Asian Journal of Applied Sciences (ISSN: 2321 – 0893)
Volume 05 – Issue 05, October 2017

Level of Knowledge Coastal People on Earthquake and Tsunami Disasters Mitigation in Bengkulu, Indonesia

Dian Agustina[1,*], Siska Yosmar[2] and Jose Rizal[3]

[1] Department of Statistics, University of Bengkulu, Indonesia

[2] Department of Mathematics, University of Bengkulu, Indonesia

[3] Department of Mathematics, University of Bengkulu, Indonesia

[*] *Corresponding author's email : dianagustina117 [AT] gmail.com*

ABSTRACT—*The classic problem in disaster mitigation activities is in planning, implementation, and sustainability. One of the contributing factors is the unavailability of information locally about the model of natural disaster occurrence and the model of human behavior as an object that is directly affected by the incident. We have conducted field surveys as well as distributing questionnaires in some coastal areas in the Province of Bengkulu. The data obtained are presented in the form of zoning maps and mathematical models that can illustrate the human behavior of earthquake and tsunami disaster mitigation. The kriging interpolation method is used in zoning map of coastal community knowledge level about earthquake and tsunami disaster mitigation. While the Structural Equation Modelling is used to see the relationship between mitigation variables with earthquake and tsunami disaster risk variables. Conclusions from the results of the study, based on simultaneous measurements of the five disaster mitigation variables, most of the coastal areas located in Mukomuko, Bengkulu Tengah and Seluma districts are included in areas with poorly prepared zone criteria. Partially, especially for Policy Statement variables, almost all districts in Bengkulu Province are perceived not yet ready by respondents from this research. Based on the resulting structural equation model, the reduction of the earthquake and tsunami risk impacts is strongly influenced by emergency response plans and disaster warning system factors.*

Keywords— Earthquake and tsunami, Zoning Map, Kriging Interpolation, Structural Equation Modeling

---

1. INTRODUCTION

After the 2004 Aceh Earthquake and Tsunami, local and international researchers have focused their attention on the offshore areas of West Sumatra, because from the historical data of the earthquake and tsunami shows that the accumulation of potential earthquake and tsunami energy has been approaching its release **[1-4]**. Several major earthquakes that occurred after the earthquake in Aceh included, on September 12, 2007, there was a tectonic earthquake with magnitude of 8.5 SR and caused a tsunami wave about 3 meters in Mukomuko District. The losses caused by this earthquake are 25 people dead, 161 injured, and 50,000 more buildings destroyed. The next earthquake on October 25, 2010, in the territory of Mentawai Islands especially North Pagai Island and South Pagai with the death toll of 456 inhabitants (http://inatews.bmkg.go.id).

Natawidjaja et al **[5]**, indicated the occurrence of major earthquake events accompanied by tsunami events in the Mentawai segment region. This will of course have a direct impact on the Bengkulu Province, especially the Mukomuko Regency and surrounding areas. This earthquake has a high probability of generating high tsunami waves, estimates of tsunami ranges ranging between 10-20 meters with the arrival time hit the ground less than 30 minutes, **[6-10]**. The results of the Natawidjaya et al, **[5]** study, in line with the article McCloskey et al.,**[2]** That there will be a substantial tsunami threat that will occur in the Indian Ocean caused by the megathrust earthquake that occurred in the western part of Sumatra island. Still in the same article, the location and contours of the island of Relgano and Pulau Pagai give greater impact of damage due to the tsunami waves, unlike Siberut Island that can protect the coast in Padang.

The results of a study conducted by the National Disaster Mitigation Agency, Bengkulu Province has a very high disaster risk index The earthquake and tsunami, ranked seventh of the thirty-four provinces in Indonesia, where Nangro Aceh Darussalam province occupies the highest position (www.bnpb.go.id). To minimize the risk index of earthquake and tsunami disaster, especially in Bengkulu Province, there is a need for synergy between the results of tsunami earthquake and coastal communities. **[11-12]**.

