Applying risk assessment approach to evaluate small island status in Kepulauan Seribu

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Abstract. Kepulauan Seribu with all potential need to be realized in an integrated management of coastal and ocean areas for sustainable development. The process of developing small islands in an integrated manner in the three islands needs to consider the risks that will occur. The purpose of this study is to analyze the level of risk in small islands and estimate the appropriate management of small islands for the Thousand Islands area. The method used in this study is a survey and observation method with an analysis of the IPCC (2014) model. The type of hazard that has the most potential to cause a disaster is a hurricane. The level of vulnerability in Harapan Island, Kelapa Island, and Kelapa Dua Island is relatively low, because there is only one hazard that has the potential to be a disaster, namely a tornado with a large enough magnitude and loss. The level of capacity owned by the three islands is quite good, so that the risk value in Harapan Island is 0.69, Kelapa Island is 0.68, and Kelapa Dua Island is 0.62 which is included in the low category.

Keywords: capacity; hazard; Kepulauan Seribu; risk; vulnerability

1. Introduction
Kepulauan Seribu is an area consisting of small islands with good natural beauty potential. The area of Kepulauan Seribu is approximately 108,000 Ha with a total of 110 islands, including 11 residential islands, 48 tourist islands, and 53 other islands [1]. Administratively, Kepulauan Seribu is divided into 6 regions, namely Panggang Island, Harapan Island and Kelapa Island which are included in the North Kepulauan Seribu District, while the South Kepulauan Seribu District consists of Untung Jawa Island, Tidung Island and Pari Island [2]. The location of Kepulauan Seribu, which is scattered and easy to be accessed by tourists because of its location close to the DKI Jakarta area and directly connected to the Bay of Jakarta, makes Kepulauan Seribu never deserted from tourist visits. This strategic position allows various potentials to be utilized properly [3].

Kepulauan Seribu has three types of tourism that highly attractive: beach tourism, nature reserve tourism, and historical tourism. Kepulauan Seribu with it’s potential needs to be realized in an integrated management of coastal and marine areas for sustainable development. Small islands have the potential to experience habitat destruction, natural changes in ecosystems, pollution, and are vulnerable to natural disasters [4]. Development activities in small islands must prioritize ecological sustainability by taking into account the carrying capacity, so that the negative impacts (physical and non-physical) of development activities can be minimized. The carrying capacity of coastal areas is an approach to the
management of small islands that pays attention to the comparison of the availability and capacity of resources to the total human population [5]. The development process in terms of managing small islands that is carried out needs to consider the risks that will occur and estimate how to handle risks that will cause negative impacts from these development activities.

Disaster risk is a potential loss or harmful impact caused by a disaster in an area within a certain period of time [6]. In general, disaster risk is a combination of hazard, vulnerability, exposure, and individual and group capacity. Small islands are vulnerable to natural disasters and human activities [7]. Small islands are at high risk of natural disasters such as hurricanes, ocean waves, and abrasion. The risk assessment is expected to be the basis for managing small islands, where the level of risk indicates the management value of the available natural resources. The lower the risk indicates that the management of small islands is quite appropriate, and vice versa [8]. This study aims to analyze the level of risk in small islands and estimate the appropriate management of small islands for the Kepulauan Seribu area. Therefore, it is important to conduct research to analyze the level of risk as a basis for management in the coastal areas and small islands of Kepulauan Seribu.

2. Material and method
This research was conducted through primary and secondary data. The primary data was obtained by survey and observation methods. The survey method was a research technique conducted using several questions as a questionnaire for ship transportation, hotel and restaurant owners/visitors, tour guides, ship charter services, cultivators, and fishery actors. Secondary data were obtained from literature studies and data from the Kepulauan Seribu National Park. Primary data is needed to analyze the level of risk in Harapan Island, Kelapa Island, and Kelapa Dua Island. To calculate the risk using the average hazard score divided by the average vulnerability score, and multiplied by the average capacity score.

Data were obtained through interviews and questionnaires with respondents. In addition to interviews, observations were also made at the location, namely the characteristics of the island, the availability of cleaning facilities, counting the number of waste disposal sites, the availability of clean water, and the environmental conditions of the surrounding waters. Secondary data was obtained from the Thousand Islands National Park and regarding the allocation of utilization space obtained from the
results of the zoning analysis of coastal areas and small islands obtained from literature studies in the form of journal references, theses, and books related to supporting research data and basic theory development materials used relevant.

The results that have been obtained are then analyzed using the concept of the IPCC model by modifying the risk criteria. The concept of the IPCC model links between hazard, vulnerability, and adaptive capacity. Hazards analyzed are hurricane, waves, abrasion, and waste. To estimate the value of vulnerability and adaptive capacity based on the magnitude, frequency, and impact of losses from hazards that have occurred and have been listed in the questionnaire. The score given to each parameter is from 1 to 3, the higher the risk score in each parameter, the more dangerous it is, so it is necessary to have an appropriate island management strategy to minimize the existing risks.

