



Use of Geographic Information System for Landslide Conservation on the Manado-Tomohon Road

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Abstract. The main problem in this study is landslides on the Manado-Tomohon road route. Almost every year in the rainy season, there are landslides even in certain events that have caused exciting materials even take away the human soul, so it is necessary to minimize it. This study aims to produce a map of the level of landslide hazard on the Manado-Tomohon road route as a basis for landslide conservation directions to minimize landslide hazards on the Manado-Tomohon road route. The methods used in this study are aerial photo interpretation, map analysis, observation, field measurement, and laboratory analysis which are then analyzed using scoring or harnessing against terrain parameters. The results showed that there are three categories of landslide hazard levels based on the dignity of the terrain parameters and the landslide persistence map on the Manado-Tomohon road route; they are the level of danger of low, medium, and high landslides. So, landslide conservation on the Manado-Tomohon road route is directed to be carried out by two approaches: the geomorphological and the technical approaches. The geomorphological approach is implemented by planting plants vegetatively. While the technical approach is carried out by changing the geometry of the slopes, controlling surface water, and controlling seepage water.

Keywords: Maps · Conservation Directives · Landslides

1 Introduction

The Manado-Tomohon road route has landslides almost every year in the rainy season, so it needs conservation efforts. Based on the land use directive map of the Directorate of Geological Environmental Management (1997) [1] the Manado-Tomohon line is classified as category B, which is directed to agriculture. [2] Only local ones are developed for rural growth. The reality in areas that often experience landslides is also used for various economic activities such as restaurants, lodging, fruit trade, and even settlements. In terms of topography, based on the Map of the Earth's Appearance of Manado sheet issued by Bakosurtanal (1991) [3] on a scale of 1: 50,000, the Manado-Tomohon line has a rough topography. It can be seen from the contour line's density where the contour line's density reflects the slope that can support landslides.

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From the geological aspect based on a geological map with a 1:250,000 scale Manado sheet (Efendi 1976) [4], this path is covered with young volcanic rocks consisting of lava, bombs, lapilli, and ash where these rocks are classified as unconsolidated rocks, so they are vulnerable to landslides. This physical condition shows that the Manado Tomohon road route can easily experience landslides, so efforts are needed to minimize landslides. Considering that the Manado-Tomohon road route is the main road route that connects Manado City with several City Regencies in North Sulawesi, this road route is one of the road lanes whose level of traffic flow density is quite high.

On the other hand, the Manado-Tomohon road route is part of the middle slope of the Lokon volcano, which was cut and used as a road. According to Varnes 1978 in Sulastoro 1994 [5], the increase in slope angles, volcanic processes, and car vibrations are among the factors that trigger landslides. Joede 1989 stated that in addition to human exploitation as an external factor triggering landslides, it is also controlled by characteristics that exist in the soil, such as geology, soil nature, geomorphology, slope state, and vegetation. Therefore, in general, landslide events are controlled by five parameters, namely: Geological conditions, precipitation, in this case, its duration and intensity, vegetation, earthquakes, and human exploitation,

These controlling factors are found in the Manado-Tomohon route. Where in addition to the slope, the slope varies from flat to steep. In terms of geology, it is composed of young volcanic rocks consisting of lava, lapilli, bombs, and ash; these rocks are classified as unconsolidated rocks, so they are vulnerable to landslides.

Related to the landslide incident on the Manado-Tomohon Line, the most major landslide incident occurred in 2014, along with the flash flood event in Manado City, where the Manado-Tomohon road route was impassable for a long time. So that the traffic flow was diverted through another channel with a farther and longer distance; moreover, it had cost lives. In terms of seismicity, it also has an effect because the Manado-Tomohon Route is part of the middle slope of the Lokon volcano, one of the active volcanoes in North Sulawesi.

Seeing the impact and risk of landslides on the Manado-Tomohon road route is quite influential on the smooth flow of traffic and community activities; efforts are needed to minimize landslide conditions on the Manado-Tomohon road route.

Based on the background of the abovementioned problems, the research problem is formulated as follows: "How to minimize landslide disasters on the Manado-Tomohon Road Route".

