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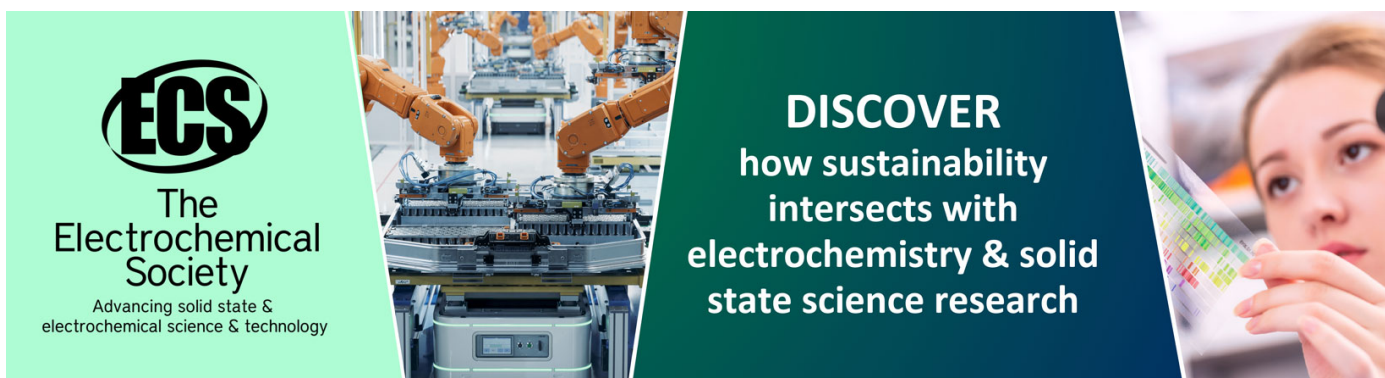
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Validating The Fully Raster-Based Suitability Model for Sea Cucumber (*Holothuria scabra*)

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Abstract. This research aimed at validating the fully raster-based suitability modelling for sea cucumber (*Holothuria scabra*) that has been created for the waters of Kiowa Bay, Enggano Island, Bengkulu. To validate the model, eighty-four sea cucumbers were cultivated on two different suitability classes. The field test phase includes setting the cultivation cages; measurement of sea cucumber weight; measurement of water quality parameter; and substrate analysis. Sea cucumbers were put into 2 cultivation cages (Cage 1: *highly suitable*, and Cage 2: *less suitable*), and for each cage, it was divided into 3 sub-cages. Before weighing, the sea cucumber was taken out from the water and then put into a tray layered with tissue, and left for 30 seconds. Measurements were conducted at the beginning of the study (t_0) and then carried out every three weeks until t_3 . The data analysis includes the Specific Growth Rate; Daily Growth Rate; Absolute Growth; and Survival Rate. The results showed that the Specific Growth Rate; Daily Growth Rate; Absolute Growth; and Survival Rate at Cage 1 (ie 0.5%; 0.88 gram; 62.28 gram; and 85.71%) better than the same parameters at Cage 2 (ie 0.34%; 0.64 gram; 45.33 grams; and 69.05%). These results indicate that the raster-based data for sea cucumber suitability model has advantages over the sea cucumber suitability model analyzed using vector-based data

1. Introduction

Sea cucumber (*Holothuria Scabra*) is an economic and important marine product which are, usually, obtained from fishing activities. To get the larger number of sea cucumbers, the cultivation is important to do. Enggano Island waters have natural resources that are potential to be utilized, developed and managed as a source of regional economic growth[1]. One of them is the development of sea cucumber cultivation.

Sea cucumber (*holothurians*) is a group of Holothuroidea class marine invertebrates (*Fylum Echinodermata*) that are widespread in marine environments throughout the world, ranging from tidal zones to deep seas, especially in the Indian Ocean and Western Pacific Ocean. Sea cucumbers are slow-moving animals, also an important component in the food chain on coral reefs and their associated ecosystems. Food sources for sea cucumbers mainly consist of organic matter in sand or mud, plankton, coral litter, and detritus found in mud or sand. Besides that some sea cucumbers also



eat small organisms such as diatoms, foraminifera, protozoa, nematodes, algae filaments and seaweed[2].

