Community Vulnerability and Capacity to Landslides in South Babakan Madang Subdistrict, Bogor Districts

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Abstract. Many countries in the world have various kinds of problems, such as disasters. Indonesia is one of the countries with high area and population affected by landslides, such as in several regions in Indonesia, namely Bogor Districts. The affected population can be caused by the increasing number of residents and built-up areas, as well as the low level of public knowledge about landslides. The high population affected can describe the level of vulnerability and capacity that exists in the community, such as in South Babakan Madang Subdistrict. The density of the population and the built-up area which includes settlements, public facilities and community knowledge related to landslides that are different in 3 Countryside namely Bojong Koneng, Cijayanti, and Karang Tengah make the people in South Babakan Madang Subdistrict vulnerable to landslides. The modified scoring method with reference to Perka BNPB No. 02 of 2012 can be used to determine the level of vulnerability and capacity of the community. The results show that South Babakan Madang Subdistrict is dominated by moderate vulnerability with an index between 0.34 - 0.67. The capacity in the South Babakan Madang Subdistrict tends to be homogeneous in the low capacity class with an index < 0.34.

Keywords: **Community Vulnerability; Community Capacity; Landslides; South Babakan Madang Subdistrict.**

1 Introduction

Community life in Indonesia is inseparable from natural disasters, such as landslides. Data from the Bogor Districts BPBD shows that the Babakan Madang Subdistrict, especially in the southern part, has a high number of landslides in 2018, i.e. 10 times. In 2018 as many as 10 landslides with losses of 57 families were threatened and 48 houses were damaged. The occurrence of landslides can cause various kinds of damage and losses to human life. Damage and losses caused are direct or indirect, for direct damage such as damage to public facilities, agricultural land, or the existence of casualties, and for indirect damage to the paralysis of economic and development activities in the affected area [1].

Efforts to reduce losses due to landslides can be done by reducing the level of vulnerability and increasing community capacity. Specifically, vulnerability is the relationship between the damage degree of the elements at risk and the intensity of the disaster [2]. However, studies examining vulnerability to landslides are limited. Vulnerability is level to which a community, structure, service or geographical area is potentially disturbed by the impact of certain hazards [3]. The vulnerability of the community to landslides causes the possibility of losses that may occur in life and physical infrastructure caused by landslides in a certain period of time [4]. The level of vulnerability can be viewed from physical (infrastructure) and social vulnerabilities. Vulnerability is defined as the total damage caused by a particular natural hazard to a specific object or an element at risk at a specific scale [5].

Unlike vulnerability, community capacity is closely related to efforts to reduce the impact of disasters, which consist of mitigation, disaster preparedness, and the ability to survive. Capacity is a system or a community that is potentially exposed to danger to adapt or change to achieve or maintain acceptable levels of function and structure [6]. Capacity is more directed at the ability of each individual in dealing with and handling disaster. The capacity is important for the community because it can withstand the effects of landslides [7].

Based on data from BPBD Bogor Districts landslide for Babakan Madang Subdistrict, where every year starting from 2011 - 2018 at least one landslide occurs with landslides found in three Countryside namely Karang Tengah, Bojong Koneng, and Cijayanti located in the South Babakan Madang Subdistrict. The highest incidence is in 2017 and 2018, where in 2017 there were 11 landslides with losses of 25 families threatened by life and 17 houses damaged. In 2018 as many as 10 landslides with losses of 57 families were threatened and 48 houses were damaged.

These countrysides have a population that continues to increase every year and the increase in buildings in the form of settlements or public facilities. With the increase in population and built area, the vulnerability and

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capacity of the community will certainly diverse in each village in 3 countrysides. By using ArcGIS technology, vulnerability and capacity in the research area can be clearly identified.

1.1 Research Problem and Objectives

As explained in the background, the facts show that landslides in the South Babakan Madang Subdistrict are quite high. The latest incident according to BPBD in October 2018 was a landslide in Cijayanti Countryside with a loss of 25 heavily damaged and lighthouses. Based on these two research questions are as follows:

1. What is the vulnerability of the community to landslides in the South Babakan Madang Subdistrict?
2. What is the community capacity to landslides in South Babakan Madang Subdistrict?

