

# How important risk analysis of plastic pollution in coastal area? Case study in Masohi, Central Maluku

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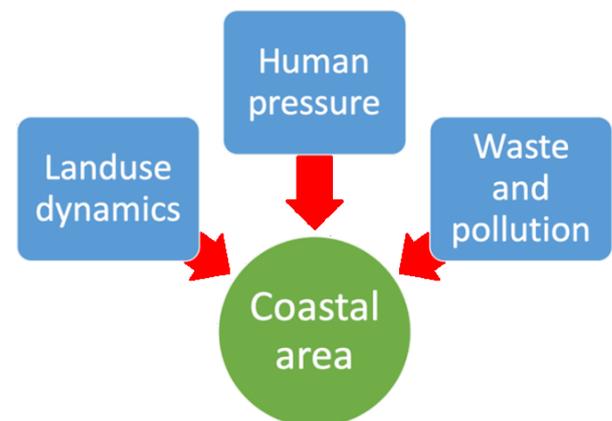
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**Abstract.** Human pressure on the coastal and aquatic surrounding ecosystem in Indonesia, through plastic waste, is increasing, considering that 60 % of the approximately 250 million people live in the coastal areas. Plastic waste originating from human activities has become a massive problem in almost all the small island and coastal regions, especially in the eastern part of Indonesia. This condition is caused by poor waste management and a lack of public awareness in disposing of waste in its place, including in an area known as its marine biodiversities and marine tourism spots like Masohi in Central Maluku. Also, the composition of waste is dominated by plastic waste that cannot be decomposed in a short period, continue circulated on the ocean currents, and will be deposited in coastal areas. Furthermore, some plastic waste will break down into micro-plastics that pollute not only the environment but also marine biota, which are often consumed by humans. This situation profoundly affects the sustainability and function of aqua- ecosystem services in coastal areas. Therefore, a comprehensive policy and regulation, and interdisciplinary study for analysing vulnerable coastal ecosystem, and mitigating the potential risk of plastic pollution in Masohi, Central Maluku are essential to be conducted.

## 1 Introduction

As an archipelagic state with a 99,093-km stretch of coastline and 16,056 registered islands [1-3], Indonesia is rich in marine biodiversity in the mangrove forests, coral reefs, and seagrass beds that can support the national economy [4-6]. The variety and heterogeneity of ecosystems in coastal areas contribute to economic development to humans. Therefore coastal areas are currently the most densely populated and diverse land-use compared with other regions.

This condition implies the high exploitation of natural resources through several activities, such as fisheries, aquaculture, mining, tourism, and forestry. The high intensity of human activities in coastal areas like manufacturing, metropolitan, housing, conservation, quarrying, eventually leads to inevitable conflicts from one to the other, including the problem affected by plastic waste. Furthermore, human pressure on the coastal and aquatic surrounding ecosystem in Indonesia, through plastic waste, is increasing [7], considering that 60% of the approximately 250 million people in Indonesia live in the coastal areas [8] (Figure 1).



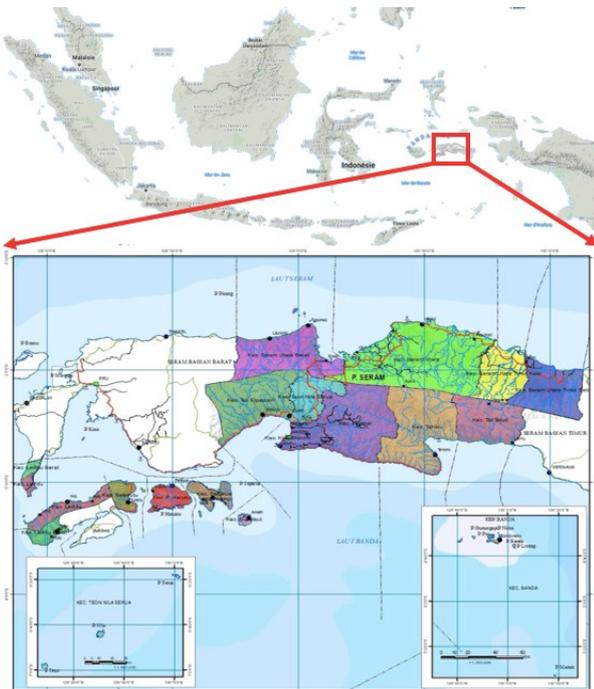
**Fig. 1.** Some problems which threaten the resources and biodiversity in the coastal area.

