

Multi-hazard systems approach to overcome multi-hazard disaster in the northern coastal region of central jawa province

Mohammad Mukhtali ^{12*}, Sudharto Hadi P.¹, Hartuti Purnaweni¹

¹ Graduate School of Environmental Science, Diponegoro University, Indonesia

² Department of Urban and Regional Planning, Diponegoro University, Indonesia

Abstract. Central Java Province is a region that has a high level of multiple disaster hazards. There are 21 types of natural disasters in the high category, such as floods, flash floods, extreme weather, extreme waves and abrasion, earthquakes, drought, several volcanic eruptions, liquefaction, tsunamis and landslides. A multi-system approach (through various adaptation & mitigation patterns based on multi-social-ecological systems) can increase community resilience. This research examine a multi-hazard system approach in increasing the resilience of coastal communities in the North Coast of Central Jawa (City of Pekalongan & Semarang). The research approach was carried out using a quantitative methods (scoring methods). Our study provides that structural mitigation (building sea dams and pumping programs), and adaptation (raising the height of house buildings & collaboration) was able to reduce the risk and increase community resilience to multi-disasters, especially floods, flash floods, tidal floods, and abrasion in Semarang and Pekalongan City. Our research suggests that it is important for policymakers to undertake structural mitigation through physical development of infrastructure and use of technology to reduce risk and increase community resilience. For communities, it is necessary to adapt by developing more disaster-resistant housing buildings.

1 Introduction

Kreimer states that cities located near the coast face a large intensity of threats from the impacts of climate change in the form of rising sea levels, tropical storms, floods, landslides, and heat and cold waves. The variations and intensity of impacts arising from the threat of disasters are multidimensional and simultaneous with each other, covering physical aspects - infrastructure, economic & business and socio-cultural [7]. Furthermore, Fankhauser and Mc Dermott stated that the impact of climate change is not only a decrease in output/production levels, but also a decrease/slowdown in regional/city economic growth [5].

Based on data from the Central Java Disaster Risk Study for 2022 – 2026, Central Java Province is a region that has an elevated level of multiple disaster hazards. There are twenty-one types of natural disasters in the high category, such as floods, flash floods, extreme

*Corresponding authors: alimukti890@gmail.com

weather, extreme waves and abrasion, earthquakes, drought, several volcanic eruptions, liquefaction, tsunamis, and landslides. In the last ten years there have been 7,816 natural disasters which resulted in 2,422 people dying, 1,578,817 people being displaced. It is estimated that flood and landslide losses in 16 districts/cities in Central Java amounted to IDR 2.01 trillion, while in the North Coast region of Central Java it amounted to IDR 6 trillion [2].

Multi-hazard area is defined as an area that is vulnerable to the occurrence of various natural disasters, so that the area is in an elevated level of danger. The multi-hazard approach is an approach to multi-disasters that is complex and multi-sectoral. The multi-systems approach explores the relationships between hazards and risks in disaster systems. According to this approach, the socio-ecological risks can be minimized so that community resilience can be increased [13, 17, 18, 8, 19, 23]. Risk reduction strategies should be evaluated across a broad spectrum of hazards in a multidisciplinary socio-ecological system/way to reduce risk and enhance resilience [1]. Resilience development is influenced by mitigation & adaptive capacity. Disaster mitigation and adaptation planning of each country encourages a multi-hazard approach with a multi-sectoral context [9, 17].

The concept of resilience continues to be studied through various multidisciplinary perspectives; and this has practical implications for aspects of planning, development and restructuring of regions/cities [12, 20, 21, 22]. The diversity of resilience concepts poses epistemological and methodological challenges and makes it difficult to operationalize. The concept of resilience has a variety of different alternative meanings so that it has implications for the implementation of different policies [3, 6, 10, 15]. Conceptually, resilience is interpreted as ability or capacity, in this case the capacity enables the affected community to be able to manage the risks [4, 11]. In general, risk is understood as the potential loss of life, injury or assets destroyed or damaged that can occur in a system, society, or community over a period. Risk tends to be determined probabilistically as a function of hazard, exposure, vulnerability, and capacity [16]. Meanwhile, resilience in a policy context is both a process and an outcome [8]. This means that process and outcome indicators are needed to measure resilience. The process is used to develop a resilience roadmap related to policies, programs, and activities while outcome indicators show what the results of development interventions have been [14].

This research will examine a multi-hazard system approach in increasing the resilience of coastal communities on the North Coast of Central Java to various natural disasters (multi-hazards) that occur in the region. The main question to be answered is " How resilient are coastal communities on the North Coast of Central Java Province to multi-hazards based on multi-systems?

2 Materials & Methods

2.1 Material

The research area covers two villages in two cities on the North Coast of Central Java Province including City of Semarang (Bandarharjo Village) and Pekalongan (Panjang Wetan Village). Details can be seen in Figure 1 below. Multi disasters in Bandarharjo Village (Semarang City) and Panjang Wetan Village (Pekalongan City) include five types, namely: floods, flash floods, extreme weather, extreme waves, and tidal floods.