There are found 7 species of sea cucumbers on Enggano Island[3]. One of them is sea cucumber or white sea cucumber. Martoyo stated that sea cucumber is a species that lives in groups that can reach 3 to 10 tails and has a long round shape[4]. Generally, the stomach part of the sea cucumber is whitish-yellow, while the back is gray to blackish with black stripes. When touched, all parts of this sea cucumber feel rough. Many sea cucumbers are found between corals that are still alive or dead and in waters that contain fine sand with fragments of coral or muddy sand.

The selection of location is the first step that determines the success of sea cucumber cultivation. Generally, sea cucumber cultivation is carried out in coastal waters in tidal areas that support rapid water exchange. This is because the location or cultivation of sea cucumbers is a place that directly affects their lives. In other words, to manage marine resources, it requires careful planning[5][6]. When one considers the management of sea cucumber, a suitability map for its farming is needed. This map is generated from a comprehensive and integrated survey. Unfortunately, the collection of such data is time-consuming and also expensive[7]. From those reasons, suitability mapping for the farming of sea cucumber has therefore been generated from models based on the parameters that affect their development.

Generally, modelling related to the suitability determination in one area is expressed as[8] [9] :

$$S = \sum w_i x_i \quad (1)$$

where S is the suitability, w is the weight of factor i , and x is the potential rating of factor i .

Wulandari have performed an analysis of sea cucumber suitability modelling using vector-based data (say it as the Suitability_Vector, for further discussion) in the waters of Kiowa Bay, Kahyapu village, in the district of Enggano [10]. The analysis used criteria, weighting and scoring which is modified from Marizal[11]. The analysis involves nine parameters that were surveyed at 51 stations: seawater acidity, depth, current velocity, temperature, salinity, brightness, dissolved oxygen concentration, condition of the seafloor, and coastal protection of the area. The results showed that the waters of Kiowa Bay contained 102,477 hectares of *highly suitable*, 62,435 hectares of *suitable*, and 197,991 hectares of *not suitable* for cultivating sea cucumber. This suitability map is the result of analysis using vector-based data and is therefore simplified and consequently uncertain. For example, if one wants to develop the cultivation of sea cucumber using pen-culture techniques with a pen size of 40 meters by 40 meters, there would be uncertainty about where the best location is possible be (in terms of position and coordinates).

DeMers states that the presentation of earth information in the vector-data models assumes the existence of homogeneity in the mapping unit in which classification and simplification are required[12]. These processes are usually carried out subjectively such that there is the possibility of over-simplification and consequent reduction in detail. Thus the results of such analysis are full of uncertainty. Using remote sensing and GIS, those uncertainties can be minimized by applying the fully raster-based suitability modelling which is can be conducted more objectively using established algorithms and mathematical formulas without any simplification required[13]. Using the fully raster-based data, Sulistyono successfully apply them to analyse the erosion and the level of degraded land in Merawu Catchment, Banjarnegara, Central Java, Indonesia[7] [14] [15].

Using the same location, data and parameters as used by Wulandari et al. [10], in 2018 Sulistyono tried to refine the previous model by performing an analysis of sea cucumber suitability modelling using fully raster-based data (say it as the Suitability_Raster, for further discussion)[16].

Instead of using weight and score as it is used when using vector-based data, ie just by selecting its values as presented in tables (which is applicable for the whole and different locations), weighting and scoring when using raster-based data were determined by analysing the PCA (Principal Component Analysis). Through this analysis, the model (or equation) will be different for one location from other

locations. For Kiowa Bay, the equation only includes four principal components (PCs) having significant values as[16] :

$$\text{Suitability} = 0.5235 * \text{PC}_1 + 0.2797 * \text{PC}_2 + 0.1329 * \text{PC}_3 + 0.0639 * \text{PC}_4 \quad (2)$$

However, the Suitability_Raster and the Suitability_Vector, are the result of models that must be validated to justify which is the most appropriate, because a model is a subjective approach which does not include all observations, but retains important aspects of reality which remains visible[17].

Refinement of the created model is possible if new information that relates to reality is found[15]. These models have to be validated by installing pen-culture nets at different locations (and for different suitability classes) and farming sea cucumbers to directly observe their growth parameters.

2. Methodology

The research area was located at Kiowa Bay, longitudes between 102.24° and 102.37° east and latitudes between 5.45° and 5.47° south. The study area was approximately 362 hectares (see Figure 1).

