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Hazard, Vulnerability and Capacity Mapping for Landslides Risk Analysis using Geographic Information System (GIS)

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Abstract. This research analyzed the levels of disaster risk in the Citeureup sub-District, Bogor Regency, West Java, based on its potential hazard, vulnerability and capacity, using map to represent the results, then Miles and Huberman analytical techniques was used to analyze the qualitative interviews. The analysis conducted in this study is based on the concept of disaster risk by Wisner. The result shows that the Citeureup sub-District has medium-low risk of landslides. Of the 14 villages, three villages have a moderate risk level, namely Hambalang, Tajur, and Tangkil, or 49.58% of the total land area. Eleven villages have a low level of risk, namely Pasir Mukti, Sanja, Tarikolot, Gunung Sari, Puspasari, East Karang Asem, Citeureup, Leuwinutug, Sukahati, West Karang Asem West and Puspanegara, or 48.68% of the total land area, for high-risk areas only around 1.74%, which is part of Hambalang village. The analysis using Geographic Information System (GIS) prove that areas with a high risk potential does not necessarily have a high level of risk. The capacity of the community plays an important role to minimize the risk of a region. Disaster risk reduction strategy is done by creating a safe condition, which intensified the movement of disaster risk reduction.

1. Introduction

One of the goals of the Republic of Indonesia as stated in the Act of 1945 is to protect the people and the country of Indonesia from all threats. This time, the threat to the country's defense is dominated by non-military threats are considered more complex and multidimensional than military threats. One form of tangible non-military threats facing Indonesia today is a natural disaster. At a certain scale, the disaster could have an impact on national stability and a threat to the development [1].

Bogor Regency in West Java has vulnerability to landslides. During the past 10 years, landslides have dominated the disastrous events contained in Bogor, as many as 116 events with thousands of human casualties and damage to facilities and settlements [2]. Bogor Regency morphological conditions are mostly high plains, hills and mountains, and relatively high rainfall. The morphological condition of Bogor Regency is mostly in the form of plateau, hills and mountains, and has high rainfall. Land formation of some areas of Bogor Regency can be seen from the image data DEM (Digital Elevation Model) processed from satellite images as shown in Figure 1.

To minimize the impact of landslides, disaster risk reduction must be done with careful consideration of the each area's characteristics. Assessment and risk mapping is considered a part of



pre-disaster stages to reduce the impact of potential disasters and as part of efforts for preparation to face the disaster [3].

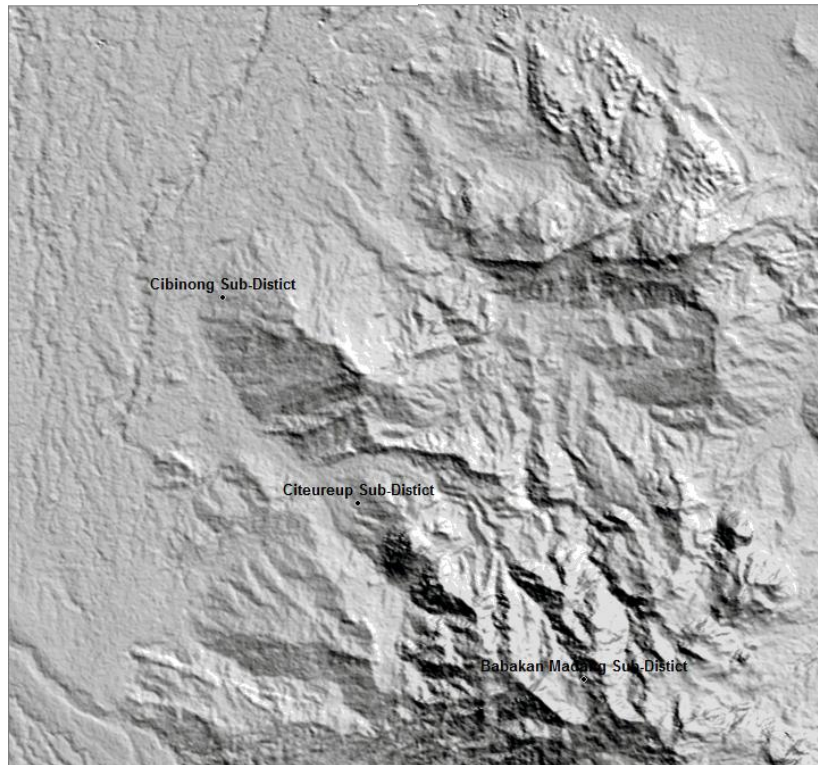


Figure 1. Digital Elevation Model (DEM) part of Bogor Regency
Source: SRTM 30 DEM from www.earthexplorer.usgs.gov.

