

## Risk Perception and Preparedness in Flash Flood-Affected Communities: Evidence from Bahorok, Indonesia

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### ABSTRACT

The Bahorok River basin has a high flash-flood hazard index. This is shown by loss of lives and damage of homes due to floods in recent years, however, no research examined community preparedness on the hazard of flash-flood. This research aimed to assess the effect of disaster experience and flood-risk perception on disaster preparedness of the people of Bukit Lawang Plantation Village. A cross-sectional survey design was used to determine the relationship between disaster experience, risk perception and preparedness as the independent and dependent variables, respectively. The results showed that disaster experience and risk perception positively and significantly affect the community preparedness. Disaster risk reduction programs in the region only focus on emergency response, rehabilitation, and reconstruction. Furthermore, increasing public awareness and preparedness has not been prioritized in reducing flood risk. This is an essential aspect for consideration because mountainous areas are often marginalized and lack access to disaster risk reduction programs.

**Keywords :** Flood-risk perception; preparedness; flash flood

### 1. Introduction

Bukit Lawang Plantation Village is located in Bahorok Sub-district, Langkat Regency in North Sumatra Province, Indonesia. It is part of the natural conservation area of Gunung Leuser National Park (GLNP), often referred to as the Tropical Rainforest Heritage of Sumatra. GLNP is the oldest National Park in the country, covering 1,094,692 hectares in Aceh and North Sumatra. At least 3,500 plant species live in various habitats in GLNP, an area designated by UNESCO as a Biosphere reserve and a world heritage site.

The village is 100-700 meters above sea level and has a hilly to steep topography. Although the area has a beautiful natural panorama that makes it a tourist attraction, it has a very high flash flood hazard. It is located in the Bahorok Watershed, where 68% has a 30% - 70% slope. The flash flood risk is also caused by destroying ecosystems in GLNP forest. In the last ten years, the area has experienced deforestation of 30,000 hectares caused by illegal logging and land conversion. The construction of home stays, restaurants, and hotels along Bahorok River increases the risk of flash-

flood disasters. Most Bukit Lawang Plantation Village residents construct houses and buildings on Bahorok River banks, hence, the river is their main source of livelihood.

Mountain areas have a high flash flood hazard (Bodoque et al., 2019a; Martins & Nunes, 2020) caused by topographic relief, slope steepness, soil type, and land use. Mountainous river basins with a drainage area often respond quickly to heavy rains, resulting in flash floods. Body floods have a short lag time of only a few hours between rain and flooding (Bodoque et al., 2019a; Martins & Nunes, 2020), resulting in many casualties caused by the flash-flood disaster.

The Bahorok area has experienced repeated flash floods in history. In November 2003, a flash flood caused 300 deaths (BNPB, 2019), and the incident was repeated in 2006, causing six deaths and 17,000 evacuations of people. Flash floods occurred again in 2013, causing 3,530 houses to be severely damaged. In 2014, the flood caused damages to 1,976 people's houses and led to one death and 5,293 house damages in five sub-districts in 2015 (Saragih, 2016). The probability and frequency of flood disasters in the Bahorok Watershed (DAS) are expected to increase in the future. This is due to the high rainfall intensity, the destruction of GLNP ecosystem, and the increasing number of hotels, homestays, and restaurants being built along the Bahorok River basin.

It is important to assess the people's preparedness in the Bahorok River basin against the danger of flash-flood. Several research found that disaster preparedness is strongly influenced by past disaster experience, knowledge, and risk perception (Aksa et al., 2020a; Becker et al., 2017). The past flood experience increases resilience in the future (Kuang & Liao, 2020). According to previous research, disaster experience is directly related to disaster awareness and preparedness (Becker et al., 2017; Hoffmann & Muttarak, 2017; Tekeli-Yeşil et al., 2011). People who have experienced flashfloods are more motivated to be involved in disaster risk reduction (Astuti et al., 2021). Disaster experience could be direct or indirect (Shaw et al., 2004; Wachinger et al., 2013). Indirect experience is obtained through disaster education, learning from experience, and acquiring explicit knowledge from teachers, media, and books (Aksa, 2020).