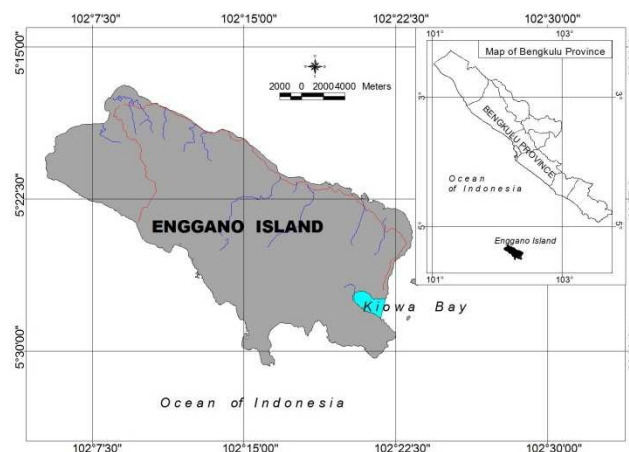


Figure 1. Location of the research in Enggano Island

A flow diagram of the study is presented in Figure 2.

To analyze and handle data, two GIS software packages were used. Meanwhile, some hardware was also required, namely a drafting tablet, equipment for fieldwork including a small boat, binoculars, compass, current meter, refractometer, Secchi disk, Tetra Test Kit O₂, DO meter, pH meter, Thermometer, pipes, waring nets, boards, stakes, ropes, trays, plastic, matches, scissors, ruler, slate board, tissue, battery, digital scales, sacks, nails, flashlights, Korean nylon cords, Global Positioning System, and digital camera.

For ease the discussion, two suitability models are presented in Figure 3 and Figure 4, while its combination is in Figure 5. Figures 5 shows that for the Suitability_Raster, the area which is most suitable for the growth of sea cucumber lies in the northwestern part of the Kiowa Bay, shown in dark blue, which is directly adjacent to the shoreline at a distance from 200 to 600 meters. This location is much more accessible than the location of the most suitable area of the Suitability_Vector. The Suitability_Raster seems more reasonable than those of the Suitability_Vector analysis. Besides, a suitable location in the Suitability_Raster is located far from the open sea such that it can protect sea cucumbers from the instability of marine conditions in Kiowa Bay.

Furthermore, the Suitability_Raster areas with lower a level of suitability (shown gradually by cyan, yellow, reddish yellow and pink) are located in the part of the study area most far away from the shore. Amazingly, for areas that are far from the shoreline, both models of suitability resulted in

similar outcomes, namely the suitability value was “*high*” in the Suitability_Raster and “*not suitable*” in the Suitability_Vector.