Based on the background and the description above, the formulation of the problem in the form of risk assessment in the context of landslide disaster risk reduction in Citeureup sub-district is described in research goal which is to analyze the level of risk of landslides in Citeureup sub-district based on its hazards, vulnerability and capacity using Geographic Information System (GIS).

2. Materials and methods

The method used in this study is a qualitative method. However, descriptive quantitative approach is done in weighting or scoring of quantitative data.

First, scoring techniques are used in the determination of threat/hazard, vulnerability, and capacity parameters. The results are poured in the form of maps in the form of overlay of these three components using software Geographic Information System (GIS). The final risk value is derived from the arithmetic operations of all three components, namely Risk (R) = Threat / Hazard (H) x {Vulnerability (V) / Capacity (C)}.

Analysis of mapping used to represent the results of the research, then Miles and Huberman analytical techniques used to analyze the qualitative interviews.

The analysis conducted in this study is based on the concept of disaster risk by Wisner *et.al*. Disaster risk assessment is analyzed with the help of Geographic Information System (GIS) applications, as well as parameter scoring techniques used in the assessment of landslide threats/hazards, physical, social, and economic vulnerabilities, and capacity of the community. Parameters, indicators, weights and values used to assess the level of risk in this study are presented in table 1.

Table 1. Variables, parameters, indicators, the weight and value of threats, vulnerabilities and capacities.

Value	Weight	Indicator	Parameter	Variable
1	0.3	Dry (<1000 mm / year)	Rainfall	Threat
2		Dry (1001 to 2000 mm / year)		
3		Medium (2001-3000 mm / year)		
4		Wet (3000-3001 mm / year)		
5		Very Wet (> 4000 mm / year)		
1	0.4	0-8%	Slope	
2		8-15%		
3		15-25%		
4		25-45%		
5		>45 %		
1	0.1	Alluvium	Geology	
2		Pratersier		
3		Miocene facies sediments		
4		Result of Volcanic Old Quaternary		
5		Results Volcano Young Quaternary		
1	0.2	Forests	Land Use	
2		Mixed Forest		
3		Gardens, Mixed Garden		
4		Paddy field, Farm, Bush / Thicket		
5		Settlement, Industry		
1	0.4	<30 buildings/ha	Home Density	Vulnerability (physical)
3		30-80 building/ha		
5		>80 buildings/ha		
1	0.3	<31 units of	Total Common Facilities	
3		32-47 units of		
5		>48 units		
1	0.3	<30%	Built Area	
3		30-60%		
5		> 60%		
1	0.6	<15 inhabitants/ha	Density	Vulnerability (social)
3		of 15-25 inhabitants/ha		
5		>25 inhabitants/ha		
1	0.2	<20	Poverty Ratio	
3		20-40		
5		>40		
1	0.2	<18 inhabitants	Total Disability	
3		18-36 inhabitants		
5		>36 inhabitants		
1	0.4	Private/government employees	Primary Source of Income	Vulnerability (economy)
3		Processing industry, trade		
5		Agriculture, miner/quarrying		
1	0, 3	<50 units	Total Industry	
3		50-100 units		
5		>100 units		
1	0.3	<30%	Productive Land Area	
3		30-50%		
5		>50%		
1	0.2	Not present	Early Warning System	Capacity
5		Present		
1	0.1	Not present	Evacuation Route	
5		Present		
1	0.1	Not Available	Alarm	
5		Available		
1	0.1	Not available	Availability of the Equipment	
3		Not adequate		
5		Complete		
1	0.3	Never	Disaster Education/Training	
3		Somewhat often		
5		Often		
1	0.2	Not present	Mutual Cooperation	
5		Present		

3. Results and discussions

3.1. Land Slide Risk Assessment

Landslides are defined as the displacement of slope-forming materials, those are debris avalanche, rocks, soil, or mixed material moving down or out of the slope. This incident is influenced by several factors, including slopes that are bare and the condition of soil and rocks are fragile. The main trigger of landslide is the high intensity of rainfall. In addition, human activity can also be a driver of landslides, namely development in protected areas, plantation activities or fields in cliff areas.

