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Vulnerability Analysis of Landslide Disaster in Nagari Sungai Pinang, Sungai Nyalo and Mandeh, XI Tarusan District, South Coastal District

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ABSTRACT

Natural disasters are disasters caused by events or a series of events caused by nature, including earthquakes, tsunamis, volcanic eruptions, floods, droughts, hurricanes, and landslides. Landslide is a phenomenon that causes vertical movement of the ground surface, especially in sloped areas and often causes property and even life losses. The condition of vulnerability to landslides can be supported by natural factors such as rainfall, geological conditions, soil types, and slopes as well as factors that can come from nature with human intervention such as land cover. The combination of anthropogenic factors and natural factors is basically the main cause of the emergence of this level of landslide vulnerability so that it is important to design mitigation efforts, both preventive and repressive, by analyzing the potential for landslide disasters that may arise in an area. One of the steps to support this problem is to provide an overview related to disaster vulnerability analysis supported by the appearance of data information from the results of GIS processing (Geographical Information System). This research focused on 3 (three) nagari areas including the Sungai Pinang, Sungai Nyalo, and Mandeh. The results of the initial description of the research area based on regional characteristics from secondary data used related to information on slope, soil type, geology, land use, and rainfall as a reference, each of which has a role that is interrelated with one another. The result found that, the parametric overlay by GIS that been used produce a description of the analysis that the level of vulnerability to landslides in the Nagari Sungai Pinang, Sungai Nyalo, and Mandeh areas is at the moderate to high level. The landslide susceptibility level starts from very low, low, medium, high, and very high levels, respectively, in the percentages of 1.30%, 6.24%, 42.93%, 41.74%, and 7.80%.

Keywords: Natural disasters, landslide vulnerability, GIS, parametric overlay

1. INTRODUCTION

Landslides are very common in Indonesia, especially during the rainy season, one of which is in Pesisir Selatan Regency. This is supported by the finding that there are many changes in land use so that the supporting factors that support the minimum potential for landslides in an area are reduced. The combination of anthropogenic factors and natural factors is the main cause of the emergence of this level of landslide vulnerability so that it is important to design mitigation efforts, both preventive and repressive, by analyzing the potential for landslide disasters that may arise in an area.

As we can observe so far, the planning of the Regional Spatial Plan (RTRW) and regional development planning rarely considers landslide susceptibility factors. This can have an impact on the destruction of the development order, loss of life, and even the emergence of other disasters. Pesisir Selatan Regency is one area that can be seen to have experienced a very significant land conversion due to the opening of natural tourism vehicles, especially around the Mandeh area. During the survey conducted in the field, many landslides were found with small to large dimensions and tend to be

close together and cause damage to infrastructure, damage to land structure, and even disrupt the activities of the surrounding community. The factors causing the occurrence of these landslides are in terms of slope aspects, geological conditions, rainfall, land cover, and also the type of soil.

Law no. 24 of 2007 concerning Disaster Management in chapter 1 general provisions, article 1, paragraph 1 explains that a disaster is an event or series of events that threatens and disrupts people's lives and livelihoods either due to natural factors and/or non-natural factors as well as environmental factors. resulting in human casualties, environmental damage, property losses, and psychological impacts. In paragraph 2 it is explained that natural disasters are disasters caused by events or a series of events caused by nature, including earthquakes, tsunamis, volcanic eruptions, floods, droughts, hurricanes, and landslides.

According to Coburn A W (1991) natural disaster is an event or series of events that can result in casualties and/or damage, loss of material, infrastructure, essential services, or means of life on a scale that is beyond normal capacity. This natural disaster is essentially a form of phenomenon caused by nature due to triggering factors both from nature itself and humans so that it has a detrimental impact.

The National Disaster Management Agency (BNPB) states that landslides are a form of soil or rock mass movement, or the mixing of the two down or out of the slope position and results in the balance of the soil or rock making up the slope. Brook et al (1991) define landslide as a phenomenon of the mass movement of soil, rock, and rock and soil debris that occurs instantly and moves towards the lower slope and is controlled by gravity and slides from the top of the impermeable layer that is saturated with water, resulting in landslides. It can also be referred to as a result of soil erosion.

From the understanding of landslides, it can be concluded that this landslide is a phenomenon that causes vertical movement of the ground surface, especially in sloped areas and often causes property and even life losses. The condition of vulnerability to landslides can be supported by natural factors such as rainfall, geological conditions, soil types, and slopes as well as factors that can come from nature with human intervention such as land cover.

Various efforts to minimize and prevent landslides have started to be carried out, but even so, these disasters continue to appear, especially in the rainy season. One of the steps to support this problem is to provide an overview related to disaster vulnerability analysis supported by the appearance of data information from the results of GIS processing (Geographical Information System). In conducting this analytical research, it is important to follow the rules and rules that apply properly so that the research results obtained are true. The validity of these results is needed to show the degree of accuracy or suitability between the data and what actually happened to the object studied in the field. To obtain data directly in a study is difficult to do, therefore for the data that has been obtained and collected previously it is important to know its validity by including testing the reliability and objectivity of what is in the field.

Related to the alignment of the previous background formulation, the formulation of the problem to be studied can be determined as follows: (1) What are the characteristics of the landslide potential land in Nagari Sungai Pinang, Sungai Nyalo, and Mandeh in Koto XI Tarusan District, Pesisir Selatan Regency? (2) What factors are the main causes of the level of vulnerability to landslides in the research area? (3) What are the potential hazards in the research area?

2. EXPERIMENTAL

This type of research used to analyze the level of vulnerability to landslides in the Nagari Sungai Pinang, Sungai Nyalo, and Mandeh areas using quantitative and qualitative research methods. Quantitative research according to Sugiyono (2017) is defined as a research method based on the philosophy of positivism and is used to examine certain populations or samples where the data collection used is related to research instruments, statistical data analysis with the aim of testing predetermined hypotheses. Qualitative research in this study is based on the results of the calculation of the area and the application of the scoring method on the results of mathematical data calculations.

Next is the qualitative method which refers to the opinion of Afifuddin (2009), is a method used to examine natural objects where the researcher is the core instrument, data collection techniques are carried out in combination, the data analysis is inductive, and the results of the research emphasize more meaning versus generalization. This qualitative section examines the perspectives on various types of land use change, at least carried out by direct observation in the research area. The analytical techniques used in this study include:

a) Scoring Technique

This technique is one way of finding the value leading to the highest number of vulnerability points by scoring each parameter value used with the aim of being able to show the level of vulnerability of the land under study.

