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Article

Environmental Suitability for Sea Ranching Harvest Type of Sandfish Sea Cucumber *Holothuria Scabra* Jaeger 1833 in Karimunjawa National Park, Indonesia

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Abstract: *Holothuria scabra* Jaeger 1833, known as sandfish visually, Its visible external body has a soft, flexible texture. Sandfish is included in the Echinodermata phylum and Holothuroidea class, which has an important ecological and economic role. This research proposes to decide the suitability site in an intermediate culture model of sea ranching harvest type based on ecological, socio-cultural and Karimunjawa National Park zoning plan. Data collected has done in March 2020, November 2020 and August 2021. The data analysed on the environmental suitability level was based on several essential criteria matrices used by ArcGIS 10.8.2. They were four classes performed (high suitable, suitable that is enough, suitable with conditionals, and not suitable) based on each variable and matrix classification from main factor (6 variables), supporting factor (5 variables), dan another factors (1 variable). The highest score was 35, and the lowest was 23 during the class interval value. The analysis showed that the aquatic environment that was High Suitable (S1) for sandfish life was Gede Lagoon. It has been determined to be highly suitable for developing sandfish cultivation. Furthermore, the Sea Ranching Harvesting Type development would recommend being carried out in waters that do not have limiting factors.

Keywords: sea cucumber; enhancement; Holothuria scabra; sea ranching

1. Introduction

Sandfish sea cucumber (*Holothuria scabra* Jaeger 1833), known as *Holothuria scabra*, is known to be sandfish visually. Its visible external body has a soft, flexible texture and its elongated body shape is like a cucumber [1]. Sandfish is included in the Echinodermata phylum and Holothuroidea class, which has an important ecological and economic role. Ecologically, the sandfish area is included in the food web and is a deposit feeder, so it can process the substrate it occupies [2]. Sandfish distribution can be found in almost all marine environments (from the intertidal zone to the deep sea) [3]. From an economic point of view, sandfish is one of the marine biotas with high economic value for export commodities. So, in some areas, sea cucumbers are becoming one of the coastal communities' livelihoods. In dry conditions, the sandfish contains 82% protein, 1.7% fat, 8.9%

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water, 8.6% ash, and 4.8% carbohydrates [4,1]. Sandfish's superiority as a raw material creates high demand in local and foreign markets.

The Food and Agriculture Organization (FAO)'s information explained that Indonesia is one of the largest exporters of sea cucumbers [5,2]. The average production of sea cucumbers from Indonesia from 1992 to 2002 was 2,556 tons of dry weight [2]. In the period 1992-2002, Indonesia's production was higher than the average annual production value in the Philippines, with about 1,686 tons dry weight per year, United States (1,301 tons dry weight per year), Papua New Guinea (1,115 tons dry weight per year), Tanzania (1,044 tons dry weight per year) and Madagascar (1,006 tons per year) in the same period of the year [6,2]. The dried products are the highest economic value in the international sea cucumber, especially the sandfish product market. According to [8], the sales value of dried in the domestic market reaches Rp. 750,000.- /kg. Meanwhile, the selling price of dry sandfish sea cucumbers in the international market reaches ± USD 33 - 47 per kg for the Vietnam region, ± USD 42 - 88 per kg (in the Philippines). ± USD 60 - 110 per kg in the New Caledonia region, the price of sea cucumbers [7,8]. The market price of dry sandfish in the Guangzhou area was ±108-$200 dollars per kg, while the retail price in the Hong Kong area was ±115-1,668 dollars per kg [9], while the European region ranges from EUR 43 to EUR 348 per kilogram (dry weight product). According to [10,3], the price of sea cucumbers such as *Holothuria (Metriatyla) scabra*, Jaeger 1833 in Europe of the market is sold at a market price of USD 1800 (EUR 1593) per kilogram.

The sandfish (*Holothuria scabra*) production potential in Indonesia is still based on the potential for fishing production in the wild. If this happens continuously without paying attention to sustainable fishing efforts, it is feared that it will lead to overfishing. Several studies showed that many sites with fishing efforts on sea cucumbers, in particular sandfish sea cucumber *Holothuria scabra*, namely West Sumatra, Lampung, Thousand Archipelago, Maluku, Karimunjawa Archipelago Central Java, West Nusa Tenggara, East Nusa Tenggara, Sulawesi (Bunaken Island) and Maluku, showed stock conditions over-exploited status [11,12]. This condition was stated too by [13] that excessive fishing activities for sandfish in nature coupled with weak efforts for effective management strategies will result in a significant decline. It would be feared that shortly, the potential for sandfish in nature would decrease and become even scarce, as evidenced by the coastal area of Karimunjawa Island in the Karimunjawa National Park, Central Java [9]. This condition certainly requires alternative efforts to conserve the sandfish sea cucumber in nature so that it can be sustainable and sustainable, such as cultivation activities, seed augmentation from nature such as marine cultivation, environmental improvement and fishing regulations. The sandfish development in intermediate culture media and nature (grow out) requires aquatic ecological conditions consistent with their natural habitat. The site selection to obtain the location suitability for both propagations, restocking and enhancing (if the seed source is obtained from outside the intended site area) should take into account the capacity analysis result of the aquatic environment based on several essential criteria for the sandfish survival in nature. The aquatic environment suitability indicators use parameters, which are the limiting variables for sandfish survival and are based on the aquatic organisms' ability parameters. Sandfish can grow and reproduce naturally with quality standard values below the tolerances [14,15].

Fisheries enhancement technology implementation, in particular, the raw material of sandfish sea cucumber (*Holothuria scabra*) using the sea ranching harvest type is inseparable from 3 main factors, namely: a) the suitability of the water's location, b) social, economic and community cultural readiness, c) seed supply, and d) magnification technology. In the process, the sandfish introduction resource for the recovery technology requires support from several aspects, most notably the environmental, socio-economic and community cultural aspects. Threats to survival in both hatchery and breeding processes, aside from predators of starfish and crabs, the most common predators of sea cucumbers are sea urchins, and molluscs of the gastropod group are communities around the site as the biggest beneficiaries of the sea urchins' presence [16]. Environmental suitability not

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only ensures survival but also ensures the expansion process stability and the sandfish life cycle. Another thing that also threatens the sandfish's existence is the habitat degradation where they live. Habitat destruction means the loss of "home" and places to find food [17]. Based on environmental characteristics, this study was conducted to analyze a suitable site for the sandfish growing media using the sea ranching harvest type in the coastal area of Kemujan Village, Karimunjawa National Park. Processing analysis for suitable locations will be performed with spatial parameters using the Geographic Information System and multi-criteria analysis. This study result would like prospected to be an instance of a study for further research, especially in the case of analyzing the extent of suitability of areas in different coastal waters for *Holothuria scabra* Jaeger 1833 enhancement and conservation in the expansion phase before being released into the wild. Providing a larger size is suitable when released into the wild and is expected to allow the sandfish to survive natural predators. According to [18], larger sandfish tend to be safe from predators than small ones, and the natural mortality rate of sandish in the larval and juvenile stages may decrease with increasing body size.

2. Materials and Methods

2.1. Study site

Research sampling of data and information collected was conducted in March 2020 as the month representing the rainy season, November 2020 as the transitional season, and August 2021 is believed to represent the dry season. It refers to several studies from [19,20,21] that argued that the most critical indicator in determining suitable sea ranching sites for the Sandfish's cultivation and farming in the coastal area is to identify habitats. Base data and information to site selection chosen used closed waters model such as a lagoon. In contrast, the Sandfish often occurs naturally in protected waters in bays or lagoons. Several observation stations representing at 3 lagoons and outside area in Kemujan Village, Karimunjawa National Park, and Central Java are shown in Figure 1.

