

# Flood Vulnerability Based On Social Economy Condition at Flood Prone Area in Purworejo Regency, Central Java, Indonesia

Nugroho Fajar Ariyanto (Ministry of Marine Affairs and Fisheries, Indonesia)  
Koji ASAI (Division of Civil and Environmental Engineering)

Based on geomorphology aspect, some areas in Purworejo Regency are categorized as flood prone areas. One of them is Butuh District which is categorized as high flood prone area. Flood occurs almost every year in this area and results losses to the community. There are four type of vulnerability on community level; two of them are social and economic vulnerability. Social and economic vulnerability is dynamically change influences the community vulnerability. The main objective of this research is to obtain information of social vulnerability. Survey method was used to obtain community information. Designed questionnaire was used to obtain the information from each respondent in community. In this research, two analyses methods were used. First, the pairwise comparison method from the analytical hierarchy process (AHP)-approach to obtained weight of social indicators in social vulnerability calculation. The second analysis method was SWOT analysis, and it was used to determine mitigation strategies based on condition in study area. There are some mitigation strategies (analyzed using SWOT analysis) based on condition in study area can be proposed for reducing impact of flood disaster. The mitigation strategies are expected to be input for government's program in the future.

**Key Words :** *Flood, social vulnerability, questionnaire survey, AHP analysis, SWOT analysis*

## 1. INTRODUCTION

Floods are dominant natural disaster in Indonesia making up 58% when compared to others. Its impacts include: structural damage (72%), evacuated people (99%), and included calamities (26 to 37%) (BNPB, 2012).

Butuh District is located on the southwest of Purworejo Regency, Central Java Province. Bedono / Butuh River and Gebang River are the two main rivers that pass through this district. Floods occur every year in this region and have resulted in losses for its communities like in December 2010 and January 2011 that inundated houses and rice fields. Since this flood happened over a long time, an appropriate method is selected as a tool to obtain information of community perception on hazard and vulnerability.

Purworejo Regency has had a flood prone area map based on the geomorphology aspect. Butuh District is located on a high flood prone area in this map. Flood occurs almost every year in this area

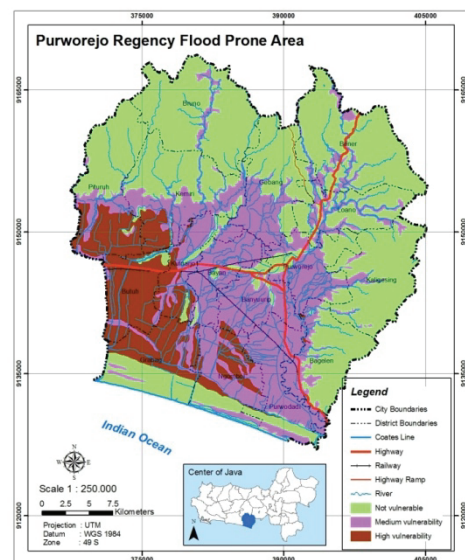


Figure.1 Purworejo Regency Flood Prone Area  
Source: *Purworejo Regency Regional Development Planning Agency*

and results losses to the community. A map of flood prone area can be seen in figure 1.

It is common to use physical analysis rather than social and economy analysis in flood assessment. Social economy information is really needed for local authorities and community itself to increase their flood management.

Community affected by flood should be involved in the flood assessment. Community should be involved in flood assessment because the community has local knowledge to assess flood event. Local community also has experience how to cope, prepare and minimize the damage. Flood risk assessment is an important element to increase community's awareness for coping with flood hazard. The combination between flood risk assessment based on physical measurement and social assessment can give valuable information in the flood risk management.

Other problems include how the response of governments and local communities in responding to these flood-prone areas. It is important for people to know strategies to cope with flooding and propose mitigation actions to reduce impact of flood disaster. Policies have been made by the government on disaster management and risk reduction, and strategies undertaken by local community which have experience on flooding.