Goals and Objectives

The purpose of this study is to compile a landslide hazard map as the basis for the direction of conservation of landslide areas on the Manado-Tomohon Road Route based on the Geographic Information System. The goal is to minimize the level of landslide danger.

2 Method

The methods used in this study are aerial photo interpretation, map analysis, observation, field measurement, and laboratory analysis which are then analyzed using scoring or harnessing against terrain parameters.

3 Results and Discussion

3.1 Object and Subject of Research

The object of the study was a landslide area on the Manado-Tomohon route. In contrast, the subject of the study was the community that lived and carried out economic activities and users of the Manado-Tomohon road route.

3.2 Medan Unit of Research Area

The terrain units of the study area are arranged based on shape, slope resemblance, and land use. The preparation of field units based on the three variables is based on the idea that the three variables are the variables that most dominantly affect geomorphological processes (especially the process of occurrence landslide).

The terrain unit characteristics in Fig. 1. Are used to describe the characteristics of terrain units throughout the study area based on the shape, slope, and land use.

The results of the land’s generalization of the physical characteristics are used to analyze the degree of landslide hazard in all-terrain units.

3.3 Landslide Hazard Level in Research Area

Based on Fig. 2, it is shown that the landslide hazard level in the study area consists of three low hazard level categories, (II) medium hazard level (III), and high landslide

No.	Unit	Lreng	Tektr	Prm	Tbl Shhh	Plp Kn	Dn Trjl	Pen Lhn	Krpt Veg	Drain Inside	Drain outside
1	V3IIHt	13	Lp	6,914	110	L	2	Ht	90	Good	Good
2	V3IIIPm	20	Lp	46,639	120	L	15	Pm	35	Good	Good
3	V3IIIPrk	17	Lpd	10.936	150	L	15	Prk	50	Good	Good
4	V3IIPm	15	G	28.913	150	L	12	Pm	8	Good	Good
5	V3IIPrk	14	Lp	0,025	140	L	10	Prk	35	Rather good	Rather good
6	V3IPm	3	Lp	4,023	170	L	20	Pm	20	Good	Good
7	V3IVHt	35	GLp	7,668	50	L	17	Ht	80	Good	Good
8	V4IIIPm	24	Lp	16,971	190	L	2	Pm	25	Good	Good
9	V4IPm	7	Lp	1,509	160	L	12	Pm	25	Rather Good	Rather Good
10	V4ITg	8	G	6,914	155	L	10	Tg	10	Good	Good
11	V2IIHt	9	Gps	82,976	170	L	10	Ht	50	Good	Good
12	V2IIIPm	20	Gdb	4,148	180	L	2	Pm	25	Good	Good
13	V2IIPrk	25	Lp	2,514	180	L	2,5	Prk	40	Rather Good	Rather Good
14	V2IIPm	12	Gdb	4,274	150	L	10	Pm	13	Good	good

Fig. 1. Characteristic of Selected Terrain Units.

No.	Unit	Lreng	Tektr	Prm	Tbl Shhh	Plp Kn	Dn Trjl	Pen Lhn	Krpt Veg	Drain Inside	Drain outside	Amount	Landslide Hazard Class
1	V3IIHt	1	2	2	4	4	3	1	2	1	2	22	li
2	V3IIIP m	2	5	2	4	4	3	1	2	1	2	26	li
3	V3IIIPr k	3	5	2	3	4	4	3	1	3	2	30	lii
4	V3IIPm	3	5	1	3	4	4	4	4	3	2	33	lii
5	V3IIPrk	3	4	2	5	4	4	3	3	3	2	33	lii
6	V3IIPm	2	1	1	5	4	3	5	4	5	2	32	lii
7	V3IVHt	2	5	5	4	4	3	3	4	3	3	36	lv
8	V4IIP m	3	5	1	5	4	2	3	4	3	2	31	lii
9	V4IIP m	1	5	4	5	4	4	3	4	3	3	36	lv
10	V4ITg	1	1	2	5	4	2	3	5	2	2	29	lii
11	V2IIHt	1	2	2	4	4	3	1	2	1	2	22	li
12	V2IIIP m	4	5	3	5	4	5	4	3	2	3	41	lv
13	V2IIPrk	1	3	3	3	4	4	5	3	2	2	30	lii
14	V2IIPm	2	2	2	5	4	5	3	4	2	2	31	lii

