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## The Sustainability Analysis of the Urban Disaster Risk Index in East Kalimantan Province, Indonesia (Case Study: City of Balikpapan)

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### ABSTRACT

Indonesia is a disaster-prone country in terms of geographical, climatological, and demographic aspects. Indonesia's geographical location between two continents and two oceans causes Indonesia to have a quite good potential in the economy as well as being prone to disasters. One of the keys to the effectiveness of disaster management is that disaster risk studies must be prepared using standard methods in the general guidelines for disaster risk assessment. The purpose of this study is to assess the sustainability of the disaster risk assessment aspect based on predetermined indices. The index consists of the threat index, vulnerability index, exposed population index, loss index, and capacity index. The data used in this study include primary data and secondary data obtained through literature studies, expert/stakeholder discussions, interviews, questionnaires, and field surveys. Sustainability analysis uses multi-aspect sustainability modeling analysis techniques. The results showed that Balikpapan City was quite sustainable in the exposed population index (75) and vulnerability index (64.29); but less sustainable on the loss index (50) and disaster threat index (33.29) and unsustainable on the capacity index (20). In addition, it is known that 26 sensitive attributes affect the sustainability of the urban disaster risk index in Balikpapan City.

**Keywords:** Risk index assessment, Disaster-prone, Urban, Multi-aspect sustainability modeling

### 1. INTRODUCTION

Indonesia is a disaster-prone country in terms of geographical, climatological, and demographic aspects. Indonesia's geographical location between two continents and two oceans causes Indonesia to have good potential in the economy as well as being prone to disasters. One of the keys to the effectiveness of disaster management, disaster risk assessments must be prepared using standard methods in the general guidelines for disaster risk assessment. The purpose of this study is to assess the sustainability of the disaster risk assessment aspect based on predetermined indices. The index consists of the threat index,

vulnerability index, exposed population index, loss index, and capacity index. The data used in this study include primary and secondary data obtained through literature studies, expert/stakeholder discussions, interviews, questionnaires, and field surveys. Sustainability analysis uses multi-aspect sustainability analysis (MSA) analysis techniques.

### 2. METHODOLOGY

This study was conducted using a survey method through in-depth interviews and observation techniques. Respondents were

taken by purposive sampling with criteria of experts who have expertise in accordance with the field under study [1] [2]. Data analysis in this study using the multi-aspect sustainability analysis (MSA) approach with MSA software developed by EXSIMPRO [3]. The value of sustainability and performance is determined

from the aggregate calculation of each aspect. This value can be in the form of an aggregate average or an aspect value that has been multiplied by the pairwise comparison. The category of sustainability status shown in Table 1.

**Table 1.** Category Index and Sustainability Status (Firmansyah, 2022)

Index Value	Sustainability Status
0 – 25	Not sustainable
> 25 – 50	Less sustainable
> 50 – 75	Sustainable
> 75 – 100	Very sustainable

### 3. RESULT AND DISCUSSION

The results showed that Balikpapan City in its existing condition was in the sustainable category on the exposed population index (75) and vulnerability index (64.29); but less

sustainable on the loss index (50) and disaster threat index (33.29) and unsustainable on the capacity index (20). In addition, there are 26 sensitive factors that affect the sustainability of the urban disaster risk index in Balikpapan City (Table 2).

**Table 2.** Index and Factors Affecting the Sustainability of the Risk Index Urban Disaster in Balikpapan City (Source: BNPB, 2012)

No.	Index	Assessment factors	Indicator Score
1	Disaster Threat	Flood disaster	Good : 3 Enough : 2 Less : 1 Bad : 0
		Landslide	
		Land cover/coastal vegetation (%)	
		Extreme Weather (Whirlwind)	
		Epidemics and Disease Outbreaks	
		Frequency of Social Conflict	
		The impact of the incident	
2	Vulnerability	Population Density (Social Vulnerability)	Good : 2 Enough : 1 Bad : 0
		GRDP per Sector (Economic Vulnerability)	
		Building Vulnerability (Physical Vulnerability)	
		Ecological/Physical Vulnerability	
		Social Sensitivity (Social vulnerability)	
		Land use/cultivation area (Economic Vulnerability)	
		Infrastructure Vulnerability (Physical Vulnerability)	
3	Population exposed	Population density	Good : 2 Enough : 1 Bad : 0
		Vulnerable Group	
4	Loss	Productive land area	Good : 2 Enough : 1 Bad : 0
		GRDP Contribution by Sector	
		Public facilities	

