Flood Risk Assessment of Heritage Building in Semarang City

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Keywords: Flood Risk Assessment, Heritage Building, Disaster Risk Management, Hazard, Vulnerability.

Abstract: Semarang City as one of the cities in Indonesia which is a flood-prone area, has historic buildings that are still functioning. The preservation of heritage building is very important, so it is necessary to carry out a building risk assessment in order to determine the safety limits of the building. This study aims to carry out a risk assessment of flood disasters in heritage buildings in the city of Semarang. The methodology used is a risk assessment carried out with a Risk assessment instrument from the guidelines of the BNPB which is elaborated with several previous studies conducted on 6 case studies of heritage temple building in Semarang City. The variables used in this risk assessment are flood hazard, vulnerability (involving of proximity to the river, building area, building elevation, building materials and conditions), and capacity. The results of the flood risk assessment showed that 2 temples had a low risk of flooding, and the others were at moderate risk. The findings in this study, although the 6 case studies are located close to river, the impact of flood risk can be controlled significantly by the financial sustainable management of cultural heritage buildings as one of the flood preparedness.

1 INTRODUCTION

The assessment of natural disaster risk in an area or specifically on buildings has been widely developed by previous studies. In general, the Crunch model is the basis for risk assessment in studies that have been carried out (Hai & Smyth, 2012; Twigg, 2015). The crunch risk model models disaster risk with components of vulnerability, hazard and capacity. Recently development of natural disaster risk models adds an exposure component and external factors. The development of a risk model is generally used to determine the risk component parameters (hazard, vulnerability, exposure, and capacity) of each component in accordance with the characteristics of the conditions in an area.

Assessment of the risk of flooding in cultural reserve buildings has been carried out in many previous studies in various countries in the world. The most significant variation in assessing flood risk in a cultural heritage is in the component of vulnerability. Vulnerability components are determined through architectural style parameters, legal status of cultural heritage, number of floors, building materials, maintenance and operating conditions, rainfall until determined through a flood simulation (Stephenson & D'Ayala, 2014; Wang, 2014).

Semarang city as the provincial capital in Central Java which is located in the area of the north coast of Java has a chronic flood problem. Several previous studies have shown that community-based disaster mitigation is quite effective for short-term flood disaster mitigation in the city of Semarang (Handayani et al., 2019; Miladan, 2016). Other research proposes mitigation based on public policies to reduce urbanization which causes flooding (Handayani et al., 2020). The age of the city is quite old (474 years in 2021), making Semarang has quite a lot of cultural heritage buildings. Due to the flood problem, various efforts have been made to conserve cultural heritage buildings from the risk of flooding. In 2018, UNESCO and the team conducted an initial strategy study to protect cultural heritage buildings in Semarang from the danger of flooding with several short-term strategies, in the form of disaster responses simulations, early warning systems, etc., as well as

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long-term plans that need to collaborate with the government and many parties (Susanti et al., 2018).

From previous studies, community-based flood disaster mitigation is one of the effective methods in Semarang. This study aims to assess the risk of flooding through the development of a flood risk assessment instrument in a case study of cultural heritage buildings, particularly Buddhist temple heritage buildings in Semarang. It is hoped that from the results of this study, a community-based flood risk assessment instrument can be developed, so that flood disaster resilience in Semarang is strengthened and cultural heritage buildings can be well conserved.

2 METHODS

The method of assessing flood risk in this study was developed from several previous studies. Participants in the development of risk models and data on case studies conducted in this study.

2.1 Flood Risk Assessment

Risk assessment instruments are based on the crunch model that has been used in the disaster assessment instruments issued by the Indonesia's National Disaster Management Agency (BNPB). Risk components consist of Hazard, Vulnerability, and Capacity.

The flood hazard component is determined based on the historical height of flood inundation that has hit the area around the building base on Indonesia's National Disaster Management Agency (BNPB) (BNPB, 2012). The vulnerability component consists of several sub-components, consists of the distance of the building to the river (Hazarika et al., 2018), the area of the affected building, the building structure material, the age of the building, the height of the building from the road, the condition of the building (maintenance), sustainability management (D'Ayala et al., 2020; Rana & Routray, 2018). Meanwhile, the capacity component is assessed based on flood preparedness (BNPB, 2012). The criteria for each component can be seen in the Table 1.

Table 1: Flood risk assessment instruments for cultural heritage buildings.

