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# Prediction and mapping of landslide hazard in North Sumatera

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**ABSTRACT**

Mapping of landslide hazard in North Sumatera is very important to identify the areas potential. In this study we try to predict and mapping of landslide hazard in North Sumatera using scoring and GIS. Compare to the ground movement vulnerability and rainfall series, the areas with steep topography have landslide hazard forecasts, which are dominated by zones with medium hazard forecasts. High-level landslide hazard forecast maps are in the areas of South Tapanuli, Mandailing Natal, Humbang Hasundutan, Central Tapanuli, North Tapanuli, South Nias, West Nias, Padang Lawas, Toba Samosir, Langkat, Samosir, Pakpak Bharat, and Karo districts.



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## 1. INTRODUCTION

Mapping of Landslide Hazard might be a simple as map that uses the location of old landslides to indicate potential instability based on variability of rainfall, slope angle, soil type and level of earthquake. In this study we try to use rainfall series to predict the landslide at North Sumatera on June 2020.

Based on its topography, North Sumatra is divided into 3 (three) parts, namely the eastern part which is relatively flat, the middle part is wavy to hilly and the western part is a wavy plain [1], [2]. The East Coast region is a lowland area with fertile areas, high humidity with relatively high rainfall, so that floods and landslides often hit the area due to reduced forest conservation, erosion and silting of rivers [3], [4]. The highlands and the West Coast, which are mostly mountainous, have variations in soil fertility, climate, topography and contours as well as areas where the soil structure is unstable. Several lakes, rivers, waterfalls and volcanoes are found in this area and parts of it are recorded as areas of tectonic and volcanic earthquakes. The condition of the complex geological structure characterized by the shape of the hilly landscape, folded with faults, apart from being an earthquake pathway is also potential to cause landslides [5], [6].

Landslide or often called ground motion is a geological event that occurs due to the movement of masses of rock or soil to the valley through the sliding plane due to the gravity of the earth [7]. Factors that cause landslides other than high rainfall, slope factors, rock / soil characteristics, water content, vegetation, loads, cliff cutting are factors that can cause landslides [8].

North Sumatra has a high level of landslide vulnerability, especially in Nias, Mandailing Natal, North Tapanuli, South Tapanuli, Central Tapanuli, Toba Samosir, Labuhan Batu, Simalungun, Dairi, Karo,

Deli Serdang, Langkat, Nias Selatan districts, Humbang Hasundutan, Pakpak Bharat and Samosir [9]. So far, the danger of landslides can only be known in prone areas without knowing when landslides will occur so that the Deli Serdang Geophysical Station feels the need to create a landslide early warning system.

The task and function of determining the potential for landslide hazards is the authority of the Center for Volcanology for Mitigation and Geological Disaster (PVMBG) under the Ministry of Energy and Mineral Resources. BMKG only conducts further, more detailed analysis based on the landslide hazard map issued by the PVMBG.

## 2. RESEARCH METHOD

In this study, using the soil movement vulnerability zone map data from the PVMBG and the interpolation map of monthly rainfall forecast data for June 2020 in the North Sumatra region from the Sampali Climatology Station. For data processing and analysis methods using GIS software [10]. The steps taken in this study can be seen in the diagram in Figure 1.

