Coping Capacity Model on Landslide Response Using OLR

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ABSTRACT

The community's unpreparedness for landslides that often occur suddenly has a big impact. This is due to community's ignorance of the symptoms and preventive measures. The improvement coping capacity in landslide-prone areas is important to mitigate the disaster. It is important to know the Coping Capacity in order to give recommendation in improvement of community's ability on landslide disaster. Thus, this study aims to construct the model coping capacity using Ordinal Logistic Regression (OLR). The model is conducted using OLS by look at the influence of mitigation knowledge, action plans and local wisdom on general knowledge about risks and efforts to save from disasters. The primary data is taken from Sidoharjo, Yogyakarta where 86,17 % in high potential landslide to the total area is 1113,99 Ha. The results are two model logistic of the coping capacity. The first result is the risks disaster model logistic with chi-square deviance value is 74.085 and sign level is 0.99. The second is the effort to save from the disaster model logistic with with chi-square deviance value is 70.492 and sign level is 0.901. It can be said that the model is well to be used to modelled the coping capacity in Sidoharjo which the most influential on risks and efforts to save from disasters are mitigation knowledge and action plans, respectively.

1. Introduction

Indonesia is a country that is vulnerable to disasters. According to the World Risk Report 2021, Indonesia is in 38th place out of 181 countries at risk of disasters [1]. There are large number of human, material, economic or environmental losses and victims as the consequences of the disasters [2]. There were 3029 disasters in Indonesia, including earthquakes, tsunamis, volcanic eruptions, floods, droughts, hurricanes and landslides throughout 2021 which contributes 20% of the occurrences [3].

One of the main cause that making evacuation difficult is that the sudden landslides doesn't have any early indications [4]. The impact of landslides throughout 2020 in Indonesia reported 124 deaths, 87 people injured and 27,375 affected and displaced [5]. The Special Region of Yogyakarta (DIY) is one of the provinces that has highest frequent landslide in Indonesia, especially in Kulon Progo. The occurrence of the landslides between 2016-2020 in Kulon Progo regency is 50% comparing of the total of DIY, raising 243 incidents [6]. Samigaluh District has the largest contribution to the occurrence of landslides in Kulon Progo Regency with an area of high hazard class of 5,688.7 Ha [7]. Among the Villages of Samigaluh District, Sidoharjo Village has the largest area which is 1,113.99 Ha [8].

The Indonesian government issued law number 24 of 2007 concerning disaster management as a legal basis for disaster management organizers. This is a response in dealing with geographical conditions in Indonesia which are prone to disasters and the impacts caused by disasters [9]. There are three phase disaster management i.e pre-disaster, during emergency, and post-disaster [10], [11]. Pre-disaster anticipation has a very important role of disaster management in order to reduce the losses and possible risks [12][13]. Disaster risk can be described as a function of hazard, vulnerability, and coping capacity [14], [15]. Hazard is directly proportional to vulnerability and inversely proportional to the ability to overcome disasters. Thus, the better the ability of the community in overcoming disasters resulting a greater risk reduction [14], [16]. The ability of the community, both individuals and groups, to take action to reduce the level of threats and the level of losses due to disasters is called Community capacity (coping capacity) [17][18].

Disaster threats can occur at any time, but if the community has the ability to deal with these threats, disaster risks can be reduced [19], [20]. Thus, understanding the coping capacity of the community in disasters is very important since it provides an overview of the real conditions in dealing with disasters. The ordinal logistic regression is a widely used approach in disaster research as well as in landslide issues. Therefore, the current study aimed to determine a model of coping capacity to know the ability of community in dealing with the landslides and mitigation in order to reduce the risk. Estimated coping capacity in this case includes knowledge on mitigation, action plans and local culture through the application of ordinary logistic regression.

2. Material and Method

This research is conducted in order to model the coping capacity of community in Sidoharjo, Samigaluh, DIY. The most important factor for landslide occurrence in Samigaluh is land conversion [21][22]. Currently, the research on the factor caused landslide has been analyzed such as slope, rainfall, soil type, lithology, vegetation density and another Other factors that influence the occurrence of landslide is slope [13].