		Critical Facilities	
		House	
5	Capacity	Disaster Management Regulations and Institutions	Good : 2 Enough : 1 Bad : 0
		Early Warning and Disaster Risk Assessment	
		Disaster Education	
		Reduction of Basic Risk Factors	
		Preparedness Development at all levels	

Based on the results of the MSA analysis, it is found that the existing conditions are as shown in Figure 1. In an effort to increase the sustainability value of the urban disaster risk index in Balikpapan City, scenarios are needed on several indicators that are sensitive to the determinants of sustainability. In this study, there are 2 scenarios needed, namely a realistic scenario and an ideal scenario. Realistic scenarios are oriented towards the improvement of several

sensitive indicators and are adapted to conditions and programs that can be implemented, while ideal scenarios require improvements to all existing sensitive indicators without special conditions. An overview of the existing conditions and the 2 proposed scenarios is presented in Figure 1, while the visualization of the achievement of each improvement indicator in the form of a polar diagram is presented in Figure 2.

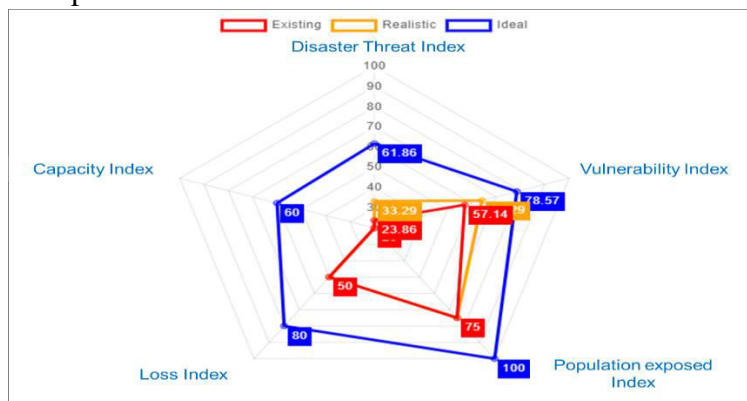


Figure 1. Status values between aspects in existing conditions (red), realistic scenarios (orange), and ideal scenarios (blue)

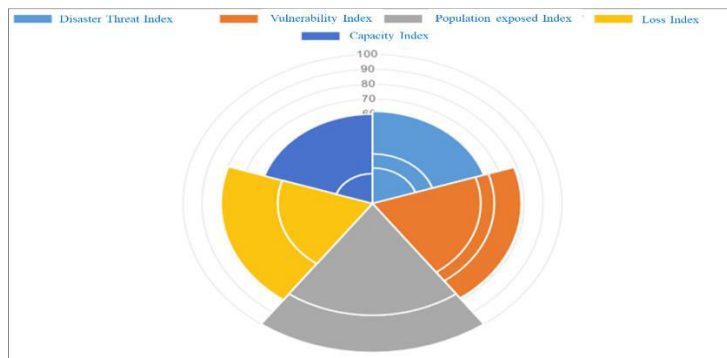


Figure 2. Status value with polar diagram between aspects in existing conditions (red), realistic scenarios (orange), and ideal scenarios (blue)

The realistic scenario requires efforts to improve on three indices, namely the disaster threat index, vulnerability index, and the exposed population index, while the ideal scenario requires improvements to all urban disaster risk indexes in Balikpapan City. A comparison of existing conditions, realistic, and ideal scenarios for each urban disaster risk index can be seen in Figures 3 to Figure 7.

### 3.1 Disaster Threat Index

In the existing condition, the disaster threat index has a value of 23.86%, if improvements are made through realistic scenarios on four

factors namely extreme weather (whirlwind), epidemics and disease outbreaks, frequency of social conflict, and the impact of the incident, the sustainability value will increase to 33.29%. If the ideal scenario is applied, then improvements will be made to five factors, namely land cover/coastal vegetation, extreme weather (whirlwind), epidemics and disease outbreaks, frequency of social conflict, and the impact of the incident, the sustainability value will increase to 61.89 %. The existing conditions, realistic scenarios, and ideal scenarios are presented in Figure 3.



