LANDSLIDE HAZARD AND RISK ZONING IN HOA VANG DISTRICT, DANANG CITY

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ABSTRACT

Landslide is one of the dangerous natural hazards in mountainous areas, causing damage to the economy, society and environment. Under the effect of gravity, weathered floors separated from the surface to the bedrock below, scroll down to a lower position in the slope. Besides, the social and economic activities, especially in the construction of transportation projects also contribute significantly increased landslide phenomena.The main purpose of research aimed at partitioning the risk of landslides in Hoa Vang district, Da Nang city. The research results show that areas with high risk of landslides occupy in large area. In general, the slope of the terrain where the thickness of the weathering layer and slopes dominate cause of the process can easily occur landslides. Besides, the production of human also impact on the landslide study area. The findings of the study may be helpful for using and protecting reasonable and beneficial land use in Hoa Vang district.

Key words: Risk, landslide, slope, deep cleavage, rainfall.

1. INTRODUCTION

Landslide is one of the dangerous natural hazards in mountainous areas, causing damage to the economy, society and environment. Landslide formed the large rib slopes, weathered floor thickness, composition much clay. When rain or melting snow, the weathered material in floor water damage and swelling, resulting in increased volume, the weight of the floor weathering. At the same time, water break early links with weathered bedrock floor. Under the effect of gravity, weathered floors separated from the surface to the bedrock below, scroll down to a lower position in the slope. Besides, the human activities of human beings, especially the construction of roads has contributed significantly to the increase in this phenomenon. Process landslides have supplied the material the mud line - stone, causing serious damage to people and infrastructure, especially causing traffic jams.

Hoa Vang district - Da Nang is the region most affected by extreme weather events such as storms and tropical depressions ... combined with slope, deep cleavage, big and concentrated rainfall during short time. These are important factors that make the risk of landslide-prone here

in this area.

2. RESEARCH METHODOLOGY

2.1. Essential research area

The study area is Hoa Vang district - Da Nang City. The average annual temperature is about 25,9^{0}C, there are two seasons: the rainy season from June 8-12 and the dry season from May 1-7. This is a hilly area with large area, high rainfall and concentrated.

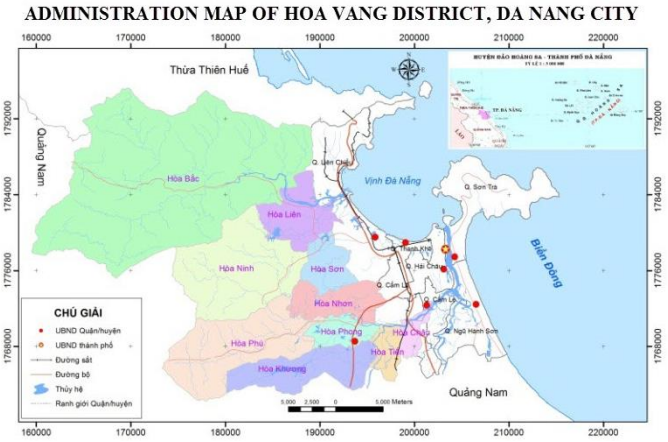

Figure 1. Administration map of Hoa Vang district, Da Nang city

2.2. Research data

The data for the study serves partition landslide risk of Hoa Vang district include:

- Terrain Hoa Vang District, scale 1: 50000
- Map of Hoa Vang District DEM
- The map of land use Hoa Vang District in 2012
- Map Location forged Hoa Vang District
- Map faulting Hoa Vang District
- Map of Hoa Vang District Traffic
- Map of Hoa Vang district rainfall
- Map of Hoa Vang soil map
- Economic and Social statistics - Danang 2011.