Risks as potential losses that can be death, life threats, material losses, and disruption of socio-economic activities of communities caused by disasters. Risk analysis aims to identify areas based on their risk level of disaster [4]. Assessment results become a reference in the formulation to cope with the negative impact of the disaster.

Risk is a function of a combination of hazard and vulnerability, and its relationship is expressed as a result of multiplication between hazard and vulnerability [5]. Disaster risk is formed at least by two factors, the place where the disaster is located, usually called a place that has the potential for disaster (hazard) and the level of vulnerability (vulnerability). Mathematically, the risks can be formulated as follows:

$$\text{Risk} = f \{ \text{Hazard, Vulnerability} \}$$

In addition to hazard and vulnerability factors, there are other factors that can play a role in increasing or decreasing disaster risk, ie capacity (capacity). Capacity is defined as a system, community or community potentially exposed to danger to adapt or change to achieve or maintain an acceptable level of function and structure [5]. This is determined by the extent to which such a social system is able to organize itself to enhance the capacity to learn from past disasters for the better protection of the future and to enhance risk reduction measures.

Risk assessment is one part of the disaster risk assessment. The risk assessment itself is part of disaster risk management. Disaster risk management is one of the phases in pre-disaster, defined as a process of identifying disaster risk types, assessments, and monitoring of results, conducted repeatedly and periodically with the objective of minimizing disaster risk [6]. According to the Asian Disaster Reduction and Response Network/ADRRN (2010), disaster risk management aims to avoid, mitigate, or divert harmful impacts from threats / hazards through prevention, mitigation and preparedness activities and efforts.

In the context of disaster prevention and development policy decisions that can pose a risk of disaster, mapping plays an important role in every stage of disaster management, and is very helpful in disaster risk reduction [7]. Landslide risk map produced can describe areas with low risk, medium, and high. The risk level is calculated by scoring the parameters of threats, vulnerabilities, and capacities, which produces maps the level of threat, vulnerability, and capacity. From the results of the mapping is done categorization of risk using the matrix multiplication method VCA (*Vulnerable Capacity Assessment*). To determine the level of risk, result of scoring vulnerability-capacity beforehand calculated and classified using VCA table to get the class of Vulnerability/Capacity (V/C). The result can be seen in the matrix Table 2 below.

3.2. Water absorption properties porous geopolymer

The features and properties of the porous geopolymer, for example, porosity, pore size distribution, pore morphology, and pore connectivity (commonly identified as the relationship between open and closed porosity), depend strongly on the composition and processing method. Research study shows that the chemical compositions of the geopolymers (in terms of their $\text{H}_2\text{O}/\text{Al}_2\text{O}_3$ and $\text{Na}_2\text{O}/\text{Al}_2\text{O}_3$ ratios) were systematically varied, allowing the porosity and water retention properties to be adjusted [6].

Figure 2 shows that geopolymers synthesized with higher $\text{H}_2\text{O}/\text{Al}_2\text{O}_3$ ratios are more porous, their larger pore size and higher pore volume giving them good water absorption and water retention

properties but decreasing their mechanical strength. The limited mechanical strength of this type of geopolymers may have restriction on some applications. By contrast, the geopolymers synthesized with lower H_2O/Al_2O_3 ratios are denser, with smaller pore sizes and lower pore volumes, resulting in better water retention and mechanical properties than materials with higher H_2O/Al_2O_3 ratios. Thus, these two types of geopolymers are suitable for different water retention applications [6].

Table 2. Matrix vulnerability-capacity landslides in Citeureup District.

V/C	Capacity		
	High	Medium	Low
Vulnerability	Low	Tangkil, Hambalang, Tajur, Sanja, West Karang Asem, Puspanegara, Puspasari, Citeureup, East Karang Asem,	
	Medium	Leuwinutug	
	High	Pasir Mukti, Sukahati, Tarikolot, Gunung Sari	

Based on the results of the matrix multiplication, Tangkil, Hambalang, Tajur, Leuwinutug, Sanja, West Karang Asem, Puspanegara, Puspasari, Citeureup, and East Karang Asem has a medium vulnerability and capacity, and including in medium V/C. Pasir Mukti, Sukahati, Tarikolot, and Gunung Sari are including as areas with high vulnerability and medium capacity, and belongs to high V/C.

