The landslide analysis by using remote sensing & scoring calculation methods of tenang waras and its surrounding area, Muara Enim district, South Sumatera

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Abstract. Indonesian country geographically formed in the ring of fire zone. This situation trigger the occurrence of various natural disasters in Indonesia such as the earthquake, volcanic eruption and even tsunami waves, besides there is also one of the natural disaster which crucial enough and occur quite often, which is the landslide. The landslide disaster happens mostly in the highland area with the steep slope. This also applies in research area which located in Tenang Waras, South Sumatera. The research area located in high altitude having range of altitude from 402 masl to 912 masl, it also has steep enough slope and high ratio of rainfall. The methods of this research are study literature, geological and landslide zones mapping which analysed and combined with the laboratory analysis by using remote sensing software and also the scoring method which able to create high accuracy calculation from both of its analysis. The results of literature study shows that the research area often happens severe landslide disasters, result from geological mapping and landslide zones which combined with laboratory analysis known that there are several landslide zone which obtained from the landslide zone mapping, each of them are located in the north eastern, north western and south western part of research area, this is similar with the result of scoring method & remote sensing analysis by using the aspect of highest importance value of slope parameter with value of 5 and the lowest value is height parameter with the value of 2.

1. Introduction

Scoring Calculation method is the common method to decide the level of suitability from an area, this method use some of the parameters which tend to flexible and can be adapted based on the particular context (Sholahuddin, 2015). This calculation method can’t stand alone, there are some other methods which support in order to create the map which become its parameters, in this case the making of map is one by using the remote sensing software such as ArcGIS, global mapper, Google earth etc. Rahman, 2010 stated that the landslide is an process of land movement in the surface either vertically or the opposite of the first position as the gravitational matter. This landslide can also be happen due to human’s doing which in the process of land utilization doesn’t follow the rules of environmental sustainability such as changing the forest into farm excessively and making the settlement in the area which has steep slope (Nugroho et al, 2010).

The research area is located in Tenang Waras, Muara Enim District, South Sumatra, based on the rainfall data from BMKG, 2016, the research area is dominated by the high amount of rainfall (>500mm/month), with the elevation around 400 – 900 masl and the slope which has high varieties from tilt to very steep which making the research area commonly include into the vulnerability zone of landslide , in this research will be discuss more in the area which has highest landslide potential in order to minimizing the drawbacks which caused by the landslide and also can be the based data which can be used by the related parties especially for the people which lives in the research area and also government and academician which interested to take study about landslide.
2. Methods
In making this research the writers use some methods which are literature study, field observation and laboratory analysis, here are the explanation of each methods:

2.1 Literature Study
By studying and understanding the geological aspect of Tenang Waras and its surrounding area, the parameters as the causes of landslides like rainfall intensities, degree of slope, type rocks (geology). All that stuff obtained by studying and also reviewing the literature from various previous researches.

2.2 Field Observation
The field observation is including the geological mapping to gain the type of lithology and then interpreting the rock unit which located in the research area, there are some other factors which causing the landslide for example geological structure, like fault or fold and then the rocks alteration which in this research doesn’t to be considered, after having geological mapping, there also mapping of landslide prone zone by taking data of the landslide spots which located in the research area, the data are landslide photos, the total area of landslide (length x wide) and also the azimuth of landslide.

2.3 Laboratory Analysis
For the laboratory analysis we’ve done the remote sensing and scoring calculation analysis, here are the explanation.

2.3.1 Remote Sensing Analysis
For laboratory analysis we conduct it by doing remote sensing analysis and also the method of scoring technique calculation, for the remote sensing analysis performed by using some of the software like ArcGIS, Google Earth Pro, Global Mapper and also the Map Source, this remote sensing analysis done in order to obtain various kind of maps like hydrology map, geological map, land use map, slope degree map and also the altitude contour map, these maps are the representative variable from various factors which become the cause of landslides in an area and then afterwards each map is delineated to obtain the boundary of it, after that, all the maps were overlay one another and after that we can obtain the grouped of land boundaries from each maps which after that are given numbering and then each number was calculated by using scoring technique until we can obtain the block area with their each landslide potential from that calculation.

