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Drone Technology Development: Potential, Challenges and Implications on Local Industry in Brunei Darussalam

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Abstract: In this modern era, society is categorized as intellectuals where society is now more sensitive to information technology. Drones are one of the aviation technologies that must be mastered because they have many positive uses. One of its uses is for mapping territories, firefighting, searching for missing persons and others. Brunei Darussalam also has drone users among its citizens whether for work or hobbies. However, the potential of drone companies has not yet been seen in Brunei Darussalam. This is because the use of drones has not yet become prominent in society and the type of services in the use of drones is still at a low level. Therefore, this study will study the potential of drone companies for local industries. The scope of this study will focus on the potential of drone companies in terms of the type of services used in local industries. The methodology that will be used is a mixed data method, namely qualitative and quantitative. The first phase is to identify the extent of the use of drone technology in local industries. The second phase is to follow the constructs to obtain the main themes from the data collected in interviews, questionnaires and documents regarding drone technology users in local industries. The themes that will be taken in each interview, questionnaire and document will be analyzed according to the stated study objectives. It is hoped that the results of this study will further assist in the use of drone technology towards the use of drones and continue to achieve Brunei Vision 2035.

Keywords*: Company, Drone, Potential, Local Industry.*

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I. INTRODUCTION

Hassan (2017) believes that increasingly technology can realize human creative ideas in a positive form, especially in the field of telecommunications. One example of technological developments that are increasingly widespread throughout the world is drone technology. Drones are an aviation technology that must be mastered because they have many positive uses. Gita (2021), Among its uses are for mapping areas, firefighting, searching for missing people and others. Mapping is currently needed to monitor forests, agriculture, buildings and so on (Alfiandy, 2021).

Nowadays, drones can be purchased at very low prices and are widely accessible on the market, and can be widely used by anyone (Hartzog, 2015). This will make most drone users without knowing the laws of air traffic regulations. In addition, according to Thomasen (2018), Respati (2020), stated that there are two very basic drone functions, namely that the drone flies and does not have humans in it. Of these two factors, the drone has the ability to enter and access areas that are difficult to explore so that it can conduct monitoring.

II. LITERATURE REVIEW

A drone known as an Unmanned Aerial Vehicle (UAV) is commonly called an unmanned aircraft. This aircraft is controlled automatically through a designed computer program, or through remote control from a driver on the ground or in another vehicle explained Privono (2011). In the beginning, drones were remotely controlled aircraft, but automatic systems are now widely applied. The development

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of drone technology has also begun to be widely applied to the needs of society, especially in the fields of trade, industry and logistics. In the world of the commercial industry, drones have been applied in various industries such as infrastructure surveillance, delivery of goods, forest firefighting, agricultural field mapping, and industrial area mapping (Suroso, 2018).

➢ *Types of Drone Technology*

Based on Indreswari's (2016) explanation of drone types, there are two types of drones, namely multicopters and fixed wing. Fixed wing is a type of drone in the shape of a regular airplane equipped with a wing system similar to a regular airplane. The fixed-wing type requires an aerodynamic design, namely the flow of air on the wings and body so that the drone can fly easily. Multicopter is a type of drone that utilizes the rotation of the propeller to fly. Multicopters are divided into two, namely single-rotor and multi-rotor. The single-rotor type is shaped like a helicopter using a single propeller, while multi-rotor uses three, four, six and eight propellers.

Drones are divided into two main types: fixed wing and multicopter. Fixed wing resembles a regular airplane with wings that require an aerodynamic design for efficient flight. Meanwhile, multicopters use propeller rotation and consist of two sub-categories: single-rotor, which is the same shape as a helicopter with one propeller, and multi-rotor, which uses three to eight propellers for better stability and maneuverability.

- *Fixed Winged Drone*

A fixed wing is a drone that is shaped like a regular airplane, which has a fixed wing shape and has the same components as an airplane. It is available in several different configurations, but usually has a frame with two wings and a single rotor (Garg, 2022). He also stated that fixed wing drones can also carry heavier loads than multi-rotor drones.

The wing structure provides exceptional stability that allows the drone to carry loads of up to 50 kg. Boon (2017) further strengthens the above opinion that fixed wing drones have excellent flight endurance capabilities and can cover a large area in one flight.

A fixed wing drone is a type of drone that resembles an airplane with a fixed wing, which usually has two wings and a single rotor. This drone can carry loads of up to 50 kg, making it more capable than a multicopter. In addition, fixed wing drones have good flight endurance, allowing them to cover a large area in one flight. The main difference lies in the ability to carry heavier loads and a wider range.

Fig 1 Fixed Wing Drone

- *Multi Rotor Drone*

A multicopter drone is a drone designed to use propellers and lift to enable it to fly and function. (Garg, 2022), The four-bladed multirotor (quadcopter) is the most widely used design because it provides the best balance between lift, control, maneuverability, and cost. The center frame connects up to eight fixed-pitch propellers that control the speed, direction, and altitude of the drone.

Multirotors are much more cost-effective than fixed-wing drones, which can cost almost twice as much. Multirotors are easy to fly, take off, and land, and they can fly autonomously with ease (Thamm et al., 2015). However, their ability to fly multiple times is limited due to their heavy battery life (Cai et al., 2014). Therefore, if a small camera is to be operated in the air for a short period of time for aerial photography, then a multirotor drone is the best choice.

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Multirotors can carry more payload than fixed-wing drones (Garg, 2022). Gómez Candón et al. (2013) used quadcopters to produce image data suitable for monitoring agricultural crops, and this was also agreed by Wan et al. (2014).

Multicopter drones use propellers to fly and offer a more effective balance between lift and cost than fixed wing drones. Quadcopters are the most common design with four propeller blades, allowing for easy and autonomous flight. Although limited by battery power, multicopters can carry more payloads and are suitable for aerial photography. The use of quadcopters in monitoring agricultural crops has also proven effective.

Fig 2 Multicopter Drone

- *Single Rotor Drone*

Single rotor drones are drones that use only one propeller to fly and function well like helicopters. Single rotor drones have been widely used in agricultural plant protection because of their powerful rotors to lift water tanks, fertilizers and others. (Gong and Fu, 2008; Guo et al., 2014; Xu et al., 2017).

Single rotor drones use one propeller to fly, resembling helicopters, and have powerful rotors, allowing them to lift heavy loads such as water tanks and fertilizers in agricultural plant protection. Although they offer good maneuverability, their use is more limited compared to multicopters and fixed wing drones.

Fig 3 Single Rotor Drone

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➢ *Components Used in Drones*

Drones are technological tools used to fly and have many components used such as motors, fans, electronic speed controller (ESC), design (frame), main flight controller, Global Positioning System (GPS), battery and transmitter.

- *Motor and ESC (Electronic Speed Controller)*

The motor is one of the main components in drone technology, serving as the main mover that provides energy to lift and operate the drone during flight. Drones generally use brushless DC (BLDC) motors because of their high efficiency, good durability, and the ability to produce large power with a relatively small size (Prasanna et al., 2019).

This motor drives the propeller, which serves to create the lift required for the drone to fly. Each motor is connected to a propeller that spins rapidly, creating a lift that allows the drone to carry loads such as cameras and sensors. Flight control is also very dependent on the motor; by changing the speed of the motor individually, the drone can perform maneuvers such as rotating, turning, and going up and down, which is important to maintain stability and quick response to input from the pilot (Rahman et al., 2020).