Pasir Mukti, Sukahati, Tarikolot, and Gunung Sari has a high vulnerability, influenced by the number of vulnerable people, ie persons with disabilities, commonly found in the region. Furthermore, there are many community-based economic activities in that region, shown by the number of factories located in Pasir Mukti, Sukahati, Tarikolot, and Gunung Sari.

Furthermore, from V/C calculation, additional of threats was added. This process is performed by using a calculator filed on the QGIS device. The result can be seen in the matrix table 3 below.

Table 3. Matrix hazard-vulnerability to landslides in Citeureup district.

Risk Matrix	V/C		
	High	Medium	Low
Threat/Danger	Low	Pasir Mukti, Sukahati, Tarikolot, Gunung Sari	Sanja, West Karang Asem, Puspanegara, Puspasari, Sanja, Leuwinutug, East Karang Asem
	Medium	Tangkil, Hambalang, Tajur	
	High		

Risk Matrix of landslides in Citeureup sub-district shows that rural areas/villages are in the low-medium threat zone, which means that those villages are belong to landslide risk of low to moderate class. Only three villages namely Hambalang, Tajur, and Tangkil are in the moderate risk class, while Pasir Mukti, Sukahati, Tarikolot, Gunung Sari, Sanja, Karang Asem West, Puspanegara, Puspasari, Sanja, Leuwinutug, and East Karang Asem East are in low risk class.

If an area has low vulnerability, although that area is located in high hazard zones, it will make the area has low risk of disaster. Due to low vulnerabilities that exist in the region, so that the disaster will not affect the physical, social, and economic condition of the region significantly.

Result from interviews indicate a high awareness of the potential for landslides or land movements in the Citeureup sub-district. Some areas are located in the hills, and in the area around the river which is prone to landslides and subsidence. However, this condition does not exist in every region in Citeureup. Only a few villages or locations that have prone points to landslides, namely Hambalang and Tajur. Both villages are located in the Hambalang hills and is the highest area in Citeureup sub-district. The region has the morphology of hills with a slope $>15\%$. The level of landslides risk in Citeureup district can be seen in figure 2.

Landslides incident were happened several times in the area of research. However, those incident did not cause casualties or collapsed buildings. Landslides occur every year in Citeureup sub-District, with different location of landslides. Although the intensity of the landslide is low and did not cause casualties, but the landslides in 2007 has led Hambalang villagers to be relocated because of the discovery of cracks extending around settlements.

Danger or threat is a natural phenomenon or man-made which has the potential to threaten human life, damage environment and loss of property. Referring to the definition of danger according to Awotona [8], that the danger can happen anywhere and anytime, and trigger disasters when meeting with vulnerable conditions [8]. The impact is generally in the form of loss and damage to humans, which is caused by the inability of man-made systems in protecting themselves and assets/possessions he had.

Based on the results of research conducted by Dianardi *et al* (2012), morphology or the outside structure of rocks that making up the earth's surface is the cause of landslide in Hambalang Hills region [9]. Tajur and Hambalang villages with a medium-high landslide potential, has a height of 500 meters with a maximum slope of 25° . This causes low slope stability and resulted in susceptible ground movement. Rock composer which have fine-grained texture causes high absorption of runoff and low adhesion to the ground, so the potential for land subsidence is high.

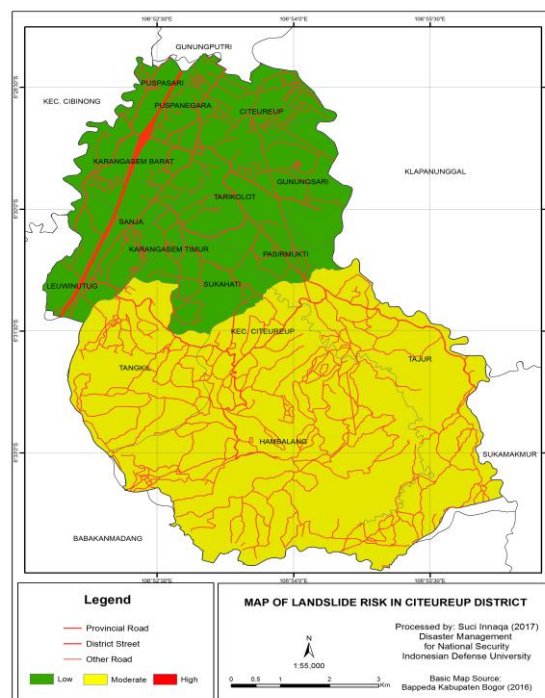


Figure 2. Map of Landslide Risk in Citeureup District. Note: Red (High Risk), Yellow (Moderate Risk), Green (Low Risk).