Direct experience is included in tacit knowledge obtained from lessons from previous disaster experiences (Aksa, 2020). In this case, direct flooding experience enriches knowledge about specific floods, such as water levels that elevate buildings (Kuang & Liao, 2020). Additionally, direct experience helps detect problems with flood management actions (Kuang & Liao, 2020). Learning from flood experiences increases individual and social capacities (Adelekan & Asiyani, 2016). Psychologically, individual learning is a mental process that connects changes in one's knowledge to behaviors (Knowles, 2012). However, some research revealed that flood disaster experience does not change community behavior because people do not want to change their routines (Lawrence et al., 2014). Several research in Australia also found that people with flood experiences are less likely to purchase flood insurance or take additional measures to prevent flooding (Box et al., 2016).

The disaster experience in this research refers to the flash-flood disaster that destroyed most tourist areas in the Bukit Lawang Plantation Village in 2003. The worst event in the Bahorok Sub-district was hitting tourists on vacation and homestay owners. Risk perception also affects the community's preparedness for natural hazards (Aksa et al., 2020b, 2020a) because individuals must know the risks to take preparedness actions (Muttarak & Pothisiri, 2013). It is helpful in understanding and analyzing human behavior when faced with a disaster (Muzenda-Mudavanhu et al., 2016; Naseri & Kang, 2017). People respond to disasters according to their hazard view because perceptions and awareness influence behavior (Ohtomo et al., 2017).

This research aimed to examine the direct experience of witnessing the flash flood disaster that has damaged public facilities, houses, and tourist attractions in the Bukit Lawang tourist area and the community risk perception concerning the preparedness behavior. This is important because disaster preparedness mitigates the potential losses caused by floods (Ao et al., 2020). The Plantation Village of Evidence Lawang has a high flash flood hazard, but no research examined community

preparedness in facing the danger of flash-flood. Research on flood disasters mostly focused on control measures and techniques (Ao et al., 2020). However, structural flood control measures cannot eliminate the risk of catastrophic flooding and sometimes only transfer the risk. This implies nonstructural measures that reduce flood losses are important in disaster management (Ao et al., 2020).

This research was conducted in the Bukit Lawang Plantation Village in the utilization area of GLNP, Bahorok District, Langkat Regency, North Sumatra Province. The village is located in the Bahorok River Basin, 100-700 meters above sea level, and has a steep hilly topography. It has a high flash-flood risk index because it is located in a valley (Figure 1) exacerbated by the 300 homestays and hotels built along Bahorok River. Additionally, the area has a landslide hazard index because 68% of the Bahorok River basin has a slope of 30% - 70%. The village is one of the areas destroyed during a flood in 2003.