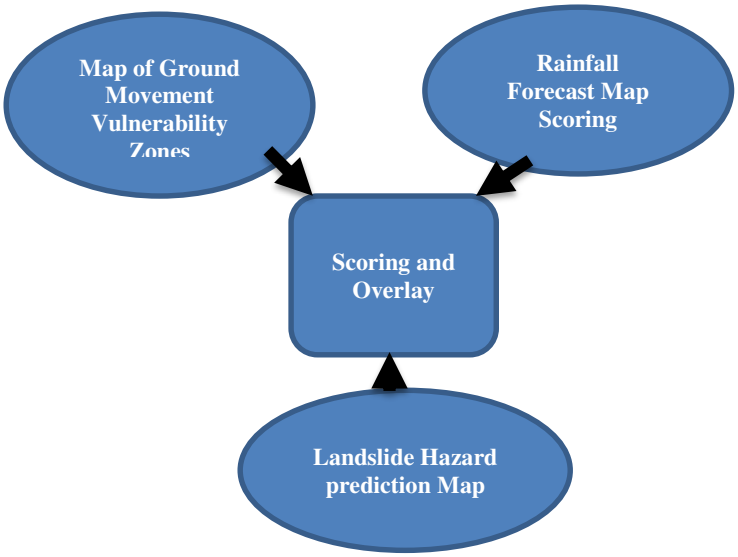


Figure 1. Mapping Flowchart

In the figure 1, provides a score on the map of the ground motion vulnerability zone. The higher the level of vulnerability the greater the score given. Interpolate rainfall data to produce a rainfall forecast map. Then the classification is carried out to provide a score for each area with different rainfall. The higher the rainfall the greater the score given. Overlay the soil movement vulnerability map and the rain forecast map. The results of the overlay are then analyzed to obtain a landslide hazard forecast map.

## 3. RESULTS AND DISCUSSION

In this study, information on the level of vulnerability of soil movement in the North Sumatra region to be hit by ground motion, so that areas that will experience ground movement problems such as landslides can be identified [11]. The soil vulnerability zone in this map is divided into 4 zones, namely the very low soil vulnerability zone, the low soil vulnerability zone, the medium soil vulnerability zone and the high soil vulnerability zone. The following table contains the scores for each ground motion susceptibility zone.

Table 1. Scoring of Ground Movement Vulnerability Zones

| Zone | Score |
|---|---|
| Very Low | 1 |
| Low | 2 |
| Midle | 3 |

| | |
|---|---|
| High | 4 |

This map contains monthly rainfall forecast information for June 2020 to find out the estimated monthly rainfall in the North Sumatra region from district to sub-district level. The zone for forecasting monthly rainfall in this map is divided into 4 zones, namely low rainfall forecast zone, medium rainfall forecast zone, high rainfall forecast zone and very high rainfall forecast zone. The distribution of the zone of the monthly rainfall forecast for June 2020 can be seen in more detail in Figure 2.