2. MATERIAL AND METHODS

The material used in this study is the primary data of the results done by the respondents to the questionnaire form. In the questionnaire there are indicators that can measure the level of community preparedness to anticipate natural disasters, especially earthquakes and tsunamis. Selection of these variables refers to the results of a study conducted by a team from LIPI - UNESCO / ISDR, 2006 **[13]** ie : Knowledge and Attitude (X_1), Policy Statement (X_2), Emergency Planning (X_3), Warning System (X_4), Resource Mobilization Capacity (X_5), and Altitude of location to sea level (Y). Indicators of each variable are arranged in a questionnaire form. Questionnaire as a tool in measuring human behavior in the form of qualitative data, must be valid and reliable. Testing the validity of the items of the questionnaire statement using the moment product correlation $r_{x,y}$, which is defined asfollows: **[14]**

$$r_{x,y} = \frac{n(\sum_{i=1}^{n} x_i y_i) - (\sum_{i=1}^{n} x_i \sum_{i=1}^{n} y_i)}{\sqrt{(n\sum_{i=1}^{n} x_i^2 - (\sum_{i=1}^{n} x_i)^2)(n\sum_{i=1}^{n} y_i^2 - (\sum_{i=1}^{n} y_i)^2)}} \tag{1}$$

Where n is the number of data, x_i the value of the questionnaire score of the ith, and y_i is the total score of the ith . The indicator of a variable is said to be valid when $r_{x,y} > r_{table}(\alpha; db = n-2)$ (value of r_{table} can be seen in **[14]**). While the test instrument reliability questionnaire with Cronbach Alpha method approach, α, is formulated as follows: **[14]**

$$\alpha = \frac{k}{k-1}\left(1 - \frac{\sum_{i=1}^{k} \sigma_i^2}{\sigma_x^2}\right) \tag{2}$$

Where k is the number of test partitions, σ_i^2 is a variant of the i-th partition , and σ_x^2 s a variant of the question.

The scope of the object area of research is very wide, so we only take some sample points from each region. To get estimation values at other points, we use the kriging interpolation method **[15]**. A value from location x_i is interpreted as a realization $z(x_i)$ of the random variable $Z(x_i)$. In the space D where the set of samples is dispersed, there are N realizations of the random variables $Z(x_1), Z(x_2), \cdots Z(x_n)$, correlated between themselves. The experimental Semivariogram model with distance h of the sample N is denoted by $\gamma(h)$ and is defined as follows : **[16]**

$$\gamma(h) = \frac{1}{2N(h)} \sum_{i=1}^{N(h)} (Z(x_i) - Z(x_i + h))^2 \tag{3}$$

where $N(h)$ is the number of pairs of points having distances h. Some theoretical semivariogram such as spherical model, exponential, Gaussian, linear (can be seen in **[16]**). Given the condition that the population averages are unknown then the appropriate interpolation for use is the Ordinary Kriging interpolation. $\tilde{Z}(X_0)$ which is formulated as follows: **[16]**

$$\tilde{Z}(x_0) = \sum_{i=1}^{n} \lambda_i Z(x_i) \tag{4}$$

With $\sum_{i=1}^{n} \lambda_i = 1$. The parameter estimate λ_i is obtained by minimizing the value of $Var(e(x_0))$. Consider again Equation (4), obtained that :

$$\hat{e}(x_0) = \sum_{i=1}^{N} \lambda_i Z(x_i) - Z(x_0) \tag{5}$$

and

$$Var(\hat{e}(x_0)) = Var\left(\hat{Z}(x_0)\right) + Var(Z(x_0)) - 2Cov\left(\hat{Z}(x_0), Z(x_0)\right) \tag{6}$$

By performing further elaboration on each equation component (Equation 6), we can write,

$$Var(\hat{e}(x_0)) = \sum_{i=1}^{N}\sum_{j=1}^{N} \lambda_i \lambda_j\, Cov\left(Z(x_i), Z(x_j)\right) + \sigma^2 - 2\sum_{i=1}^{N} \lambda_i Cov\left(\left(Z(x_i), Z(x_0)\right)\right) \tag{7}$$

