International Journal of Research and Review
Vol. 3; Issues: 1; 2023
Website: https://ejournal.penerbitjurnal.com/index.php/research/index
Research Paper E-ISSN: 2349-9788; P-ISSN: 2454-2237

The Causing Factors Mapping of Landslides on Riau Province National Roads

Talitha Fully Rahmayanti, Ayomi Dita Rarasati

Civil Engineering Departement, Faculty of Engineering, Universitas Indonesia

Corresponding Author: Talitha Fully Rahmayanti

ABSTRACT

Landslides are one of the natural disasters that often occur in areas that have a wet tropical climate which is common in Indonesia. Riau Province is one of the provinces that regularly experiences landslides. In Riau Province, over the last decade (2013-2022) there have been 69 landslides and several was a landslide which cut off transportation access for the National Road that connects Riau Province with West Sumatra Province, North Sumatra Province and Jambi Province. The occurrence of repeated occurrences at the same/adjacent landslide locations in short period of time is caused by the landslide handling that has not been maximized or even has not even done, thus affecting the implementation of landslide disaster risk control. The purpose of this study is to recommend a risk control strategy for landslide disaster risk control in Riau Province National Road. This research was carried out by collecting data through a questionnaire survey. Then followed by qualitative risk analysis in order to obtain the dominant risk that affects the landslide disaster in Riau Province.

Keywords: Landslide, Risk Control Strategy, National Road

INTRODUCTION

Landslides are one of the natural disasters that often occur in areas that have a wet tropical climate which is common in Indonesia. In fact, according to the 2022 Disaster Infographic from the National Disaster Management Agency Number 5/U365-170123/099/Ben-Indonesia/BNPB/31122022, there were 634 landslides that occurred in 2022 in Indonesian territory. The National Disaster Management Agency noted that landslides are the most frequent disaster causing fatalities in 2022, even though the scale of the incident is small. At least 7 (seven) landslides causing fatalities occurred in 2022, including:

1. Landslide on April 28th 2022 in Mandailing Natal, North Sumatra, which caused 12 fatalities.
2. Landslide on May 21 2022 in Cijeruk, Bogor, West Java, which caused 4 fatalities.
3. Landslides on June 22, 2022 in Bogor Regency, which caused 3 fatalities.
4. Floods and landslides that occurred in 13 sub-districts in Garut Regency on July 15 2022 caused 1,239 people to be evacuated and 1 fatality.
5. A landslide on September 26 2022 in Kota Baru District, South Kalimantan, which caused 9 fatalities, occurred in an illegal gold mining area in Kotabaru.
6. Landslide on 12 October 2022 in Bogor City, West Java, which caused 1 out of 8 people who were buried in it died.
7. Landslide on October 15 2022 in Jeneponto Regency, South Sulawesi, which caused 3 fatalities.

Damage caused by mass movements due to landslides, not only causes direct damage such as damage to public facilities, agricultural land, or human casualties, but also indirect damage that paralyzes development activities and economic activities in the disaster area and its surroundings (Hardiyatmo , 2006). There is no exception in the case of road infrastructure which is a connecting line for all economic activities in a region and determines the development of a country.

According to the Law of the Republic of Indonesia Number 38 of 2004, it is stated that a road is a transportation infrastructure which includes all parts of the road including auxiliary buildings and equipment intended for traffic, which are above ground level, below ground level and/or water, and

above water, except for railroads, lorry roads and cable roads. It is also explained in the Law that Roads have an important role, especially with regard to the realization of balanced inter-regional development, the distribution of development results and the strengthening of national defense and security in the framework of realizing national development.

Among the five types of roads, National Roads have a significant impact and are an important factor in driving economic growth. The National Road has a high traffic volume and is used by large and heavy trucks and buses. The National Road also functions as a connecting road between provinces and even between islands which can facilitate the process of economic activity.

Riau Province, as the province with the second largest Gross Regional Domestic Product (GRDP) value on the island of Sumatra and in the third quarter of 2022 Riau Province contributed 5.12 percent to the national economy. The existence of the accessibility of the National Road that connects Riau Province with North Sumatra Province, West Sumatra Province and Jambi Province directly by land or connecting with provinces and even other countries with sea and air transportation nodes. In fact, one of them is the Port of Dumai which is the largest CPO port in the world that accommodates the needs of 20% of CPO in Indonesia. Thus, the accessibility of the National Road in Riau Province is crucial.

