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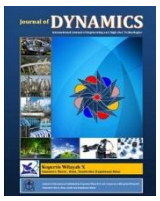


# Slope Analysis Based on SRTM Digital Elevation Model Data: Study Case on Rokan IV Koto Area and Surrounding


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## Abstract

The level of slope influenceed by the condition of the rocks beneath the surface. On high level of slopes, amount of surface runoff and water transport energy is also enlarged. This caused by greater gravity, in line with the surface tilt from the horizontal plane. In other words, topsoil eroded more and more. When the slope becomes twice as steep, then the amount of erosion per unit area be 2.0 - 2.5 times more (Arsyad, 2000). The area of study are include in Rokan IV Koto area that can be accessed through the road from Ujung Batu City toward west up to Banjar Datar village. Based on SRTM data obtained, the roads in study area has a minimum elevation of + 80 m and a maximum + 545 m. Rugged road conditions with slope ranging from 2 ° to 47.84 ° causing this area having potential of landslides. The purpose of this study is to map the locations that have fairly steep slopes and potential landslides.



**Keywords**: slope, SRTM, landslide, erosion.


## 1. Introduction

Slopes Stability are affected against rock conditions beneath the surface. At high slope level, the amount of flow, and energy of water transport, is also enlarged. This is due to the increasing in gravity, in line with the tilted soil layerfrom horizontal plane. In other words, eroding topsoil will get increase. As it becomes wider twice as steep, the amount of erosion per unit area increase 2.0 to 2.5 times [1]. The research area is located at the Rokan IV Koto subdistrict which has various slope, so there are several locations that have slope level from flat to steep.

## 2. Regional Geology

The Rokan IV Koto area and its surroundings is consist of several formations beneath its surface and the geological structure that forms the current topographic conditions [2].

Based on the Geological Map of Lubuk Sikaping Sheet (1983) NS Rock, DT Aldiss, JA Aspden, MCG Clarke, A. Djunuddin, et al mentions that the constituent rock formations in the study area consist of Sihapas Formation composed by quartz sandstone, carbonaceous flakes, conglomerate; Then the younger formation is the Telisa Formation of carbonaceous to calcareous silt, silty sandstone and shale, conglomerate, limestone and glauconitic shale (Fig. 2).

The geological condition of the study area was also formed due to the india-australia plate-induced forces against Eurasia, which resulted highlands on with trends from southeast western [3]. The structural patterns formed were anticline and sinklin folds extending north-west.

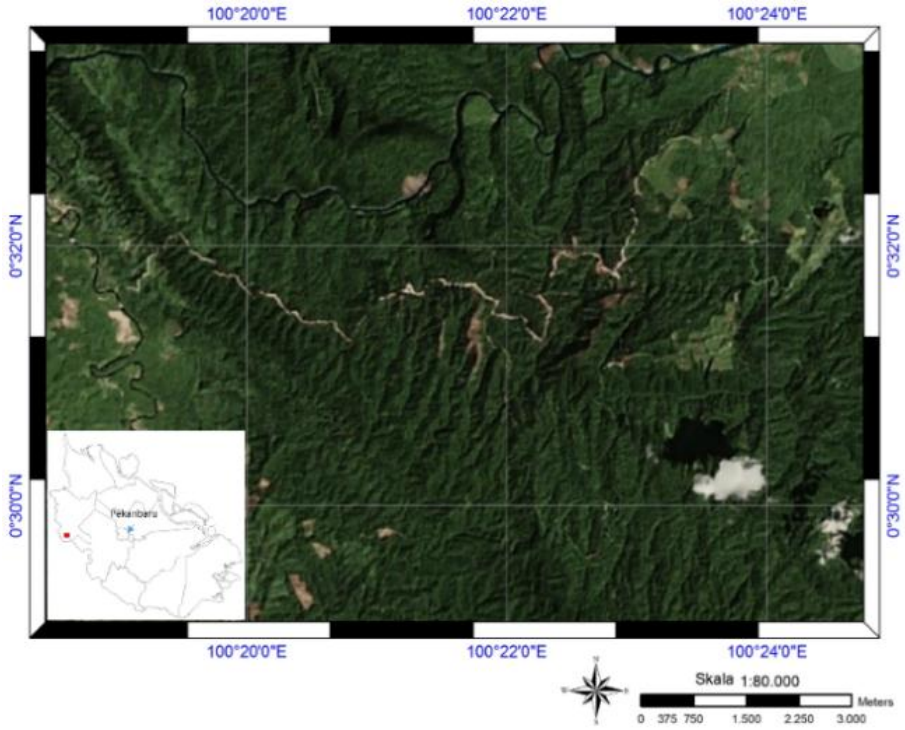



Fig. 1. Location map of Research Area

With some fault lineament in the western part of the study area which also have directions parallel to the folds [4].