Factors analyzed for vulnerability to landslides in Nagari Sungai Pinang, Sungai Nyalo, and Mandeh are seen from the combination of values for rainfall levels, soil types, geological conditions, land cover, and slopes with the following scoring class provisions:

A. Lereng		
Kelas lereng	**Skor**	**Bobot**
< 8 %	1	15%
8 – 15%	2	
15 – 25 %	3	
25 – 45	4	
> 45%	5	

B. Curah Hujan		
Curah Hujan Tahunan	**Skor**	**Bobot**
<1.000	1	30%
1.000 – 2.000	2	

2.000 -2.500	3	
2.500 – 3.000	4	
> 3.000	5	

C. Jenis Tanah		
Kelas lereng	**Skor**	**Bobot**
Tidak peka terhadap erosi	1	20%
Agak peka terhadap erosi	2	
Kurang peka terhadap erosi	3	
Peka terhadap erosi	4	
Sangat peka terhadap erosi	5	

D. Geologi		
Kelas lereng	**Skor**	**Bobot**
Alluvial	1	20%
Bahan sedimen lapuk	2	
Bahan vulkanik	3	
Bahan vulkanik mengalami pelapukan ringan	4	
Batuan vulkanik sebagian besar telah mengalami pelalpukan	5	

E. Tutupan Lahan		
Kelas lereng	**Skor**	**Bobot**
Hutan vegetasi lebat/badan air	1	15%
semak belukar	2	
Kebun campuran dan lading	3	
Perkebunan dan sawah irigasi	4	
Kawasan permukiman /terbangun	5	

So the provisions of the scoring formula are:

Score = (15% x slope class factor + (30% x rainfall class factor) + (20% x geology) + (20% x soil type class factor) + (15% x land use))

The results of the study found the range of landslide susceptibility in the Nagari Sungai Pinang, Sungai Nyalo, and Mandeh areas as follows:

Range Result Value = minimum value – maximum value (sum of scores)

= 1.9 – 4.15

= 2.25

So that the landslide susceptibility class is determined as many as 5 layers with a range:

= 2.25 : 5

= 0.45

Described in the following table:

Rentang Nilai	Tingkatan Kerentanan Longsor
1.90-2.35	Sangat Rendah
2.36-2.80	Rendah
2.81-3.25	Sedang
3.26-3.70	Tinggi
3.71-4.15	Sangat Tinggi

b) Descriptive Analysis Techniques

Descriptive analysis technique refers to the opinion of Sugiyono (2017) is an analysis by describing or describing the data that has been collected previously as it is without intending to make conclusions that apply generatively. The choice of this technique was based on the research objective, namely to analyze the characteristics of the land areas in the 3 (three) Nagari which are the research areas related to the level of vulnerability to landslides.

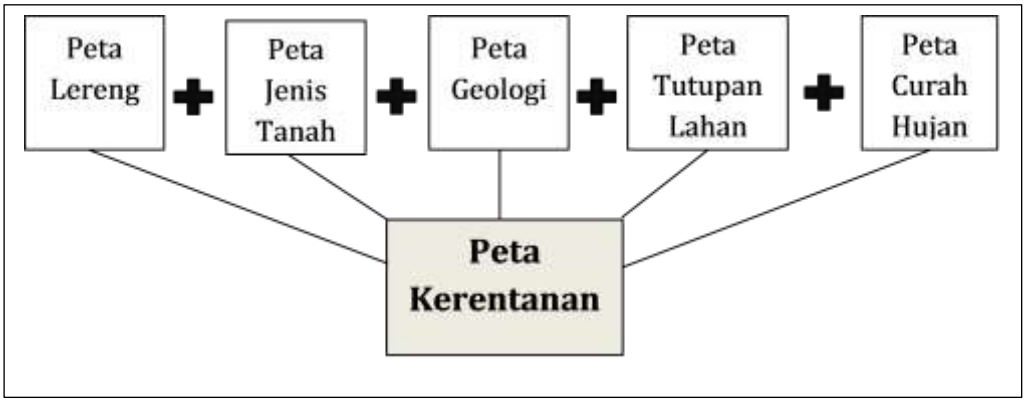
The three Nagari areas which are the research areas can be seen to have a steep to flat topography, which is indicated by the closeness between the morphology of the hills around the coastal area. To explain how the level of vulnerability to landslides in the three Nagari area is, a descriptive analysis technique is needed so that the results given can be explained in a fundamental way on the data that has been obtained and processed previously.

c) Mapping Spatial Analysis Techniques

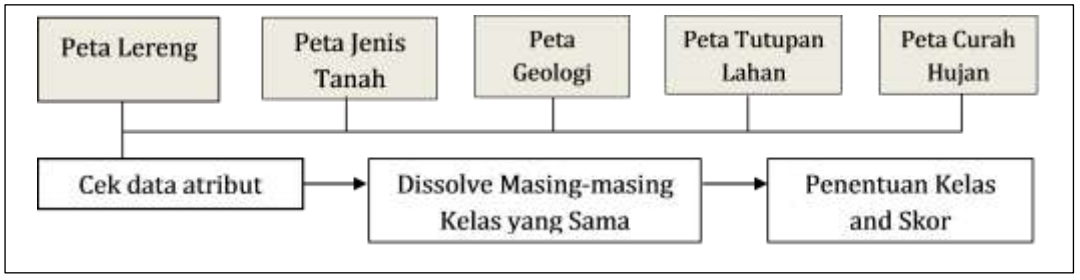
Spatial analysis technique is an approach in the study of geography and also the study of disciplines related to it. This technique shows the correlation between the dynamics of the interrelationships of various phenomena in an earth's space so that it is in accordance with the opinion of Schaefer (1953) which states that spatial science is related to the formulation of laws governing the spatial distribution of certain functions on the earth's surface. Spatial analysis technique is a form of technique used to process GIS data (Geographic Information System) so that the results will depend on the location or place where the object is studied.

Some of the functions of the spatial analysis used in this study, citing the opinion of Eddy Prahasta (2009), include Reclassify (Reclassification), namely the activity of reclassifying a data so that it eventually becomes a new form of spatial data and is based on certain attribute criteria. Furthermore, Overlay, which is a functionality technique that produces a new layer of spatial data from a combination of several previous spatial data so that the resulting output is a combination of at least two layers that are combined. And the last

is Digital Image Processing to assess the intensity of the distribution in spatial space. The data processing scheme carried out is related to the Overlay function along with the parameter data used, namely:



The technical process carried out is first done by checking the attributes by looking at the description of each parameter before it is classified according to its similarity. This class determination also includes affixing a predetermined score to the research instrument. The score obtained is then inputted and undergoes several overlay processes in layers so that after that, the same data is merged and the value is determined according to the provisions of the scoring analysis formula. This score class will later be classified as a vulnerability level according to the weight class score after it is dissolved and then categorized. The flow of data processing vulnerability of this landslide disaster, namely:



This method directly describes how the interrelationships between the variables used affect each other so as to produce the final value of vulnerability for the combination of the determined scores. The combined variables are ordered from the lowest layer concerned with the lithosphere, anthropo-biosphere, to the atmosphere.