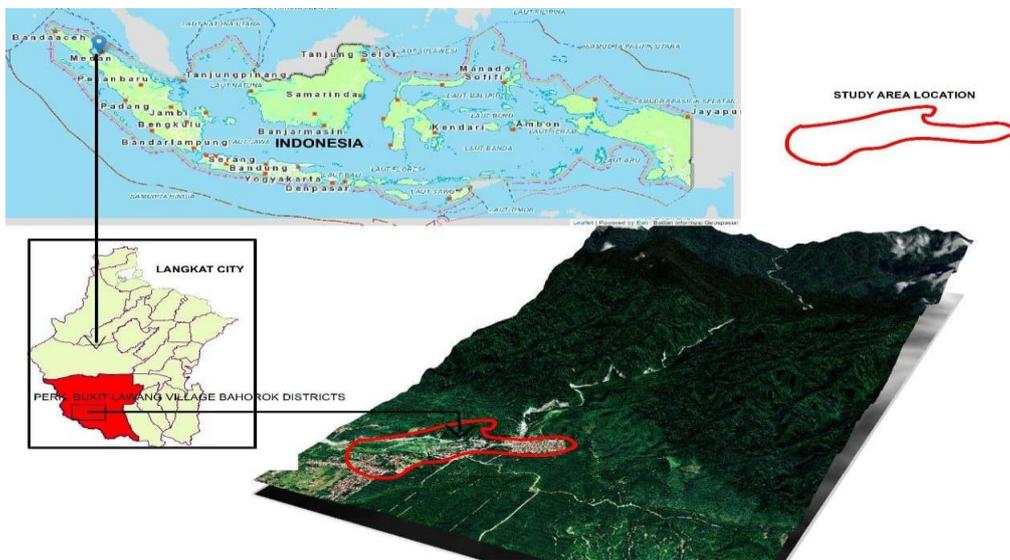


Figure 1. Map of research locations

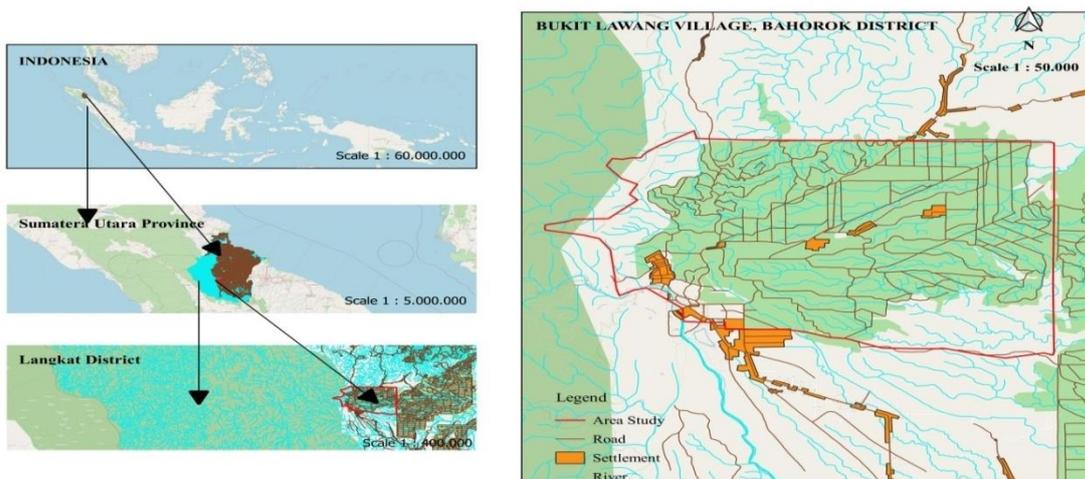


Figure 2. Research location

## 2. Methods

This research used a cross-sectional survey design (Figure 3) to determine the relationship between disaster experience and risk perception and disaster preparedness in the Bukit Lawang Plantation Village community. The independent variable were disaster experience and risk perception, while the dependent was disaster preparedness.

A total of 208 respondents representing households were selected with a purposive random sampling technique using inclusion criteria. The criteria were the people of the Bukit Lawang Plantation Village, aged between 18 and 59, able to read and write, having experience of flood disasters, and are willing to be respondents. Data were collected through the household interview technique. The following hypotheses were tested:

H1: Past disaster experiences significantly and positively affect flood preparedness behavior.

H2: Flood risk perceptions positively and significantly affect disaster preparedness.

Bukit Lawang Plantation Village was selected because it was severely affected by the 2003 flash flood disaster that damaged most residents' houses and tourist attractions and caused 300 deaths.

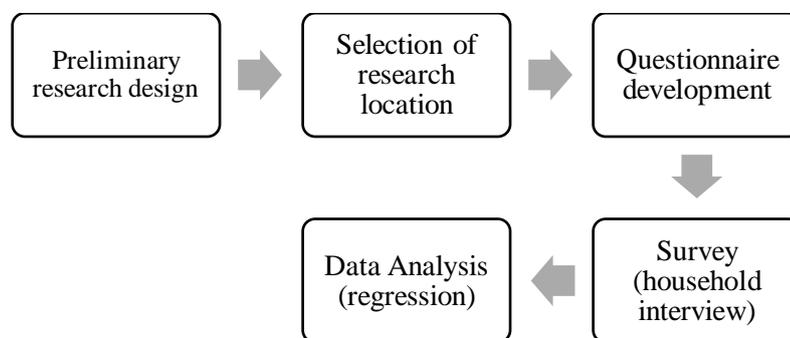


Figure 3. Research flow chart

### 2.1 Measuring and Instrument

The questionnaire to measure disaster experience, risk perception, and flood disaster preparedness comprised 15 question items, namely 6 about disaster experience, 5 related to risk perception, and 4 about flash-flood disaster preparedness.