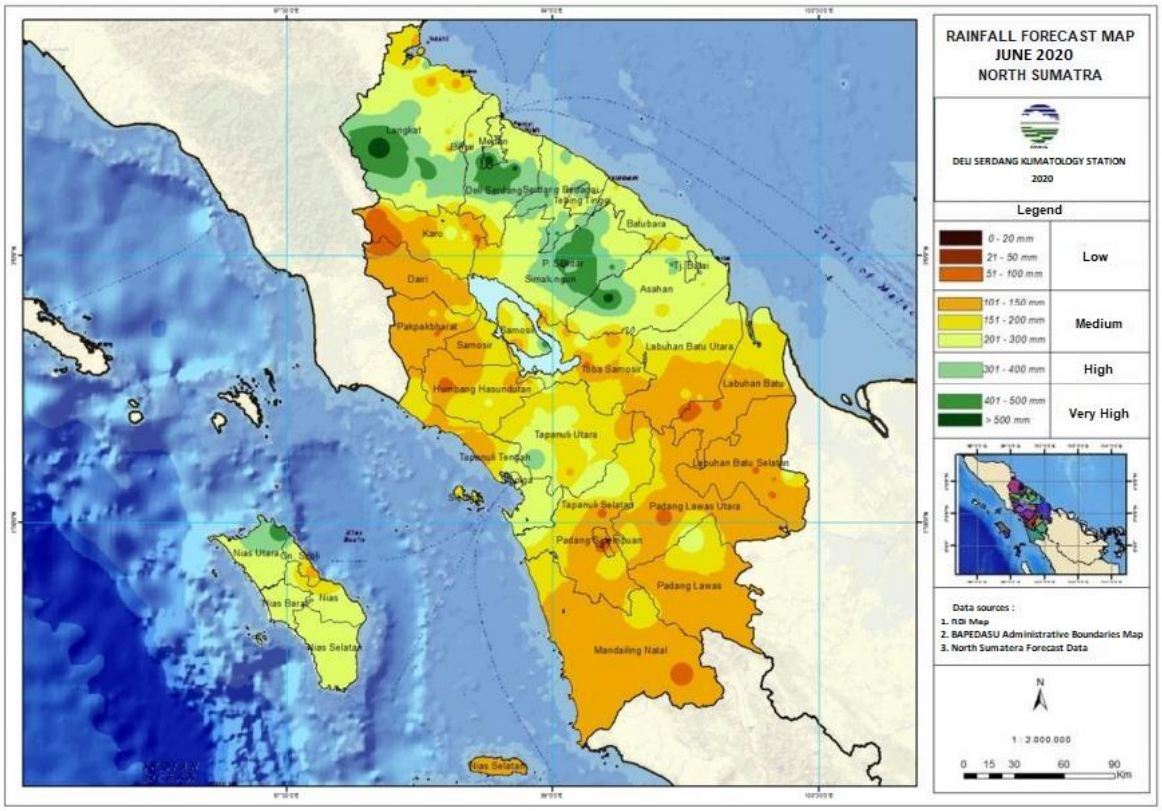


Figure 2. Rainfall Forecast Map for June 2020 in North Sumatra

The following table contains the scores for each zone of the rainfall forecast

Table 2. Rainfall Forecast Zone Scoring

| Zone | Score |
|---|---|
| Low | 1 |
| Medium | 2 |
| High | 3 |
| Very High | 4 |

This map is the result of an overlay (merging process) of the mobile soil vulnerability zone map and the monthly rainfall forecast map for June 2020. This aims to identify areas of North Sumatra that are potentially hazardous to landslides. Landslide hazards in this study are divided into three classes of hazard levels, namely low, medium and high levels. Map of landslide hazard estimates in the North Sumatra region can be seen in more detail in Figure 3.

