi climate. In that case, specific sensors fitted to Drones can be used to detect the vertical distribution of aerosol substances in the air.



(Source: https://www.sciencedirect.com)

Figure 20: Aerosol Detection in the Air by Drone

4.5.9. Monitoring of city greeneries

In a very highly congested city such as Dhaka, Drones can be used to obtain a high-resolution measurement of fine particles in street canyons and above the rooftop level.

4.5.10. Drones in urban transport studies

Drones in urban transport studies Drone-based data are significant sources for transport volume studies in densely populated cities like Dhaka. 3D images can provide valuable information required for vital transport planning in city areas. Available data, as well as information, can be used for traffic volumetric analysis as well as help in planning for a healthy transport system in Bangladeshi urban centers. Traffic congestions create chaos in pick hours as well as time-consuming working hours throughout the year.

4.5.11. Drone Use in Maritime Surveillance

``Bangladesh can use UAV for surveillance in maritime territory like other countries of the world.

(Sources: https://www.navalnews.com/naval-news/2020/09)

Figure 21: MQ-9B Sea guardian during the maritime capabilities' demonstration flight over Southern California waters in September 2020

4.5.12. Waterlogging management

In Bangladesh, city areas are prone to waterlogging during the rainy periods as well as cause immense traffic problems to city dwellers. Drones can be used to map waterlogged areas, identify the causes as well as take quick and necessary actions to free submerged roads from waterlogging. In addition, drones can be used to detect unauthorized temporary shops as well as vendors occupying footpaths and sometimes a part of the main road to create traffic congestion.

(Source: https://www.observerbd.com/)

Figure 21: Drone conducting a land survey in Bangladesh

The southwest coastal belt across Satkhira, Jessore, Jhenaidah, and Khulna Districts are primarily affected due to unabated encroachment of canals and a lack of proper drainage. Silting in nearby rivers, like the Chitra and the Madhumati, as well as canals, have significantly reduced the water flow (The Daily Star 01/05/2017). It has also become an increasingly concerning issue in urban areas such as Dhaka and Chittagong Districts due to rapid urbanization as well as poor waste management. Waterlogging can be particularly problematic at the end of the monsoon period (August/ September).

The information obtained from the drone, there are about 150 acres of land in Mollakandi, big and small Harina Mouzas of Padua union of Daudkandi Upazila of the district has not been possible to take under cultivation due to waterlogging. As a result, the people of the area are being deprived of about 400 tons of paddy production, worth Tk 1.5 crore while there are such problems in many places in this area. On December 19, 2021, the waterlogged areas were monitored by drones.

4.5.13. Flash Flood identification in Hilly areas

In Bangladesh, flash floods are caused by heavy or excessive rainfall in a short period over a relatively small area. During flash flooding, water levels rise and fall rapidly with little or no warning. The most affected areas are in the Haor Basin of the northern belt of Bangladesh, which is made up of Sylhet, Sunamganj, Moulvibazar, Habiganj, and Netrakona Districts, as well as the southeast in Chittagong, Cox's Bazar, and Bandarban Districts (BWDB 2014; WMO 2003). Flash floods are most common from April to July and from September to October (WMO 2003). Flash floods carry sediment that has eroded from hilly catchment areas. During heavy rainfall in the hilly regions, massive erosion occurs on exposed surfaces of the hills. It is not possible to detect and take an image by Satellite due to the short time duration of Flash Flood one to two hours. However, drone technology can resolve this drastic problem. This is because it is cost-effective as well as quick response time rather than satellite image.

4.5.14. Public Health Management

The use of drones in healthcare has steadily increased in recent years all across the world. Drones have been successfully evaluated in various pilot programs as well as are already implemented in some settings for transporting samples and delivering blood, vaccines, medicines, organs, life-saving medical supplies, and equipment.

The potential for drone use in clinical microbiology, infectious diseases, and epidemiology is vast. Drones may help to increase access to healthcare for individuals that might otherwise not benefit from appropriate care due to remoteness and lack of infrastructure or funds. However, factors such as national airspace legislation and legal medical issues, differences in topography and climates, cost-effectiveness, and community attitudes and acceptance in different cultures and societies currently impede the widespread use of drones. Significant cost savings compared with ground transportation, speed and convenience of delivery, and the booming drone sector will probably drive drone implementation in various areas of medicine shortly. Drones can also bring medicine to inaccessible places.

(Sources: https://economictimes.indiatimes.com)

Figure 23: Drone based solution of India's malaria crisis

4.5.14.1. Using drones against COVID-19 pandemic

4.5.14.1.1. Surveillance

To reduce people-to-people contact and the risk of getting infected to police officials and other staff, drones enable monitoring the vast swathe of an area without physical engagement. This trend began in China and now this technology is being used by law enforcing authorities in many countries to make citizens aware of the government guidelines on lockdown and social distancing and to record the movement of violators. But the use of drones for surveillance raises the question of whether they do a privacy breach or violate property rights.

(Sources: https://www.dw.com)

Figure 24: German police mull wide use of drones for corona-surveillance

In Bangladesh, only the Chattagram Metropolitan Police (CMP) has taken such an initiative to monitor unnecessary gatherings and identify the culprits, however, the technology is being used in a very limited scope(Ramadan et al., 2017)(*Using Drones against COVID-19 | The Daily Star*, n.d.).

Satkhira district police are using drone-mounted cameras to ensure that people are maintaining social distancing and to detect people who made unnecessary gatherings in defiance of restrictions to prevent transmission of coronavirus.

4.5.14.1.2. Disinfectant spraying

According to DJI (the world's largest drone-making company), a typical spraying UAV can carry around 16 liters of disinfectant and it can cover 100,000 square meters area per hour. Spraying disinfectants with drones is 50 times faster than traditional methods(*Using Drones against COVID-19 | The Daily Star*, n.d.). These spraying drones are quite cheaper than the other drones and easy to handle. They can be mobilized easily and they also reduce the risk of health and sanitation workers getting exposed to both the coronavirus and chemical disinfectants. Countries such as Indonesia, India, Chile, Colombia, the Philippines, and the UAE have successfully used these disinfecting drones.

4.5.14.1.3. Delivering Goods intralogistics and surveillance operations

Unmanned aerial vehicles (UAVs or "drones") can be used in Bangladesh to deliver goods in the first and last mile, as well as for intralogistics and surveillance operations. Although popularized in the media in recent years, UAVs will not replace traditional ground-based transportation. However, they will augment delivery with point-to-point as well as automated operations.

(Source: https://www.dhl.com)

Figure 25: Delivering Goods intralogistics and surveillance operations by Drone

4.5.15. Food delivery

Food deliver5y One of the most promising uses of drones in transport may be food delivery. Providing products such as frozen food, ready-to-eat dishes or even daily groceries from large chains may become be the next big thing in the food and restaurant industries. At first, drones will be used to deliver such products to remote, difficult-to-access places that depend on external food supplies, such as oil rigs, research stations, and isolated islands. Once proper regulations have been established, drones may perform the same tasks in residential areas, decreasing delivery times and increasing the efficiency of the entire transport value chain.

4.5.16. Wildlife conservation

Drones fitted with high-definition thermal cameras are used to track, inspect as well as monitor livestock remotely.

Drones fitted with thermal cameras can identify poachers from their heat signatures even if they are hiding in thick foliage. This effort has proved beneficial for the vulnerable one-horned rhino.

In Bangladesh Forest Department has plans to monitor the Sundarbans, the world's largest mangrove forest and a Unesco world heritage site, using drones to check crimes like poaching of tigers as well as deer.

The department is also considering erecting a net fence around the forest to prevent the intrusion of tigers into the localities. Besides, there is a huge presence of sea as well as forest robbers. To check such crimes, the Forest Department is planning to deploy drones. Drones will play an effective role in checking illegal intrusion into the Sundarbans, poaching, and robberies, and identifying illegally net fishing in the forest

The new moves came after the Indian forest department succeeded in checking such crimes and tiger attacks successfully after implementing the two initiatives on their part of the Sundarbans.