In addition to the slope, land use is one of the criteria that influence the occurrence of landslides.

Land which there is a building or tree crops with strong roots actually reduce the potential for landslides than vacant land or just overgrown plants without strong roots like vegetables. The area with the mountainous topography or have high slope has high potential for ground movement or landslides. This is in accordance with the results of the study that describes the highest village area (Hambalang, and part of Tajur) that includes in high class category for potential ground movement. This condition is inevitable, because the condition of a region is *given* to the region itself. Later, vulnerabilities and capacities of a those region which would make the threat/danger become a disaster or not. Map of threat generated in this study are shown in figure 3 below.

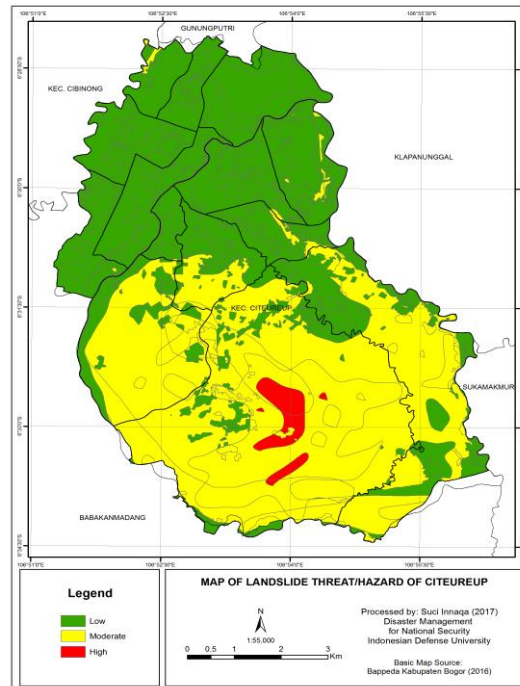


Figure 3. Map of landslide threat/danger of Citeureup District. Note: Red (High Threat), Yellow (Moderat Threat), Green (Low Threat).

Based on the research result, tabel 4 shows the level of lanslides hazard in Citeureup District. Based on the scores of hazard parameters, the hazard level in Kecamatan Citeureup is dominated by low-moderate hazards. The total area of low hazard area is 3,325.17ha (48,68%), medium hazard area is 3,386.43 (49.58%), and the area in high hazrd is only 118,96 (1.74%). A total of 11 villages are located in low hazard areas, while three villages, Hambalang, Tangkil and Tajur are in moderate hazard areas. High landslide hazard areas are found only in a small part of Hambalang Village.

3.3. Physical, Social, Economic Vulnerability and Capacity related to Landslides Disaster

Efforts to reduce disaster can be done either by reducing the level of vulnerability. Identification and vulnerability assessments should be done to reduce the impact of disaster. Wisner *et. al* explain to understand the vulnerability using Pressure Release Model (PAR). PAR consists of two parts, represented by two diagrams, Pressure Model and Release Model. To discuss vulnerabilities, researchers used a model to analyze the pressure in understanding the root causes of vulnerability in Citeureup District. Vulnerabilities is known as one of the factors that influence a natural event to turn to a disaster. Disasters will happen when hazards meet vulnerable conditions. In this discussion, the physical vulnerability describe the level of infrastructure damage that occurs during a disaster.

Tabel 4. Landslides hazard level in Citeureup District.

Village	Population (person)	Area (ha)	Hazard					
			Low	%	Medium	%	High	%
Tangkil	813	776.42	183.83	23.68	592.59	76.32		
Hambalang	11097	2295.33	221.10	9.63	1955.27	85.18	118.96	5.18
Tajur	12527	1110.45	426.44	38.40	684.01	61.60		
Pasir Mukti	10343	188.67	172.93	91.66	15.74	8.34		
Sukahati	9616	309.32	193.49	62.55	115.83	37.45		
Leuwintug	14308	223.17	222.47	99.69	0.70	0.31		
Sanja	15185	292.21	292.21	100.00				
Karang Asem Barat	31521	276.60	276.60	100.00				
Karang Asem Timur	11184	92.96	92.38	99.37	0.59	0.63		
Tarikolot	20655	293.07	290.65	99.17	2.42	0.83		
Gunung Sari	13108	324.51	311.43	95.97	13.08	4.03		
Citeureup	17280	367.69	367.69	100.00				
Puspanegara	18304	139.41	139.41	100.00				
Puspasari	14833	140.74	134.55	95.60	6.20	4.40		
TOTAL	200774	6830.55	3325.17	48.68	3386.43	49.58	118.96	1.74

