RESILIENCE AND FLOOD RISK MANAGEMENT IN A COASTAL ZONE

Muzakar Isa¹, FX. Sugiyanto², Indah Susilowati³

¹Faculty of Economics and Business, Universitas Muhammadiyah Surakarta, Surakarta, Indonesia, ²,³Faculty of Economics and Business, Universitas Diponegoro, Semarang, Indonesia.

Email: ¹muzakar.isa@ums.ac.id, ²fx.sugiyanto09@gmail.com, ³q100110115@student.ums.ac.id

Article History: Received on 25th July 2019, Revised on 31st August 2019, Published on 06th October 2019

Abstract

Purpose: The article conducts the study that the northern coast of Central Java province in Indonesia is considered as the critical area of flood path. The region always suffers from floods due to the heavy rain and/or the sea-level rise. Therefore, people are suffering and the ecosystem is deteriorating.

Methodology: Vulnerability and resilience are considered based on the use of indicators. An indicator or a set of indicators can be defined as an inherent characteristic that quantitatively estimates the conditions of a system. They usually focus on minor, feasible, palpable and effective part of a system offering people a sense of bigger representation. Therefore, it is very important to know effects on people, cities and natural resources by these indicators.

Result: Results of the present study indicated that levels of vulnerability and the community resilience of the northern coast of Central Java to flood were in the medium category. In addition, the level of coastal community resilience was affected by the exposure of flood risk programs and the public adaptive capacity variable.

Applications: This research can be used for universities, teachers, and students.

Novelty/Originality: A number of efforts have been made to manage and mitigate the flood problems, despite the fact that results are incomplete and still restructuring from time to time. It is realized that infrastructural capacity for flood control, community awareness, and other multi-factors significantly contribute to solving the flood problem in the regions.

Keywords: Flood, Coastal, Risk Management, Resilience.

INTRODUCTION

Indonesia is ranked sixth in the world for its exposure to flood risk (Isa, 2016). From 1815 to 2015, floods reached 5,233 occurrences or approximately 38.99% from the total nature disaster in Indonesia (Badan Nasional Penanggulangan Bencana, 2016; Luo et al, 2016). Central Java province has relatively a high frequency of natural disasters, particularly floods on the northern coast of Central Java. In 2016, the data indicated the vulnerability of the coastal zone to floods (Oliveira et al, 2018; Chahine, 2018; Mailybaev et al, 2018).

During 2011-2015, there were 368 cases of flood in Central Java indicating the rising number of cases. Figure 1 shows the total number of disasters in 2000-2014. In addition, the flood has numerous effects. During 2011–2015, it was confirmed that 58 people were killed in Central Java; 191,422 were evacuated; 31.012 Ha of the area and 139 km of road were destroyed; and 1,104 houses were heavily damaged due to flood (Isa, 2016).

Floods definitely have various consequences including economic losses. Generally, adaptation and mitigation are carried out before floods to reduce consequences. They can reduce the probability and magnitude of the stimulus, reduce the vulnerability and enhance resilience. Even in the absence of adaptation and mitigation, the community would have the ability to reduce effects of floods through community resilience (Bahremand, 2015; Iravani et al, 2015).

Figure 1: The Number of Natural Disaster in Central Java Province

Source: Isa 2018
The concept of risk describes the assessment of the frequency of occurrence and magnitude of consequences associated with hazard activities. An advantage of this approach is that the risk does not automatically imply the occurrence of negative outcomes. Risk management typically involves some mixtures of mitigation and adaptation and thus conferring upon the risk management models the potential, to sum up, perspectives that cover the growth and risk.

Flood-prone area poses risks including personal casualties, damage, and loss. The flood risk represents the function of vulnerability and hazard. The "vulnerability" term refers to a condition that causes people unable to cope with the flood in a certain area. Vulnerability is dynamic according to conditions, systems, and environment of a community. The flood area vulnerability consists of three aspects, namely the exposure, sensitivity, and adaptive capacity.

The low level of flood risk indicated a high level of community resilience. The present study conceptualized the production function as a function of community resilience to flooding. There was a relationship between the output and input of the production function. The research aimed to analyze the influence of vulnerability aspects (exposure, sensitivity, and adaptive capacity) on community resilience.