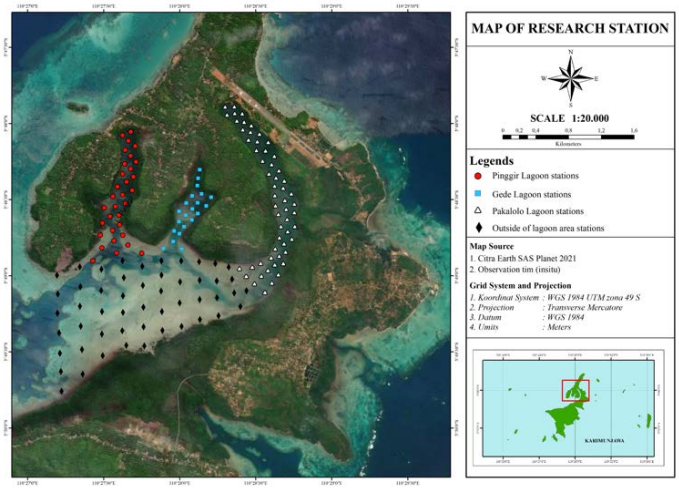

Figure 1. Location of research observation at 4 cluster areas in the Karimunjawa National Park, West Java, Indonesia

2.2. Data collection

The data and information collected through the stage were divided into 3, namely: a) direct data collection (in situ), b) collection of location information performed by FGD, and c) literature search to complete data and information so research objectives can be answered. Data collection is done by first determining the research station. Using GIS software, observation stations were randomly designed [22]. Research stations are chosen so that they can reflect the characteristics of the investigated waters. Field data collection

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was performed at 07.00-16.00 WIB at 157 stations. Water quality parameters were observed representing physical and chemical parameters (depth, sea surface temperature (SST), pH, DO, total dissolved solids (TDS), salinity and substrate). Supporting indicator data and information are generated from direct interviews and literature reviews. The use of data collection methods through FGDs refers to [23] explaining that Focus Group Discussions (FGD) are often used as a qualitative approach to gain in-depth social-cultural issues understanding. This method was intended to obtain data from individuals intentionally selected groups and not samples to represent the broader population statistically.

2.3. Data analysis

Water quality parameters analysis involves establishing a suitability matrix compiled through a literature review to see the limiting parameters required for cultivation and rearing activities. Water environment data before further analysis was performed by standardization. Standardization is a method of simplifying calculations where standardization is a dimensional expression that is converted to a non-dimensional expression and becomes a scale [24]. Conventional standardization methods were used to standardize parameters using standard deviation [25,24]. The data normalization technique used a range of 1 to 3 to convert all data from different scales to the standard scale [24]. Furthermore, the literature blinded the data normalization results in the suitability matrix form. The "high suitable" is with four scores (S1), the "suitable that is enough" class with three scores (S2), the "suitable with conditionals" is with two scores (S3), the "not suitable" given one score (N) [26], and base on the literature previously examined based on quality range value references. The following formula was used to determine class intervals and the sea ranching environment parameters' suitability value for marine cultivation [27,28]:

$$I = \frac{N_{max} - N_{min}}{\sum K}$$

Where: I is the class interval; K is the number of desired land suitability classes; N max is the Maximum end value; N min is the minimum final value. Further, the class intervals and suitability values are obtained based on the above formulas and calculations, as in Table 1.

Table 1. Environmental suitability parameters for sandfish sea cucumber habitat

No.	Parameters	Units	High Suitable	Suitable enough	Suitable with conditionals	Not suitable	Quality value reference
			S1	S2	S3	N	
A.	Main Factors						
1.	Depth	m	2 – 5	1.5 – 7	1.5 – 10	< 1,5 or >10	[29,30]
2.	SST	°C	30 – 33	26 – 29	22 – 25	< 22 or > 33	[29,31,32]
3.	pH	unit	0.1 – 8.6	7.6. – 8.0	< 7.5	< 0.1 or > 8	[29,30,33]
4.	DO	mg/L	6.1 – 9	4 – 6	< 4	< 4 0r > 9	[29,30,34,31]
5.	TDS	gr/L	15.1 – 30	3 -15	30,1-34	< 3 or > 34	[33,14]
6.	Salinity	‰	30.1 – 34	27 – 30	20-29	< 20 or > 34	[29,34,31]
B.	Supporting factors						
7.	Area protection*	-	good	sufficient	deficient	nothing	[35, 21]
8.	Area contamination	-	nothing	nothing	a few	there is	[36]
9.	Area safety	-	quaite safe	less safe	less safe	not safe	[36]
10.	Supporting facilities	-	good	moderate	sufficient	deficient	[37,9]

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No.	Parameters	Units	High Suitable	Suitable enough	Suitable with conditionals	Not suitable	Quality value reference
			S1	S2	S3	N	
11.	Local wisdom	-	there is	there is	a few	nothing	[8,9]
C.	Another attention factor						
12.	Land use	-	a lot of	moderate	a few	nothing	[38]

Note: Each value was developed and analyzed based on [8]; *) Map of the zoning plan by National Marine Park Karimunjawa (2012)

Further analysis was carried out for multi-criteria analysis to determine the location suitability stratification using the Analytical Hierarchy Process (AHP) [39,40]. [41] explains that AHP was used in multi-criteria decision-making problems in uncertain situations. All parameters from the factors of environment analysis variables are structured in an attributes AHP, and each attribute's relative importance was given a subjectively judged value. After completion, the AHP analysis would then be integrated to determine the overall ranking of each aquatic environmental suitability factor parameter [42,41]. Field data in the observation points form was converted to grid data. Subsequently, the inverse distance-weighted interpolation technique and distance analysis [22] in the ArcGIS desktop 10.8.2 program with the authorization number ESU238733964 (The Environmental System Research Institute (ESRI)) were used to convert the collected data, so that it used in spatial analysis (Figure 2).

Analysis of the geographic information system using tools was highly suitable for processing various variable criteria with different spatial and temporal scales from different sources for time-saving and cost-effective analysis [43]. The GIS-based multi-criteria decision analysis approach is practical because several production variables can be evaluated. Each is weighted according to its relative importance in aquatic environmental conditions based on environment quality standard criteria and refers to different references from previous research results. Each parameter multi-criteria was compared in pairs to form a matrix of each criterion level. The priority for each criterion was obtained by counting each matrix row number and dividing by the matrice total number. The sorting of the score matrix result was then layout in desktop GIS software.

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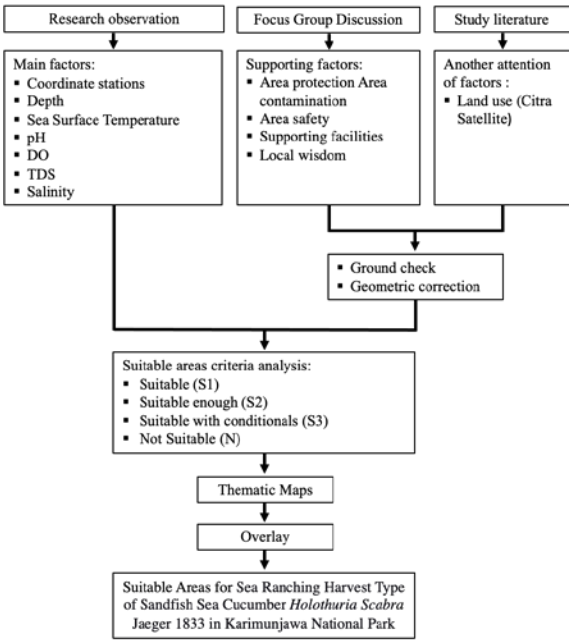

Figure 2. Determination flow chart of suitable areas for sea ranching harvest type of Sandfish Sea Cucumber *Holothuria scabra* using GIS software

3. Results

3.1. Main Factors

Parameters in this research observation were water quality as the main variables collected from 157 stations, including depth bathymetry, waters temperature, pH, dissolved oxygen, total dissolved solids and salinity related to the growing conditions for sandfish sea cucumbers to be grown. Living conditions determination is adapted to the water quality standards of sandfish sea cucumber cultivation. The direct results or direct observational studies show differences in values between each sampling point. The difference in values between 157 stations from 4 groups, namely Pinggir Lagoon (32 stations), Gede Lagoon (21), Pakalolo Lagoon (53 stations) and Outside area (51 stations), are then adjusted to each parameter quality standards. Quality standards use it more accessible to the habitat suitability scoring. The mean value with each parameter's standard deviation value is shown in Table 2.