In addition, the efficiency of motor use is very important to extend the flight time, where an efficient motor can produce more lift with less battery consumption. A good cooling system is also required because motors can generate heat during operation, and the integration of motors with the flight control system ensures that the drone flies stably and can accurately perform the desired maneuvers. Overall, the use of motors in drone technology is crucial to the performance and success of flight operations, both for recreational and commercial applications (Lee et al., 2021).

Although the Electronic Speed Controller (ESC) has a very important purpose in real-life multirotor, in a drive chain model it has very little importance. In the model, its function is reduced to transferring current from the battery to the motor under constant voltage. However, when designing a multirotor, the ESC still needs to be sized according to the maximum current flowing to the motor.

- *Propeller*

The use of a fan, or propeller, in drone technology is very important because it functions as the main element to produce the lifting force required for the drone to fly. Propellers work by rotating and creating a difference in air pressure above and below the blade, which produces lift (Cheng et al., 2020).

The fan on the drone is designed to achieve maximum efficiency in producing lift. Propeller blade design, including length, width, and shape, affects performance and energy efficiency. Longer propellers can produce more lift, but may also be heavier and require more energy (Hussain & Zaki, 2021). There are various types of propellers used in drones, including two-bladed and three-bladed propellers. Two-bladed propellers are usually lighter and have better efficiency in certain conditions, while three-bladed propellers can provide greater lift and better stability in flight (Liu et al., 2019).

The fan plays a crucial role in the flight control of the drone. By changing the speed of each motor connected to the propeller, the drone can perform various maneuvers, such as spinning, turning, and flying up or down. This handling is important to maintain the stability and responsiveness of the drone during flight, especially in unstable wind conditions (Gao et al., 2021). Overall, the use of propellers in drone technology is very important to produce lift, provide flight control, and affect energy efficiency and the overall flight experience.

- *Body Frame*

The use of frames in drone technology is an important aspect that affects the structure, stability, and overall performance of the drone. The frame serves as the basic framework that accommodates all other components, including motors, propellers, flight control systems, batteries, and sensors. Drone frames are usually made of various materials, such as plastic, carbon fiber, aluminum, or composite. Choosing the right material is very important because it can affect the weight of the drone and the strength of its structure. A lighter frame allows the drone to fly more efficiently and longer, while strong and durable materials provide protection against impacts and ensure structural integrity during flight (Siddiqui et al., 2021).

Frame design can vary based on the type and purpose of use, with different configurations such as quadcopter, hexacopter, and octocopter, each offering advantages and disadvantages related to lift and stability (Bhatnagar et al., 2020). A good design facilitates the installation of other components and helps in cable management and cooling systems (Li et al., 2019). In addition, an aerodynamic frame can reduce air resistance, increase flight efficiency, and maintain the balance of the drone (Abdulrahman et al., 2022).

Many drone users choose a frame that can be customized to adjust the size and features according to their specific needs, including the addition of cameras and sensors to improve the drone's capabilities in various applications (Khan et al., 2021). Overall, the use of accurate frames is very important for the performance and success of drone flights in various missions.

- *Main Flight Controller*

The use of flight controllers in drone technology is a crucial element responsible for organizing and controlling the drone flight as a whole. The flight controller functions as the "brain" of the drone, processing data from various sensors such as accelerometer, gyroscope, barometer, and GPS to determine the position, orientation, and speed of the drone (Niemann et al., 2020). With this information, the flight controller can adjust the speed and direction of the motor based on commands from the user or a programmed mission, using a control algorithm to enable the drone to perform maneuvers such as rotating, turning, and flying up or down (Corke et al., 2017). In addition, the flight controller has the ability to stabilize drone flight, especially in unstable wind

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conditions, by automatically adjusting the speed of the motor to maintain balance and reduce vibration (Khan et al., 2021).

Many modern flight controllers also offer various flight modes, such as stabilization mode, GPS mode, and manual mode, giving users the flexibility to choose the mode that best suits their mission needs (Kumar et al., 2019). In addition, the flight controller can be integrated with various additional systems, such as cameras and monitoring sensors, allowing drones to perform various missions, ranging from mapping to surveillance (Ali et al., 2021). Overall, the flight controller plays a key role in improving the performance and functionality of the drone, ensuring a stable, safe, and efficient flight in various applications.

- *Global Positioning System (GPS)*

The use of GPS in drone technology plays a very important role in improving navigation, monitoring, and flight control. The Global Positioning System (GPS) allows drones to determine their position and orientation with high accuracy, which is essential for safe and directed flight. By relying on signals from satellites, drones can follow pre-programmed routes, especially in mapping and surveying missions (Santos et al., 2021).

In addition, GPS helps stabilize drone flight by providing continuous position information, allowing the drone to automatically correct its position if it encounters disturbances due to wind or other external factors (Zhang et al., 2020). Many modern drones are equipped with automatic flight features that rely on the GPS system, allowing the drone to perform certain missions, such as aerial photography or area monitoring, with high accuracy and reducing the pilot's workload (Baker et al., 2019). GPS also plays a role in drone safety features, such as automatic return to home (RTH), which reduces the risk of losing the drone (Khan et al., 2021). Additionally, GPS is often integrated with other sensors, such as cameras and LiDAR, to enhance data acquisition capabilities, producing more accurate and detailed maps (Chase et al., 2022). Overall, the use of GPS in drone technology is crucial for accurate navigation, automated flight control, and increased mission effectiveness in a variety of applications.

- *Battery*

The use of batteries in drone technology is a very important aspect as it provides the energy source required for operation and flight. Lithium polymer (LiPo) and lithium-ion (Li-ion) batteries are the most popular battery types used in drones. The battery serves as the main energy source, and the capacity and voltage of the battery selected affects the flight distance and operating duration of the drone. LiPo batteries, for example, offer high energy with light weight, making them an ideal choice for most applications (Yang et al., 2020).

In addition, battery weight is a critical factor affecting the carrying capacity and flight stability. Therefore, the selection of lighter and more compact batteries allows the drone to carry more payload without sacrificing flight performance (Chen et al., 2021). The battery is also equipped with a power management system to monitor and control the charging status, ensuring that the battery is not overcharged or overdischarged (Fathabadi et al., 2019).

Battery life cycle, which refers to the number of charging and discharging cycles that can be performed before the battery performance decreases, is important for users when planning the use of the drone (Zhang et al., 2020). In applications requiring longer flights, selecting the appropriate battery type and capacity is critical to drone mission effectiveness in a variety of applications, including agricultural monitoring and freight transportation (Vaughan et al., 2021). Overall, the proper use of batteries in drone technology can improve lifespan, performance, and mission effectiveness.

- *Power Module*

The power module in drone technology is an important component responsible for supplying and managing electrical power to all drone systems, including motors, receivers, and sensors. It functions to convert the voltage from the battery to the level required for various components in the drone, ensuring that each system operates with high efficiency (Gupta et al., 2020).