By using lagrange multipler method with lagrange $2p$ parameter, we get the lagrange multiplier equation for (7) as follows:

$$F(\lambda, p) = \sum_{i=1}^{N}\sum_{j=1}^{N} \lambda_i \lambda_j\, Cov\left(Z(x_i), Z(x_j)\right) + \sigma^2 - 2\left\{\sum_{i=1}^{N} \lambda_i Cov\left(\left(Z(x_i), Z(x_0)\right)\right) + p\left(\sum_{i=1}^{N} \lambda_i - 1\right)\right\} \tag{8}$$

By deriving Equation (8) on the parameters λ_i and p, the lagrange solution is obtained:

$$Cov\left(\left(Z(x_i), Z(x_0)\right)\right) = \sum_{i=1}^{N} \lambda_i Cov\left(\left(Z(x_i), Z(x_0)\right)\right) + p \quad (9)$$

Let $\boldsymbol{\Gamma}_{(n+1)x(n+1)}$ covariant nonsingular matrix between observed variables, $\boldsymbol{\lambda}_{(n+1)X1}$ weight vector, and $\mathbf{T}_{(n+1)x1}$ covariance vectors between the observed variables of the location-i with location to be estimated, Equation (9) can be written in matrix form as follows $\mathbf{T} = \boldsymbol{\lambda}\boldsymbol{\Gamma}$. So we get the weight value for each observation data for equation (4) as follows:

$$\boldsymbol{\lambda} = \boldsymbol{\Gamma}^{-1}\mathbf{T} \quad (10)$$

In addition to the kriging interpolation method, in this paper also used the maximum likelihood method. This method is used to obtain parameter values from structural equation model which can maximize likelihood function. Suppose given $\boldsymbol{X}_{px1}$ is a vector for the indicator variables, Structure Equation Modeling can be written as follows: **[17]**

$$\boldsymbol{X} = \boldsymbol{\Lambda}\boldsymbol{\xi} + \boldsymbol{\delta} \quad (11)$$

where $\boldsymbol{\xi}_{nx1}$ is a vector for latent variables with $E(\boldsymbol{\xi}) = \mathbf{0}$ and $Cov(\boldsymbol{\xi}) = \boldsymbol{\Phi}_{pxp}$, $\boldsymbol{\delta}_{px1}$ is the vector for the measurement error with $E(\boldsymbol{\delta}) = \mathbf{0}$, $Cov(\boldsymbol{\delta}) = \boldsymbol{\Psi}_{pxp}$, $\boldsymbol{\Lambda}_{pxn}$ is the loading factor matrix ($\boldsymbol{\Lambda}$) or coefficient showing the relationship between $\boldsymbol{X}$ and $\boldsymbol{\Lambda}$. While the value of covariance between $\boldsymbol{\delta}$ and $\boldsymbol{\xi}$ is written $Cov(\boldsymbol{\delta}, \boldsymbol{\xi}) = \boldsymbol{\Lambda}\boldsymbol{\Phi}\boldsymbol{\Lambda}' + \boldsymbol{\Psi}$.

Let $x_1, x_2, x_3 \dots x_n$ be a pupulation example having a probability function of $f(x;\theta)$where $\theta \in R^K$ is an unknown parameter vector. The Likelihood function for equation (11) is as follows:

$$L(\boldsymbol{X};\theta) = \prod_{i=1}^{n} f(x_i;\theta) \quad (12)$$

Maximum Likelihood Estimation of θ is defined as $\hat{\theta} = \max_\theta L(\boldsymbol{X};\theta)$, assuming $\boldsymbol{X}$ is Normal distribution $N_P(\boldsymbol{\mu}, \boldsymbol{\Sigma})$ with the probability density function $f(x) = |2\pi\boldsymbol{\Sigma}|^{-1/2} exp\left\{-\frac{1}{2}\left((\boldsymbol{x}-\boldsymbol{\mu})^T\boldsymbol{\Sigma}^{-1}(\boldsymbol{x}-\boldsymbol{\mu})\right)\right\}$, then the estimated MLE parameter can be written: **[18]**

$$\ell(x;\hat{\boldsymbol{\mu}}, \boldsymbol{\Sigma}) = -\frac{n}{2}\{\log|2\pi\boldsymbol{\Sigma}| + tr(\boldsymbol{\Sigma}^{-1}\boldsymbol{S})\} \quad (13)$$

