Efficient mapping for fodder cultivation with commercial small drone

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Abstract. To optimise land use, an overview regarding its topography of the proposed land is essential to be portrayed, especially to depict the slope, elevation, calculation of cut and fill, as well as planning for water supply. However, in practice, high-resolution topographic data are hard to obtain and are highly priced. As an alternative solution, commercial small drones could be utilized to improve the input for such data. Commercial small drones could be utilized as a photogrammetric approach to obtain detailed digital surface model (DSM). This study aimed to get high-resolution of topography condition using commercial small drones and evaluate the result comparing to terrestrial surveying. The approach was done using Drone DJI Phantom 3 Professional, where the ground control points (GCPs) were undertaken with GPSMAP 64s SEA. The study area was ±23 ha proposed for fodder cultivation, located at Ngantru Village, Bojonegoro, East Java Province in Indonesia. Outcomes obtained from the analysis were orthophoto, digital models, and contours. The results yielded an efficient approach for mapping compared to field/terrestrial surveying. The drone approach only cost IDR ±4,000,000, whereas terrestrial mapping (using electronic total station) was worth up to IDR ±25,000,000. As the expense altered significantly, the process of collecting data varied as well. The overall data acquisition using drone only took 2 hours to complete, while field survey may require up to 2 days of acquisition. Although results accuracies were also an issue, the output reliability for drone with errors from 0.5 to 6 m was somewhat acceptable. In conclusion, small commercial drones were one way to undertake efficient mapping (in terms of cost and time) compared to field/terrestrial survey.

Keywords: Digital surface model, Topographic mapping

1. Introduction
To optimise land use, an overview regarding its topography of the proposed land is essential to be portrayed. In many perspectives, including fodder cultivation as well, topographic mapping is one of such main parameters to be put into an account when undertaking planning for agricultural production. In agriculture, especially in fodder cultivation, topographic mapping is essential to depict the slope, elevation, calculation of cut and fill, as well as planning for water supply. As a result, this will indeed affect the number of productivity at the end.

However, in practice, high-resolution topographic data are hard to obtain and are highly priced. As an alternative solution, commercial small drones could be utilized to improve the input for such data. Since its significant development for civil/commercial type of platforms, especially in 2012 and 2013 [1], drone has recently been very easy to utilize. Commercial small drones could be performed as a
photogrammetric approach to obtain detailed digital surface model (DSM). Reconstructing original 3D models of space objects based on the two-dimensional images obtained from different points of sight has been a hot research area in the field of photogrammetry and computer vision [2].

This study aimed to get high-resolution of topography condition using commercial small drones and evaluate the result comparing to terrestrial surveying.

2. Materials and Methods
2.1. Study Location
The fodder cultivation study was located at Sentra/Sekolah Peternakan Rakyat (SPR) Mega Jaya, Ngantru Village, Bojonegoro Regency, East Java Province, Indonesia. SPR Mega Jaya was positioned approximately at 573003 mE and 9218285 mS (WGS 1984, UTM 49S). The situation surrounding SPR Mega Jaya is given in the Figure 1.

![Figure 1. Study location at SPR Mega Jaya.](image)

2.2. Tools and Software
Tools used for this study included commercial drone, i.e. DJI Phantom 3 Professional, and a consumer-grade receiver GPS, i.e. GPS Garmin GPSMAP 64s SEA (Figure 2). Software utilized for the study were ArcGIS 10.4.1, Agisoft Photoscan Professional, and Pix4D Capture (iOS).
3. Results and Discussion

3.1. Data Acquisition

The data acquisition was initially undertaken by building up both flight plan and ground control points (GCPs). As the flight mission was built using Pix4D Capture [3], information of the flight height, captured area, as well as time estimation of the data acquisition could be attained. The proposed area of interest of ±23 ha was captured in 85 m height which took approximately 14 minutes of acquisition. The depiction of the flight mission for SPR Mega Jaya in Pix4D Capture was showed in Figure 3.

As soon as the flight mission was established, GCPs were required to be well-planned as well. As for this study, GCPs were placed in sparse locations, yet represent the extent of the purposed area of interest. The GCPs were measured using a consumer-grade GPS which has been reported to have 5-10 m accuracies [4-6]. Number of GCPs used within the study was 3 points. Depiction of GCPs established surrounding SPR Mega Jaya was showed in Figure 4.
Figure 4. Ground control points established surrounding SPR Mega Jaya.

The information for each GCP and errors obtained from the field measurement were explained in Table 1. It needed to be put into a concern that the varied numbers of errors (0.7 m to 5.8 m) for each GCP were based on the coverage situation of the surrounding (i.e. vegetation, buildings, etc), as the GPS was mainly influenced by such conditions. However, despite the errors, it has been stated that consumer-grade receivers can provide acceptable accuracy and precision for environment as they are easy to use and inexpensive [7]. For this concern, the errors were not a significant considerations, as the main objective was to evaluate the efficiencies of commercial small drones for fodder cultivation. However, a further project-dependant study is required to overview the error results using consumer-grade GPS receiver.

