Small island development based on the capture and mariculture feasibility at three islands in Kepulauan Seribu

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Abstract. Kepulauan Seribu consists of small islands that have enormous fishery potential that can be a fisheries investment. The existence of investment in fisheries business by considering the carrying capacity is expected to ensure the results of capture fisheries or mariculture production from fishery businesses, which can affect the needs of the Kepulauan Seribu citizen. The purpose of this study is to analyse the carrying capacity of fishery business investment in Kepulauan Seribu with a business feasibility method approach so that it can be carried out sustainably. The research method was built by survey and observation with a feasibility study and multi-criteria analysis. The main potential of capture fisheries in Harapan Island, Kelapa Island, and Kelapa Dua Island are tuna, yellowtail fish, and squid, while mariculture product is grouper. Capture fishery or mariculture activity at the research location has met the investment criteria to be feasible. Capture fishery and mariculture activity in Kelapa and Harapan Islands have the better carrying capacity for investment based on ecological, economic, and social aspects. Therefore, the development of Kepulauan Seribu must be carried out based on the feasibility of development and investment by considering the community's ecological, economic, and social aspects.

Keywords: carrying capacity, fishery business, investment, Kepulauan Seribu, small islands.

1. Introduction
Kepulauan Seribu is part of the territorial waters of DKI Jakarta, which is directly connected to Jakarta Bay. Based on Local Government Regulation DKI Jakarta No. 1986 of 2000, Kepulauan Seribu consists of 110 islands which are divided into 6 administrative regions, and 11 of them are inhabited, namely Untung Jawa Island, Pari Island, Lancang Island, Tidung Besar Island, Tidung Kecil Island, Pramuka Island, Panggang Island, Harapan Island, Kelapa Island, Kelapa Dua Island, and Sebira Island. The area of Kepulauan Seribu is approximately 108,000 Ha [1]. Kepulauan Seribu consists of small islands that have huge fishery potential. The potential for fisheries resources in the Thousand Islands is dominated by reef fish, pelagic and mariculture resources. This is because the condition of the waters is determined by the distribution of coral reef ecosystems [2].

Fisheries business carried out in Kepulauan Seribu are mariculture and capture fisheries. Mariculture activities highly developed in Kepulauan Seribu are seaweed cultivation, grouper, rabbitfish, shellfish, and sea cucumber cultivation. Seaweed cultivation is mainly carried out on inhabited islands, while other cultivation businesses use floating net cages [3]. In addition, there are capture fisheries activities.
in Kepulauan Seribu, namely tuna, yellowtail, pomfret, kiete, mackerel, and squid [4]. According to the Jakarta Marine Department, reef fish production has decreased while mariculture production has increased from 2017 to 2019. The marine fishery is the main potential business for Kepulauan Seribu to meet economic needs. In addition to improving Kepulauan Seribu, it can positively affect the DKI Jakarta government's economy.

The fishery business in Kepulauan Seribu is very potential to be developed, but has a fairly high vulnerability due to wind waves and tides. Environmental and ecosystem damage has occurred in the last few decades. The integration of ecological functions for fishery business development is very important to avoid negative impacts as access to fishery activities [2]. Carrying capacity is the maximum intensity of resource use that sustainably takes place by considering the balance of existing resources. The ability of an area to produce fish biomass by taking into account the time, area, and fishing environment is called the carrying capacity of the fishery. Kepulauan Seribu, as one of the small islands in Indonesia, has potential beauty that can be developed as a fishery investment. The presence of investors does not only determine the carrying capacity of investment in an area, regulations in the community can also determine it to provide services or facilities to potential investors [5].

Investment activities need to pay attention to initial costs according to the needs of each business actor. The investment value is IDR 68,967,333 can meet the needs of operational costs, planting costs, and variable costs in capture fisheries activities [6], during the investment value of IDR 24,600,000 can meet the beginning capital for grouper mariculture activity in Kepulauan Seribu [7]. Investments in fishery businesses are expected to ensure that capture and mariculture production results from fishery businesses can influence the needs of Kepulauan Seribu or DKI Jakarta by paying attention to social and economic needs aspects. Therefore, it is important to conduct research to analyze the carrying capacity of fishery business investment by taking into account time, area, and environment so that fishery business can be carried out in a sustainably. This study aims to analyse the carrying capacity of fishery investment in Kepulauan Seribu with a feasibility study to be carried out sustainably.