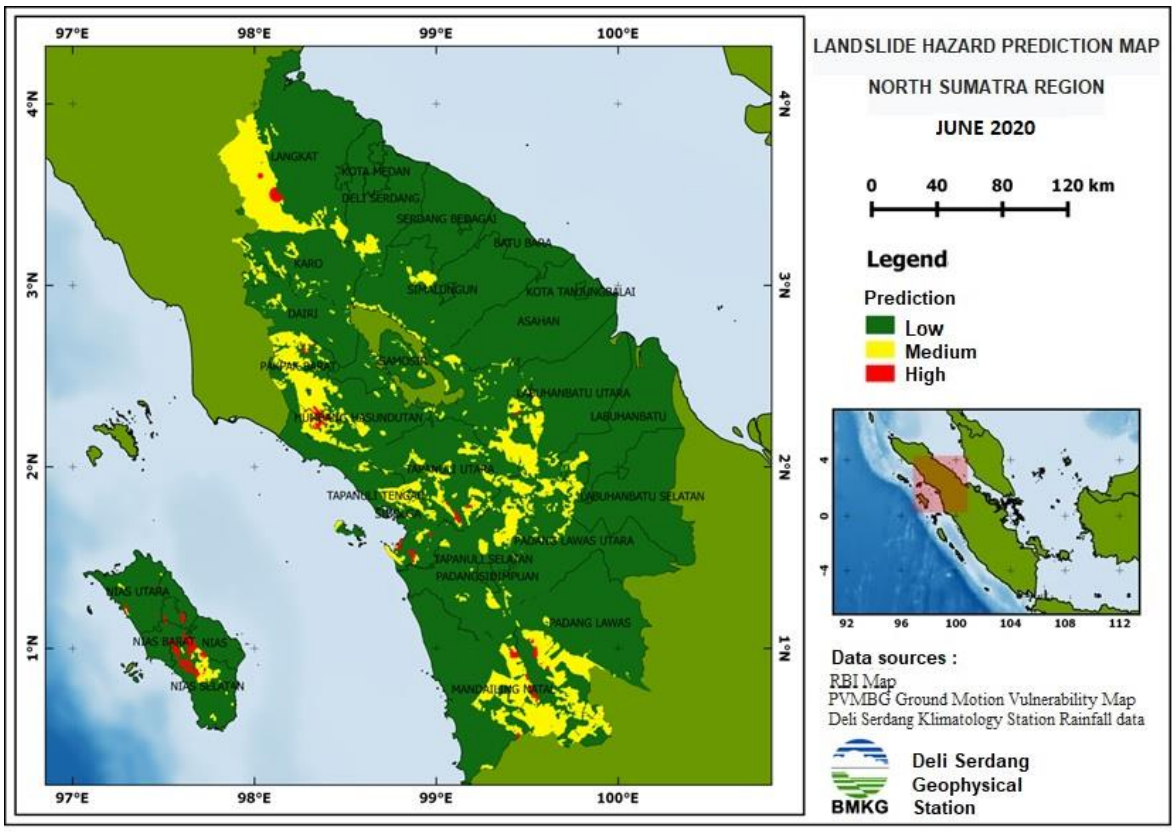


Figure 3. Landslide Hazard prediction Map for June 2020

In the landslide hazard prediction map above, green areas have low landslide potential because they are areas with flat to sloping topography. Areas in yellow are areas with moderate potential for landslides. This area has a steep topography but due to low rainfall forecasts, it has the potential for medium level landslide hazards. The area in red has a steep topography and a high rainfall forecast so that it is included in the high potential landslide hazard forecast.

Table 3. Areas with high landslide potential in June 2020

| Sub-District | District | Sub-District | District | Sub-District | District | Sub-District | District |
|---|---|---|---|---|---|---|---|
| STM HULU | DELI SERDANG | PUNCAK SOROK MARAPI | MANDAILING NATAL | UMBUNASI | NIAS SELATAN | SAYUR MATINGGI | TAPANULI SELATAN |
| PAKKAT | HUMBANG HASUNDUTAN | RANTO BAEK | MANDAILING NATAL | AFULU | NIAS UTARA | SIPIROK | TAPANULI SELATAN |
| PARLILITAN | HUMBANG HASUNDUTAN | SIABU | MANDAILING NATAL | ALASA | NIAS UTARA | BADIRI | TAPANULI TENGAH |
| POLLUNG | HUMBANG HASUNDUTAN | TAMBANGAN | MANDAILING NATAL | NAMOHALU ESIWA | NIAS UTARA | KOLANG | TAPANULI TENGAH |
| TARABINTANG | HUMBANG HASUNDUTAN | BOTOMUZOI | NIAS | BARUMUN | PADANG LAWAS | LUMUT | TAPANULI TENGAH |
| BARUS JAHE | KARO | HILISERANGKAI | NIAS | SOSA | PADANG LAWAS | PINANGSORI | TAPANULI TENGAH |
| BATANG SERANGAN | LANGKAT | MAU | NIAS | DOLOK | PADANG LAWAS UTARA | SITAHUIS | TAPANULI TENGAH |
| BOHOROK | LANGKAT | SOMOLO-MOLO | NIAS | PADANG BOLAK JULU | PADANG LAWAS UTARA | TAPIAN NAULI | TAPANULI TENGAH |
| BATANG NATAL | MANDAILING NATAL | ULUGAWO | NIAS | KERAJAAN | PAKPAK BARAT | TUKKA | TAPANULI TENGAH |
| BUKIT MALINTANG | MANDAILING NATAL | LOLOFITU MOI | NIAS BARAT | SALAK | PAKPAK BARAT | ADIAN KOTING | TAPANULI UTARA |
| HUTA BARGOT | MANDAILING NATAL | MANDREHE | NIAS BARAT | SITELLU TALI URANG JEHE | PAKPAK BARAT | GAROGA | TAPANULI UTARA |
| KOTANOPAN | MANDAILING NATAL | MANDREHE UTARA | NIAS BARAT | SIANJUR MULAMULA | SAMOSIR | PAHAE JAE | TAPANULI UTARA |
| MUARA SIPONGI | MANDAILING NATAL | ULU MARO O | NIAS BARAT | SITIO-TIO | SAMOSIR | PAHAE JULU | TAPANULI UTARA |
| NAGA JUANG | MANDAILING NATAL | AMANDRAYA | NIAS SELATAN | SIPISPIS | SERDANG BEDAGAI | PANGARIBUAN | TAPANULI UTARA |
| PAKANTAN | MANDAILING NATAL | GOMO | NIAS SELATAN | AEK BILAH | TAPANULI SELATAN | PURBATUA | TAPANULI UTARA |
| PANYABUNGAN | MANDAILING NATAL | HILIMEGAI | NIAS SELATAN | ANGKOLA SELATAN | TAPANULI SELATAN | SIMANGUMBAN | TAPANULI UTARA |
| PANYABUNGAN BARAT | MANDAILING NATAL | LOLOMATUA | NIAS SELATAN | ARSE | TAPANULI SELATAN | SIPAHUTAR | TAPANULI UTARA |
| PANYABUNGAN SELATAN | MANDAILING NATAL | LOLOWAU | NIAS SELATAN | BATANG ANGKOLA | TAPANULI SELATAN | TARUTUNG | TAPANULI UTARA |
| PANYABUNGAN UTARA | MANDAILING NATAL | MAZO | NIAS SELATAN | SAIPAR DOLOK HOLE | TAPANULI SELATAN | BORBOR | TOBA SAMOSIR |
| | | | | | | NASSAU | TOBA SAMOSIR |

