MITIGATION AND MANAGEMENT LEVEL PLANNING TO LANDSLIDE, STUDY CASE: NGADIMULYO VILLAGE, AND TUMENGGUNGAN VILLAGE, WONOSOBO REGENCY, CENTRAL JAVA, INDONESIA

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Abstract-This Paper discusses about the correctness of mitigation and management planning towards a Landslide Disaster. Landslide have been a major issue in these villages in the past seven years. The main issue concerning the increase of potential landslide in these villages are the uncertainty of extreme weather patterns as well as major land use changes in the area. This study was done in Ngadimulyo Village and Tumenggungan Village in Central Java in Indonesia. Although both village were not the most hazard prone to landslide in the Central Java Province, the study was done to understand how the people mitigate and manage in response to the landslide disaster in the area. This study consists in 3 main steps; the first step of this study is to analyze the villages which part of the villages are the most prone towards the landslide disaster by using spatial analysis overlay method consist of different variables. The second part of the study is to get the data directly at the field, to observe, verify, and interview key informants to acquire the data regarding the management and mitigation method in response to landslide. The third and last part of the study which is aim of the study is to analyze the acquired data, and classify those data based on scoring analysis of which area that are has the correct and optimal way to mitigate landslide based on descriptive analysis.

Index Terms—Landslide, Mitigation, Management, Prevention

INTRODUCTION

A. Study Region

Ngadimulyo Vilage and Tumenggungan village are villages that are in the District of Selomerto, in Wonosobo Regency of Central Java Province, Indonesia. These Villages are located relatively in the center of Wonosobbo. Wonosobo Regency is one of the regencies in the Central Java that are prone towards the hazard of landslides. The main reason Wonosobo Regency is one of the regency that is vulnerable towards the hazard of Landslide because of its topographic factors. Wonosobo has a relatively high topographic relief which are the main factors of the occurrence of landslide disasters in the past years [1]. Although Selomerto district is not the most vulnerable district towards the hazard of Landslide in Wonosobo Regency, the district still faces major economic and social loss in the region from the impact of the land slide.

The tropical climate of the villageshas two seasonal changes annually. The dry season starts in April, and the rainy season starts in October. The temperature of these villages ranges from 26 – 30 ˚C and up night it can go down as low as 18˚C. Ngadimulyo and Tumenggungan Village have a yearly rainfall for up to 4250 mm [1]. The villages have the range of elevation level between 500 and 600 meters above the sea level, and have a slope gradient between 0 % and 40 %. This shows that these two villages have a topographic feature of hilly terrain and a slope that are very steep in some part of the village.

The land use of the village is mostly open field, as well as agricultural use, forest, and residential building area. The two villages have 2 small main roads that are connected towards the main avenue of the district in the northern area. The two villages also have one artery streets that connects the village with each other.

B. Landslides Factors

Landslide is a phenomenon that happen to a soil or a rock that fell from a certain point of elevation towards the lower elevation which is caused by the force of gravity [2]. There are number of factors that could potentially contribute to the occurrence of a land slide. Those contributing factors could be distinguished by natural factors, as well as anthropogenic factors. Natural factors consist of an event or a physical characteristic of the regions that could potentially contribute to the occurrence of land slide. Those natural factors could consist such as: the amount of rainfall, elevation, slope, geological factors, type of soils the amount types and concentration of vegetation, etc. Besides natural factors, human activity could also contribute to the occurrence of land slide those factors could include the land use change from forest to buildings or farmland, drainage and irrigation system, etc.

Landslide and could be seen when an amount of soil move from a place that has have higher elevation towards the lower elevation point. The land slide phenomenon happens when the soil move simultaneously at once and it happens within a short amount of time. Basically, landslide will happen if these factors are happening all at once [3]:

1. Landslide will happen when the slope gradient of land happens to be steep;
2. Landslide will happen when the topsoil got eroded when it received a heavy amount of rainfall;
3. Landslide will happen when the ground water flow could not be contained and could potentially erodes the topsoil from the bottom to the top.