2.3.2 Scoring Calculation Method
Scoring technique is one of the method which use to give the value towards some parameters which in this case there are six parameters which are litho type, soil type, rainfall, slope, land use and height, these parameters were obtained from the result of remote sensing which using the help of software, from that six parameters then there is the calculation of potential value as shown on the table 1 below. There also the importance value which in this case can be interpreted based on the research location, we decided that the slope parameters with the importance value of 5 while the height parameter is the lowest which is 2, the explanation of this can be found in the result section below.

| Component | Amount | Value of Interest | Maximum Value | Minimum Value |
|-----------|--------|-------------------|---------------|---------------|
| Litho Type | 1      | 4                 | 1x4x4 = 16    | 1x1x4 = 4     |
| Rainfall  | 1      | 4                 | 1x2x4 = 8     | 1x1x4 = 4     |
| Slope     | 1      | 5                 | 1x4x5 = 20    | 1x1x5 = 5     |
| Land Use  | 1      | 3                 | 1x4x3 = 12    | 1x1x3 = 3     |
| Height    | 1      | 2                 | 1x4x2 = 8     | 1x1x2 = 2     |

| Total     |        |                   | 64            | 18            |
From the overall amount of table 1 above, obtained the maximum value and the minimum value, and then calculated these two values by using this formula:

$$X = \frac{\text{MaxV} - \text{MinV}}{5},$$

where:
- $X$ = Interval Score,
- MaxV = Maximum Value,
- MinV = Minimum Value.

$$X = \frac{64 - 18}{5} = 9.2 = 9$$

(fulfillment of numbers)

After calculating the value above, we’ve got the interval which can be used to classified the level of landslide vulnerability is 9,2 or we can make it even to become 9 which after that can be allocated in the table of classifying the landslide level (table 2).

| Land Classification Towards Landslides |
|----------------------------------------|
| Non Vulnerable | Potential Vulnerable | Quite Vulnerable | More Vulnerable | Very Vulnerable |
| 18 – 27         | 28 – 36              | 37 – 45          | 46 – 54         | 55 – 64         |

3. Result & Discussion

3.1 Literature Study

Based on literature study can be known that the research area is an area which has a high vulnerability of landslide, can be interpreted by take a look at the height which around 402 – 912 masl, the higher of elevation, the greater moisture which influencing that area, and then the slope which is very steep reaching more than 55° which influencing the landslide plane to become more influenced by the help of gravitational forces.

3.2 Mapping of Landslide Prone Zone

In making this map there is an interesting thing which can be concluded which is the slope parameter become the highest in influencing the landslide, this is because after we done mapping the landslide prone zone we got some of spot which has landslide on it, total there are 6 spots, this mapping done in the whole area of research area and can be interpreted that the landslide in the research area are located at Northwest, Northeast and Southwest, in the whole of landslide spot interestingly it is happen in the elevation which far enough range which almost 400 masl in difference, after that we can conclude that the elevation is the least factor to influence the landslide disaster, proven by the explanation above. The landslide spots can be seen in figure 1 below.
Variables which become the causes of landslide disaster which stated by Nugroho et al, 2010 become one of our reference in doing the calculation of scoring technique, but we added one variable which based on our opinion are also very important as one of the cause of landslide disaster which is lithotype.

3.3 Lithotype

Based on the geological mapping in the research area there are 4 kinds of lithology (figure 2), this actually causing difference of characteristics every rock units, the four kind of lithology and their score can be seen in table 3 below.

Table 3. The classification of litho type variable

| No. | Litho Type           | Score |
|-----|----------------------|-------|
| 1.  | Andesitic Lava       | 1     |
| 2.  | Pyroclastic Breccias  | 2     |
| 3.  | Autobreccia Lava     | 3     |
| 4.  | Lapillistone         | 4     |
3.4 Rainfall

The determination of rainfall classification in this case also based on the opinion of Nugroho et al, 2010 which divided the classification into 4 classes but in this case we modified it or changing the value of class to adjust with the rainfall condition which occur in the research area (table 4) the rainfall data obtained from BMKG, 2016. (Figure 3)

| No. | Rainfall (mm/month) | Score |
|-----|---------------------|-------|
| 1.  | 401 – 500           | 1     |
| 2.  | > 500               | 2     |
3.5 Slope

The determination of slope scoring also based on the Nugroho et al, 2010 but of course still there is some adjustment by retrieving that the research area is having the high level of slopes degree, the scoring classification also divided into 4 class like the table 5 below which we create it based on the map of slope as shown in the figure 4 below, the slopes variable is the most important variable and really influence the landslide disaster occurrence.