Based on the processing results, high-level landslide hazard forecast maps are in the areas of South Tapanuli, Mandailing Natal, Humbang Hasundutan, Central Tapanuli, North Tapanuli, South Nias, West Nias, Padang Lawas, Toba Samosir, Langkat, Samosir, Pakpak Bharat and Karo. The distribution of areas with high and medium landslide potential in June 2020 can be seen in table 3 and Table 4.

Table 4. Areas with medium landslide potential in June 2020

| Sub-District | District |
|---|---|
| AEK SONGSONGAN | ASAHAN |
| BANDAR PASIR MANDOGE | ASAHAN |
| BERAMPU | DAIRI |
| GUNUNG SITEMBER | DAIRI |
| LAE PARIRA | DAIRI |
| PARBULUAN | DAIRI |
| PEGAGAN HILIR | DAIRI |
| SIDIKALANG | DAIRI |
| SIEMPAT NEMPU HILIR | DAIRI |
| SILAHI SABUNGAN | DAIRI |
| SILIMA PUNGGA-PUNGGA | DAIRI |
| SITINJO | DAIRI |
| TANAH PINEM | DAIRI |
| TIGALINGGA | DAIRI |
| GUNUNG MERIAH | DELI SERDANG |
| KUTALIMBARU | DELI SERDANG |
| SIBOLANGIT | DELI SERDANG |
| STM HILIR | DELI SERDANG |
| STM HULU | DELI SERDANG |
| DOLOKSANGGUL | HUMBANG HASUNDUTAN |
| ONAN GANJANG | HUMBANG HASUNDUTAN |
| PAKKAT | HUMBANG HASUNDUTAN |
| PARANGINAN | HUMBANG HASUNDUTAN |
| PARLILITAN | HUMBANG HASUNDUTAN |
| POLLUNG | HUMBANG HASUNDUTAN |
| SIJAMAPOLANG | HUMBANG HASUNDUTAN |
| TARABINTANG | HUMBANG HASUNDUTAN |
| BARUS JAHE | KARO |
| JUHAR | KARO |
| KUTABULUH | KARO |
| LAUBALENG | KARO |
| MARDINDING | KARO |
| MERDEKA | KARO |
| MEREK | KARO |
| MUNTE | KARO |
| TIGABINANGA | KARO |

| Sub-District | District |
|---|---|
| BILAH BARAT | LABUHANBATU |
| RANTAU SELATAN | LABUHANBATU |
| RANTAU UTARA | LABUHANBATU |
| SUNGAI KANAN | LABUHANBATU SELATAN |
| AEKNATAS | LABUHANBATU UTARA |
| KUALUH HULU | LABUHANBATU UTARA |
| KUALUH SELATAN | LABUHANBATU UTARA |
| NA IX-X | LABUHANBATU UTARA |
| BATANG SERANGAN | LANGKAT |
| BESITANG | LANGKAT |
| BOHOROK | LANGKAT |
| KUALA | LANGKAT |
| KUTAMBARU | LANGKAT |
| SALAPIAN | LANGKAT |
| SEI BINGAI | LANGKAT |
| SEI LEPAN | LANGKAT |
| BATAHAN | MANDAILING NATAL |
| BATANG NATAL | MANDAILING NATAL |
| BUKIT MALINTANG | MANDAILING NATAL |
| HUTA BARGOT | MANDAILING NATAL |
| KOTANOPAN | MANDAILING NATAL |
| LINGGA BAYU | MANDAILING NATAL |
| MUARA BATANG GADIS | MANDAILING NATAL |
| MUARA SIPONGI | MANDAILING NATAL |
| NAGA JUANG | MANDAILING NATAL |
| NATAL | MANDAILING NATAL |
| PAKANTAN | MANDAILING NATAL |
| PANYABUNGAN | MANDAILING NATAL |
| PANYABUNGAN BARAT | MANDAILING NATAL |
| PANYABUNGAN SELATAN | MANDAILING NATAL |
| PANYABUNGAN TIMUR | MANDAILING NATAL |
| PANYABUNGAN UTARA | MANDAILING NATAL |
| PUNCAK SORIK MARAPI | MANDAILING NATAL |
| RANTO BAEK | MANDAILING NATAL |
| SIABU | MANDAILING NATAL |
| TAMBANGAN | MANDAILING NATAL |
| ULU PUNGKUT | MANDAILING NATAL |