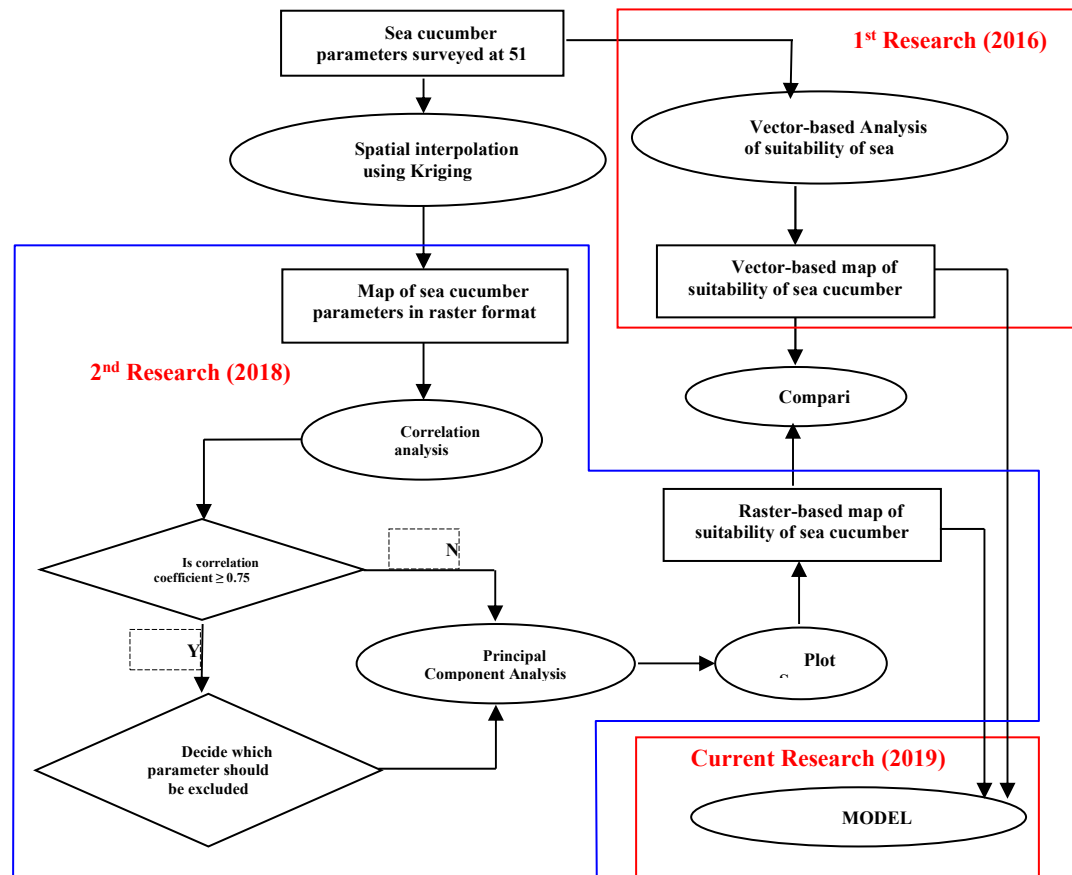


Figure 2. Flow diagram of the study (modified from[16])

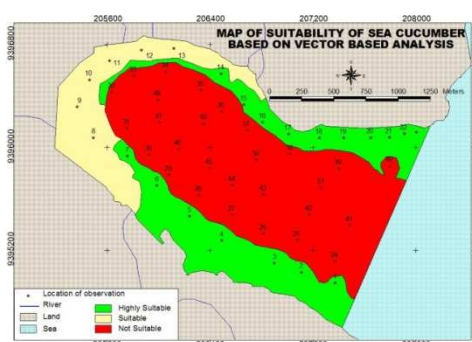


Figure 3. Vector-based map of suitability for sea cucumber

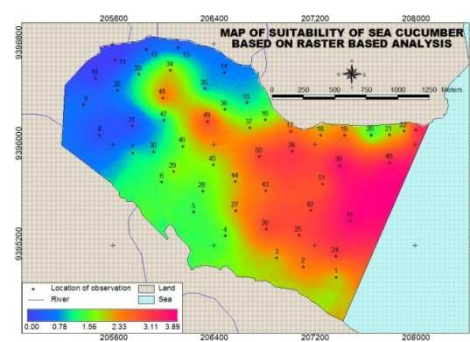


Figure 4. Raster-based map of suitability for sea cucumber

To validate the raster-based suitability model for sea cucumber that has been built, sea cucumbers were cultivated in two cages installed at two different suitability classes (at different locations). Then, their weight is monitored and measured during the period of research. In more detail, the field test phase includes: 1). Preparation for installing a cultivation cage; 2). Measurement of sea cucumber weight; 3). Measurement of water quality parameter; and 4). Substrate analysis.

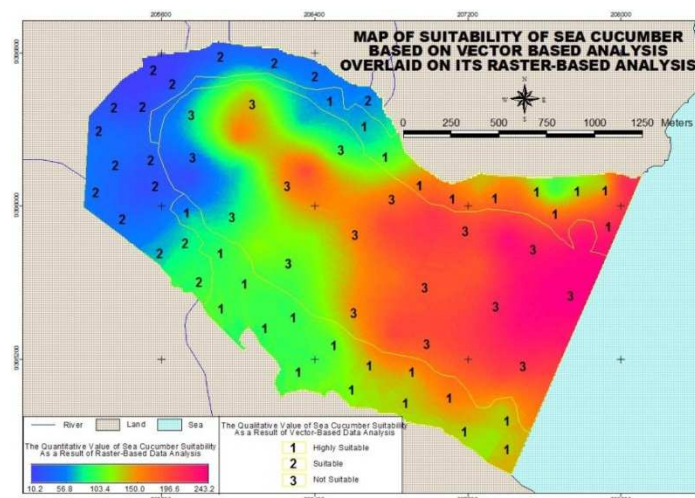


Figure 5. Vector-based map of suitability of sea cucumber (the yellow line) overlaid on the raster-based map