The research was conducted at Harapan Island, Kelapa Island, and Kelapa Dua Island on 29 August – 1 September 2020. Harapan Island and Kelapa Island are two islands located side by side. However, Kelapa Dua island is located in front of Kelapa Island in the northern region of the Kepulauan Seribu. figure 1 shows the location of the field survey with the island concerned.

3. Results and discussion
The grouping of hazard levels can be assessed by taking into account the indicators in each parameter. The score is given according to the results of observations and interviews, the greater the score, the more dangerous. The following are the results of the classification of hazard levels on Harapan Island, Kelapa Island, and Kelapa Dua Island.

3.1. Capture hazard potency fisheries investment
Capture hazard potency on the three islands have relatively the same characteristics. Assessment of potential hazard by calculating the score on each indicator. Indicators for each parameter have been modified according to the needs of the location [9]. The grouping of hurricane hazards with land openness indicators on the three islands gets a high score, and the slope of the three islands gets a high score. The higher the hazard parameter score, the more potential it is to cause a disaster. The results of the assessment of scores based on the questionnaire and observation are presented in table 1.

The results of the classification of hazard levels in table 1 show that the scores on the hurricane parameter on the three islands are higher than the other parameters. This is due to the hurricane that occurs in flat areas that tend to be sloping, which can trigger strong wind movements because the frictional force between the wind and the ground is relatively small [10]. Hurricanes usually occur in

| Parameters of | Indicators                        | Harapan Island | Kelapa Island | Kelapa Dua Island |
|---------------|----------------------------------|----------------|---------------|-------------------|
| Waves         | Height wave                      | 2              | 2             | 2                 |
| Abrasion      | Typology of coast                | 2              | 2             | 2                 |
|               | Vegetation cover                 | 2              | 2             | 1                 |
|               | Shape of coastline               | 1              | 1             | 1                 |
| Hurricane     | Protected area                   | 3              | 3             | 3                 |
|               | Slope                            | 3              | 3             | 3                 |
| Waste         | Number of trash cans             | 1              | 1             | 1                 |
|               | Trash found around the island    | 1              | 1             | 1                 |
|               | Public and tourists concern      | 1              | 2             | 1                 |
|               | about site cleanliness           |                |               |                   |

Table 1. The results of the score assessment of hazard levels.
tropical climates, Kepulauan Seribu, which have a tropical climate, with the influence of the movement of the west and east monsoons, causing them to be prone to hurricane disasters.

From the results of the hazard level grouping, then the disaster potential analysis is based on indicators of intensity, magnitude, and impact. Intensity is assessed how often the disaster occurs. The magnitude is assessed from the area affected by the disaster. Impact is assessed from the victims affected during the disaster. The assessment of potential disasters is obtained from the modified IPCC model which is tailored to the needs. The results of disaster potential in Harapan island, Kelapa island, and Kelapa Dua island are presented in figure 2.

**Figure 2.** The results of disaster risk.
Based on the results of potential disasters on the three islands, the parameter that has the potential to cause disasters is a hurricane. On Harapan Island, the hurricane intensity score was 1, with magnitude and impact scores of 2.76 and 2.70, respectively. On Pulau Kelapa and Pulau Kelapa Dua, the cyclone intensity score was 1, with a magnitude and impact score on both islands of 2.50. The difference in the value of magnitude and impact scores in the three islands is caused by different population densities.

**Figure 3.** The result of vulnerability in three islands.
Harapan Island, with an area of approximately 6.7 hectares, is entirely populated by residents, while Kelapa Island with an area of 277,345 hectares and Kelapa Dua Island with an area of 13.09 hectares is not entirely populated by settlements. Increasing population and residential density are more at risk of being affected by disasters [3].

The magnitude and impact caused by waves on the three islands are included in the low category with an average score ranging from 1-2; this is because both on Harapan Island, Kelapa Island, and Kelapa Dua Island have built breakwater. so as to minimize sea wave runoff which can also affect coastal abrasion. Areas that are prone to high wave disasters are determined based on the frequency and wave height of more than 2 meters, while on the three islands the wave height does not reach more than 2 meters [11]. So Harapan Island, Kelapa Island, and Kelapa Dua Island are included in the low category of high waves.

The potential for abrasion is still in the low category, this is because the vegetation cover on the three islands is quite good. According to [12], stated that the abrasion that occurred in Kepulauan Seribu was caused by waves and currents that eroded the coast because it was not protected by mangroves. Also in the three islands have been built breakwater as an effort to reduce the risk of abrasion hazard [13]. The potential for waste disasters on the three islands is in the low category, this is because there are adequate waste disposal facilities. So the hazard that has the potential to cause disaster is hurricane.