In addition, the power module is equipped with a power management system that monitors and controls energy consumption, prevents battery depletion, and ensures that all components operate within a safe range, thus increasing the lifespan of the components and the entire system (Huang et al., 2019). The design of the power module is also prioritized to be compact and lightweight, so as not to increase the overall weight of the drone, allowing the drone to carry additional loads without sacrificing flight performance (Zhang et al., 2021).

The effectiveness and reliability of the power module are important to ensure stable and safe operation, especially in various weather conditions and vibrations during flight (Khan et al., 2021). In addition, the power module is often integrated with other systems in the drone, such as the flight control and communication systems, to ensure better coordination between components and smooth operation during flight (Wang et al., 2020). With all these aspects, the power module is a very important element in ensuring the performance and efficiency of the drone in various applications.

- *Power Distribution Board*

Power distributors in drone technology are essential components that serve to distribute electrical power to various systems and components in a drone, including motors, receivers, and sensors. By ensuring that each part receives sufficient and stable power supply, power distributors help prevent interference or overloading of any one component, which can cause damage (Liu et al., 2020). The design of power distributors is usually compact and lightweight, which allows for easy installation in the limited space of a drone without disrupting its aerodynamics (Zhang et al., 2021).

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In addition, power distributors are equipped with safety features such as overcurrent detection and short-circuit protection, ensuring that the system will automatically disconnect when a problem occurs, protecting components from damage (Nguyen et al., 2019). It also works in integration with the flight control system, allowing for better and more responsive power management during flight (Gao et al., 2020). With efficient power distribution and good management, power distributors can improve the flight time and overall performance of drones, allowing them to carry out various missions such as monitoring, delivery, and photography more effectively (Huang et al., 2021).

Therefore, power distributors are a very important component to ensure stable and efficient operation in various drone applications.

- *Transmitter Dan Receiver*

Transmitters and receivers are essential components in drone technology that enable communication between the operator and the drone itself. The main function of the transmitter is to send commands from the operator to the drone, while the receiver is responsible for receiving the commands and sending them to the drone's flight control system. This two-way communication allows the operator to send commands and receive feedback such as telemetry data and flight status, ensuring that the operator always has up-to-date information about the drone's position and condition (Mandal et al., 2020).

The transmitter and receiver operate at various radio frequencies, such as 2.4 GHz and 5.8 GHz, where the selection of the appropriate frequency is important to reduce interference from other signals (Bergstrom et al., 2021). The communication distance between the transmitter and receiver also affects the drone's performance; a powerful transmitter with a sensitive receiver can extend the flight range and improve signal robustness, which is important in challenging environments (Gupta et al., 2020).

Security in communication is a critical aspect, especially in critical applications such as security monitoring, so many systems are equipped with encryption features to protect data (Xu et al., 2021). In addition, the transmitter and receiver also work in integration with other systems such as GPS and flight control systems, allowing the operator to plan and execute missions more efficiently (Kumar et al., 2020).

Therefore, the transmitter and receiver are very important components in ensuring effective and safe communication between the operator and the drone.

➢ *Uses of Drone Technology*

Drone technology began as a military tool development. It has various forms and levels of capabilities that are used based on needs, for example to make mapping and surveys, send aid, identify areas that are observed, to make attacks on the enemy (Tice, 1991). Syahrul (2021) stated that drone technology began as a military tool, its use has rapidly expanded to commercial, scientific, entertainment, agricultural and industrial uses. This, commercially valuable drone technology is the result of recent advances in GPS, sensors, batteries, motors, lightweight structural materials and advanced manufacturing techniques. (Hazel and Aoude, 2015).

However, there is also drone technology used for entertainment, namely drone racing. Drone technology is a remote-controlled aircraft that has 4 propeller blades that are quite difficult to play if you do not have experience in controlling it. The drone motor that controls the four propeller blades is placed in a square arrangement with the same distance from the center of mass and the motor is oriented upwards, explained Hafizi (2023).

Drone technology, originally developed for military purposes, has now expanded into a variety of fields including commercial, scientific, entertainment, agricultural, and industrial. Advances in GPS, sensors, batteries, motors, lightweight materials, and manufacturing techniques are driving this innovation. In entertainment, drones are also used in racing, which requires specialized skills to operate due to the balance and control of their four propeller blades.

- *Use of Drone Technology in Entertainment*

The use of drone technology in the entertainment industry has opened up new opportunities for creative performances and extraordinary audience experiences. One of the main applications is in drone light shows, where hundreds to thousands of LED-lit drones are flown simultaneously to form visual formations and patterns in the air. These are commonly used at large events such as festivals, concerts, and celebrations, replacing fireworks with safer and more environmentally friendly alternatives (Smith & Wang, 2021). In the film and television industry, drones have become an essential tool in filming, offering unique aerial perspectives that are difficult to achieve with conventional cameras.

High-quality camera technology mounted on drones allows directors to capture cinematic aerial footage for more dramatic visual effects (Johnson, 2022). Autonomous drones equipped with tracking sensors can also follow moving actors or objects, facilitating the filming of dynamic action scenes (Chen & Roberts, 2023).

In addition, in theme parks and concerts, drone technology is also used to produce interactive performances that are responsive to audience movements or synchronized with music or the theme of the event. In fact, some theme parks use drones to deliver interactive aerial shows that coordinate with the storyline (Kim & Lee, 2022). The use of drones in entertainment has brought a new dimension in visual and cinematic presentation, making them a popular and innovative choice in today's entertainment industry and there is also the use of drone technology in drone competitions.

In drone competitions, various latest technologies are applied to improve the performance and capabilities of drones in facing different challenges. First-Person View (FPV) technology, for example, allows operators to see a direct view of the drone as if they were in the cockpit, which is very

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useful for races that require fast and responsive controls (Jones, 2022). For competitions involving complex routes or obstacles, navigation sensors such as lidar and infrared are used to help the drone automatically avoid objects, providing the ability to move smoothly through obstacles (Smith & Lee, 2021). GPS technology is also a critical component in ensuring that the drone stays on the designated route, especially in competitions involving large areas (Anderson, 2020). Additionally, AI and machine learning applications allow drones to identify objects, analyze routes, and make autonomous flight adjustments (Brown, et al., 2023). Furthermore, the selection of components such as high-capacity lightweight batteries and powerful motors ensures that drones can operate for longer at optimal speeds, a factor that is important for success in competitions (Green, 2021). All of these technologies give drones an advantage in facing more challenging routes and improving their abilities in competitions.

- *Use of Drone Technology in Industrial*

The use of drone technology in industry has shown great potential in improving efficiency, safety, and productivity in various sectors. In the field of inspection and monitoring, drones are used to inspect infrastructure such as bridges, buildings, and pipelines by providing detailed views without the need for risky manual inspections (Zhang & Wang, 2020).

In the agricultural sector, drones monitor crops and spray pesticides efficiently, helping farmers collect data on crop water and nutritional needs (Smith et al., 2021). Drone technology is also used in logistics and shipping, where it delivers packages directly to the recipient location, reducing delivery times, especially in hard-to-reach areas. In land mapping and surveying, drones quickly produce topographic maps and 3D models, facilitating project planning and monitoring construction progress (Johnson, 2022). Additionally, in emergency situations, drones are used for search and rescue in hard-to-reach areas, providing real-time information to authorities (Chen & Lee, 2023).