Fig 1. Map of Pekalongan & Semarang City

2.2 Methods

The research approach was conducted using quantitative methods (scoring methods). The quantitative approach is conducted by scoring adaptation, mitigation and resilience variables (scale 1 – 4). Data was taken from two hundred respondents for two villages namely Bandarharjo Village in Semarang City and Panjang Wetan Village in Pekalongan City. There are three research variables and indicators, namely adaptation, mitigation, and resilience.

Table 1. Research variables and indicators.

Variables	Indicators
Adaptation index/score	Economic, social, ecological adaptation
Mitigation index/score	Structural & non-structural mitigation
Resilience index/score	Social - ecological resilience

3 Result and Discussion

3.1 Adaptation, Mitigation and Resilience in Semarang City

Mitigation, adaptation, and resilience conducted in dealing with multi-disasters in Semarang City can be seen in table 2, 3 and 4 below. Based on table 2, it shows that the highest mitigation score is structural mitigation, which is physical infrastructure, namely sea walls and flood pumps. Based on table 3, shows that the highest adaptation score is raising the house building, while other adaptation patterns have low scores. With various mitigation and adaptation patterns being implemented, most of the community stated that resilience to various disasters is getting stronger, especially resilience to hydrological disasters. More details can be seen in table 4 below.

Table 2. Score of Mitigation in Semarang City (Bandarharjo Village)

Mitigation	Score	Category
-Embankment Construction	52	high
-Construction of Diversion Channels	13	low
-Greening in the Middle and Upper Areas	13	low
-Flood Pumping	52	high
-River Normalization	13	low
-Development of Early Warning Systems	16	low
-Flood Disaster Training and Simulation	13	low
-River Boundary Policy	26	low
-Disaster Map Making	28	medium
-Land Use Policy	26	low
-Natural Disaster Legislation	26	low

Table 3. Score of Adaptation in Semarang City (Bandarharjo Village)

Adaptation	Score	Category
-Adaptation of Income Sources	13	low
-Adaptation of Non-Agricultural Economy	6	low
-Adaptation of Building Materials	10	low
-Innovation in the Fisheries Sector	13	low
-Collaboration with Other Parties in Making Changes	13	low
-Changes in House Height	46	high

Table 4. Community Resilience in Semarang City (Bandarharjo Village)

Comparison of Community Resilience After Mitigation & Adaptation	%
-More very weak	0
-More weak	0
-Stronger	85
-More very strong	15
Total	100

3.2 Adaptation, Mitigation and Resilience in Pekalongan City

Mitigation, adaptation, and resilience conducted in dealing with multi-disasters in Semarang City can be seen in table 5, 6 and 7 below. Based on table 5, it shows that the highest mitigation score is structural mitigation, which is physical infrastructure, namely river wall. Based on table 6, shows that the highest adaptation score is raising the house building and collaboration, while other adaptation patterns have low scores. With various mitigation and

adaptation patterns being implemented, most of the community stated that resilience to various disasters is getting stronger, especially resilience to hydrological disasters. More details can be seen in table 7 below.

Table 5. Score of Mitigation in Pekalongan City (Panjang Wetan Village)

Mitigation	Score	Category
-Embankment Construction	20	low
-Construction of Diversion Channels	20	low
-Greening in the Middle and Upper Areas	20	low
-Flood Pumping	60	medium
-River Normalization	40	low
-Development of Early Warning Systems	20	low
-Flood Disaster Training and Simulation	40	low
-River Wall	80	high
-Disaster Map Making	40	low
-Land Use Policy	40	low
-Natural Disaster Legislation	40	low

Table 6. Score Adaptation in in Pekalongan City (Panjang Wetan Village)

Adaptation	Score	Category
-Adaptation of Income Sources	39	low
-Adaptation of Non-Agricultural Economy	31	low
-Adaptation of Building Materials	20	low
-Innovation in the Fisheries Sector	22	low
-Collaboration with Other Parties in Making Changes	53	medium
-Changes in House Height	46	medium

Table 7. Community Resilience in in Pekalongan City (Panjang Wetan Village)

Comparison of Community Resilience After Mitigation & Adaptation	%
-More very weak	6
-More weak	16
-Stronger	59
-More very strong	19
Total	100

4 Conclusion

Our study provides that multi-system approach (through various adaptation & mitigation patterns based on multi-social-ecological systems) can increase community resilience to multiple disasters especially hidrology disaster namely: floods, flash floods, extreme

weather, extreme waves, and tidal floods. In Semarang City, structural mitigation (building sea walls and pumping programs) and adaptation (raising the height of house buildings) was able to reduce the risk and increase community. In Pekalongan City, structural mitigation (river wall) and adaptation (raising the height of house buildings and collaboration among stakeholders) was able to reduce the risk and increase community. Our research suggests that it is important for policymakers to undertake structural mitigation through physical development of infrastructure and use of technology to reduce risk and increase community resilience. For communities, it is necessary to adapt by developing more disaster-resistant housing buildings. In addition, it is necessary to improve collaboration between stakeholders in adapting to hydrological disasters that occur in the coastal areas of the cities of Semarang and Pekalongan (in the North Coast of Central Java).

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