## 2. RESEARCH OBJECTIVE

The main goal of this research is to determine level of flood vulnerability based on social economy condition of the people who live in flood hazard area. The research objectives of this study are:

1. To characterize social economy condition of people in study area.
2. To know level of vulnerability based on social economy condition of people in study area.
3. To gather information about people responses and coping mechanisms on flood hazard.
4. To propose mitigation strategies based on the condition in study area.

## 3. RESEARCH METHODOLOGY

### 3.1 Research Study Area

This study area is located in Purworejo Regency, Central Java Province. There are some areas categorized as high flood prone areas, one of them

is Butuh District.

In this research, purposive sampling method was used. The sample area is Kedung Agung Village. This village is located on eastern part of Butuh District. In this village, flood occurs almost every year and results in losses especially in the agriculture sector. Map of the study area can be

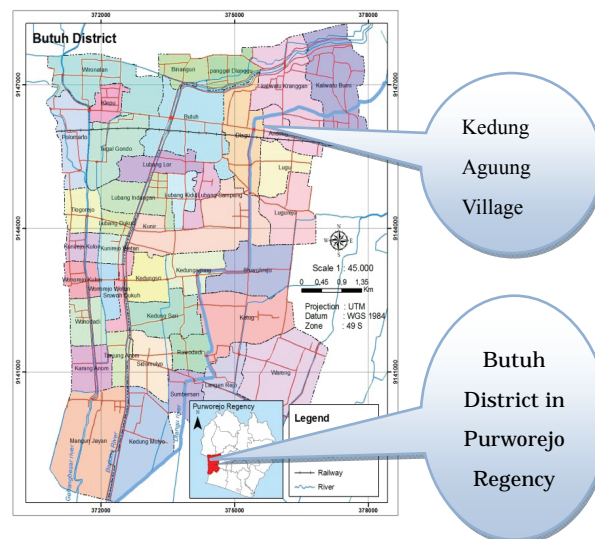


Figure 2. Study Area

seen in the figure 2.

### 3.2 Data Collection

Data collection category is divided into:

1. The secondary data; consist of base maps which were collected from related the number of sources. The other secondary data include demographical information and statistical data of the study areas. It was used to verify primary data and its analysis.
2. Primary data collection was conducted by interview and questionnaire survey. It used discussion with community and key informants. The primary data cover information of social economy condition of the respondents.

### 3.3 Data Analysis Method

#### a) Preliminary Analysis

Data from questionnaire were processed using Microsoft Office software, presented in graphic form, for analyzing the social economy condition of people.

#### b) Analytical Hierarchy Process (AHP) Analysis

The AHP Analysis developed by Saaty (1977) was

used in this research in order to determine the weight of an element at risk (social indicators) before making calculation on social vulnerability. In this case we use the pairwise comparison method. The AHP which is a method of measurement to formulate and analyze multi-criteria decision making has become a significant methodology to solve engineering problems (Wang and Raz, 1991). Triantaphyllou et al. (1995) defined that the AHP has become a significant methodology to solve engineering problems and some of the industrial engineering applications.

The AHP has a unique superiority in multi factor comprehensive evaluation and it just needs less quantitative data that can make clearly comparative analysis on the complex decision problems. Moreover, it is applicable to decision situations involving subjective judgment and can be used for both qualitative data and quantitative data (de Steiguer, J.E., 2003).

#### c) SWOT Analysis

The second main analysis method was SWOT analysis developed by Albert Humphrey in 1960's. This analysis was used to determine mitigation strategies based on condition in this study area.

## **4. RESULT AND DISCUSSION**

### **4.1 Social Economy Condition (Element at Risk)**

The main objective of this research was to determine level of flood vulnerability based on social economy condition of the people who live in flood hazard area. The respondents in this research are households who live in the flood hazard area. The elements at risk of social economy condition analyzed in this research were corresponding with flood hazard. There are eight social indicators analyzed as element at risk in this study.