3. RESULTS AND DISCUSSION

This study was preceded by a survey to the district area for approximately one month. In the distribution of questionnaires, we involve 21 survey teams that are students of Mathematics Department of Bengkulu University. Previously, the survey team had conducted training in disseminating techniques and how to fill out the questionnaire form. Respondents in this study amounted to 550 respondents, where the selection of villages from each district and community is done by purposive sampling method. General description of respondents, 58% male sex while the remaining 42% female. By age category, respondents were dominated by productive age, 21-40 by 50%. While from the education level majority of high school graduates and have jobs as Fishermen and housewives.

Can be seen in Table 1, it is concluded that each item question of each research variable is valid. It is based on r_{count} value of each item bigger than $r_{table}(\alpha; n-2)$ = 0.088 (can be seen in **[14]**). Reliable testing of each variable gives Alpha Cronbach value greater than 0.60, so it can be said that the questionnaire is reliable.

Table 1: Test results validity and realibility indicators of research variables

Variable	Indicators	Value of		Conclusion
		Correlation	Alpha crobach	
Knowledge and Attitude ($\mathbf{X_1}$)	X_{11}	0,620	0,763	Valid and Reliable
	X_{12}	0,474		
	X_{13}	0,573		
	X_{14}	0,523		
Policy Statement ($\mathbf{X_2}$)	X_{21}	0,538	0,812	Valid and Reliable
	X_{22}	0,675		
	X_{23}	0,754		
Emergency Planning ($\mathbf{X_3}$)	X_{31}	0,608	0,710	Valid and Reliable
	X_{32}	0,140		
	X_{33}	0,578		
	X_{34}	0,357		
Warning System ($\mathbf{X_4}$),	X_{41}	0,164	0,712	Valid and Reliable
	X_{42}	0,568		
	X_{43}	0,678		
	X_{44}	0,328		
Resource Mobilization Capacity ($\mathbf{X_5}$),	X_{51}	0,454	0,669	Valid and Reliable
	X_{52}	0,399		
	X_{53}	0,256		
	X_{54}	0,279		

The measures used in measuring the level of community preparedness are categorized into five categories: Very Ready (80-100), Ready (65-79), Nearly Ready (55-64), Less Ready (40-54), and Not Ready (less than 40) (LIPI-UNESCO, 2006) **[13]**. As shown in Figure 1, Based on the results of measurement and simultaneous treatment of the five variables of earthquake and tsunami disaster mitigation, the areas in the district of Bengkulu Province have not been included in the zone is very ready in the face of the possibility of earthquake and tsunami disaster.

The scope of this study area is very wide, with time and cost constraints, only a few areas we have done the distribution of questionnaires. To obtain information in other areas, we apply interpolation ordinary kriging (Equation 4 and 10). This method is used because of the unavailability of information about the average population level of public knowledge. Actual data and interpolation results, we describe in the form of maps, as shown in Figures 1 and 2.

Figure 1: Zoning Map of Coastal Peoples Knowledge Level of Bengkulu Province Region Based on the simultaneous measurement of Five Variables of Earthquake and Tsunami Disaster Mitigation

From Figure 1, Especially for coastal areas, areas located in Mukomuko, Central Bengkulu and Seluma districts, including areas not ready for earthquake and tsunami. Natawidjaja et al. **[5]** estimates the Mukomuko area is one of the districts that will have a direct impact with a major earthquake that is likely to occur in the region of western Sumatra.