2.1 Landslide in Sidoharjo

The level of landslide hazard is categorized as high risk landslide, moderate risk landslide, and low risk landslide. The landslide hazard map in Samigaluh sub-district can be seen in Figure 1. It can be seen that areas with a high level of vulnerability are spread almost evenly in Sidoharjo Village and are dominantly located in the northern part of the study area. Areas with a moderate level of vulnerability are scattered in the southern part of the study area. It can be seen in the figure that there are no areas with landslide rates in the low category. The landslide vulnerability classification used in the preparation of the landslide vulnerability map is presented in Table 1.

Based on Table 1, Sidoharjo Village has areas with high and moderate landslide levels. Sidoharjo Village has the highest level of landslides in the widest high category in Samigaluh District, namely 959.94 Ha or 86.17% of the total area, so landslides are very frequent. Meanwhile, moderate landslides have an area of 154.05 Ha (13.83%). There are no areas with low landslide level categories. The landslide vulnerability level is identified based on processing of Landsat imagery. One of the factors causing high landslide rates is steep slopes. In addition, the intensity of the rain makes water act as driving force causing landslides.

2.2 Community Capacity

According to the Perka of the National Disaster Management Agency (BNPB) No. 2 of 2012 general concepts in disaster risk assessment consist of 3 components namely disaster threat, vulnerability and capacity. The relationship between these variables is shown in the following concept.

$$Disaster\ Risk = \frac{Hazard\ x\ Vulnerability}{Capacity} \tag{1}$$

Based on fequation (1), it can be understood that the smaller the Capacity (C) value, the higher the risk. Conversely, if the value of C is large, then the vulnerability becomes smaller[23].

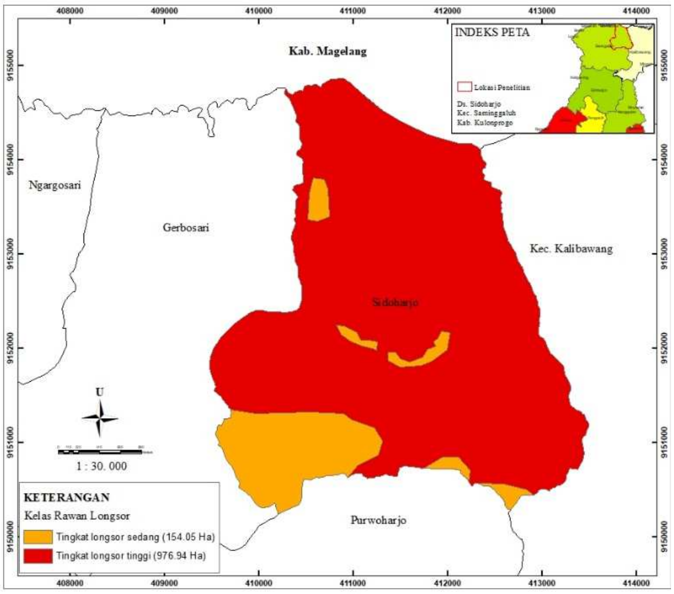

Figure 1. Landslide Hazard Map in Sidoharjo Village

Table 1. Landslide Vurnerability Level

No	Landslide Potential Level	Score	Area (Ha)	Percentage
1	High	>3.53	959.94	86,17
2	Moderate	2.26 – 3.53	154.05	13.83
3	Low	<2.26	0	0

2.3 Ordinal Logistic Regression in Data Analysis Process

The landslide hazard The next process in this research is to analyze the data using ordinal logistic regression[18]. The Ordinal Logistic Regression Model is often known as the cumulative logit model. In this model, the response variable or also called the dependent variable is in the form of ordinal data with categories, predictor or independent variables can be in the form of categorical, continuous or a mixture of both variables which are symbolized by In this model the logit function is defined:$YkX' = (X_1, X_2, .., X_p)$.

