Study of social vulnerability as an effort on disaster risk reduction (study on suburban communities in Yogyakarta, Indonesia)

W Utami
Sekolah Tinggi Pertanahan Nasional, Yogyakarta, Indonesia
E-mail: westiutami@gmail.com

Abstract. A community-level social vulnerability assessment is an important on disaster risk reduction system. The methods to measure social vulnerability in this study used variables of education level, health level, income level and vulnerable groups. The study was conducted through a census of 365 rural community households in Bantul District, Yogyakarta Special Region. The research method was quantitative with scoring system on each influential variable. The results showed that between variables of vulnerability have relevance, where people with low income have a tendency level of low education. The results show that marginalized communities were at high vulnerability level, with the details were as follows: 35.1% of the community were at high social vulnerability (very vulnerable) and 56.4% of the community were people with moderate social vulnerability; people with low vulnerability was only 8.5%. The high number of vulnerable people in the periphery was because most of the population had low income and education level. The vulnerability distribution of each household in this study is further presented in maps to facilitate spatial analysis.

1. Introduction

Social vulnerability is often forgotten in a disaster-risk reduction framework system. In some cases, the level of social vulnerability is sometimes not included in calculating the amount of risk and costs needed for recovery/post-disaster activities. Social vulnerability can be said to be part of a social gap that affects the inability of community groups when a disaster occurs (Cutter 2003, 242-261). With this condition, measurement of the level of vulnerability is an important component and a key component in an effective disaster-risk reduction strategy (Birkmann, 2006; Ignacio, 2015).

A research conducted by Birkman stated that measuring the level of social vulnerability has been a controversial concept (Birkman, 2010). This is because these measurements have not included the community's response/ability to respond to disasters and how to take vulnerability into account separately from the ability to overcome/reduce the level of disaster risk. Apart from the controversy, the calculation of the magnitude of the level of vulnerability (specifically social vulnerability) is very necessary so that a reduction in the risk impacts that will occur can be done comprehensively.

The indicator used to find out the social conditions of the community is the standard from the United Nations Development Program's Index (UNDP, 2000). The parameters used include indicators of level of welfare, gender disparity and poverty level. Other indicators namely the results of consensus and the social science community state that several factors influencing social vulnerability are limitations to access to resources (including information, knowledge and technology), limitations to power and political representation, social capital, limitations of social networks and connections, age, physical conditions, infrastructure conditions, population density (Cutter 2003).
Previous studies on social vulnerability mainly focus on limited indicators such as welfare with parameters on income and density (Duta, 2013; Cutter, 2003). In this study, the researcher employs 4 indicators to measure social vulnerability of each household member, including income, education, health, and number of vulnerable people. Various studies state that the poverty rate is an important indicator of the level of vulnerability of the community (Duta, 2011). Poverty sometimes makes it difficult for individuals/communities to rise up and require a long time to recover when a disaster occurs. A high level of poverty also results in a high risk felt by the community in the event of a disaster.

The measurement of social vulnerability on previous studies (Calvo, 2013; Birkman, 2010; Duta, 2011) were conducted at the state, provincial, or district level. Whereas this study conducted the measurement of social vulnerability at the household level by investigating information on the individual level of the household members. This measurement model is considered to be able to portray the social vulnerability in more details so that the results can be more appropriate to be applied into disaster mitigation.

2. Methods

This research used quantitative methods to assess the level of social vulnerability of the community. The technique was carried out to obtain data through a census of 365 households located in Dusun Sayangan, Jagalan Village, Bantul Regency, Daerah Istimewa Yogyakarta, Indonesia. Arrangement of social vulnerability level in the form of maps is conducted by spatial analysis. The data in this research consisted of primary data and secondary data. Primary data included interviews with 365 households, checking the field to cross-check the x, y coordinates of each house. Meanwhile, secondary data included family card data, administrative maps, population data, and GeoEye image. Variables used to measure the level of social vulnerability included the level of income, the level of health, the existence of vulnerable groups, and the level of education. The vulnerable groups in this research included: residents with disabilities/disabled, elderly, toddlers, and pregnant women. Vulnerability assessment was carried out for each individual in each household so that the data of each household were a representation of the conditions of social vulnerability of each individual. GeoEye’s image was utilized to compile a spatial distribution of vulnerabilities. This image has a fairly high spatial resolution of 1.5 - 3 meters and has the advantage of being clear enough to represent each building/household in the research location/suburban area. Geographic Information System (GIS) was used to facilitate spatial analysis of the distribution of social vulnerability level of each household. The variable level of social vulnerability consisting of 4 (income, education, health level, vulnerable groups) were further revealed to be a number of questions arranged in questionnaire form.