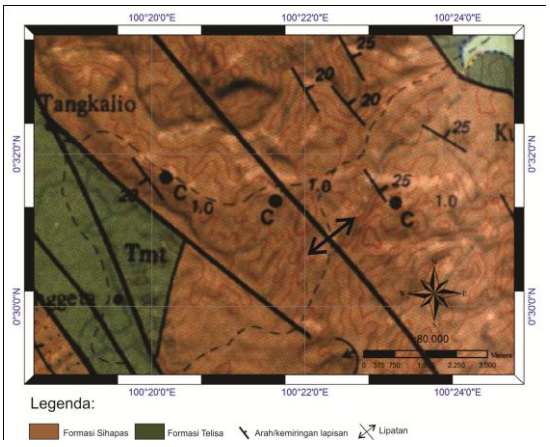



Fig. 2. Geological map of Research Area

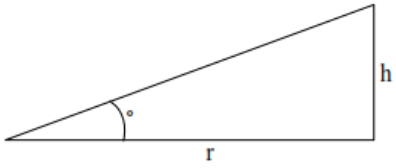
## 3. Methodology

The research data obtained from Digital Elevation Model using SRTM with pixel grid format which measuring the value of all pixel from all of direction. SRTM data is called SRTM3 that has 90 meters spatial resolution. DEM SRTM data is provided in 16-bit simple raster binary. SRTM has the same data format as other GRID formats [5], Which consists of cells that each cell has a height value. The elevation value at DEM SRTM using 1984 WGS datum, not from sea level. But since the 1984 WGS datum almost coincides with sea level, so it is possible for a high-scale to ignore the difference between the two. The vertical DEM of DEM SRTM refers to the geoid (EGM 96) so that the height at this DEM SRTM is an orthometric height. DEM SRTM has elevation from -32767 to 32767 meters, based on altitude ranges that exist on earth [5].

Table 1. Specifications of SRTM Data [5].

| *Nama* | *Resolusi Spasial* | *Proyeksi* | *Datum Horizontal* | *Datum Vertikal* | *Satuan Tinggi* | *Ukuran Sel* |
|---|---|---|---|---|---|---|
| SRTM3 | 90 meter | Geografis | WGS 84 | WGS 84 / EGM 96 geoid | meter | 0.00083 |

Basically, To do the slope research, the measurement come from the comparison of horizontal distance and vertical distance, according to Nugraha [5] by knowing the difference of height and distance between the two points, it can be calculated the percentage of slope shown with the following picture.




$$Persentase\ Kelerengan\ (\%) = \left[\frac{h}{r}\right] x\ 100\%$$

Fig 3. Ilustration of slope formula.

By Using SRTM data, in calculating the slope value of one pixel, involving 3x3 pixels

illustrated in Fig. 3 and its calculations on the formula quoted from Burrough [6] below,

$$\left[\frac{Height\ (h)}{Distance\ (r)}\right] = \sqrt{\left[\frac{dz}{dx}\right]^2 + \left[\frac{dz}{dy}\right]^2} \quad (1)$$

$$\left[\frac{dz}{dx}\right] = \left[\frac{((c+2f+i)-(a+2+g))}{8\ x\ grid\ width}\right] \quad (2)$$

$$\left[\frac{dz}{dy}\right] = \left[\frac{((g+2h+i)-(a+2b+c))}{8\ x\ grid\ width}\right] \quad (3)$$

Where dz denotes the height and dx is the horizontal distance and dy is the vertical distance, for the a-i constant is the area of the grid used.

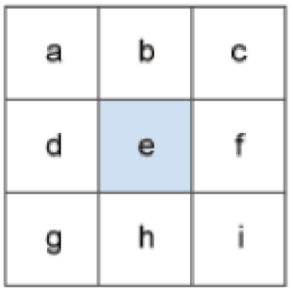



Fig. 4. The pixel illustrations calculated in the calculation of pixel slope values in DEM / DTM raster grid format[6].

Calculation of this slope slope using van zuidam classification, 1985 by looking based on the percentage of slope and degree of slope in the classification into 7 sections ranging from Flat into Very Steep.

| Slope Class | Nature, Process and Natural Conditions |
|---|---|
| $0^0$-$2^0$ (0-2%) | Flat to almost flat, no meaningful denudation process |
| $2^0$ - $4^0$ (2-7%) | Gentle, low-speed ground motion, sheet erosion and soil erosion (sheet & rill erosion), erosion swamps. |
| $4^0$ - $8^0$ (7-15%) | More Gentle, the same as above, but with a higher magnitude. |
| $8^0$ - $16^0$ (15-30%) | Slightly steep, a lot of ground movement and erosion, especially landslides that are flat. |
| $16^0$ - $35^0$ (30-70%) | Steep, intensive denudation processes and ground movements are common. |
| $35^0$ - $55^0$ (70-140%) | Very steep, rocks generally begin to unfold, a very intensive denudational process, have begun to produce rework material. |
| > $55^0$ >140% | Very steep, exposed rocks, a very strong denudational process and prone to falling rocks, rarely grown plants (limited) |

Fig 5. Slope classes with the nature of processes and natural conditions [2].