Table 2. Environmental quality parameters value range at the research observation area in Karimunjawa National Park, Central Jawa

Parameters	Research Stations			
	Pinggir Lagoon	Gede Lagoon	Pakalolo Lagoon	Outside area
N (station)	32	21	53	51
Depth (meter)	0,50 - 1,10 ± 0,30	0,50 - 4,48 ± 0,11	0,50 - 4,00 ± 0,14	1,90 - 11,90 ± 0,69
SST (°C)	28,37 - 30,11 ± 0,08	29,65 - 30,52 ± 0,03	29,30 - 30,99 ± 0,03	29,51 - 30,12 ± 0,04
pH	7,30 - 7,78 ± 0,02	7,29 - 7,77 ± 0,02	7,31 - 7,73 ± 0,01	7,58 - 7,96 ± 0,03
DO (mg/L)	5,32 - 8,79 ± 0,20	3,25 - 7,22 ± 0,15	4,89 - 7,37 ± 0,07	5,14 - 7,37 ± 0,11
TDS (gr/L)	0,00 - 21,20 ± 1,22	18,60 - 21,40 ± 0,04	15,90 - 21,10 ± 0,11	19,990 - 21,00 ± 0,06
Salinity (‰)	0,00 - 21,73 ± 1,32	18,52 - 22,02 ± 0,06	15,47 - 21,71 ± 0,13	20,16 - 21,56 ± 0,08

The depths waters (bathymetry) stratification analysis results found that the depth range in 3 lagoons and outside waters area in the Karimunjawa National Park waters ranged from 0.50 to 11.72 meters. In contrast, the waters from the outside area to the sea

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ranged from 1.90 to 11.90 ± 0.69 meters. Figure 1a explains that a depth of > 5 meters can be seen from the mouth area of each lagoon. In contrast, the bathymetry is in the maximum lagoon at a depth of between 3.0 to 4.5 meters. The average depth value in closed waters sufficiently protected against waves and currents was 0.50 to 1.51 meters. Sea Surface Temperature (SST) range in Pinggir Lagoon ranges from 28.37 to 30.11 ± 0.08 °C, the SST range in Gede Lagoon ranges from 29.65 to 30.52 ± 0.03 °C, while in Pakalolo Lagoon, it is warmer than 2 other lagoons, which ranged from 29.30 to 30.99 ± 0.03 °C (Figure 3b). The pH in 3 Lagoons area and wetlands outside the lagoon resulted in a pH range value that showed no significant difference in Pinggir Lagoon, Gede Lagoon and Pakalolo Lagoon and Outside Area (Figure 3c).

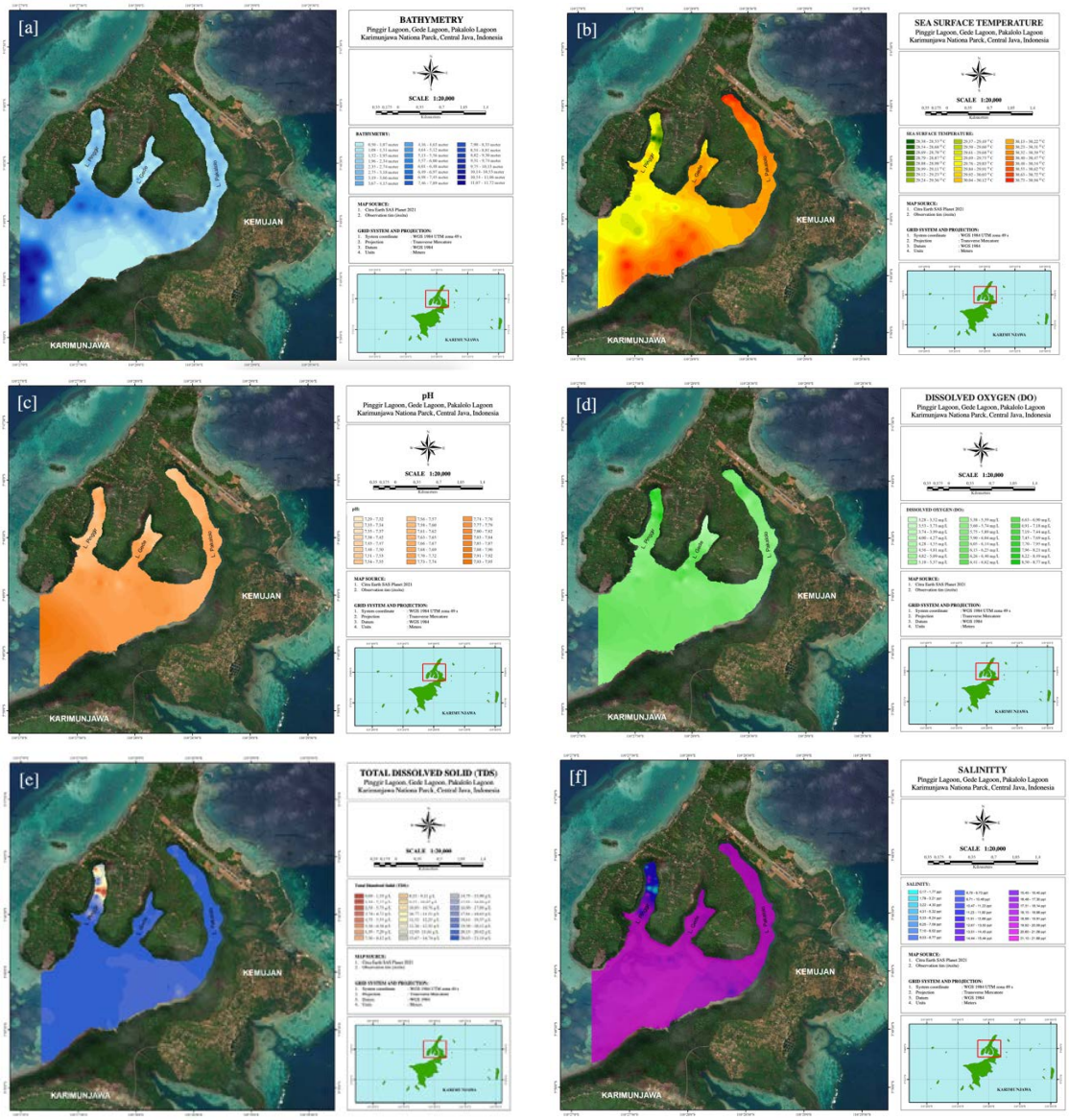

Figure 3. Water environment parameter distribution

The DO concentration range values of each lagoon, where Pinggir Lagoon ranged from 5.32 to 8.79 ± 0.20 mg/L, Gede Lagoon was 3.25 to 7.22 ± 0.15 mg/L, Pakalolo Lagoon was 4.89 to 7.37 ± 0.07 mg/L while in the waters from the mouth of each lagoon towards the sea the values varied between 5.14 to 7.37 ± 0.11 mg/L (Figure 3d). The TDS concentration in Pinggir Lagoon ranged from 0.00 to 21.20 ± 1.22 gr/L, in Legon Gede Lagoon ranged from 18.60 to 21.40 ± 0.04 gr/L, Legon Pakalolo was 15 .90 - 21.10 ± 0.11 gr/L while in the waters from the mouth of each lagoon to the sea, the value varies between 19.99 - 21.00 ± 0.06 gr/L (Figure 3e). The analysis results of the distribution of salinity

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concentrations in the three lagoons varied and found a significant difference among the three lagoons. The values results between Gede Lagoon and Pakalolo Lagoon resulted in a relatively similar range of values ranging from 18.52 to 22.02 ± 0.06 and 15.90 to 21.10 ± 0.11. In comparison, the range value in Legon Pinggir's waters ranged from 0.00 to 21.73 ± 1.32 (Figure 3f).