Risk Component	Risk Parameter	Risk Value	Risk Score	Weight (In Each Component)
Hazard	Height of flood			100%
	<0.76m	1	0.33	
	0.76-1.5m	2	0.67	
	>1.5m	3	1	
Vulnerability	Distance to the river			14.29%
	>3km	1	0.33	
	0.6-3km	2	0.67	
	<0.6km	3	1	
	Building area			14.29%
	<200m^2	1	0.33	
	200-500m^2	2	0.67	
	>200m^2	3	1	
	Building frame material			14.29%
	Concrete	1	0.33	
	Masonry	2	0.67	
	Timber	3	1	
	Age of building			14.29%
	<10years	1	0.33	
	10-30years	2	0.67	
	>30years	3	1	
	Height of base to road			14.29%
	>1m	1	0.33	
	-1m to 1m	2	0.67	
	<-1m	3	1	
	Building condition			14.29%
	Good	1	0.33	
	Poor	2	0.67	
	Very Poor	3	1	
	Sustainability management			14.29%
	Good	1	0.33	
	Poor	2	0.67	
	Very Poor	3	1	
Capacity	Preparedness			100%
	Very Poor	1	0.33	
	Poor	2	0.67	
	Good	3	1	

From the risk score from the results of the field assessment, the risk calculation is carried out using the following Formula 1 (BNPB, 2012).

$$R = \sqrt{H \times V \times (1 - C)} \quad (1)$$

Where R=risk score, H=hazard score, V= vulnerability score, and C=capacity score.

From the risk value, the level category of risk is determined based on the criteria shown in the Table 2.

Table 2: Risk category parameter.

Risk Score	Risk Category
<0.33	Low
0.33-0.67	Moderate
>0,67	High

2.2 Case Study

The risk assessment of cultural heritage buildings was carried out at 6 temples located in Semarang, namely Tay Kak Sie Temple, Tek Hay Bio Temple, Siu Hok Bio Temple, Hwie Wie Kiong Temple, Seh Hoh Kiong Temple, Sam Po Kong Temple. The locations of these 6 buildings are scattered on the riverbank in the city of Semarang, shown in Figure 1 and Figure 2.

1a) Tay Kak Sie Temple.

(1b) Tek Hay Bio Temple.

(1c) Siu Hok Bio Temple.

(1d) Hwie Wie Kiong Temple

(1e) Seh Hoh Kiong Temple.

(1f) Sam Po Kong Temple.

Figure 1: Temple heritage buildings.

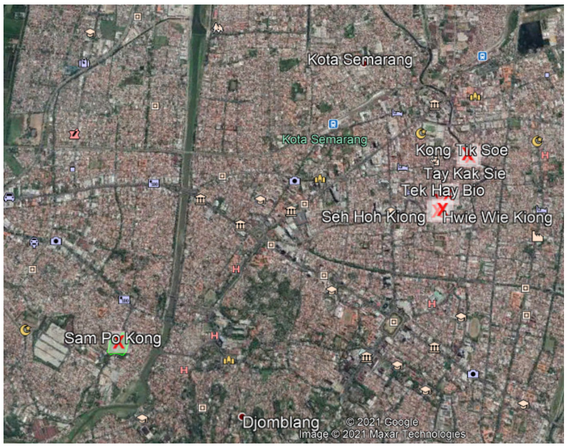

Figure 2: Location of case study in Semarang City.

3 RESULTS AND DISCUSSION

Following are the results of the risk component survey in the field shown in the Table 3. The results of the score assessment and risk category are shown in the Table 4. From the results of the risk assessment carried out, a risk map can be described as shown in Figure 3. The resulting risk map is a contribution to disaster risk management, both in the prevention, mitigation, preparedness, recovery, and lessons learned phases (Rimba et al., 2017).

It can be seen from the flood risk map that these six temples are located in the river area, but the resulting risk assessment has various values. The most influencing factor is the capacity for flood disaster preparedness. From the 6 temples surveyed, Tek Hay Bio Temple and Sam Po Kong Temple have flood preparedness, where the aspect that is reviewed is the aspect of preparedness from the aspects of operation and maintenance.

In fulfilling the operational and maintenance aspects, Sam Po Kong Temple is equipped with a financial model in the form of a tourist attraction as shown in Figure 4. The existence of a financial model placing cultural heritage buildings into cultural heritage gives them more ability to face the risk of flood impacts. It appears that the building has been upgraded and maintained. Meanwhile, at the Tek Hay Bio Temple, preparedness is shown by the presence of a fairly solid Buddhist community in the temple, so that preparedness in the financial aspect comes from the community of the people. In the other 4 temples, the financial aspect for disaster preparedness is still relatively limited, considering the limited financial model unlike the other 2 temples.

Table 3: Case Studies Data.