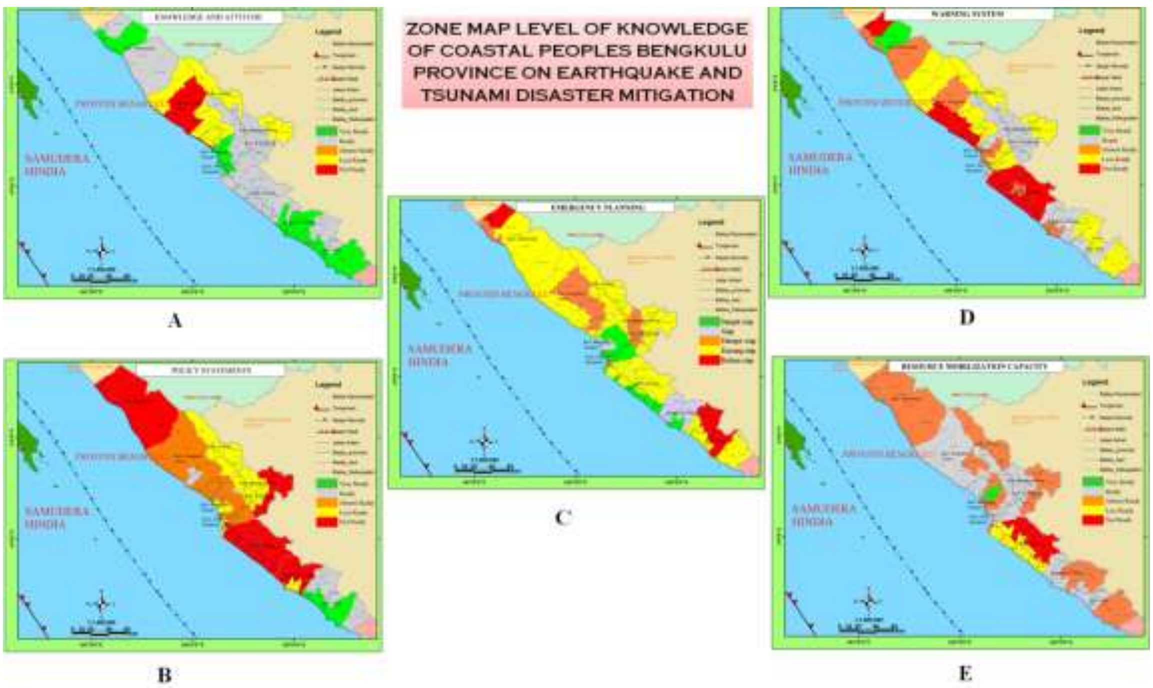

Figure 2 : Zoning Map of Coastal Peoples Knowledge Level of Bengkulu Province Region Based on the Partial

Measurement of Five Variables of Earthquake and Tsunami Disaster Mitigation. (A) Knowledge and Attitude, (B) Policy Statement, (C) Emergency Planning, (D) Warning System, (E) Resource Mobilization Capacity.