3.2. Supporting factors

Several data and information components during the FGD implementation focused on providing informational data for environmental suitability level analysis for placing the sea ranching harvest type as a medium for growing sandfish before release to the wild. The variables grouped as supporting parameters were collected based on the FGD results involving sea cucumber fishermen, village officials, fisheries extension officers and the Karimunjawa National Park manager. Another variable includes the zone area based on the Karimunjawa National Park's Map, pollution from community activities, area security, supporting facilities, and easy access to seed delivery, as well as the community supporting local culture to sandfish enhancement in the Karimunjawa National Park area.

a. The conservation area is a protected area when determining the breeding location in the coastal region. Locations not protected from wind, currents and waves can make setting up difficult. In addition, the unprotected place disrupts the marine animal's habitat.
b. The contaminated areas are coastal waters that are not polluted by waste, which is the main requirement for aquaculture activity, including sea cucumber cultivation. The Karimunjawa National Park waters are generally not contaminated as there is no industrial activity yet. At the same time, the waste from settlements is still small because the population is still small so it is still rapidly accumulated by the waters. The discussions and interviews results have led to the following points for attention:
    1. Pinggir Lagoon is an area that becomes a path for seaweed farmers on the outskirts adjacent to the Penaeus monodon cultivation area. According to local people in the Pinggir Lagoon water area, there is an unpleasant odour from the waste from shrimp farming.
    2. Gede Lagoon is an area that is well suited as a location for the sea ranching development. Based on the interviews and discussion results in the Gede Lagoon waters, there is no activity on land, namely seaweed farming in the outside lagoon area.
    3. Pakalolo Lagoon is a location close to the airport. Fishermen used to find sandfish in the Pakalolo Lagoon area. However, after the airport construction, it was difficult for fishermen to catch sea cucumber, especially sandfish (*Holothuria scabra*) types.
    4. Estuary estuary is not recommended by fishermen and the community due to the seaweed growing area.
c. The safety factor is significant. Safety area includes location security in every company, including cultivation activities. Cultivation activities with the sea ranching model should be safe from pests and bad people. In addition, for the successful release of the wild, the breeding area must be safe from thieves who can catch all the sea

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cucumbers. The safety factor can be overcome through socialization and law enforcement. Achievements from the viewpoint of the safety variable, it is explained that the safety at the community expansion stage of their fisheries groups will help during the surveillance process, as this area is a fishing route when they go to seaweed farming Surface.

d. The support facilities, as in general coastal areas and small islands, support facilities are still minimal. The support facilities in the sea cucumber development activities include sea cucumber farming facilities and natural forage farming facilities that support sea cucumber expansion activities. The facilities for sowing and growing natural food for the stock of sea cucumber seeds are not yet available at the research location. They supported the Sea Ranching Harvest Type development, facilities and infrastructure to facilitate media and transport routes to the site so that it can be developed as a site for sea cucumber cultivation (from the raw materials available for the sea ranching at sea).

e. The local wisdom aims to discover if some areas or sites are sacred to the community, rarely visited by the community and often avoided as fishing grounds. It is known that in the areas of Pinggir Lagoon, Gede Lagoon, Pakalolo Lagoon and the Outside Area community, there are no sacred sites as a form of local culture. Therefore, technically sacred areas or sites are suitable for serving as marine farms and local cultural areas.

3.3. Another attention factor

Land use data information referred to here is a term for land use that means the regulating process of a coastal area supported by other resources. Before undertaking some land use activities or land planning for the sea ranching suitability site, it is necessary to have a figure soil approach, which is an approach to manipulating or processing existing figure soil patterns by reducing, adding and changing geometric patterns. This approach is also a relationship between the open building mass and the figure-ground. The chosen approach refers to the zone map of Karimunjawa National Park. It was explained that in the Karimunjawa National Park zoning plans, the Pinggir Lagoon waters, Gede Lagoon, Pakalolo Lagoon and around the outside area are the cultivation zone and the traditional fishing zone.

The map reference to the conformity analysis is the Management Plan Zone Map by the Karimunjawa National Park. The reference detailed zoning area is described in figure 4. The Destination area is the cultivation zone and the traditional fishing zone, as stated in the Karimunjawa National Park Zoning Division in 2012.

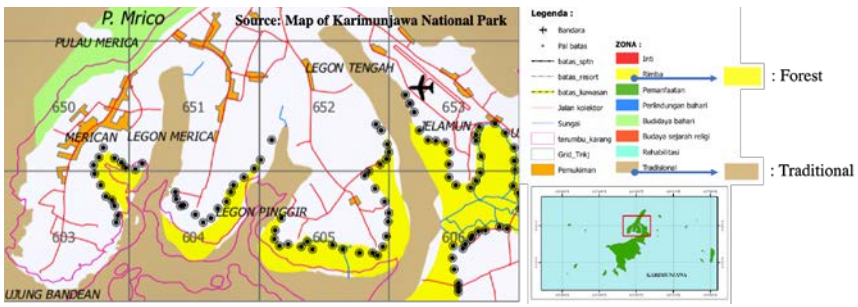

Figure 4. The intersection of the Karimunjawa National Park zoning map as a basis for analysis on the GIS desktop (Source: Map of the zoning plan by National Marine Park Karimunjawa, 2012)

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3.4. Environmental suitability

Aquatic environment suitability is one of the aspects determining the sea cucumber enlargement and cultivation success in the Kemujan Village waters, Karimunjawa National Park. The suitability score matrix for each variable in Table 3 was used to analyse the suitability matrix in the compliance map overlay. The analysis score was evaluated to get the suitability class of the three kinds of factors that can be developed, after which the environment site feasibility analysis's results can be seen that each variable is S1 (30 to 35); S2 (25 to 29); S3 (20 to 24) and N (< 20).

Table 3. Suitability matrix index for the sea ranching harvest type of Holothuria scabra in Karimunjawa National Park, Central Java, Indonesia

No.	Parameters	Pinggir Lagoon (A)	Gedhe Lagoon (C)	Pakalolo Lagoon (B)	Outside of lagoon area (D)
A.	**Main factors**				
1.	Depth (meter)	3	4	3	3
2.	Sea surface temperature (°C)	2	2	2	3
3.	pH	2	2	2	2
4.	DO (mg/L)	2	3	2	3
5.	TDS (mg/L)	2	4	3	3
6.	Salinity (‰)	1	3	2	3
B.	**Supporting factors**				
7.	Protection area	2	4	3	3
8.	Contamination area	1	3	2	2
9.	Safety area	1	3	2	1
10.	Supporting facilities	3	3	1	1
11.	Local wisdom	4	4	4	4
C.	**Another attention factors**				
12.	Land use	▪ Near housing areas. ▪ Cultivation area (fish pond). ▪ Seaweed cultivation area. ▪ Centre for seaweed collectors.	▪ Near housing areas. ▪ Directly related to the airport area.	Near housing areas	▪ Seaweed cultivation area ▪ Traditional fishing area
Total score: A+B+C+D		**23 (S3)**	**35 (S1)**	**26 (S2)**	**28 (S2)**

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From the suitability results of each parameter of each variable using the criteria (see Table 3) was performed the suitability waters evaluation for each station. The evaluation results are described in the following subchapters:

a. Pinggir Lagoon waters in Table 3 show a score of 23, the evaluation results of this value against the criteria suitable that is enough for the sea cucumber rearing development area (S3). The class was characterized by factors with a rather strict limit for sustainable use. The condition is assumed because all parameters measured at the research site have no severe limitations for specific sustainable applications. These restrictions would reduce productivity and land profits and increase inputs from land exploitation.
b. The Gede Lagoon waters, from the calculation results of the suitability value, Table 3 shows a score of 35, the evaluation results of that value using the criteria for each variable show that the waters at the research location are in the high suitable area (S1) for the cultivation of sandfish sea cucumbers.
c. The Legon Pakololo waters exhibit a sandfish sea cucumber environment of 26. The evaluation results of this value by using each variable scoring criteria, it can be concluded that it is smaller than the waters of Gede Lagoon, included in the category suitable with conditionals (S2) for the sandfish sea cucumbers cultivation. This suitability class has severe limitations in maintaining the treatment applied level to the parameters requiring attention in that location.
d. The Outside area, the eligibility score is 28 (S3). The coastal area is the environmental condition for the sandfish sea cucumber cultivation. However, due to its location outside the lagoon, it is feared from the safety side that it is low. In addition, it will face difficulties in the monitoring and evaluation process.

Further analysis results based on the scores classification for each parameter are presented in a map overlay using GIS. Spatial analysis combining water quality parameters, socio-infrastructure and land use potential shows that approximately 41.24% of the Gede Lagoon wetland area's total development potential (8.28 Ha) is included in the highest feasible category in the Gede Lagoon waters. While the total study area percentage, the area classified as suitable, is 1.86% of the total value of the study area of 444.32 Ha. The results of the distribution analysis of values from unsuitable to suitable levels are shown in Figure 6.