The flood disaster experience was measured by six items with two answer choices of yes or no which scored as one point (1) and zero (0), respectively. The questionnaire to measure flood disaster experiences was developed from Ejeta et al. (2018).

This research measured direct flood experience by asking the community whether they experienced damage to their houses, lost property, were victimized, or experienced evacuation. The direct experience was considered to have influenced risk perception and flood disaster preparedness behavior (Ao et al., 2020; Kuang & Liao, 2020; Lawrence et al., 2014).

Disaster risk perception was measured by perceived hazard probability and consequences. Probability and consequences are important attributes of people's perceptions of environmental threats (Lindell & Perry, 2012). The community was asked about the possibility of a flood disaster in the Bukit Lawang Plantation Village in the future and the potential impact. The instrument for measuring flood risk perceptions was developed from Bodoque et al. (2019b), Gobo et al. (2013), Martins & Nunes (2020), and Roder et al. (2019). Risk perception helps understand and analyze human behavior when faced with a disaster (Muzenda-Mudavanhu et al., 2016). According to their view of the hazard, people respond to floods because of perceptions and awareness influence behavior (Aksa et al., 2020b). The perception of flash-flood disaster risk was made as a Likert scale on a 5 point scale, where 1 = strongly disagree and 5 = strongly agree.

The questionnaire to measure flood disaster preparedness was developed from [Terpstra \(2011\)](#). The instrument was developed by [American-Red-Cross \(2015\)](#) and consists of five variables, including storing food and water, having an emergency kit, developing an emergency plan, attending at least one disaster preparedness workshop, and participating in at least one disaster preparedness simulation ([American-Red-Cross, 2015](#)). Flood disaster preparedness was measured by four-question items, with two answer choices of yes or no which scored as one point (1) and zero (0), respectively. Additionally, the community was asked to provide a correct response in preparing themselves for the flash flood disaster.

The questionnaire was tested on 30 people in the Bukit Lawang Plantation Village, not included as respondents. This is in line with [Flowerdew & Martin \(2005\)](#), which stated that a questionnaire must first be tested by involving at least 20 respondents to ensure it is consistent with the research. The pilot respondents' feedback was modified to ensure that the questionnaire wording could be understood easily. Each question item's readability was used to assess the questionnaire.

## 2.2 Data Analysis

The research instruments were analyzed with validity and reliability tests using the Alpha Cronbach, followed by regression analysis to assess the effect of disaster experience and risk perception on disaster preparedness. Data were processed using software SPSS 24, while testing was conducted using one degree of freedom and a significance of 0.05.

## 3. Results and Discussion

### 3.1 Respondents' Characteristics

A total of 208 respondents representing households in Lawang Plantation in North Sumatra were interviewed. [Table 1](#) shows the demographic characteristics of respondents.

Table 1. Respondents characteristics

Variable	N	%
<b>Age Group (years)</b>		
Less than 25	40	19.7 %
25-35	82	39.7 %
35-45	31	14.8 %
45-55	44	21.3%
More than 55	11	4.9%
<b>Gender</b>		
Male	106	50.8%
Female	102	49.2%

Most respondents were aged between 25 and 35, and 50.8% were males. The reliability test showed that all variables had high reliability values and a Cronbach's Alpha > 0.6. This shows that all variables are feasible to use, as shown in [Table 2](#).

Table 2. Variable reliability test

Variable	Item	Alpha Coefficient	Information
X1 (Flood experience)	6	1.000	Reliable
X2(Flood Risk Perception)	5	0.843	Reliable
Y(Flood Preparedness)	4	0.721	Reliable

### 3.2 Flood Experience

Interviews on flood experiences found that 46.4% of respondents had direct disaster experiences during the 2003 flash flood. Also, 51.4% had witnessed damage to houses and buildings, 49.5% stated that their families died due to the flash-flood disaster in 2003, and 47.1% said that their family members were injured (Table 3).