3. RESULTS AND DISCUSSION

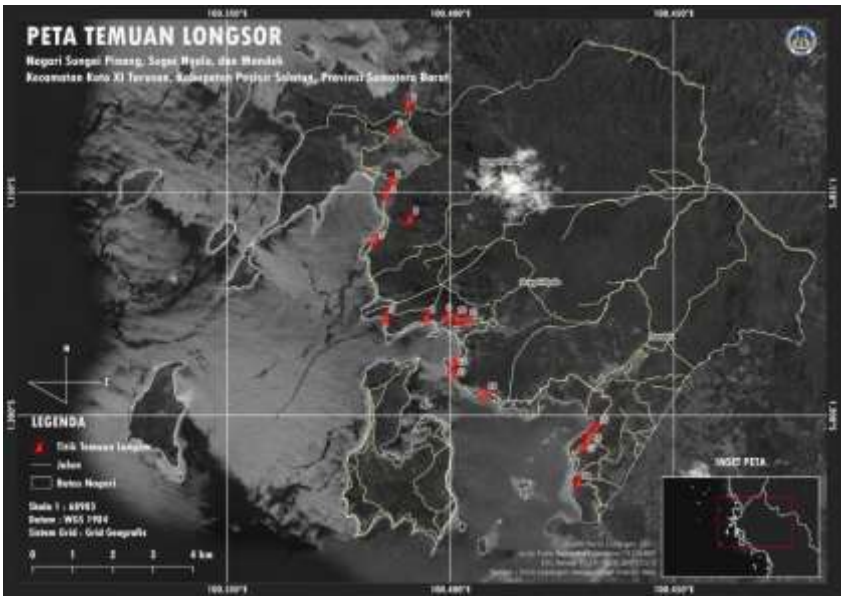
Pesisir Selatan Regency is a Regency located on the southernmost part of the west coast of West Sumatra Province, more precisely at 0°57'31.21" - 2°28'42.32" South Latitude and 100°17'48.64" - 101°17'34.3" East Longitude (BPS, 2021). Pesisir Selatan Regency has an area of approximately 5749.89 km2 with a population of approximately 420,000 people. This district has a mountainous topography with an altitude ranging from 0-1000 m above sea level, has 57 islands, is fed by 18 rivers, including 11 large rivers and 7 small rivers. Pesisir Selatan Regency has a tropical climate with temperatures in the range of 23° – 32° Celsius during the day, and 20o – 28o Celsius at night.

Meanwhile, the overall rainfall for Pesisir Selatan Regency in a monthly average is 224.63 mm/month. The condition of land cover in Pesisir Selatan Regency today is dominated by dense forest as much as 70.54 percent, 13.37% shrub forest, 6.07% rice fields, 2.30% plantations, and the rest are villages, mixed gardens, and other people's gardens scattered in the villages. district village. Pesisir Selatan Regency has 15 sub-districts, one of which is Koto XI Tarusan District.

Koto XI Tarusan District is located in the northernmost part of Pesisir Selatan Regency, more precisely at 100.19' - 100.34'7" East Longitude and 0.59' - 1.17'30" South Latitude. This district consists of several nagari, namely: Siguntua, Taratak Sungai Lundang, Barung-Barung Balantai Selatan, Barung-Barung Balantai, Barung-Barung Balantai, Duku, North Duku, Batu Empty, Batu Hampa Selatan, Nanggalo, Kapuh Utara, Kapuh , Sungai Rawa, Taluak Raya, Pansua Village, Ampang Pulai, Karam Island, Carocok Anau, Mudik Aia, Mandeh, Sungai Nyalo, and Sungai Pinang and covers an area of about 7.7% of the total area of Pesisir Selatan Regency.

In this research related to the level of vulnerability to landslides, it is focused on 3 (three) nagari areas including the Sungai Pinang, Sungai Nyalo, and Mandeh. The results of the initial description of the research area based on regional characteristics from secondary data used related to information on slope, soil type, geology, land use, and rainfall as a reference, each of which has a role that is interrelated with one another. In plain view, the slopes in the three research nagari areas have complex levels ranging from flat, sloping, slightly steep, steep, and very steep areas. For the geological parameters used, it was found that the Nagari Sungai Pinang, Sungai Nyalo, and Mandeh areas contain alluvium (qal) and oligo-miocene volcanic rocks (tomp) where their presence dominates the three research areas. In terms of soil type, it is classified that the three nagari areas studied have soils of alluvial type, weathered sediments, and volcanics with mild weathering. The land cover in the research area was identified as covered by shrubs, swamp scrub, secondary dry land forest, secondary swamp forest, settlements, dry land agriculture, mixed dry land agriculture, rice fields, and open land. Meanwhile, the results of calculating data obtained from BMKG, the average rainfall in this area reaches 2500-3000 which is categorized into a relatively high class.