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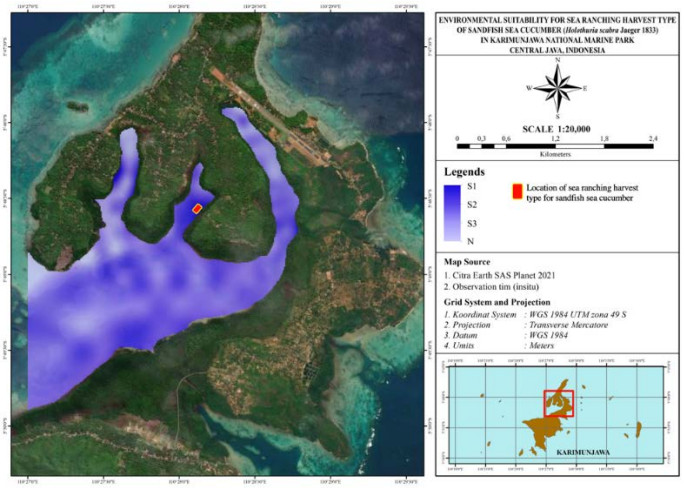

Figure 5. The suitable area for sea ranching harvest type of *Holothuria Scabra* in Karimunjawa National Park, Central Java, Indonesia

Good water quality conditions generally support sites with suitable categories, but from social infrastructure, which can be different sites if sea ranching for sandfish sea cucumbers is developed. This study's results indicate the outputs relevant for determining the Gede Lagoon area of Kemujan Village as an extension area for sandfish sea cucumbers. The analysis of this study result is expected to provide input to the relevant authorities in the Karimunjawa Islands to support the further development of the sea cucumber improvement program to maintain its sustainability. If the existing potential is not fully exploited, it must be provided for buffer zones and other fishing activities to develop environmentally friendly and sustainable sea cucumber cultivation. Furthermore, it is necessary to set up or provide an area for transport routes so that fishing boats can still sail to the traditional fishing area.

4. Discussion

4.1. Environmental quality

[44] explained that Holothuria scabra could live in different water depth stratifications. The survival stratification depends on the size and age of sea cucumbers in nature. The average depth value in the lagoons (Pingir Lagoon, Gede Lagoon and Pakalolo Lagoon), which are closed water areas and sufficiently protected against waves and currents, was found to be 0.50 to 1.51 meters. It was added that at a young age, the sandfish sea cucumbers tend to be dispersed in high and low tide areas, and after the sea cucumbers have grown in size, they will move at depths between 0.40 to 1.50 m or at low tide. The depth of coastal area stratification for sea cucumber survival, especially *Holothuria scabra* species, was closely related to the water clarity state. The water clarity average for sandfish survival ranges from 0.5 to 1.5 m. [30] stated that the life viability for sandfish in the wild waters is required in conditions of high waters clarity, free of materials and components as a source of water contaminants.

The SST values generated in the field during this research were in agreement with [14] that the SST value in the Karimunjawa Islands coastal waters included in the Karimunjawa Village administrative area, Kemujan Village, and Parang Village areas of Central Java Province have a range of value was 28.76 to 29.54 °C. Their tolerance value for

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sandfish life is around 26 to 30 °C [33]. [4] stated that the temperature characteristics considered appropriate for sandfish to survive and grow in nature range from 24.0 to 30.0 °C. Another opinion from [45] statement explains that different media temperatures affect sandfish's embryo and larval development in his plankton stage study in 4 treatments. It is concluded that temperature influences embryo development, egg hatching, larval development and larval survival in each of these treatments. It was produced at a temperature of 32 °C with the highest egg hatchability of 76.83%. The larval stage was observed with a water temperature treatment of 30 °C. The highest development of the larval survival was 7.97%, with a percentage of the larval stage, *Pentactula* spp, reaching 43.93%.

The pH values range is in line with the study of [1], investigating the sea cucumber density in the Buntal Island waters, Kotania Bay, West Seram Regency, in the pH range between 7.8 to 8.0. According to [45], pH distribution was influenced by fluctuations in the content of O_2 and CO_2, where even a small change in pH will affect changes and imbalances in the CO_2 concentration, the effects on the organisms living in the waters. A relatively high concentration of CO_2 also affects changes in water quality parameters, especially in the carbonate system. Most aquatic biotas are sensitive to changes in pH values. The ideal value for life is between 7 to 8.5 [46]. The pH concentration for sea cucumber survival ranges from 6.5 to 8.5 [30]. Another expressed view by [31] is that the pH value tolerance of the water for the sand sea cucumber's life is 7.9 to 8.4. The pH below 4.8 and above 9.2 is classified as polluted water [47].

Aquatic environmental conditions on juvenile culture's marine ranching equipment for *Holothuria scabra* and *Haliotis squamata* in a polyculture system performed on three different media resulted in a DO concentration range of 5.45 to 5.78 mg/L [48], it was explained in this study that based on the results of the DO measurement of 5.45 to 5.78 mg/L. The DO concentration required by organisms in the waters depends on the species level. At the species level, each biota reacts differently to fluctuations in DO. The DO in the water comes from air diffusion, and the photosynthesis process results in the aquatic plant, both micro (such as phytoplankton) and macro (such as seagrass, macroalgae and mangroves). The DO concentration in the sea ranching for culturing sea cucumbers from different studies was recorded by [49] in pen culture, or intercultural is 4.59 to 5.77 mg/L and 4.44 to 5.65 mg /L. Another research by [50] is that the DO optimal concentration for sandfish sea cucumber growth is > 3 mg/L, [4] and [51] between 4 to 8 mg/L.

The research from [52] on limited media, like sea cucumber cultivation in Hansisi Village and Uiasa Village recorded in the Semau Island area, East Nusa Tenggara, found the TDS range for sea cucumber survival of 0.5 to 3.0 mg/L (Hansisi Village) and 0.005 to 0.003 mg/L (Uiasa Village). The study shows that the measurement results show a difference in the turbidity value of the two sites but that it is a good value for the life of the biota. In nature, the turbidity ecological influence can reduce the sunlight penetrating power, and the sunlight's weak penetration will decrease the water's primary productivity level [53]. Kaffah et al (2018) also explained that the salinity range for freshwater is usually < 0.5, estury waters was between 0.5-30 and coastal to marine is 30-40. In several other studies by [4,33,51,8,54], concentration salinity for sandfish sea cucumber survival has an optimal range between 20-29. The salinity distribution in nature can be influenced by several factors, including water circulation, an evaporation process, high and low rainfall and river discharge. The salinity concentration in the coastal area can influence the balance of osmoregulation in the body of sea cucumbers in energetic and growth processes.

Other analyzes besides the aquatic environment quality parameters (physics and chemistry) are also based on substrate conditions and seagrass habitat composition found during data collection activities. The four groups' site sampling in the Kemujan Village's coastal area shows the Pinggir Lagoon and Gede Lagoon in the deep areas where seagrass habitats occur. Seagrass conditions analysis referring to the results in [55] found that seagrass vegetation was currently only performed in Gede Lagoon, with the seagrass species found: *Enhalus acoroides* and *Cymodocea serrulata*. Also added in the study that the substrate composition in the 4 study areas was mud substrate (32.4%); mud mixed sand

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(21.6%); clay (19.2%), sand (12.3%), gastropod shells (9.3%), and others (5.2%). The aquatic environment feasibility analysis for the expansion site was analyzed based on 12 parameters from 3 groups of factors, which is a reasonably accurate analysis output. The parameter components used as a basis for determining future sea ranches are in line with the research of [55] and [56] that the selection and design of a marine ranching site (sea ranching) is the first step in marine culture construction.