Heavy rain from the rainy season could also increase the vulnerability of landslide, since more rain means higher erodibility from the soil. The start of the rainy season with intense rain is the time that is most vulnerable to occur landslide. Since the soil is still dry and very unstable from the dry season, when it is exposed to high intensity rain from the start of rainy season the soil will be more exposed by the heavy rain which will caused erosion and potentially landslide in a larger scale [4].

Landslide also happened caused by human activity, more specifically because of land use change over time. Land use change affects the stability of the topsoil in a high topographic relief. The loss of forest and the appearance of new settlement and building will make the soil stability prone towards landslide [5]. Other human activity that affects landslide, such as:

1. Excessive digging in a steep slope;
2. Deforestation;
3. Improper irrigation and drainage system;
4. Improper farming techniques;
5. Leeks in drainage pipe which could cause erosion;
6. Constructing building in steep slope without proper engineering and techniques.

Based on number of factors that contribute to the occurrence of the landslide, it can be hypothesized that most of the descriptions of the study region meet the criteria of the landslide factors. From the heavy annual rainfall, high steep slope, as well as the distribution of the building that are in the high slope [6]. This will be proven by providing a map that shows the sensitivity of the region towards the hazard of landslides.

C. Previous Landslides in the Region

Landslides occurred in both village almost every rainy season when the intensity of rainfall reach its peak. In Tumenggungan, Heavy rainfall during the 2004 rainy season caused major economic loss since 50% of the roads are in Tumenggungan Village are blocked by the debris of the landslides. The blockades of the roads that are caused by the debris, hindered the distribution of the agriculture product during the harvest season which caused farmer cannot sell their harvest product effectively [7].

D. Mitigation and Management for the Landslide

Mitigation and management planning and action is a way to reduce and to prevent the impact and the loss when disaster appear. Mitigation can be built through development and fruitful planning, or it can be built through the increase of awareness regarding the disaster. Mitigation and management of disaster can be approach during, before, and after the disaster occurs.

There are several factors that needs to be look at to know whether the process and the way of mitigation is right or not. Those factors include [8]:

1. Early warning system;
2. People's Awareness to act toward disasters;
3. Management during the disaster event;
4. Preventive measures;
5. Post-disasters action planning.

The aim of this study is to analyze the mitigation and management level in Tumenggungan and Ngadimulyo Village that have been done or have yet to be done to prevent loss and damage reduction from the impact of the landslide, which are being analyze based on the five criteria mentioned above.

METHODS

E. Data Collecting

This study will use two different types of data, which are primary and secondary data. For primary data, the data were acquired directly at the region of study. The data that were being acquired on the field consist of photographic data for observation, verification of secondary data, and in depth interview with key informants. The observation that were held at the field was to know which part of the area that are prone towards landslide disasters. The interview that were done at the village is to acquire information in regards to the ways and methods of the mitigation and management towards landslide disasters. The key informants that were interviewed are the ones who have the knowledge and capabilities to know the details and technical information regarding the mitigation and management processes. The key informants that were interviewed consist of head of district, head of villages, and local villagers that happened to be affected by the landslide events in the pass. The questions that were being asked to the informants are regarding the factors that consist of process and ways of the mitigation and management processes (See 1.D above).

The secondary data for this study is required to analyze those data to know which part of the villages that are most prone towards the disaster of landslide. The secondary data that are required to be analyze to create a map that shows the region that are prone towards landslides are:

1. Topographic map: Acquired from Digital Elevation Model Satellite;
2. Rainfall Data: Acquired from regional development bureau Central Java;
3. Land Use Map: Acquired from Indonesian Geoportal;
4. Soil and Geological Maps: Acquired from the Indonesian Secretary of Agriculture.

F. Data Processing

The Secondary Data that were stated above are used to create map that shows the regions that are prone to hazard which spreads throughout the two villages. The secondary data are basically acquired in a form of maps. To create the regions that are prone to landslide map (Sensitivity map), we first must give a scoring method to the parameter for each of the variable so each thematic map can be overlay based on our classification requirements, the score that will be given to each variable will be stretched from 1-5, the higher the score the more prone the area towards the landslide. After giving each variable several rates have been done, we then proceed to use overlay method with the application ArcGIS 10.1, to create the map that shows the region that are prone to landslides.