However, the accessibility of the National Road in Riau Province is often disrupted and even cut off due to landslides that close and damage the road body. In the last 10 years (2013-2022) causeways in Riau Province have repeatedly experienced road closures and restrictions due to landslides.

In Riau Province, high rainfall is one of the factors that most often causes landslides. During a long dry season, the soil will dry out and form cracked cavities or pores. During the rainy season, rainwater will enter and seep into the cracked soil and fill the voids, causing soil shifts to occur. This causes the high risk of landslides to increase, especially in November which always has high rainfall.

Soil conditions in Riau Province are also one of the factors causing the high rate of landslides. Soil in Riau Province is dominated by peat and alluvial soil. Peat is a type of soil that comes from half-decayed plant residues and is not like ordinary soil. Where at the top of the peat is soil, but at the bottom it contains water with a depth of 2-3 meters. Of the total area in Riau, half is peat. Even with alluvial soil which is the result of sediment from the sedimentation process of other rocks that have not been compacted, alluvial soil has loose properties and is permeable to water, so that the material easily moves when it rains.

In Riau Province, during the last decade (2013-2022) there have been 69 landslides. Where, 9 landslide locations are recurring landslide locations. Landslide events at the same location in Riau Province that have occurred in the last 10 (ten) years, including:

- On KM 77+700 landslides occurred in 2013 and 2022
- On KM 58+500 landslides occurred in 2013 and 2021
- On KM 234+627 there were landslides in 2013 and 2017
- On KM 80+870 landslides occurred in 2013 and 2022
- On KM 95+525 there were landslides in 2013 and 2016
- On KM 80+550 landslides occurred in 2014, 2016 and 2022
- On KM 128+000 landslides occurred in 2014 and 2016
- On KM 77+400 landslides occurred in 2016, 2018 and 2022
- On KM 109+600 landslides occurred in 2018, 2019 and 2022

Repeated occurrences at the same/adjacent landslide locations in the near future are caused by handling that has not been maximized or has not even been carried out. The large number of landslide events and the high risk of landslides have not been in line with the number of permanent treatments being carried out.

MATERIALS & METHODS

This research was conducted to recommend risk control strategies for handling landslides and how to increase the time and cost efficiency of landslide handling by optimizing programming and planning processes. To get accurate research results, it is necessary to have a research method, namely a scientific way to obtain information with specific purposes and uses. This chapter will explain the research methods to be carried out which include research strategies, research stages, research variables, research instruments, data collection, analysis methods, and conclusions.

In this study, to measure respondents' opinions on the impact of each risk factor in the existing control strategy, risk impact criteria were used according to the Circular Letter of the Minister of Public Works and Public Housing Number 04/SE/M/2021 concerning Guidelines for Implementing Risk Management at the Ministry of Public Works and Public Housing.

1. The Possibility Criteria for risk with a low tolerance (low tolerance event) is used for an event that has a very low intensity within a span of more than 1 (one) year in one UPR, for example: corruption, economic/financial crisis, work accidents resulting in fatalities, natural disasters, and building fires.
2. Possibility Criteria for a risk that is more tolerable (non-low tolerance event), using a percentage (the number of possibilities divided by the total activity/transaction) if the population can be determined or using the number of frequencies if the population cannot be determined.

The criteria for the Level of Possibility of Risk include:

Table 1 Performance Reduction Impact Criteria

Impact	Score	Ministry Unit	T-1 Unit	T-2 Unit	T-3 Unit
Insignificant	1	x<5% of Performance Target			
Minor	2	5%≤x≤10% of Performance Target			
Moderate	3	10%<x≤20% of Performance Target			
Significant	4	20%<x≤25% of Performance Target			
Very Significant	5	x<25% of Performance Target			

Source: Circular Letter of the Minister of Public Works and Public Housing Number 04/SE/M/2021

Table 2 Possibility of Risk Criteria Level

Possibility Level	Score	Possibility Criteria		
		High Tolerance Risk		Low Tolerance Risk
		Precentage	Frequency	
Very Unlikely	1	x ≤1%	x<2 times in 1 year	≤1 occurrence in the last 5 years
Unlikely	2	1%<x≤10%	2<x≤5 times in 1 year	1 occurrence in the last 5 years
Possible	3	10%<x≤20%	6<x≤9 times in 1 year	1 occurrence in the last 3 years
Likely	4	20%<x≤50%	10<x≤12 times in 1 year	1 occurrence in the last 2 years
Almost Certain	5	x >50%	x>12 times in 1 year	≥1 occurrence in the last 1 year