Ocean plastic waste originating from human activities has become a massive problem in almost all the small island and coastal regions, especially in the eastern part of Indonesia [9]. This condition is caused by poor waste management and a lack of public awareness in disposing of waste in its place (Figure 2), including in an area known as its marine biodiversities and marine tourism spots like Masohi (Figure 3) and Salahutu (Figure 4).

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**Fig. 2.** Poor waste management and a lack of public awareness in disposing of waste in its place in Masohi (Courtesy: A.A. Risanti, 2019).

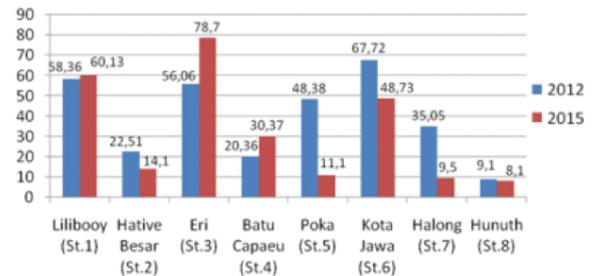


**Fig. 3.** Masohi as a capital city of Central Maluku.



**Fig. 4.** Local peoples used the shore as their waste dump in Salahutu (Courtesy: M.R. Umarella, 2020).

Also, the volume of waste in Maluku reaches 800 tons per day, and its composition is dominated by plastic waste that cannot be decomposed in a short period, continue circulated on the ocean currents, and will be deposited in coastal areas [10]. Furthermore, some plastic waste will break down into micro-plastics that pollute not only the environment but also marine biota, which are often consumed by humans. This situation definitely and profoundly affects the sustainability and function of aqua- ecosystem services in coastal areas, e.g., decreasing of coral reef cover (Figure 5) [10].



**Fig. 5.** Poor waste management in Masohi affects the decrease in coral reef cover [10].

Therefore, a comprehensive policy and regulation, and interdisciplinary study for analyzing vulnerable coastal ecosystem [11], and mitigating the potential risk of plastic pollution; while balancing the coastal ecosystem services to the coastal society and services to the coastal ecosystem in Masohi, Central Maluku are essential to be conducted. Meanwhile, in assessing the coastal landscape characteristics and coastal resources, efforts are often hindered by the limited availability of data, lack of data access, and resources for assessment. These constraints lead to inappropriate expectations concerning the outcomes of the analysis. For that reason, the integration of GIS technology and remote sensing is needed in this research [1-2, 12-17].

## 2 Risk Analysis of Plastic Pollution in Masohi

With the vast areas of coastal ecosystems in Masohi, the 3-M activities (Mapping-monitoring-modeling) can be conducted by desk evaluation of documents (official reports, planning, and programs) and employing the abundance of geomorphological data, remote sensing data, and other supporting spatial data such as hydro-oceanographic parameters, base-maps, and socio-economic data. Spatial monitoring of the distribution of plastic waste is crucial to be done by identifying the origin of the waste, the composition of the waste carried into the ocean, how the circulation of waste in the sea, and how much waste is deposited in coastal areas and small islands. Identification of the origin of waste is essential since ocean currents are connected globally so that accumulated debris may come from other regions. Local policies and risk analysis of ocean plastic waste study, in general, is still rarely done, and for Indonesia,

in particular, it has never been done. This research activity better carried out in several stages, namely:

1. Identify the policies and understanding of the role and perceptions of the stakeholders on plastic waste and pollution.
2. Mapping the volume and composition of waste in watershed output in Masohi.
3. Identification of coastal landscape characteristics and tidal patterns, as well as conducting numerical models of ocean currents, will be used in predicting the potential movement of waste and their sediment locations.
4. Identification of the location of waste deposits in coastal areas precisely mapped using medium-resolution remote sensing imagery using radar and optical (Landsat 8 and Sentinel 2 - Figure 6) with digital classification using input spectral values and using spectral libraries from field and laboratory spectrometer measurements. The results will be tested using a confusion matrix through a field check to verify the modeling results.
5. Risk analysis of plastic pollution through the in-depth analysis as well as identification for interventions, policies, and regulations to minimize the risks in the coastal and aquatic ecosystem.