The steepness of a slope depends on several factors including: slope geometry, rock mass strength / slope soil structure, general orientation of weak field structure (discontinuity), groundwater condition (high water level), work load (static or dynamic load ) [7-15].

## 4. Results and Discussion

Based on the result of SRTM data processing and the survey of the research location, the slope level is quite varied ranging from sloping to very steep. The slope of the slope is divided into several levels, ranging from a flat slope range of 0-2 degrees, developing generally in the northeast and southwest sections with a percentage of the area of 13% of the study area. For the slope class in the rather oblique category that ranges from 2 to 4 degrees, occupying almost 34% of the research area, developing in the northwest to southeast. For a grade of 4 - 8 degrees slopes with a sloping category, occupying almost 23% developing in the northwest to southeast and parts of the southwest. For a rather steep category slope class with a range of 8 - 16 degrees, occupies 13% of the research area. For the steep category slope class with a range of 16 - 35 degrees, occupies 11% of the research area. For the steep category slope class with a range of 35 - 55 degrees, occupies 6% of the research area.

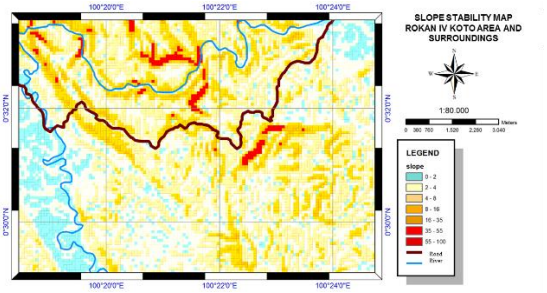



Fig 6. Slope map of research area , red color indicates the point of location of the potential occurrence of landslides.

In the A-A 'SRTM cross section covered with satellite image data, the slope of the slope is quite steep with slope level above 140% with a slope angle of almost $71.2^0$ (Fig. 7). This indicates that the cross-sectional position has a fairly low slope stability, this can affect the steepness of the slope at that location, with the tropical conditions in Indonesia and the high level of rain this can trigger avalanche potential at the location around the area.

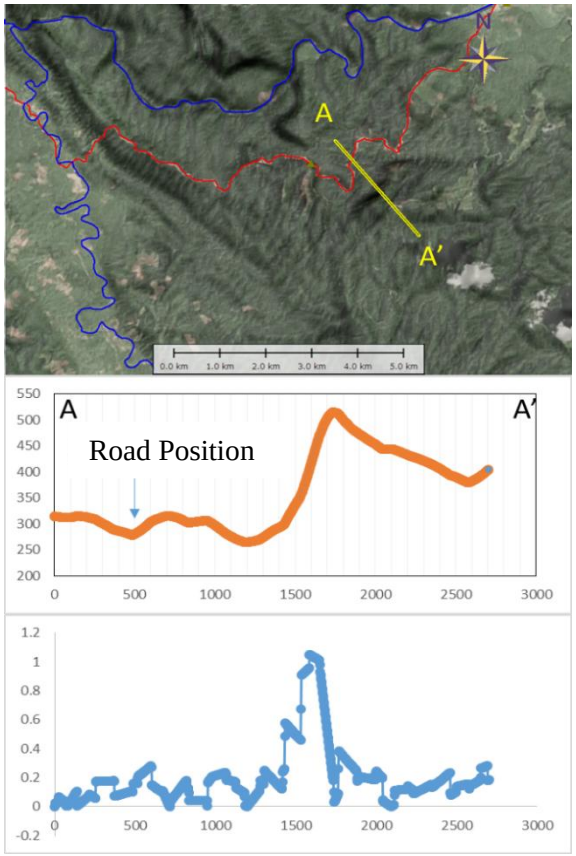



Fig 7. Crosssection of slope profile of the A-A'

Based on the appearance at the location site, especially on the access road at some point, there were found steep slope levels (figure 8). This indicates that the potential rate of erosion and landslides is quite large.From the slope map (Fig. 5), some dangerous zones are indicated in red, this indicates in the zone, the slope of the slope at a high risk stage that indicates landslide potential.

Fig 8. Road conditions with steep slope sides on the road wall.

## 5. Conclusion

Based on the research results obtained results include:

1. Slope slope conditions in Rokan IV Koto area vary from flat to very steep.
2. SRTM data integration combined woth geological conditions in the research location can justify the location points that potentially the occurrence of landslides.

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