(Source: https://www.airbornedrones.com/)

Figure 26: Wildlife monitoring at the park using a drone

4.5.17. Livestock Management

The imagng and mapping capabilities of the drones are used for counting as well as taking stock of herds of animals in Bangladesh. With the application of high-resolution infrared cameras, every single animal is identified as a separate heat mark enabling counting with high accuracy. Furthermore, it helps the assessment of its health based on a temperature comparison, allowing swift identification as well as treatment of ill animals. In addition, Drones can also locate the routes, position of animals, their newborn babies, available foods and water, and their predators around them.

4.5.18. Surveillance of Power Plants

The drone can be used in nuclear facilities to monitoring its security and safety and assess environmental impact in Bangladesh such as The Rooppur Nuclear Power Plant will deliver 2.4 GWe(1200 MW each Unit) to the national GRID from the year 2024.

(Source: https://www.bsf.org.bd/)

Figure 27: Ruppur nuclear power plant

4.5.19. UAV Law in Bangladesh

Drones are permitted in Bangladesh, have to obtain permission from the air traffic control authority before maneuvers.

Authorizations have to be submitted 45 days in advance to the Civil Aviation Authority of Bangladesh (CAAB). The mandatory details of the application include:

- Personal data of the pilot
- Purpose of the drone flight (e.g., training, photography, videography, research, etc.)

- Description of the copter (including departure weight and safety features like fail-safe)
- Date/time of the maneuver
- Flight location including coordinates
- Information about existing drone insurance
- Distance to the nearest medical facility and the nearest fire station
- In Bangladesh, the minimum age for controlling drones is 18. Do not drink alcohol at least 8 hours before flying. During your flights, you must have a fire extinguisher with you which can be used to put out a spontaneously occurring fire. Safety distances and flight ban

- Drones can only be operated within visual line of sight in Bangladesh. The use of FPV systems requires a separate permit.

- Drones have to keep a distance of 18.5 kilometers (10 miles) to airports, or must obtain authorization from the air traffic control authorities.

- Drones have to keep 9 kilometers (5 miles) of distance from a built-up area and to keep 300 meters (1000 feet) away from buildings, vehicles, people, animals, and ships as long as they are not directly involved in the flight maneuver.

- Drones are not allowed to fly over gatherings of people in Bangladesh.

- During a flight, to carry the following documents to accompany: approval of the CAAB, insurance document, a document with personal data of the pilot (name, address, and telephone number), flight restrictions of the drone according to the manufacturer.

To facilitate flying permission, use of Drone has divided in to 4 classes:

Class A- Use in Recreational purposes

Class B- Use in Government, Private Organizations like noncommercial sectors such as educational and research works.

Class C- Use in Survey, Still Photography, Making Cinema, Feasibility study of development Projects etc. in commercial and professional works.

Class D-Use in State /Military Necessity

By considering Aircraft and General People Protection, Safety and Necessity Operation Zone has been divided in to 3 categories. The zone will be specified by CAAB Drone Application through Geofencing

- **Green-There will be no need for Permission**

  3 Km outside of airport and not above 50 ft.

  3 to 5 Km outside of airport and not above 50 ft.

- **Yellow Zone: Restricted Area, Military, Populated Area, Congested Area**

- **Red Zone: Prohibited Area, Danger Area, Airport KPI, Special KPI**

4.5.20. Data Analysis and Findings:

The primary data have been collected from 117 respondents from 17 different sources.

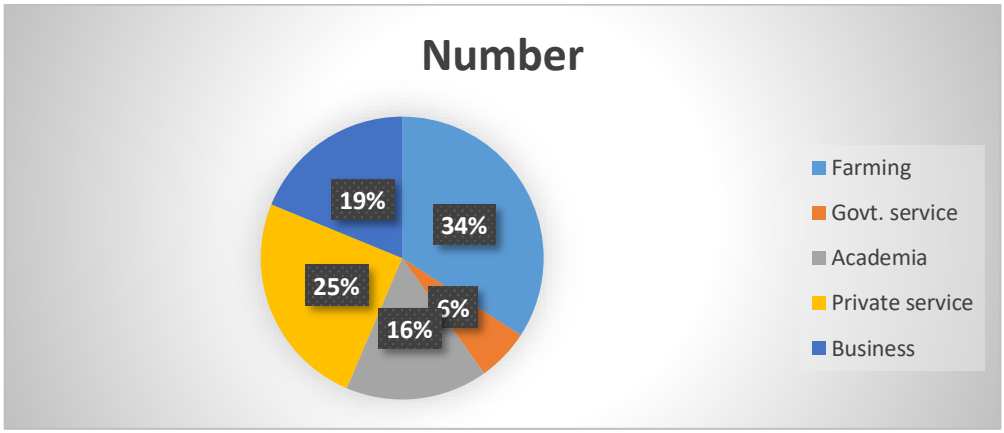


Figure 28: Pi Chart Showing Data Collected from Different Professions

From the above figure it has been observed that from 117 responders, the highest number of responders were from farmers that were 34 percent. Furthermore, the lowest number of responders are private service holders who were 25 percent. Government service, academia and business-related professionals were 6 percent, 16 percent, 19 percent respectively.

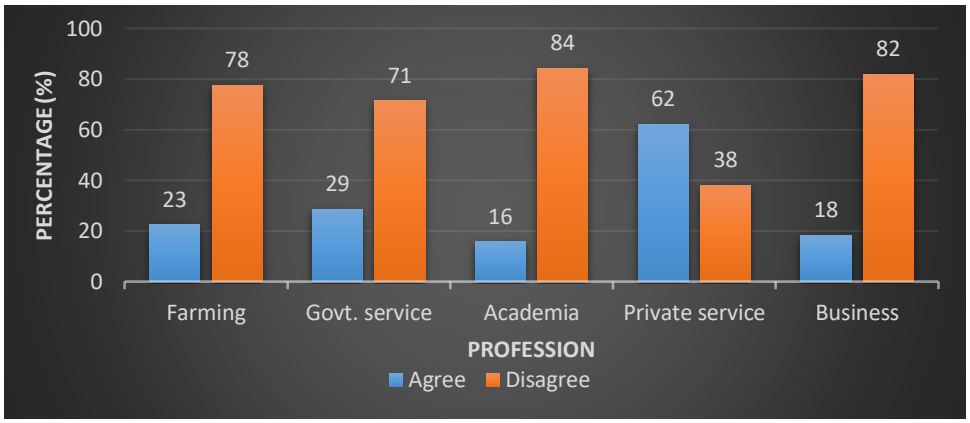


Figure 29: Opinion of Responders regarding Uses of UAV in agriculture sector

From the above figure, it has been observed that regarding the question **Uses of UAV in agriculture sector is easy.** 23 percent answer were agreed and 78 percent were disagreed in the farming sector. In case of Government service holder 29 percent were agreed with the question. On the other hand, 71 percent disagreed with the opinion. Furthermore, in case of Academia 16 percent agreed with the question. On the other hand, 84 percent disagreed with the opinion. In addition, in case of private service holder's 62 percent agree with the opinion. However,38 percent disagree with the opinion. In case of business service holders, 18 percent agreed 38 percent disagreed with the opinion.