$$\pi_j = P(Y = j) = \frac{\exp(\theta_j + X'\beta)}{1 + \exp(\theta_j + X'\beta)} \quad (2)$$

and

$$P(Y \leq j) = \pi_1 + \pi_2 + \cdots + \pi_j \quad (3)$$

Where $\pi_j$is the probability and , is the parameter of the regression coefficient. The model is then transformed linearly into:$Y = j\ \theta_j \beta$

$$ln\left(\frac{P(Y \leq j)}{1 - P(Y \leq j)}\right) = \theta_j + X'\beta \quad (4)$$

With j = 1,2,3,…,k-1. The inference of the parameters can be tested using the Likelihood ratio statistical test for the simultaneous test and the Wald test statistic for the partial test[24].

The response variables in this study were knowledge of disaster risk reduction and knowledge of saving families with predictor variables namely knowledge of mitigation, action plans and local culture. Testing the hypothesis in this study, namely:

- Ho: (the i-independent variable has no significant effect on the dependent variable).$\beta_i = 0, i = 1,2, \dots, p$
- Ha: (the i-independent variable has a significant effect on the dependent variable).$\beta_i \neq 0, i = 1,2, \dots, p$

Test statistics on this model viz

$$(W^*)^2 = \left[\frac{\widehat{\beta}_i}{se(\widehat{\beta}_i)}\right]^2 \sim \chi^2_{a,1} \quad (5)$$

The decision making is ultimately based on the above model viz[25]: Reject if or (p-value<).$H_0 (W^*)^2 > \chi^2_{a,1}\alpha$.

3. Result and Discussion

The research was conducted on communities adjacent to the landslide points. Then analyzed based on data that has been collected by distributing questionnaires, to as many as 40 respondents as a research sample. There are 14 landslide points in Sidoharjo Village as shown in Figure 2.

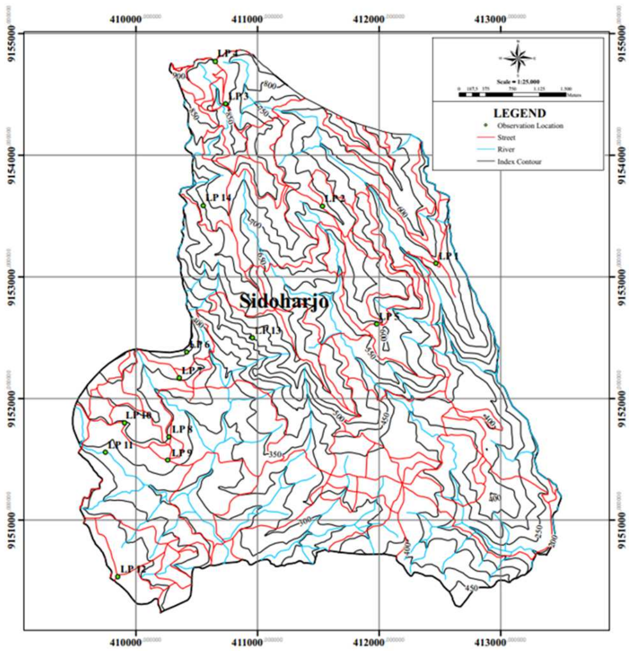

Figure 2. Distribution Map of Landslide Point

3.1 Community Capacity Statistics

Community capacity in dealing with disasters is modeled using response variables consisting of general knowledge of disaster risk reduction and disaster relief. The predictor variables consist of the level of mitigation knowledge, action plans and local culture. The description of each response variable is shown in Table 2.

Based on Table 2, 20 people, half of the respondents, dissatisfied with the general knowledge of landslide risk. Only a few respondents, i.e 4 people (10.0%) stated that they were satisfied with their knowledge about landslide risk reduction. Most of the community's knowledge about disaster relief was in the quite satisfied and dissatisfied categories, 15 people (37.5%) each. The least is in the satisfied category, namely 4 people (10.0%).