#### a) Income

Income is important because it deals with the capacity and current conditions, before and after the flooding associated with the preparation, recovery, and mitigation. It was found that most people in study area have low income (< Rp. 500.000 /month).

#### b) Occupation

Occupation relates to the ability to recover from conditions caused by flooding. It was found that

most of respondents have occupation in agriculture sector as farmer or agricultural labor. The economic sector in this village is very dependent on agriculture sector. When floods occur and inundate agriculture land, it severely impacts the village economy.

#### c) Period of Stay

Period of stay also relates to the ability to recover from conditions caused by flooding. People in study area have experienced flood almost every year, but they can recover from it. It was found that 91% of respondents have lived in this area for more than 20 years (the respondents were household heads).

#### d) Number of Family Members

It relates to behavior of people when confronted with a flood. A family with a few members can save itself more easily than a large family. It was found that most of the households have small families (1-3 persons).

#### e) Gender ratio in Family

This element also relates to behavior of people when confronted with a flood. In case of a disaster, a man has more power than woman. He has stronger body which is useful in evacuation, and leads his family to a safer place. It was found that most of the households have 33%-66% of woman in their family.

#### f) Education Level of Household Head

This element relates to the ability of household head find way to save his family when a flood occurs, and generate their own mitigation / coping strategies. It was found that more than 50% of respondents have only elementary education level or are even uneducated. So, people in the study area have low level of education. It affects their way of thinking on disaster management.

#### g) Proportion of Age in Family

It relates to behavior of people when confronted with a flood. In case of disaster, older people and children are more vulnerable than young and adult people. It was found that in the study area, there are more elderly people than younger ones. It happens because the young generation moves and lives in other cities for work or education.

#### h) House Status

This element relates to capability to bear the risk and recover after flood. People who rent house bear more risk than people who have their own house. In

this study area, it was found that most of respondents (> 90%) have their own house.

**4.2 Social Vulnerability Analysis**

AHP method was used to determine the weight of each criterion before calculation of social vulnerability. It is usually offered with the pair-wise comparison technique that simplifies preference ratings among decision criteria.

Based on the decision makers, this method comes to decompose the decision problem into elements, according to their common characteristics, and levels, which correspond to the common characteristic of the elements (Berrittella, 2007). The social vulnerability equation can be formulated as follows;

$$\text{Social Vulnerability } SV = \sum_{i=1}^{i=n} W_i S_i \quad (1)$$

where *W* is the weight value of criterion obtained from the pairwise comparison method on AHP analysis, *S* is the score of vulnerability of each criterion, *i* = 1,2,...*n* = number of criterion.

In this stage, all of the weights are defined by the pairwise comparison approach. The structure of the decision problem is generated for computing the priorities of the elements as matrix **A** shown in

		<b>Criterion</b>				
<b>Alt.</b>		C <sub>1</sub>	C <sub>2</sub>	C <sub>3</sub>	...	C <sub>N</sub>
A <sub>1</sub>		a <sub>11</sub>	a <sub>12</sub>	a <sub>13</sub>	...	a <sub>1N</sub>
A <sub>2</sub>		a <sub>21</sub>	a <sub>22</sub>	a <sub>23</sub>	...	a <sub>2N</sub>
A <sub>3</sub>		a <sub>31</sub>	a <sub>32</sub>	a <sub>33</sub>	...	a <sub>3N</sub>
⋮		⋮	⋮	⋮	⋮	⋮
A <sub>N</sub>		a <sub>N1</sub>	a <sub>N2</sub>	a <sub>N3</sub>	...	a <sub>NN</sub>

Figure 3. Pairwise Comparison Matrix

figure 3.

In which, *a<sub>ij</sub>* represents the pairwise comparison rating between the element *i* and element *j* of a level with respect to the upper level. The entries *a<sub>ij</sub>* are governed by the following rules: *a<sub>ij</sub>* > 0; *a<sub>ij</sub>* = 1/*a<sub>ji</sub>*; *a<sub>ii</sub>* = 1. The table below reports the relative importance scale that used in the pairwise comparison of AHP (Saaty, 1977).