From the research questions that have been generated, this research aims to:

1. Analyzing the vulnerability of the community to landslides in South Babakan Madang Subdistrict.
2. Analyzing the capacity of the community to landslides in South Babakan Madang Subdistrict.

1.2 Description of Research Area

Geographically the research area is located at coordinates $6^0$32'50 "LS - $6^0$39'20" LS and $106^0$52'00 "BT - $106^0$58'30" BT. The research area borders on other regions, among them are:

1. North :Citeureup Subdistrict
2. East :Sukamakmur Subdistrict.
3. South :Megamendung Subdistrict
4. West :Sukaraja Subdistrict

The research area covers the South Babakan Madang Subdistrict which consists of three Countryside namely Bojong Koneng, Cijayanti, and Karang Tengah (Fig. 1). The area of the research area that includes three countrysides as follows.

Table 1. Research Area.

Countryside	Number of Villages	Area (Ha)
Bojong Koneng	15	1859,83
Cijayanti	8	1684,65
Karang Tengah	14	3534,67
Total	**37**	**7079,15**

In the study area there were 37 villages as seen in Table 1, where in Bojong Koneng Countryside consisted of 15 villages namely Bojong Koneng Village, Bojong Gook-Tegal Luhur Village, Cibingbin-Muara Village, Cikeas Village, Curug Village, Curug-Gombong Village, Garungsang-Cibingbin Village, Gunung Batu Village, Gunung Batu Kidul Village, Pasir-Gunung Village, Sudi-Tapos Village, Besakih Park, Tampak Siring Park, Udayana Park, and Tapos-Pasir Hayam Village.

Cijayanti Countryside consists of 8 villages, namely Babakan Village, Cijayanti II Village, Cijayanti III Village, Cimanggurang Village, Legok Banteng Village, Rubber Sand Village, Maung Village, and Sentul City. Karang Tengah Countryside consists of 14 villages, namely Kampung Babakan, Kampung Babakan Ngantai, Kampung Blok Dukuh, Kampung Ciburial, Kampung Cigobang, Kampung Cimandala, Kampung Glewer, Kampung Karang Tengah, Kampung Landeuh, Kampung Leuwi Goong, Kampung Sukamantri, Kampung Wangun I, Kampung Wangun I, Kampung Wangun I, Kampung Wangun I Wangun II, and Wangun Cileungsi Village.

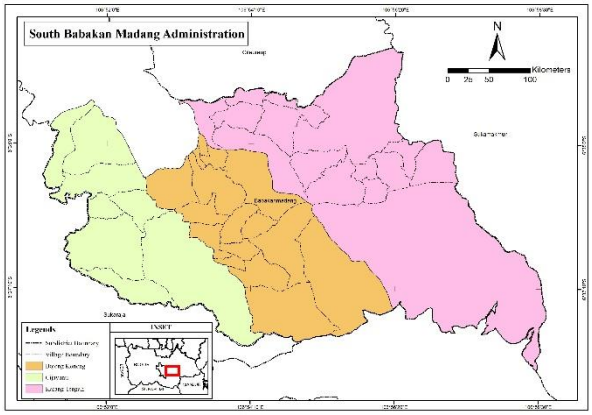

Fig. 1. Research Area in the South Babakan Madang Subdistrict

2 Variable and Method

There is some variable and method for determining community vulnerability and capacity to landslides. In this research, vulnerability variables were used with reference to Perka BNPB No. 02 of 2012 and have been modified according to the study area such as population density, and sex ratio for social vulnerability. Estimated number of houses (house density), and number of public facilities for physical vulnerability. The variable capacity is used with reference to Perka BNPB No. 02 of 2012 which is based on 5 levels of resilience *Hyogo Framework Actions* (HFA).

