The Marxan model for determining no-catch zones based on conservation targets in the north-eastern region of Simeulue District

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Abstract. Aceh Governor’s Decree Number 523/1297/2018 concerning the Determination of Reserve Reservation for Aceh Waters allows Pinang, Siumat and Simanaha Islands (PISISI) in the northeast region of Simeulue Island to become one of the conservation zones that have a no-take zone. Therefore, it is necessary to have a scientific analysis of the management and zoning plan especially in determining the location of the core zone (no-take zone). Determination of the core zone is the most important part in planning to protect coastal areas as a form of sustainable management of fish resources and the environment. The purpose of this study is to determine the location of no-take zones based on conservation targets that have high biodiversity values in the PISISI area of Simeulue Island. Therefore, the Marxan model is used which is a design plan for the conservation zoning design. The analysis shows that there are eight areas that can be used as a no-catch area based on coastal habitats, biodiversity, and high conservation value. The model results indicate that no-take zones will be able to protect 80% of conservation targets. Simulation results also show that the area of the no-take zone is around 2,283.89 ha.

1. Introduction
Residents in the areas of Pulau Pinang, Siumat and Simanaha (PISISI) in Simeulue Regency, Aceh, Indonesia are mostly fishermen who use the waters for fishing, fish farming, sea transportation and marine tourism [1]. The high utilization made by the community is believed to disrupt biodiversity and ecosystem resources. Utilization has the potential to threaten existing resources because the community exploits these resources for their survival. The area of PISISI are utilized by small-scale fishing communities. They are an important part of the economy of coastal communities as traditional
fishermen. Small-scale fishing is an alternative employment opportunity [2] as well as an inseparable part of coastal culture [3].

The extent of the PISISI conservation area requires a high selective and effective way to determine no-take/catch zones [4]. To optimize the PISISI area that has been reserved, it is necessary to have integrated strategies to the management plan specifically to determine no-catch zones. Determination of the no-take zone is the most important part in planning based on Ministerial Marine and Fisheries Regulation No. Per.30/MEN/2010 to protect coastal areas as a form of sustainable fisheries resource management. PISISI area is one of marine protection areas (MPA) that has ecological data from the survey results by Fauna & Flora International so that it is better prepared to be managed compared to other MPAs in Simeulue Regency.

One strategy to reduce pressure on coastal ecosystems is to have a conservation area with a no-take location in the right location. In addition, effective management can provide many benefits such as increasing the size, abundance, diversity, and biomass of fish [5][6], improving/increasing fish stocks through larval dispersal from MPAs [7] and increasing coral reef resilience [8]. The existence of a no-catch zone can also increase the yield of small-scale fisheries production in the medium to long term [9][10] and restore overpopulated fish populations [11].

Systematic conservation planning is an approach used to design conservation areas that meet biodiversity targets [12]. The application of this approach in practice is supported by a lot of software, one of which is Marxan. Marxan (Marine Reserve Design Using Spatially Explicit Annealing) has been used in more than 180 countries to design conservation areas both on land and at sea [13]. Marxan is the most widely used conservation zoning design planning software in the world [14].

Marxan with zoning is a software based on geospatial information systems that is recognized and trusted to design zoning based on conservation criteria in accordance with its designation. Marxan has been widely used in several countries, one of which is Indonesia in the need to determine the MPA [15]. Marxan is often used as a decision support tool that can provide several zoning options for biodiversity conservation. Marxan also algorithmically analyzes ecological aspects to protect biodiversity and minimize negative social impacts by accommodating socio-economic aspects [10] that ultimately resulted in recommendations for areas suitable for core production at a low cost. This Marxan has also been used to design conservation areas in Marine Park, Europe and in Indonesia [16], [17].

Therefore, it is highly appropriate to use Marxan software for the sake of conservation by determining no-fishing areas in one area. The purpose of using Marxan in this study is to determine the location of no-take zones based on conservation targets that have high biodiversity values in the PISISI KKP Regency of Simeulue.