In the energy and utilities industries, drones inspect solar and wind farms and electrical lines, improving maintenance efficiency and reducing risks to workers (Brown, 2022). All of these applications demonstrate that drone technology not only increases productivity but also reduces costs and risks, making it an essential tool in the modern era.

➢ *Rules for the Use of Drone Technology*

An important thing to consider in the use of drone technology is the journalistic ethics factor. Culver (2014) stated four things that need to be considered in terms of journalistic ethics when the media utilizes the use of drone technology. The first is safety. Consideration for the safety of people who are under the drone's flight path. The second rule is accuracy and context. Drone technology can remove facts from the context of events. For example: Photos or videos of demonstrations taken using high-flying drone technology do not determine how big the protests are raised by the protesters. The third rule is privacy. The biggest problem with the use of drone technology is the violation of privacy. Not a few people are disturbed when there is a drone flying over them and taking pictures. Finally, conflict of interest. The media must not take pictures with drone technology.

Therefore, drone technology users must comply with the regulations that have been stated by the national government, such as drone technology users having experience and proficiency in using drone technology, knowing the prohibited places to fly and take pictures using drone technology, and users must respect the privacy of others.

In Brunei Darussalam, a regulation has been made by the Unmanned Aircraft Department of the Civil Aviation Department to control the flight activities of people from the public and any company. This is to avoid any complaints from the public and to avoid injury or loss. The regulation will be displayed in Appendix A.

The regulation stated in Appendix A is first of all, drones will operate in the morning only and are not allowed to fly drones at night. Second, the public and any company are not allowed to fly drones five kilometers near prohibited places such as airports, palaces and military. Third, it is not allowed to fly drones in people's homes and it is not allowed to fly drones in busy or crowded places. Lastly, drones are not allowed to operate above the specified height limit of two hundred feet or fifty meters above sea level without permission from certain parties.

➢ *Industrial Revolution*

Iqbalsweden (2018) stated that industry 4.0 is a more advanced development than previous revolutions. Industry 1.0 began in the 1800s, when a major revolution began in various fields such as agriculture, factories, mining and transportation. The emergence of machines seemed to replace the role of humans or animals, which was still limited. Industry 2.0 is a revolution that achieved very high achievements due to the emergence of electricity and driving motors in the use of technology, explained Ghufron, (2018). Changes are happening quite quickly in industry 3.0 (Decky, 2019), which is an industry that uses electronic goods, information technology and automation. This computer-based automated system makes industrial machines no longer controlled by humans. Digital technology and the internet are also known in this era (Viva, 2018). The latest industrial revolution or known as the 4.0 industrial revolution.

Industry 4.0 is a revolution from industry 3.0 which uses the internet or IOT (Internet Of Things) to play an important role. Nowadays, Lom, M., Pribyl, O., & Svitek, M. (2016) stated that the internet is not just used to search for materials, but with the internet everything can be connected brilliantly, starting from cloud storage, robotics and the development of Artificial Intelligence (AI). In this case, the use of artificial intelligence is very widespread around us, starting from games, drones, flight cockpit tools to more advanced levels that help our daily lives (Raymond, 2016).

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- *Internet of Things (IoT)*

The presence of Internet of Things (IoT) technology, where every object can be uniquely identified, equipped with sensors and connected directly to the internet. Internet of Things (IoT), many also call it the Internet of Everything (Yao, Yen, and Yip, 2015). IoT was first introduced in 1999 by Kevin Ashton, officially proposed in 2005 and first known in the 2010s, and in recent years has attracted the attention of academics and users (Ju & Li, 2011). The use of Internet of Things in drone technology is a concept which aims to expand the benefits of connectivity from the internet by connecting remotely and continuously, explained Alfiandy (2021). The use of this Internet of Things is also able to arrange drones to move within the expected time and place that we arrange. This is very beneficial in terms of mapping areas, border surveillance and agriculture. The use of this Internet of Things also has many types such as the use of raspberry Pi, ESP-32CAM and OpenCV.

- *Rasberry Pi*

Raspberry Pi or better known as Rasphi is a microcomputer module that also has digital input and output ports like on a microcontroller board. Among the advantages of Rasberry Pi compared to other microcontroller boards is that it has a port to display such as a TV or PC monitor as well as a USB port for keyboard and mouse (Jaka, 2018). Raspberry Pi was made in England by the Raspberry Pi Foundation. Initially, Raspberry Pi was shown as a computer science learning module at school.

Raspberry Pi is a minicomputer the size of a credit card. Aula and Dony (2022) state that the raspberry Pi has a Broadcom BCM2835 system chip (SoC), which includes an ARM1176JZF-S 700 MHz processor (the firmware includes a number of "Turbo" modes so users can try overclocking, up to 1 GHz, without affecting the warranty), a VideoCore IV GPU, and is initially shipped with 256-megabyte RAM, later upgraded to 512MB. Includes a built-in hard disk or solid-state drive, but uses an SD card for booting and long-term storage.

III. RESEARCH PROBLEMS

Since the use of drone technology in Brunei Darussalam has not yet seen a big impact, this is because the use of drone technology is still not prominent to the community and the type of services in the use of drones is still at a low level. Apart from that, no one stated in the study that the use of drone technology in local industries does not provide job opportunities in Brunei Darussalam. This is because there is no local industry looking for new workers who are skilled in the use of drone technology.

➢ *Research Objectives*

The following are the three objectives of the study:

- To know the use of drone technology in drone companies in local industries.
- To know the statistics of the use of drone technology that can be applied in local industries in Brunei Darussalam.
- To assess opinions on how drone technology can have a positive impact on local industries.

➢ *Research Questions*

The following are three research questions:

- What are the local industries using drone technology in drone enterprises?
- To what extent is drone technology used in local industries in Brunei Darussalam?
- How can drone technology have a positive impact on local industries?

IV. RESEARCH METHODOLOGY

The methodology that will be used is a mixed data method, namely qualitative and quantitative. The advantage of the mixed method using qualitative and quantitative data collection will provide a broader picture of the potential of drone enterprises for local industries (Ambiyar, 2019). The study sample that will be used is cluster sampling from drone pilots or drone users in 6 selected local industry places, namely the Royal Brunei Police Force, Fire and Rescue, Public Works Department, Innovaero.co, Skyvisionbn and the Civil Aviation Department. Therefore, a total of 20 respondents will be taken as a study sample, namely 3 people in each selected local industry such as drone pilots, engineers and coordinators. While respondents from the Civil Aviation Department will be taken in only a few people. This study will use questionnaire and interview instruments. The conversation was recorded by the researcher using a small tape recorder. In order to achieve the objectives of this study, questionnaires were given to samples selected by the researcher who have different ages, education levels, and backgrounds. questionnaire in which the researcher will make simple and understandable questions about the use of drone technology to respondents with answers that use strongly agree, agree, moderate, disagree and strongly disagree.

After making an audio recording and questionnaire, the researcher conducted an interview activity. The purpose of the interview was to find out some information that was not known through the questionnaire. Interviews with respondents were formal involving topics related to the function of drone technology, the extent to which drone technology is used by them and how drone technology can have a good impact in an enterprise. The researcher also interviewed several samples from the Civil Aviation Department.

