UAV (Unmanned Aerial Vehicle) for Landslide Analysis Case Study in Grenggeng Village, Kebumen District, Central Java

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Abstract. Remote sensing technology has developed rapidly; one of them is data acquisition techniques using UAV (Unmanned Aerial Vehicle). With high-resolution aerial photographs, an unmanned aerial vehicle (UAV) can be a flexible, cost-effective, and accurate monitoring of landslide technique. This research aimed to determine and test the utilization of unmanned aerial vehicles (UAVs) in congested areas. Data was collected at Grenggeng Village, Kebumen Regency, using unmanned aerial vehicles cruising altitude of 90 – 110 meters above ground level and a spatial resolution of 5 – 10 cm over a 0.200 km² area. In November 2020, the research site will be a landslide area with similar rock lithology to the Halang Formation’s sandstone and claystone layers. Direct field observations revealed the geological structures involved and the rock lithology that produced the slip field, seepage, and the sorts of vegetation that the community had planted. According to aerial photography data, the relief appears to be a straight-line pattern in the direction of the geological structure, the slope of the layers, and different vegetation. Aerial photography using UAV can also be used to carry out rehabilitation and reconstruction techniques.

Keywords: UAV, Landslide, Grenggeng

1. Introduction

The use of remote sensing in the earth sector multiplies with the Unmanned Aerial Vehicle (UAV) technology [1]. This is due to the increasingly advanced technology supporting remote sensing to provide benefits and convenience in analyzing various matters related to disaster analysis [2]. UAV is an unmanned aircraft technology equipped with sensors, cameras, and GPS to take pictures. The results of taking photographs using UAVs will be processed into aerial photos that can be used for mapping and disasters [3].

In general, UAVs can be divided into 2 (two) types, namely fixed-wing UAVs and rotor types. Both kinds of UAVs have their advantages and disadvantages. Such as UAVs with fixed wings type have benefits in the wide cruising area but require a relatively large and flat area for take-off and landing. Different conditions exist in UAVs with a rotor type that can hover (stop in the air) and can be flown in all terrains because it does not require a large location for take-off or landing. Still, the cruising area of this type of UAV is narrower than the fixed-wing type. For both the rotor and fixed-wing types, the data obtained can be used for mapping, or what we know as photogrammetry techniques. The photogrammetric processing generated from the UAV can produce a vertical photo image aerial
(orthophoto) and Digital Surface Model (DSM). This information can be used to identify objects in digital analysis. The availability of high-resolution data, which is still limited to certain areas, is the advantage of UAVs in their relatively fast, flexible operation and the ability to fly at low altitudes to produce very high-resolution images [4].

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UAV technology can be used easily and efficient in terms of time. The data obtained too has a high spatial resolution, so the error in object identification or measurement of an object in the field can be minimized. The use of technology UAV can make it easier for users to identify hard-to-reach objects. UAVs in disaster management can be carried out quickly and efficiently, so UAV technology is very appropriate for use in rapid mapping.

Landslides are one of the most common disasters in Indonesia. During 2017-2020, 1,951 landslides occurred (gis.bnpb.go.id). Grenggeng Village, Kebumen Regency, experienced a landslide in November 2020, with an area affected by landslides of almost 1 hectare. Morphological conditions and vegetation cover after the landslide made it difficult to access for quick analysis. This is the underlying utilization of UAV technology to identify difficult-to-reach objects with a quick analysis.

This study aims to conduct a rapid landslide analysis based on aerial photo sightings from UAVs. The research focuses on aerial photographs, which are then combined with direct observations in the field to obtain optimal data. UAV technology has a low cost and time effectiveness compared to conventional methods, so that it is suitable to be applied to areas with a small scope. The data obtained also has a high spatial resolution so that errors in object identification or measurement of an object in the field can be minimized.

2. Data and Methods

The research was conducted in Grenggeng Village, Karanganyar District, Kebumen Regency. The location is in the hills with coordinates UTM 340620mT; 9159829mU (Figure 1). The use of data in this study is primary data from taking pictures by unmanned aircraft with a multirotor type (quadcopter). The UAV technology used is shown in Figure 2, while the specifications are shown in Table 1.

![Figure 1. A) Research Location (Source Google Earth), B) Research Area Based on SRTM of Java](image)
In the spatial analysis, DEM analysis and detailed mapping were carried out using a UAV. DEM is derived from the results of the photoshoot, which is then made orthomosaic. The coordinate system in the mapping uses the UTM projection of the WGS 1984 datum. GCP (ground control points) uses features easily recognizable in the field, such as road junctions and people’s houses.

In the field data analysis, several activities were carried out, including measuring rock layers; measuring the thickness of soil and bedrock; contact of rocks and geological structures made using a compass and geological hammer; look for the former avalanche that occurred and its signs; look for seepage in groundwater, and making tie points with GPS as well as secondary data in the form of geological maps and topographic maps.

Figure 2. UAV technology multirotor type (Source: http://www.dji.com/phantom)

The multirotor type UAV vehicle was chosen to suit hilly and rocky terrain conditions. The multirotor type UAV technology can fly without requiring a large area for takeoff and landing. In simple terms, the stages of the data acquisition test carried out can be observed in Figure 3.

| UAV Specifications          | Camera Specification          |
|-----------------------------|-------------------------------|
| Type                        | Quadcopter                   |
| Weight                      | 1.380 gram (including         |
|                            | propeller and battery)       |
| Acceleration                | 20m/s                         |
| Flight Duration             | 28 minutes                    |
| Energy/Voltage              | intelligent flight battery    |
|                            | 81.3 Wh / 15.2 V              |
| Transmission Distance       | remote control 3.5 km         |
| ISO                         | 100 – 1600 (Photo); 100 – 3200 (Video) |

Table 1. UAV and Camera Specifications used in Research
3. Results and Discussion

The research area is one of the pandanus woven producing regions of Kebumen. Geologically, according to Asikin [5], it is included in the Halang Formation, which consists of alternating sandstone, limestone, marl, and tuff with breccia inserts (Figure 4) and one of the constituents of the Serayu Mountains zone aged Middle Miocene - Late Miocene (15 - 5 mya) [5]. In general, mosaic vegetation mixed with open land is a type of land use in which there are also village settlements and yards with various vegetation [6].