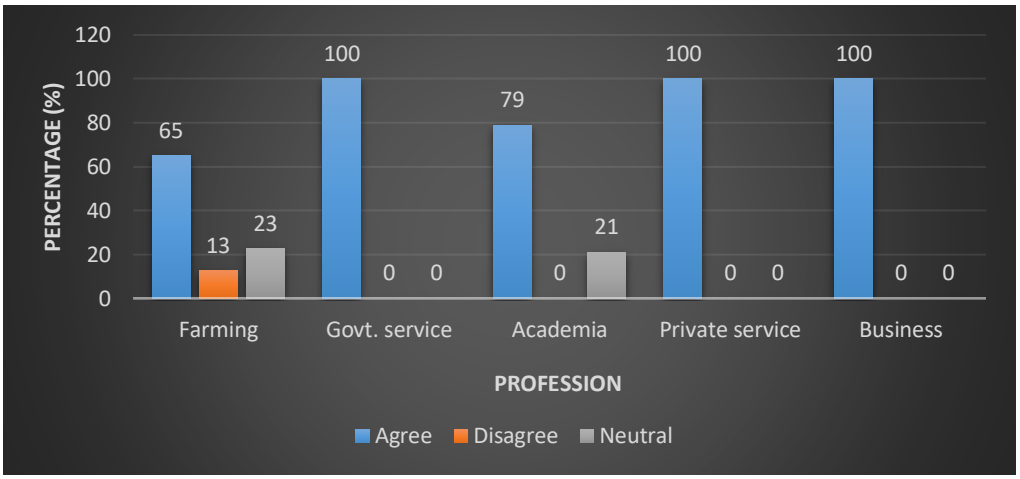


Figure 30: Respondents having Knowledge of Uses of UAV in agriculture sector

From the above figure it has been observed that regarding the question **Uses of UAV in agriculture sector** 65 percent answer were agreed,13 percent were disagreed and 23 percent were neutral in the farming sector. In case of Government service holder 100 percent werev agreed with the question. Furthermore, in case of Academia 79 percent agreed with the question. On the other hand, 21 percent were neutral with the opinion. In addition, in case of private service holder's and business profession100 percent were agreed with the opinion.

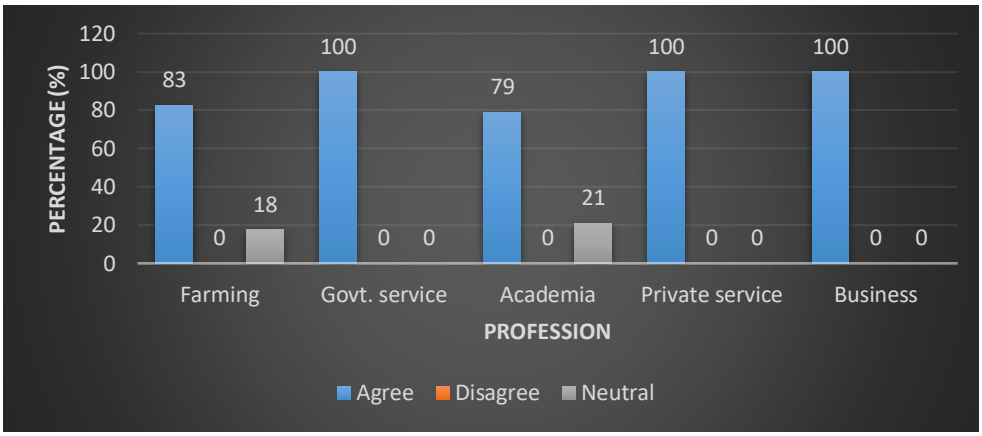


Figure 31: Opinion of Respondents regarding Use of UAV for high field capacity and efficiency

From the above figure it has been observed that regarding the question **UAV can be used for high field capacity and efficiency** 83 percent answer were agreed who were engaged in farming, and 18 percent were neutral. In case of Government service holder 100 percent agreed with the question. Furthermore, in case of Academia 79 percent agreed with the question. On the other hand, 21 percent were neutral with the opinion. In addition, in case of private service holder's as well as business profession100 percent were agreed with the opinion.

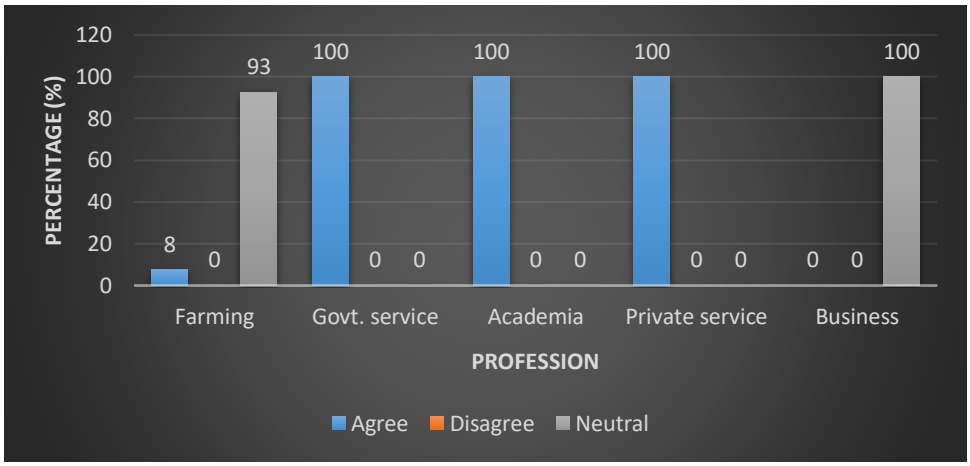


Figure 32: Opinion of Respondents regarding Use of UAV for Significant water saving/water logging management

From the above figure it has been observed that regarding the question UAV can be used significantly for water saving/water logging management 8 percent answer were agreed who were engaged in farming, and 93 percent were neutral. In case of Government service holder 100 percent agreed with the question. On the Furthermore, in case of Academia 100 percent agreed with the question.

In addition, in case of private service holder's 100 percent agreed with the opinion.

In addition, in case of business service holder's 100 percent were neutral with the opinion.

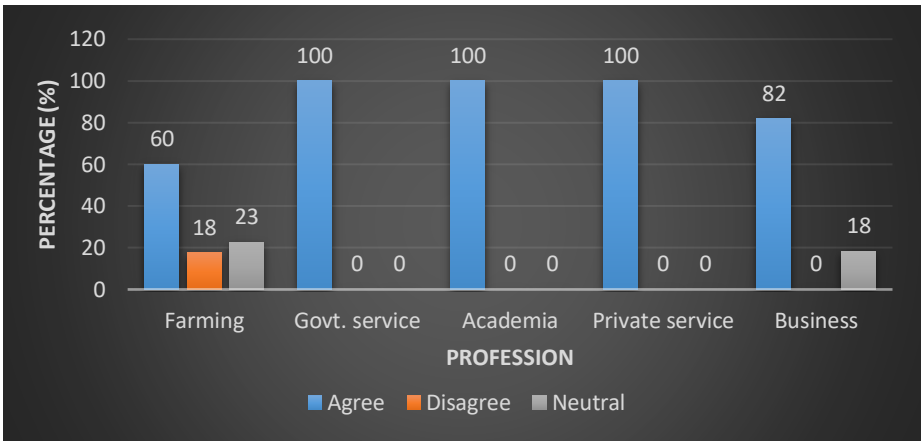


Figure 33: Opinion of Respondents regarding Use of UAV for crop/yield security in the agriculture sector

From the above figure it has been observed that regarding the question **UAV can be very useful for crop/yield security in the agriculture sector** 60 percent answer were agreed who were engaged in farming, 18 percent disagreed with the opinion and 23 percent were neutral. In case of Government service holder 100 percent agreed with the opinion. On the Furthermore, in case of Academia 100 percent agreed with the opinion. In addition, in case of private service holder's 100 percent agreed with the opinion.

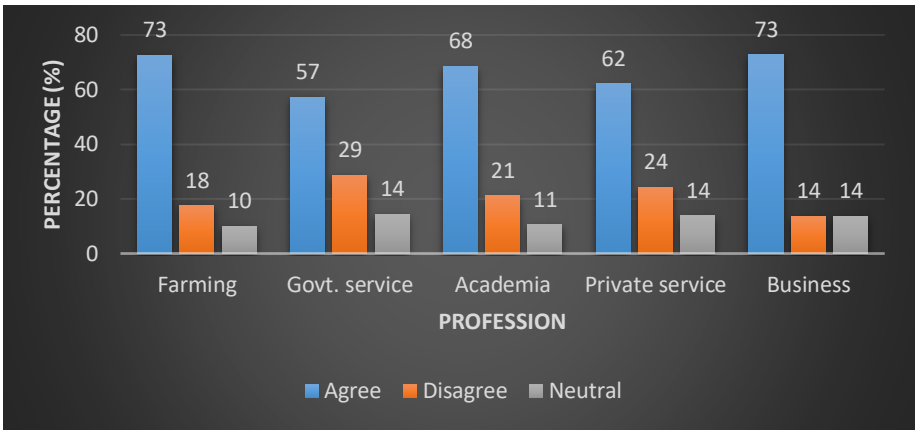


Figure 34: Opinion of Respondents regarding Use of UAV for pest /disease control in the agriculture sector

From the above figure it has been observed that regarding the question **UAV can be very useful for pest/disease control in the agriculture sector** 73 percent answer were agreed who were engaged in farming, 18 percent disagreed with the opinion and 10 percent were neutral. In case of Government service holder 57 percent were agreed 29percent disagreed with the opinion and 14 percent were neutral. With the opinion. On the Furthermore, in case of Academia 68 percent agreed with the opinion21percent disagreed with the opinion and 11 percent were neutral. In addition, in case of private service holder's 62 percent agreed with the opinion opinion24percent disagreed with the opinion and 14 percent were neutral. In addition, in case of business personal 73percent were agree with the opinion 14percent disagreed with the opinion and 14 percent were neutral.