Table 2. Response Variable Statistics

No	Category	Landslide Risk Reduction		Rescue from Disaster	
		Frequency	Percentage	Frequency	Percentage
1.	Very Dissatisfied	4	10.0%	6	15%
2.	Not satisfied	20	50.0%	15	37.5%
3.	Quite Satisfied	12	30.0%	15	37.5%
4.	Satisfied	4	10.0%	4	10.0%
5.	Very satisfied	0	0.0%	0	0.0%
	Total	40	100%	40	100%

The description of the predictor variable data which consists of the level of knowledge about mitigation, action plans and local culture is presented in Table 3.

Based on Table 3 the capacity of the community with parameters of the level of knowledge about landslides is mostly in the sufficient category with 20 people (50.0%), 12 people (30.0%) are in the good category, and 4 people (10%) are in the less category. The capacity of the community with the parameters of the action plan is mostly in the sufficient category as many as 28 people (70.0%), in the less category as many as 7 people (17.5%) and in the good category as many as 5 people (12.5%). The capacity of the community with local culture parameters is mostly in the good category, namely 34 people (85.0%), in the sufficient category 4 people (10.0%) and in the less category 2 people (5.0%).

3.2 Risks Disaster Model Logistic

The capacity of the people examined in the research includes knowledge about mitigation, action plans, and local culture. The Goodness of Fit test was carried out to see whether the ordinal logistic regression model obtained was feasible to use to determine the effect of independent variables on reducing the risk of landslides. The test results are shown in Table 4. The hypothesis tested is H0: the logit model is feasible to use and H1: logit model is not worth using. It is known that the Chi Square value of the Deviance method is 74.085 with a degree of freedom of 11and significance level of 0.999. The test criteria are reject Ho if the significant value is less than 0.05. The Deviance test value in the table above shows that the significance value is 0.999. The decision taken is to accept Ho because the significance value is greater than 0.05. The conclusion is that the logit model obtained is feasible to use. To determine the significance of the influence of community capacity on landslide risk reduction, an analysis was performed using ordinal logistic regression test statistics. The results of this test are shown in Tabel 5.

Table 3. Predictor Variable Statistics

No	Category	Knowledge level		Action plan		Local culture	
		Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
1.	Less	4	10.0%	7	17.5%	2	5.0%
2.	Sufficient	20	50.0%	28	70.0%	4	10.0%
3.	Good	12	30.0%	5	12.5%	34	85.0%
	Total	40	100%	40	100%	40	100%

Table 4. Goodness of Fit Test Risks Disaster Model

	Chi-Square	Df	Sig.
Deviance	74.085	117	.999

Table 5. Influence of community capacity on landslide risk reduction

		Estimates	std. Error	Wald	df	Sig.
Threshold	[Y1 = 1.00]	3,709	3,388	1,199	1	0.274
	[Y1 = 2.00]	6,663	3,477	3,672	1	0.055
	[Y1 = 3.00]	8,741	3,614	5,851	1	0.016
Location	Mitigation Knowledge (X1)	0.151	0.158	0.920	1	0.338
	Action Plan (X2)	0.209	0.102	4,212	1	0.040
	Local Wisdom (X3)	0.127	0.164	0.597	1	0.440

Table 6. Goodness of fit test for the effort to save from disaster model

	Chi-Square	df	Sig.
Deviance	74.085	117	.999

Based on the output results, it shows that the action plan has an effect on reducing the risk of landslides with a significance of (0.040) <0.05, while mitigation knowledge and local culture each have a significance of 0.338 and 0.440 > 0.05. Thus, the action plan variable has an effect on landslide risk reduction. Local knowledge and culture variables have no significant effect on landslide risk reduction at the 95% confidence level.

The logistic regression equations are:

$$\ln[P(Y \leq 1|x)] = 3{,}709 + 0{,}151X_1 + 0{,}209X_2 + 0{,}127X_3$$

$$\ln[P(Y \leq 2|x)] = 6{,}663 + 0{,}151X_1 + 0{,}209X_2 + 0{,}127X_3$$

$$\ln[P(Y \leq 3|x)] = 8{,}741 + 0{,}151X_1 + 0{,}209X_2 + 0{,}127X_3$$

The sign (+) on the knowledge variable about mitigation means that the higher the knowledge the community has about landslide disaster mitigation, the less the risk will appear. Likewise, the action plan and local culture variables both have a positive influence on reducing the risk of landslides.