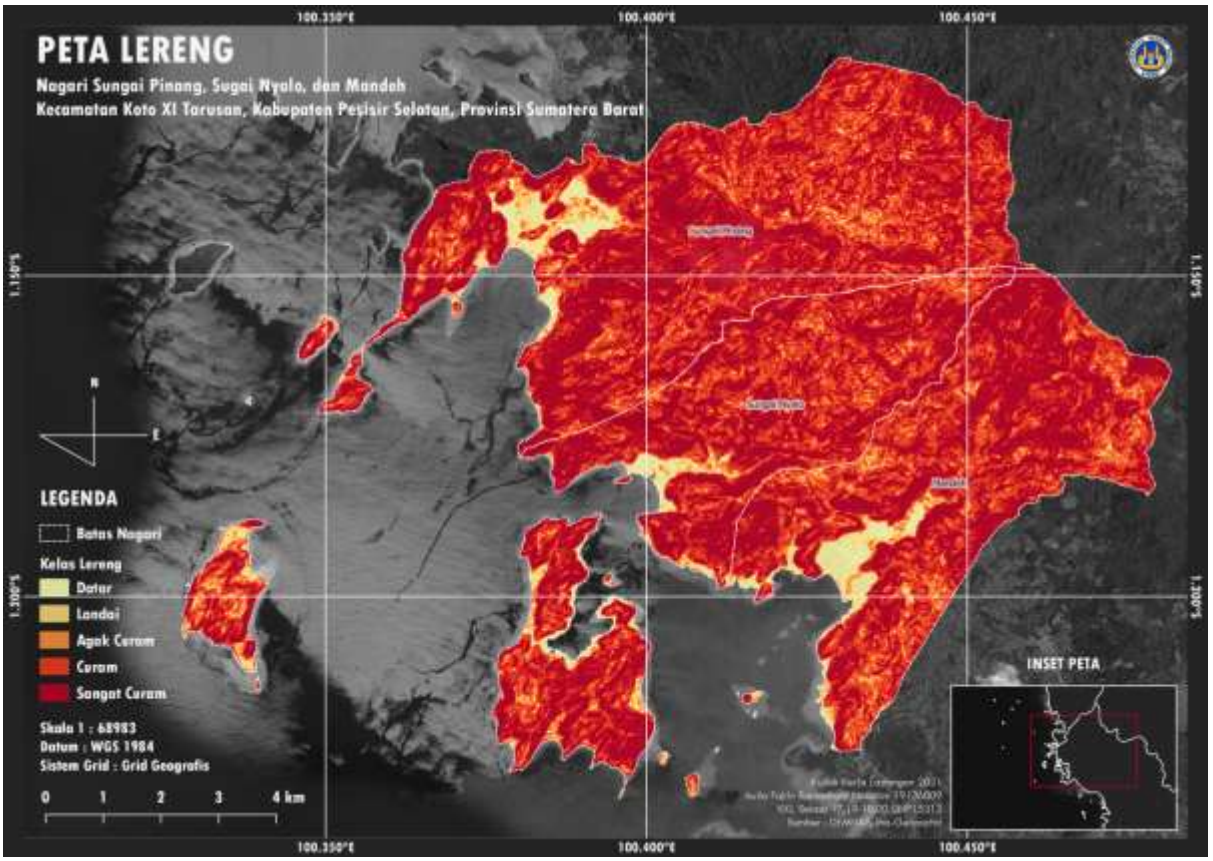
A. Landslide Finding



The landslide finding point above was obtained from the results of a field survey where the data obtained was recorded using the Avenza Map application. These landslide points are mostly found around roads which are certainly very dangerous for the surrounding community because transportation access is very close to contact the area where there is damage caused by this event. From the results of field monitoring, it is indicated that these avalanches are caused by the conversion of land which was originally a land covered with vegetation to become an access road where on the right and left sides are dredging so that it is very vulnerable to potential erosion that triggers landslides in the area.

B. Slope

Turangan (2019) argues that the slope is a form of surface that connects the higher ground surface with the lower ground level. There are three types of slopes, namely natural slopes, man-made slopes, and embankment slopes. Usually in every case where the soil surface tends to be steep, the gravity component is heavier and can trigger the movement of the soil mass, especially if there are no elements that can support the weight of the soil, such as for woody vegetation, or man-made concrete walls. Slope refers more to the ratio between the difference in height and distance and even the slope of the surface angle, in this case the ground surface.



Lereng	Kemiringan	Skor	Luas (Ha)	Persentase
0-8%	Datar	1	496.72	5.68%
8-15%	Landai	2	530.61	6.07%
15-25%	Agak Curam	3	1088.54	12.45%
25-45%	Curam	4	3118.03	35.66%
> 45%	Sangat Curam	5	3509.13	40.14%

It was found that the land in the three nagari areas studied had a slope class which was dominated by very steep land, which was 40.13% followed by a steep grade of 35.66%. If analyzed from the map, it can be clearly seen that land with a safe slope, which is flat to gentle, only has a small area of coverage and is usually part of the area inhabited by the community.

Such topographic appearances can be justified because the Nagari Sungai Pinang, Sungai Nyalo, and Mandeh areas consist of hilly areas and even stretch areas around the coast. From the map observation, the area that has land with a flat slope is occupied by the areca river area, as well as the

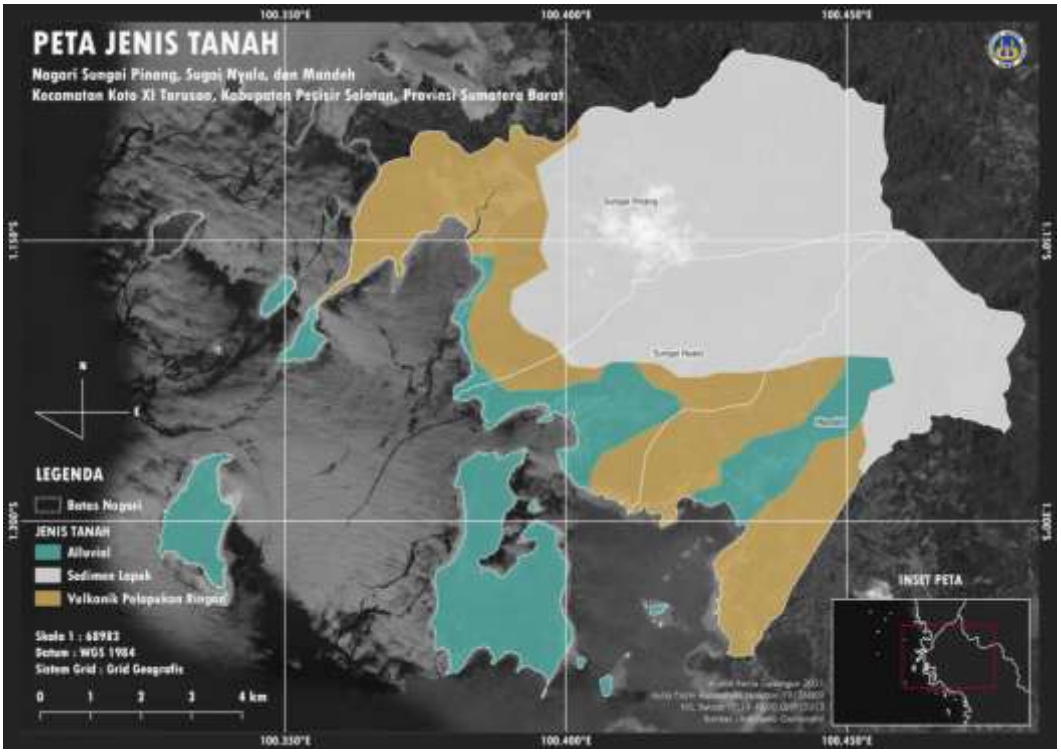
very steep land criteria. Meanwhile, the second position is in the Mandeh region, followed by the Sungai Nyalo area.

