

Analysis of Landslide Disaster Impact Identification Using Unmanned Aerial Vehicle (UAV) and Geographic Information System (GIS) (Case Study: Ngesrep Sub District, Semarang City)

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Abstract. Landslide is a natural disaster that commonly happens in Indonesia, especially in Region of Semarang that geologically has hilly topography. In Semarang city, there are 22 Sub Districts classified as landslide potential areas, which one of them is Sub District Ngesrep, based on to BPBD Semarang. The disaster of landslides can cause human injuries and loss in infrastructure, life, and assets. Disaster management requires identifying for the impact of landslide disaster at a location. One of the methods to identifying the impact of landslide disaster uses UAV technology. UAV technology can be used to collect, map, extract information of landslide and build Digital Model in surface or elevation based on overlapping imageries. Elevation data from UAV are combined with data of rainfall, land cover and geological which will produce the map of the potential landslide disaster. The map of the potential landslide disaster is combined with the result of land cover digitation to determine the impact of landslide disaster.

Keyword: Digital Model, Land Cover, Landslide, UAV

1. Introduction

Indonesia region is located in the tropical climate area with two seasons that is summer and winter with characteristics of weather changes, temperature and wind direction is quite extreme. Climatic conditions in Indonesia and topographic conditions of the surface and rocks that are relatively diverse both physically and chemically will result in fertile soil conditions. The condition can cause some bad consequences for humans such as the occurrence of hydro meteorological disasters such as floods, landslides, forest fires, and drought.

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Landslide is a natural disaster that commonly happens in Indonesia, especially in Region of Semarang that geologically has hilly topography. In Semarang city, there are 22 sub-districts classified as landslide potential areas that one of them is Sub District Ngesrep based on to BPBD Semarang. In 2016, in the Bukitsari region of Sub District Ngesrep, cases of the landslide had been happening on October 4, 2016. This disaster not only causes human injuries but loss in infrastructure, life, and assets. Topography with the moderately steep condition and relatively high-intensity of rainfall become main factors for a landslide in Sub District Ngesrep.

Disaster management needs to identify impacts for the landslide to make decision process and prevent this from happening again. One method to identify landslide impacts is using unmanned aerial vehicle technology (UAV). UAV is one solution to identify the impact of landslide disaster. UAV produce imagery with low altitude flight, the effectiveness of time in gaining images, low-cost budget than using satellite imagery, and less cloud disruption. This paper presents the use UAV to collect data of landslide area.

The data processed into Digital Surface Model (DSM) and Digital Elevation Model (DEM) that provides elevation information based on images overlapping. DSM and DEM data are processed to obtain surface slope data. The result is combined with data of rainfall, land cover and geological which will produce the map of landslide potential. The map of landslide potential is combined with the result of land cover digitation to determine the impact of landslide disaster.

2. Materials and Methods

2.1 Materials

In this paper using primary and secondary data as follows: an UAV Images, a Photograph of the location of the landslide impact, a Landsat Image, The Recording of GPS data and questionnaire, a Physical Building Map, a Land Cover Map, a Slope map, a Land Type Map, a Potential Water Ground Map, and The Rainfall data.

2.2. Methods

2.2.1 Unmanned Aerial Vehicle (UAV) Technology

The UAV (Unmanned Aerial Vehicle) has become a popular platform to facilitate this method by using sensors to capture aerial photograph data. The pilot and automatic remote control can take the photos manually. UAV have advantages such as low altitude flight, effectiveness of time in gaining images, low-cost budget and build a map disaster areas that have high risk. Disadvantages of UAVs are in terms of small format cameras, image coverage and low resolution [3].

Aerial photographs taken by UAV are processed such as orthorectification, mosaicing, 3D modeling of DSM and DEM so that the conversion of DEM data into slope data [1]. Orthorectification is a process of geometric correction of satellite imagery or aerial photographs to correct geometric errors of an image originating from topographic, sensor geometry and other errors. The result of orthorectification is an orthoimages. The orthoimages have been geometrically corrected from removing the effects of image distortion induced by the sensor, viewing perspective and relief for the purpose of creating a planimetrically correct image.

The aerial photograph mosaic is a combination of two or more overlapping aerial photographs that making a combination image with displaying images that have a large area coverage [5]. Combining overlap or sidelap photo parts does mosaicing an image. Mosaicing results are done making 3D DSM and DEM models until DEM data is converted to slope data.