Citeureup sub-District can be divided into two characteristic regions, regions with urban characteristics (including West Karang Asem and Puspanegara), and characterized by rural, namely the village of Tarikolot, Sanja, Leuwintug, East Karang Asem, Citeureup, Sukahati, Tajur, Tangkil, Hambalang, Pasir Mukti, Puspasari, and Gunung Sari. Physical vulnerability scoring result shows that West Karang Asem, Puspanegara, and Puspasari are in high physical vulnerability, the village of Karang Asem Sanja and East Karang Asem are in moderate physical vulnerability, and nine other villages are in the lower levels of physical vulnerability. Area with urban characteristics have a more complex activity, which is more densely populated, that lead to the construction of public facilities nearby. According to Wisner *et.al*, a fragile physical environment can lead to a condition of an area to be unsafe. Hazardous locations and the condition of the infrastructure and buildings that are not protected is the cause of the development of vulnerability. Although the roots of the problem and the dynamic pressure has been overcome, but the unsafe conditions that triggered the danger by potential soil movement prone to make the area subject to landslides.

3.3.1. Physical Vulnerability. Physical vulnerability often associated with spatial planning perspective, which is associated with the arrangement of settlements, the network of infrastructure and tools that support the social economic, and strategic areas the territory. Spatial planning is a form of intervention from the development activities that are multidimensional and allows various forms of disaster risk reduction activities to be integrated. In determining the form of the activities carried out, of course, depend on the type of disaster and the purpose of the activity. For example, the Citeureup District has done a landslide risk reduction by holding crops that can bind water. The aim is to reduce the absorption of water directly to the soil so that runoff water will not seep into the ground. Betung bamboo tree were planted in several locations including areas that prone to landslides. This is an appropriate efforts in the environment so that disaster risk reduction strategies can be realized. Additionally, attempts to do next is to build a sewer to drain the water flow so that runoff water will not seep into the soil in the area that is friable and has a hollow structure.

The value of physical vulnerability is obtained from the scores of three parameters derived from the Village Potential Data of 2014 issued by Statistics Indonesia (*Badan Pusat Statistik-BPS*). The first parameter used in assessing physical vulnerability is house density. According to BPS Bogor District (2016), the total number of houses in Citeureup sub-district is 54,304 houses, mostly in West Karang

Asem Village, which is 8543 houses and the lowest in Tangkil Village, 226 houses. However, East Karang Asem village has the highest house density, which is 34.50 houses per hectare, and Tangkil Village has the lowest house density of 0.29 houses per hectare.

The second parameter to assess physical vulnerability is the number of public facilities. Based on the Village Potential Data, Hambalang Village has the largest total of public buildings, with 54 buildings dominated by religious facilities, while the village with the smallest number of facilities is Tangkil which has only six public facilities buildings. Most educational facilities are located in Puspanegara and Karang Asem Barat villages. Religious facilities are commonly found in Hambalang Village, namely musholla or langgar (BPS, 2014).

The third parameter is the percentage of land area built in Citeureup sub-district. Puspasari village has the largest widened area of 87.02%. The smallest built-up land area is in Hambalang Village, which is only 7.51%.

3.3.2. Social Vulnerability. Social vulnerability illustrates the vulnerability to the safety of people if a disaster occurs. Based on calculations that have been done, there are four villages that have high social vulnerability, namely Pasir Mukti, Sukahati, Tarikolot, and Citeureup. Hambalang village, Tajur, and Tangkil have low social vulnerability, while seven villages/other villages are in the medium level of vulnerability. The population density has a role in determining a region included in vulnerable category or not. The higher the density the higher the condition followed by social activities in it. Although the highest population density is in the Village Puspanegara, East Karang Asem, West Karang Asem and Puspasari, but the four regions are in the middle class of social vulnerability. In addition to overcrowding, there are other indicators in the form of people with disabilities and poor people who are part of the vulnerable groups.

Based on PAR models, there are few constituent parts that affect the vulnerability: the root causes, dynamic pressures and unsafe conditions. The root cause of vulnerability is always located on the problems of economic, demographic, and political processes, which may affect the distribution and allocation of resources in the community.