Table 5. The classification of slopes variable

| No. | Degree of Slope       | Score |
|-----|-----------------------|-------|
| 1.  | 0° – 16°              | 1     |
| 2.  | 17° – 35°             | 2     |
| 3.  | 36° – 55°             | 3     |
| 4.  | > 55°                 | 4     |

Figure 4. Slope Map of Research Area

3.6 Land Use

The determination of land use as one of the causes of landslide disaster are based on the level of how high is a land can be the causes of landslide disaster and because on the research area majority there are four kinds of land which are water body, forest, farm and rice fields & settlements (figure 5) with the water body for example like river and lake with the lowest score while rice fields & settlements with the higher score, for more comprehends can be seen on the table 6 below.

Table 6 The classification of land use variable

| No. | Land Use               | Score |
|-----|------------------------|-------|
| 1.  | Water body             | 1     |
| 2.  | Forest                 | 2     |
| 3.  | Farm                   | 3     |
| 4.  | Rice fields & Settlements | 4     |
3.7 Height

The height classification is determinate based on Nugroho et al, 2010, which are divided the height parameter into three levels which are 400 – 550 masl, 501 – 700 masl, 701 – 850 masl and 851 – 1000 masl (figure 6 & table 7)

Table 7. The classification of height variable

| No. | Height          | Score |
|-----|----------------|-------|
| 1.  | 400 – 550 masl | 1     |
| 2.  | 551 – 700 masl | 2     |
| 3.  | 701 – 850 masl | 3     |
| 4.  | 851 – 1000 masl| 4     |
3.8 Discussion

Based on the data we’ve got after calculating by using the scoring calculation, there are 5 types of land classification which belongs to the unit of landslide decider, which are non-vulnerable, potential vulnerable, quite vulnerable, more vulnerable and very vulnerably, the total of land unit that we got are 275 land units.

3.8.1 Non-Vulnerable

In the research area there is only 9 of land units which include into this classification, this is a very small amount if we count percentage it will only be 3.27% mostly the land unit of this classification is located in Northeast, East and Southeast of research area, and there is no any settlements in this land unit (table 8)

Table 8. The land units which include to non-vulnerable land classification.

| Non Vulnerable Land Units |
|---------------------------|
| LU 59                     |
| LU 69                     |
| LU 72                     |
| LU 85                     |

3.8.2 Potential Vulnerable

The area with the potential vulnerability in the research area is up to 82 land units which percentage will be around 29% this classification spread all over this research area. The area with the potential vulnerable become an area with the lowest possibility of landslide disaster if it is compare with any other land units in the research area, but of course still there is a possibility that the area with potential vulnerable can transform into quite vulnerable when there is another parameter which also has the influence towards the landslide disaster but not mention or be calculated in this research (Table 9)

Table 9. The land units which include to potential vulnerable land classification.

| Potential Vulnerable Land Units |
|--------------------------------|
| LU 71                         |
| LU 93                         |
| LU 133                        |
| LU 169                        |
| LU 198                        |

3.8.3 Quite Vulnerable

There are about 101 land units which belongs to the quite vulnerable classification, that covers up to 36.72% of land units in the research area, it is spread all over the research area especially in the area with slope of not to steep (table 10)
### Table 10
The land units which include to quite vulnerable land classification.

| Quite Vulnerable Land Units |
|-----------------------------|
| LU 1 | LU 46 | LU 106 | LU 142 | LU 173 | LU 214 | LU 246 |
| LU 2 | LU 47 | LU 107 | LU 143 | LU 177 | LU 216 | LU 248 |
| LU 3 | LU 52 | LU 108 | LU 145 | LU 183 | LU 218 | LU 253 |
| LU 5 | LU 55 | LU 110 | LU 148 | LU 184 | LU 221 | LU 255 |
| LU 8 | LU 56 | LU 114 | LU 150 | LU 185 | LU 223 | LU 257 |
| LU 15 | LU 275 | LU 117 | LU 152 | LU 186 | LU 224 | LU 261 |
| LU 17 | LU 60 | LU 120 | LU 153 | LU 187 | LU 225 | LU 266 |
| LU 18 | LU 61 | LU 123 | LU 157 | LU 193 | LU 229 | LU 267 |
| LU 20 | LU 63 | LU 124 | LU 159 | LU 194 | LU 230 | LU 268 |
| LU 24 | LU 65 | LU 125 | LU 161 | LU 196 | LU 236 | LU 269 |
| LU 32 | LU 80 | LU 126 | LU 162 | LU 201 | LU 237 | LU 271 |
| LU 34 | LU 81 | LU 127 | LU 164 | LU 203 | LU 238 | |
| LU 35 | LU 83 | LU 128 | LU 165 | LU 206 | LU 239 | |
| LU 38 | LU 101 | LU 130 | LU 170 | LU 207 | LU 240 | |