Source: Circular Letter of the Minister of Public Works and Public Housing Number 04/SE/M/2021

Table 3 Questionnaire

Risk Category	**Risk Factor**		**Frequency (1-5)**	**Impact (1-5)**
Natural	X1	Soil Type		
	X2	Rainfall		
	X3	Slope		
	X4	Land Use		
	X5	Earthquake		
Human Activity	X6	Cliff cutting in rock quarry on steep slopes		
	X7	Piling up landfills on slopes.		
	X8	Construction Work		
	X9	Land use changes such as deforestation to become wetlands which cause erosion by surface water and cause the soil to become soft		
	X10	Regional development that is not balanced with public awareness, so that the spatial plan is not adhered to which ultimately harms itself.		
	X11	The drainage system on the slopes is poor and causes the slopes to become steeper as a result of being eroded by canal water on the cliffs		

Source: author's modification (2023)

Furthermore, a qualitative risk analysis was carried out according to the Circular Letter of the Minister of Public Works and Public Housing Number 04/SE/M/2021 concerning Guidelines for Implementation of Risk Management in the Ministry of Public Works and Public Housing. UPR prepares a risk map that contains the results of the risk assessment according to priority. However, the Risk Assessment for this research is modified due to the use of only 2 out of 7 criterias stated in the Circular Letter of the Minister of Public Works and Public Housing Number 04/SE/M/2021, 5 other criterias that considered irrelevant for this research are Financial Impact Criteria, Reputation Impact Criteria, Law Impact Criteria, Criteria for the Impact of Occupational Accidents and Diseases, and Organisation Disruption Impact Criteria. Therefore, the risk map is described in the Risk Analysis Matrix as follows:

Table 4 Risk Analysis Matrix

Risk Analysis Matrix 5x5			**Impact Level**				
			1	2	3	4	5
			Insignificant	Minor	Moderate	Significant	Very Significant
Possibility Level	5	Almost Certain					
	4	Likely					
	3	Possible					
	2	Unlikely					
	1	Very Unlikely					

Tolerance Limit

Source: Circular Letter of the Minister of Public Works and Public Housing Number 04/SE/M/2021, modified by author

When compiling a risk map, pay attention to the level of risk as follows:

Table 5 Risk Level

Risk Level	Colour
Very High	
High	
Moderate	
Low	
Very Low	

Source: Circular Letter of the Minister of Public Works and Public Housing Number 04/SE/M/2021, modified by author

RESULTS

Questionnaires have been conducted to 32 respondents in the field of practitioners, have a minimum S1 education, have a minimum of 5 years experience in handling landslides. Of the 32 respondents who filled out the questionnaire, all of them had >5 years of work experience with 19 respondents with undergraduate education and 13 respondents with Masters-S3 (Table 6).

Table 6 Respondent Demographics

Respondent based on Position		
1	Staff	15
2	Surveyor	6
3	Assistant Manager	0
4	Manager	0
Total		**21**
Respondent based on Education		
1	>S1	0
2	S1	19
3	S2-S3	13
Total		**32**

Table 7 Respondent Questionnaire Results

Landslide Cause	Frequency					Impact				
	1	2	3	4	5	1	2	3	4	5
Soil Type	1	4	11	4	12	0	5	12	11	4
Rainfall	6	2	6	6	12	1	3	14	11	3
Slope	1	6	9	11	5	0	0	9	12	11
Land Use	9	14	6	3	0	11	14	7	0	0
Earthquake	12	5	7	4	4	3	9	13	7	0
Cliff cutting in rock quarry on steep slopes	4	7	10	8	3	4	11	9	6	2
Piling up landfills on slopes.	5	9	12	4	2	15	11	5	1	0
Construction Work	10	16	6	0	0	14	11	4	2	1
Land use changes such as deforestation to become wetlands which cause erosion by surface water and cause the soil to become soft	2	5	9	10	6	0	5	13	10	4
Regional development that is not balanced with public awareness, so that the spatial plan is not adhered to which ultimately harms itself.	4	10	12	5	1	6	12	10	4	0
The drainage system on the slopes is poor and causes the slopes to become steeper as a result of being eroded by canal water on the cliffs	2	3	7	14	6	1	5	12	6	8