Based on this research, areas that have a high population density may not necessarily be in high social vulnerability criteria. This is because the other indicators such as vulnerable groups that trigger the vulnerability of an area when viewed from the side of the social community. Vulnerable population requires more attention, especially the population of disabilities. This is due to population disabilities have limitations in performing self-rescue efforts, and limited participation in complicity life situations. Therefore, it is necessary for the proper handling of individual persons with disabilities so that they will have the same response with other residents who do not have disability issues.

3.3.3. Economic Vulnerability. Economic vulnerability shows the condition of the vulnerability of the resource and economic activity of society. Citeureup sub-district's economic activity is divided into two, namely relying on the industrial sector and agro-tourism. Agrowisata concentrated in hilly areas like Hambalang and Tajur, while for the industry is concentrated in the West Karang Asem and Tarikolot. Economic vulnerability seen from productive land area, number of industries, and the source of the main income. The region has productive land area, primarily located in rural areas, are extremely vulnerable in the event of a disaster. Productive land in the form of farms, fields, and plantations become damaged and economic activity disrupted. Wisner *et.al* states, economic vulnerability has basically two concepts, namely the vulnerability of macroeconomic and micro-economic vulnerability. From the standpoint of looking at macro economy more widely, such as the vulnerability of the economic growth of a country when disaster strikes, this may impact on the market or economic activity. From the standpoint of microeconomics, economic vulnerability focuses on the impact of shocks to the individual or household level, where household income is the main thing that is most influential. The decline in household income levels make a household is unable to meet basic needs.