V. RESEARCH FINDINGS

➢ *Research Question 1: What Local Industries Use Drone Technology in Drone Enterprises?*

The findings from research question 1 are based on an interview instrument held with the Civil Aviation Department (Unmanned Aircraft). This is to find out the use of drone technology in drone companies in the local industry. The Unmanned Aircraft party has stated that the types of drones used have two themes: 'types of drones' and 'types of services'.

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Table 1 Response Information Regarding the First Research Question.

First theme	Types of drones	industrial	Multi rotor	Quadcopter
				Hexacopter
				Octacopter
		entertainment	Single rotor	-
			Multi rotor	
			Fixed wing	
Second theme	Service type		Cleaning tall buildings	-
			Transportation of supplies	
			Checking the bridge	
			Checking tight spaces	

The first theme shows that there are two types of drone technology usage, namely industrial and gaming. In the sub-themes, namely 'single rotor', 'multi rotor' and 'fixed-wing'. While industrial only uses multi-rotor drones, namely 'quadcopter', 'hexacopter' and 'octacopter'.

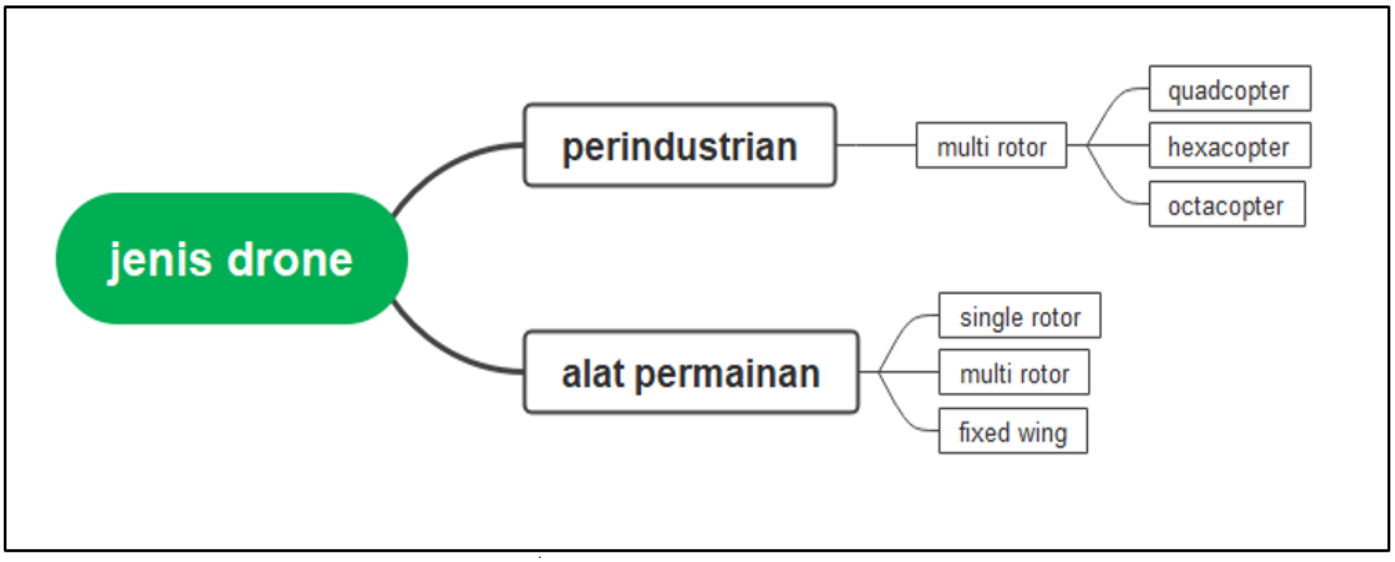

Fig 4 Results of the First Research Question.

The types of services that drone technology users use also make drone technology a success, such as transporting supplies, cleaning tall buildings, inspecting bridges and inspecting narrow spaces.

- *Research Question 2: To What Extent is Drone Technology used in Local Industries in Brunei Darussalam?*

The findings of the second research question, namely the extent to which drone technology is used in local industries in Brunei Darussalam, aim to achieve the objective of knowing the statistics on the use of drone technology that can be used in local industries in Brunei Darussalam. The findings of this second question were with the Department of Civil Aviation from the Unmanned Aircraft unit through interviews.

The Umanned Aircraft party also registers drones for the public and local industries to find out the statistics on drone registrations to Brunei, whether drones for industry or toy drones. Below is a table of drone registration statistics entering Brunei from 2019 to 2023.

Table 2 Statistic of Registration Drone

year	Jan	Feb	Mac	April	May	Jun	Jul	Ogs	Sep	Okt	Nov	Dec	total
2019	8	1	3	4	3	1	8	3	1	6	5	13	56
2020	21	11	6	8	7	25	17	16	19	11	13	18	172
2021	17	11	14	15	8	11	13	3	10	11	20	23	156
2022	30	11	7	10	14	17	24	20	12	13	6	9	173
2023	14	11	6	9	6	2	1	12	8	8	6	4	76

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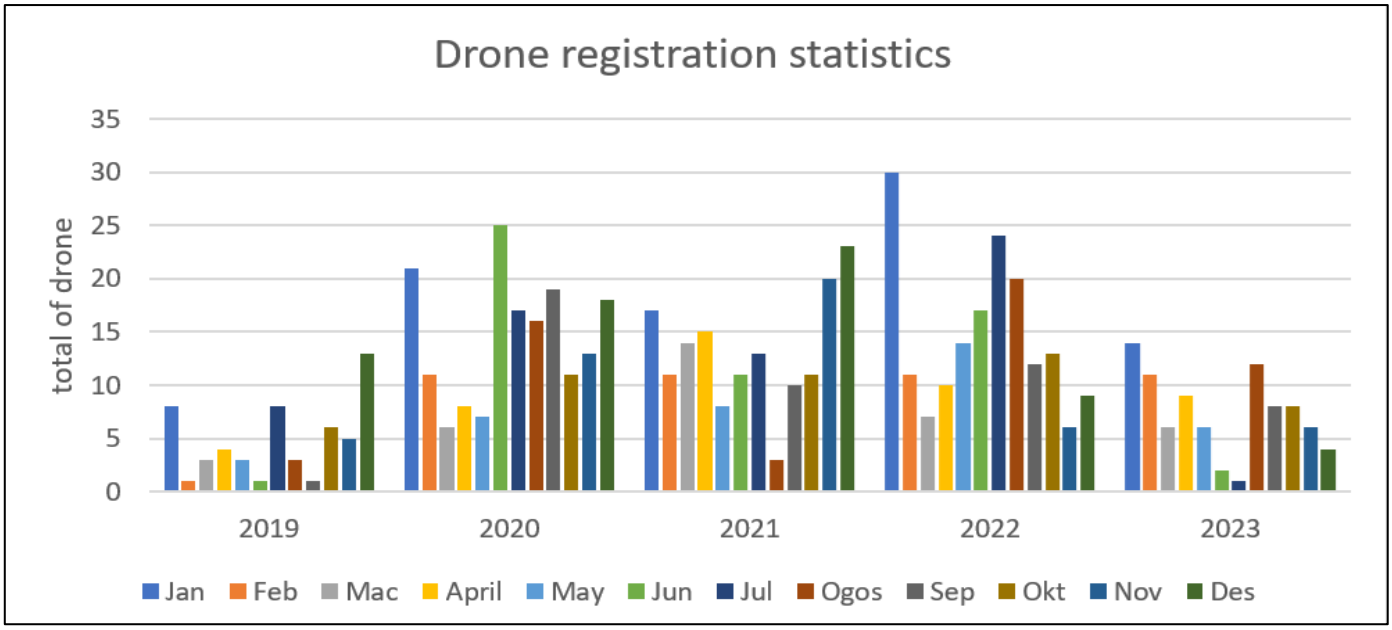