2.3. Research Methodology

The mapping landslide risk Hoa Vang district - Da Nang City shall comply with the following procedures:

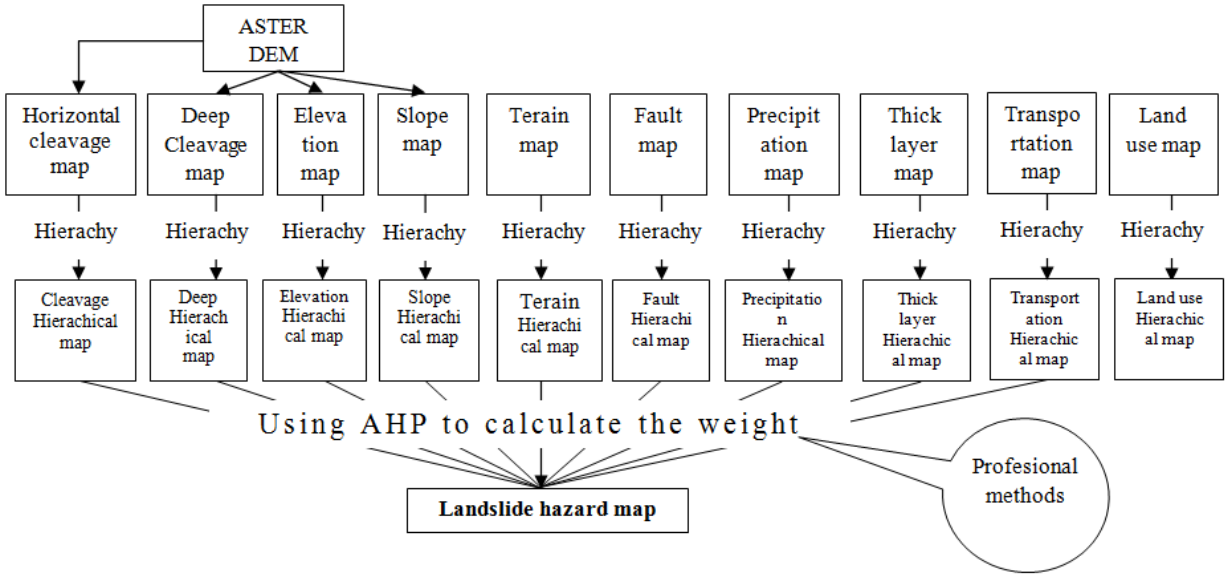

Figure 2. Diagram the process of mapping landslide risk

In the process of implementing projects, we have used a number of techniques including photo manipulation process, image filtering, image re-classification, calculated on raster data, raster data statistics ...

Using of remote sensing and GIS software to process the original data. ASTER DEM images are compressed properly adjust the map reference system. Then proceed in the ENVI image noise filtering, format conversion of data in the Global mapper, finally established the cross-sectional distribution maps, slope and deep cleavage.

The traffic map, geomorphology, Fault density, rainfall and land use is converted from vector to raster data using GIS software and then conducted hierarchical objects.

3. RESEARCH CONTENT

3.1. Assess the role of factors affecting landslide

3.1.1. Horizontal cleavage factor

This map represents the density of streams in the basin. River density greatly affect the timing concentrated rainfall in the catchment, river density will be large dense river network, traffic heavy flooding in the rainy season, dry in the dry season.

Maps to cut the input data to establish the types of hazard maps of different environments. It is a map used to determine environmental risks. In mapping landslides, people consider factors that cut across the terrain. Greater degree of landslides mainly distributed in regions with small cross-sectional density distribution, degree of small landslides occur in areas where the largest cross-sectional resolution.

Table 1. Relationship between horizontal cleavage value to landslides

Horizontal cleavage (km/km^2)	Landslide	Area (ha)	Score
Below 0,5	Average	615,94	3
0,5 - 1,5	Relative Strong	251,087	5

1,5 - 2,5	Very Strong	309,22	9
2,5 - 3,5	Strong	258,11	7
Above 3,5	Weak	1092,84	1

3.1.2. Deep cleavage factor

Map deep cleavage performing topographic height difference of 1km^2. Domain terrain changed often forms the valley slopes, slopes along major rivers, making water flow rates large, concentrated short time. Deep cleavage reflects the terrain divided vertically. Big deep cleavage usually leads to the development of the system and the erosion groove flank landslides, landslides pouring.

To establish deep cleavage map for the territory, people often use networks squares method of terrain by Xpiridonop (1970) offer. In this way, people determine the excess of the divide on the basis of local invasion or the difference between the maximum height and minimum height:

$I = (Z_{max} - Z_{min}) / S$

I: deep cleavage values (unit: m)

Z_{max}: High largest value (m)

Z_{min}: minimum elevation value (m)

S: The area of the territory, taking 1km^2.