2.1. Vulnerability Variable and Method

The variable population density is the population for each size of the village area. Population density is calculated into the vulnerability of the community to landslides because with a high population density, the chances of falling victims due to landslides will be even greater [8]. Variables of vulnerable groups are vulnerable groups of society seen by their sex are women. Women's ability to deal with disasters will be lower because the tendency of women to be physically weaker than men, so that the female population will need the help of male residents [8].

Table 2. Classification of Social Vulnerability.

Parameter	Unit	Weight	Classification	Value	Score
Population Density (People/Ha)	<17 People/Ha	60%	Low	1	Value Class / Maximum Value of Class
	17-30 People/Ha		Moderate	2	
	>30 People/Ha		High	3	
Sex Ratio	>110	40%	Low	1	
	100-110		Moderate	2	
	<100		High	3	

Variable estimated number of house is a building that functions as a habitable residence for each settlement area. Variables of public facilities are facilities in residential environments that function to support the implementation and development of social/cultural life. All variables mentioned above are then processed using the scoring method with reference to Perka BNPB No. 02 of 2012 [4], Research by Sari [6], and Research by Bayuaji [9]. Based on all three, modifications and adjustments were made to the research area as in Table 2 and Table 3.

Table 3. Classification of Physical Vulnerability.

Parameter	Unit	Weight	Classification	Value	Score
House Density (unit/Ha)	<15 Unit/Ha	60%	Low	1	Value Class / Maximum Value of Class
	15-25 Unit/Ha		Moderate	2	
	>25 Unit/Ha		High	3	
Public Facilities (unit)	>5 Unit	40%	Low	1	
	3-5 unit		Moderate	2	
	<3 Unit		High	3	

After scoring, mathematical calculations were carried out to obtain the Landslide Vulnerability Index (*LVI*) using the following formula.

$$SVI = (PDS \times 60\%) + (SRS \times 40\%) \quad (1)$$

$$PVI = (HDS \times 60\%) + (PFS \times 40\%) \quad (2)$$

$$LVI = (SVI \times 60\%) + (PVI \times 40\%) \quad (3)$$

SVI is the Social Vulnerability Index and *PVI* is the Physical Vulnerability Index, where the index is obtained by summing the score of each parameter that has been multiplied by the weight. All calculations are then processed and analyzed using ArcGIS. Spatial and descriptive analysis is used to clarify the results of the calculations.

2.2 Capacity Variable and Method

In order to provide landslide vulnerability maps, various methods such as fuzzy logic, statistic methods, and Analytic Hierarchy Process (AHP) can be used [10]. This research used a scoring method that similar to the AHP method, where the scoring method based on Perka BNPB No.2 of 2012 [11]. It determining the capacity agreed upon by various countries in the world, where from the agreement of the Hyogo Framework for Actions (Action Framework - HFA) there are five levels of resilience. The following are five levels that have been modified referring to the research conducted by other research [12-14] which has been adjusted to the research area.

Table 4. Classification of Community Capacity.

Level	Capacity Parameter	Achievement	Class			Capacity Value	Score
			Low	Moderate	High		
1	Education	House on stilts Greening in settlement areas Landslide retaining wall in settlement area	v			1	Value Class / Maximum Value of Class
2	Early Warning	Simulation faces a landslide disaster Signposts & early warning systems					
3	Rules and Institutions	Establishment of institutions / communities / forums to deal with and overcome landslides		v		2	
4	Basic Risk	Routine activities by institutions / communities / forums			v	3	
5	Preparedness	Successful institutions / communities / forums to make all communities have high capacity related to landslides					

Capacity values obtained through interviews with 118 respondents using the purposive sampling method. The scoring method is used as in Table 4. Mathematical calculations are then performed by multiplying the score and weight (100%). The scoring that was done then processed using ArcGIS to be analyzed spatially and descriptive analysis was carried out to clarify the processed results.

3 Results and Discussion

3.1 Community Vulnerability to Landslides

The vulnerability of the community is obtained through the social vulnerability index and physical vulnerability index multiplied by each weight and then summed up so that the overall vulnerability index of landslides in each village of the study area can be identified.