Fig 5 Drone Registration Statistics Entering Brunei in 2019 to 2023

Analysis of drone registration statistics in Brunei from 2019 to 2023 shows a mixed development over the five years. The annual registrations peaked in 2022 with 173 registrations, but experienced a sharp decline in 2023 of 56.07%, reflecting a significant change in drone usage trends. The largest increase occurred in 2020 with a 207% jump compared to 2019, which may be due to the increased use of drones in COVID-19 pandemic-related activities such as delivery or monitoring. Despite a small decline of 9.30% in 2021, the number of registrations remains high, indicating continued interest in drone technology.

In 2022, registrations increased again by 10.90%, reflecting increased awareness and acceptance of the technology. However, in 2023, a sharp decline may be due to factors such as new regulations, costs, or a reduction in activities requiring the use of drones. Additionally, analysis of monthly patterns shows that the highest registrations typically occur in the middle of the year, with July in 2022 and August in 2023 recording the most registrations. Conversely, the months with the lowest registrations show a downward trend in some months throughout the year, such as 2023 recording only 1 registration in July.

Overall, this data illustrates the dynamic changes in the drone industry in Brunei, with a surge in usage in certain years and a challenging decline in 2023, requiring further research to identify the factors influencing this trend and devise strategies to support future growth.

The picture below is the statistics of drone use permits throughout the year 2022 to 2023.

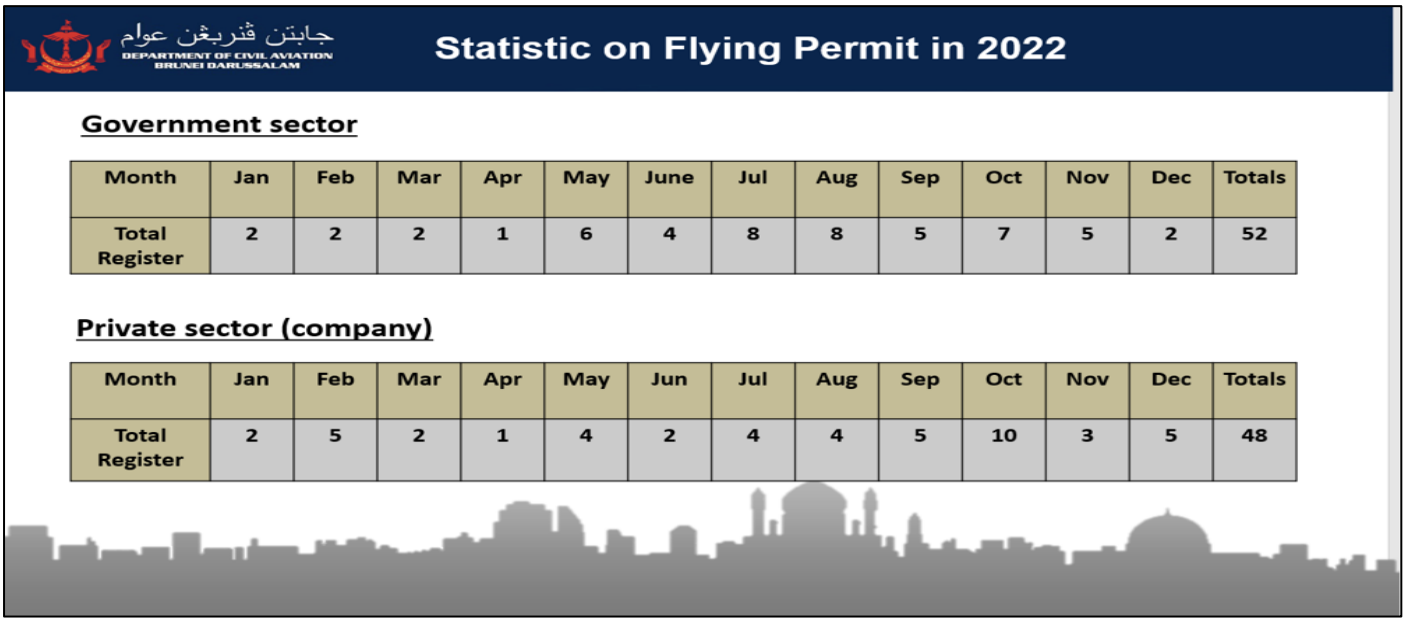

Fig 6 Statistics for Drone Flight Permit Registrations in 2022 to 2023. (Source: Department of Civil Aviation)

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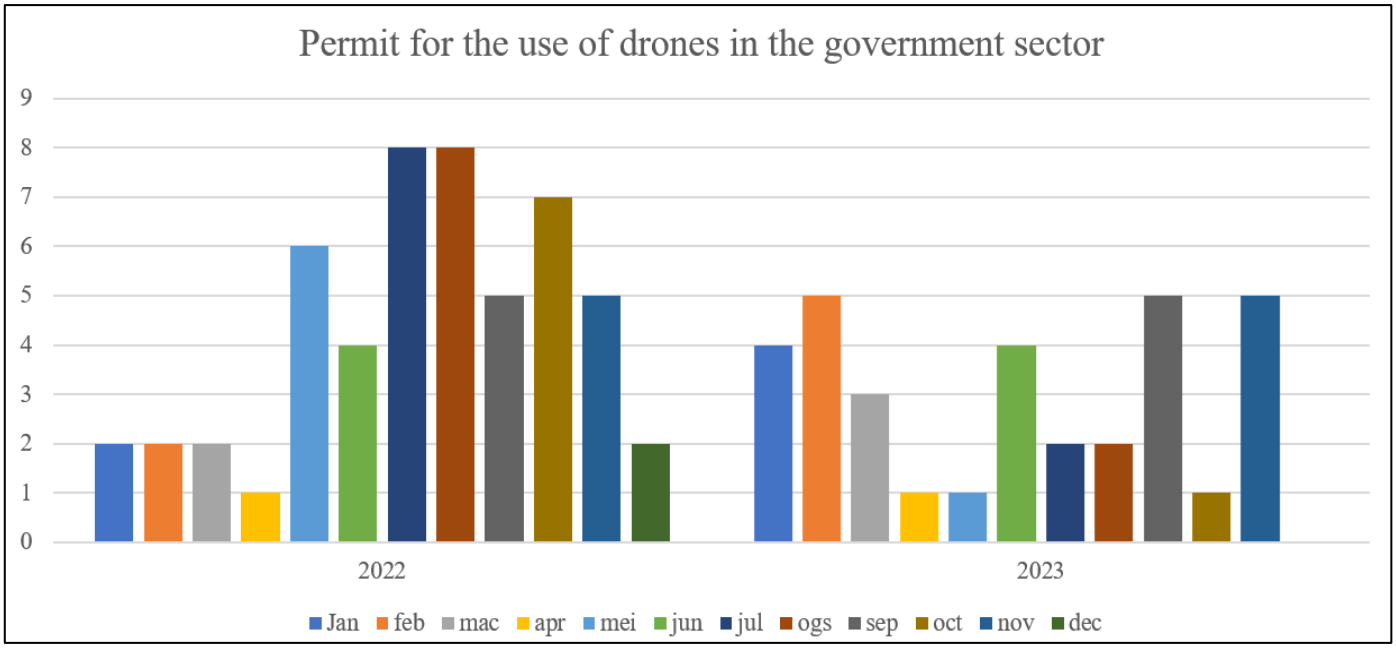