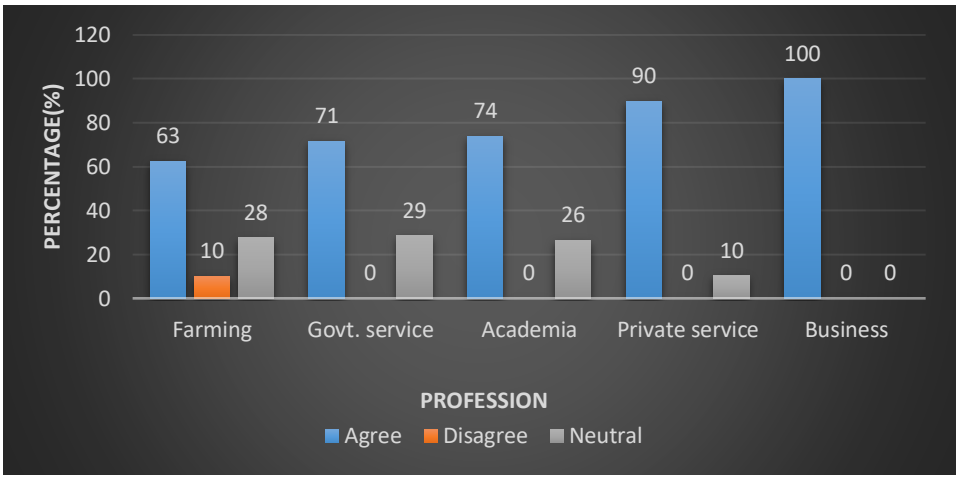


Figure 35: Opinion of Respondents regarding Cost Efficiency and Effectiveness in UAV/Drone based agriculture method compared to traditional method

From the above figure it has been observed that regarding the question **UAV/Drone based agriculture method is more cost efficient and effective compared to traditional method.** 63 percent answer were agreed who were engaged in farming, 10 percent disagreed with the opinion and 28 percent were neutral. In case of Government service holder 71 percent were agreed and 29 percent were neutral with the opinion. Furthermore, in case of Academia 74 percent agreed with the opinion and 26 percent were neutral. In addition, in case of private service holder's 90 percent agreed with the opinion and 10 percent were neutral. In addition, in case of business personal 100percent were agree with the opinion.

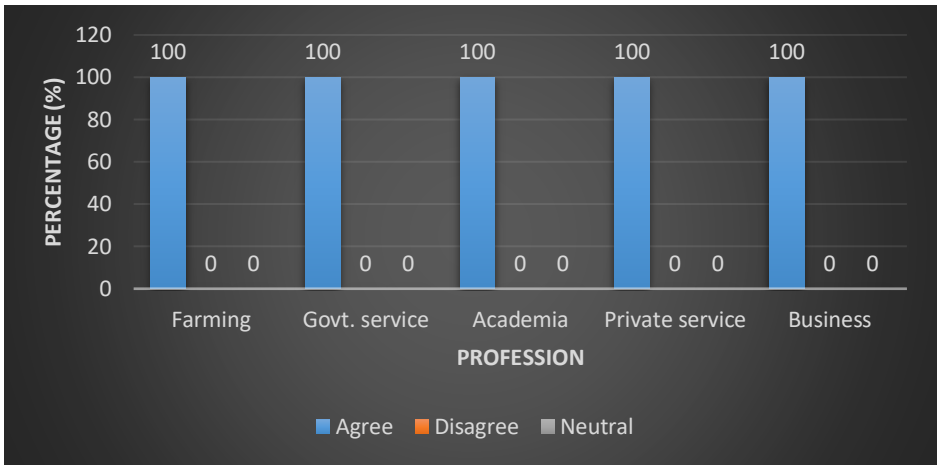


Figure 36: Opinion of Respondents regarding Utilization of UAV/Drone for Disaster Risk Management

From the above figure it has been observed that regarding the question **Utilization of UAV can be very crucial for Disaster Risk Management** 100 percent answer were agreed who were engaged in farming, With the opinion. On the Furthermore, in case of Academia 100 percent agreed with the onionin addition, in case of business personal 100 percent were agree with the opinion.

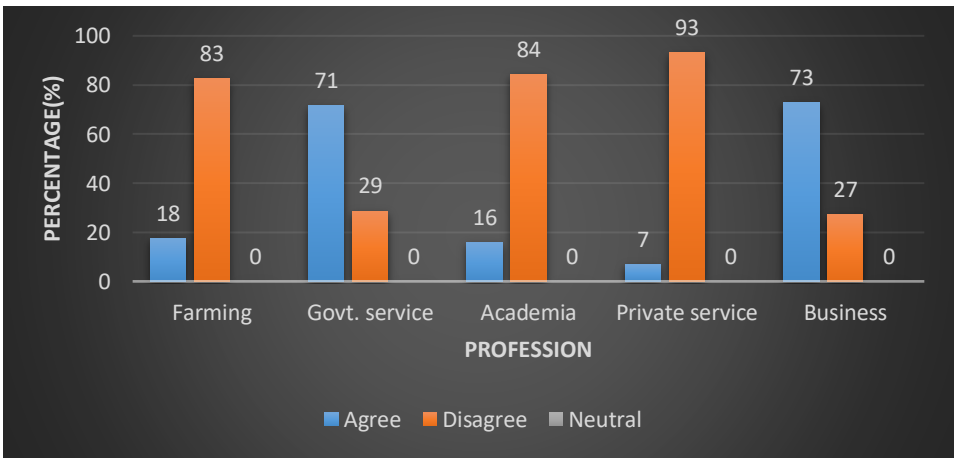


Figure 37: Opinion of Respondents UAV/Drone Policy/Drone Policy of Bangladesh as user friendly

From the above figure it has been observed that regarding the question **UAV (Drone) Policy of Bangladesh is user friendly.** 18 percent answer were agreed who were engaged in farming, 38 percent disagreed with the opinion. In case of Government service holder 71 percent were agreed 29percent disagreed with the opinion with the opinion. On the Furthermore, in case of Academia 16 percent agreed with the opinion 84 percent disagreed with the opinion. In addition, in case of private service holder's 7 percent agreed with the opinion 93percent disagreed with the opinion. In addition, in case of business personal 73percent were agree with the opinion 27percent disagreed with the opinion.