2.2.2 AHP (Analytical Hierarchy Process)

The Analytical Hierarchy Process is a general theory of measurement to make a decision support model developed by [2] where this decision support model will describe problem multi factor or multi criteria problems into a hierarchy. The AHP has a special concern with multi criteria structure, its measurement and on dependence within and between the groups of elements of its structure. It has found its widest applications in multi criteria decision-making, planning, and resource allocation and in conflict resolution. AHP makes a complex problem can be solved into several groups to form a hierarchy so that the problem will seem more structured and systematic [4]. AHP must first determine the purpose of the case problem; specify criteria and alternatives, then according to the following steps:

1. Making a matrix of criteria comparison with the value that has been entered.
2. Making the priority vector weights.
3. Calculate lambda.
4. Calculate the Consistency Index (CI).
5. Finding Ratio Consistency (CR), Level of consistency if CR value < 0.1.

3. Results and Discussion

3.1. Orthophoto Mosaic

The orthophoto mosaic is generated from aerial images that are made up of 1387 images with a covered area of 3.75 km² so that it can be seen in fig 1. The orthophoto mosaic itself shows the wide of the area damaged by landslide disaster. The average flight height of this aerial photo acquisition is 211 m. Based on the comparison of the average flight height with DJI Phantom 3 camera resolution of 3.61 mm; the spatial resolution obtained is 7.87 cm/pixel.



Fig. 1. The Orthophoto

3.2. Analysis of Landslide Impacts

The UAV images can be utilized for classification of areas affected by landslide disaster. The result of the classification there is 2 areas affected by a landslide that can be seen in fig 2. Using UAV methods so that the acquisition data of objects can be easily obtained can use mapping of disaster potential areas. In fig 2 (a) can be seen an image from UAV shows a building affected by a landslide disaster. In the house, almost half of the buildings affected by landslide disaster and endanger near of building. In area 1 is a dense residential location so that it may endanger the safety of people living in the area. In the Sub District Ngesrep made possible the main priority in mitigation landslide because the location is one of the densely populated areas in the location potential to landslide disaster. In fig 2 (b) can be seen the locations affected by the landslide disaster are areas not including settlements. Area 2 is a location affected by landslides so that the area is not expected to be a residential area.

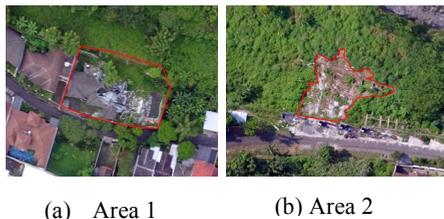


Fig. 2. Area Affected Landslide

In fig 2 can be seen there are 2 locations affected by the landslide that is the first area around to 1,026.339 m² and the second area that affected by landslide disaster around to 521 m². The authorities can utilize an UAV technology to mapping the risk areas affected by landslides. The UAV can be used to collect landslide disaster data from another location. All types of landslides are covered by the database, which stores not only main attributes, but also various complementary data, including data on landslide causes, impacts, and mitigation. The database can be utilized for decision making in determining the mitigation of landslide disaster. The authorities may create a regulation to regulate settlements in locations prone to landslide disaster in order to avoid human injuries and loss material.

3.3. ANALYSIS OF LANDSLIDE HAZARD Based on BNPB (Badan Nasional Penanggulangan Bencana)

The map of landslide hazard based on BNPB can be seen on fig 3. Landslide hazard based on BNPB is a simplification of levels contained in SNI. Level of landslide hazard is divided into 3 levels so as to allow zone division differences that including within a certain category. In fig 3 illustrates estimated of landslides hazard according to the low level has a wider area. It happens because the estimated level of landslides hazard according to the low level and the lowest level joins into one zone so as to show the wider area.

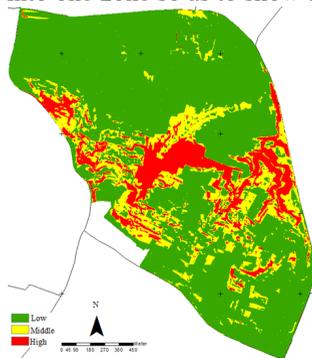


Fig. 3. The Map of Landslide Hazard Based on BNPB

The map of landslide hazard base on BNPB is divided into three levels that are low, medium and high. Estimated of landslides hazard according to the low level around 182.64 ha (71.85%), according to the moderate level around 41.471 ha (16.31%) and according to the high level around 30.094 ha (11.84%) of the total area of 254.205 ha.