LITERATURE REVIEW

Flood's Risk

Flood is a state in which water is found in low lands around the river as a result of his inability to accommodate and drain the water. The flood resulted in a lot of personal sacrifices such as the risk of damage and loss if the region was vulnerable. When there is a flood, but the region is not vulnerable, communities can address the disturbing events, while when conditions of a society are vulnerable in the region, but not life-threatening event occurs, then it will not be a disaster. According to Tuner Il et al and Cutter the risk of flood (R) can be calculated using the following formula:

\[ R = H \cdot V \]  

Where:

- \( H \) (Hazard): Natural or artificial phenomena that have the potential to threaten human life, damage and loss.
- \( V \) (Vulnerability): Conditions of regions and communities leading to incapacity in encountering a threat of danger.
- \( R \) (Risk of the flood): Interaction between levels of vulnerability with existed threats.

Vulnerability

The vulnerability is a condition that leads to the inability of regions and communities in encountering floods. This vulnerability is dynamic in line with the conditions of environmental systems and social life. The vulnerability of a region against floods is because of three cases namely exposure, sensitivity, and adaptive capacity.

\[ V = E, S, AC \]  

Where:

- \( E \) (Exposure): Values that exist in the location where floods can occur.
- \( S \) (Sensitivity): Level(s) of a natural system against floods and level changes caused by such changes.
- \( AC \) (Adaptive Capacity): The ability of a community or an environment to react and adapt to the reduction of danger, and greater losses.

Resilience

The resilience is the ability to resolve problems arising from post floods, and also the ability to survive and deal with floods so that the risks can become minimal. The level of social resilience against flood shows the power of a community is facing floods. The level of the community's resilience can be considered as efforts of communities to manage their activities during and after the flood; hence, this is a community effort to produce activities. Therefore, the resilience of communities against floods can be considered as a product.

The study was a production function of community resilience against floods. The production function is the relationship between the input and output. The resulting output is determined by factors of production such as (1) capital, (2) labor, and (3) technology. In this production function, it is assumed that there is no technological change, so that its equation based on Barro, and Sala-i-Martin (2003), is stated as follows:

\[ Y = f(K, L) \]  

Where \( Y \) represented that the output was a function of \( K \) for the capital accumulation and \( L \) for the labor. The empirical equation model of resilience is as follows.

\[ R(it) = \alpha + \beta1 E(it) + \beta2 S(it) + \beta3 KA(it) \]  

Where,

- \( \alpha \): Intercept
$\beta_1, \beta_2, \beta_3$ : Parameter / Coefficient

$R\ (it)$ : Resilience

$E(it)$ : Exposure

$S(it)$ : Sensitivity

$KA\ (it)$ : Adaptive Capacity

**METHODOLOGY**

**Research Location**

Central Java province is one out of 34 provinces in Indonesia. Central Java province has an area of 3,254,412 Ha as 1.70% of the Indonesian area. Central Java is located between $5^\circ\ 40'$ and $8^\circ\ 30'$ South Latitude and between $108^\circ\ 30'$ and $111^\circ\ 30'$ East Longitude. Central Java province is bordered by the Indian Ocean and the special region of Yogyakarta in the South, the West Java province in the West, East Java province in the East, and Java Sea in the North.

Central Java province has a little more than 53% of its area. Lowlands in Central Java province are in the coastal area in the north and south of the coastal area of Central Java province. The North Coast region is the most prone to flood. The flood was caused by (1) high rainfall, (2) overflow of river water and (3) destruction of Weirs/levee/floodgates. Most floods occur in Pati, Pekalongan, and Semarang regions. Some major rivers exist across the region. Therefore, they make it vulnerable to flood. Changes in land use due to the residential growth, agricultural expansion and recent industrial development in lowland areas contribute to the degradation of coastal areas including Pati, Pekalongan, and Semarang. The present study was conducted in three research sites including the east (Pati), central (Semarang), and west (Pekalongan) of the northern coast of Central Java. Figure 2 shows the location and geographic coordinates of the research region.

![Figure 2: Location of the research area](chart.png)

Source: Isa et al. 2013

**Data Processing and Analysis**

Vulnerability and resilience are considered based on the use of indicators. An indicator or a set of indicators can be defined as an inherent characteristic that quantitatively estimates the conditions of a system. They usually focus on minor, feasible, palpable and effective part of a system offering people a sense of bigger representation. Therefore, it is very important to know effects on people, cities and natural resources by these indicators.