C. Soil Type

Soil type is basically a form of soil taxonomic unit described in science. Soil types are usually the result of soil classification based on certain properties, in accordance with Blum's opinion (2018) where he states that every soil has a set of definition of certain properties which form a distinctive feature.

Soil type can determine the level of resistance to erosion. For example, there are several types of soil that are sensitive to erosion. Soil properties that affect runoff and erosion are part of the infiltration capacity and erodibility of the soil. This infiltration is closely related to how water can seep into the soil (mm/hour). Arsyad (1980) suggested that coarse-textured or sandy soils have a much higher capacity and rate of infiltration, as well as soils with fine-sand textures because the soil grains are said to be easily carried by water. Erodability is the sensitivity of the soil to the power of being destroyed and washed away by rain water, which according to Kartasapoetra and Sutedjo (1991) if the erodability of the soil is high, it means that the soil is sensitive and easily eroded, and vice versa.

Examples of soil types that are sensitive to erosion include inceptisols which are undergoing development because they have a fairly high level of erodability related to their structure. The resistance of the soil itself to erosion is also influenced by its location related to the slope, the cover, to the rock structure.



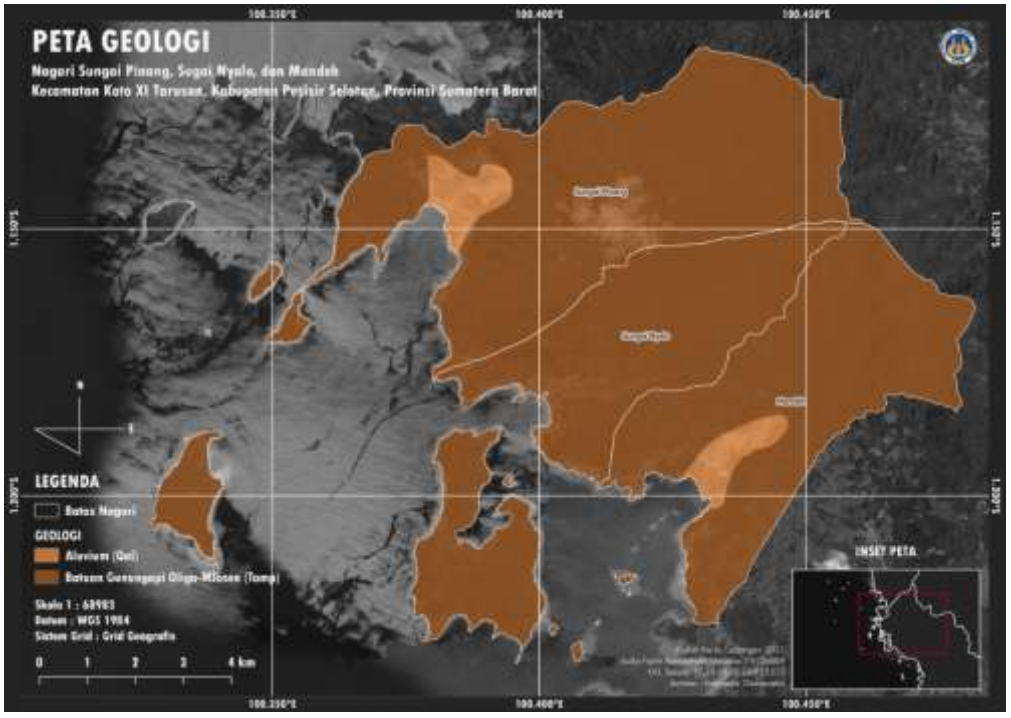
The type of soil found in the research area consists of Alluvial soil, Weathered sediment, and also Volcanic with light weathering. From the analysis of the processed data, Alluvial soil types which

are characterized by not sensitive to erosion with a score of 1 are found in areas that tend to be sloping to flat due to their proximity to the upstream area of the river and also to the coast. As for the soil type of sediment with weathered properties so that it is somewhat sensitive to the presence of erosion. Weathered sedimentary soil type has the most dominant percentage compared to other soil types found in the research area, which is 51.44% and is located in an inland area with a hilly topography.

Jenis	Keterangan Tanah	Skor	Luas (Ha)	Persentase
Alluvial	Tidak Peka	1	1854.45	21.09%
Sedimen Lapuk	Agak Peka	2	4522.86	51.44%
Vulkanik Pelapukan Ringan	Peka	4	2414.61	27.46%

D. Geological Conditions

Geological conditions discuss the properties and materials that make up the earth, its structure, and the processes that occur in its dynamics. In discussing the geological conditions of the Nagari, the research area places more emphasis on rock formations.