Cost and Benefits Analyses:

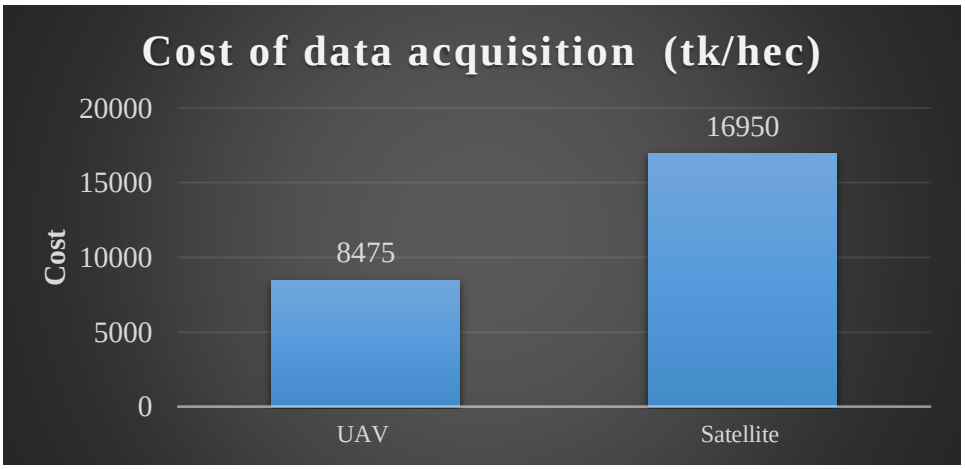


Figure 38: Cost Comparison between UAV/Drone and Satellite for Data acquisition in the Agriculture Sector

According to the above figure, the cost of data acquisition for satellite technology is almost double in comparison with UAV drone technology. Moreover, drone technology is more economic in contrast with satellite technology.

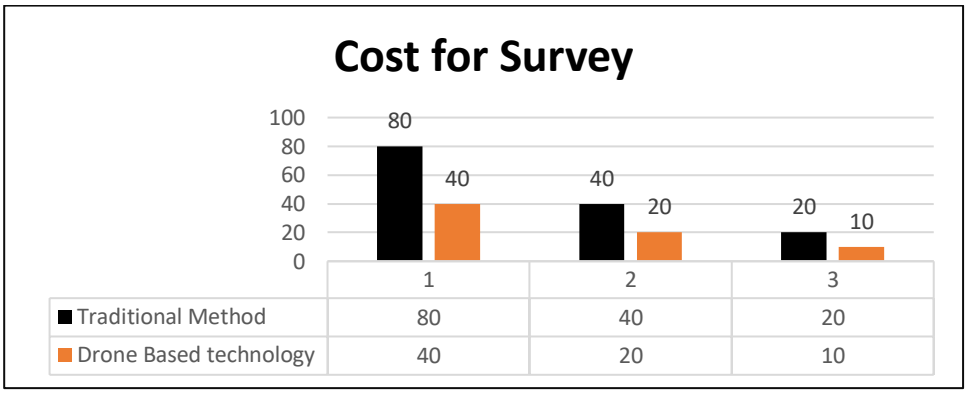


Figure 39: Cost Comparison between UAV/Drone and Traditional Technology for Data acquisition

According to the above figure, the cost of survey for traditional technology is almost double in comparison with UAV technology. Moreover, UAV technology is more economic in contrast with traditional technology.

Statistical Analyses:

Frequency Table

Table 1: Uses of UAV in agriculture sector is easy

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	**Agree**	36	28.8	30.8	30.8
	Disagree	81	64.8	69.2	100.0
	Total	117	93.6	100.0	
Missing	**System**	8	6.4		
Total		125	100.0		

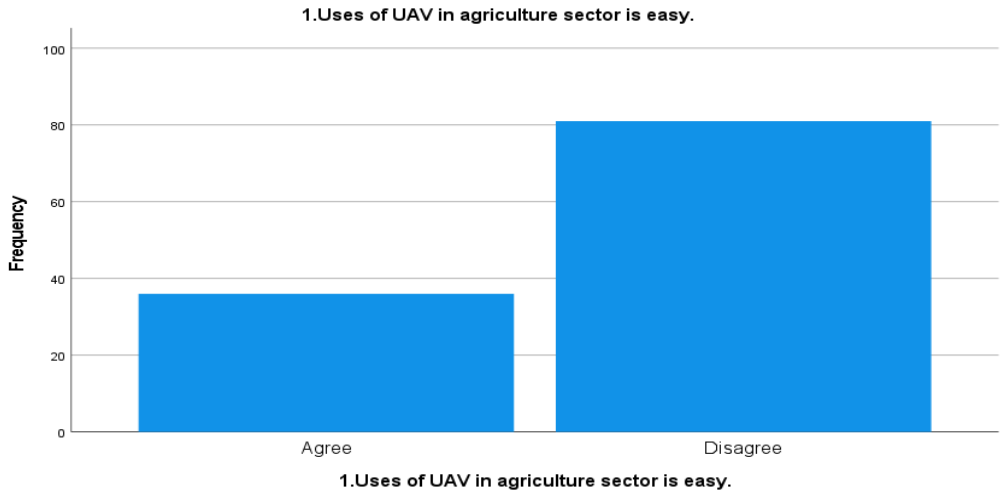


Table 2: Uses of UAV in agriculture sector

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	**Agree**	99	79.2	84.6	84.6
	Neutral	13	10.4	11.1	95.7
	Disagree	5	4.0	4.3	100.0
	Total	117	93.6	100.0	
Missing	**System**	8	6.4		
Total		125	100.0		

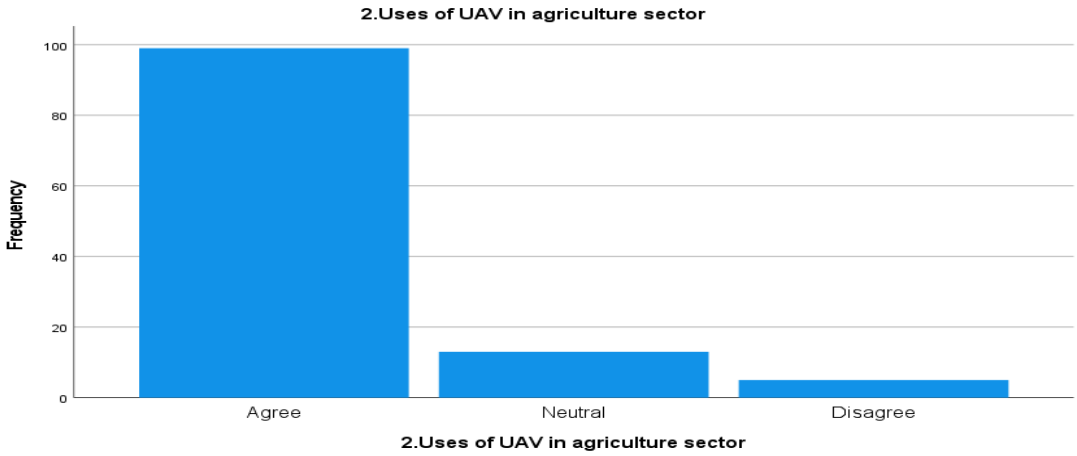


Table 3: UAV can be used for high field capacity and efficiency

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	**Agree**	106	84.8	90.6	90.6
	Neutral	11	8.8	9.4	100.0
	Total	117	93.6	100.0	
Missing	**System**	8	6.4		
Total		125	100.0		

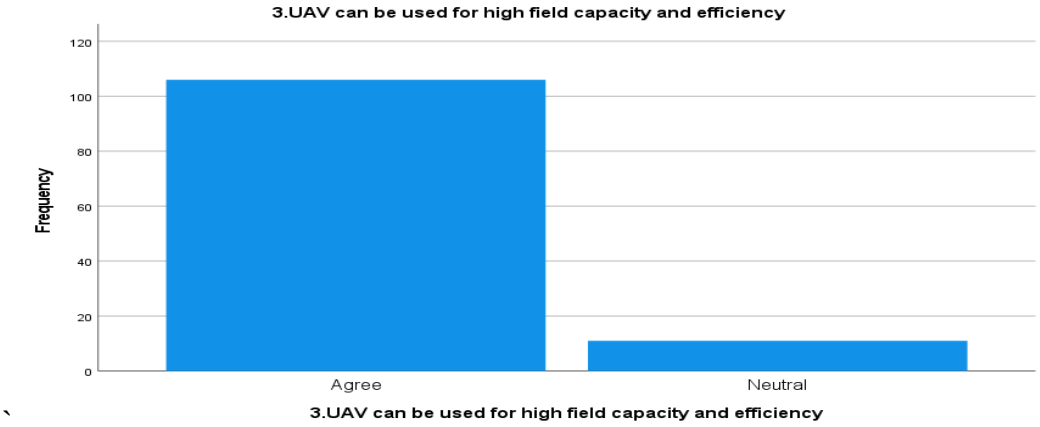


Table 4: UAV can be used significantly for water saving/water logging management

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	**Agree**	58	46.4	49.6	49.6
	Neutral	59	47.2	50.4	100.0
	Total	117	93.6	100.0	
Missing	**System**	8	6.4		
Total		125	100.0		