Following Saaty (1980, 2000), the priorities of the elements can be estimated by finding the

Table 1. The AHP Pairwise Comparison Scale

Importance Intensity	Verbal Scale	Explanation
1	Equal importance	Two elements contribute equally
3	Moderate importance of one element over another	Experience and judgement favour one element over another
5	Strong importance of one element over another	An element is strongly favoured
7	Very strong importance of one element over another	An element is very strongly dominant
9	Extremely importance of one element over another	An element is favoured by at least an order of magnitude
2,4,6,8	Intermediate values	Used to compromise between two judgements
Reciprocals of above nonzero	If activity <i>i</i> has one of the above nonzero numbers assigned to it when compared with activity <i>j</i> , then <i>j</i> has the reciprocal value when compared with <i>i</i>	

principal eigenvector *w* of the matrix **A**.

$$AW = \lambda_{\max} W$$

When the vector **W** is normalized, it becomes the vector of priorities of elements of one level with respect to the upper level.  $\lambda_{\max}$  is the largest Eigen value of the matrix **A**.

The AHP allows inconsistency, but provides a measure of the inconsistency in each set of judgments. The consistency of the judgmental matrix can be determined by consistency ratio (*CR*):

$$CR = CI/RI$$

where *CI* (consistency index) for a matrix of order *n* is

$$CI = (\lambda_{\max} - n) / (n - 1)$$

and random index (*RI*) as average consistencies of

Table 2. The Average Consistencies of Random Matrices

n	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49

randomly generated matrices as follows;

The pairwise comparison method of AHP can be done practically through scheme as seen in figure 4.

Questionnaire used in this research not only for obtaining social economy information, but also information about importance of element at risk based on people's perception and experience. The statement from people was converted to number using pairwise comparison scale as seen in Table 3.

Using this scale, the statement was converted to

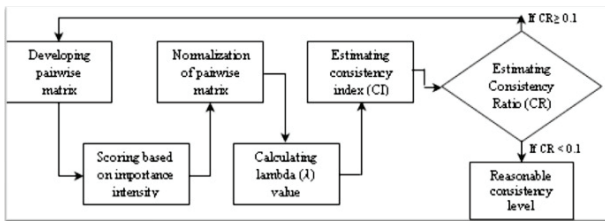


Figure 4. Pairwise Comparison Scheme of AHP

Table 3. Pairwise Comparison Rating Scale

Pairwise Comparison 9 Points Continuous Rating Scale								
1/9	1/7	1/5	1/3	1	3	5	7	9
extremely less important	very strongly less important	strongly less important	moderately less important	equally	moderately more important	strongly more important	very strongly more important	extremely more important

numeric values, for matrix analysis purposes. According to this scale, there are numeric values related to the statement, which are:

- 7: very strongly more important
- 5: strongly more important
- 3: moderately more important
- 1: equally important
- 1/3: moderately less important
- 1/5: strongly less important
- 1/7: very strongly less important

Finally, the following matrix was obtained.

$$\begin{pmatrix} 1/1 & 3/1 & 3/1 & 5/1 & 5/1 & 7/1 & 7/1 & 7/1 \\ 1/3 & 1/1 & 1/1 & 3/1 & 3/1 & 5/1 & 5/1 & 5/1 \\ 1/3 & 1/1 & 1/1 & 3/1 & 3/1 & 5/1 & 5/1 & 5/1 \\ 1/5 & 1/3 & 1/3 & 1/1 & 1/1 & 3/1 & 3/1 & 3/1 \\ 1/5 & 1/3 & 1/3 & 1/1 & 1/1 & 3/1 & 3/1 & 3/1 \\ 1/7 & 1/5 & 1/5 & 1/3 & 1/3 & 1/1 & 1/1 & 1/1 \\ 1/7 & 1/5 & 1/5 & 1/3 & 1/3 & 1/1 & 1/1 & 1/1 \\ 1/7 & 1/5 & 1/5 & 1/3 & 1/3 & 1/1 & 1/1 & 1/1 \end{pmatrix}$$

The next step in this method follows the scheme in Figure 4. Matrix above was normalized to obtain eigenvectors. The eigenvectors represent weight of the criterion. Computed eigenvector is derived from the sum of normalized row with the total rows. The normalized matrix was squaring, and these processes are known as an iteration operation. This iteration is repeated to make sure the consistency of difference eigenvector with the previous calculations.