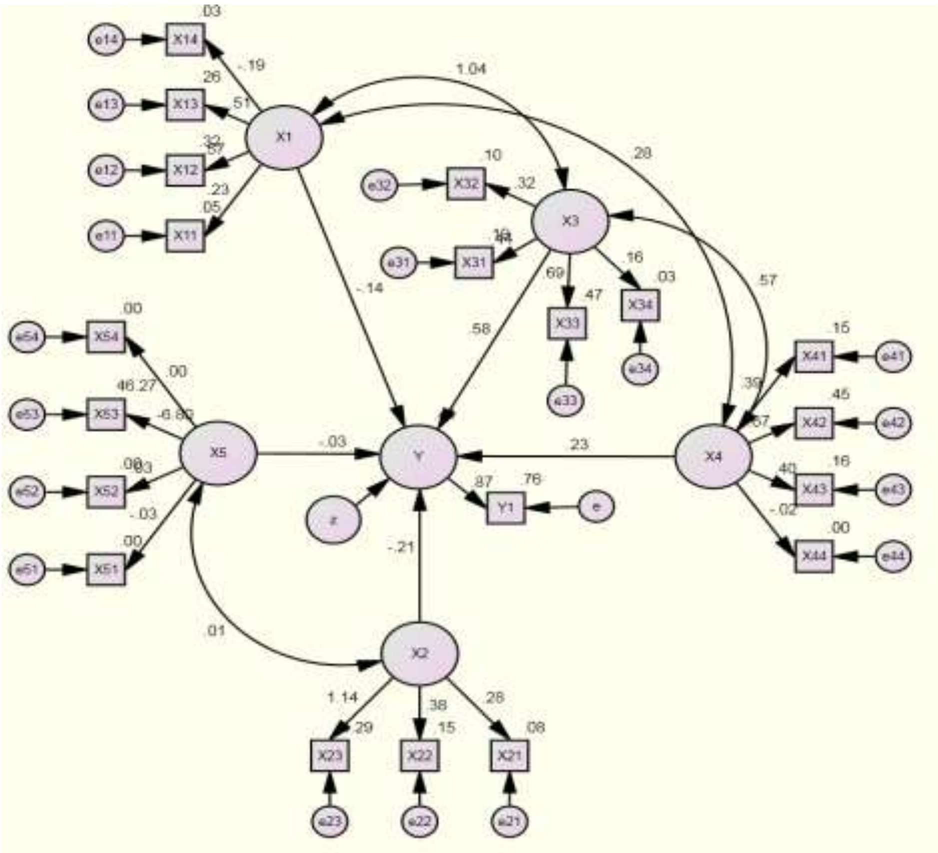

Figure 3 : Diagram and Parameter Values of The Structural Equation Modeling of The Five Earthquake and Tsunami Disaster Mitigation Variables and One Variable of The Disaster Risk Index

From Figure 3, The structural equation modeling can be written in the form of a linear relationship as follows:

$$Y = -0.142\, X_1 - 0.207\, X_2 + 0.575\, X_3 + 0.230\, X_4 - 0.035\, X_5 \tag{14}$$

From Equation 14, the reduction of the earthquake and tsunami risk impacts is strongly influenced by the emergency response and disaster warning system factors. With this result, there needs to be a follow-up of the government either in the form of policy direction, or if it already exists, it is necessary to socialize the policy **[11,12]**.

Partially, for the Knowledge and Attitude (X_1), there are four indicators used to measure these variables: self-preservation procedures (X_{11}), availability of safety equipment (X_{12}), building standards (X_{13}), and signs of tsunami occurrence (X_{14}). The linear model generated between the variables and the indicators is shown in the following equation

$$X_1 = 0.230\, X_{11} + 0.566\, X_{12} + 0.514\, X_{13} - 0.187 X_{14} + e_1 \tag{15}$$

From Equation (15), the indicators X_{12} (0.566) and X_{13}(0.514) give considerable weight in measuring the variability of X_1 but this is reversed with indicators of tsunami signs. In Figure 2A, the areas that are categorized as not ready are the coastal areas in North Bengkulu and parts of Central Bengkulu. Recommendation that can be proposed is the need for socialization activities will be the signs of the occurrence of the tsunami along with the procedure of rescue when large earthquakes occur around the area.

Furthermore, for the Policy Statement (X_2), variable, there are three indicators to determine the variability of the variables: evacuation route guidance X_{21}, emergency response fund X_{22}, and disaster management and education X_{23} Significantly, respondents gave greater weight i.e 1.137 to indicator X_{23}. While the smallest weight is given on the indicator X_{21}. Equation 16 is formula multiplication of each weight of the indicator of the variable (X_2),

$$X_2 = 0.297\, X_{21} + 0.382\, X_{22} + 1.137\, X_{23} + e_2 \quad (16)$$

Seen from the results of the mapping Figure 2B, Mukomuko, Seluma and South Bengkulu districts become red areas or areas that are not ready in the face of disaster, especially on the side of the Policy Statement. The recommendation proposed the need for evacuation path guidance socialization activities in the area.