Table 5. Landslide Vulnerability Index in Each Village of the Bojong Koneng Countryside.

Villages	SVI*0,6	PVI*0,4	Landslide Vulnerability Index
Bojong Koneng	0,28	0,29	0,57
Bojong Gook - Tegal Luhur	0,36	0,35	0,71
Sudi - Tapos	0,28	0,35	0,63
Tapos - Pasir Hayam	0,40	0,40	0,80
Garungsang - Cibingbin	0,48	0,35	0,83
Cibingbin - Muara	0,28	0,35	0,63
Pasir Ipis - Gunung Batu	0,40	0,35	0,75
Gunung Batu	0,48	0,40	0,88
Curug - Gombong	0,36	0,40	0,76
Cikeas	0,36	0,27	0,63
Gunung Batu Kidul	0,60	0,40	1,00
Taman Udayana	0,48	0,40	0,88
Taman Tampak Siring	0,36	0,40	0,76
Taman Besakih	0,36	0,40	0,76
Curug	0,28	0,40	0,68

Table 6. Landslide Vulnerability Index in Each Village of the Cijayanti Countryside.

Villages	SVI*0,6	PVI*0,4	Landslide Vulnerability Index
Babakan	0,40	0,21	0,62
Cimanggurang	0,28	0,29	0,57
Cijayanti II	0,40	0,21	0,62
Cijayanti III	0,28	0,24	0,52
Pasir Karet	0,36	0,19	0,55
Pasir Maung	0,48	0,13	0,61
Legok Banteng	0,36	0,27	0,63
Sentul City	0,36	0,24	0,60

Table 7. Landslide Vulnerability Index in Each Village of the Karang Tengah Countryside.

Villages	SVI*0,6	PVI*0,4	Landslide Vulnerability Index
Landeuh	0,28	0,40	0,68
Karang Tengah	0,20	0,40	0,60
Ciburial	0,28	0,40	0,68
Glewer	0,36	0,40	0,76
Babakan	0,44	0,35	0,79
Leuwi Goong	0,28	0,27	0,55
Cimandala	0,20	0,27	0,47
Babakan Ngantai	0,60	0,40	1,00
Wangun I	0,32	0,40	0,72
Wangun II	0,48	0,35	0,83
Wangun Cileungsi	0,36	0,35	0,71
Blok Dukuh	0,28	0,21	0,49
Sukamantri	0,20	0,40	0,60
Cigobang	0,20	0,40	0,60

Community vulnerability to landslides in each village (Fig. 2) can be seen from the social vulnerability index and physical vulnerability index which previously had gained dominance in the vulnerability index of high-class landslides, of which 19 villages had 19 villages located in the north to south of the research area are in the high class landslide vulnerability index.

The high class landslide vulnerability index, when viewed based on its social and physical vulnerability index, is between 0.68 - 1.00 (Table 5, 6, 7). A total of 18 other randomly distributed villages were in the medium class landslide vulnerability index. Moderate class landslide vulnerability index, when viewed based on its social and physical vulnerability index, is between 0.34 - 0.67.

The level of vulnerability of the community in every village is diverse. Another research [15] stated that community vulnerability was determined based on 13 indicators just based on census data. In this study only two indicators were used, namely physical vulnerability (estimated number of houses, number of public facilities) and social vulnerability (population density, vulnerable groups), which in this study were not only based on census data but also direct field survey results so that could be known as the level of community vulnerability in more detail.