The Variable that have been inputted to create the map that shows the sensitivity of the region towards the landslides are:

1. Rainfall: the higher the rainfall the higher the score
2. Slope: the higher the slope the higher the score
3. Types of Soil
4. Types of Rock (geological features): Alluvial rock has a lower score, while sediment rock has a medium score, while Igneus rock have the highest score.
5. Land Use: forest have a low score, while farming fields have medium score, and buildings and ponds have the highest score.

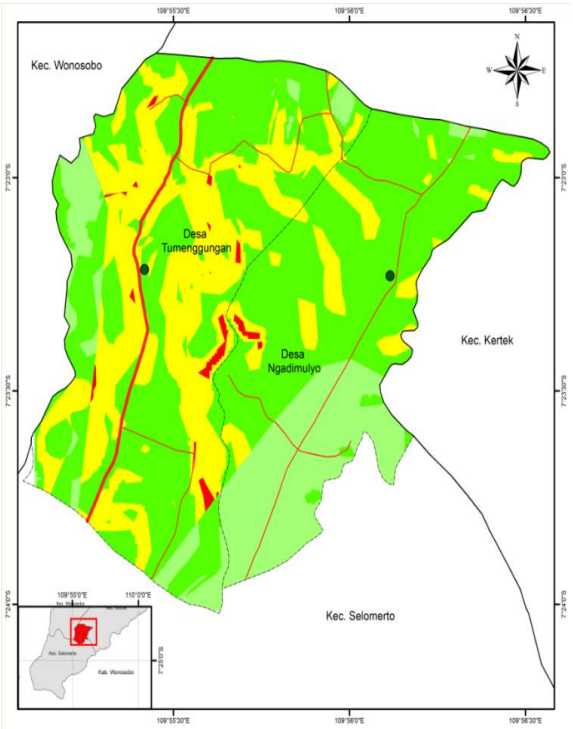


Fig. I: Map that shows Level of Prone to Landslide Hazard in Ngadimulyo Village, and Tumenggungan Village, Wonosobo Regency, Central Java. The Grey-green shows it has low sensitivity, green shows average sensitivity, Yellow shows high sensityvity, and red shows very high sensitivity.

After the overlay method, has been done, it will give us the map that shows regions that are prone towards the land slide (fig. 1). This map will show which part of the region that are the most sensitive towards the landslide hazard. With this map, the field could be observed based on which part of the maps that are the most sensitive towards the landslide hazard.

G. Analysis

There are multiple ways to analyze the data that have been acquired through secondary sources, and through first hand sources. For instance, the primary data that have been analyzed through spatial analysis using GIS software is to create a map that shows the level of prone to landslide hazard in the villages. Those data will be used on the field to collect/verify the data primarily. After we get the data through observation and in-depth interview, those data will be analyze descriptively to show the level of mitigation and management that have been implemented by the local people there. The data those have been collected primarily shall be analyze in the same way as to produce the map that shows level of prone to hazard in the Villages. Which includes distinguish each variable parameter that have different weigh. Then each of its variable have different types of classification based on what the informant's answers within the interview. After classifying the answer, we shall give different score system based on the correctness/rightness mitigation category. The analysis table can be shown in Table 1.

After classifying the data based on the parameter of each variable, the results of the analysis will be shown in a table format for each region. The region and its border to know the level of its mitigation will be selected will be drawn out based on data analysis from the in-depth interview. Then table II shows the score of its classification level of the correctness of mitigation and management towards the landslide hazard after calculation has been done based on table i. The progress of this study can be shown in fig.2 where it shows the flow diagram and each step by step progress from the background problem to collecting data, to analyzing and data processing as well as describing the results and conclusion.