The research location was a sub-urban area that had a population density of 11,941 people per km2 with the threat of an earthquake and a fairly high fire. In addition, this area had a very tight building density in which the age of the buildings were very old with very narrow road conditions (1-2 m). The area was chosen as research location because of its high physical vulnerability and threat of disasters.

3. Results and Discussion

The results of the analysis and percentage of level variables of various social vulnerability in this research are presented in Figure 1.
It can be seen from Figure 1 that the level of income and education of some people is classified as very low, as well as the condition of vulnerable groups in the research location that is classified as quite a lot. Explanation of each variable that affects the level of vulnerable groups is presented as follows:

3.1. Income level
Income is a crucial element that determines the level of community welfare, or in some income level studies it is often used as an indicator to measure poverty levels. Although Calvo said that vulnerability is not only related to the aspect of poverty, in this case it is measured through the level of income (Calvo 2013, pp. 721-740; Ligon 2013 pp. C95-C102), several other studies make poverty as an indicator in measuring the level of vulnerability.

Households with high income indicate that the households are more prosperous. Meanwhile, those with low income (less than 1 million) can indicate that the households belong to the less prosperous/poor group. The level of welfare or the level of poverty in a household is very influential on the level of social vulnerability. Households with a high level of welfare are certainly stronger, more resilient and easier to rise when a disaster strikes.

From the census carried out on 365 households, there were 124 households (33.8%) with income of less than 1 million. These data show that there are many households with income below regional minimum wage in the research locations indicating less prosperous life. The low level of income in these households is certainly influenced by several factors, namely the type of work they are engaged in, the level of education and skills, knowledge and experience, limited capital, limited access and conditions of the population in sub-urban areas that cause the powerlessness of the population’s access to land as a source of livelihood. It is this community powerlessness that has caused some households head to work as odd jobs with erratic work (construction workers, silver craftsmen, pedicab drivers, masseurs, washers, housemaids, scavengers) with an income of approximately Rp. 35,000,-/day.
Most of the households in the research location, which was 190 (51.8%), had income of 1 to 2.9 million/month, which could be categorized as middle welfare level. Meanwhile, there were only 15 households in the location which had income from 5.1 to 9.9 million, and 6 households in the location which earned more than 10 million. The total number of households with income of more than 5 million was only 5.7%. This condition shows that only a small percentage (5.7%) of the total 365 households have high income/welfare level. The distribution and description of income levels to the level of social vulnerability in Dusun Sayangan can be explained by cross tabulation analysis of the two data presented in table 1.

Table 1. Cross tabulation of income against social vulnerability

| Education | Income | Class 1 | Class 2 | Class 3 |
|-----------|--------|---------|---------|---------|
| Bachelor  | < 10 Mln* | 3 | 0,8 | 9 | 2,5 | 14 | 3,8 | 16 | 4,4 | 1 | 0,3 |
| high Sch  | 5,1 – 9.9 mln | 3 | 0,8 | 4 | 1,1 | 6 | 1,6 | 68 | 18,6 | 14 | 3,8 |
| junior Sch| 3,1 – 5 mln | 0 | 0 | 9 | 2,5 | 61 | 16,7 | 41 | 11,2 |
| Elementary Sc | 1 – 3 Juta Million | 0 | 0 | 2 | 0,5 | 1 | 0,3 | 45 | 12,3 | 68 | 18,6 |
| > 1 Million | > 10 Million | 0 | 0 | 53 | 14,5 | 71 | 19,5 |

Source: Household census of Dusun Sayangan in 2014

The results of the cross tabulation show that households with income of less than 1 million, i.e. as many as 71 (19.5%), were in very vulnerable social conditions (class 3 vulnerability); 53 households (14.5%) were in class 2 vulnerability; and none of the households with income below 1 million was in good social condition (class 1 vulnerability). These results indicate that there is a very strong relation between the level of income and the level of social vulnerability. The higher the income of each household, the better the level of social vulnerability; and the lower the level of income, the more the vulnerable households in social conditions.

Table 2. Graph of relationship between education level and income

| Social Vulnerability | < 10 Mln* | 5,1 – 9.9 mln | 3,1 – 5 mln | 1 – 3 Juta Million | > 1 Million |
|----------------------|-----------|---------------|--------------|-------------------|-------------|
| Income               | Acn %     | Acn %         | Acn %        | Acn %            | Acn %       |
| > 10 Million         | 5 | 1,4 | 1 | 0,3 | 0 | 0 |
| 5,1 – 9.9 Million    | 7 | 1,9 | 7 | 1,9 | 1 | 0,3 |
| 3,1 – 5 Million      | 10 | 2,7 | 20 | 5,5 | 0 | 0 |
| 1 – 3 Juta Million   | 9 | 2,5 | 125 | 34,2 | 56 | 15,3 |
| > 1 Million          | 0 | 0 | 53 | 14,5 | 71 | 19,5 |