Tendency of the action plan effect on the level of landslide hazard is followed by finding the odds ratio value. The odds ratio calculation for the action plan variable is exp (0.151) = 1.16. This means, there is a tendency of 1.16 times to increase knowledge about reducing the risk of landslides if the community has a plan for dealing with disasters.

3.3 The Effort to Save from Disaster Model Logistic

The disaster rescue variable is analyzed based on community capacity variables consisting of knowledge on mitigation, action plans and local culture.

The Goodness of Fit test was carried out to see whether the ordinal logistic regression model obtained was feasible to determine the effect of independent variables on rescue from landslide disasters. The test results are shown in table 6.

It is known that the Chi Square value of the Deviance method is 70.492 with a degree of freedom of 87 with a significance level of 0.901. The test criterion is to reject Ho with a significance value of less than 0.05. The Deviance test value in the table above shows that the significance value is 0.901. The decision taken is to accept Ho because the significance value is greater than 0.05. The conclusion is that the logit model obtained is feasible to use.

To determine the significance of the influence of community capacity on rescue from landslides, an analysis was carried out using ordinal logistic regression test statistics. The results of this test are shown in Table 7.

Based on the output results, it shows that the mitigation knowledge variable has a sig value (0.017) < 0.05 and the action plan variable has a sig value (0.045) < 0.05. The local culture variable has a sig value (0.132) > 0.05. Thus, the variables of knowledge of mitigation and action plans have some effects on reducing the risk of landslides, while the variables of local culture have no significant effect on reducing the risk of landslides at the 95% confidence level.

Table 7. Influence of community capacity on rescue from landslides

		Estimates	std. Error	Wald	df	Sig.
Threshold	[Y1 = 0.00]	4,538	3,583	1,604	1	0.205
	[Y1 = 1.00]	6,788	3,492	3,778	1	0.052
	[Y1 = 2.00]	8,889	3,593	6.122	1	0.013
	[Y1 = 3.00]	11601	3,828	9,184	1	0.002
Location	Mitigation Knowledge	0.402	0.168	5,738	1	0.017
	Action Plan	0.207	0.104	4,009	1	0.045
	Local Wisdom	0.246	0.164	2,270	1	0.132

The logistic regression equations are:

$$\ln[P(Y \leq 0|x)] = 4{,}538 + 0{,}402X_1 + 0{,}207X_2 + 0{,}246X_3$$

$$\ln[P(Y \leq 2|x)] = 6{,}788 + 0{,}402X_1 + 0{,}207X_2 + 0{,}246X_3$$

$$\ln[P(Y \leq 3|x)] = 8{,}741 + 0{,}402X_1 + 0{,}207X_2 + 0{,}246X_3$$

The sign (+) on the knowledge variable about mitigation means that the higher the knowledge the community has about landslide disaster mitigation, the less the risk will appear. Likewise, the action plan and local culture variables both have a positive influence on reducing the risk of landslides.

The magnitude of the tendency of the effect of the action plan on the level of landslide hazard is followed by finding the odds ratio value. Calculation of the odds ratio for the variable knowledge of mitigation is exp (0.402) = 1.04. This means that there is a tendency of 1.04 times to increase general knowledge about saving families from disasters if the community has knowledge about mitigation. The odds ratio calculation for the action plan is exp (0.207) = 1.23. This means that there is a tendency of 1.23 times to increase general knowledge about saving families from disasters if the community has a plan for dealing with disasters.

4. Conclusion

Community capacity in dealing with disasters has an important role in reducing the risk of landslides and rescue efforts when a disaster occurs. Ordinal logistic regression can be used for modeling community capacity because it has the ability to show the magnitude of the influence community capacity for landslide risk reduction. The risk of loss due to landslides has an inverse relationship with the community's knowledge of disaster mitigation, action plans, and local wisdom. Landslide risk reduction is influenced by the action plan variable. The variable of self-rescue from disasters is influenced by knowledge about mitigation and action plans.

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