The primary data of the present study was as follows: (1) Flood zone vulnerability data including the exposure, sensitivity, and adaptive capacity, and (2) data of flood risk. The respondents were directly interviewed using questionnaires. The questionnaires were used as a guide for the researcher and contained a list of questions to obtain respondents' answers as the data.
The present study used multinomial logistic regression. Multinomial logistic regression was used to analyze effects of vulnerability index on flood risk levels. This method was assumed as an appropriate tool because the dependent variable, flood risk level, was multinomial or had more than two attributes: 3 for high-risk level, 2 for medium risk level, and 1 for low-risk level.

RESULTS AND DISCUSSION

The level of flood zone vulnerability on the northern coast of Central Java affected the flood risk including personal casualties (death, injury, and evacuation), damages, and losses (Badan Nasional Penanggulangan Bencana, 2016). Flood risk indicated that there were unsolved economic problems about the flood zone vulnerability and community resilience to flooding indicating the scarcity and inefficiency of flood management.

The flood risk among the public indicated their ability to cope with the flood. The low flood ratio delineated that society was impervious to flood. Flood risk consisted of personal casualties, damages, and losses, and thus it referred to the “community resilience”. When the flood occurred, the level of social resilience could be determined by the level of its vulnerability.

Vulnerability

The vulnerability index was 0.63 on the northern coast of Central Java. The index indicated the medium level of vulnerability despite diverse results for city or district. The exposure variables and adaptive capacity were at high vulnerability levels. Both variables significantly contributed to determination of the vulnerability level of the northern coast of Central Java with index values of 0.81 and 0.73 respectively. The sensitivity variable was classified into the medium vulnerability with an index of 0.36. The levels indicated that the government and society should pay more attention to the exposure variables that consisted of flood frequency, flood duration, number of elderly and infants, and distance of settlements from the flood area (De Bruijn, K. M. (2004)).

Causes of the flood zone vulnerability were divided into three aspects: flood aspects, local government service aspects, and individual aspects. Flood and local government service were the external aspects of society. Therefore, the local government and community can mitigate flood as a solution, for instance, to create rain infiltration, improve drainage, normalize the river, arrange buildings in accordance with the applicable Spatial Plans, and conduct institutional development. Institutional development can be in forms of strengthening the Local Disaster Management Agency, the flood Standard Operation Procedure (SOP) development, and strengthening the flood prevention management.

Flood and local government services were external aspects of the flood zone vulnerability on the northern coast of Central Java. The aspects consisted of flood frequency, water level, and flood duration. In addition, the vulnerability level was also affected by the distance of the settlement from the river. It was also affected by the lack of local government services such as (1) early warning of flood, (2) dissemination of flood prevention, (3) training for flood prevention, (4) non-governmental organizations involved in flood, (5) evacuation route, (6) the number of flood emergency services, (7) the distance of evacuation site from settlements, (8) the number of aid camp for victims, (9) access to health services, and (10) conditions of river, levees, and floodgates.

Based on internal aspects of the community, the high vulnerability to flood was caused by low level of public awareness such as obtaining flood information as well as individual insurance. The low educational background and numbers of infants and elderly were also influential. The alternative solution as the dissemination in technology and knowledge was necessary to address the internal issue (Clark, M. J. (1998)).

Resilience

The “community resilience to flood” index was 0.83 in the northern coast of Central Java. It indicated that people had relatively high resilience to flooding on the northern coast of Central Java. The damaging aspect significantly indicated the community resilience to flooding following by losses and personal casualty’s aspects. Damages to the northern coast of Central Java included (1) damages to buildings and equipment such as cars, motorcycles, furniture, and electronics, (2) trading facilities such as shops and kiosks, (3) agriculture facilities such as land and farm machinery, (4) livestock facilities such as farms and stables, (5) fishery facilities such as ponds or pools, and (6) fishing equipment such as boats, engines, and nets.

The community resilience level on the northern coast of Central Java was diverse based on damages. This level was in line with the value; the higher the value was, the higher the community resilience to flood was, and vice versa. The analysis results indicated that: (1) In the trading sector, the amount of losses can be determined through the multiplication of trade turnover and the number of days-off, (2) In the agricultural sector, the crop failure would automatically reduce the crop yields, (3) In the livestock sector, floods increased the number of livestock deaths, (4) In the fishery sector, the unfavorable conditions for the fishermen would lead to reduced income, and (5) the unavailability of fish due to flood conditions, (6) In other sectors, people could not carry out their daily activities such as going to workplaces. However, the northern coast community had a high level of community resilience to floods.