3.2 Vulnerability
The vulnerability of small islands can be interpreted as the ease of damage that occurs on small islands. The level of vulnerability of each type of hazard analyzed is the frequency, magnitude, and losses resulting from the types of hazards that exist. The frequency is considered to be an indicator to determine the potential for disasters that can be caused. The magnitude is considered to be an indicator of vulnerability to determine the extent of the damaged area. Losses are assessed as costs incurred as a result of the damage incurred. The results of the vulnerability level are presented in figure 3.

Vulnerability is the tendency of an entity to experience damage, thus the vulnerability of small islands can be interpreted as the ease with which a system of small islands can be damaged [14]. Based on the picture of the level of vulnerability in Harapan Island, Kelapa Island and Kelapa Island Two frequencies of all types of hazards are included in the low category. On the indicator the magnitude and losses caused by hurricanes are higher than other hazards. The level of losses due to disasters depends on the frequency

![Figure 4](image-url). The result of the capacity level in three island.
of occurrence, and the area exposed [15]. Although the frequency of hurricanes tends to be low, ranging from 1-2 times a year, the area exposed is quite large. This is due to the characteristics of small open islands, with flat land forms dominated by settlements [16].

3.3. Capacity level
Capacity is a combination of existing community, social or organizational capabilities and can reduce the impact of disaster risk [17]. The Adaptation Capacity from the risk potential study conducted on 3 small islands namely Harapan Island, Kelapa Island and Kelapa Dua Island which were studied included: Availability of clean water, Community understanding signs of disaster, availability of waste disposal, Community and tourists care about the cleanliness of the location [18]. These four indicators were chosen as an effort to reduce the hazards that have an impact on small islands due to waves, abrasion, hurricanes, and waste. The results of the capacity level are presented in figure 4.

Vulnerability can affect the island's ability to adapt to changes that occur. One thing that can be done to reduce vulnerability in small islands is to increase adaptive capacity [19]. The capacity of the availability of clean water on the three islands is included in the very good category, this is due to the availability of WWTP (Wastewater Treatment Plant) facilities on Harapan Island and Kelapa Dua Island. The availability of clean water in Kelapa Island depends on Harapan Island WWTP, with the area of Kelapa Island being larger than Harapan Island, some people think that the available water is sometimes not very good. This causes the score of clean water availability in Kelapa Island is not as high as Harapan Island and Kelapa Island. In addition, the reason why the WWTP (Wastewater Treatment Plant) facility was not built on Kelapa Island is because of the high cost of operations in small island areas with high salinity, which can lead to shorter tool life [20].

The availability of landfills on the three islands is in the very good category. The number of trash cans is large, there is a bank waste on Harapan Island, as well as the role of Pokdarwis in improving tourism services and increasing tourist awareness of the cleanliness of the island [21]. In addition to Pokdarwis, the role of the Thousand Islands National Park is also very important in socializing to the public to maintain the cleanliness of the island, this is in line with the indicators of community and tourist concern for the cleanliness of the islands in the three islands getting quite high scores [22].

3.4. Risk of the small island
Based on the overall results of both potential hazards, vulnerability level, and the level of capacity showed potential disaster risks in Harapan Island, Kelapa Island and Kelapa Dua island as follows. The results of the disaster risk are presented in table 2.

Based on the results in table 2 the potential risks derived from the average of danger is multiplied by the mean. The average vulnerability is then divided by the average capacity. Harapan Island, Kelapa Island, and Kelapa Dua Island have a hazard level of 1.40, 1.32, and 1.35, respectively, with a vulnerability level of 1.37, 1.28 and 1.31 respectively. The capacity levels of each island are 2.78, 2.5, and 2.88. The risk levels in Harapan island, Kelapa island, and Kelapa Dua island were 0.69, 0.68, and 0.62, respectively. This shows that the results of disaster risk in Harapan island, Kelapa island and Kelapa Dua island are in the low category.

| Location         | Hazard | Vulnerability | Capacity | Risk |
|------------------|--------|---------------|----------|------|
| Harapan Island   | 1.40   | 1.37          | 2.78     | 0.69 |
| Kelapa Island    | 1.32   | 1.28          | 2.5      | 0.68 |
| Kelapa Dua Island| 1.35   | 1.31          | 2.88     | 0.62 |
4. Conclusion
The potential for disaster on Harapan Island, Kelapa Island, and Kelapa Dua Island is in the moderate category. This is because there is only one type of hazard that has the potential to cause disaster, it’s hurricane. The highest vulnerability values in the three island are also caused by hurricane. The availability of clean water in Harapan Island, Kelapa Island, and Kelapa Dua Island is included in the high category, so that it can support the needs of the surrounding community. The risk value on Harapan Island is 0.69, on Kelapa Island is 0.68, and Kelapa Dua Island is 0.62. The difference in risk values in the three Island is due to the different values in vulnerability and capacity. So that the results of the disaster risk level in Harapan Island, Kelapa Island, and Kelapa Dua Island are included in the low category.

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