Utilization of unmanned aerial vehicle photogrammetric technology for analysis of landslide areas

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Abstract. The problem of landslides that occur in West Java continues to increase every year, one of the landslides that claimed many lives is a landslide that occurred in Kampung Cimapag, Sukabumi Regency. Changes in land use change and steep topographic conditions are factors that have caused this disaster to occur. This problem will continue if there is no in-depth study related to factors causing landslides. The purpose of this study is to map in detail the topographic conditions of Cimapag Village, so that an analysis of topographic conditions can be carried out and then an analysis of the potential hazards of aftershocks. The problem solving method used in this research is mapping with photogrammetric techniques using a drone vehicle, or Unmanned Aerial Vehicle (UAV) Photogrammetry. The results of this study are orthophoto maps with a spatial resolution of 8.11 cm, and produce several products such as orthophoto maps, three-dimensional models, and Digital Elevation Models. Based on the measurement of the slope of the landslide, the value of the slope is 51.78% with the condition of the slope which is not covered by vegetation. These conditions can potentially occur aftershocks.

1. Introduction

The use of UAVs for natural disaster analysis, especially landslides, has been widely used in the last decade. Based on research conducted by [1], the combination of Unmanned Aerial Vehicle and Surface from Motion algorithm can be used for monitoring landslide areas. With the use of multi-temporal aerial photographs, the direction of landslide movement can be seen from overlapping between aerial photographs. The advantage of using aerial photographs for landslides is a high degree of accuracy so that it produces an accurate model of movement direction[2], as well as the final product that can be displayed in 3-dimensional form so that it is easy to understand related to landslide areas.

Research also conducted by [3] on the use of UAV in the form of multi-rotors for the analysis of landslides in the Village of Ricasoli, Italy. In this study, the use of UAV can provide an overview of the characteristics of landslides with accurate results. The advantage of UAV in this paper is the potential for repeat measurement in the short term with high accuracy [4], especially when compared to terrestrial surveys such as using Electronic Total Station or Terrestrial Laser Scanner [5]. Besides being fast, the results of aerial photographs produced also have a high resolution and high level of precision, so it is very helpful in the visualization and mapping of a disaster area that has a certain area coverage[6].
Besides being effective in conducting studies related to landslides, the use of UAVs can also be done as a reference in the process of rapid response evacuation in landslides[7]. One of the advantages of UAV is that it can be used in various fields [8], so it is possible to do rapid mapping (rapid mapping) in areas affected by landslides [9] [10]. According to this study, from the results of rapid mapping it was found that human factors have a role in the occurrence of landslides. So that efforts are needed in providing understanding to the community to control the risk of landslide disasters.

In this paper, we will discuss the use of Photogrammetric UAVs to analyze landslide conditions in the Cimapag Kampung area, based on BNPB data [11], landslides that occurred on December 31, 2019 resulted in loss of lives and areas of buried houses. To anticipate the occurrence of aftershocks, the UAV technology is used to analyze the topographical conditions of the landslide area.

2. Methods

This research was conducted in Cimapag Village, Sirnaresmi Village, Sukabumi Regency. Cimapag village is one of the traditional villages that still preserves ancestral customs. One of the problems in Cimapag Village is that there are conditions that are prone to landslides. The position of the Cimapag Village is illustrated in the figure 1.

![Figure 1 Research Location](image-url)
The method used is the photogrammetric method using a drone vehicle, in this study the devices used include:

| No | Jenis                          | Spesification                          | Use                                      |
|----|--------------------------------|----------------------------------------|------------------------------------------|
| 1  | Drone                          | DJI Phantom 4 Pro (focal length 8.8 mm) | capturing photos                         |
| 2  | Global Positioning System Receiver | Trimble 5700                             | Measuring Ground Control Point and Independent Check Point |
| 3  | GPS Data Processing Software    | Leica Geo Office                        | Processing GPS observation point         |
| 4  | Photogrammetry Processing Software | Metashape Photoscan                  | Processing Image Data                    |
| 5  | Data Analysis Software          | Global Mapper                           | Analyse Topography for Landslide         |
| 6  | Cartography Software            | ArcMap 10.3                              | Create map layout                        |

Systematically, the flow of activities in this study is in the figure 2 as follows:

An explanation of the research flow diagram above is as follows:
1. Identification and formulation of the problem: this stage contains the activities of identifying and formulating problems that occur at the research location as well as conducting initial studies that produce an overview of the research.