Like cross-sectional maps, depth maps cleavage is also used to establish hazard maps. In a landslide mapping the deep cleavage factors play a role in the rise and development of landslides. Largest landslide extent concentrated in the densely dissected average depth; followed by density separation greater depth.

Table 2. Relationship between deep cleavage value to landslides

Deep cleavage (m/km^2)	Landslide	Area (ha)	Score
Below 30m	Average	619,89	3
From 30 - 50m	Very Strong	136,31	9
From 50 - 100m	Strong	529,56	7
From 100 -150m	Relative Strong	691,07	5
Above 150m	Weak	661,09	1

3.1.3. Terrain elevation factor

Energy terrain proportional to the height of the terrain. Many research results show that, if the terrain elevation> 500m landslide occurred on the 1000m is strong and this process occurs very strong. Results of high-level terrain as follows:

Table 3. Relationship between elevation value to landslides

Elevation (m)	Landslide	Area (ha)	Score
0 - 100	Weak	893,03	1
100 - 250	Average	328,04	3
250 - 500	Relative Strong	617,52	5
500 - 1000	Strong	587,36	7
>1000	Very Strong	100,04	9

3.1.4. Slope factor

The slope factor has a decisive role to landslides. When the slope angle becomes larger, the smaller the stability of slopes, the greater the energy terrain, enabling landslide originated gravity. Topographic slope from 350-450, the landslide occurred most powerful, if the slope is greater than 450, the process is mainly down sores. There are many methods for mapping slope. In this topic, we use the DEM map for mapping slope.

Table 4. Relationship between slope value to landslides

Slope (0)	Landslide	Area (ha)	Score
<8 và >45	Weak	795,81	1
8 - 15	Average	414,61	3
15 - 25	Relative Strong	647,08	5
25 - 35	Strong	477,15	7
35 - 45	Very Strong	168,43	9

3.1.5. Form factor - the source of topographic

In addition to the above factors, landslides are related to morphology - the source terrain. Topography on the accumulated geological structure, composed mainly by metamorphic rocks, the slopes of dominance, prone to landslides. These types of wear plain terrain, surface accumulation with a small incline at more landslides occur.

The decentralization of landslides according to morphology-origin based on landforms map-derived morphology of the study area, the results are as follows:

Table 5. Relationship between Morphology - origin value to landslides

Morphology - origin	Landslide	Area (ha)	Score
Denudation plain folded structures on undulating tilt array; delta erosion-accumulation of multiple origins; accumulation plain sea breeze	Weak	341,41	1
Hill intrusion - denudation bowl shape with convex slopes, composed of different rock	Average	463,02	3
Valley, the valley between the mountains tectonic - surface erosion hills and hills form	Relative Strong	40,70	5
Ranges, massifs denudation on structural-lithological arch, formed by magma intrusions and granitic	Strong	1373,40	7
Denuded mountains - is created on the local cumulative type structure, composed mainly by metamorphic rocks, the slopes of dominance	Very Strong	311,41	9

3.1.6. Fault density factor

Fault density are factors that greatly affect the landslide, they directly affect the density and sliding point scale. In the same lithologies are easily generated landslides in the zones where the dam breaks, cracks, because this is where the soil vulnerable to weathering depth, easy-saturated water and low shear strength.

The mapping Fault density maps were interpolated from tectonic faults. Results of

correlation between Fault density and landslides are shown in the following.

Table 6. Relationship between fault density value to landslides

Fault density (km / km^2)	Landslide	Area (ha)	Score
0 - 0,733724	Weak	1605,90	1
0,733725 - 1,467448	Average	332,93	3
1,467449 - 2,201172	Relative Strong	344,18	5
2,201173 - 2,934896	Strong	234,65	7
2,934897 - 3,66862	Very Strong	12,33	9

3.1.7. Factors average annual rainfall

Rainfall has a great influence to landslides. This is important only to the slope. Most landslides occur in the rainy season, especially in times heavy and prolonged rainfall continuously. The average annual rainfall of Hoa Vang district is quite large.