2. Material and Methods
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 fishers and cultivators. Secondary data were obtained from literature studies and data from the DKI Jakarta Environmental Agency. Primary data is needed to analyse feasibility study and investment support capacity of fishery business. To calculate the business feasibility analysis using several variables, namely business profits, Benefit-Cost Ratio (B/C), Net Present Value (NPV), Internal Rate of Return (IRR), and payback period, this calculation uses the formula from Umar (2013) [8].

Data were obtained through interviews and questionnaires with respondents. This research were analysed using the feasibility study for analysing investments fishing effort to approach economic viability or financial and analysis of multi-criteria analysis (MCA) was used to determine the carrying capacity of business investment fisheries. The feasibility study analysis data includes investment and costs (income and expenditure), while the analysis data on the carrying capacity of fishery business investment results from interviews with questionnaires and direct observations in the field.

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. Multi-Criteria Analysis (MCA) was an approach used to analyse problems by involving various criteria. MCA analysis has advantages when applied in stochastic and complex systems such as fisheries management. The MCA approach was simple, transparent, and intuitive, although it has strong technical and theoretical support in its procedures [9]. In this study, the MCA approach is used to assessed and evaluated fishery business indicators regarding the degree of importance and conditions related to several conditions in the future.
The criteria used in the study consisted of three criteria, namely Harapan Island, Kelapa Island, and Kelapa Dua Island, comparing the carrying capacity of fishery businesses that took into account ecological, economic, and social aspects with a feasibility study.

3. Results and discussion
The carrying capacity of fisheries business analysis uses the approach that nature has a maximum limit for human use over a long period of time. Fisheries business carried out on Harapan Island, Kelapa Island, and Kelapa Dua Island consists of capture fisheries and mariculture. The investment carrying capacity criteria can be assessed by considering three aspects, namely ecological, economic, and social aspects. The analysis results are seen based on calculating weights and scores using the SIC formula by Mendoza and Prabhu [10].

3.1. Capture fisheries investment
Capture fisheries activities on the three islands have relatively the same characteristics. There are three types of fishermen based on fishing time: daily, weekly, and monthly fishermen. The most commonly used fishing gears are traps and fishing rods. The fishing locations are primarily carried out in Kepulauan Seribu, with the target types of fish caught being yellowtail fish, tuna, and squid. The results of the assessment of weights and scores based on the questionnaire are shown in figure 1.

The capture fisheries business on Kelapa Island for the ecological and economic aspects has a total high value compared to the other two islands, namely 3.51 and 2.77. In contrast, for the social aspect, Kelapa Island has the smallest total value (3.10). The score was obtained because the water quality of Kelapa Island follows the water quality standards for marine biota are the brightness of the waters above 5 m, having water temperatures ranging from 28°C-30°C, the waters having a pH of 7-8.5, salinity of 33-34 ppm, and dissolved oxygen content above 5 mg L⁻¹ [11]. Environmental quality as an ecological aspect is the main point in fisheries business so that fishery resources can be used sustainably [12]. Capture fisheries activities on Harapan Island, Kelapa Island, and Kelapa Dua Island by social aspect are quite influential for the economy of the island community. However, when viewed from the fisherman's overall income, this opinion is quite a small income. If the ship consists of 7-8 fishers, the income must be divided according to the number of fishers. Catch from the three islands is sold chiefly...
on each island itself or taken home as food for the family. Besides being sold on the island, some of the fish caught are sold in Jakarta.

The results of business feasibility support the calculation of economic aspects. Business activities have expenses and income. Expenditure costs consist of investment, operational, and maintenance costs. In capture fisheries business activities, investment costs consist of vessels, machines, and fishing gear. The most considerable investment cost incurred is the cost of the ship. According to Nasution and Hutauruk [13], ships can be aged up to 8-12 years to be reinvested within a particular time. The catch greatly influences entrance fees on each trip. Based on interviews with fishers, the average frequency of fishing trips on Harapan Island, Kelapa Island, and Kelapa Dua Island is 160 trips in one year. Weather factors strongly influence the implementation of the trip. The average weight of tuna catches reaches 17 kg per trip with a selling price of IDR 35,000 per kg. The average weight caught by yellowtail fish reaches 8 kg per trip with a selling price of IDR 20,000 per kg, while squid reaches 5 kg per trip with IDR 35,000 per kg. The increase in catch is influenced by the maintenance of population stocks in line with the achievement of ecological, social, and economic goals [14].

The results of the assessment of weights and scores are based on the questionnaire of capture fisheries business.

Figure 2. The results of the assessment of weights and scores are based on the questionnaire of capture fisheries business.