Preparation for installing a cultivation cage

Cage for the cultivation of sea cucumbers is a fence in the form of a fence with a length of 6 meters, a width of 2 meters, and a height of 150 cm which limits the area in the sea to a certain area which is used as a place to cultivate sea cucumbers. Cultivation cage material consists of waring nets, nails, wooden stakes, sacks filled with sand and the dividing wall of the board set 15 cm under seabottom. To measure the weight of sea cucumber, a digital scale with an accuracy of 1000 grams is used. The installation of the cage starts from the immersion of stakes, installation of waring nets, filling the sacks as ballast placed on the edge and inside the cage and fixing the board in waring as adhesive and ballast waring as well (see Figure 6).

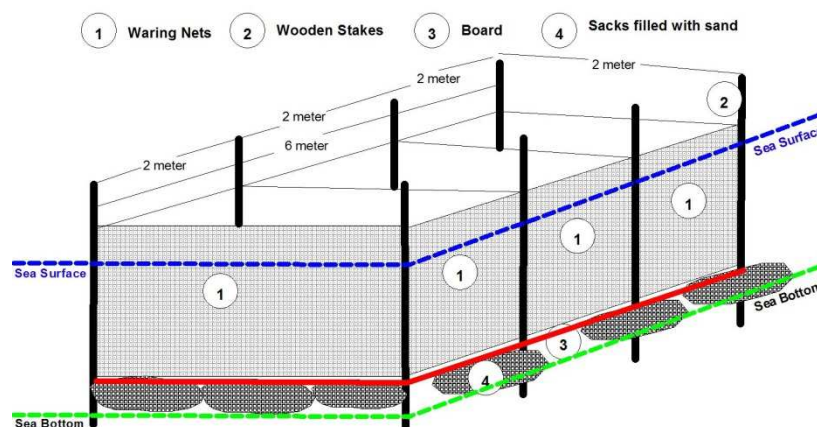


Figure 6. Diagrammatic Construction of Cultivation Cages

Measurement of sea cucumber weight

Eighty-four sea cucumbers were prepared with an initial weight between 60 grams and 266 grams. Sea cucumbers are divided into 2 cultivation cages (each with 42 sea cucumbers) with 3 sub-cages (each with 14 sea cucumbers). In the beginning, all sea cucumbers are weighed (as t_0), then the next measurement is done at every two weeks until t_3 . Before weighing the sea cucumber is taken from the water and then put it into a tray filled with tissue and left for 30 seconds, then begins to be weighed.

The treatment in this study is a variation of the location, which consists of 2 treatments (cages) and 3 replications (sub-cages) as follows:

Treatment	The Suitability Raster	The Suitability Vector
Cage 1	<i>Highly Suitable</i>	<i>Highly Suitable</i>
Cage 2	<i>Less Suitable</i>	<i>Highly Suitable</i>

The analysis used was to compare the different levels of stocking density and survival rates before and after the research activities took place. When two types of treatment are compared, then the average value is used.

Measurement of Water Quality Parameter

Measurement of water quality parameters is carried out during monitoring activities. The parameters measured include physical parameters (depth and temperature) and chemical parameters (salinity, acidity, and dissolved oxygen).

Substrate Analysis

Substrate sampling was carried out every three weeks during the study, then the substrate samples were analyzed in the laboratory to find out the organic matter content in the cultivation cage area. The measurement of the organic content of the substrate was carried out by the ash analysis method, by taking it, weighing 100 grams and putting it in an oven at the temperature of 45°C until it has constant weight (for 3 days). A dry substrate is crushed and put back into the oven and left 30 minutes at really dry temperature. Then weighed again and then is crushed and put into the oven at 45°C for 30 minutes after constant, the substrate was weighed 25 grams and ignited in the furnace with a temperature of 700°C for 3.5 hours. Then the remaining substrate is finally weighed. Analysis of the organic content of the substrate was carried out in the Soil Science Laboratory (at the Department of Soil Science) and the Fisheries Laboratory (at the Department of the Marine Sciences), Bengkulu University.