Fig. 2. Harkat Terrain Parameters and Landslide hazard classes.

hazard level (IV). It is dominated by moderate landslide hazard levels. The low landslide hazard class is found on the middle slopes of denudated volcanoes and on the slopes of volcanoes with a slope of 8%-25%, which is used for forests and settlements. High landslide hazard levels are found on the middle slopes of strongly denudated volcanoes and denudated lower slopes with a slope of 15% to 40%, which is used for settlements and forests.

Figure 3 the extent of landslide hazard in the study area.

3.4 Conservation Directives Di Research Areas

Conservation is an effort to keep the soil productive and durable with other resources. Conservation can be carried out by using mechanical and vegetative methods [6]. Mechanical methods are used for soil and building construction. It aims to reduce surface flow which works to slow down the surface flow, and channel surface flows with non-destructive forces. While, a vegetative method is used for plants to reduce the destructive power of falling rain, reducing surface flow and erosion.

In connection with the condition of the Manado-Tomohon road route, which almost every year in the rainy season, there are landslides, and based on the dignity of the terrain parameters have low, medium, and high hazard level categories dominated by moderate landslide hazard levels, hence the directives for conservation that can be carried out in order minimizing the danger of landslides is to apply the two conservation techniques,

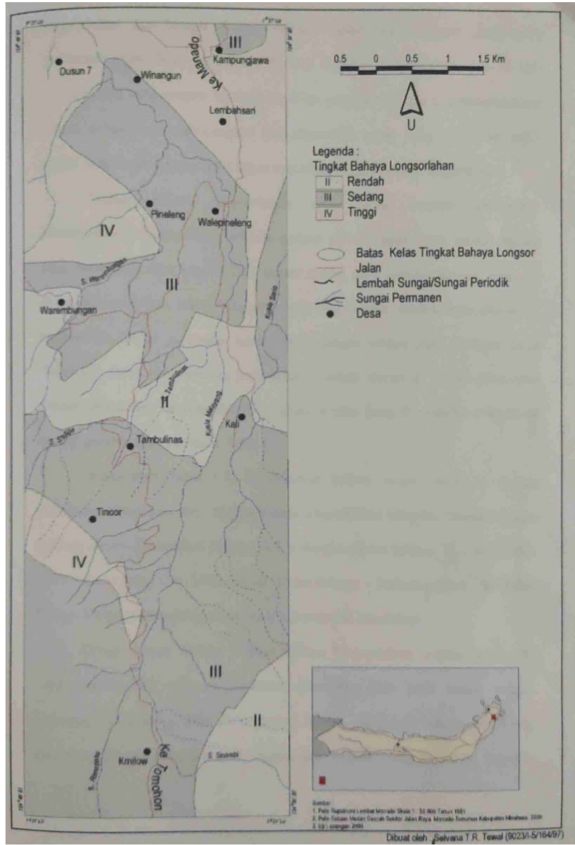


Fig. 3. Map of Landslide Hazard Level of Manado-Tomohon Road Route

namely through mechanical and vegetative methods, especially in areas that are classified as danger levels high landslides with a slope of slopes are sloping to steep, so that the condition of the soil is maintained not easily shifted, also maintains the productivity of the soil if used for agricultural enterprises. Likewise, in terms of economic activity, residents who live on the Manado-Tomohon road route and other communities as users of the Manado road route -Tomohon still feel safe in particular activities in improving economic resources and supporting the welfare of the community.

4 Conclusion

4.1 Conclusion

To minimize the danger of landslides on the Manado-Tomohon road route, conservation directions that can be applied are to use mechanical and vegetative methods, especially in areas with high avalanche hazard levels and sloping to rugged topography.

4.2 Suggestion

In areas with a moderate to high landslide hazard, land use is adjusted to its designation and pays attention to the rules of land carrying capacity.

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