Assessment of socioeconomic vulnerability of coastal community in management of floods in Mataram

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Abstract. Natural disasters that often occur in coastal areas are tidal floods and river floods. Flood vulnerability management of coastal areas has become increasingly important to mitigate and prevent floods. The purpose of the study was to analyze the socio-economic vulnerability of the Mataram City coast. The spatial-DPSIR approach was employed to study the socio-economic and ecological framework. The socio-economic vulnerability was analyzed using the following parameters: population density, poverty level, livelihoods, land ownership, awareness of disasters, the presence of business areas and trade areas, and physical damage to buildings. The analysis result of the coastal flood socio-economic vulnerability showed that most of the Mataram coast were classified as intermediate. The results of this study are expected to become a reference for development and management, especially in spatial planning policies for a disaster-secure coastal area.

Keywords: coastal disaster, DPSIR, socioeconomic vulnerability

1. Introduction

Indonesia is an archipelago which faces many natural disaster potentials such as floods, droughts, earthquake, volcanic eruptions, and tsunamis. Based on the data collected by the Indonesian National Board of Disaster Management (Badan Nasional Penanggulangan Bencana (BNPB)), the most common natural disaster in Indonesia is flooding. Geological disasters such as earthquakes and tsunamis located in coastal areas are rare but cause the highest death tolls [1]. Coastal floods are floods that occur in coastal areas which include coastal flatlands. Floods in coastal areas in the form of tidal floods occur due to tidal dynamics and river floods occur due to surface runoff as a part of the rainfall that flows from the land into the river system.

Vulnerability is a community’s low resistance in facing threats that influence the disaster risk level. Vulnerability can be viewed from the environmental, economic, and socio-cultural factors, and social conditions such as poverty, social pressure, and a less than strategic environment which may decrease the community’s resistance in facing threats. Coastal vulnerability can be measured using physical and socio-economic indicators. Physical indicators include geomorphologic parameters, changes in the coastline, beach slope, sea-level rise, waves, and average tides. Socio-economic vulnerability indicators include the population number, education level, average income, livelihoods, economic activities/trade, and physical damage to buildings due to floods [2,3,4,5,6]. This paper will focus on the socio-economic

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vulnerability of coastal flood disasters. The main difficulties in assessing socio-economic indices of vulnerability lie in the assessment and ranking of the socio-economic indicators [4].

Interactions between the ecological and socio-economic systems in the coastal area require integrated management. One of the management frameworks that could identify environmental problems, sources, and solutions and the correlation between the ecological and socio-economic systems is the Driver-Pressure-State-Impact-Response (DPSIR) Framework [7]. The DPSIR approach was developed by the European Environment Agency [8] based on the Pressure-State-Response (PSR) framework previously developed by the Organization for Economic Co-operation and Development (OECD) in 1993 [9]. DPSIR is commonly used in the field of ecology, environment, and socio-economic activity management because this approach can analyze the complex causality between the environmental and socio-economic systems. In the DPSIR framework, the development of socio-economy is the driver (D) which causes pressure (P) on the environment. In response to the pressure, environmental conditions (S) change and these have an impact (I) on human health, the ecosystem, et cetera. Response (R) is the feedback for D, S, and I in the form of adaptation and prevention policies [10].

The application of the DPSIR framework using the Geographical Information System (GIS) is used in assessing the ecological and socio-economic impacts due to the utilization of coastal and marine land [11,12], estuary area management [13], and in analyzing large city development and spatial resistance [14]. The qualitative DPSIR approach combined with SIG as the visualization tool and quantitative synthesis results in a more comprehensive assessment of the environmental condition [13,15].

This study aimed to create a socio-economic and ecological conceptual framework for coastal vulnerability using the spatial-DPSIR and to analyze the socio-economic vulnerability index of Mataram City.

2. Method

The study was conducted on the coast of Mataram City which is the capital of West Nusa Tenggara Province. Mataram City is located between 116°04’–116°10’ E and 8°33’–8°38’ S. Administratively, Mataram City is divided into 6 sub-districts, two of which, Ampenan Sub-district and Sekarbela Sub-district, are located on the coast (figure 1).
The study used both primary and secondary data. Primary data were obtained through (1) Field observations to see the actual condition of the study location, (2) Interviews using questionnaires to collect perception data of coastal flood disasters with 105 respondents. The field surveys were conducted between April and July 2019. Secondary data were collected through the perusal of various reports and literature from several relevant agencies/institutions.

The study method employed in this study was the qualitative approach with the DPSIR framework approach combined with spatial data, resulting in a comprehensive description to assess the correlation between resource utilization activities by the people and the coastal area vulnerability. The DPSIR framework consisted of five components: (1) Drivers (trigger factors) which explain the triggers of a certain environment change; (2) Pressures are pressures caused by a Driver; (3) State change is the change in environmental conditions; (4) Impact, the effect of environmental change on community welfare, and (5) Response is the measurable response or actions in overcoming the issues that arise by involving the stakeholders.