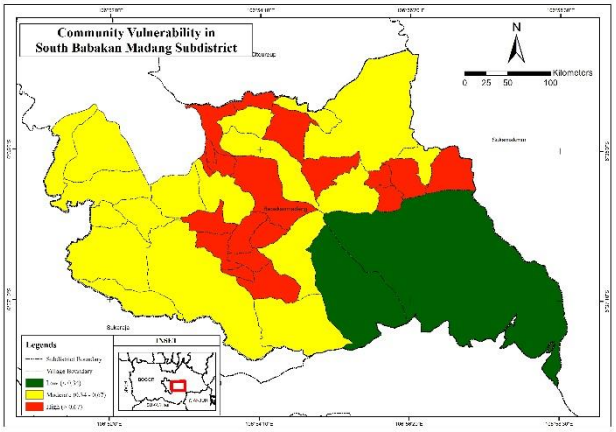

Fig. 2. Community Vulnerability in the South Babakan Madang Subdistrict

3.1.1 Social Vulnerability

Social vulnerability in each village (Fig. 3) and seen from population density and vulnerable groups based on the dominant sex ratio are in the middle class social vulnerability, of which a total of 37 villages as many as 24 villages are included in the moderate class social vulnerability.

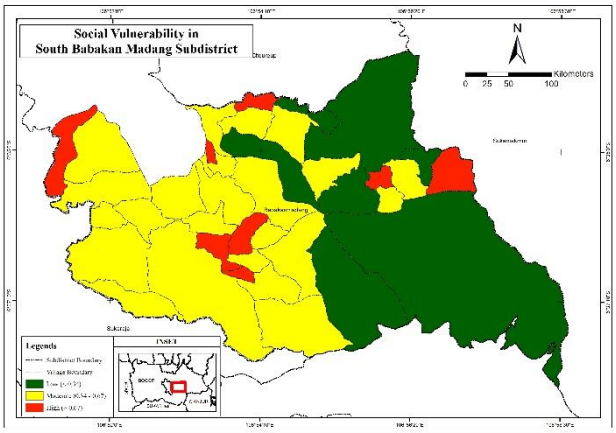

Fig. 3. Social Vulnerability in the South Babakan Madang Subdistrict

A total of 8 villages are in high class social vulnerability. The population density in the eight villages is more than 30 people/ha, and the sex ratio is less than 100, which means that every 100 female residents have less than 100 male population, the social vulnerability index in the high class ranges from 0.68 - 1, 00.

Other villages, namely Karang Tengah Village, Leuwi Goong, Sukamantri, Cimandala, and Cigobang, are in low class social vulnerability. The population density in these five villages only reached less than 17 people/ha, and the sex ratio was more than 110, which means that every 100 female population there are more than 110 male residents. The social vulnerability index in the low class ranges from 0.00 - 0.33.

3.1.2 Physical Vulnerability

Physical vulnerability in each village (Fig. 4) and seen from the estimated number of houses in each residential area in each village and the number of public facilities including health, education and worship facilities in each dominant village in high-class physical vulnerability, of which 37 villages are 26 villages are in high class physical vulnerability. Estimates of the number of houses in high class physical vulnerability are more than 25 houses/ha, and the number of public facilities is less than 3 units. The high class physical vulnerability index is between 0.68 - 1.00.

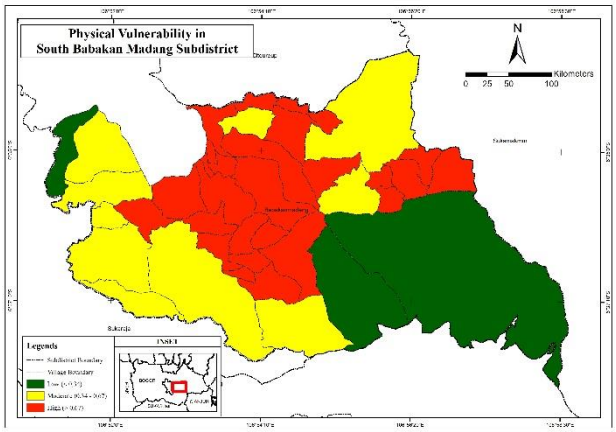

Fig. 4. Physical Vulnerability in the South Babakan Madang Subdistrict

A total of 10 villages are included in the moderate class physical vulnerability. The estimation of the number of houses in the physical vulnerability of the class is 15-25 houses/ha, and the number of public facilities is 3-5 units. The class physical vulnerability index is between 0.34 - 0.67. There is only 1 village with low class physical vulnerability, namely Pasir Maung Village.