Consistency test also made using consistency index (CI) and consistency ratio (CR) formula. The results of those calculations are shown in table 4.

From the table 4, the consistency ratio (CR) is

Table 4. Eigen Value λ, CI, and CR

λ	CI	CR
8.371725	0.053104	0.037662

0.037662 (< 0.1). It means that the ratio indicates reasonable consistency, and we can use eigenvectors as the weights of social indicator for social vulnerability calculation.

The second part of the vulnerability formula is score of vulnerability. Data from interviews of the respondents have processed to obtain quantitative data from the eight social factors. Vulnerability assumptions of social indicators were made that associated with scores as shown in table 5.

The final value of the social vulnerability of each household is obtained by multiplying each weight value by the score of vulnerability level which is owned by each household.

Social vulnerability class is divided into three categories: Low Vulnerability, Moderate Vulnerability, and High Vulnerability. Class intervals obtained by the difference between the highest score of the class and the lowest score of the class, and then divided by the number of intervals. The social vulnerability class from the people in Kedung Agung Village can be seen in table 6.

### 4.3 Local Knowledge and Coping Strategies

Local knowledge and coping strategies are important point in disaster risk management. According to Warburton and Martin (1999), local knowledge is a collection of facts and relates to the entire system of concepts, beliefs and perceptions that people hold about the world around them. In this study, some local knowledge founded and analyzed were knowledge of living in flood hazard area, reason of living in flood prone area, level of flood, and time needed for normal activities after flood event. Another element which can reduce the risk factor is coping strategy.

According to Blaikie, P., et.al, (1994), coping strategy is a manner in which people acted within the existing resources and ranges of expectations of a situation to achieve various ends. Thus, the community's coping strategy is a way of solving the problems within the availability of its resources.

Table 5. Score of Vulnerability of Social Indicators

No.	Social Indicators	Assumption
1.	Income	<ul style="list-style-type: none"> <li>Score 3, if income &lt; Rp. 500.000,- (Low income),</li> <li>Score 2, if income Rp 500.000,- Rp. 1.000.000,- (Medium income),</li> <li>Score 1, if income &gt; Rp. 1.000.000,- (High income).</li> </ul>
2.	Occupation	<ul style="list-style-type: none"> <li>Score 3, if household head's occupation in agricultural sector.</li> <li>Score 1, if household head's occupation in non agricultural sector (trader, officer etc).</li> </ul>
3.	Period of Stay	<ul style="list-style-type: none"> <li>Score 3, if period of stay in study area &lt; 10 years,</li> <li>Score 2, if period of stay in study area between 10 – 20 years,</li> <li>Score 1, if period of stay in study area &gt; 20 years,</li> </ul>
4.	Size of Family	<ul style="list-style-type: none"> <li>Score 3, if stay alone,</li> <li>Score 2, if family members are &gt; 4,</li> <li>Score 1, if family members are between 2</li> </ul>
5.	Proportion of Gender in Family	<ul style="list-style-type: none"> <li>Score 3, if women's percentage in family &gt; 66%,</li> <li>Score 2, , if women's percentage in family 33% - 66%,</li> <li>Score 1, if women's percentage in family &lt; 33%.</li> </ul>
6.	Proportion of Age in Family	<ul style="list-style-type: none"> <li>Score 3, if family has &lt; 5 year old children,</li> <li>Score 2, if family has elderly people (&gt; 60 year),</li> <li>Score 1, if family members are in between 5 years old – 60 years old.</li> </ul>
7.	Education Level of Household Head	<ul style="list-style-type: none"> <li>Score 3, if household head is uneducated,</li> <li>Score 2, if household head's education level in elementary and junior high school,</li> <li>Score 1, if household head's education level in senior high school or above.</li> </ul>
8.	House status	<ul style="list-style-type: none"> <li>Score 3, if it is rent house,</li> <li>Score 1, if it is own house.</li> </ul>