4.2. Environmental suitability

The aquatic environment suitability level analysis of the sandfish sea cucumber habitat shows that the conditions are not suitable (N) following the requirements (S3) and appropriate (S1). Thus, the aquatic environmental conditions at four focus sites in Kemujan Village, Karimunjawa National Park, are still in waters of concern for marine biota survival. However, three sites (Gede Lagoon, Pakalolo Lagoon and Outside of lagoon area) were classified as applicable under the condition. The environmental conditions in the inappropriate category of Pinggir Lagoon waters were believed to be due to the density of seaweed cultivation activities and waste disposal resulting from the shrimp cultivation on the mainland of Pinggir Lagoon, which was directly connected to the waters. While in the Gede Lagoon waters, the necessary environmental fulfilment conditions can guarantee the growth and proliferation of sandfish.

In addition, aquatic environment analysis and the suitability assessment process added to the variables habitat and water bottom substrate. Referring [56] explained that the Gede Lagoon waters became a recommended site for developing the sea ranching harvest type. In addition, to environmental suitability based on water parameters, it was also found that the composition of the sand substrate was between 92 to 98% and mud substrate from 1 to 3%. It also added that Gede Lagoon waters in the selected area have seagrass habitats, both *Cymodecea serrulate* and *Enhalus accoroides*. In generally overgrown, the seagrass ecosystem as a habitat for *Holothuria scabra* by several seagrass species, including *Enhalus acoroides*, *Cymodocea serrulata*, *C. rotundata*, *Halodule uninervis* and *Syringodium isoetifolium*, *Thalassia hemprichii* [34,57]. The study results by [58] explained that the higher preference and survival in Enhalus acoroides indicated that this species was the preferred attachment substrate for Holothuria scabra larvae compared to other seagrass species. According to [34], the presumption was that juvenile *Holothuria* scabra could be found in the seagrass ecosystem, especially on the seagrass leaves species *Enhalus acoroides* and *Talassia hempricii*. The high survival rate of the *Enhalus* acoroides substrate is thought to be due to certain chemicals that can attract and metamorphose larvae. Added the seagrass extracts of *Enhalus acoroides*, *Cymodecea serrulata* and *Talassia hempricii* could induce metamorphosis and adhesion to artificial plastic substrates.

Aquatic environmental factors can control the sea cucumber species distribution. Good water quality conditions reflect well-carrying capacity for sandfish sea cucumber to life, and good water quality conditions allow sandfish sea cucumber populations to grow and reproduce well [51]. This explanation also agrees with [3] in general, the reproductive cycle period of *Holothuria scabra* can be related to several aquatic environmental factors, such as temperature, natural food, environmental factors such as sea water temperature, food availability, and the daily illumination period tolerated by each marine organism [59,60]. The resulting aquatic environment suitability for the life of *Holothuria scabra* can be used to make feasibility recommendations for the sandfish cultivation development and the sea cucumber enhancement resources, especially as recommendation input for utilization planning of Karimunajawa National Park waters.

4.3. Sea ranching harvest type design

Before release, the growing sandfish sea cucumber tools are called a temporary container or intermediate culture, and some call it cages with plug-in tongues. The term sole is a good net that is buried at the bottom of the waters, and about ± 30 cm goes in or

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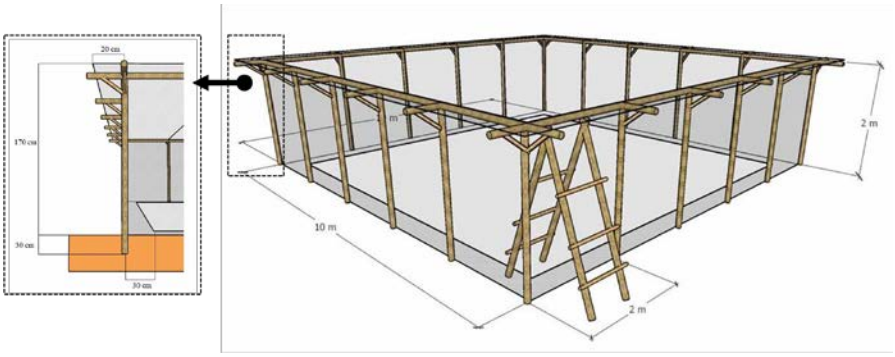
above and hangs out so that the sandfish sea cucumbers can grow, do not escape outside the container, and predators do not enter the container [55]. The intermediate culture, combined with the tongue-shaped guard on the top, was developed as a Sea Ranching Harvest Type. The mesh size in the Sea Ranching Harvest Type is adjusted according to the size of the sea cucumber seeds. The smaller the seed size, the smaller the mesh size is used compared to the seed's larger size (Figure 5a and Figure 5b). The Sea Ranching Harvest type, in general, is without the use of the tongue on the top. It is generally referred to as nets in the square form of different sizes depending on the number of sea cucumber seeds to be grown. [61] explains that sandfish sea cucumbers can escape at the bottom of the waters and move from shallow waters (seagrass ecosystems) to deeper waters in coral reef ecosystems.



(a) Prototype design (Source: [55])

(b) Sea ranching harvest type (Source: Research team, 2021)

Figure 6. Sea Ranching Harvest Type *Holothuria scabra* design in Karimunjawa National Park, Central Java, Indonesia (a. Prototype design, and b. Sea Ranching Harvest)

The marine harvest type design with predator safety at the top around the perimeter as a safety so that predators such as crabs cannot enter the intercultural is described in Figure 6. The Sea Ranching Harvest Type design construction as Holothuria scabra magnification medium should use materials easily found at the site [55]. Some materials as described by [16] are as follows: a) The netting material is of the black "waring" type, b) The frame is made of sustainable wood, and c) The beam type that functions as a base pin whose main specifications are durable or not easily brittle.

5. Conclusions

The aquatic environment suitability degree of the sandfish sea cucumber *Holothuria scabra* Jaeger 1833 habitat in the Karimunjawa National Park waters with the focus study site in Kamujan Village in Karimunjawa National Park at four selected stations (Pakalolo Lagoon, Gedhe Lagoon, Pinggir Lagoon and Outside of lagoon area) and each variable classification matrix namely main factors (6 parameters), supporting factors (5 parameters) and another attention factor (1 parameter), a total score of 12 variables. The scores highest is 35, and the lowest is 18. The analysis showed that the aquatic environment was suitable (S1) for the *Holothuria scabra* Jaeger 1833 life in Gede Lagoon. It can be determined that the Gede Lagoon coastal area is suitable for the *Holothuria scabra* cultivation, with a total area of 8.28 ha (1.86%) of the total area of 444.32 Ha. On the other side, the Sea Ranching Harvest Type development would be carried out in waters that do not have limiting factors, and these waters have been determined to be very suitable for sea cucumber cultivation. The sandfish sea cucumber cultivation or breeding should be done using the search method, one of the efforts to preserve the type of marine organisms that are reptiles and equipped with a part that prevents predators from entering the intercultural. However, this certainly requires further research that analyzes the makeup details of predators that can reproduce outside the intermediate net during the nocturnal and diurnal.

6. Patents

Author contributions: Conceptualization: M.M., Y.S., A.S.N., S.T.H., A.R.S.., K.K. and D.W.H.; methodology: M.M., A.R., R.W., M.R.A.P., S.E.P., B.S., A.W., L.P.A., A.N. and D.W.; Funding acquisition: M.M., Y.S., A.S.N., S.T.H., A.R.S., A.R., R.W., K.K., D.W.H., M.R.A.P., S.E.P., B.S., A.W., L.P.A., A.N. and D.W.; writing-original draft preparation: M.M., Y.S., A.S.N., S.T.H., A.R.S.., K.K., D.W.H., M.R.A.P., A.W. and L.P.A.; writing-review and editing: M.M., Y.S., A.S.N., R.W. and A.R. All authors have read and agreed to the published version of the manuscript.

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Institutional review board statement: Not applicable

Informed consent statement: Not applicable

Data availability statement: All data and information were included in the final report of the research. The study was titled "Development of technology for the Enhancement of sea cucumber resources, especially *Holothuria scabra* Jaeger 1833 species enhancement in Karimunjawa National Park" in 2020 and 2021.

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titled "Development of technology for the Enhancement of Sea Cucumber Resources, especially *Holothuria scabra* Jaeger 1833 species enhancement in Karimunjawa National Park". This research resulted in a scientific article titled "Growth Rate and Survival of Prospective Broodstock *Holothuria scabra* Jaeger 1833 on Stock Enhancement in Karimunjawa National Park".