The identification of coastal flood socio-economic vulnerability was done through a quantitative approach based on the matrix in table 1. Social vulnerability is the vulnerability condition against people’s social susceptibility in facing coastal floods. Economic vulnerability is vulnerability from the people’s economy point of view, the vulnerability of the assets they own, and vulnerability of the trade or production business locations due to coastal floods [5].

| Indicator                  | Weight | Vulnerability categories for each variable | Low | Moderate | High |
|----------------------------|--------|-------------------------------------------|-----|----------|------|
| Income                     | 4      | > Rp. 1.500.000                           | Rp 700.000 – Rp 1.500.000 | < Rp 700.000 |
| Livelihoods                | 3      | Government employee/army/police employee | Entrepreneur/private employee | Labour/unemployment |
| Education                  | 2      | Graduated from high school                | Graduated from elementary/junior high school | Not school/did not pass elementary school |
| Population density         | 1      | < 10 people/ha                            | 10-25 people/ha | > 25 people/ha |
| Citizen status             | 1      | Native                                    | Immigrant | Rent |
| Building ownership         | 1      | Own                                       | Agency | Rent |
| Settlements                | 1      | Village                                   | Small town | Large town/city |
| Land use                   | 1      | Bare rocks/ coastal areas                 | Forest/agricultural | Urban/industrial |
| Economic activities/ trading area | 1      | Agricultural                              | Commercial/industrial | Tourism |

Source: [2,3,4,5,6]

### 3. Result and discussion

#### 3.1. DPSIR Analysis

Coastal and marine environmental management requires a comprehensive approach that integrates all its components. The spatial-DPSIR approach is an approach that could describe the social-economic and ecologic conditions comprehensively and integrates all the components involved. The Mataram City coast had three main activities, i.e. catch fishery, beach tourism, and a marine transportation route. The Mataram City beach had undergone a lot of sedimentation from the river and abrasion due to extreme waves. The regional government built a jetty and sea wall on part of the beach to control the abrasion. Floods due to the tides occur during certain seasons and the water recedes not long after. River floods occur almost every year in the Ancar River. Ancar River is the boundary between Ampenan Sub-district and Sekarbela Sub-district with fairly densely populated settlements along the riverside. The floods occur because the river flow is partially obstructed by net cages and trash disposed of in the river.
The driving forces of the coastal floods in Mataram City were the increased population number and changes in land use in the coastal area (figure 2). The average population growth in Mataram in 2018 reached 2%. The population growth in the two sub-districts was different, with Sekarbelia Sub-district reaching 3.79% and Ampenan Sub-district 1.88%. The changes in land use from field/brushland to settlements were more common in Ampenan Sub-district than in Sekarbelia Sub-district (figure 3A). The GIS analysis for the area covered by settlements/buildings in Ampenan Sub-district reached 35% of the total area. In Sekarbelia Sub-district was only 20%. The highest population density was found in two kelurahan (urban villages) in Ampenan Sub-district, namely Central Ampenan Kelurahan and Dayenpeken Kelurahan with densities exceeding 190 people/ha (figure 3B).

![Figure 2. The DPSIR approach in coastal flood vulnerability.](image)

![Figure 3. (A) Settlement distribution map; (B) Population density map.](image)
The main activities in the Mataram coastal area were being caught fishers and entrepreneurs. The population growth had caused pressure in the coastal area in the form of the need for more space for settlements and infrastructure. Also, the people's habit of disposing of waste materials to the river had further increased the risk of flooding. Utilization of the coastal land could potentially cause spatial conflicts with other activities such as coastal tourism. Other pressures included climate change such as the rising sea level and land subsidence.

Changes in environmental conditions (state change) which were found in Mataram City were the increased risk of settlement area/infrastructure vulnerability, a poor drainage system, and partially obstructed river flow. The impacts of coastal floods were damage to settlements/infrastructure and the decline in water resources in the coastal area.

The action responses to overcome these issues were through regulations of spatial use in the coastal area and riverbanks, coastal flood management strategies in the form of socialization to alter the pattern of waste disposal in the river, the regulation of the distance between settlements/buildings and the shoreline and regulations in institutions responsible for coastal disaster mitigation. Further responses in spatial planning of the coastal and marine areas require political policies from both the central and regional governments in the form of laws and related regulations. There needs to be involvement of the stakeholders such as the coastal communities, tribal elders, NGOs, researchers, the private sector/industry, and the government in establishing these regulations.

3.2. Analysis of coastal flood socio-economic vulnerability

Assessment of vulnerability in the present study was conducted based on data from the Central Bureau of Statistics (BPS) and the results of the survey of factors that influence vulnerability. Coastal flood socio-economic vulnerability assessment employed nine parameters: income, livelihoods, education, population density, citizen status, building ownership, settlements, land use, and economic activities.

The results of the coastal flood socio-economic vulnerability analysis of the coast of Mataram revealed that most of the area, which included 8 Kelurahan in Ampenan and 4 Kelurahan in Sekarbela, were in the intermediate level. A high vulnerability level was only found in Central Ampenan Kelurahan, Ampenan Sub-district, which had a high population density and is located along the Ancar River. Coastal floods would cause a decline in people's living quality. A low vulnerability level was found in the northern part of the Ampenan Sub-district and the southern part of Sekarbela Sub-district where most of the land cover was still dominated by agricultural fields. Socio-economic vulnerability is mostly influenced by income, livelihoods, land cover, and economic activity factors. The results of the survey showed that most of the people were entrepreneurs, which is classified as intermediate vulnerability. Mataram City as the province capital city is an urban area, making the land cover classified as high vulnerability. The economic activities were classified as intermediate vulnerability as they were dominated by commercial areas rather than agricultural areas. The coastal flood socio-economic vulnerability spatial distribution can be seen in figure 4.
4. Conclusion
The spatial-DPSIR approach can describe the interactions between the environment and the socio-economic conditions of the coast of Mataram, especially coastal flood disasters. The analysis of the coastal flood socio-economic vulnerability revealed that most of the Mataram coast were classified as intermediate. These results signify the importance of mitigating the coastal flood disaster by blocking extreme waves on the beach by constructing beach barriers in the form of jetties or walls. In addition, there needs to water resource and land cover management in the form of coastal spatial planning regulations and efforts to build the coastal community’s awareness in maintaining the environment.

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