2. Literature study: the activity of gathering information and theories used to map landslides.

3. Flyway planning: the flyway planning stage includes determining the boundary of the flying area, determining the sidelap and overlap, flight height, take-off position, and camera settings. At this stage the software used is Drone Deploy.

4. GCP Measurement: Measurement of Ground Control Points using GPS Geodetic with Static methods. The output from GCP measurements is land coordinates using the UTM Zone 48S coordinate system.

5. Aerial Photo Acquisition: Aerial photo acquisition using a DJI Phantom 4 Professional UAV rotor wing vehicle, the software used for the acquisition is Drone Deploy.

6. Aerial Photo Processing: at this stage, all photos taken are processed with Metashape Photoscan software, while the stages of this processing are Photo Alignment, Geometry Modeling, 3D Coordinate Formation, 3D Coordinate Transformation, Orhomosaik.

7. Georeferencing: the stage of georeferencing by rectifying photos of objects on the model using GCP coordinate data.

8. Orthofoto Maps: orthophoto map making using ArcGIS and Global Mapper software.

3. Results and Discussion

The results obtained from photogrammetric measurements are photographs which are then processed using Agisoft Photoscan software. In this study, the number of photos used was 403 photos taken at a height of 305 meters. The resulting spatial resolution is 8.11 cm / pixel, this value is greater than the resolution of high resolution satellite imagery which has a spatial resolution of 30 cm. In this study Ground Control Point measurements were also carried out as ground points for aerial photography.

The quality of the GCP values is shown in table 2. The accuracy of the GCP is 17 cm, twice the GSD value of the photographic image. This accuracy value can be said to be not very good considering the value of the accuracy of control points. As for this study control was not carried out using Independent Check Points due to the minimal number of points being measured.

| Jumlah | X Error (cm) | Y Error (cm) | Z Error (cm) | XY Error (cm) | Total (cm) |
|--------|--------------|--------------|--------------|---------------|------------|
| 5      | 8.095        | 14.026       | 7.615        | 16.194        | 17.896     |

After processing Ground Control Points, a Dense Cloud model is generated which consists of 22,624,928 points. The next step is to make texture. The picture shows an example of texture from the landslide area.
In the resulting texture, researchers can visualize the condition of the landslide area interactively because it is in the form of three dimensions so as to increase understanding of the landslide area. The resulting model also has high accuracy so that it represents the actual form. The picture shows a comparison of landslide model models with real / actual photos.

Figure 3 Landslide 3D Model

From this model, orthophoto and Digital Elevation Model of the landslide area were made. Ortophoto will display an orthogonal picture of the landslide area. In addition to displaying images, users can also take measurements on the map, such as distance and area measurements. An overview of the Orthopedic landslide area is shown in the figure. Besides orthophoto, the product also produced is Digital Elevation Model. In DEM, researchers can analyze topographical conditions of landslides, such as obtaining slope values, transverse and elongated profile landslides and topographic conditions from landslide areas to landslide-affected areas. The picture shows the landslide area of Ortophoto.

Figure 4 Comparison Between Image and 3D Model
Based on data from the DEM, the elevation value at the peak of the landslide is 905,756 meters while the basic elevation in the landslide area is 808,176 meters. The flat distance between the summit and the base is 185 meters. The picture shows an long section profile of the landslide area.
Figure 7. Landslide Long Section

From the picture the slope value of -27.38° or 51.78% is obtained. Based on, the value of the slope is included in the category of Tipa A Zone or an area prone to aftershocks. This needs to be anticipated by the government and local residents.