Source: Household census of Dusun Sayangan in 2014

The analysis in this research shows that income has a strong influence on the level of social vulnerability of the community. The condition of the community in the sub-urban areas where there is a transition between urban and rural influences with the condition of the population having limited access to decent work due to the ability and low education makes them unable to escape the conditions of poverty. The relationship between the level of income and the condition of public education are presented in table 2.
Based on the results of cross tabulation, it can be explained that the majority of households with high income were able to send their family members to the undergraduate level. On the other hand, none of the households with income below 1 million was able to send their family members to education to the tertiary level. The graph of the relationship between the two variables, namely the level of education and the level of income, is a linear graph that can be presented in Figure 2.

Figure 2. Graph of the relationship between education levels and income
Source: Household census of Dusun Sayangan (2014)

Figure 2 shows that most of the families with low income were only able to send their families to elementary or junior high school, and only a small percentage of 4% can afford to attend high school education. Economic difficulties and limited access of the community make their lives not move from adversity from generation to generation. When every family with an income below 1 million cannot send their children to higher education, the limited ability/skill will affect the family. This condition implies that when a person has limitations in terms of education level, skills/creativity/abilities, the access to jobs and decent livelihoods will also occur.

3.2. Level of education

The level of education in various theories can be categorized into formal and informal education. In this research, formal education level is used to measure the level of social vulnerability, but it is not impossible that information on informal education in relation to disaster management can be obtained through interviews with the community so that it can increase the score/assessment of community education/understanding in disaster-risk reduction. Formal and informal education has an influence on how the community has the ability to obtain a decent livelihood, influence on community capacity in facing disasters.

In the research area located in sub-urban areas, the results indicate that the level of education of the community was still relatively low, in which some people with education at the elementary - junior school, high school level were very large (62%), and only 12% of the people achieved undergraduate/master education level.

3.3. Vulnerable groups

Some demographic groups, such as very young families, very old families, disabled people, single parents, and low income families are seen as vulnerable (King and MacGregor 2000). In this research, vulnerable groups are distinguished based on the level of vulnerability felt when an earthquake strikes. Vulnerable groups include: elderly, pregnant women, toddlers and disabled groups. If there is more than 1 vulnerable group in one family, the assessment will certainly be different from that of the vulnerable groups of the elderly who enter the early age of 65-68 years old.
The results of the census show that there were vulnerable groups in 52% of the households in Dusun Sayangan. The large number of indigenous people who live for a long time in Dusun Sayangan with high life expectancy, a large number of people, and a high density is one of the factors in the high number of vulnerable groups. By classifying vulnerable groups, it is expected to provide an overview of the conditions of population’s vulnerability in detail. Data of distribution of the vulnerable groups can be used as a basis and consideration in disaster management, which include the issue of evacuation for vulnerable groups where 1 house has only one vulnerable group that is very old, the safe evacuation models for vulnerable groups who are unable to walk, the existence of a vulnerable group in a household with physical and environmental vulnerability in the class 3, and the evacuation site is far enough. By relying on these data, it is expected that the prepared disaster management model will be more friendly and care for the concerns of vulnerable groups.

3.4. Health Level
Health is an important factor to assess the condition of a population. Healthy and strong citizens certainly have better abilities when a disaster occurs. From the results of the census conducted by the community in Dusun Sayangan, most of the citizens (93%) were in good health.

3.5 Analysis of Social Vulnerability Levels
From the results of the assessment of the 4 social vulnerability variables, accumulation of assessment was obtained with the highest score 17 and the lowest score 4. To categorize vulnerabilities into 3 classes, vulnerability level intervals are needed with the following calculations:

The results of classifying social vulnerability can be categorized into 3 classes with a range of values as presented in table 3.

| No | Values | Class | Account | Prosentase |
|----|--------|-------|---------|------------|
| 1  | 3 – 7  | 1     | 31      | 8.5 %      |
| 2  | 8 – 12 | 2     | 206     | 56.4 %     |
| 3  | 13 – 17| 3     | 128     | 35.1 %     |

Source: Household census of Dusun Sayangan (2014)

3.6 Social Vulnerability Map
The preparation of social vulnerability map in this research was carried out by interpreting each building appearance/house based on Geo-Eye imagery. Checking 365 houses was done to add and inventory between buildings and household units. Distribution of each building based on shape and area is used as spatial data in which there is information on the attribute data related to social vulnerability variables.