Fig 7 Number of Drone use Permits in the Government Sector

In 2022, there were 52 drone flight applications, while in 2023, this number decreased to 33, showing a decrease of 36.54%. Overall, the highest monthly application numbers were recorded in July, August, September, and November with 10 applications each. On the other hand, the lowest application numbers occurred in April and December, with only 2 applications each month. On average, the months with the highest applications recorded an average of 5 applications, while the lowest months recorded an average of as little as 1 application.

The significant decrease in 2023 compared to 2022 is likely due to changes in policy or regulations, or other factors such as reduced interest among applicants. This analysis suggests the need to further investigate the factors influencing this trend in order to devise more effective strategies for the future.

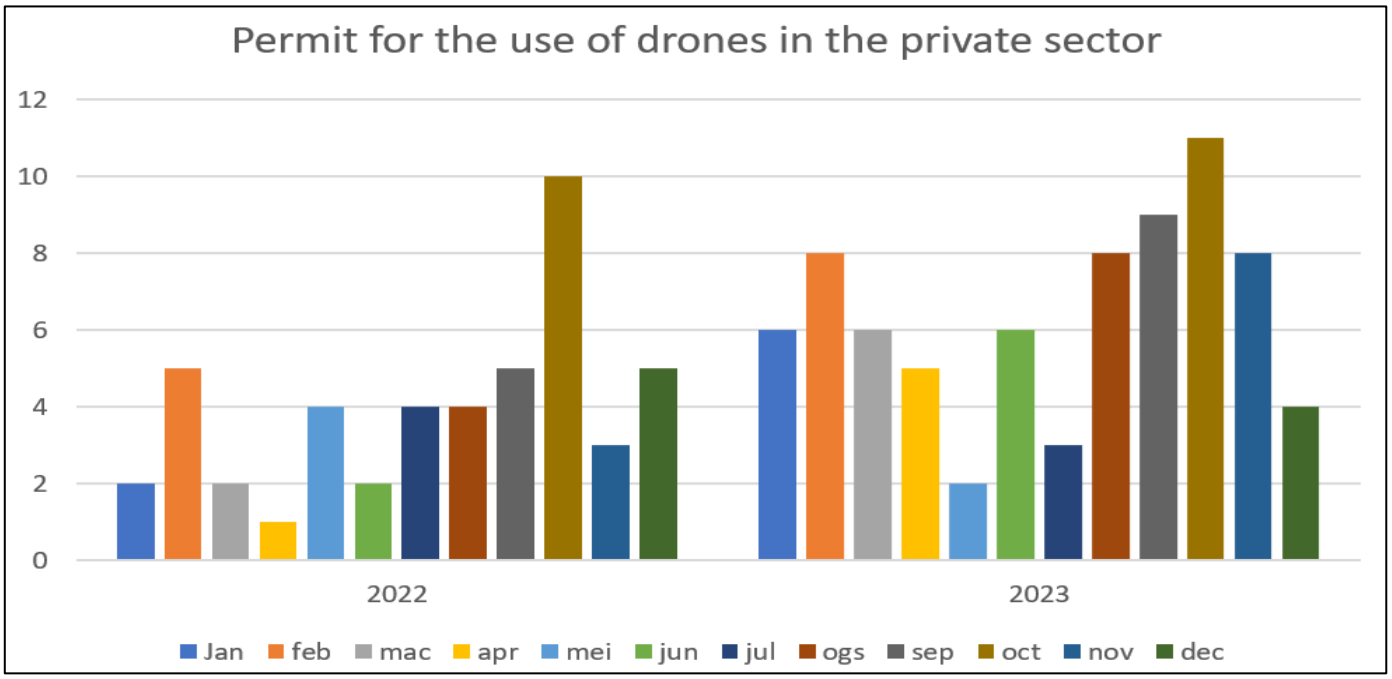

Fig 8 The Number of Drone use Permits in the Private Sector

In 2022, the number of drone flight permit applications in Brunei was 52, while in 2023, this number increased to 81, recording an increase of 55.77%. The month with the highest number of applications in both years was October, with 10 applications in 2022 and 11 applications in 2023. On the other hand, the month with the lowest number of applications in 2022 was April (1 application), while in 2023, May and December recorded lower numbers of applications, with 2 and 4 applications respectively.

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Overall, almost all months in 2023 showed an increase in the number of applications compared to 2022, except for a few months such as July, which decreased from 4 applications to 3. This significant increase in the number of applications reflects the growing interest in the use of drones in Brunei, which may be driven by technological developments, decreasing costs, or a wider awareness of their benefits. October has consistently been the most active month, possibly due to weather factors, business activities, or special events requiring the use of drones.

- *Research Question 3: How Can Drone Technology Have a Positive Impact on Local Industries?*

Construct B is to find out the impact of drone technology use on the country. The figure below shows the average score and standard deviation on the items in construct B:

Table 3 Construct B Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Enhance the country's ability to monitor border security.	102	3	5	3.92	.685
Use of drones in environmental monitoring	102	1	5	3.93	.721
Scientific research that contributes to the progress of the country.	102	1	5	3.86	.718
Improve domestic delivery efficiency.	102	1	5	3.92	.727
Complex and challenging security operations.	102	1	5	3.84	.741
Become a major contributor to the country's economy	102	2	5	3.76	.677
Generate income through drone technology services.	102	3	5	3.87	.655
Help increase the competitiveness of local industries.	102	2	5	3.83	.705
In public services helps save operating costs.	102	2	5	3.84	.671
Increase the productivity of the country's agricultural sector.	102	2	5	3.83	.705

Based on the data, statistical analysis of the impact of drone use shows that this technology makes significant contributions in various sectors of the country. In terms of security, the use of drones in border monitoring recorded an average score of 3.92, indicating a high level of agreement that it helps improve national security control. In addition, drones also play an important role in environmental monitoring with an average score of 3.93, proving its ability to protect ecosystems and manage natural resources more efficiently.

In terms of scientific research, drones recorded an average score of 3.86, indicating its growing role in assisting innovation and knowledge development. In the logistics sector, the use of drones increases delivery efficiency with an average score of 3.92, indicating that this technology has the potential to optimize the delivery operations of goods and services. In addition, drones also play an important role in complex and challenging security operations with an average score of 3.84, proving its ability to support military and public safety operations.

From an economic perspective, the drone industry is predicted to be a major contributor with an average score of 3.76, indicating confidence that this sector can generate income and open up new job opportunities. Next, the use of drone technology in public services received a score of 3.84, which shows its effectiveness in saving government operating costs.