![Figure 3. Flowchart of Data Acquisition with UAV](image)

**Figure 3.** Flowchart of Data Acquisition with UAV

**Figure 4.** Geological Map of Research Area [5]
Topographically, the research location is at an altitude of 149 meters above sea level and experienced a landslide in November 2020, resulting in two houses being affected. Photographs were taken at 10.00 WIB with the aircraft cruising altitude between 90 – 110 meters above ground level with a resulting spatial resolution of 5 –10 cm with an area of 0.200 km² (Figure 5). Identification of landslide areas includes identifying active and inactive landslides based on the characteristics of the appearance of the resulting aerial photos in the form of perimeter landslides, landslide forms, seepage, land cover, and vegetation patterns.

![Orthophoto from UAV](image)

**Figure 5. Orthophoto from UAV**

Orthophoto can interpret initial identification based on the hue/color of the ground surface. Active landslides have a slightly lighter shade of the ground surface with a brown color and give the impression that the land is agitated so that vegetation is rarely seen. Active landslides Most of them have land cover in the form of pandanus, shrubs, and coconut vegetation, with two houses, heavily damaged. Inactive landslides form a pattern of vegetation soil parallel to the landslide perimeter. The vegetation planting pattern is bamboo, sengon, which has a height of approximately 10 meters and is located at the landslide estuary. Indirectly serves to reduce the movement of soil material.

Landslides in the study area have an elongated, curved shape with a straight line (Figure 6) in the direction of N 169 E and parallel to the perimeter and ridge of the landslide. Seepage water is at a sloping road that follows the slope notches lengthwise and is associated with the loss and scarp landslides. In addition, the meeting of the soil layer (regolit) and bedrock also resulted in the appearance of water seepage on the surface (Figure 6).
Soil moisture is one of the dynamic systems that affect the occurrence of landslides [7]. Seepage that impacts erosion can trigger landslides due to soil fractures, increasing water to seep into the soil, and increasing the load on the soil mass. This type of avalanche is caused by the movement of soil and rock masses on a flat or wavy sloping plane with a relatively shallow depth of the landslide field and forms a slightly curved or almost planar shape [8]. A downslope movement of material along a unique planar surface of weakness such as a fault, joint, or bedding plane is known as a translational or planar landslide. Translational landslides are responsible for some of the world's largest and most destructive landslides. These landslides are not self-stabilizing and occur at all scales. Where there are steep discontinuities, they can be quite fast (Figure 7).

This type of avalanche is caused by the movement of soil and rock masses on a flat or wavy sloping plane. Fine to medium sand textured soil is loose and unconsolidated with a thickness of between 1 – 3 m, supporting the bedrock in the form of alternating sandstone with claystone. Sandstone has a thickness between 5 - 20 cm and a thickness of claystone between 2 - 5 cm.

Direct observations in the field showed a line streak in the direction of the landslide body on the bedrock (sandstone) and became a weak plane (the western fault escarpment). This is reinforced by houses being carried away by partial landslides and the appearance of seepage at the landslide escarpment. Besides being caused by high rainfall during November 2020, topographically, it is on a rather steep slope class (15 -25%). The land cover exacerbates this at the landslide site in pandanus trees with taproots (Figure 9).
Figure 7. The type of landslide in the study area with relatively shallow scrap [9] with modified...

The lineament appearance of the orthophoto results derived into DSM (Digital Survey Model) can indicate the geological structure involved (Figure 8). Lineaments can be defined as linear geomorphological elements that represent geological structures or lithological contacts.

Figure 8. DEM from UAV; Sections A - B show subsidence parallel to the bedrock; Cross-section C - D shows sudden subsidence as evidence of the geological structure involved.
Figure 9. Vegetation is a type of pandanus plant with taproots

The condition of roots that are large enough to not be able to act as a binder of soil aggregates, on the contrary, makes the soil structure weak and increases soil movement, and is less than optimal in preventing erosion. As a result, the volume of soil undergoing transportation will improve and increase the load above the slip plane. Based on the results of the interpretation of aerial photos (pictures), the occurrence of landslides is also influenced by the winding and steep road structure without any drainage ditches. The winding road causes the possibility of surface runoff from rainwater to be concentrated at a certain point. In conditions of high rainfall, the volume of water collected is quite large in a short time. Furthermore, the runoff will seep into the ground and affect the slip plane.

4. Conclusion

UAV vehicles can be used to conduct rapid mapping of natural disasters because they have many advantages. One of the advantages of UAV technology is that it can be used in various fields, efficient in time and cost. Photogrammetric analysis can be used as a reference for the geological structures involved.

The study area is spatially located in a place whose surface resembles a water catchment area (basin). Other factors such as road construction and inappropriate land use are triggered by anthropogenic factors (human activities). Various disasters that have occurred apart from being caused by topographic and climatic factors, one of the things that trigger disasters is anthropogenic factors (human activities). Based on the analysis results, anthropogenic factors are the most controllable factors to reduce disaster risk. This encourages the need to increase public awareness of natural disasters. In addition, all stakeholders related to disaster and the environment need to work together so that disaster risk can be minimized.

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6. References

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