The mapping Average annual precipitation is performed by interpolating the values measured in the rain gauge stations. Then, subjects decentralized average annual rainfall of Hoa Vang District.

Table 7. Relationship between the average annual rainfall value to landslides

The average annual rainfall (mm /year)	Landslide	Area (ha)	Score
< 2500	Weak	956,17	1
2500 - 3000	Average	712,03	3
3000 - 3500	Relative Strong	731,90	5
3500 - 4000	Strong	105,06	7
> 4000	Very Strong	24,75	9

3.1.8. Factor in soil layer depth

Landslides occurred in areas with strong large ground floor thickness. When thick ground floor, rainfall will be absorbed into the soil, increasing the weight of the soil mass and prone to landslides.

Table 8. Relationship between thick layer value to landslides

Thick layer (cm)	Landslide	Area (ha)	Score
<30	Weak	1517,30	1
30 - 50	Average	228,05	3
50 - 75	Relative Strong	163,42	5
75 - 100	Strong	49,14	7
>100	Very Strong	555,92	9

3.1.9. Transportation density factor

The construction of transport networks, particularly in the mountains have a major impact on the landslide. When construction traffic, we have changed the flank slope, vegetation cover, ... has made the process of developing ribs, especially landslides. The results show that, there are many landslides occurred in areas where roads go through, especially the new line construction.

Table 9. Relationship between transportation density value to landslides

Transportation density (km/km^2)	Landslide	Area (ha)	Score
0 - 1,3948662	Weak	1941,74	1
1,3948663 - 2,7897324	Average	317,04	3
2,7897325 - 4,1845986	Relative Strong	196,91	5
4,1845987 - 5,5794648	Strong	66,44	7
5,5794649 - 6,974331	Very Strong	7,84	9

3.1.10. Land use factors

Land use is mentioned as a land surface cover. The area coverage rate as well as natural forests or production forests are less frequent landslides and opposite.

Table 10. Relationship between land use value to landslides

Land use	Landslide	Area (ha)	Score
Ground water streams	Weak	45,43	1
Plantation, natural	Average	1904,03	3
Perennial land	Relative Strong	34,36	5
Annual crop land, pasture, shrub	Strong	200,90	7
Residential land, soil, land availability	Very Strong	286,46	9

3.2. Calculate the weight of the factors affecting landslide

All targets were selected for inclusion in the assessment are related to landslide of the study area. However, it emerged in a number of indicators directly affected, strongly dominated landslides. Through fieldwork and learn some documents and consult the professionals. Threads used method of comparing pairs to determine coefficients for each indicator before integration into the evaluation landslide. This method is Saaty (1977) developed in the context of the process of supporting decision-making, called "analysis Hierarchy Process - AHP," also known as "smart pairwise comparison". Topical use AHP tool integrated in ArcGIS to calculate weights of criteria, the results are as follows:

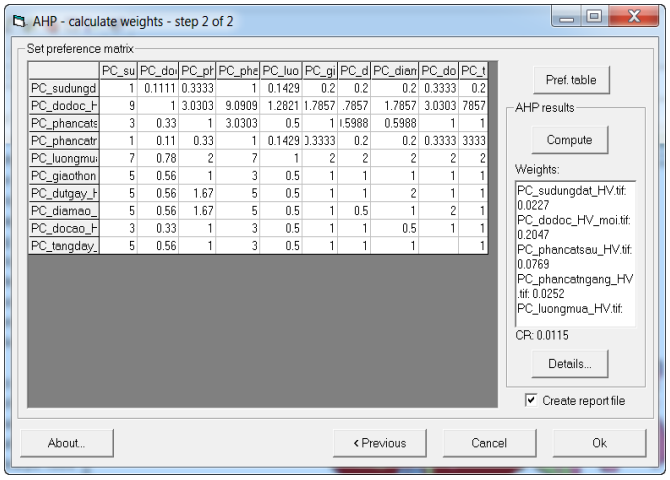

Figure 3. The degree of importance of the criteria

According to Figure 3.6, we see consistency index CR (0.0115) is less than 0.1, the results calculated weights of the criteria to achieve reliability values.