The data analysis includes:

a. Specific Growth Rate (%)

Specific Growth Rate (SGR) is calculated by the formula[18]:

$$SGR = \frac{\ln W_t - \ln W_0}{t} \times 100 \quad (3)$$

Where

W₀ : Average weight of individuals at the beginning of the study (gram)
 W_t : Average weight of individuals at the end of the study (gram)
 t : Research duration (days)

b. Daily Growth Rate (gram) is calculated using the formula from[19]:

$$DGR = \frac{W_t - W_0}{t} \quad (4)$$

c. Absolute Growth

The absolute growth is calculated by the formula from[20]:

$$AG = W_t - W_0 \quad (5)$$

d. Survival Rate (%)

The survival rate (SR) of sea cucumber can be calculated using formula[21], as follows:

$$SR = \frac{N_t}{N_0} \times 100 \quad (6)$$

Where

No : Number of individuals at the beginning of the study (tail)
 Nt : Number of individuals at the end of the study (tail)

e. Analysis of the physical-chemical and biological data of these waters is aimed at evaluating the level of suitability of the waters in the cultivation cages in the waters of Kiowa Bay, Enggano Island to support the life of sea cucumbers. The results of this environmental observation are then explained descriptively about the effect on the condition of the sea cucumber biology.

f. Substrate Organic Content

Analyse the organic content (OC) of sediments with the following formula[22] :

$$OC = \frac{A-B}{A} \times 100\% \quad (7)$$

Where

A = Constant Weight of Substrate
 B = Ash Weight

3. Result and Discussion

The result of growth and survival rate of sea cucumber during the period of research is presented in Table 1.

Table 1. The Result of Growth and Survival Rate of sea cucumber^{*)}

Cage 1								
	Wo	No	Wt	Nt	AG	SGR	DGR	SR
Sub-Cage 1	165,79	14	199,57	14	33,79	0,26	0,48	100,00
Sub-Cage 2	143,93	14	190,50	10	46,57	0,39	0,66	71,43
Sub-Cage 3	131,36	14	237,83	12	106,48	0,84	1,50	85,71
Average	147,02		209,30		62,28	0,50	0,88	85,71

Cage 2								
	Wo	No	Wt	Nt	AG	SGR	DGR	SR
Sub-Cage 1	160,57	14	248,40	10	87,83	0,61	1,24	71,43
Sub-Cage 2	177,71	14	178,89	9	1,17	0,01	0,02	64,29
Sub-Cage 3	139,71	14	186,70	10	46,99	0,41	0,66	71,43
Average	159,33		204,66		45,33	0,34	0,64	69,05

^{*)}Notation and abbreviations can be seen at the equation or formula given

A. Growth

The high growth in sea cucumber can certainly be influenced by various factors, one of which is environmental factors. Also, another factor is that the high food supply provided during the research period which directly affects the growth of sea cucumber[23].

Based on the results of measurements during the study showed that the treatment of sea cucumber cultivated on Cage 1 resulted in an Absolute Growth of 62.28 gram, SGR of 0.5%, and DGR of 0.88 gram. The high addition of weights at the Cage 1 location is thought to be due to environmental factors and water substrate, where the substrate waters in the Cage 1 location are dominated by seagrass plants and sandy mud. This result is similar to the research of Jasmadi[24], concluding that the growth of sea cucumber in the treatment placed on the sandy substrate resulted in the highest

absolute growth. Another study conducted by Louhenapessy[25], from 4 types of substrate used to see the growth rate of sea cucumber, which has the best growth rate is on the mud substrate. Seagrass ecosystems with sandy mud substrate is a habitat for sea cucumber, this ecosystem usually has high organic content and detritus which is the main food for some types of sea cucumber in general[26].

Sandy mud substrate with seagrass plants will ensure the availability of nutrient sources that can meet the needs of sea cucumber. Sabilu states that sea cucumber is thought to be able to use food well, so that the food that is used to survive and maintain the body, is also used to increase the weight that is metabolized and synthesized as meat[27]. The sandy mud area with seagrass plants is the area with the largest distribution of sea cucumber both in the number and the size[28].