2. Materials and Methods
2.1. Data Collection
The research was conducted through several stages of activities namely preparation and data collection, Marxan analysis, core zone size analysis, and field activities. The study was conducted on Simeulue Island as shown in Figure 1. Data and information that was used as material in this study were compiled from various related agencies which included spatial data and attributes in the form of 1:50,000 Fine Maps. Digital administrative boundary maps were used as basic material for making map layers, distribution of coastal ecosystem habitat data, descriptive editorial data or tabulation and biodiversity data.

2.2. The Marxan Model
This study uses Marxan as a tool to help determine zoning. The data used by Marxan are in the form of spatial data of conservation targets, costs and planning units. The data is then used as input for Marxan according to the needs and requirements for determining the core zone [18].
2.3. Planning Unit / Area of Interest (AOI)
The planning unit is the basis for Marxan in analyzing where each feature to be analyzed must be spatially limited [19]. This planning unit will also be the basis of Marxan's calculations to determine the core zone after the unit was inputted as a conservation target and cost data.

2.4. Conservation Targets
The conservation target in Marxan's input is the ecological parameters that will be protected in the form of the distribution of important habitats of coastal ecosystems by inputing High Conservation Value (HCV) [20].

3. Result and Discussion
3.1. Coastal Habitat (Coral and Mangrove Reefs)
The extent of the study area used in the analysis of the no-take zone is 44,404.10 ha. This area includes coral reef habitat and seagrass habitat (Figure 2). Most of the mangrove habitats are in the mainland so that all are not included in the study area. The area of coral reef habitat in the PISISI MPA is 6748.55 ha and the mangrove area is 50.08 ha. Data on the distribution of coastal habitats was obtained from the Geospatial Information Agency.

Figure 1. Study area in the northeastern region of Simeulue Island

Figure 2. Distribution of Important Coastal Habitats Based on a BIG Study
3.2. Location of High Biodiversity Value / High Conservation Value

The results of an ecological survey conducted by FFI in 2018 at the PISISI MPA were 17 observation points (Figure 3) and the results of the Marxan analysis are shown in Figures 4 and Figure 5. This ecological survey is intended to find out which locations have high biodiversity values, in accordance with the no-capture zone design scenario in this study.

The cost values that exist in PISISI KKP are presented in Figure 6 which concerns aspects of the shipping channel, estuary, and rubble cover (Rubble Cover). This shipping channel is used for the benefit of passenger ports and cargo and one of the human activities that have an impact on the survival of larvae and juvenile marine biota, which can be disrupted by sea waves caused by ships and carried by ship water ballast [16]. Furthermore, the river mouth as one of the producers of sedimentation is one that can cause damage to an ecosystem. The effect of this sedimentation results in death of coral reefs during the coral recruitment process [21].

Sedimentation can also make coral polyps be closed so that zooxanthellae that are symbiotic with corals do not get chlorophyll intake which will make the corals die. Sedimentation area is obtained from the digitization on the screen that has been done. In addition, the highest coral fault cover is found in Gosong Sambai, Gosong Batee Dua, Gosong Air Manis, Pinang Island, Babi Island and Gabui Island. Coral fracture is a result of waves and currents and also cannot be used as a substrate for new coral recruitment [22].

3.3. No-catch Zone Locations

Based on the results of the Marxan analysis in accordance with the scenario that has been made that the red colour in Figure 6 is the best solution showing the best no-catch zone. The area was chosen based on the results of Marxan which is 733.97 ha, which is divided into 8 sections in total. In general, Marxan has met the target in accordance with the initial planning in the scenario both in habitat area, HCV location priority. The area chosen by Marxan is evenly distributed starting from the western area of the study area to the eastern area of the study area. Then in this analysis process, Marxan has done 100 times of repetition (number of iterations) where the results get the same results (stagnant).
Figure 4. Location of (a) fish abundance, (b) diversity, and (c) biomass that is high in the Marxan model
(a) Coral cover

(b) Coral recruitment

**Figure 5.** The location of (a) coral cover and (b) coral recruitment that is high in the Marxan model

**Figure 6.** The Area Selected by Marxan, which is the best location for a no-take zone
4. Conclusions
The Marxan model applied in the KKIS PISISI Simeulue District based on conservation targets resulted in 8 no-take zones. The zoning results are based on the application inputs of mangrove coastal habitat, coral reefs, and locations with high biodiversity.

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