People in the study area have implemented some coping strategies. It can be divided into two categories, short term and long term. They were

Table 6. Social Vulnerability Class

Social Vulnerability Class	Value
Low Vulnerability	0.38216 – 0.54750
Moderate Vulnerability	0.54751 – 0.71284
High Vulnerability	0.71285 and above

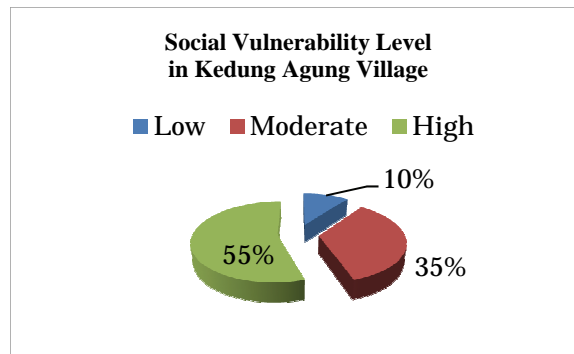


Figure 5. Social Vulnerability Level

implemented before, during, and after flooding.

Short term

- Before flood  
Storing food, storing clean water, elevating fire wood, saving belongings, working together to clean canal.
- During flood  
Staying at home, evacuating valuable documents, evacuating to a safer place, help each other and sharing food and information.
- After flood  
Borrow money for recovery, working together to clean up the house and residential area, repairing minor damage, drying wet household appliances.

Long term

- Before flood  
Building using concrete material, raising house foundation, saving money, elevating electronic appliances, food reserving, saving valuable documents.
- After flood  
Raising the foundation of the house, choosing appliances that are resistant to water.

**4.4 Mitigation Strategies**

Vulnerability can be reduced by putting in place various measures that develop resiliency to a natural hazard impact. For example, if a person is considered vulnerable because they do not

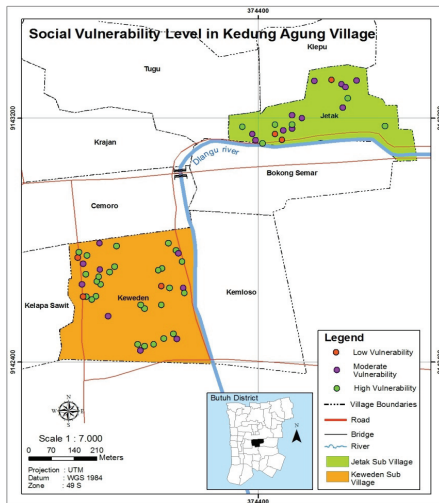


Figure 6. Distribution of Social Vulnerability in Kedung Agung Village

understand what to do in the event of a cyclone, a simple education program will reduce their vulnerability. Essentially, these activities for reducing vulnerability, therefore risk, are called mitigation strategies, which is one step in the risk management process.

In this research, SWOT analysis was used for analyzing mitigation actions/strategies based on conditions in study area. SWOT analysis can be applied by analyzing and sorting out various things that affect the four factors (Strengths, Weaknesses, Opportunities and Threats), and then apply to the SWOT matrix. Strengths and Weaknesses are internal factors, while Opportunities and Threats are external factors of people in the community. Strengths and Opportunities have positive impacts, while Weaknesses and Threats have negative impacts for people.