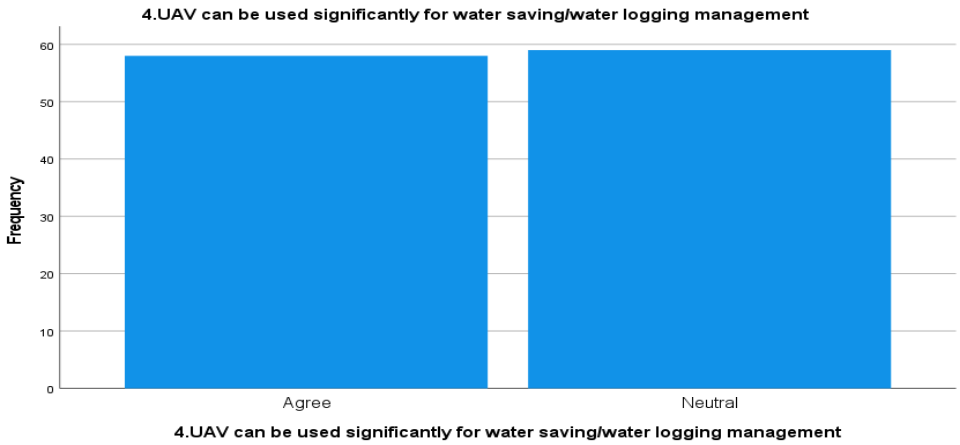


Table 5: UAV can be very useful for crop/yield security in the agriculture sector

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	**Agree**	97	77.6	82.9	82.9
	Neutral	13	10.4	11.1	94.0
	Disagree	7	5.6	6.0	100.0
	Total	117	93.6	100.0	
Missing	**System**	8	6.4		
Total		125	100.0		

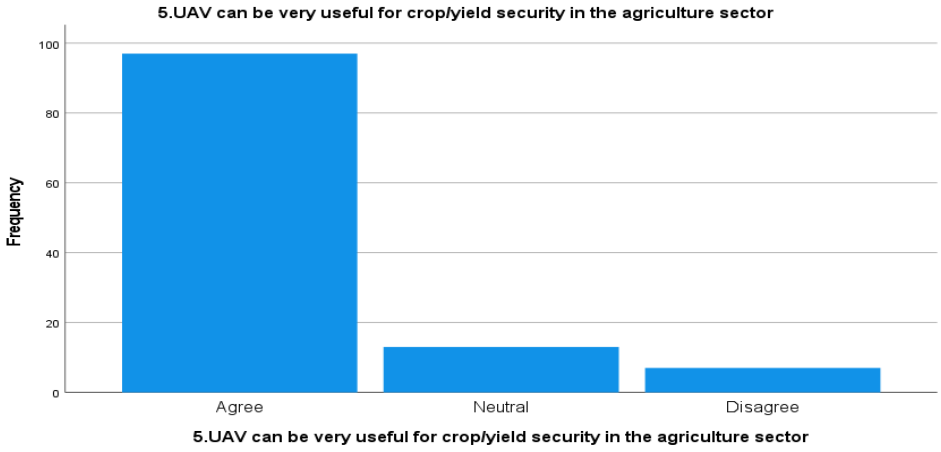


Table 6: UAV can be very useful for pest/disease control in the agriculture sector

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	**Agree**	80	64.0	68.4	68.4
	Neutral	17	13.6	14.5	82.9
	Disagree	20	16.0	17.1	100.0
	Total	117	93.6	100.0	
Missing	**System**	8	6.4		
Total		125	100.0		

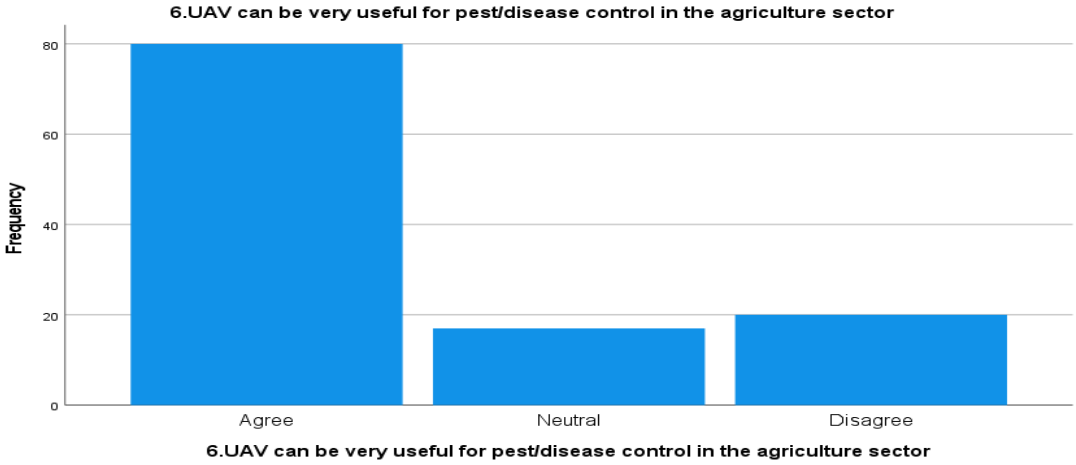


Table 7: UAV/Drone based agriculture method is more cost efficient and effective compared to traditional method

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	**Agree**	92	73.6	78.6	78.6
	Neutral	21	16.8	17.9	96.6
	Disagree	4	3.2	3.4	100.0
	Total	117	93.6	100.0	
Missing	**System**	8	6.4		
Total		125	100.0		

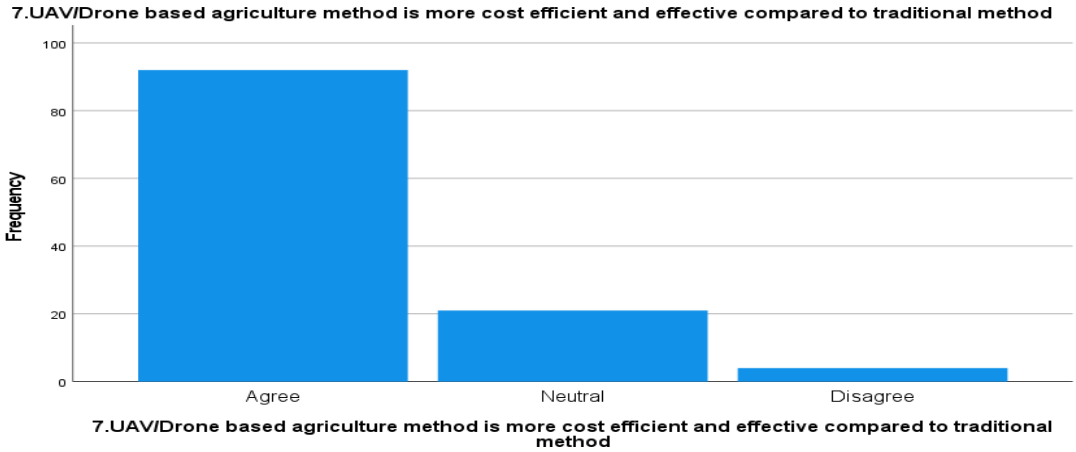
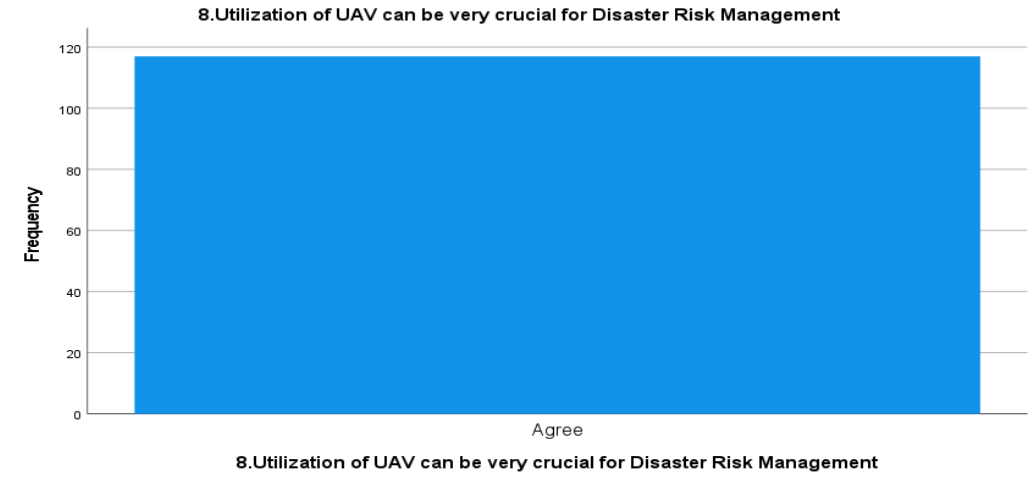