From the results of the questionnaire, it was found that the opinions of the respondents varied but there was still a dominant value for each factor. Soil type has a frequency value of 5 and impact 3,

rainfall has a frequency value of 5 and impact 3, slope has a frequency value of 4 and impact 4, land use has a frequency value of 2 and impact 2, vibration (earthquake) has a frequency value of 1 and impact 3, Cutting of cliffs in rock mining on steep slopes) has a frequency value of 3 and impact 2, Piling of fill soil on slopes has a frequency value of 3 and impact 1, construction work has a frequency value of 2 and impact 1, Changes in land use such as deforestation forests into wetlands which cause surface water to erode and cause the soil to become soft has a frequency value of 4 and an impact of 3. Development of an area that is not balanced with public awareness, so that the RUTR is not adhered to which ultimately is self-defeating has a frequency value of 3 and an impact of 2, and Slope drainage system that is not good which causes steeper slopes due to scouring by canal water on the cliffs has a frequency value of 4 and an impact of 3.

Next, plotting is carried out on the risk map according to the frequency and impact values. So it was found that 5 out of 11 factors had a high level of risk, namely soil type, rainfall, slope, land use changes such as deforestation to become wetlands which caused erosion by surface water and caused the soil to become soft, and a drainage system on slopes that not good which causes the slope to become steeper due to scouring by the channel water on the cliff. Factors that have a low level of risk include land use, cutting of cliffs in rock mining on steep slopes, and development of areas that are not balanced with public awareness, so that the RUTR is not adhered to which ultimately harms itself.

Table 8 Risk Map

Risk Analysis Matrix 5x5			Impact Level				
			1	2	3	4	5
			Insignificant	Minor	Moderate	Significant	Very Significant
Possibility Level	5	Almost Certain			- Soil Type - Rainfall		
	4	Likely			- Land use changes - Poor Drainage System	- Slope	
	3	Possible	- Piling up landfills	- Cliff cutting - Land Development			
	2	Unlikely	- Construction Work	- Land Use			
	1	Very Unlikely			- Earthquake		

Tolerance Limit

Permanent countermeasures require time for careful investigation, analysis and planning. Slope failure prevention methods are divided into three categories, namely:

1. Reducing the forces that cause ground motion by:
   a. Surface water control
   b. Change slope geometry
2. Add forces that resist movement by:
   a. Control of seepage water
   b. Soil Nailing
   c. Stockpiling at the foot of the slope (contra load).
3. If the two methods above cannot overcome the failure of the slope that occurs then take other measures (stabilization, relocation, cross building and use of lightweight materials).

Based on archival analysis, the handling of landslides that have been carried out on the Riau Province National Road with points 1 and 2 above has been quite effective and reduced landslides, but in several locations such as the Riau Province-West Sumatra National Road which has a tendency for

landslides to repeat in different places. the same/adjacent require further study regarding the necessary handling.

CONCLUSION

For 5 factors that have a high level of risk, including soil type, rainfall, slope, changes in land use such as deforestation to become wetlands which cause erosion by surface water and cause the soil to become soft, and a drainage system on slopes that is not good which causes the slopes to become steeper as a result of being eroded by canal water on the cliffs, special attention and treatment is required to reduce the impact and frequency of landslides that occur due to these factors. Handling that can be done is in the form of reducing the forces that can cause ground movement, as well as adding forces that can restrain or slow down the movement of landslides. Thus, landslides can be anticipated and handled earlier.

Regarding the handling of landslides related to national roads that have a tendency to recur, it is recommended to carry out more detailed research using the Slope Inventory Survey, Slope Inspection Survey, and/or Detailed Survey to find out the causes of recurrence and their prevention and handling.

REFERENCES

Hardiyatmo, H.C. 2006. Mekanika Tanah I. Gadjah Mada University Press, Yogyakarta.

Nandi. Longsor. Jurusan Pendidikan Geografi. Bandung. FPIPS-UPI. 2007.

The National Disaster Management Agency Number 5/U365-170123/099/Ben-Indonesia/BNPB/31122022. 2022 Disaster Infographic.

Surat Edaran Menteri Pekerjaan Umum dan Perumahan Rakyat Nomor 04/SE/M/2021 tentang Pedoman Penerapan Manajemen Risiko

_____. 2004. Undang-Undang Republik Indonesia Nomor 38 Tahun 2004 Tentang Jalan. Pemerintah Republik Indonesia. Jakarta. 43 hlm

******