The examination on three locations indicated different results, but in general, the number of evacuated victims was minimal as personal casualties. The number of victim’s death due to floods on the northern coast of Central Java could be considered as a low value. However, the flood did not necessarily have an impact on death. Injury and evacuation were two
common risks due to floods (Aerts, J. C., Botzen, W. W., Emanuel, K., Lin, N., De Moel, H., & Michel-Kerjan, E. O. (2014)).

Resilience and Risk Management

There were three alternatives to the community resilience to flooding on the northern coast of Central Java including the high, medium, and low resilience. The above three alternatives were gained from Multinomial Logistic Regression by defining variables of flood zone vulnerability including exposure, sensitivity, and adaptive capacity as independent variables.

Multinomial regression analysis models explained that there was conformity with the data that was indicated by Pearson and Deviance Values. Pearson had a sig value of 0.374 and Deviance was equal to 0.057. According to values, the significance of Chi-Square values was greater than 0.05; hence, it could be concluded that the model was fit to the empirical data. The result of the Nagelkerke value was 0.081 meaning that 8.1% of community resilience variable could be represented by exposure, sensitivity, and adaptive capacity variables (Johnson, C. L., & Priest, S. J. (2008)).

The Likelihood Ratio Test determined the simultaneous significance of the model. It was carried out by comparing the model in which predictor variables were exposure, sensitivity, and adaptive capacity to the community resilience. It was obtained that the sig value of intercept was 0.000. Therefore, the exposure, sensitivity, and adaptive capacity variables simultaneously had significant positive effects on the community resilience to floods in the northern coast of Central Java.

Tests were performed on individuals to assess the parameter significance of predictor variables using the Likelihood Ratio Test. Based on the Likelihood Ratio Test, the significance value of exposure and adaptive capacity variables were less than 0.05; hence, it could be concluded that both variables were positive and significant in affecting the community resilience to flooding at α = 5%. The sensitivity variable was positive, but insignificant in affecting the community resilience to flooding at α = 5%.

Tests on individuals indicated the parameter significance of predictor variables using the Wald Test. Table 1 presents the statistical test for the Wald Test.

| Response Variable | Predictor Variable | Wald | Sig.  | B    | Exp (B) |
|-------------------|--------------------|------|-------|------|---------|
| Medium Community Resilience | Intercept          | 12.277 | 0.000 | -6.135 | 1.242   |
|                   | X1                 | 3.251 | 0.0710 | 0.217 | 1.087   |
|                   | X2                 | 0.926 | 0.336 | 0.083 | 1.110   |
|                   | X3                 | 7.151 | 0.007 | 0.105 | 1.110   |
| High Community Resilience | Intercept         | 13.240 | 0.000 | -5.832 | 1.425   |
|                    | X1                | 10.745 | 0.001 | 0.354 | 1.104   |
|                    | X2                | 1.655 | 0.198 | 0.099 | 1.032   |
|                    | X3                | 0.777 | 0.378 | 0.032 | 1.032   |

Source: Isa (2018)

The medium level of coastal community resilience to the flood was affected by adaptive capacity variables (sig: 0.007) and exposure variables (sig: 0.071). The high level of community resilience was only affected by exposure variables (sig: 0.0001).

Exposure and adaptive capacity positively and significantly contributed to the community resilience to flood. According to both variables, the government could perform several efforts to enhance community resilience such as:

a) Preventing the settlement construction in the area adjacent to the flood zone; stabilizing the river, levees, floodgate; and organizing and conducting the socialization of flood-prone area map;

b) Improving the community education level;

c) Providing health services in the flood zone;

d) Establishing the precise evacuation route/path, and constructing an evacuation camp in the area of flood zone;

e) Encouraging to establish the disaster relief non-governmental organizations;

f) Providing education for the public on information access;

g) Providing the socialization and education of hazard insurance services;

h) Constructing flood emergency camps during the flood;

i) Providing early warning signs;

j) Organizing the socialization and training to address and relieve the hazard

CONCLUSION

The present research concluded that the exposure and adaptive capacity positively and significantly contributed to the community resilience to flood on the northern coast of Central Java Province in Indonesia. According to both variables, the
government could make great effort to enhance community resilience.

ACKNOWLEDGMENT

The author confirms that the data do not contain any conflict of interest.