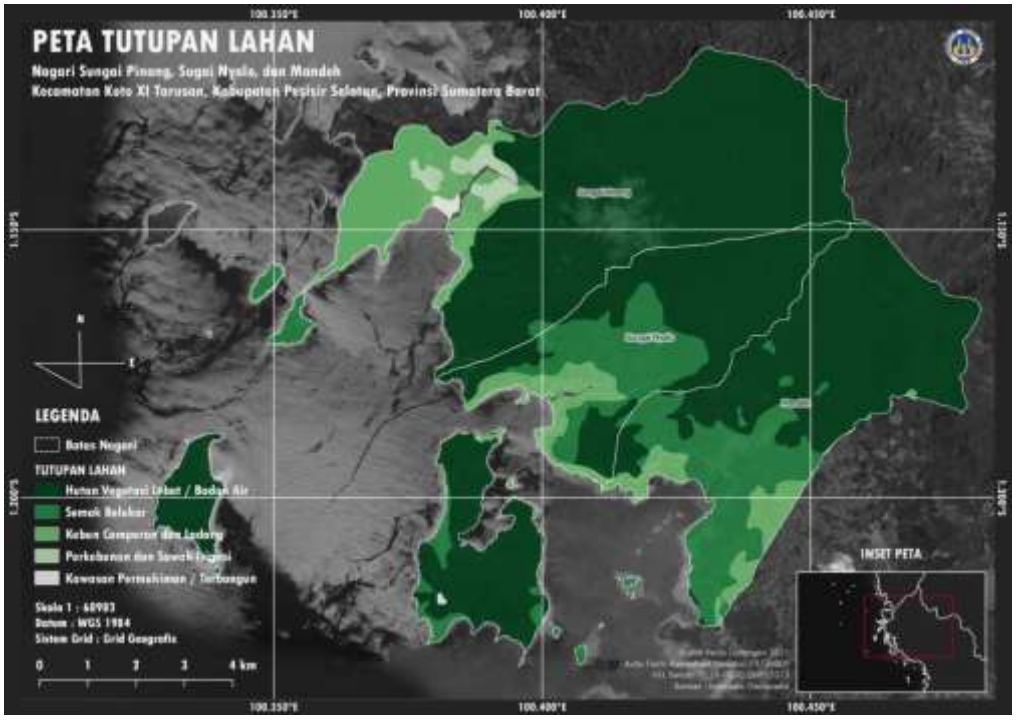


Based on the information contained in the map, the research area is dominated by two rock formations, namely Alluvium (Qa) which is a coastal alluvium material and volcanic rocks of Oligo-Miocene (Tomp) age which dominate the area as much as 95.87% or equivalent to 8444.53 Ha. For the Mandeh and Sungai Pinang areas, the presence of Alluvium rock types is supported by the presence of two large river upstreams in the vicinity, while for the Sungai Nyalo area there is no Alluvium rock type but is fully dominated by Oligo-Miocene volcanic rock types. Details of the area and percentage of the geological part of the research area can be observed from the following table:

Jenis Batuan	Skor	Luas (Ha)	Persentase
Alluvium (Qa)	1	363.67	4.13%
Gunungapi Oligo-Miosen (Tomp)	4	8444.53	95.87%

D. Land Cover

Land cover is a form of physical appearance on the earth's surface that describes the dynamics between natural phenomena and social phenomena. In line with the opinion of Liang (2008), land cover serves as a provider of information for modeling purposes and to understand natural phenomena that occur in a scope of the earth's surface.



From the observations of secondary data used, land cover in the research area consists of secondary dry land forest, secondary swamp forest, shrubs, swamp scrub, dry land agriculture, mixed dry land agriculture, rice fields, settlements, and open land. These nine land covers are then categorized based on predetermined class categories related to the characteristics and dynamics that occur in the land cover space.

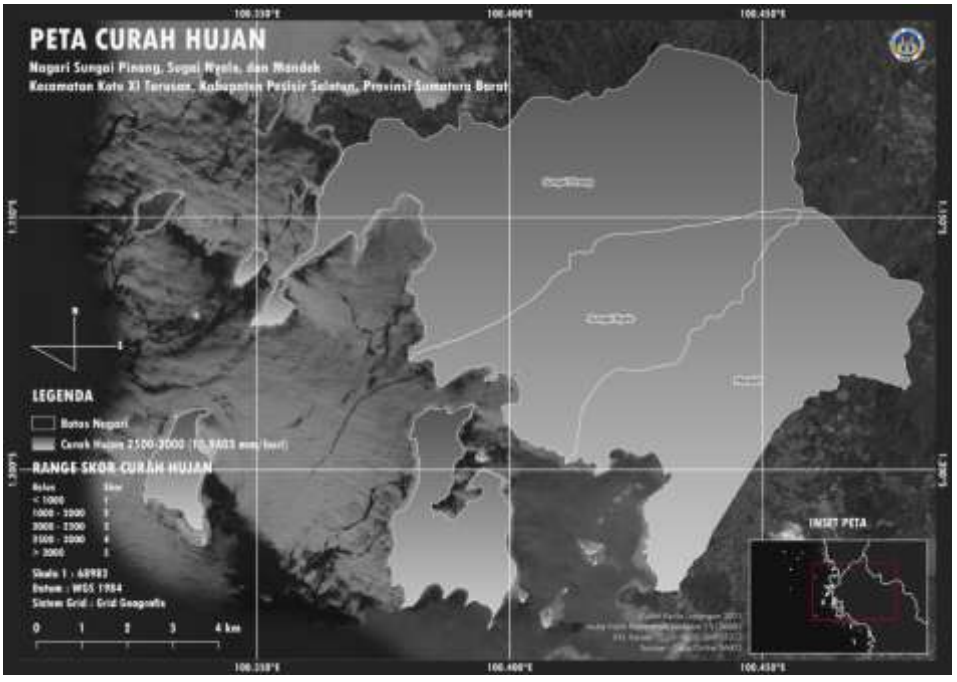
The results of the area calculation show that Nagari Sungai Pinang, Sungai Nyalo, and Mandeh are dominated by 72% of secondary dry forest land cover which is included in the category of dense vegetation forest/water body. The class category with the lowest percentage of cover is in the residential/built area category, which is 0.20%. However, the results of observations made in the field show that the presence of landslides is actually very close to built-up areas such as roads and open land around it. It is certain that even though it is represented by a small percentage, supported by other parameter factors, not to mention the maturity of good development planning, this small percentage

actually contributes greatly to the potential for landslides to occur in the location of the built-up area on a sloped area.

Tutupan Lahan	Skor	Kategori Kelas	Luas (Ha)	Persentase	
Hutan Lahan Kering Sekunder	1	Hutan Vegetasi Lebat / Badan Air	6535.09	72%	72.06%
Hutan Rawa Sekunder	1	Hutan Vegetasi Lebat / Badan Air	5.4	0.06%	
Belukar	2	Semak Belukar	1434.39	15.8%	15.92%
Belukar Rawa	2	Semak Belukar	11.07	0.12%	
Pertanian Lahan Kering	3	Kebun Campuran dan Ladang	954.48	10.5%	10.25%
Pertanian Lahan Kering Campur	3	Kebun Campuran dan Ladang	21.83	0.24%	
Sawah	4	Perkebunan dan Sawah Irigasi	96.18	1.06%	1.06%
Permukiman	5	Kawasan Permukiman / Terbangun	15.64	0.17	0.20%
Lahan Terbuka	5	Kawasan Permukiman / Terbangun	2.67	0.03	

E. Rainfall

In line with what was explained in the previous section on soil type parameters, rainfall also plays a major role in the occurrence of landslides. Hasnawir (2012) argues that the characteristics of rain that trigger landslides are used to obtain the relationship between rainfall and landslides, including shallow landslides.