Table 11. Statistics of the weighting factors arising landslide

Factors	Slope	Elevation	Deep	Horizontal	Terain	Fault	Precipitation	Transport station	Land use	Thick layer
Weight	0.2047	0.0804	0.0769	0.0252	0.107	0.1153	0.1784	0.0947	0.0227	0.0947

Based on the above table shows. these factors have a decisive role to landslides is slope (0.2047). rainfall (0.1784). Other factors such as Fault density. height. deep cleavage. transport. land is dense with similar values. Factors such as land use or distribution delicate little influence landslide.

3.3. Zoning landslide risk Hoa Vang District

Map of landslide risk is based on 10 partial maps. The topic has been using GIS spatial analysis in combination with AHP method according to the formula:

LSI=0.2047*Slope + 0.0804*Height + 0.0769*Deep + 0.0252* Horizontal + 0.107* Terain+ 0.1153* Fault+0.1784* Precipitation + 0.0947* Transport station + 0.0227* Land use + 0.0947*Thick layer.

The study results showed that the values of Hoa Vang District LSI smallest and largest value are 1.2496 to 5.9070.

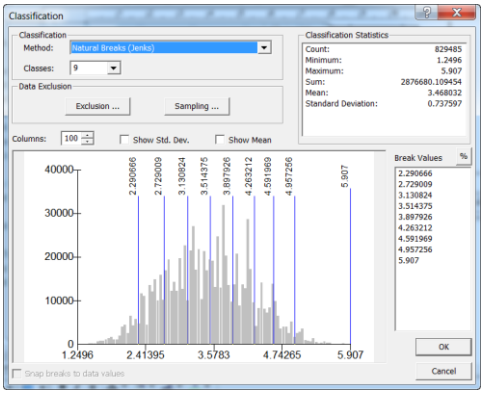

Figure 4. Diagram of LSI value Hoa Vang district

Then. subjects conducted divide the number of landslide risk level based on the formula:

$\Delta x = (x_{max} - x_{min}) / n$; where n: number of levels to divide (n = 5).

Table 12. Landslide hierarchy in Hoa Vang district

Level landslide	Value
1	1.2496 – 2.1811
2	2.1811 – 3.1126
3	3.1126– 4.0440
4	4.0440– 4.9755
5	4.9755– 5.9070

On the basis of decentralization landslides. subjects conducted mapping landslide risk Hoa Vang district - Da Nang based on GIS. the results are as follows:

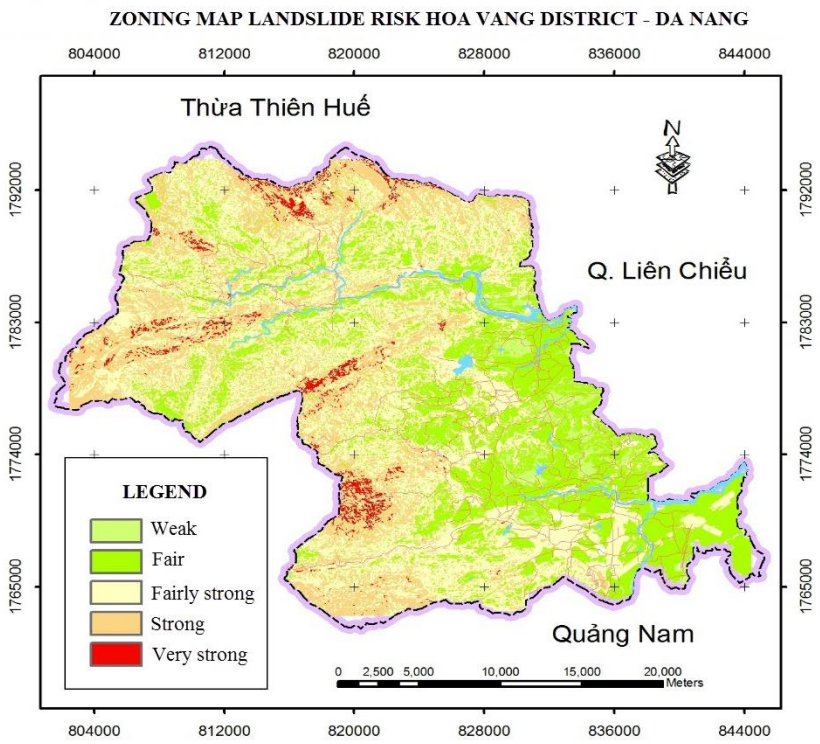

Figure 5. Zoning map landslide risk Hoa Vang district - Da Nang

Table13. Statistical Area (ha) the variety of diferent landslide

Risk level	Area (ha)	Rate (%)
Very low risk	5428.3	7.76
Low risk	20729.4	29.62
Average risk	25957.8	37.09
High risk	16437.1	23.48
Very high risk	1440.1	2.06