Table 8: Utilization of UAV can be very crucial for Disaster Risk Management

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	**Agree**	117	93.6	100.0	100.0
Missing	**System**	8	6.4		
Total		125	100.0		



T-test

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means							
						Significance		Mean Diff.	Std. Error Diff.	95% Confidence Interval of the Difference	
		F	Sig.	t	df	One-Sided p	Two-Sided p			Lower	Upper
Sum2	Equal variances assumed	.	.	-1.443	1	.193	.386	-5.0	3.4641	-49.01558	39.01558
	Equal variances not assumed			.	.	.	.	-5.0	.	.	.

Table 9: Group Statistics

Group Statistics					
	Gender	N	Mean	Std. Deviation	Std. Error Mean
Sum2	Male	2	28.0000	2.82843	2.00000
	Female	1	33.0000	.	.

Independent -samples t-test was conducted to compare the mean opinion of Male and Female. There was no significant difference between the opinions for Male (M=28.00, SD=2.82843 and Female (M=33.00), P=.386, t(1)=-1.443

Table 10: One-way ANOVA

ANOVA					
Sum2					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	16.667	1	16.667	2.083	.386
Within Groups	8.000	1	8.000		
Total	24.667	2			

A one-way between groups ANOVA was conducted to compare the average opinion from the male and female. There was no significant difference between males and females' opinion P=.386, [F (1,1)] =2.083.

Regression Analyses:

Table 11: Regression Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	-0.985	0.572		-1.722	0.119	-2.278	0.309
	Gender	.332	0.103	0.358	3.21	0.011	0.098	0.565
	There is Barrier	0.731	0.123	0.661	5.921	<.001	0.452	1.010

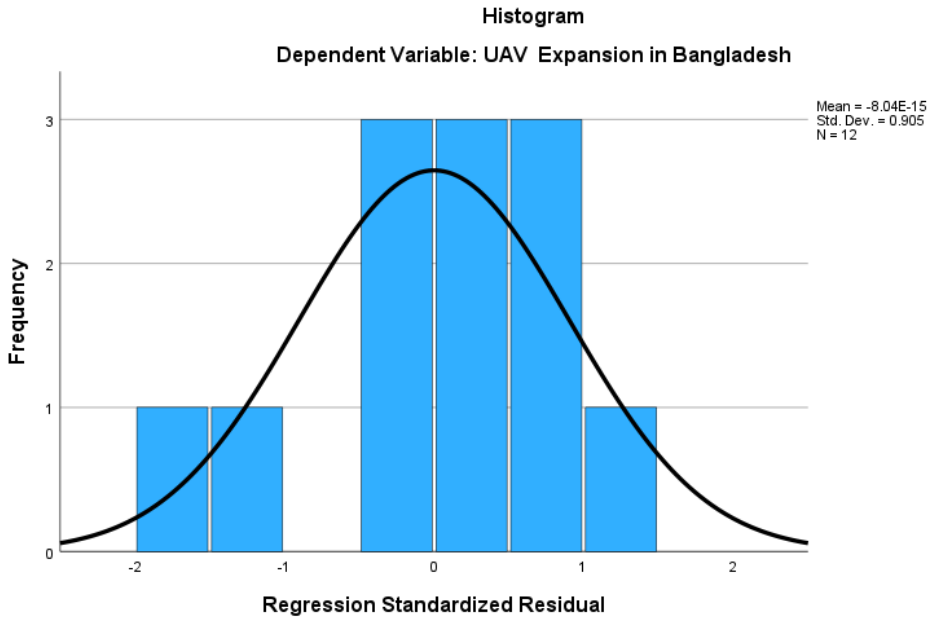
a. Dependent Variable: UAV Expansion in Bangladesh

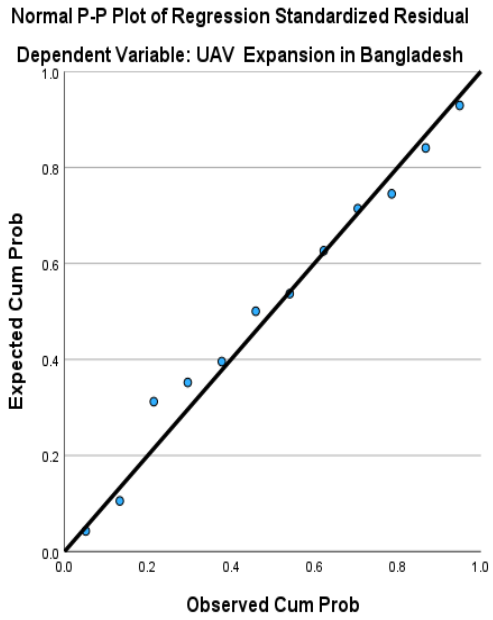
A multiple regression test has been conducted to assesses the relationship between the barrier as well as the UAV Uses in Bangladesh.

From the above data, it has been observed that there was a significant positive relationship between the barriers and the UAV uses in Bangladesh

(β = 0.661, t = 5.921, P = < 0.001 which is less than P = 0.05. Also, there was significant positive relationship between the gender and the UAV uses in Bangladesh

(β = 0.358, t=3.21, P=0.011 which is less than P= 0.05).




Normal P-P Plot of Regression Standardized Residual
Dependent Variable: UAV Expansion in Bangladesh
Expected Cum Prob
Observed Cum Prob
0.0
0.2
0.4
0.6
0.8
1.0

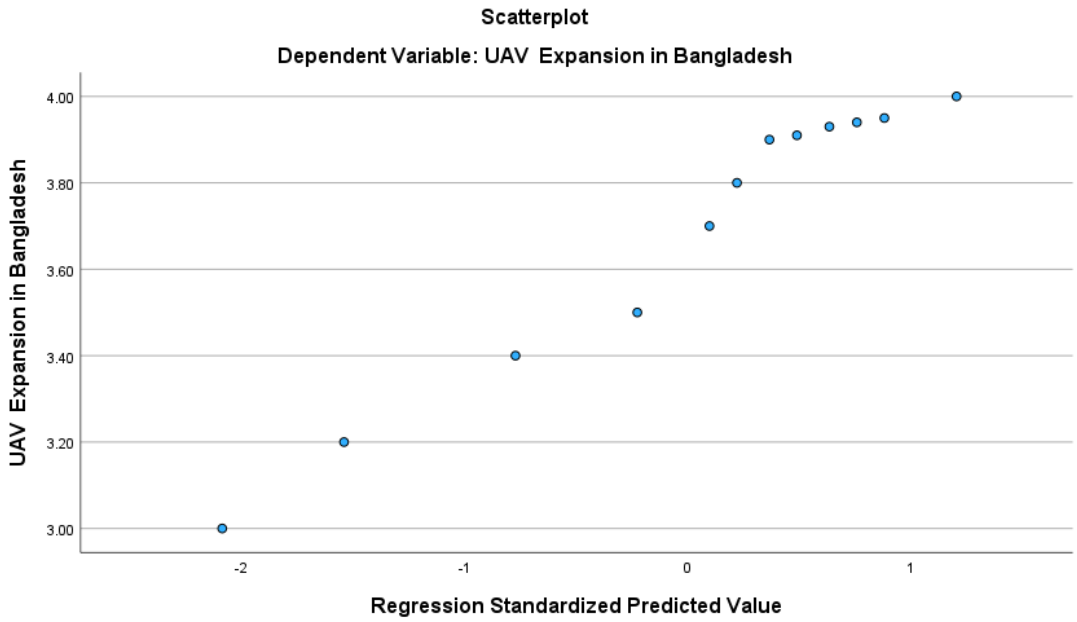

Scatterplot
Dependent Variable: UAV Expansion in Bangladesh
UAV Expansion in Bangladesh
Regression Standardized Predicted Value
4.00
3.80
3.60
3.40
3.20
3.00
-2
-1
0
1