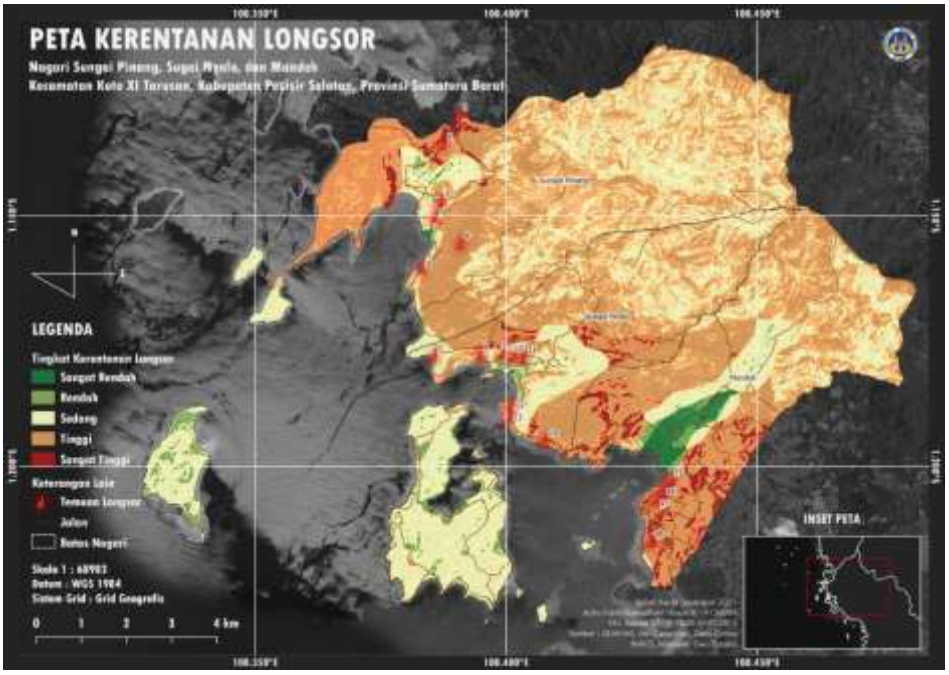
In the study area, one level of rainfall class was found with a score of 4, which is around 2500-3000 mm/year with a 100% evenly distributed percentage, this category of rainfall is included in

the high level. With these findings, the description of the driving factors that refer to the possibility of a high level of vulnerability to landslides will be correlated in a straight line as well.

Curah Hujan	Skor	Luas (Ha)	Persentase
2500-3000	4	8811.19	100%

F. Three Nagari Landslide Vulnerability Level

Regarding the several parameters used in the analysis of landslide susceptibility in Nagari Sungai Pinang, Sungai Nyalo, and Mandeh, it was found that 5 (five) vulnerability levels were very low, low, medium, high, and very high spread throughout the research area.



The overlay results as a whole describe that the vulnerability to landslides in the Nagari Sungai Pinang, Sungai Nyalo, and Mandeh areas tends to be at a moderate to high level. The medium level of vulnerability reached an area percentage of 42.93% and then followed by the dominance of a high vulnerability level of 41.74%. For the low to very low level of vulnerability, it has a fairly small percentage, more precisely at the level of 7.54% of the total area of the research area. To find out the details of the area in hectares and also the percentage of each class can be seen in the following table and graph:

Rentang Nilai	Tingkat Kerentanan	Luas (Ha)	Persentase
1.90 - 2.35	Sangat Rendah	117.43	1.30%
2.36 - 2.80	Rendah	568.17	6.24%
2.81 - 3.25	Sedang	3907.43	42.93%
3.26 - 3.70	Tinggi	3799.12	41.74%

3.71 - 4.15	Sangat Tinggi	709.96	7.80%

The findings of landslide points in each nagari that were taken as samples were on average in areas with moderate to very high potential, but a small portion were also found in areas with low potential.

1. Nagari Sungai Pinang Landslide Vulnerability

In Nagari Sungai Pinang, the landslide finding points are at a moderate to very high level of vulnerability where at each level it is represented by the findings of two samples.

Nagari Sungai Pinang		
Titik Temuan	**Tingkat Kerawanan Kawasan Temuan**	**Ketinggian Lokasi (mdpl)**
1	Sangat Tinggi	38
2	Sangat Tinggi	8
3	Sedang	7
4	Sedang	42
5	Tinggi	35
6	Tinggi	9

Based on the results of the calculation of the area in hectares and the percentage especially in the Nagari Sungai Pinang area, the level of vulnerability to landslides is at a moderate level with an area percentage of 48.5% followed by high level vulnerability of 36.34% of the total area.

Luas Kawasan Rentan Longsor Nagari Sungai Pinang		
Tingkat Kerentanan	**Luas (Ha)**	**Persentase**
Sangat Rendah	6.54	0.14%
Rendah	388.78	8.008%
Sedang	2354.39	48.5%

Tinggi	1764.3	36.34%
Sangat Tinggi	340.71	7.02%

2. Landslide Vulnerability of Nagari Sungai Nyalo

Landslide findings for the Nagari Sungai Nyalo area are slightly different where there are two samples of findings located in low-risk areas. This is because in this low area the land cover is less able to support the soil mass. The other findings were in the moderate area as much as two points, and the most dominating was in the area with a high level of vulnerability at eight, twelve, thirteen, and fourteen finding points.

Nagari Sungai Nyalo		
Titik Temuan	**Tingkat Kerawanan Kawasan Temuan**	**Ketinggian Lokasi (mdpl)**
7	Sedang	65
8	Tinggi	15
9	Rendah	26
10	Rendah	12
11	Sedang	11
12	Tinggi	44
13	Tinggi	19
14	TInggi	8

In the calculation of the area of landslide-prone areas in Nagari Sungai Nyalo, no land with very low potential was found, and in fact the landslide-prone area was dominated by a high level of vulnerability as much as 46.71%.

Luas Kawasan Rentan Longsor Nagari Sungai Nyalo		
Tingkat Kerentanan	**Luas (Ha)**	**Persentase**
Sangat Rendah	0	0%
Rendah	77.61	4.44%
Sedang	778.23	44.45%
Tinggi	817.81	46.71%
Sangat Tinggi	77.38	4.41%

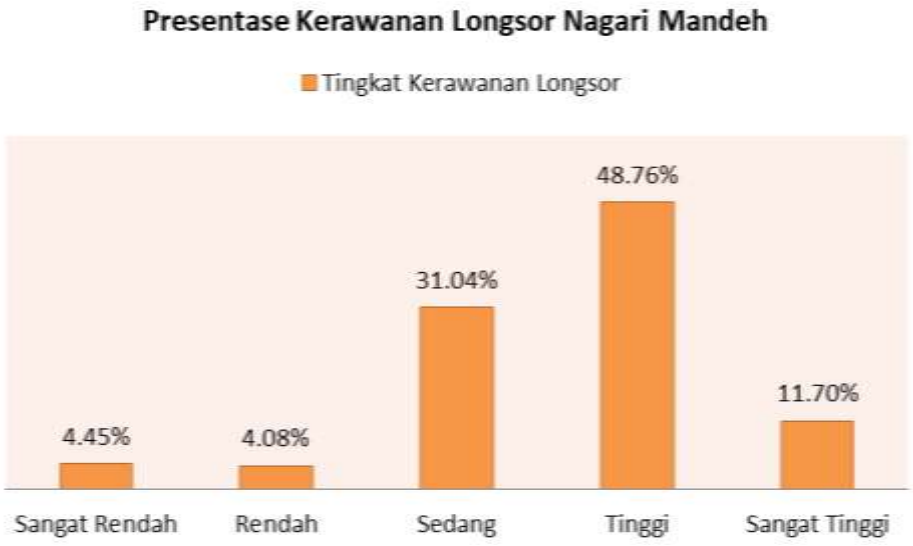
3. Landslide Vulnerability of Nagari Mandeh