Conflict of interest: The authors would declare that there is no conflict of interest in this article's preparation, analysis, writing and publication. As a research fund provider, the Research Incentive Program of the National Innovation Research Agency, Republic of Indonesia, has no role in research design, data collection, analysis or interpretation of data and information, manuscript writing, or the decision to publish research results.

References

1. Bachmid, S.; Siahainenia, L.; & Tupan, S.I. The relation of Sea Cucumber Density (Holothuroidea) with seagrass density in the waters of Buntal Island-Kotania Bay, District of West Seram. *Jurnal TRITON* **2020**, *16*, 2, 84-96.
2. Wirawati, I.; Jasmadi; Pratiwi, R.; Widyastuti, E; Ibrahim, P.S. Commercial sea cucumber trading status in Indonesia. *Aquaculture, Aquarium, Conservation & Legislation* **2021**, *14*, 6, 3204-3216.
3. Venâncio, E.; Félix, P.M.; Brito, A.C.; Azevedo e Silva, F.; Simões, T.; Sousa, J.; Mendes, S.; Pombo, A. Reproductive biology of the sea cucumber *Holothuria mammata* (Echinodermata: Holothuroidea). *Biology* **2022**, *11*, 5, 622.
4. Martoyo, J.; Aji, N.; Winanto, T. *Sea cucumber cultivation*. 6th Edisi Revisi.; Penebar Swadaya: Jakarta, Indonesia, 2006; pp. 4.
5. Choo, P.S. Population status, fisheries and trade of sea cucumbers in Asia. In *Sea cucumbers: A global review of fisheries and trade*, Ed. Rev., FAO Fisheries and Aquaculture Technical Paper No. 516; FAO: Rome, Italy, 2008; p. 317.
6. Conand, C. Present status of world sea cucumber resources and utilisation: An international overview. In *Advances in sea cucumber aquaculture and management*. FAO Fisheries Technical Paper, No. 463; FAO: Rome, Italy, 2004; pp. 13-23.
7. Pattinasarany, M.M.; Manuputty, G.D. Potency of commercially important sea cucumber in seagrass ecosystem at Suli Waters, Central Maluku. *PAPALELE: Jurnal Penelitian Sosial Ekonomi Perikanan dan Kelautan*, 2018, 2,1, 1-7.
8. Padang, A.; Sangadji, M.; Lukman, E.; Subiyanto, R. Growth and the survival of sandfish (holothuria scabra) reared in floating net cages. *Jurnal TRITON* **2017**, *13*, 2, 115-124.
9. Nastiti, A.S.; Putro, H.D.; Mujiyanto; Hartati, S.T. Transportation of sea cucumbers (*Holothuria scabra*) in the context of fisheries enhancement in Karimunjawa National Park. *Jurnal Biologi Indonesia* **2021**, *17*, 1, 93-104.
10. Purcell, S.W.; Ngaluafe, P.; Lalavanua, W.; Ceccarelli, D.M. Market price trends of Latin American and Caribean sea cucumbers inform fisheries management. *Regional Studies in Marine Science* **2018**, *17*, 127-132.
11. Nuraini, S.; Wahyuni, I.S.; Hartini, S.T. Sea cucumber resources and reef fish study in Sembian Islands, Sinjai Regency, South Sulawesi. *Jurnal Penelitian Perikanan Laut* **1992**, *71*, 81-88.
12. Kudato, V.E.; Sambali, H.; Ngangi, E.L.; Kusen, D.J.; Longdong, S.N.; Rimper, J.R. Growth of Sea Cucumber *Holothuria scabra* reared in cage with different substrates in Bahoi Coastal Waters. *Budidaya Perairan* **2022**, *10*, 2, 88-98.
13. Harahap, M., Sulardiono, B.; Suprapto, D. Analysis of maturity rate of gonad lollyfish (Holothuria atra) in Menjangan Kecil Island, Karimunjawa. *Management of Aquatic Resources Journal (MAQUARES)* **2018**, *7*, 3, 263-269.
14. Sulardiono, B.; Purnomo, P.W.; Haeruddin, H. Environmental Suitability for Holothuroidea Habitat in Karimunjawa. *Indonesian Journal of Fisheries Science and Technology* **2017**, *12*, 2, 93-97.
15. Sugama, K.; Giri, A.N.A.; Zairin, M. Prolog: Biology aspect and sandfish (*Holothuria scabra*) cultivation, In *Book Chapter: Biology aspect and sandfish* ((*Holothuria scabra*). Penerbit AMAFRAS Press, Jakarta. Indonesia, 2019); pp V-XIV.
16. Nurwidodo; Rahardjanto, W.; Husnah; Mas'odi; Hidayatullah, M. S. *Manual guide: easer of sea cucumber cultivation (integrated with seaweed cultivation)*. Penerbit CV Kota Tua, Malang, Indonesia, 2018; pp. 9-10.

17. Darsono, P. Short communication: sea cucumber (Holothurians) much to be protected. *J. Biol. Indon.*, **2005**, *III*, 9, 405-410.
18. Cho, G.; Kim, D.; Jung, S.; Jung, I. H.; Kim, S. Estimating age-specific natural mortality for sandfish in the eastern coastal waters of Korea. *Mathematics* **2020**, *8*, 9, 1612, pp. 2.
19. Purcell, S.W.; Hair, C.A.; Mills, D.J. Sea cucumber culture, farming and sea ranching in the tropics: Progress, problems and opportunities. *Aquaculture* **2012**, *368*, 68-81.
20. Hair, C. A. Sandfish (*Holothuria scabra*) production and sea-ranching trial in Fiji. In Asia-Pacific tropical sea cucumber aquaculture. Australian Centre for International Agricultural Research. *Canberra Australia Proceedings* **2012**, 136, 129-141.
21. Ceccarelli, D.M.; Logan, M.; Purcell, S.W. Analysis of optimal habitat for captive release of the sea cucumber *Holothuria scabra*. *Mar. Ecol. Prog. Ser.* **2018**, *588*, 85-100.
22. Radiarta, I. N.; Erlania, E. Water quality index and distribution of nutrient around integrated marine aquaculture in Ekas Bay, West Nusa Tenggara: an important factor for seaweed aquaculture. *Jurnal Riset Akuakultur* **2015**, *10*, 1, 141-152.
23. Nyumba, T.O.; Wilson, K.; Derrick, C.J.; Mukherjee, N. The use of focus group discussion methodology: Insights from two decades of application in conservation. *Methods in Ecology and evolution* **2018**, *9*, 1, 20-32.
24. Malek, N.H.A.; Wan Yaacob, W.F.; Md Nasir, S.A.; Shaadan, N. Prediction of water quality classification of the Kelantan River Basin, Malaysia, using machine learning techniques. *Water* **2022**, *14*, 7, 1067, pp. 6.
25. Prakash, R.; Tharun, V.P.; Devi, S.R. A comparative study of various classification techniques to determine water quality. In *2018 Second International Conference on Inventive Communication and Computational Technologies (ICICCT)*, IEEE, 2018; pp. 1501-1506.
26. Mujiyanto; Syam, A.R.; Wijaya, D.; Purnamaningtyas, S.E. Suitability water quality parameters for seaweed culture at Muara Gembong coastal area, Bekasi District. In *IOP Conference Series: Earth and Environmental Science* **2020**, *521*, 1; p. 012012.
27. Ariyati, R.W.; Sya'rani, L.; Arini, E. The suitability analysis of Karimunjawa and Kemujan Island territory for sea weed culture site using Geographical Information System. *Jurnal Pasir Laut* **2007**, *3*, 1, 27-45.
28. Alamsyah, R. Suitability water quality parameters for seaweed culture at panaikang distric sinjai regency. *Jurnal Agrominansia* **2016**, *1*, 2, 61-70.
29. Martoyo, J.; Aji, N.; Winarto, T. *Sea cucumber aquaculture*, Ed. I. Penerbit Penebar Swadaya, Jakarta, Indonesia, 1994; p. 69.
30. Kordi, M.G.H. *An easy way to cultivate sea cucumbers*. Penerbit Andi Offset, Yogyakarta, Indonesia, 2010; p. 122.
31. Xiyin, L.; Guanghui, Z.; Qiang, Z.; Liang, W.; Benxue, G. Studies on hatchery techniques of the sea cucumber, *Apostichopus japonicus*. FAO Fisheries and Aquaculture Technical Paper No. 516; FAO: Rome, Italy, 2005, 287-296.
32. Giraspy, D.A.B.; Walsalam, I. G. Aquaculture potential of the tropical sea cucumbers *Holothuria scabra* and *H. lessoni* in the Indo-Pacific region. *SPC Beche-de-mer Information Bulletin* **2010**, *30*, 29-32.
33. Al-Rashdi, K.M.; Claereboudt, M.R.; Eeckhaut, I. Prelimianry trails on hatchery and Larval development of the Sea Cucumber *Holothuria scabra* (Jaeger, 1833), in the Sultanate of Oman. *Asian J. Fish Aquat. Res* **2018**, *2*, 3, 1-9.
34. Mercier, A.; Battaglene, S.C.; Hamel, J.F. Settlement preferences and early migration of the tropical sea cucumber *Holothuria scabra*. *Journal of Experimental Marine Biology and Ecology* **2000**, *249*, 1, 89-110.
35. Hartati, S.T.; Tjahjo, D.W.H.; Samusau, A.S. Recovery status of sea cucumber in the Seribu Islands. *Jurnal Riset Jakarta* **2020**, *13*, 1, 7-16.
36. Culha, S.T.; Dereli, H.; Karaduman, F.R.; Culha, M. Assessment of trace metal contamination in the sea cucumber (*Holothuria tubulosa*) and sediments from the Dardanelles Strait (Turkey). *Environmental Science and Pollution Research* **2016**, *23*, 12, 11584-11597.
37. Firdaus, M. Bab V: Growth aspect in the cultivation of Sandfish Sea Cucumber, *Holothuria scabra*. In *Book Chapter: Biology aspect and sandfish* ((*Holothuria scabra*). Penerbit AMAFRAS Press, Jakarta, Indonesia, 2019; pp. 53-80.