Table 14. Statistical Area (ha) of landslide risk levels in the communes of Hoa Vang District

Commune	Very low		Low		Average		High		Very high	
	Area (ha)	Rate (%)	Area (ha)	Rate (%)	Area (ha)	Rate (%)	Area (ha)	Rate (%)	Area (ha)	Rate (%)
Hòa Bắc	223.6	*0.01*	4470.2	*0.14*	16031.3	*0.48*	11288.5	*0.34*	1079.1	*0.033*
Hòa Châu	214.3	*0.24*	669.9	*0.76*	0	*0.00*	0	*0.00*	0	*0.000*
Hòa Khương	146.8	*0.03*	2326.0	*0.50*	1955.4	*0.42*	271.4	*0.06*	3.1	*0.001*
Hòa Liên	1116.3	*0.30*	1964.5	*0.53*	475.9	*0.13*	126.5	*0.03*	11.5	*0.003*
Hòa Nhơn	1214.9	*0.39*	1816.5	*0.58*	121.4	*0.04*	2.1	*0.00*	0	*0.000*
Hòa Ninh	467.8	*0.05*	3207.7	*0.31*	3872.5	*0.38*	2500.1	*0.24*	205.8	*0.020*
Hòa Phú	236.2	*0.03*	2776.2	*0.32*	3271.6	*0.38*	2248.4	*0.26*	140.6	*0.016*
Hòa Phong	222.6	*0.12*	1465.1	*0.80*	143.1	*0.08*	0	*0.00*	0	*0.000*
Hòa Sơn	1235.2	*0.52*	1077.1	*0.45*	83.3	*0.04*	0.1	*0.00*	0	*0.000*
Hòa Tiến	350.6	*0.27*	956.2	*0.73*	3.3	*0.00*	0	*0.00*	0	*0.000*

Across the table and figure above shows an area at risk of landslides is very high (2.06%) and high landslide (23.48%) distributed along the transportation route in the province of Hoa Bac Commune. Hoa Ninh and Hoa Phu. Risk of landslides in the lowland low as Hoa Chau. Hoa Tien and Hoa Nhon Hoa Khuong.

3.4. Solutions

Depending on specific conditions. we can offer solutions appropriate to prevent landslides. In general. the following main measures:

- Anti-destructive effects of surface water by digging drainage ditches to bring water to flow in the other direction or accelerate the drainage on the slope surface (groove-oriented systems. grading slopes) to limit the process of infiltration. grass crops prevent soil erosion.

- Anti-damaging effects of ground water in the drainage system of underground (underground trench. tunnel drainage. underground wells ...).

- Reduce the load on the sliding block by digging down a rocky section to increase the static balance (applied when the slide above. laid on the bottom). comfortable canvas slopes. not construction in a position to increase the load on the slope.

- Using structural measures such as retaining walls. embankments against erosion. piles prop system. ... in the foot slopes with deep set nails lying on the sliding surface and ground stability [3].

4. CONCLUSION

From the research results landslide risk in Hoa Vang district - Da Nang. subjects can draw the following conclusions:

- Hoa Vang district is prone to landslides Danang high. The mountainous Hoa Bac Commune. Hoa Phu and Hoa Ninh is likely where most landslides.

- The mapping landslide combination of GIS and AHP is very convenient. established processes simple and easy way to bring high efficiency. This is the way modern mapping. which provides a large amount of information.

- The results of the research has mapped landslide risk map based on 10 unisex arise affecting landslide.

- From the results of the study. subjects were given a limited number of solutions to the risk of landslides in the study area.

- Due to limited resources and time to analyze new threads impacts arising landslide of 10 factors. The socio-economic factors other research areas have not been studied specifically.

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