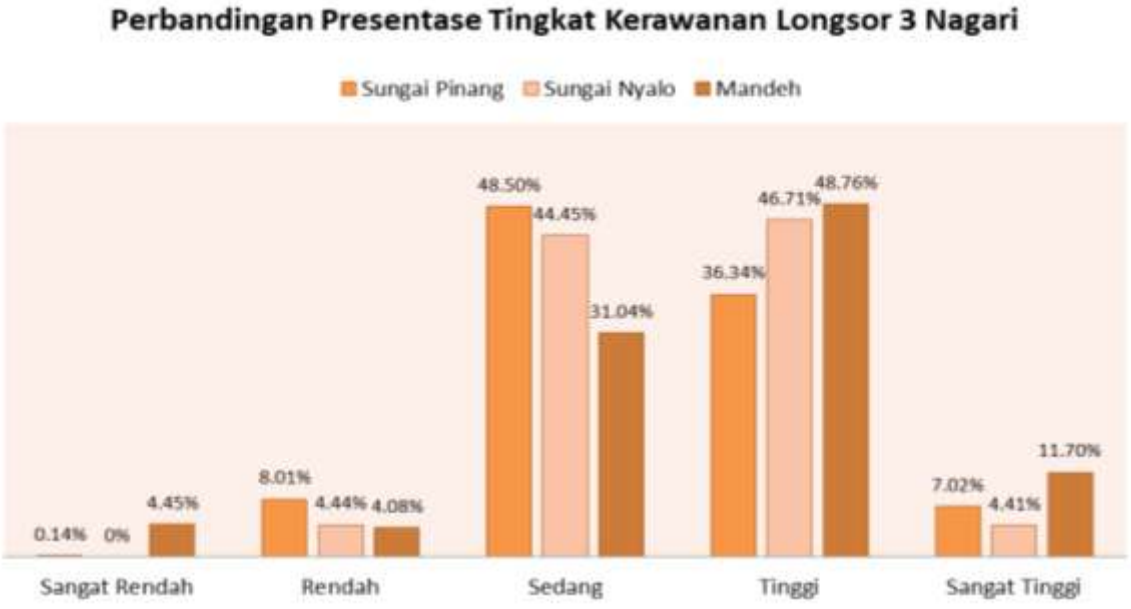
The landslide susceptibility level in Nagari Mandeh is at the right level in relation to the four sample points found in the area with a high to very high level of vulnerability with a balanced distribution.

Nagari Mandeh		
Titik Temuan	**Tingkat Kerawanan Kawasan Temuan**	**Ketinggian Lokasi (mdpl)**
15	Sangat Tinggi	9
16	Tinggi	34
17	Tinggi	50
18	Sangat Tinggi	35

Landslide vulnerability in Nagari Mandeh which is more dominant is at a high level with a percentage of 48.76%, and a low to very low level at 8.53% where in this area is dominated by residential land use to rice fields and plantations which tend to be sloping to flat.

Luas Kawasan Rentan Longsor Nagari Mandeh		
Tingkat Kerentanan	**Luas (Ha)**	**Persentase**
Sangat Rendah	110.9	4.45%
Rendah	101.8	4.078%
Sedang	774.81	31.04%
Tinggi	1216.99	48.76%
Sangat Tinggi	291.87	11.70%





4. CONCLUSION

Nagari Sungai Pinang, Sungai Nyalo, and Mandeh areas in Koto XI District basically have a topography that tends to be hilly, supported by the existence of Bukit Barisan crossings in the area. Slope conditions in this research area can be said to be very complex, starting from the presence of gently sloping land to very steep. There are three types of soil in the research area including alluvial, weathered sediment, and volcanic with light weathering where the largest percentage is weathered sediment. The geology of Nagari Sungai Pinang, Sungai Nyalo, and Mandeh consists of Alluvium (Qa) rock formations as well as Oligo-Miocene (Tomp) volcanic rocks. The land cover in the research area consisted of secondary dry land forest, secondary swamp forest, shrubs, swamp scrub, dry land agriculture, mixed dry land agriculture, rice fields, settlements, and open land. Furthermore, in the research area, it was found that one level of rainfall class was around 2500-3000 mm/year with a percentage of 100% evenly, this category of rainfall was included in the high level level. The results of the parametric overlay used produce a description of the analysis that the level of vulnerability to landslides in the Nagari Sungai Pinang, Sungai Nyalo, and Mandeh areas is at a moderate to high level. The landslide susceptibility level starts from very low, low, medium, high, and very high levels, respectively, in the percentages of 1.30%, 6.24%, 42.93%, 41.74%, and 7.80%. The Nagari Sungai Pinang area has landslide findings at three levels of areas prone to landslides, namely two points at a medium level location, two points at a high level location, and two points at a very high level so that the distribution tends to be balanced. Meanwhile, for the Sungai Nyalo area, the landslide finding points are spread across three classes of vulnerability, namely low, medium, to high where the dominant area is the area with high vulnerability as much as 46.71%. The Nagari Mandeh area has four landslide points found in areas with a high to very high level of vulnerability. The landslide vulnerability in Nagari Mandeh which is more dominant is at a high level with a percentage of 48.76%. It can be said that the characteristics of potential landslides in Nagari Sungai Pinang, Sungai Nyalo, and Mandeh in the District of Koto XI Tarusan, Pesisir Selatan Regency are influenced by factors related to slope, soil type, geological structure, land cover, and rainfall. The linear landslide susceptibility level is shown in a straight line based on the calculation results with the total being sorted from very low to very high. If the level of landslide susceptibility found in the three nagari landscapes that are the area under study is ignored, it can have an impact in the form of damage to public facilities, as evidenced by the location of landslides around the road. Furthermore, the danger that can be caused is the emergence of fatalities due to accidents due to damage to facilities due to landslides or due to direct landslides. The failure of the facility development strategy also contributed

to the occurrence of landslides around the research area due to inequality in providing efforts to avoid this landslide disaster.

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