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The results of the calculation of business feasibility are in table 1. The assessment results of the economic aspects of capture fisheries are influenced by several variables, namely the number of captured biota, investment capital, investment profit, and total production. Based on the profit, the total value of revenue is greater than the total investment cost, so the business is feasible. This study uses a discount rate of 3.75%, an interest rate determination from Bank Indonesia. The average NPV for the three islands is positive, therefore capture fisheries business is feasible based on the value of net income [15]. The IRR value for the fishing business on Harapan Island, Kelapa Island, and Kelapa Dua Island is worth more than the interest rate set by the bank, which is 3.75%. This result indicates that fishers can repay loans so that the business is feasible to run. The B/C value for the three islands has a positive value, indicating a profitable business investment and can cover the costs incurred for the business. Based on the value of the payback period or the time required for the return of investment capital [8], capture
The cultivation area of mariculture also pays attention to the area so that it can be appropriately utilized. The cultivation area of one hectare can be used effectively for 20 floating net cage units or 5% of the ideal area [19]. Currently, cultivators from the three islands are still using less than 5% of the ideal area.

### Table 1. The result of calculation feasibility study of capture fisheries in three islands.

|                      | Harapan Island | Kelapa Island | Kelapa Dua Island |
|----------------------|----------------|---------------|-------------------|
| Total Investment Cost (IDR) | 17,800,000     | 12,900,000    | 14,100,000        |
| Business Profit (IDR)     | 20,600,000     | 31,520,000    | 30,080,000        |
| NPV (IDR)                | 63,868,878     | 93,912,412    | 80,656,515        |
| IRR (%)                 | 67             | 54            | 42                |
| B/C Ratio               | 3.48           | 2.98          | 2.49              |
| Eligibility Status      | Eligible       | Eligible      | Eligible          |
| Payback Period (Years)   | 0.9            | 0.4           | 0.5               |

fisheries businesses in the three islands have less than 1 year, meaning that fishers do not need long to return their capital. Kelapa Island has the fastest payback period compared to the two islands, which is 0.4 years with a profit of IDR 31,520,000 and the total production reaches more than 1000 kg per year. Based on the economic aspect, Kelapa Island has a high value to be used as an investment for capture fisheries business activities.

The analysis of carrying capacity of capture fisheries business investment using multi-criteria analysis in figure 2 shows that Kelapa Island based on carrying capacity is better for fishery business investment than the other two islands. Currently, fishers from Harapan, Kelapa, and Kelapa Dua Islands already have a fishing group called Fisheries Area Access Management (PAAP) which Kepulauan Seribu National Park manages. Fishers are taught to use logbooks to record daily catches by entering fishing locations, the results of which are expected to know the direction of fish migration. However, the PAAP group is less than optimal in managing income and improving the skills of fishers.

### 3.2. Mariculture investment

Cultivation activities on Harapan Island, Kelapa Island, and Kelapa Dua Island are floating net cages with different cultivation methods for each farmer. The floating net cage cultivation technique is widely used because it is relatively easy to do. After all, fish are kept at a high-density level without worrying about the quality of oxygen in the water. The results of the calculation of the weight and score of the mariculture business are presented in figure 3.

In addition, to capture fisheries activities, mariculture activities need to pay attention to water quality to determine the success of mariculture. The brightness of the waters for mariculture activities should be more than 3 m [11]. The water brightness for Harapan and Kelapa Islands has a value of more than 3 m, while Kelapa Dua Island has a brightness value below the criteria of 2 m. In addition to brightness, current velocity significantly affects cultivation activities because too large a current velocity will damage the cage media [16]. The ideal current velocity for cultivation activities is 0.15-0.30 m s⁻¹ [17]. The results show that the three islands have less than ideal current speeds because they are below the criteria. These results also show that the waters of the three islands are quite calm. The water temperature of the three islands shows the optimum temperature for the growth of cultured fish, which is 27°C-32°C [18]. The salinity of the waters indicates that they have good salinity levels with tolerances by the quality standards of marine mariculture activities, which are around 30-34 ppm. Salinity greatly affects the level of production of mariculture activities. If the salinity is not suitable, there will be disturbances to the growth and balance of the fish body. The floating net cage area is not recommended to be close to the mainland because the area can be contaminated with freshwater, affecting salinity levels [16]. Cultivation activities also pay attention to the area of the area so that it can be appropriately utilised. The cultivation area of one hectare can be used effectively for 20 floating net cage units or 5% of the ideal area [19].
for cultivation. So based on the ecological aspect, Kelapa Island has the highest value compared to the two islands, so it is better for mariculture investment.