In addition, drones also help increase the competitiveness of local industries with an average score of 3.83, proving that this technology can strengthen the business ecosystem in the country. In the agricultural sector, drones increase productivity with an average score of 3.83, proving its ability to speed up the process of monitoring and managing crops. Overall, the analysis findings show that the use of drones has a positive impact in various sectors, with a consistently high average score, proving the effectiveness of this technology in supporting national development.

- *Job Opportunities*

Construct C is to find out whether the use of drone technology can open up job opportunities. The figure below shows the average score and standard deviation on the items in construct C:

Table 4 Construct C Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Creating many job opportunities in various sectors	102	2	5	3.86	.661
Drone operating skills.	102	2	5	3.75	.681
Demand for technicians	102	2	5	3.69	.689
Use of drones in the delivery sector	102	1	5	3.68	.747
Drone pilots are an important role	102	1	5	3.84	.741
Drones in security create jobs.	102	2	5	3.75	.681
The use of drones in the broadcasting industry.	102	2	5	3.88	.649
Entrepreneur in creative services	102	2	5	3.95	.651
The field of aerial mapping using drones	102	2	5	3.89	.716
Job opportunities in agriculture	102	2	5	3.75	.710

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Data analysis shows that the use of drone technology has a significant impact on job opportunities in various sectors. The average score obtained is in the range of 3.68 to 3.95, reflecting a high level of agreement among respondents on the role of drones in creating job opportunities. The standard deviation, which is in the range of 0.649 to 0.747, shows a moderate variation in the respondents' answers, which means that most individuals have a fairly uniform view on the benefits of this technology on the job market.

The use of drones in the broadcasting industry (M = 3.88, SD = 0.649) and aerial mapping (M = 3.89, SD = 0.716) indicates a high demand for skilled workers who can operate drones for aerial recording and digital mapping. This indicates a growing need for experts who can apply this technology in various fields such as urban planning, geographical area monitoring, as well as the agricultural sector. Meanwhile, the entrepreneurial sector in creative services recorded the highest average score (M = 3.95, SD = 0.651), indicating that the use of drones in creative industries such as photography, aerial videography, and digital marketing is seen as an area with great potential for growth.

In the agricultural sector, the use of drones recorded an average score of 3.75 with a standard deviation of 0.710, indicating that this technology is increasingly accepted as a tool that can increase productivity and create more job opportunities. Drones are now widely used in monitoring crop health, automatically spraying fertilizers and pesticides, and mapping agricultural areas, leading to an increase in demand for drone operators and their maintenance technicians.

The study also showed an increasing need for specialized skills related to drone technology. For example, drone maintenance technicians (M = 3.69, SD = 0.689) are now increasingly needed, indicating that job opportunities are not only limited to drone operation, but also to technical aspects such as equipment repair and maintenance. In addition, drone pilots in the construction industry (M = 3.84, SD = 0.741) are also seen as playing an increasingly important role in ensuring the effectiveness of construction site monitoring, project mapping, and building structural analysis.

In the security sector, drone use is also associated with increased job opportunities, with a mean score of 3.75 and a standard deviation of 0.681. The technology is used in monitoring industrial areas, national borders, and public safety operations, which creates a need for drone operators and related technical service providers. The same is true for the delivery sector, where drone use recorded a mean score of 3.68 with a standard deviation of 0.747. This makes it one of the sectors with the lowest levels of agreement compared to other sectors, possibly due to regulatory challenges, high implementation costs, and concerns about the safety of deliveries using drones.

While overall the data shows that most respondents agree with the benefits of drones on job opportunities, there is variation in their level of confidence in certain sectors. For example, drone use in creative services has a lower standard deviation (0.651), reflecting a more consistent view among respondents. In contrast, drone use in the delivery sector had the highest standard deviation (0.747), indicating there was more variability in respondents' perceptions of the challenges and potential of this sector.

- *National Economy*

Construct D is to find out the impact of the use of drone technology on the national economy. The figure below shows the average score and standard deviation on the items in construct D:

Table 5 Construct D Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
The use of drones has had a positive impact on the country's economy.	102	2	5	3.75	.713
The logistics sector in the country benefits greatly from drone technology.	102	2	5	3.76	.720
Drones open up opportunities for the development of the technology sector	102	2	5	3.78	.684
The drone industry makes a significant contribution to the country's economic development.	102	1	5	3.69	.820
Drones have the potential to attract more foreign investment into the country.	102	2	5	3.83	.691

The use of drones in the national economy was analyzed based on several key aspects, including the overall economic impact, benefits to the logistics sector, contribution to technological development, impact on economic growth, and potential to attract foreign investment.

In terms of overall economic impact, the average score recorded was 3.75 with a standard deviation of 0.713. The score range between 2 and 5 indicates that there are a small number of respondents who disagree, although the majority gave a score in the medium to high range.

The logistics sector recorded an average score of 3.76 with a standard deviation of 0.720. The minimum and maximum scores were in the range of 2 to 5, reflecting a slight difference in views, but the overall level of agreement was still high.

From the perspective of technology sector development, the use of drones is associated with the creation of new opportunities in the field of technology with an average score of 3.78 and a standard deviation of 0.684. The minimum score was also at 2, indicating that there is no strong

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opposition to the view that drones contribute to the development of the technology sector.

For the contribution of the drone industry to the national economic development, the average score recorded was 3.69. The standard deviation of 0.820 indicates that there is a greater difference of opinion among respondents than on other aspects. The wider range of scores, from 1 to 5, indicates that some respondents are less confident about the impact of the drone industry on direct economic growth. The final aspect in this analysis is the potential of drones in attracting foreign investment, which recorded the highest average score of 3.83 with a standard deviation of 0.691. The range of scores between 2 and 5 indicates that no respondent completely rejects this idea, with the majority showing a higher level of confidence than the other aspects analyzed.

VI. CONCLUSION

This study found that drone technology has great potential in local industries in Brunei Darussalam, but its use is still not widespread. Data shows an increase in registrations and applications for drone use permits in recent years, especially in the private sector. The use of drones has proven to be beneficial in various fields such as security, environmental monitoring, agriculture, industry, logistics, and entertainment. In terms of economic impact, drone technology has helped improve operational efficiency, generate employment opportunities, and open up investment opportunities in the technology sector. However, several challenges still exist such as strict regulation, a shortage of skilled drone workers, and the high cost of owning and operating drones on a large scale. Therefore, a more effective strategy needs to be formulated to promote the development of the drone industry more comprehensively in Brunei Darussalam.

SUGGESTIONS FOR FUTURE RESEARCH

This study found that drone technology has great potential for local industries in Brunei Darussalam, but its use is still limited. Drones provide benefits in various sectors such as security, agriculture, logistics, and entertainment, as well as creating job opportunities and contributing to economic growth. However, challenges such as strict regulation, high costs, and a shortage of skilled labor still exist. For future studies, focus should be placed on improving drone policies and regulations, developing workforce training and skills, and integrating AI and IoT technologies to enhance drone capabilities. In addition, studies on the economic and social impacts and the use of drones in disaster management are also important to expand the benefits of this technology. With further studies, Brunei can leverage drone technology more widely and support the Brunei Vision 2035 towards a more advanced technology-based economy.

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