REFERENCES

1. Bahremand, A. (2015). The concept of translation in different teaching approaches and methods. UCT Journal of Social Sciences and Humanities Research, 3(1), 5-9.
2. Bencana, Badan Nasional Penanggulangan. 2016. Laporan Badan Nasional Penanggulangan Bencana [National Disaster Management Authority]. Jakarta: BNPB.
3. Chaline, I. C. (2018). Exposing the Conscious Self: Lived Problem Solving Experience in a Socio-Cultural Context. International Electronic Journal of Mathematics Education, 13(3), 221-231. https://doi.org/10.12973/iejme/3880
4. Iravani, M. R., Niknejadi, F., & Jahandoost, Z. (2015). The Relationship Between Age And Job Satisfaction Consultants Government Girls High School In Isfahan In 2012-2013 Academic Year. Health, 70(22.65), 24.
5. Isa, Muzakar. 2016. Natural Disaster: Negative or Potisitive Impact to Economy Growth? Kudus: The 3rd University Research Colloquium 2016.
6. Luo, C., Li, M., Peng, P., & Fan, S. (2018). How Does Internet Finance Influence the Interest Rate? Evidence from Chinese Financial Markets. Dutch Journal of Finance and Management, 2(1), 01. https://doi.org/10.20897/djfm/89590
7. Mailybaev, G. S., Zhexembayeva, Z. R., Nurgaliyeva, S. A., Zholumbayeva, R. M., & Utegulov, D. E. (2018). The efficiency of the education system in Kazakhstan: Programme for International Student Assessment (PISA). Opción, 3(85-2), 600-626.
8. Oliveira, F. K. D., Oliveira, M. B. D., Gomes, A. S., & Queiros, L. M. (2018). Identifying User Profiles from Statistical Grouping Methods. Journal of Information Systems Engineering & Management, 3(1), 06. https://doi.org/10.20897/jisem.201806
9. Aerts, J. C., Botzen, W. W., Emanuel, K., Lin, N., De Moel, H., & Michel-Kerjan, E. O. (2014). Evaluating flood resilience strategies for coastal megacities. Science, 344(6183), 473-475. https://doi.org/10.1126/science.1248222
10. De Bruijn, K. M. (2004). Resilience and flood risk management. Water Policy, 6(1), 53-66. https://doi.org/10.1016/j.watpol.2004.0004
11. Johnson, C. L., & Priest, S. J. (2008). Flood risk management in England: a changing landscape of risk responsibility?. International Journal of Water Resources Development, 24(4), 513-525. https://doi.org/10.1080/07900620801923146
12. Clark, M. J. (1998). Flood insurance as a management strategy for UK coastal resilience. Geographical Journal, 333-343. https://doi.org/10.1046/j.1475-4959.1998.3330333.x
13. Crichton, D. (2008). Role of insurance in reducing flood risk. The Geneva Papers on Risk and Insurance-Issues and Practice, 33(1), 117-132. https://doi.org/10.1057/palgrave.gpp.2510151
14. Merz, B., Hall, J., Disse, M., & Schumann, A. (2010). Fluvial flood risk management in a changing world. Natural Hazards and Earth System Sciences, 10(3), 509-527. https://doi.org/10.5194/nhess-10-509-2010
15. Shaw, R., & Sharma, A. (Eds.). (2011). Climate and disaster resilience in cities. Emerald Group Publishing.
16. Dolan, A. H., & Walker, I. J. (2006). Understanding vulnerability of coastal communities to climate change related risks. Journal of Coastal Research, 1316-1233. https://doi.org/10.1108/S2040-7262(2011)6
17. Klein, R. J., Nicholls, R. J., & Thomalla, F. (2003). Resilience to natural hazards: How useful is this concept?. Global environmental change part B: environmental hazards, 5(1), 35-45. https://doi.org/10.1016/j.hazards.2004.02.001
18. Djordjević, S., Butler, D., Gourbesville, P., Mark, O., & Pasche, E. (2011). New policies to deal with climate change and other drivers impacting on resilience to flooding in urban areas: the CORFU approach. Environmental Science & Policy, 14(7), 864-873. https://doi.org/10.1016/j.envsci.2011.05.008
19. Van Dongeren, A., Ciavola, P., Viavattene, C., De Kleermaeker, S., Martinez, G., Ferreira, O., ... & McCall, R. (2014). RISC-KIT: resilience-increasing strategies for coasts-toolKIT. Journal of Coastal Research, 70(sp1), 366-372. https://doi.org/10.2112/SI70-062.1
20. Filatova, T. (2014). Market-based instruments for flood risk management: a review of theory, practice and perspectives for climate adaptation policy. Environmental science & policy, 37, 227-242. https://doi.org/10.1016/j.envsci.2013.09.005