Table 12: ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	**Regression**	1.145	2	.572	64.261	<.001[b]
	Residual	.080	9	.009		
	Total	1.225	11			

a. Dependent Variable: UAV Expansion in Bangladesh
b. Predictors: (Constant), There is Barrier, Gender

From the above data it has been observed that the overall model is significant since P value is less than 0.05.

Findings:

I. At present, UAVs are being used in land use management, traffic and transportation management, City Planning, Landscape image capturing all kinds of socio-economic and resettlement survey, inventory database preparation and EIA assessment, Media, University research (application and development). However, the utilization of UAV is Limited in agricultural sector in Bangladesh as the initial startup cost his very high. Furthermore, data processing software as well as hardware price is costly.

II. Government regulation regarding flying Drone is strict. This is because flying a drone requires approval from different Government bodies.

III. Importing UAVs is difficult due to Strict Government rules as well as Regulation

IV. There is shortage of technical manpower

V. Lack of awareness regarding UAV uses among general people as well concerned policy.

4.6. Challenges

There are several challenges to the implementation of UAVs in Bangladesh that are as follows:

The initial cost of purchase – Drones with features that are suitable for use in agriculture are quite expensive. One of the challenges is the balance between the UAV cost and the performance. High performance of the UAV with long flight time, stability, as well as limited interference, will be expensive and prevent farmers from adopting the application as they are very resistant to any new costs. The second challenge is that farmers need time to accept new technology and to be convinced that profits from this scheme are guaranteed.

Figure 40: 'Geo X- 8000 Drone' used in Agriculture Survey in Bangladesh

Figure 41: MATRICE200 Series V2 Drone used in Survey in Bangladesh

Quality software – Right from planning the flight path to processing the final image, software plays a crucial role in the applicability of this technology.

Flight time and flight range – Most drones have short flight ranges thus limiting the acreage that they can cover. The ones with the longer flight ranges are relatively more expensive.

Legal aspects – Different nations have their regulatory regimes regarding the use of UAVs in agriculture.

Acceptability on the farmer front – Technological unawareness may be a hurdle in its penetration.

Interference with the airspace – Drones share the same airspace with manually manned aircraft. As a consequence, collusion can occur.

Connectivity – Mostly farmlands may not have good connectivity, thus either the farmer has to invest in connectivity or buy a drone capable of capturing data locally for later processing. Many early drone technologies for agriculture relied on

uploading images to the cloud for processing or even returning to a computer to upload and then pushing through to an analytics program to create the NDVI maps. With limited mobile phone coverage in many agricultural regions and large distances to travel between fields and the office, farmers and agronomists have complained that this can become an arduous process. And, without the benefit of real-time, actionable insights in the field, many believe the technology is not worth their time and cost.

Weather dependency – Drones' operations are heavily dependent on climatic conditions, thus limiting their usage.

Knowledge and Skill- An average farmer cannot analyze the drone images as it requires specialized skills and knowledge to translate them into any useful information. Under these circumstances, the farmer has to acquire the skills and knowledge of software of image processing or hire skilled personnel conversant with the analysis software.

Misuse-There is a chance of misuse to infringe the privacy of people as well as the illegal transfer of information.

CHAPTER-5: RECOMMENDATIONS AND CONCLUSION

5.1. Introduction

It is anticipated that through this study, the researcher would be able to understand the tremendous prospects to use the UAV for sustainable development such as socio-economic as well as environmental sustainability in Bangladesh. Using drones for geographical research can increase the accuracy of field data and save time as well. Drones not only send a 2D view of the earth but also can collect point clouds for 3D for physical and man-made objects easily as well as rapidly.

The use of UAV in Bangladesh will enhance geographers' understanding of space, save time as well as open further scope for land use detailing. Obtaining precise and appropriate data on land and water bodies is a prerequisite for making effective as well as timely, economic and strategic plans in a densely populated country such as Bangladesh.

As a result, the use of UAV now has become a significant part of national planning as well as development schemes for this country. Availability of precise and reliable 'UAV data' would help immensely in launching economic plans and their effective as well as appropriate implementations.

5.2 Recommendation

Forest growth and information on their sustainability can be obtained by deploying Multi (true color images) and Hyperspectral UAV in areas such as Sundarbans in the south, the Chittagong Hill Tracts in the east and south-east, as well as Sylhet forests in the northeast parts of the country. These drones are affordable as well as easy to handle. In addition, small and medium-size drones are mostly used for conducting atmospheric research including studies on atmospheric composition,

pollution, vertical aerosol distribution, as well as surface temperatures.

These UAV-based techniques will ameliorate farm production efficiency significantly with more and more applications, which have shown remarkable improvements for large farm data acquisition compared to conventional farm surveillance.

At present, UAVs are used at a very limited scale in Bangladesh. Even then, the authorities have imposed various restrictions to regulate uav flights in the country. Use of UAV can be categorized as A, B, C & D.

Class A drones are for recreational use as well as must weigh below five kilograms, and must not be flown above 500 feet above the ground. Class B drones are for non-commercial use, such as surveying large areas for personal studies as well as research. Class C drones are allowed for commercial use and may weigh above five kilograms. Drones used in state or military work are grouped as Class D and require no permission.

UAVs to be used for research and academic purposes belong to the B category and require permission before flying. In Bangladesh, the Civil Aviation Authority grants permission to fly UAVs after specifying the cases. However, airports, cantonments, as well as key point installations are marked as red zones and flying drones over those areas are strictly prohibited. UAVs flying for recreational purposes, does not require permission. However, for academic research and educational purposes, it comes under scrutiny. However, if small UAVs are deployed for the detection of aerosol substances in the air, the experiment must be carried out in a perfect weather condition, otherwise, the results may be distorted.

Larger UAVs, on the other hand, are expensive that assure good results even in bad weather conditions.

The researcher could be able to motivate the policymakers for undertaking further actions to address the underscored challenges for exploring UAVs in Bangladesh. Financial support could be provided through government incentives, foreign investment, and public-private partnerships, ensuring Industry-University collaboration, capacity building in relevant research projects.

In addition, financial assistance could be provided for expanding this lucrative industry to build up skilled manpower by providing appropriate training for operating UAVs properly. Mass awareness should be built up among people regarding UAV uses as well as concerned policy.

Besides these, the concerned authority could take assistance from foreign experts to build up UAV industries in Bangladesh. Civil Aviation Authority of Bangladesh should use advanced technologies, navigation aids, modern equipment such as surveillance radar (TCAS) Traffic collision avoidance systems to monitor UAVs properly to avoid midair collision as well as maintain safety concerns.

Moreover, instead of focusing on regulations restricting UAV usage, it's time for the authorities in Bangladesh to take a proactive role in catalyzing the growth of UAV start-ups for service innovation, through liberal regulations, research, and development (R&D) supports as well as lead usages.

5.3. Limitations of the Study and Scope of the Further Research

There was no dedicated semester for research. Furthermore, there was the unavailability of reliable secondary data sources.

Detailed research may be done further in collaboration with relevant university industries. In addition, the scope of future research is Field-based research.

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