3.4. Landslide Risk Landscape Analysis

The map of risk evaluation landslide can be seen in fig 4 with classification into 3 levels that are low, medium and high. In Sub District Ngesrep has several locations that have high risk. The risk of a landslide disaster is present in steep slopes. There is more than 10 percent of the area located at high-risk locations for landslides. Location in steep slopes

should be monitored to avoid the impact of landslide disaster. Authorities and decision makers can use a map of risk evaluation landslide so they are considered in development plans and/or that appropriate risk mitigation measures are implemented.

The landslide risk for an object or an area must be calculated with reference to a given time frame for which the expected frequency or probability of occurrence of an event of intensity higher than a minimum established value is evaluated [6].

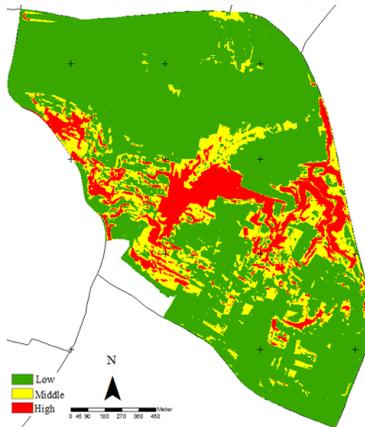


Fig. 4. The Map of Risk Evaluation Landslide

3.5. Analysis Of Landslide Hazard Impacts On Landslide Risk Landscape

The classification of areas affected by the landslide disaster is merged combination with the zoning risk of landslide disaster such as fig 5. Merging can be identified about the accuracy of the landslide risk zonation result on the impact of the affected area.

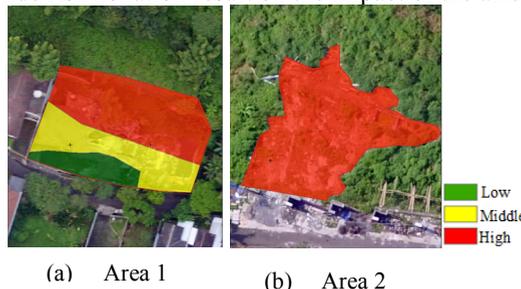


Fig. 5. Combined a Map of Landslide Hazards and Landslide Affected Areas

Fig 5 shows the area 1 where there is zoning risk of landslide disaster consisting of three classes with according to the low level around 141.3 m² (13.77%), according to the moderate level around 326.812 m² (31.18%) and according to the high level around 522.5 m² (50.91 %) of the total affected area of 1026.3 m². The area 2 where there is zoning risk of landslide disaster consisting of one class with according to the high level around 520.82 m² (100%) of the total affected area of 520.82 m².

4. Conclusion

UAV technology can be used to mapping the risk areas affected by landslides. The orthophoto mosaic generated from aerial images that are made up of 1387 images with a covered area of 3.75 km² so that it can be seen in fig 1. The orthophoto mosaic itself shows

the wide of the area damaged by landslide disaster. Based on the comparison of the average flight height with DJI Phantom 3 camera resolution of 3.61 mm, the spatial resolution obtained is 7.87 cm/pixel.

Mapping of disaster potential areas can be used by using UAV methods so that the acquisition data of objects can be easily obtained. UAV images shows a building affected by a landslide disaster. In the Sub District Ngesrep made possible the main priority in mitigation landslide because the location is one of the densely populated areas in the location potential to landslide disaster.

The authorities can utilize UAV technology to mapping the risk areas affected by landslides. UAV can be used to collect landslide disaster data from another location. All types of landslides are covered by the database, which stores not only main attributes, but also various complementary data, including data on landslide causes, impacts, and mitigation. The database can be utilized for decision making in determining the mitigation of landslide disaster. The authorities may create a regulation to regulate settlements in locations prone to landslide disaster in order to avoid human injuries and loss material.

In this research, AHP method has been used to determine landslide hazard impacts on landslide risk. AHP can be used for a special concern with multi criteria structure, its measurement and on dependence within and between the groups of elements of its structure. So that AHP results can be utilized for decision-making. AHP results in area 1 generate 3 classes zoning risk of landslide disaster consisting with according to the low level around 141.3 m² (13.77%), according to the moderate level around 326.812 m² (31.18%) and according to the high level around 522.5 m² (50.91 %) of the total affected area of 1026.3 m². While in area 2 generate 1 class zoning risk of landslide disaster consisting with according to the high level around 520.82 m² (100%) of the total affected area of 520.82 m².

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