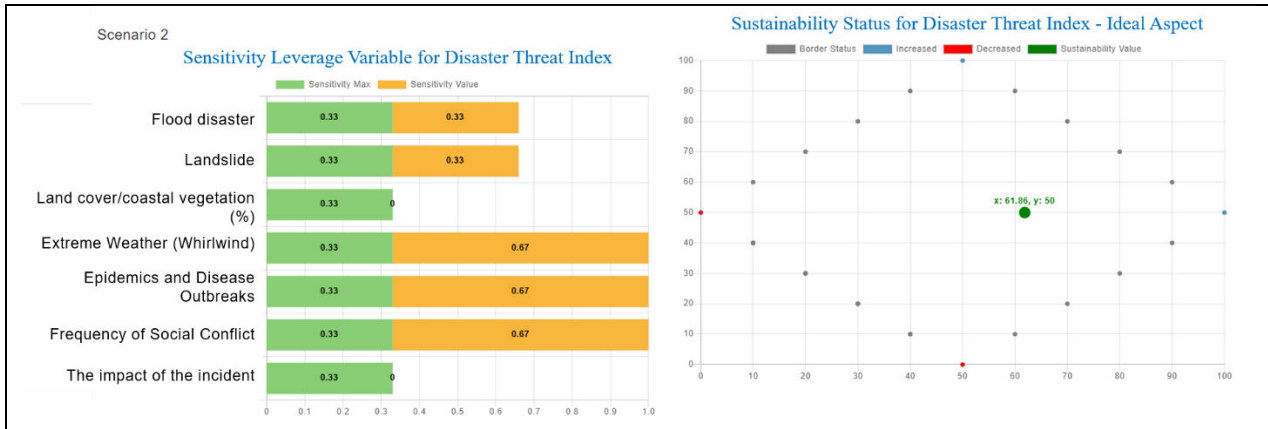


Figure 3. The value of the sustainability status of the disaster threat index in the existing conditions, scenario 1 (realistic) and scenario 2 (ideal)

### 3.2 Vulnerability Index

In the existing condition, the vulnerability index is 57.14%, if improvements are made through realistic scenarios on one factor, namely population density (social vulnerability), the sustainability value will

increase to 64.29%. If the ideal scenario is applied, improvements will be made to two factors, namely population density (social vulnerability) and social sensitivity (social vulnerability), so the sustainability value will increase to 78.57%. The existing conditions, realistic scenarios, and ideal scenarios are presented in Figure 4.





Figure 4. The value of the sustainability status of the vulnerability index in the existing conditions, scenario 1 (realistic) and scenario 2 (ideal)

### 3.3 Population exposed Index

In the existing condition, the population exposed index is in the sustainable category with a value of 75%, an ideal scenario is

applied, then improvements will be made to one factor, namely the vulnerable group, then the sustainability value will increase to 100%. The existing conditions, realistic scenarios, and ideal scenarios are presented in Figure 5.