| Sub-District | District |
|---|---|
| ULUGAWO | NIAS |
| LOLOFITU MOI | NIAS BARAT |
| AMANDRAYA | NIAS SELATAN |
| FANAYAMA | NIAS SELATAN |
| GOMO | NIAS SELATAN |
| LAHUSA | NIAS SELATAN |
| LOLOMATUA | NIAS SELATAN |
| LOLOWAU | NIAS SELATAN |
| MANIAMOLO | NIAS SELATAN |
| MAZO | NIAS SELATAN |
| SUSUA | NIAS SELATAN |
| TOMA | NIAS SELATAN |
| UMBUNASI | NIAS SELATAN |
| AFULU | NIAS UTARA |
| LAHEWA | NIAS UTARA |
| LAHEWA TIMUR | NIAS UTARA |
| SITOLU ORI | NIAS UTARA |
| TUHEMBERUA | NIAS UTARA |
| BARUMUN | PADANG LAWAS |
| BATANG LUBU SUTAM | PADANG LAWAS |
| SOSA | PADANG LAWAS |
| SOSOPAN | PADANG LAWAS |
| ULU BARUMUN | PADANG LAWAS |
| BATANG ONANG | PADANG LAWAS UTARA |
| DOLOK | PADANG LAWAS UTARA |
| DOLOK SIGOMPULON | PADANG LAWAS UTARA |
| HALONGONAN | PADANG LAWAS UTARA |
| HULU SIHAPAS | PADANG LAWAS UTARA |
| PADANG BOLAK | PADANG LAWAS UTARA |
| PADANG BOLAK JULU | PADANG LAWAS UTARA |
| KERAJAAN | PAKPAK BARAT |
| PAGINDAR | PAKPAK BARAT |
| PERGETTENG-GETTENG SENGKUT | PAKPAK BARAT |
| SALAK | PAKPAK BARAT |
| SIEMPAT RUBE | PAKPAK BARAT |
| SITELLU TALI URANG JEHE | PAKPAK BARAT |
| SITELLU TALI URANG JULU | PAKPAK BARAT |

| Sub-District | District |
|---|---|
| TINADA | PAKPAK BARAT |
| HARIAN | SAMOSIR |
| NAINGGOLAN | SAMOSIR |
| ONANRUNGGU | SAMOSIR |
| PALIPI | SAMOSIR |
| PANGURURAN | SAMOSIR |
| RONGGUR NIHUTA | SAMOSIR |
| SIANJUR MULAMULA | SAMOSIR |
| SIMANINDO | SAMOSIR |
| SITIO-TIO | SAMOSIR |
| SIPISPIS | SERDANG BEDAGAI |
| DOLOK PARDAMEAN | SIMALUNGUN |
| DOLOK SILAU | SIMALUNGUN |
| GIRSANG SIPANGAN B | SIMALUNGUN |
| HARANGGAOL HORISON | SIMALUNGUN |
| HATONDUHAN | SIMALUNGUN |
| JORLANG HATARAN | SIMALUNGUN |
| PANOMBEAN PANEI | SIMALUNGUN |
| PEMATANG SILIMAHUT | SIMALUNGUN |
| PURBA | SIMALUNGUN |
| RAYA | SIMALUNGUN |
| RAYA KAHEAN | SIMALUNGUN |
| SIDAMANIK | SIMALUNGUN |
| SILAU KAHEAN | SIMALUNGUN |
| SILIMAKUTA | SIMALUNGUN |
| AEK BILAH | TAPANULI SELATAN |
| ANGKOLA BARAT | TAPANULI SELATAN |
| ANGKOLA SELATAN | TAPANULI SELATAN |
| ANGKOLA TIMUR | TAPANULI SELATAN |
| ARSE | TAPANULI SELATAN |
| BATANG ANGKOLA | TAPANULI SELATAN |
| BATANG TORU | TAPANULI SELATAN |
| SAIPAR DOLOK HOLE | TAPANULI SELATAN |
| SAYUR MATINGGI | TAPANULI SELATAN |
| SIPIROK | TAPANULI SELATAN |
| BADIRI | TAPANULI TENGAH |
| KOLANG | TAPANULI TENGAH |