Risk Component	Hazard	Vulnerability							Capacity
	H	V_1	V_2	V_3	V_4	V_5	V_6	V_7	C
Heritage Temple Building	Height of Flood (m)	Distance to the river (m)	Buildin g Area (m^2)	Building Frame Material	Age of Building (year)	Height of Base from road (m)	Building Condition	Sustainability Management	Preventio n Action
Tay Kak Sie Temple	0.10	46.94	1850	Timber	260	0.5	Good	Good	Good
Tek Hay Bio Temple	1.00	45.78	649	Concrete	264	1	Good	Good	Excellent
Siu Hok Bio Temple	0.20	27.00	252	Masonry	267	0	Good	Poor	Poor
Hwie Wie Kiong Temple	0.00	58.53	1794	Timber	220	0.5	Good	Poor	Good
Seh Hoh Kiong Temple	0.00	78.65	3453	Timber	139	1	Poor	Poor	Good
Sam Po Kong Temple	1.00	398.00	32200	Concrete	296	3	Excellent	Excellent	Excellent

Table 4: Results of flood risk assessment in cultural heritage buildings.

Risk Component	Hazard	Vulnerability								Capacity	Risk	
Heritage Temple Building	H	V_1	V_2	V_3	V_4	V_5	V_6	V_7	Weighted V	C	Risk Value $R = \sqrt[3]{H \times V \times (1-C)}$	Risk Category
Tay Kak Sie Temple	0.33	1	1	1	1	0.33	1	1	0.713	0.67	0.427	Moderate Risk
Tek Hay Bio Temple	1	1	1	1	1	1	1	1	0.713	1	0	Low Risk
Siu Hok Bio Temple	1	1	1	1	1	1	1	1	0.714	0.33	0.541	Moderate Risk
Hwie Wie Kiong Temple	1	1	1	1	1	0.33	1	1	0.857	0.67	0.454	Moderate Risk
Seh Hoh Kiong Temple	0.33	1	1	1	1	1	1	1	0.857	0.67	0.454	Moderate Risk
Sam Po Kong Temple	1	1	1	1	1	1	1	1	0.617	1	0	Low Risk

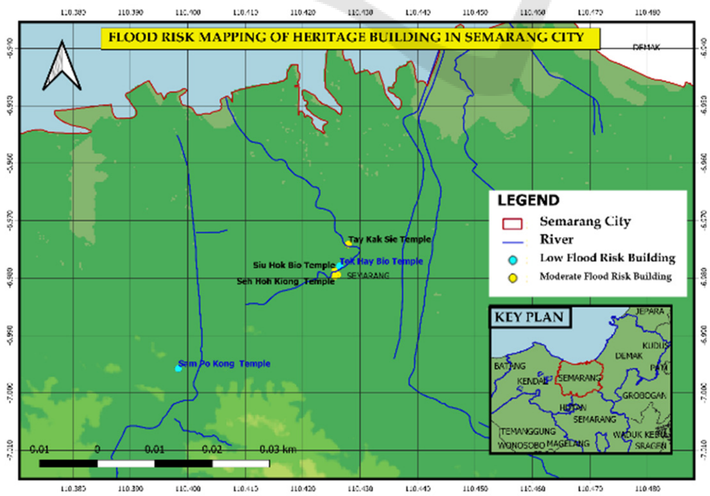

Figure 3: Flood risk map on temple heritage buildings in the Semarang city.

Figure 4: Tourism in Sam Po Kong as Financial Model.

The discovery of sustainability issues related to finance in cultural heritage buildings is relevant to previous studies, where financial models have also been developed related to the sustainability of cultural preservation buildings (Guide, 2021; Jelinčić & Šveb, 2021; Pålsson Skarin, 2011).

In this study, there are several limitations, including the limited access to historical data obtained from interviews with temple administrators which were validated with several secondary sources. Primary data sources as historical evidence of inundation height, the exact age of the building cannot be found with certainty.

However, from the instruments and results of field surveys conducted, the instruments developed by elaborating on several previously developed instruments can provide findings related to the importance of financial sustainability in flood disaster mitigation efforts in cultural heritage buildings.

4 CONCLUSIONS

The findings in this study indicate that the risk of flooding can be reduced by increasing the capacity in the aspect of financial sustainability.

The assessment instrument developed by elaborating several instruments in this study can provide a finding in a case study of cultural heritage buildings in the city of Semarang.

With the risk mapping carried out in this study, it can help stakeholders involved in the conservation of cultural heritage buildings in formulating strategies and determining policies related to flood disaster resilience in cultural heritage.

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APPENDIX

Risk Assessment Survey Form

No.	**Heritage Building Risk Assessment**		
1	**Building**		
2	**Location**		
	City:		
	Coordinate:		Latitude
			Longitude
3	**Building Function:**		
4	**Area of Building (m^2):**		
5	**Height of Building:**		
6	**Building Structure Material:**		
7	**Building Visitor:**		
	Slack conditions:		
	Moderate conditions		
	Crowded conditions:		
8	**Years Building was founded:**		
9	**History of renovation**	**Year**	**Renovation Detail**
10	**Disaster History** (Fire, earthquake, flood, volcano, tornado):	**Year**	**Disaster detail and impact**
11	**Notes**		
12	**Plan Sketch**		