Table i: Classification Level of Correctness of Mitigation and Management towards Landslide Hazard

No.	Parameter	Weight	Classification	Category	Score
1	Early Warning System	5%	The region does not have the facility to provide information regarding Landslide to the people	Very Low	1
			The region has minimal facility to provide information regarding Landslide to the people	Medium	3
			The region has facility to provide information regarding Landslide to the people	Very High	5
2	People's Awareness toward Land Slide Disasters	10%	Low Awareness	Very Low	1
			Have some sort of awareness/knowledge in response to Landslide Hazard	Medium	3
			Have a very high awareness and knowledge as well as implementing them sustainably in response to Landslide Hazard	Very High	5
3	Management during the disaster event	15%	The region does not have a management program	Very Low	1
			The region has a management program when landslide occurs, but only done by the local villagers, not from the government and private sector.	Low	2
			The region has a management program when landslide occurs, done by the local villagers, the government and private sector.	Medium	3
			The region has a management program when landslide occurs, done by the local villagers, the government and private sector. The management action during the disaster event done in a quick way.	High	4
			The region has a management program when landslide occurs, done by the local villagers, the government and private sector. The management action during the disaster event done in a quick way, with little to no economic loss.	Very High	5
4	Preventive measures towards landslide disasters	60%	There is no preventive measures at all towards the landslide disasters	Very Low	1
			Very minimal preventive measures to prevent landslide disasters	Low	2
			Preventive measures are done in a traditional way such as planting trees in an unconventional way, and building traditional technology to prevent landslides	Medium	3
			Preventive measures are done by the people, local government, and private sector with a high technological infrastructure.	High	4
			Preventive measures are done by the people, local government, and private sector with a high technological infrastructure, and done in a sustainable way with integrated planning.	Very High	5
5	Post Disaster Action Planning	10%	Post disaster action done not effectively with no real plan and strategy.	Very Low	1
			Post disaster action done effectively with plan and strategy.	Medium	3
			Post disaster action done effectively with plans and strategies, which are done very efficiently and perfectly between government, local villagers, and private sectors.	Very High	5

Table ii: Score of Correctness of Mitigation and Management towards Landslide Hazard

Classification Level of Correctness of Mitigation and Management towards Landslide Hazard	
Classification	Score
Low	1-2,3
Medium	>2,3-3,6
High	>3,6-5

RESULTS

H. Observation Results

Based on the survey done in firsthand at the field, we went to the area that are prone towards landslide and other places that are have a highly dense population and buildings. Based on observation that most of the landslides that have occur in both villages are in a steep slope area where the vegetation is very minimal. Some of the steep slope areas have been built with a wall to prevent landslides towards the road area as well as towards the building. Although the technology of the wall is not highly advance, it seems it has been effectively build to prevent landslide. On the other hand, there are some landslides that manage to break through the wall barrier which caused the wall to be destroyed when landslide happened.

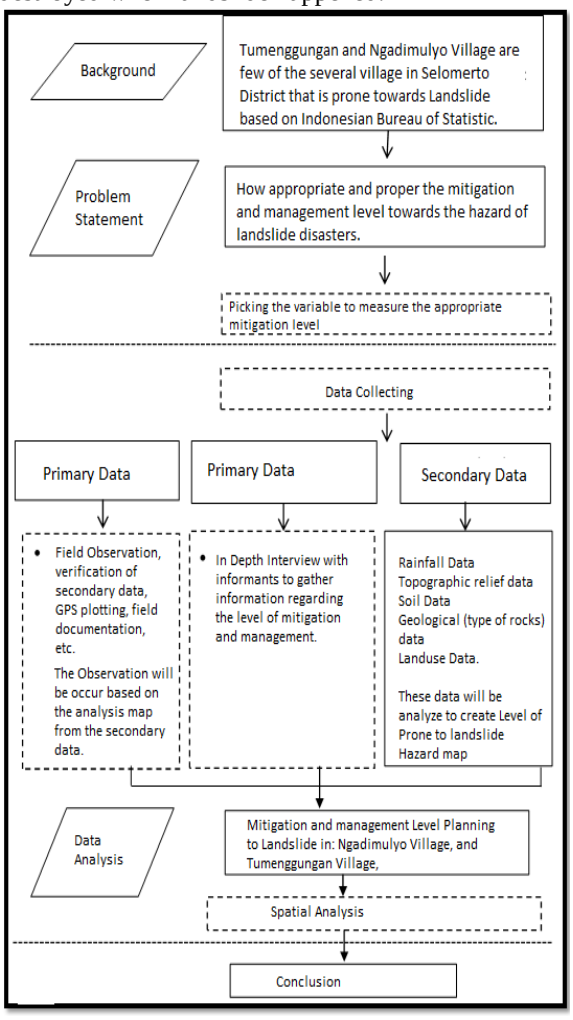


Fig. II: a step by step flow diagram for this study.