The classification results of vulnerability levels are categorized into 3, namely high vulnerability, moderate vulnerability, and low vulnerability. Each household represented by blocks as presented in the map image represents the condition of its social vulnerability. The results of spatial data processing and analysis of the level of vulnerability are presented in Figure 3.
Based on the analysis of the frequency distribution of the level of social vulnerability, the social vulnerability of the number of households in class 3 vulnerability includes 128 households (35.1%), and households that are in the second class of vulnerability reach 56.4% (206) of the total 365 households.

There are several factors that influence the high percentage of highly vulnerable households (class 3) and class 2 vulnerability. A spatial factor is one of them, where this area is a sub-urban area, namely the border with urban areas and rural areas. Most people in sub-urban areas are mostly unable to access and adapt to the economy in the city. The powerlessness of capital, skills, education, and access to the economy makes people in the sub-urban area work in the lower sector (labor/service sector) with low income. Limited access to productive land (area and low level of soil fertility) as a source of livelihoods distinguishes sub-urban communities from rural communities. This condition causes some people in the suburban area to be in the middle to lower economy.

The results of the analysis of social vulnerability variables indicate that the values of the high variables that influence the conditions of social vulnerability are the high vulnerable groups, income level, and education level. Vulnerable groups are conditions of population composition that is difficult to change in a community group. Meanwhile, income and education are variables that can be changed and improved in quality. Education is an important factor that can be sought to improve the social quality of the people in Dusun Sayangan. With higher education, it is expected to increase the income of the people in Sub urban area.

4. Conclusion

The high level of social vulnerability of sub-urban areas is caused by low levels of income and education levels. Changes in urban and rural areas make sub-urban areas not have agricultural land as a source of livelihood. Non-permanent occupations of people including daily laborers, domestic helpers, scavengers, etc. result in low income that is far below the standard. In this research, income and education have a linear correlation where people with low income are only able to get an elementary and junior high school education, and vice versa. The high level of social vulnerability of the community results in a high level of risk felt by the community in the event of a disaster.
Acknowledgement
The authors would like to thank all parties who helped in the smooth running of this research.

References

[1] Cutter L Susan Social, Boruff J Bryan, Shirley Lynn W, 2003 Social Vulnerability to Environmental Hazards, *Social Science Quarterly* **84** 2 pp 242-261

[2] Birkman J and B Wisner 2006 *Measuring the un-measurable UNU-EHS* source 5 Available at: http://www.ihdp.unu.edu/file/get/3962

[3] Dutta Indranil, Foster James, Mishra Ajit 2011 *Measuring vulnerability poverty Social choice and welfare* 37 4

[4] Birkmann J 2010 *Measuring Vulnerability to Natural Hazards: Towards Disaster Resilient Societies The Journal of Risk and Insurance* **77** 4 pp. 959-961

[5] Ignacio F Andeas J, Cruz T Grace, Nardi Fernando, Henry Sabine, 2016 *Assessing the effectiveness of a social vulnerability index in predicting heterogeneity in the impacts of natural hazards: Case study of the Tropical Storm Washi flood in the Philippines Special issue on vulnerability to climate-related disasters* **13** 91 -129

[6] Calvo C and Stefan D 2013 *Vulnerability to individual and aggregate poverty Social Choice and Welfare* **41** 4

[7] Ligon E and Schechter L 2003 *The Economic Journal* **113** 486 pp C95 – C102

[8] S M Metev and V P Veiko 1998 *Laser Assisted Microtechnology* (Berlin : Springer-Verlag)

[9] J Breckling 1989 *The Analysis of Directional Time Series: Applications to Wind Speed and Direction* (Berlin, Germany: Springer)

[10] S Zhang, C Zhu, J K O Sin, and P K T Mok 1999 *IEEE Electron Device Lett* **20** pp 569–571

[11] M Wegmuller J P, Von der Weid, P Oberson, and N Gisin, 2000 *High resolution fiber distributed measurements with coherent OFDR Proc. ECOC’00* paper 11.3.4 p 109

[12] R E Sorace, V S Reinhardt, and S A Vaughn 1997 *High-speed digital-to-RF converter U.S. Patent* 5 668 842

[13] M Shell 2002 *IEEE tran homepage on CTAN* [Online] Available: http://www.ctan.org/tex-archive/macros/latex/contrib/supported/IEEEtran/

[14] *FLEXChip Signal Processor (MC68175/D)* Motorola 1996

[15] PDCA data sheet *Opto Speed SA* 12-70 (Switzerland : Mezzovico)

[16] A Karnik 1999 *Performance of TCP congestion control with rate feedback: TCP/ABR and rate adaptive TCP/IP* (M. Eng. Thesis Bangalore, India: Indian Institute of Science)

[17] J Padhye, V Firoiu, and D Towsley 1999 *A stochastic model of TCP Reno congestion avoidance and control* (Amherst, MA : Univ. of Massachusetts)

[18] *Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specification* 1997 IEEE Std. 802 11