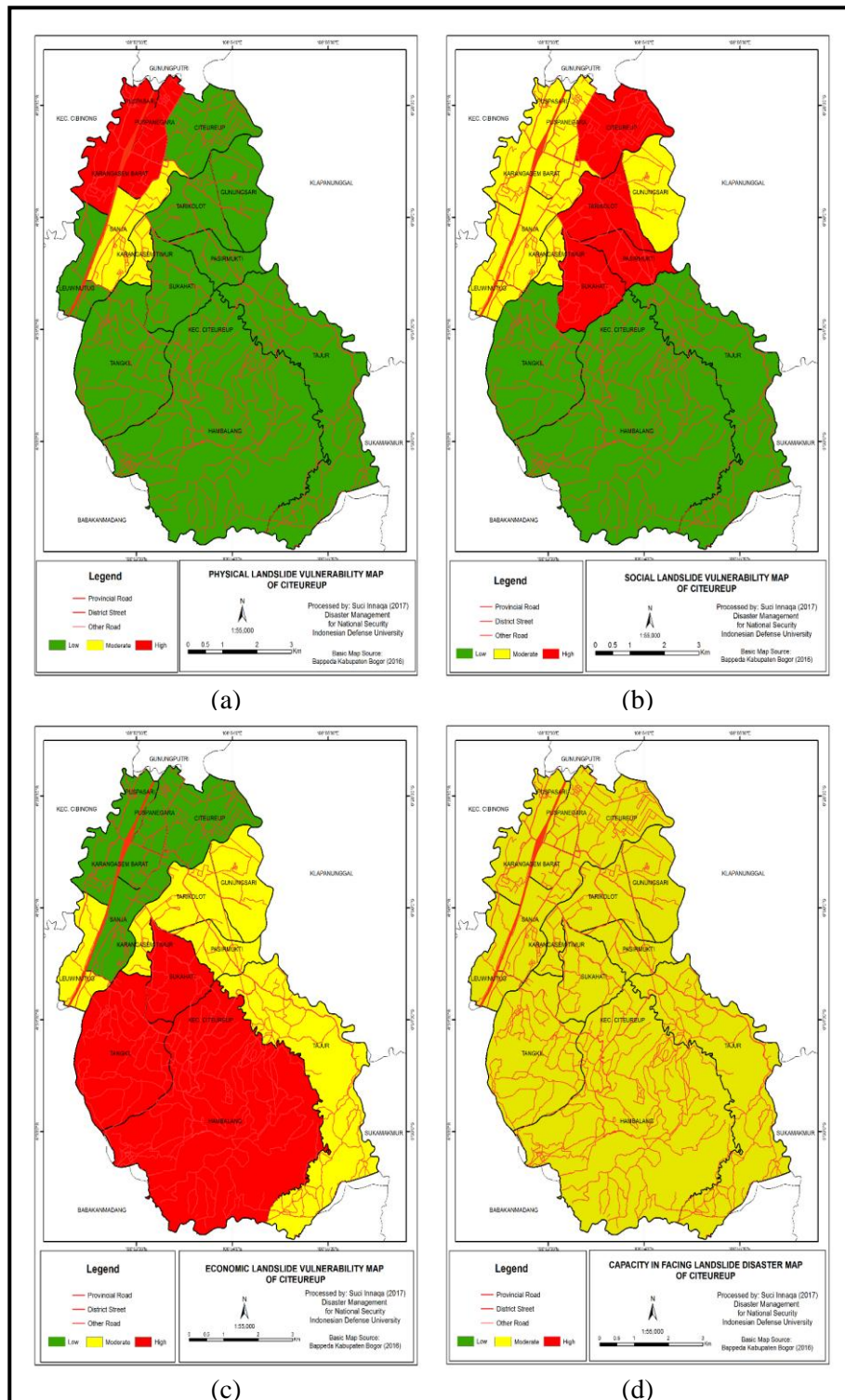


Figure 4. Physical Landslide Vulnerability Map (a), Social Vulnerability Map(b), Economic Vulnerability Map(c), and Capacity in Facing Landslide Disaster-Map in Citeureup sub-district(d). Note: Red (High), Yellow (Moderate), Green (Low).

The impact will lead to the creation of conditions of household poverty. Most villagers Hambalang and Tajur build their livelihoods in the agricultural sector that produces crops. Village/other urban livelihoods depend largely on the industry, working as laborers or as an employee.

Fragile local economic conditions resulting from livelihood at risk, as well as a low income can increase vulnerability. Therefore, efforts should be done to strengthen the livelihoods of the rural for example with income diversification opportunities, such as the creative economic activities so that each family have other income sources besides the main income.

3.3.4. Capacity. Capacity can be defined as the ability of the regions and communities in the face of disaster. There is a reciprocal relationship between vulnerability and capacity, especially in access to resources (assets), both natural psychological, social or financial. Improved access to resources indicate an increased capacity to face and recover from hazard events, nor vice versa. Increasing the capacity of the area can be done through several strategies, one of them by relying on community participation and development orientation.

The study assessed the physical capacity of the existence of early warning systems, evacuation routes, signs for danger signs, and availability of equipment, while social rated capacity of educational disaster institutions and cooperativeness. Based on the results of scoring each indicator of the capacity, the whole villages in the Citeureup sub-district included in the medium capacity class. That is, the capacity in the Citeureup sub-district is good enough. Based on the findings, the physical capacity in the Citeureup sub-district can be said to have a low value. This is due to the lack of early warning systems, evacuation routes, and signs for danger signs. This is because of the Citeureup sub-district has not been included in the priority procurement and construction of an early warning system of Local Disaster Management Agency (*Badan Penanggulangan Bencana Daerah-BPBD*) Bogor Regency. The reason is the landslide that occurred in Citeureup sub-district has not reached the level of severe catastrophic events, despite having a region with high potential. Similarly, the presence of evacuation routes and danger signs mark does not exist in the Citeureup sub-district, although the government has drawn up districts with the initiative as a step preventive evacuation path. However, the capacity of a high social value, due to the introduction and dissemination on disaster reduction has been done, even in formal education. Moreover, the existence of village institutions such as youth clubs, village-level disaster task force, as well as other institutions to be a forum of mutual cooperation in the motion disaster risk reduction.

Distribution of physical, social, economic vulnerabilities and capacities in the Citeureup sub-district can be seen in figure 4. The figure shows that area of economic vulnerability is the largest compare to social and physical vulnerability. Red color shows areas with high vulnerability. However, overall capacity of Citeureup sub-district falls into medium category (yellow color). When overall capacity of an area is high, it could compensate the high vulnerability and decrease the risk in facing disaster.

4. Conclusions

The conclusion of this research is that Citeureup sub-district has low-level landslide risk, although it has high potential for land movement. This shows that areas with high landslide potential do not necessarily have high risk level. Villages with moderate risk are Hambalang, Tajur, and Tangkil villages, while low-risk villages include Pasir Mukti, Sanja, Tarikolot, Gunung Sari, Puspasari, Karang Asem Timur, Citeureup, Leuwintug, Sukahati, West Karang Asem West and Puspanegara. The capacity of the community plays an important role to minimize the risk of a region. Disaster risk reduction strategy is done by creating a safe condition, which intensifies the movement of disaster risk reduction.

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