I. Interview Results

The interview was done to know two main things, the first one is to know how the mitigation and management process were done to face landslides, and the second one is to know where those mitigation and management process were done exactly on the village. Since there are two villages and there are several sub-village in each village, there will be different ways and method to do the mitigation and management processes. The reason on why it is different is because in each village or even sub-village have its own landslide characteristic, physical characteristic, and social structure, therefore the processes are different.
Based on descriptive qualitative analysis on from the interview, the results shown that both village have different methods of mitigation and management process. There are even number of differences of mitigation and management process within the village. Table III to VI shows the classification level and its calculation based on descriptive qualitative analysis.

Calculation of West Tumenggungan			
Parameter	Score	Weight	Results
Early Warning System	5	0.05	0.25
People's Awareness	5	0.1	0.5
Management during Landslide Events	5	0.15	0.45
Preventive Measures	3	0.6	1.8
Post Disaster Action Planning	3	0.1	0.3
Total			3.3

Table III: Calculation of West Tumenggungan

Calculation of East Tumenggungan			
Parameter	Score	Weight	Results
Early Warning System	5	0.05	0.25
People's Awareness	5	0.1	0.5
Management during Landslide Events	4	0.15	0.45
Preventive Measures	2	0.6	1.2
Post Disaster Action Planning	3	0.1	0.3
Total			2.7

TableIV: Calculation of East Tumenggungan

Calculation of South Ngadimulyo			
Parameter	Score	Weight	Results
Early Warning System	3	0.05	0.15
People's Awareness	3	0.1	0.3
Management during Landslide Events	2	0.15	0.3
Preventive Measures	2	0.6	1.2
Post Disaster Action Planning	3	0.1	0.3
Total			2.25

Table V: Calculation of South Ngadimulyo

Calculation of North Ngadimulyo			
Parameter	Score	Weight	Results
Early Warning System	3	0.05	0.15
People's Awareness	3	0.1	0.3
Management during Landslide Events	2	0.15	0.3
Preventive Measures	3	0.6	1,8
Post Disaster Action Planning	3	0.1	0,3
Total			2,85

Table VI: Calculation of North Ngadimulyo

Based on Table III to Table VI, it can be noted that Western Tumenggungan have the highest total score for 3.3, while the lowest is South Ngadimulyo for 2.25. Those Table could be spatially analyzed further by using ArcGIS 10.1 and will results a map that that shows each region score (figure 3).

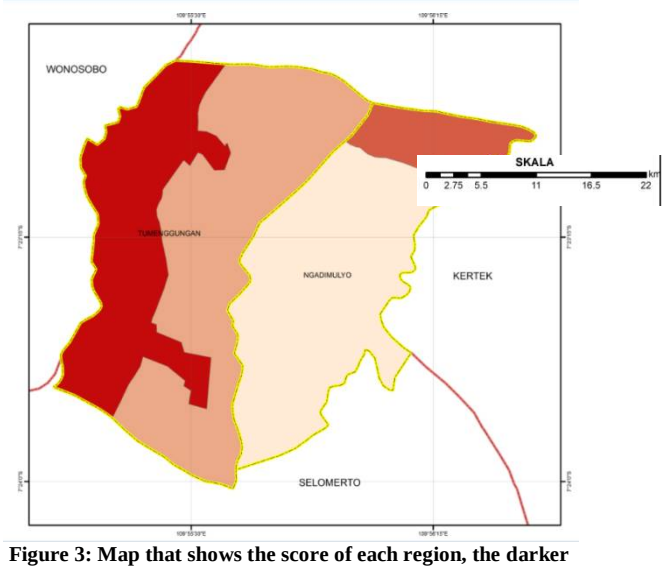


Figure 3: Map that shows the score of each region, the darker the colour the higher the mitigation score

DISCUSSION AND CONCLUSION

Based on the map that shown in figure 3, we can further more classify those number based on the classification from Table II so that it could show a map

that shows the correctness of the mitigation and management level on both villages, the map could be shown in Figure 4.

