Development of UAV technology in seed dropping for aerial revegetation practices in Indonesia

A Andrio
Drone Research Initiative for Environmental Project
Email: msiresadi@outlook.com

Abstract. The Unmanned Aerial Vehicles (UAVs) applications or known as quadcopter drones have been considerably growing since the 20th century through now. In this project, we introduce the use of drone to support the revegetation practices. The project aims to develop a quadcopter drone that is capable of dispersing Tamarindus indica seeds in revegetation fields with potential for revegetation. T. indica is tree species that commonly used for revegetation in Indonesia. This work includes following steps. First, a drone takes an aerial photo of the demonstration plots to highlight existing vegetation and obstruction. The result is the information that is used to develop the best seed dropping and planting pattern. The map then is uploaded into the drone. Second step is developing mechanized canisters containing a germinated seed. The seeds then released from canisters installed in drone and break open upon impact with the soil to allow the germinated seeds to take root in the predetermined positions. The proposed drone assisted seed dropping system will provide an essential tool for an efficient revegetation. Due to the effectiveness, this system is also suitable for revegetation in ecosystem where germination has not occurred or for planting in areas with difficult access.

1. Introduction
Unmanned aerial vehicles (UAVs) or unmanned aircraft systems (UAS) and remotely piloted aircrafts (RPAs) are popularly known as drones. These tools have evolved and developed rapidly over the past decade and widely used in many sectors from environment to archaeology. UAV will soon be an important applicable tool for conservation and revegetation practices [1]. A drone can provide not only efficient and effective methods but also low-cost and low-impact solution to environmental managers working in a variety of ecosystems. Their agility, image quality and logistic abilities make them become advantageous tools. For example in West Java, a drone has been used in assessing the biodiversity of tea plantation by using drone capability in capturing and analysing aerial image [3].

Revegetation programmes defined the forest rehabilitation approaches and technical intervention methods such as seed planting. In Asia, there are various tree species being used for revegetation. Those species including teak (Tectona grandis), mahogany (Swietenia mahagoni), tamarind (Tamarindus indica), damar (Shorea javanica) and durian (Durio zibethinus) [4,5]. In Indonesia, T. indica has been used widely in revegetation practices. This species can grow up to 30 m in height in 1,000 m elevation and produce seed. The revegetation of T. indica can be commissioned by planting the seed [2,7].

However, current ongoing revegetation practices are having challenges. Those challenges related to the preparation and operation phase. In preparation stage, revegetation practices require comprehensive assessment of lands that will be revegetated. That assessment should cover vast area and available immediately. The current revegetation practices by commissioning direct seeding through hand sowing are also facing difficulty. This method obviously requires labours. Furthermore,
the coverage of labours are limited by access. As a result sowing can not reach areas that obstructed by hills and rivers for safety concerns for the workers. Regarding efficiency, it is estimated that a drone can distributed 10 seeds per minute. Due its nature, UAV has capability in the term of visual and transportation matters. Correspondingly, through this project we introduce the use of drone to support the revegetation practices. The project aims to develop a quadcopter drone that is capable of dispersing *T. indica* seeds in revegetation fields with potential for revegetation.

2. Materials and Methods

2.1. Dropping area

The UAV was test-flown in areomote1 hectare demonstration dropping area located in hilly area with elevation at 800 m in West Java (Figure 1). This area was barren lands that previously used as plantation. The land covers in this area consisted of mix of grasses, bushes and few trees. The area was selected first by using satellite image.

![Figure 1. The situation of 1 hectare experimental dropping area.](image1)

![Figure 2. The location of launch station where drone was launched and the dropping area that separated by hill and has distance of 400 m.](image2)

2.2 UAV specification

The specification of drone used in this project can be seen in the Table 1 below.

| Parameter        | Value                  |
|------------------|------------------------|
| Diagonal size    | 400 mm                 |
| Weight           | 1,380 g                |
| Motor type       | 2312                   |
| Motor thrust     | 800 g/axis             |
| No. of axis      | 4                      |
| Speed            | 5 m/s or 18 km/h       |
| Flight time      | 30 minutes             |

2.3. Seed preparation and canister development

The *T. indica* seeds were obtained from the *T. indica* fruits. The seeds than weighed and measured. The measurement of seed is very important to provide the payload data for designing the drone canister. Since we used the built up drone, than the payload of seed is limited and must be calculated.
The seed canister functioning to release the seeds on the selected site in dropping area. The seed canister contains seed plastic container, door, motor, battery and receiver (Figure 3). It is designed that the signal will be sent through receiver to open the door. When the door opened, a *T. indica* seed will be released. The canister door opening mechanism and the receiver are powered by the battery. In designing the canister, all seed canister components are weighed and measured to determine how many seeds can be carried. After the seed canister is developed, the canister is installed on the bottom of the drone body (Figure 4).

![Figure 3](image1.png)  ![Figure 4](image2.png)

**Figure 3.** The seed canister components: (a) canister door, (b) motor, (c) plastic canister containing seeds, (d) battery and (e) receiver.