Table 3. Respondents' flood experience

Flood Experience	Frequency	Percentage
1. Have you ever experienced damage to your house due to flooding in your area?	89	42.7%
2. Have you ever experienced property loss due to flooding in this area?	89	42.7%
3. Have you ever witnessed the damage caused to the house of your neighborhood due to a flood disaster in your area? (Have you ever witnessed damage to houses in your neighborhood)	107	51.4 %
4. due to flood disaster in your area? Has anyone of your household members experienced injury due to a flood disaster in your area? (Has any member of your household suffered injuries as a result of floods in your area?)	98	47.1%
5. Has anyone of your family members previously Died of a flood disaster in this area? (Is there a member of your family who previously died from the floods in this area?)	103	49.5%
6. Have you personally evacuated due to the flood disaster in your area?)	95	45.5%

### 3.3 Flood Risk Perception

People in Bukit Lawang Plantation Village have a high flood risk perception of 87.90% towards flood disasters. Most respondents believe in the probability and consequences of a flash-flood disaster, while 91.44% believe that a flash flood would disrupt their daily life. Furthermore, 88.46% of the community believed that the flash flood in Bukit Lawang Plantation caused the deaths of hundreds of people, as shown in Table 4.

Table 4. Flood risk perception

Flood Risk Perception	Frequency	Percentage
Flash floods could recur in the Bukit Lawang Plantation Village in the future	182	87.50%
When a flash flood occurs in our village, hundreds of people will die	183	88.46%
when a flood disaster occurs in Bahorok Village, their homes, schools, and infrastructure would be seriously damaged	180	86.83%
When a flood disaster occurs in Bahorok Village, daily life is disrupted for a long time	190	91.44%
When a flood disaster occurs in Bahorok Village, my family and I would be threatened with being victims	177	85.28%

### 3.4 Flood Preparedness

Community preparedness for flood disaster in Bukit Lawang Plantation Village is low at 35.58%. About 3.85% of respondents stated that the village had not held a workshop on awareness and preparedness for flood disasters in Bahorok. Only 45.29% stated that their village often regularly conducted flood evacuation drills. The rest stated that the village had not carried out flood evacuation drills.

Table 5. Flood preparedness

Flood Preparedness	Frequency	Percentage
Assemble an emergency kit (including a first aid kit, a battery-powered radio, food, water)	198	95.19 %
We have agreed with neighbors, friends, and family to help each other in evacuation in the event of a flood disaster	68	32.69 %
Our village often organizes workshops on flash-flood awareness and preparedness in Bahorok Village	8	3.85%
Our village often conducts flood evacuation drills regularly at least once a year	94	45.19 %

### 3.5 Multiple Regression Analysis Results

Multiple regression tests showed that the flood positively and significantly affected disaster preparedness. This is seen from the statistical t-test value of  $P = .000 < .050$ , supporting hypothesis 1. A positive coefficient indicates that an increase in disaster experience significantly increases the disaster preparedness variable. Testing hypothesis 2 showed that flood risk perception positively and significantly affected disaster preparedness with  $P = .006 < .050$ , as shown in Table 6.

Table 6. Multiple regression test results

Variable	B	t	p-value	Description
Constant	-0485			
X1 (Flood Experience)	0213	7754	0000	Significant
X2 (Flood Risk Perception)	0075	2787	0006	Significant
$\alpha$		= 0.050		
Determination Coefficient (R <sup>2</sup> )		= 0.266		
F-count		= 37 109		
p- value F		= 0.000		

Simultaneous testing showed that disaster experience and risk perception significantly affect disaster preparedness. The simultaneous influence of the independent variable on the dependent variable has a coefficient of determination (R Square) of 0.266 or 26.6%, while factors outside this research influence 73.46%.