Indicators for Emergency Planning (X_3) variable include: Equipment and equipment rought (X_{31}), training and disaster simulation (X_{32}), alternative illumination devices (X_{33}), and important phone numbers (hospitals, police, firemen) (X_{34}). The third indicator has the greatest weight among other indicators that is equal to 0.688, while X_{34} has the smallest weight. Associated with Figure 3C, people's awareness in Mukomuko District to have important phone numbers such as: ospital, police, fire brigade need to be improved. Here is the relationship model between the Emergency Planning variable and its indicators:

$$X_3 = 0.441\, X_{31} + 0.318\, X_{32} + 0.688\, X_{33} + 0.163\, X_{34} + e_3 \quad (17)$$

Variable Warning System (X_4) is measured by four indicators, namely: traditional disaster warning system, technology based disaster warning system, information access, and disaster warning system simulation. From equation (17) and Figure 2D, it is necessary to simulate a disaster warning system involving all stakeholders in Mukomuko, North Bengkulu and Seluma.

Variable Warning System (X_4) is measured by four indicators, namely: traditional disaster warning system, technology based disaster warning system, information access, and disaster warning system simulation. From Equation (17) and Figure 2D, it is necessary to simulate a disaster warning system involving all stakeholders in Mukomuko, North Bengkulu and Seluma.

$$X_4 = 0.393\, X_{41} + 0.669\, X_{42} + 0.398\, X_{43} - 0.019\, X_{44} + e_4 \quad (18)$$

The last mitigation variable is the Resource Mobilization Capacity variable (X_5). This variable is measured by four indicators, namely: family / social network (X_{51}), saving / insurance (X_{52}), access to media information (X_{53}), and evacuation mobilization (X_{54}). The relationship between the variables and their indicators is as follows:

$$X_5 = -0.026\, X_{51} + 0.032\, X_{52} - 6.802\, X_{53} + e_5 \quad (19)$$

Mukomuko district is an area that needs to pay attention in an effort to increase evacuation mobilisai through the expansion of family and social network (Figure 2E).

4. CONCLUSION

In general, coastal areas in the province of Bengkulu not including areas that are ready to face the earthquake and tsunami disaster. Based on the simultaneous measurement of the five disaster mitigation variables, most of the coastal areas located in Mukomuko, Bengkulu Tengah and Seluma districts are included in areas with less prepared zone criteria (Figure 1.). While partially (Figure 2), especially for Policy Statement variables, almost all districts in Bengkulu Province perceived not yet ready. From the structural equation modeling (Equation 14), the level of public understanding of: Knowledge and Attitudes, Policy Statement and Resource Mobilization Capacity is still low. There is a need for concrete and immediate steps to minimize disaster risks in the form of socialization and dissemination of the results of earthquake model studies and models of community level knowledge on earthquake and tsunami disaster mitigation.

From the Equation 15-19, the level of public knowledge on some indicators of the earthquake and tsunami disaster mitigation variables is still low, such as signs of tsunami occurrence, evacuation route guidance, important phone numbers, disaster warning system simulation, and evacuation mobilization. Based on the results of the current survey, these factors are needed by communities in an effort to reduce the impact of earthquake and tsunami disaster risk.

5. ACKNOWLEDGEMENT

This research has been supported by Research Ministry, Technology, and High Education which Number: 061/SP2H/LT/DRPM/IV/2017 and have been done based on by Letter of Assignment Agreement Implementation Competitive Research Grant Fiscal Year 2017 Number: 947/UN30.15/LT/2017.

6. REFERENCES

[1] EOS: Earth Obsevatory Singapure. "West Sumatra Tectonics and Tsunami Hazard". Singapure. 2015.

[2] McCloskey, J., Antonioli, A., Piatanesi, A., Sieh, K., Steacy, S., Nalbant, S., Cocco, M., Giunchi, C., Huang, J.D., Dunlop, P., "Tsunami Threat in the Indian Ocean from a Future Megathrust Earthquake West of Sumatra", Earth and Planetary Science Letters 265 pp 61–81, 2008.

[3] Philibosian, B., K. Sieh, D. H. Natawidjaja, H.-W. Chiang, C.-C. Shen, B. W. Suwargadi, E. M. Hill, and R. L. Edwards, "An Ancient Shallow Slip Event on the Mentawai Segment of the Sunda Megathrust, Sumatra, J. Geophys. Res., 117, B05401, doi:10.1029/2011JB009075. 2012.