The results of the analysis of social aspects for the three islands relatively have the same value. Cultivation activities have not significantly affected the economic viability of the island community. For some cultivators who have not yet found a market for selling their cultivated crops, some cultivators sell their cultivation products to collectors or restaurants on their island. According to one cultivator on Harapan Island, harvested products are usually sold to Muara Karang. However, due to Covid-19, the market does not want to accept cultivation results due to health protocols. Although, according to one of the cultivators in Kelapa Island, they already have a foreign market, namely sales to Hong Kong.

**Figure 3.** The result of multi-criteria analysis of capture fisheries in three islands.

**Figure 4.** The results of the assessment of weights and scores based on the questionnaire of mariculture business.
answer from cultivators shows that market information is not evenly distributed among cultivators, so that they only act as price recipients [20].

The cost of assembling a floating net cage is the largest investment cost compared to feed and seeds. The difference in investment costs on the three islands is influenced by the number of holes or the size of the floating net cage. On average, harvesting activities on Harapan Island, Kelapa Island, and Kelapa Dua Island are carried out every 6 months so that in a year, the cultivator does 2 harvests. At the same time, there are other harvesting techniques, namely harvesting activities within 8 months, 12 months, and 14 months due to using naturally caught seeds. The average total production in Harapan Island is 200 kg per type of fish per harvest. Types of cultured fish consist of coral grouper with a selling price of IDR 200,000 per kg, brown-marbled grouper with a selling price of IDR 70,000, giant grouper with a selling price of IDR 50,000, black kwaci grouper with a selling price of IDR 30,000, and star pomfret fish with a selling price of IDR 70,000. Kelapa Island has a total average production of brown-marbled grouper of 80 kg with a selling price of 60,000 per kg. In comparison, Kelapa Dua Island has an average total production of 60 kg of brown-marbled grouper with a selling price of 70,000 per kg. The results of the calculation of the business feasibility of mariculture activity are in table 2.

The feasibility analysis results of the mariculture business of Harapan Island, Kelapa Island, and Kelapa Dua Island have a feasible status based on investment criteria. The three islands have NPV values with positive results, but Kelapa Dua Island has the largest value, which is IDR. 23,144,172. The number of NPV shows that cultivation business activities have a benefit of IDR. 23,144,172 so that the business

|                      | Harapan Island | Kelapa Island | Kelapa Dua Island |
|----------------------|----------------|---------------|-------------------|
| Total Investment Cost (IDR) | 13,000,000     | 12,500,000    | 3,700,000         |
| Business Profit (IDR)  | 10,560,000     | 9,040,000     | 6,920,000         |
| NPV (IDR)             | 17,743,245     | 15,288,687    | 23,144,172        |
| IRR (%)               | 19             | 19            | 77                |
| B/C Ratio             | 1.60           | 1.61          | 3.94              |
| Eligibility Status    | Eligible       | Eligible      | Eligible          |
| Payback Period (Years)| 1.2            | 1.4           | 0.5               |

Figure 5. The result of multi-criteria analysis of mariculture business in three islands.
is feasible to run. The IRR value of the cultivation business of the three islands is greater than the bank interest rate of 3.75%, so that the business is said to be feasible. The IRR value shows the percentage value of the return on capital used in the cultivation business. The three islands have a positive B/C value indicating a profitable business investment. Kelapa Dua Island has a payback period value of 0.5 years, while Harapan Island and Kelapa Island have 1.2 years and 1.4 years. The result of payback period shows that Kelapa Dua Island only takes 6 months to return the investment costs. So based on the economic aspect, the cultivation of Harapan Island is suitable as an investment.

The results of the multi-criteria analysis of mariculture investment in figure 5 indicate that Harapan Island has a better carrying capacity. Currently, some cultivators make mariculture activities as a sideline when they are not at sea because the market for cultured fish is not as large as that of caught fish. These results are expected to be considered for investors or the government to provide capital for fishers. They can be used as consideration for related institutions to provide training or find a market for cultivators. The pattern of community and investor involvement must be planned from the start [21].

4. Conclusion
Fisheries businesses on Harapan Island, Kelapa Island, and Kelapa Dua Island are capture fisheries and mariculture. The business can be an investment with three aspects, namely ecological, economic, and social. Based on the analysis of investment carrying capacity, Kelapa Island is better supported to invest in capture fisheries and Harapan Island to invest in mariculture based on ecological, economic, and social aspects with score 3.09 and 2.53. Fishing and mariculture in Harapan Island, Kelapa Island, and Kelapa Dua Island are feasible because they meet the investment criteria. Therefore, the development of Kepulauan Seribu must be carried out based on the feasibility of development and investment by taking into account the community's ecological, economic, and social aspects.

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