### 3.6 Discussion

This research showed that 46.4% of the Bukit Lawang Plantation Village people had direct disaster experiences during the 2003 flashflood. Table 3 shows that most people experienced damage and lost their families due to the flash-flood disaster. Witnessing the damage to houses and buildings improves disaster preparedness. Table 3 shows that 51.4% of the people witnessed firsthand the damage caused by the flash-flood disaster. Some research found that personal experiences such as suffering damage and loss of property increase risk perception and disaster preparedness in the future (Adelekan & Asiyandi, 2016).

The people also have indirect experience from the bodily flood disaster from stories and experiences conveyed by their parents. The history of the most severe bodily 2003 flood is often told orally by the people in the village. This was evidenced by the community responses during field data collection.

The past disaster experience significantly increased flood preparedness, with  $P = .000 < .050$ . This finding corroborates Ejeta et al. (2018), which showed that past flood disaster experiences positively and significantly impacted preparedness. It stated that people directly affected by disaster

events in the past had high anxiety that could increase community participation in disaster preparedness activities. Furthermore, this finding corroborates (Atreya et al., 2017), which found that flood experience is a key driver of disaster preparedness. Lawrence et al. (2014) also stated that the flooding experience directly influences protective responses and preparedness. Direct experience influences individual risk perception and enhances mitigation behavior (Harvatt et al., 2011).

There was a high disaster risk perception of 87.90% among the people. They believe in the probability and consequences of flooding, presumably because some have suffered damage to their houses and lost their assets and family members to the flash-flood disaster. Furthermore, the high disaster risk perception is thought to be due to the high frequency of flood disasters in the area. The 2020 flood disaster destroyed a homestay restaurant built in the Bukit Lawang tourist area and damaged the connecting bridge between villages.

The flash flood disaster in 2020 influenced the high-risk perception among the people. According to Felgentreff (2003), the risk perception increases dramatically after a disaster but fades over time. The high flood risk perception has a positive and significant impact on disaster preparedness. However, disaster experience and risk perception affected preparedness by only 26.6%. This is seen in Table 6, which shows the value of the coefficient of determination ( $R^2 = 0.266$ ).

Overall preparedness of the Bukit Lawang Plantation Village community for flash-flood disasters is still low at 32.69%. Only questions about assembling an emergency kit, including a first aid kit, a battery-powered radio, food, and water, received a percentage of 95.18%. The community prepared emergency kits presumably because they experienced flash-flood disasters.

The low community preparedness against the danger of flash-flood is caused by the lack of local government role. The contribution of local government authorities to increase community preparedness against the danger of flash-flood is very low. This is evidenced by the respondents' answers stating that the Bukit Lawang Plantation Village has not held a workshop on awareness and preparedness for flood disasters (Table 5). Field observations showed that no significant effort had been made by local authorities to protect people's lives and infrastructure. Additionally, no programs have been initiated by the government or universities for disaster risk reduction in the area.

The disaster risk reduction policies implemented in the region only focus on emergency response, rehabilitation, and reconstruction (Saragih, 2016). Increasing public awareness and preparedness is not prioritized in reducing flood risk. Also, mountainous areas are often marginalized and rarely touched by disaster risk reduction programs.

Mountainous areas remain highly vulnerable and less resilient (Tullos et al., 2016) due to the unique challenges associated with flood management. Tullos et al. (2016) identified four challenges to flood management in the mountains, including limited data, accessibility, and infrastructure, complex hydrology and limitations to knowledge on flood processes, governance structure, and response resources, and sensitivity to climate and landscape changes.

One challenge of reducing flood risk in the mountainous tourist area of Bukit Lawang is the weak governance structure and lack of planning that increases the community's risk. This research recommends increasing community capacity to improve flood disaster preparedness in the future. Additionally, there is a need for good cooperation between the government, NGOs, and universities to reduce flash flood risks in the Bukit Lawang tourist area.

#### 4. Conclusion

This research confirmed hypotheses 1 and 2 that past disaster experiences positively and significantly affect flood preparedness. Flood risk perception also positively and significantly affects disaster preparedness. However, community preparedness is low because the disaster risk reduction

program only focuses on emergency response. The local government has also not supported community capacity building.

### Conflict of Interest

The authors declare that there is no conflict of interest with any financial, personal, other people or organizations related to the material in this article.

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