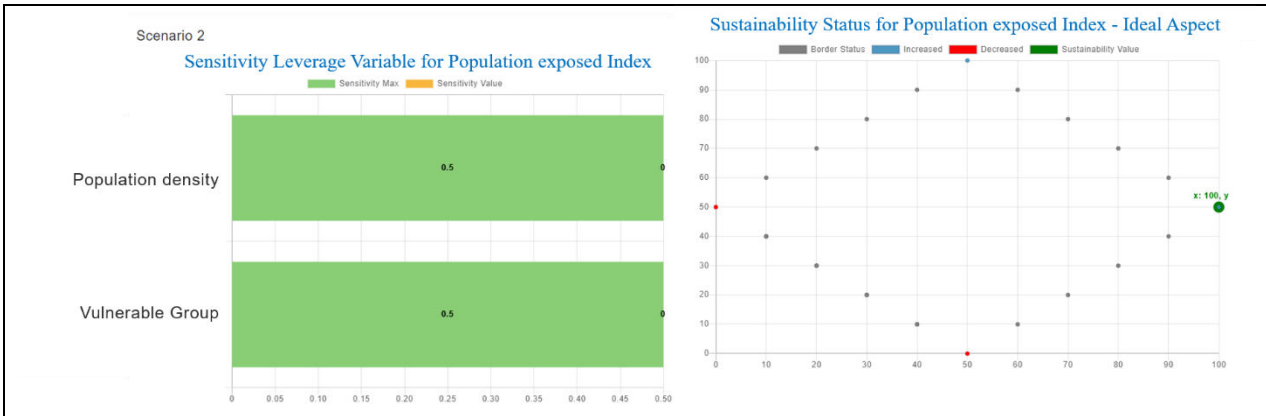


Figure 5. The value of the sustainability status of the population exposed index in the existing conditions, scenario 1 (realistic) and scenario 2 (ideal)

### 3.4 Loss Index

In the existing condition, the loss index is at a value of 50%, if improvement efforts are made through the ideal scenario, then improvements will be made to three factors namely

productive land area, critical facilities, and houses, and the sustainability value will increase to 80%. The existing conditions, realistic scenarios, and ideal scenarios are presented in Figure 6.





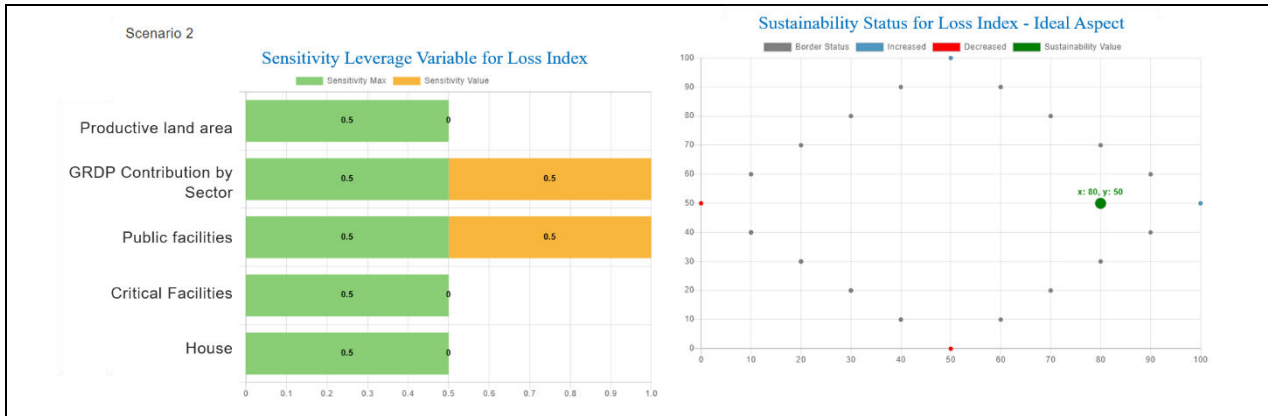


Figure 6. The value of the sustainability status of the loss index in the existing conditions, scenario 1 (realistic) and scenario 2 (ideal)

### 3.5 Capacity Index

In the existing condition, the capacity index is at a value of 20%, if improvement efforts are made through an ideal scenario, then improvements will be made to two factors,

namely early warning and disaster risk assessment and preparedness development at all levels, the sustainability value will increase to 60%. The existing conditions, realistic scenarios, and ideal scenarios are presented in Figure 7.





Figure 7. The value of the sustainability status of the capacity index in the existing conditions, scenario 1 (realistic) and scenario 2 (ideal)

## 4. CONCLUSION

Sustainability assessment from the aspect of disaster risk assessment in Balikpapan City is one of the efforts to implement effective disaster management. Of the 26 factors that are divided into 5 aspects of sustainability assessed, the results show that the City of Balikpapan in its existing condition is in the sustainable category on the exposed population index (75) and vulnerability index (64.29); but less sustainable on the loss index (50) and disaster threat index (33.29) and unsustainable on the capacity index (20). Improving the sustainability status of the aspect of disaster risk assessment in the City of Balikpapan, it can be done through improvement efforts that are outlined in realistic and ideal scenarios.

## AUTHORS' CONTRIBUTIONS

All authors contributed starting from the data collection process, data processing and data analysis as well as writing the proceedings for presentation.

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