4. Conclusion

Based on the results of this study it was concluded that the UAV Utilization can be used in landslide study, by utilizing the principle of photogrammetry with the Surface from Motion algorithm, it can produce various products such as photo maps, Digital Elevation Models, and 3 Dimensional Models. The product can be used for various things such as slope analysis, measurement of area and distance, as well as interactive visualization so as to increase user understanding in analyzing landslide areas. Based on the calculation of the slope obtained from the DEM, the slope level of the landslide area is quite high at 51.78%. The value of the slope has the potential for aftershocks.

References

[1] A. Lucieer, S. M. de Jong, and D. Turner, ‘Mapping landslide displacements using Structure from Motion (SfM) and image correlation of multi-temporal UAV photography’, Prog. Phys. Geogr., vol. 38, no. 1, pp. 97–116, Feb. 2014, doi: 10.1177/0309133313515293.
[2] M. Ihsan and D. Sugandi, ‘Pemanfaatan Produk Fotogrametri Digital Untuk Media Pembelajaran’, J. GEA Jur. Pendidik. Geogr., vol. 19, no. 2, pp. 113–122, Oct. 2019, doi: 10.17509/gea.v19i2.19358.
[3] G. Rossi, L. Tanteri, V. Tofani, P. Vannocci, S. Moretti, and N. Casagli, ‘Brief Communication: Use of multicopter drone optical images for landslide mapping and characterization’, Nat. Hazards Earth Syst. Sci. Discuss., pp. 1–14, Feb. 2017, doi: 10.5194/nhess-2017-46.
[4] M. Ihsan, L. Somantri, N. T. Sugito, S. Himayah, and A. R. Affriani, ‘The Comparison of Stage and Result Processing of Photogrammetric Data Based on Online Cloud Processing’, IOP Conf. Ser. Earth Environ. Sci., vol. 286, p. 012041, Jun. 2019, doi: 10.1088/1755-1315/286/1/012041.
[5] D. Skarlatos and S. Kiparissi, ‘COMPARISON OF LASER SCANNING, PHOTOGRAHAMMETRY AND SFM-MVS PIPELINE APPLIED IN STRUCTURES AND
ARTIFICIAL SURFACES’, ISPRS Ann. Photogramm. Remote Sens. Spat. Inf. Sci., vol. I–3, pp. 299–304, Jul. 2012, doi: 10.5194/isprsannals-I-3-299-2012.

[6] C. Arango and C. A. Morales, ‘Comparison Between Multicopter Uav and Total Station for Estimating Stockpile Volumes’, ISPRS – Int. Arch. Photogramm. Remote Sens. Spat. Inf. Sci., vol. XL-1/W4, pp. 131–135, Aug. 2015, doi: 10.5194/isprsarchives-XL-1-W4-131-2015.

[7] J. M. P. Czarnecki, J. J. Ramirez-Avila, and L. A. Hathcock, ‘Structure from Motion with Unmanned Aerial Vehicles. A Best Practices Guide for New Users’, p. 7.

[8] W. Anurogo et al., ‘A Simple Aerial Photogrammetric Mapping System Overview and Image Acquisition Using Unmanned Aerial Vehicles (UAVs)’, J. Appl. Geospatial Inf., vol. 1, no. 01, pp. 11–18, 2017.

[9] M. W. Smith, J. L. Carrivick, and D. J. Quincey, ‘Structure from motion photogrammetry in physical geography’, Prog. Phys. Geogr., vol. 40, no. 2, pp. 247–275, 2016, doi: 10.1177/0309133315615805.

[10] M. Kasprzak, K. Jancewicz, and A. Michniewicz, ‘UAV and SfM in Detailed Geomorphological Mapping of Granite Tors: An Example of Starościckie Skaly (Sudetes, SW Poland)’, Pure Appl. Geophys., vol. 175, no. 9, pp. 3193–3207, Sep. 2018, doi: 10.1007/s00024-017-1730-8.

[11] BNPB, ‘Bencana Alam Propinsi (Jawa Barat)’, Data Informasi Bencana Indonesia (DIBI), 2017. [Online]. Available: http://bnpb.cloud/dibi/tabel1a. [Accessed: 28-Feb-2018].