**Figure 4.** Illustration of seed canister attached on the bottom of the drone (see the arrow).

2.4. **UAV Mission**
We have conducted 2 flights. First flight was to map and assess the feasibility of the dropping area. Continuing the first flight, the sequential flight was to test the canister by dropping the seed. The drone was flown from the station located 400 m in the direction of 240° compass bearing from the dropping area. The launch station and dropping area are bordered by vegetated hill. The determination of the station location in hilly area is to test the capability of drone to transport seed crossing the hill. This also simulate the inaccessible condition that the hill may obstruct the revegetation practices if conducted by human (Figure 2).

2.4.1. **Mapping dropping area**
The drone was flown and capturing the aerial photo of dropping area. The aerial photo then analysed digitally to differentiate the existing vegetation and obstruction. This imagery data then will be used to determine the exact dropping location.

2.4.2. **Dropping activity**
The canister was installed and drone is ready to fly. The drone was flown to the selected dropping area determined by using map developed before. During the flight we measured the performance of the drone. Those drone performance indicators consisting how far drone is travelled, time required and the number of *T. indica* seeds that can be delivered.

3. **Results and Discussion**

3.1. **T. indica seed payload**
The *T. indica* seed payload in the canister is the most important in this project since we use the drone to deliver the seeds. To calculate how many seeds can be carried, first we weighed the data of canister component as described in Table 2.
| Parameter       | Value (gram) |
|-----------------|--------------|
| T. indica seed  | 4            |
| Plastic canister| 20           |
| Canister door   | 2            |
| Motor           | 17           |
| Battery         | 10           |
| Receiver        | 5            |

The following equation is used to calculate how many seeds can be carried by 400 mm drone.

- Canister component load: plastic canister + canister door + motor + battery + receiver... (1)
- Drone gross payload (used the data in Table 1): (motor thrust x 4) – weight of drone... (2), since the drone requires 50% of the motor thrust to manoeuvre, than the motor thrust should be reduced to 50%
- The number of T. indica seeds that can be carried is (equation 2 – equation 1)/ T. indica seed weight

Based on the calculation, the number of T. indica seed that can be carried by drone is around 40 seeds. This number is illustrated in the Figure 5 below. The number of T. indica seeds delivered by drone is a flexible number. The number of seeds can be increased by adjusting the features of UAV. This can be done by:

- Increasing the number of UAV axis from quadcopter to hexacopter [6].
- Increasing the thrust of UAV.
- Reducing the weight of canister components.
- Adding the number of blade and increasing the length of blade [6]. In this project, the UAV only uses 2 blades. Nonetheless, it is reported that increasing the UAV blades from 2 to 4 can increase the UAV thrust up to 50%.

3.2. Mapping dropping area

The aerial photo of 1 hectare dropping area captured by UAV in the previously first flight then analysed by using software. The analysis aims to differentiate obstructions in the form of vegetation and open field that suitable for planting the seed. In the Figure 6, the existence of obstruction was
represented by red band while the most suitable open field represented by green to blue band. By flying and avoiding the obstructions identified by the map, hence the seed planting can be optimized by targeting most potential planting locations.

Obstructions in the form of trees may cause the seed cannot successfully land on the soil [8,9,10]. Furthermore, if the seed landed in the soil that near dense vegetation, as a consequence the seed will suffer competition for nutrition and other resources.

However, the map only able to identify the suitability of planting area based on the physical entities or obstructions. Other important parameters for instance chemical factors such as pH cannot be identified.

3.3. Dropping activity

The UAV flown covering 100 m x 100 area or 1 hectare was following regulated zigzag pattern pathway. In total the drone will travel up to 700 m to cover 1 hectare dropping area. Assuming drone speed is 5 m/s (18 km/h) than the 1 hectare area will be covered for around only for 140 seconds. Assuming that the seed planting spacing is 20 m, then for 1 minutes drone can drop 36 seeds (Figure 7). The estimated time, seed and path distance required to cover 1 hectare planting area in 5 m, 10 and 20 m seed spacing assuming the drone speed is constant at 5 m/s (18 km/h) is available in Table 3.

![Figure 7. The pathway of UAV for seed planting covering 1 hectare dropping area.](image)

| Dropping area (hectare) | Spacing (m) | Path (m) | Seed | Time (seconds) |
|-------------------------|-------------|----------|------|----------------|
| 1                       | 20          | 700      | 36   | 140            |
| 1                       | 10          | 1100     | 121  | 220            |
| 1                       | 5           | 2200     | 440  | 440            |

4. Conclusion

This project has signified the applications of 2 primary functions of UAV. First, the UAV has proven its visual capability from capturing aerial photo to imagery analysis assisted by software, resulting in map. Naturally, UAV is a transportation platform that able to carry materials from 1 location to other locations. By calculating the UAV payload and articulated that into the development of canister, a system that can carry, transport and drop seeds has been developed. As a platform that moving in the air space, UAV championed the speed achievement reaching up to 5 m/s (18 km/h).
5. References

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