The estimated number of houses in this village is less than 15 houses/ha or more precisely for this village, there are 10 houses/ha, and more than 5 public facilities or exactly 6 units in this village. The low class physical vulnerability index is between 0.00 - 0.33.

3.2 Community Capacity to Landslides

The results of interviews with government officials and the local community with a total of 118 respondents, the community's capacity for landslides in the Babakan Madang Subdistrict in the south was dominated by low capacity.

Table 8. Community Capacity in Entire Village of the Bojong Koneng Countryside.

Capacity Level		Information
1	House on stilts	13 Respondent
	Greening in settlement areas	25 Respondent
	Landslide retaining wall in settlement area	14 Respondent
2	Simulation faces a landslide disaster	5 Respondent
	Signposts & early warning systems	Only a few villages have simple signposts & early warning systems
3	Establishment of institutions / communities / forums to deal with and overcome landslides	There are institution / community / forum to cope with landslides in 3 villages
4	Routine activities by institutions / communities / forums	There are no routine activities held by institutions / communities / forums
5	Successful institutions / communities / forums to make all communities have high capacity related to landslides	Because level 4 is not fulfilled, there is no success achieved

The results of the recapitulation show that of the 15 villages in Bojong Koneng Countryside only 3 villages were in the moderate class (level 3), namely Taman Besakih, Taman Tampak Siring, and Taman Udayana. The other villages, which are as many as 12 villages, are only in levels 1 to 2, which are classified as low class capacity.

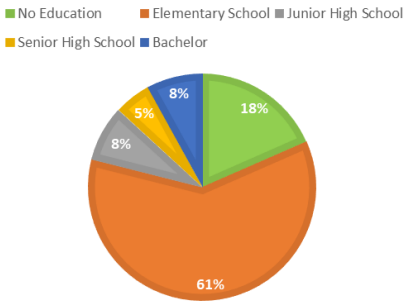

Fig. 5. Education Levels in All Villages, Bojong Koneng Countryside

Based on the results of interviews with a total of 38 respondents (Table 8) spread across 15 villages in the Bojong Koneng Countryside, the education level (Fig. 5) was dominated by elementary school graduates or 61%, there were even 18% of people who did not attend school as shown in Figure 5.

Table 9. Community Capacity in Entire Village of the Cijayanti Countryside.

Capacity Level		Information
1	House on stilts	0 Respondent
	Greening in settlement areas	31 Respondent
	Landslide retaining wall in settlement area	5 Respondent
2	Simulation faces a landslide disaster	7 Respondent
	Signposts & early warning systems	Only a few villages have simple signposts & early warning systems
3	Establishment of institutions / communities / forums to deal with and overcome landslides	There are institution / community / forum to cope with landslides in 1 village
4	Routine activities by institutions / communities / forums	There are no routine activities held by institutions / communities / forums
5	Successful institutions / communities / forums to make all communities have high capacity related to landslides	Because level 4 is not fulfilled, there is no success achieved

The results of the recapitulation show that of the 8 villages in Cijayanti Countryside there is only 1 village in the moderate class (level 3), namely Sentul City. Other villages, which are as many as 7 villages, are only in levels 1 to 2, which are classified as low class capacity.

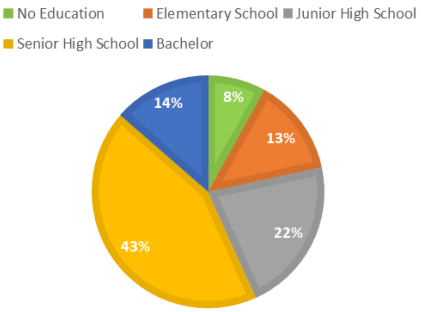

Fig. 6. Education Levels in All Villages, Cijayanti Countryside

Based on the results of interviews with a total of 37 respondents (Table 9) spread across 8 villages in Cijayanti Village the level of education (Fig. 6) was dominated by high school/vocational high school graduates or by 43%, and 14% of those who did not attend school as shown in Figure 6.