### 3.8.4 More Vulnerable
In this classification there are about 70 land unit which divided mostly in the middle, south and around the steep slope at the north area of map (figure 7), the percentage of it is 25.45 % for more information about all the land units can be seen in table 11 below.

### Table 11
The land units which include to more vulnerable land classification

| More Vulnerable Land Units |
|-----------------------------|
| LU 9 | LU 41 | LU 116 | LU 197 | LU 227 | LU 195 |
| LU 10 | LU 42 | LU 119 | LU 202 | LU 228 | LU 251 |
| LU 11 | LU 43 | LU 121 | LU 208 | LU 232 | LU 252 |
| LU 12 | LU 45 | LU 122 | LU 210 | LU 233 | LU 254 |
| LU 13 | LU 53 | LU 149 | LU 211 | LU 244 | LU 256 |
| LU 16 | LU 82 | LU 154 | LU 212 | LU 245 | LU 258 |
| LU 22 | LU 102 | LU 155 | LU 213 | LU 247 | LU 260 |
| LU 23 | LU 105 | LU 156 | LU 219 | LU 249 | LU 262 |
| LU 25 | LU 109 | LU 163 | LU 220 | LU 250 | LU 265 |
| LU 26 | LU 111 | LU 166 | LU 222 | LU 189 | LU 39 |
| LU 30 | LU 115 | LU 167 | LU 226 | LU 191 | |
| LU 31 | LU 37 | LU 36 | LU 33 | LU 40 | |

### 3.8.5 Very Vulnerable
The areas which included into this very vulnerable land unit is located at Northwest, Northeast and Southwest (figure 7) of research area, this is similar as what we’ve got from landslide prone zone mapping which also found the landslide in that position. Commonly this classification dominates the very steep slope (>55%) and supported by other parameters. But fortunately there are no any settlements in that area, the land unit can be found on table 12 below.

### Table 12
The land units which include to very vulnerable land classification

| Very Vulnerable Land Units |
|-----------------------------|
| LU 21 | LU 192 | LU 235 | LU 264 |
| LU 27 | LU 199 | LU 242 | |
| LU 28 | LU 200 | LU 259 | |
| LU 29 | LU 234 | LU 263 | |
4. Conclusion
Based on the overall result of scoring technical analysis to determine the landslide area of Tenang Waras and its surrounding area, we discovered some of the important aspect which are the research area are divide into 275 land units which all of this land units are created based on 5 parameters of landslide causes which area litho type, rainfall, slope, land use, and the height, from 275 land units after having calculation intensively by using scoring technique and the classified it with the landslide determination table, obtained 5 classification which belongs to the research area which are non vulnerable with 9 land units, potential vulnerable with 82 land units, quite vulnerable with 101 land units, more vulnerable with 70 land units and the last is very vulnerable 13 land units so as the result of this research hopefully this can be used by the government and the local community as one of the reference of landslide disaster mitigation efforts, this can also increasing the alertness towards the landslide disaster which at last can be useful to minimize the material loss and even casualties. Suggestions for the next research is that this research has to be done periodically in this research area because of the parameters which become the references are so flexible.

Acknowledgments
Thanks to Allah SWT, my Parents, my lecturer, DR. Endang Wiwik Dyah Hastuti and also every person related in making this paper.

5. References
[1] Bulletin of Meteorological Agency, Klimatologi & Geofisika. February 2016. Buletin Evaluasi & Prakiraan Hujan di Sumatera Selatan.
[2] Nugroho, et al. 2010. Undergraduate Thesis, Geomatics Engineering, rsg025.0691Nugp.
[3] Rahman, A. 2010. Jurnal Bumi Lestari, Volume 10 No. 2, 191 – 199.
[4] Sholahuddin, M. 2015. Case Study of Jepara District. University of Dian Nusantoro.