| Sub-District | District |
|---|---|
| LUMUT | TAPANULI TENGAH |
| MANDUAMAS | TAPANULI TENGAH |
| PANDAN | TAPANULI TENGAH |
| PASARIBU TOBING | TAPANULI TENGAH |
| PINANGSORI | TAPANULI TENGAH |
| SARUDIK | TAPANULI TENGAH |
| SIBABANGUN | TAPANULI TENGAH |
| SIRANDORUNG | TAPANULI TENGAH |
| SITAHUIS | TAPANULI TENGAH |
| SOSORGADONG | TAPANULI TENGAH |
| TAPIAN NAULI | TAPANULI TENGAH |
| TUKKA | TAPANULI TENGAH |
| ADIAN KOTING | TAPANULI UTARA |
| GAROGA | TAPANULI UTARA |
| MUARA | TAPANULI UTARA |
| PAHAE JAE | TAPANULI UTARA |
| PAHAE JULU | TAPANULI UTARA |
| PANGARIBUAN | TAPANULI UTARA |
| PARMONANGAN | TAPANULI UTARA |
| PURBATUA | TAPANULI UTARA |
| SIATAS BARITA | TAPANULI UTARA |
| SIMANGUMBAN | TAPANULI UTARA |
| SIPAHUTAR | TAPANULI UTARA |
| SIPOHOLON | TAPANULI UTARA |
| TARUTUNG | TAPANULI UTARA |
| AJIBATA | TOBA SAMOSIR |
| BALIGE | TOBA SAMOSIR |
| BONATUA LUNASI | TOBA SAMOSIR |
| BORBOR | TOBA SAMOSIR |
| HABINSARAN | TOBA SAMOSIR |
| LAGUBOTI | TOBA SAMOSIR |
| LUMBAN JULU | TOBA SAMOSIR |
| NASSAU | TOBA SAMOSIR |
| PARMAKSIAN | TOBA SAMOSIR |
| PINTU POHAN MERANT | TOBA SAMOSIR |
| SIANTAR NARUMONDA | TOBA SAMOSIR |
| SILAEN | TOBA SAMOSIR |
| TAMPAHAN | TOBA SAMOSIR |
| ULUAN | TOBA SAMOSIR |

During June 2020, a landslide incident was recorded in Hurase Village, Batang Angkola District, South Tapanuli Regency, as published on the online media Metro24.co which explained that the landslide incident occurred on Wednesday night, June 3, 2020 after heavy rain. After analyzing the Batang Angkola Subdistrict, it is included in the zone which is predicted to have a high landslide hazard potential.

Personel Polres Tapsel dan warga bersihkan pohon tumbang dan tanah longsor. (reza/metro24.co)

Figure 4. Landslide incident in Batang Angkola District (Metro24, 2020)

## 4. CONCLUSION

Based on the results of the study of landslide hazard forecasts in June 2020, the areas with steep topography have landslide hazard forecasts, which are dominated by zones with medium hazard forecasts. High-level landslide hazard forecast maps are in the areas of South Tapanuli, Mandailing Natal, Humbang Hasundutan, Central Tapanuli, North Tapanuli, South Nias, West Nias, Padang Lawas, Toba Samosir, Langkat, Samosir, Pakpak Bharat, and Karo districts. The distribution pattern of the landslide hazard prediction area has the same pattern as the distribution pattern of the rainfall forecast area.

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