Table 10. Community Capacity in Entire Village of Karang Tengah Countryside.

Capacity Level		Information
1	House on stilts	11 Respondent
	Greening in settlement areas	36 Respondent
	Landslide retaining wall in settlement area	14 Respondent
2	Simulation faces a landslide disaster	4 Respondent
	Signposts & early warning systems	Only a few villages have simple signposts & early warning systems
3	Establishment of institutions / communities / forums to deal with and overcome landslides	There is no institution / community / forum to cope with landslides in each village
4	Routine activities by institutions / communities / forums	There are no routine activities held by institutions / communities / forums
5	Successful institutions / communities / forums to make all communities have high capacity related to landslides	Because level 4 is not fulfilled, there is no success achieved

The results of the recapitulation show that of the 14 villages in Karang Tengah Countryside there are all in the low class (levels 1 and 2). Based on the results of interviews with a total of 43 respondents (Table 10) spread across 14 villages in Karang Tengah Village for the level of education (Fig. 7) dominated by high school / vocational school graduates or by 33%, and elementary school graduates as much as 32% as shown in Figure 7.

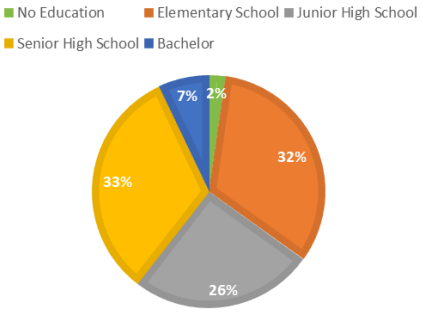

Fig. 7. Education Levels in All Villages, Karang Tengah Countryside

The results of the interviews showed that the achievements of the community in 37 villages, as many as 33 villages were in a low class (Fig. 8). This is because based on the results of interviews in each village the level of achievement carried out is only at levels 1 and 2, which have carried out several disaster risk reduction actions with little achievement in each individual. There are only 4 villages in the middle class capacity, namely Sentul City, Taman Besakih, Taman Tampak Siring, and Taman Udayana.

Other research [14] stated that the capacity of the community research area (Cibanteng Countryside), with reference to the HFA (Hyogo Framework Action) tended to be at a low capacity level. Similar to the southern part of the Babakan Madang sub-district, where the community is at a low capacity level with reference to the HFA. This can be attributed to the achievement of a relatively low community, which is in line with the level of education of the community in each village that dominates elementary and high school graduates. Characteristics of a person or group and their situation that influence their capacity to anticipate, cope with, resist and recover from the impact of a natural hazard [13].

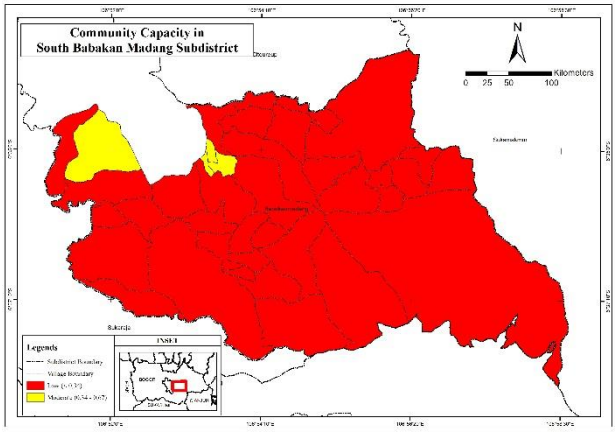

Fig. 8. Community Capacity to Landslides in South Babakan Madang Subdistrict

4 Conclusion

The community vulnerability to landslides in South Babakan Madang Subdistrict seen in terms of social and physical is dominated by the moderate vulnerability, with an index between 0.34 - 0.67 that dominates the western part. High vulnerability that dominates the north to the east.

The community capacity to landslides in South Babakan Madang Subdistrict tends to be homogeneous, with low-class capacity (index < 0.34) almost dominating the entire village. With a higher education level, it does not guarantee that someone has a high capacity to landslides, and vice versa.

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