38. Taylor, A.L.; Nowland, S.J.; Hearnden, M.N.; Hair, C.A.; Fleming, A.E. Sea ranching release techniques for cultured sea cucumber *Holothuria scabra* (Echinodermata: Holothuroidea) juveniles within the high-energy marine environments of northern Australia. *Aquaculture* **2016**, *465*, 109-116.
39. Saaty, T.L. Decision making with the analytic hierarchy process. *International journal of services sciences* **2008**, *1*, 1, 83-98.
40. Rizqi, M.P.; Supono. Site suitability analysis for community-based tropical sea cucumber Holothuria scabra grow-out in North Sulawesi waters. *Marine Research in Indonesia* **2019**, *44*, 1, 1-10.
41. Hsiao, Y.J. The socio-economic impact of coastal environment changes on fishing communities and adaptation strategies. *Fishes* **2022**, *7*, 5, 243, pp. 6-7.
42. Vaidya, O.S.; Kumar, S. Analytic hierarchy process: An overview of applications. *European Journal of operational research* **2006**, *169*, 1, 1-29.
43. Mugiyo, H.; Chimonyo, V.G.; Sibanda, M.; Kunz, R.; Masemola, C.R.; Modi, A.T.; Mabhaudhi, T. Evaluation of land suitability methods with reference to neglected and underutilised crop species: A scoping review. *Land* **2021**, *10*, 2, 125.
44. Hamka, M.S.; Samadan, G.M.; Yuliana, Y. Suitability analysis of cultivation site for sandfish sea cucumber (*Holothuria scabra*) based on water quality parameters in Foya Village waters, Gene Subdistrict, South Halmahera District. *Hemyscyllium* **2021**, *1*, 2, 66-72.
45. Rukminasari, N.; Nadiarti; Awaludin, K. The effect of acidic level of media on calcium concentration and growth of *Halimeda* sp. *TORANI (Jurnal Ilmu Kelautan dan Perikanan)* **2014**, *24*, 1, 28-34.
46. Susana, T. Acidity level (pH) and Dissolved Oxygen as water quality indicator at around Cisadane River Estuary. *Jurnal Teknologi Lingkungan* **2009**, 5, 2, 33-39.
47. Amić, A.; Tadić, L. Analysis of basic physical-chemical parameters, nutrients and heavy metals content in surface water of small catchment area of Karašica and Vučica Rivers in Croatia. *Environments* **2018**, *5*, 2, 20, pp. 4.
48. Sembiring, S.B.M.; Wardana, I.K.; Sugama, K. Grow-out of sea cucumber, *Holothuria scabra* and abalone, *Haliotis squamata* fry in polyculture system. *Jurnal Riset Akuakultur* **2018**, *13*, 1, 21-28.
49. Padang, A.; Lukman, E.; Sangadji, M. The utilisation of benthic diatoms as food for sea cucumbers in the context of cultivating sea cucumbers. *In Final Research Report*. Competitive Grant Funding Program 2nd Year, DP2M DIKTI, Ambon, Indonesia, 2015; p. 46.
50. Sutaman. *Manual guide: sea cucumber aquaculture*. Penerbit Kanisius, Yogyakarta, Indonesia, 1993; pp. 55-56.
51. Sulardiono, B.; Hendrarto, B. Analysis of the density of sea cucumbers (Holothurians) based on the type of coral cover in Karimunjawa Waters, Central Java. *Jurnal Saintek Perikanan* **2014**, *10*, 1, 7-12.
52. Muskananfola, E.; Dahoklory, N.; Sunadji, S. Bioecological conditions and development of sea cucumber cultivation in the waters of Hansisi and Uiasa Villages, Semau Island. *Jurnal Aquatik* **2021**, *4*, 2, 17-22.
53. Rohmah, W.S.; Suryanti, S.; Muskananfola, M.R. The Influence of depth on primary productivity in Jatibarang Reservoir, Semarang. *Management of Aquatic Resources Journal (MAQUARES)* **2016**, *5*, 3, 150-156.
54. Kaffah, S.; Supriatna; Damayanti, A. (2020, March). Cilamaya estuary zonation based on sea surface salinity with 2 Sentinel-2A satellite imagery. In *IOP Conference Series: Earth and Environmental Science* **2020**, *481*, 1, p. 012071
55. Nastiti, A.S.; Hartati, S.T.; Widhihastuti, R.; Rahman, A.; Mujiyanto; Nurfiarini, A.; Syam, A.R.; Muryanto, T.; Sarbini, R.; Hendayana, Y. Technical Guidance: Application of recovery technology and opportunities for the Sea Cucumber (Holothuria scabra) resource development in Karimunjawa National Park. AMAFRAD Press, Jakarta, Indonesia, 2022; 69 p.
56. Zhou, X.; Zhao, X.; Zhang, S.; Lin, J. Marine ranching construction and management in East China Sea, Programs for sustainable fishery and aquaculture. *Water* **2019**, *11*, 6, 1237, pp. 7
57. Purcell, S.W.; Simutoga, M. Spatio-temporal and size-dependent variation in the success of releasing cultured sea cucumbers in the wild. *Reviews in Fisheries Science*, **2008**, *16*, 1-3, 204-214.

 doi:10.20944/preprints202209.0427.v1

58. Indriana, L.F. Bab III: Spawning, egg incubation and nursery method of sandfish sea cucumber larva. In *Book Chapter: Biology aspect and sandfish* ((*Holothuria scabra*). Penerbit AMAFRAD Press, Jakarta, Indonesia, **2019**; pp. 27-42.
59. Kubota, T.; Tomari, M. Reproduction in the apodid sea cucumber *Polycheira rufescens*: semilunar spawning rhythm and sex change. *Journal of the Marine Biological Association of the United Kingdom* **1998**, *78*, 1, 249-267.
60. Gaudron, S.M.; Kohler, S.A.; Conand, C. Reproduction of the sea cucumber *Holothuria leucospilota* in the Western Indian Ocean: biological and ecological aspects. *Invertebrate Reproduction & Development* **2008**, *51*, 1, 19-31.
61. Aziz, A. Some notes on Aspidochirotid Holothurians. *OSEANA* **1995**, *22*, 4, 11-23.