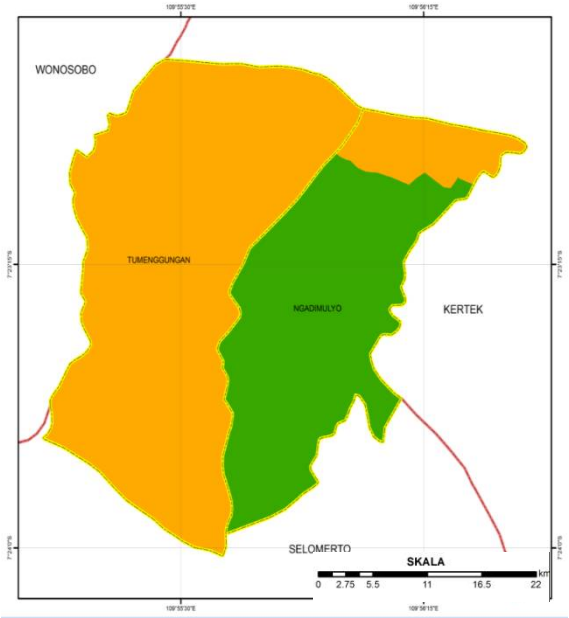


Figure 4: Map that shows each region classification of correctness of mitigation and management towards Landslide Hazard in Ngadimulyo Village and Tumenggungan Villege. Orenge indicates Medium, and Green Indicates Low.

Based on fig. 3 and 4 which shows the mitigation and management score and classification score, it shows that the Tumenggungan Village have a medium mitigation and management process to face landslide disasters. On the other hand, Ngadimulyo village got the classification divided where the northern part of the village is classified as medium, while the southern part is classified as low.

Since based on table II, the most dominant aspect to show whether the mitigation and management process is correct or not is very dependent on the preventive measures variable which has the most weight (60%). That is why the North Ngadimulyo and West Tumenggungan have relatively higher score than other region villages. Preventive measures are how the structural building are build and how the building and the infrastructure are not so sensitive towards the impact of the land slides.

The lowest mitigation score which is classified as low is in southern Ngadimulyo. The main reason why this part of the village is classified as low level in terms of mitigation and management process, is because this part of the village does not receive a lot of landslide disasters lately (seen in fig. 1), therefore the management and mitigation process and technology is not as advanced and the people is not as aware as another region. Although there are several places that are prone towards landslide, but it is not located near in a highly populated area.

In Conclusion, this study shows the level of correctness in mitigation planning and management process towards the impact of landslide in these 2 villages which shows that different part of the areas in the region provides different ways and process for facing the landslide disaster.

REFERENCES

[1] Badan Pusat Statistik Wonosobo (Wonosobo Central Bureau of Statistic). “Wonosobo Dalam Angka 2015. 2015. (In Indonesian)

[2] Thahjono. “Direktorat Geologi dan Tata Lingkungan”. 2003(In Indonesian)

[3] Arsyad S. “Konservasi Tanah dan Air”. IPB Press, Bogor.1989(In Indonesian)

[4] Aris Dwi. W. 2010. “Tingkat Kerentanan Longsor Lahan pada Lokasi Permukiman di Kecamtan Gedangsari Kabupaten Gunung Kidul”. Thesisi. Yogyakarta: Fakultas Geografi UGM. 2010 (In Indonesian)

[5] Andi. Surono. “Potensi Bencana Geologi di Kabupaten Garut. Prosiding Semiloka Mitigasi Bencana Longsor di Kabupaten Garut”. Pemerintah Kabupaten Garut. 2003(In Indonesian)

[6] Badan Informasi Geospasial. “Peta Rupabumi Indonesia Banjarnegara”. 2015(In Indonesian)

[7] Kedu, DIY. Terjadi 32 Kali Tanah Longsor. Suara Merdeka. 2004 (In Indonesian)

[8] Mubekti. “*Mitigasi Daerah Rawan Tanah Longsor Menggunakan Teknik Pemodelan Sistem Informasi Geografis”*. Pusat Teknologi Inventarisasi Sumberdaya Alam Badan Pengkajian dan Penerapan Teknologi. 2008.

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