**Fig. 6.** Remote sensing data in Central Maluku from Sentinel-2 imagery.

## 2.1 Mapping the coastal landscape and resources

An interdisciplinary approach between remote sensing data and geographic information systems (GIS) are used to identify the coastal landscape characteristics and coastal resources in Masohi. Following the growing availability of GIS technology and satellite images, numerous research work has been carried out to map the coastal landscape and their resources, e.g., coral reef, mangrove, and seagrass through mid to high-resolution satellite images and large scale topographic maps [2, 16, 18]. Field measurements using a purposive sampling method should be conducted to validate the analysis from satellite images data, as well as to obtain more detailed information about the recent condition, such as coral reefs cover, mangrove conditions, hydro-oceanographic parameters, and water quality.

## 2.2 Empirical social research

Government policy, as well as the information of the community and stakeholders' perception of plastic waste and pollution, are necessary to create a waste management action plan based on community participation and local wisdom. In-depth interviews, Focus Group Discussions (FGD), and participatory mapping with key persons, local community, and local government using a sketch map based on the mapping results of coastal landscape and resources should be conducted to obtain comprehensive results from the perspective of community and stakeholders, i.e., the volume of waste for each household, current policy, and regulations, as well as challenges and obstacles on waste management in Masohi. The systematic procedure that makes significant use of the range of human geographical methods, primarily the methods of empirical social research, will be worked out in detail in close exchange with the local partners. One methodical focus is on different forms of interviews, which will involve consulting experts and decision-makers and also persons from the population groups relevant to the questions. The following methods should be applied: 1) expert interviews, in-depth interviews; 2) network analysis; 3) focus group discussions; 4) participatory appraisal; 5) surveys, observations and photographic documentation that have been standardized to a limited extent if the question so allows.

## 2.3 Data acquisition

Primary physical data from field observation and secondary data from satellite images, maps, and other reports should be collected during the fieldwork [16, 19]. Meanwhile, another social-economic data and coastal community characteristics, including characteristics of respondents, the impact of tourism on the environment, and the current waste management in each community, should be obtained as well. Data related to the physical condition as well as social aspects are needed in order to do the risk analysis and to obtain the objective of the research. Those data are:

1. Data related to coastal landscape characteristics will be obtained from satellite images interpretation, previous reports, and research, interviews with the governmental agencies, field observation, and direct measurement (Figure 7).
2. Data related to coastal resources and hydro-oceanographic factors. Those data can be obtained from field measurement, observation, satellite image interpretation, modeling, as well as previous research and reports.
3. Data related social aspect, community characteristics, and government approach to the community. Those data can be obtained from interviews, participatory urban appraisal techniques, observation, and previous reports.
4. Data related to governmental planning, policy, and regulations can be obtained from the governing document and office visit.



**Fig. 7.** An example of field observation to obtain data related to coastal typology in Salahutu (marine deposition coast).

Finally, it is expected that a waste management action-plan in Masohi could be developed based on the mapping of the coastal landscape, coastal resources, volume and composition of waste, local community behavior, as well as their adaptive capacity.

### 3 Summary

A comprehensive policy and regulation, and interdisciplinary study for analyzing vulnerable coastal ecosystem, and mitigating the potential risk of plastic pollution; while balancing the coastal ecosystem services to the coastal society and services to the coastal ecosystem in Masohi, Central Maluku are essential to be conducted. It is expected that a waste management action-plan in Masohi could be developed based on the mapping of the coastal landscape, coastal resources, volume and composition of waste, local community behavior, as well as their adaptive capacity.

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