Table 1. Ground control points established surrounding SPR Mega Jaya.

| GCP Number | Latitude (°) | Longitude (°) | Altitude (m) | Error (m) |
|------------|--------------|---------------|--------------|-----------|
| GCP 1      | -7.0718      | 111.6661      | 95           | 2.2872    |
| GCP 2      | -7.0698      | 111.6618      | 103          | 0.7867    |
| GCP 3      | -7.0731      | 111.6608      | 87           | 5.8499    |

3.2. Data Processing

The processing of photogrammetric work was done with Agisoft Photoscan Professional 1.2.7 [8], as Agisoft is a common program to use still images of stationary objects to generate point clouds, 3D models and orthophotomaps [9]. Steps undertaken to finally yield orthophoto and digital elevation model was the establishment of dense cloud, mesh, texture, and tiled model, which was done in sequence. The resulting outputs for the point cloud, dense cloud classes, and tiled model are given below.

Figure 5. Photogrammetric process.
3.3. Orthophoto Results
From the above process, the orthophoto map acquired from drone survey could be attained. The orthophoto map was essential as the depiction resulted better understandings regarding the area. The representation of SPR Mega Jaya and its surrounding is given in the picture below.

![Orthophoto map of SPR Mega Jaya area.](image)

**Figure 6.** Orthophoto map of SPR Mega Jaya area.

3.4. Topographic Results
Finally, after all data acquisition and processing were done, the topographic results were yielded, i.e. contour and digital surface model. Both contour and digital surface model map of SPR Mega Jaya area are showed in Figure 6.

From maps in Figure 7, it could be informed that the overall survey of ±23 ha yielded elevations ranging from 59.965 m to 124.254 m (DSM-based topography). For the surrounding area of SPR alone (where existing buildings for cattles were positioned), the elevation approximately ranged from 96 m to 99 m.
3.5. Efficient Mapping

Compared to terrestrial mapping (using electronic total station or theodolite), drone mapping is one of such efficient approaches beneficial to be applied, especially for farmers which has low investment. This is mainly based on 3 aspects, i.e. cost, time, and man-power (related to the teamwork intricacy). Finally, the gross efficiency (percentage ratio of external work achieved compared to the total expenditure (project limit)) for both methods were calculated, based on the project limit for each aspect. The comparison between both methods, including the calculation results of the efficiency is given below.

Table 2. Efficiency results for terrestrial surveying and commercial small drone method.

| No. | Description                  | Project Limit      | Terrestrial Surveying | Gross Efficiency (%) | Commercial Small Drone | Gross Efficiency (%) |
|-----|------------------------------|--------------------|-----------------------|----------------------|------------------------|----------------------|
| 1   | Cost for 23 Ha Survey        | IDR 30,000,000     | ± IDR 25,000,000      | 16.67                | ± IDR 4,000,000        | 86.67                |
| 2   | Time Consumption             | 3 days (24 working-hours)* | 2 days (16 working-hours)* | 33.33               | 14 minutes            | 98.54                |
| 3   | Man-power Requirements       | 4 persons          | 3 persons             | 25.00                | 2 persons             | 50.00                |

* Assumption of 1 day equals to 8 working-hours
From Table 2, there were some limitations regarding the aspects considered within this study. The cost for ±23 ha survey was limited to IDR 30,000,000 with 3 days (24 working-hours) and 4 persons of man-power. The efficiency calculated was mainly based on this limitations.

In cost perspective, terrestrial surveying commonly required IDR 1,000,000 – IDR 1,500,000 per hectare, depending on the location of the project. This cost was a common commercial value applied in surveying business environment in Indonesia. Within this study, the cost of terrestrial survey was estimated to be IDR 1,200,000. Therefore for a ±23 ha survey the total project was worth IDR ±25,000,000. However, in contrast drone mapping only cost IDR ±4,000,000, which included IDR 500,000 – IDR 1,000,000 for drone rent, IDR 200,000 for GPS rent, and for an estimated value for the qualification. From the project limit of IDR 30,000,000, the gross efficiency for both terrestrial surveying and drone survey amounted to 16.67% and 86.67%, respectively.

In terms of time consumption terrestrial mapping may require 5-10 ha per day, depending on the site condition. For this study, 10 ha per day was estimated for the terrestrial surveying, resulting the project to be accomplished in 2 consecutive days or around 16 working-hours. In contrast drone mapping only required 14 minutes of data acquisition for the same surface area. Therefore, the gross efficiency for field surveying and drone survey accounted to 33.33% and 98.54%, respectively.

With respect to man-power (which represented the teamwork intricacy or complexity), terrestrial surveying required 3 persons (1 surveyor and 2 helpers), where drone survey only needed 2 persons in charge for the data acquisition which consisted of 1 surveyor and 1 helper. Hence, the gross efficiency for terrestrial surveying and drone survey was 25% and 50%, respectively. Overall, the average gross efficiency for terrestrial surveying was 25%, whilst utilizing commercial small drone achieved 78.40%.

From the three aspects, it is apparent that drone mapping is one efficient approach to be utilized. For mapping agricultural areas/purposes, especially for activities with low investment, though had a fairly significant error for mapping (up to 5.8 m), considering the efficiencies, drone mapping could be a good choice compared to terrestrial mapping.

4. Recommendation
The derivation from digital surface model (DSM) to digital terrain model (DTM) is essential for future works. On the other hand, it is recommended that more information should be given to farmers regarding drone and its potential usage for field mapping. Remembering its efficient approach for future farming activities, it is expected that the usage of commercial small drone is possible to be undertaken by farmers as well.

5. Conclusion
In conclusion, small commercial drones were one way to acquire a high-resolution map of topography condition and undertake efficient mapping (in terms of cost and time) compared to field/terrestrial survey.

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