Based on analysis, there are some factors as Strengths of people in the study area:

- Good social networking
- Family with few members
- Own house status
- Realizing they live in risky area
- Have traditional early warning
- Good physical coping mechanism
- Good social coping mechanism

Some factors as Weaknesses of people in the study area:

- Low income people

- Low education level
- Occupation in agriculture sector
- Old generation
- More women in family
- Long recovery time after flood
- Lack of economic coping mechanism
- Low knowledge on Disaster Risk Reduction
- Mostly have high social vulnerability
- Located in flood prone area (geomorphologic aspect)
- Bad condition of rivers
- Inappropriate irrigation system
- Land use changing in upstream area

Some factors as Opportunities for people in the study area:

- Government shows good political will on Disaster Risk Reduction
- Government have made some strategies on Disaster Risk Reduction
- Special agency of disaster management is established
- People awareness on Disaster Risk Reduction is increasing

Some factors as Threats for people in the study area:

- Located in flood prone area (geomorphologic aspect)
- Bad condition of rivers
- High rainfall
- Inappropriate irrigation system
- Land use changing in upstream area
- Limited fund on Disaster Risk Reduction
- Lack of program on Disaster Risk Reduction
- Low multi-stakeholders involvement on Disaster Risk Reduction

There are series of strategies which integrate the SWOT factors. The application is how the strengths are able to take advantage of opportunities, how to overcome weaknesses, then how the strengths are able to face threats, and how to overcome the weaknesses for making threats to be real or create a new threat.

#### S - O Strategies

- Introduce integrated Early Warning System
- Regular training/simulation of disaster
- Involving non-government organization on disaster risk reduction
- Strengthen individual, community, and

institutional capacity building

- Networking and information sharing on disaster management
- People's representation on special agency

W - O Strategies

- Create more nonagricultural employment
- Increasing education and training on disaster risk reduction (formal & non formal)
- Women empowerment program
- Increasing water and irrigation system
- Integrated disaster management on land use planning
- Flood hazard mapping
- Allocation budget on infrastructure development

S - T Strategies

- Encourage social organization on disaster risk reduction
- Social approach on land use changing
- Find alternative funding for disaster risk management

W - T Strategies

- Social conflict management
- Preparing emergency preparedness plan
- Preparing recovery plan
- Coordination between stakeholders on preparedness, response during flood, and after flood recovery

**5. CONCLUSIONS**

- 1) Social economy condition in this study area is influenced by agricultural sector. There are eight social indicators analyzed as element at risk of flood disaster. Most of them show that social economy condition of people in study area is in the low level.
- 2) Based on social vulnerability analysis, flood social vulnerability level from people in this study area: 55 % in high vulnerability, 35 % in moderate vulnerability, and 10 % in low

vulnerability. It means if flood occurs more frequently or are more severe, more people will be affected severely.

- 3) Local people have their own responses to flood disaster. They also have social institution and networking that can be valuable for disaster risk reduction. Flood coping strategy has been applied by community in this village to reduce damage and loss. People make strategies by preparing physical and social way to alleviate the impact based on local knowledge.
- 4) There are some mitigation strategies (analyzed using SWOT analysis) based on condition in this study area can be proposed for reducing impact of flood hazard. The mitigation strategies are expected to be input for government's program in the future. They are not solution, but provide guidance for making better policies / programs on disaster risk management.

**References**

Badan Nasional Penanggulangan Bencana (BNPB). 2012. Statistik Bencana Tahun 2012. (<http://www.bnpb.go.id>)

Blaikie, P., Cannon, T., Davis, I., and Wisner, B. (1994). *At Risk Natural Hazard: People's Vulnerability and Disaster*. Published by Routledge. London.

Triantaphyllou, E., Mann, Stuart H. 1995. Using The Analytic Hierarchy Process For Decision Making in Engineering Applications: Some Challenges. *Inter'l Journal of Industrial Engineering: Applications and Practice*, Vol. 2, No. 1, pp. 35-44.

Warburton, Hilary, and Martin, Addrianne, (1999). *Local People's Knowledge in Natural Resources Research*. Natural Resources Institute. University of Greenwich.

(Received January 11, 2013)