[4] Meltzner, A. J., K. Sieh, H.-W. Chiang, C.-C. Shen, B. W. Suwargadi, D. H. Natawidjaja, B. Philibosian, and R. W. Briggs, "Persistent Termini of 2004 - and 2005-like Ruptures of the Sunda megathrust", J. Geophys. Res., 117, B04405, 2012, doi:10.1029/2011JB008888.

[5] Natawidjaja, D. H., Sieh, K., Chlieh, M., Galetzka, J., Suwargadi, B. W., Cheng, H, "Source Parameters of the Great Sumatran Megathrust Earthquakes of 1797 and 1833 Inferred from Coral Microatolls". *J. Geophys. Res.* 111, B06403. doi:10.1029/2005JB004025, 2006.

[6] B.A.D. Van Veen., D. Vatvani. , F. Zijl., "Tsunami flood modelling for Aceh & West Sumatra and Its Application for an Early Warning System" Journal of Continental Shelf Research vol. 79 pp. 46–53, 2014,

[7] Borrero, J., Sieh, K., Chlieh, M., Synolakis, C., "Tsunami Forecasts for Western Sumatra", Journal of PNAS Vol 103, no. 52, pp. 19673-19677, 2006, doi:10.1073/pnas.0604069103.

[8] Goda, K., Yasuda, T., Mori, N., and Maruyama, T., "New Scaling Relationships of Earthquake Source Parameters for Stochastic Tsunami Simulation", Coastal Engineering Journal, Vol. 58, No. 3, 2016, Japan Society of Civil Engineers Coastal Engineering committee DOI: 10.1142/S0578563416500108

[9] Mörner, N.A., "Converting Tsunami Wave Heights to Earthquake Magnitudes". Open Journal of Earthquake Research, 6, 89-97. 2017. https://doi.org/10.4236/ojer.2017.62005

[10] Muhammad, A., Goda, K., and Alexander, N., "Tsunami Hazard Analysis of Future Megathrust Sumatra Earthquakes in Padang, Indonesia Using Stochastic Tsunami Simulation". *Front. Built Environ*. 2:33. doi: 10.3389/fbuil.2016.00033. 2016.

[11] Shannon, R., Hope, M. and McCloskey, J., "The Bengkulu Premonition: Cultural Pluralism and Hybridity in Disaster Risk Reduction. Area", 43: 449–455. doi:10.1111/j.1475-4762.2011.01029.x, 2011

[12] McCaughey, J., Lubis, A. M., Huang, Z., Hill, E. M., Eriksson, S., Sieh, K., "Earthquake and tsunami hazard in West Sumatra: Integrating Science, Outreach, and Local Stakeholder Needs", Geophysical Research Abstracts, Vol. 14 EGU2012-8535, 2012.

[13] LIPI – UNESCO/ISDR, "Kajian Kesiapsiagaan Masyarakat dalam Mengantisipasi Bencana Gempa Bumi & Tsunami". Laporan Kegiatan Deputi Ilmu Pengetahuan, Kebumian Lembaga Ilmu Pengetahuan Indonesia, Jakarta. 2006.

[14] Singarimbun, M dan S, Effendi., "Validitas dan Reliabilitas Instrumen Penelitian, dalam Djamaludin Ancok ed". *Metode Penelitian Survai*,. LP3S, Jakarta, 1987

[15] Cressie, N., "Spatial Prediction and Ordinary Kriging", Journal of Mathematical Geology, Vol. 20, No. 4. pp 405-421. 1988.

[16] Cressie, N ., "Statistics For Spatial Data. New York: John Wiley and Sons, Inc. 1993.

[17] Joreskog, K. G., "A General Approach To Confirmatory Maximum Likelihood Factor Analysis". Journal of Psychometrika-vol. 34, no. 2, 1969.

[18] Hardle, W., "Applied Multivariate Statistical Analysis", .Humbolt-Universitat zu Berlin.Jerman. 2007