Different from the treatment at Cage 1, the treatment at Cage 2 shows a lower rate of Absolute Growth which is 45.33 gram, SGR of 0.34%, and DGR of 0.64 gram. The low addition of weights in this treatment is thought to have a dominant sand substrate with fewer seagrasses, the incompatibility of the environment and natural habitat of sea cucumbers in nature has an impact on the low addition of Absolute Growth, SGR, and DGR of sea cucumbers. This result is in a line with the statement of Yokoyama that sea cucumber will process sediments faster in a finer substrate which is thought to contain a lot of algae, bacteria, fungi, detritus and organic matter[29]. Furthermore, sediment which is located on the surface of the sandy substrate is poor of nutrition, so that sea cucumbers develop a technique of behaviour adaptation to eating by consuming large amounts of sediment[30]. The eating behaviour aims to maximize the absorption of nutrients obtained from organic matter content in sediments as well as efficiency in movement[31].

B. Survival Rate

The survival rate of sea cucumber during the study for Cage 1 was 85.71% and for Cage 2 it was 69.05%. The high survival rate of sea cucumber which is maintained in each treatment is thought to be caused by environmental conditions that support the survival rate of sea cucumbers so that sea cucumbers can maintain their survival rate. Another indication that arises is that the Kiowa Bay area is a productive area capable of producing organic materials. Food for sea cucumber is in the form of detritus and plankton available in the waters of its habitat[32]. Seagrass ecosystems are one of the most productive ecosystems in the shallow sea waters, have an important role in supporting life and the development of bodies, namely as habitat for biota, sediment catchers, nutrient recyclers and so on.

C. Water Quality

The location of the study is in open areas and there are tides so that water fluctuations and water quality may change at any time. The value of water quality in both research locations is presented in Table 2.

Table 2. Results of measurements of water quality during the study

Parameter	Treatment		Optimum Value
	Cage 1	Cage 2	
Temperature (°C)	28.7-28.9	26.9-27.6	24-30 °C[33]
Salinity (ppt)	30-31	23-25	28-34 ppt[33]
Acidity	7.7	7.7-7.8	7-8.5[21]
Dissolved Oxygen	7.3-7.6	5.0-5.5	> 5ppm[34]
Substrate Organic (%)	5.98	5.18	-

The results of water quality during the study showed that the quality of the waters in the two study areas was still in optimum condition for the growth and survival of sea cucumbers and can still be tolerated by sea cucumbers and is still suitable as a place for cultivating sea cucumbers.

From the results of the above research, especially if one only observed the average value of sea cucumber growth (Specific Growth Rate, Daily Growth Rate, and Absolute Growth) and Survival Rate, it can be seen that Suitability_Raster can better distinguish the results of growth rates rather than the Suitability_Vector. In the Suitability_Raster, different suitability values or class have produced

different growth rates and survival rates of sea cucumber, while at the same class of suitability in the Suitability_Vector the result of growth rate is different.

Another advantage of the Suitability_Raster is in pointing the installation place for pen-culture nets in the field[16]. For example, if a pen-culture net with a size of 40 meters by 40 meters (1,600 m²) was to be installed, the exact location could be easily determined from the Suitability_Raster by selecting 16 adjacent pixels (assuming that the pixel size is 100 m²), such that the coordinates could be determined precisely. In contrast, this cannot be done using the Suitability_Vector, in which the locating of pen-culture nets with an area of 1,600 m² is difficult to locate. In other words, the Suitability_Vector has a high degree of uncertainty compared with the Suitability_Raster in determining exact places. Also, the Suitability_Raster has a higher level of confidence, due to its data inputs are more original than those of the Suitability_Vector, in which data input is simplified causing the variation of earth information is reduced[12].

4. Conclusion

These results indicate that the raster-based data for sea cucumber suitability model has advantages over the sea cucumber suitability model analyzed using vector-based data.

5. Acknowledgments

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References

- [1] Bappeda Provinsi Bengkulu and C.V. Mitra Konsultan, *Laporan Akhir Penyusunan Tata Ruang Dan Potensi Pulau Enggano*, Bappeda Provinsi Bengkulu, Bengkulu, 2004.
- [2] L. H. Hyman, *The Invertebrates: Echinodermata The Ceolomate Bilateria. Vol. IV*. McGraw-Hill Book Company, New York, 1955.
- [3] D. Purnama, and D. Hartono, *Studi Jenis Dan Distribusi Teripang Holothuroidea Di Perairan Pulau Enggano*, Lembaga Penelitian Universitas Bengkulu, Bengkulu, 2013.
- [4] D. Sartika, "Aspek Biologi Reproduksi Taripang Pasir (*Holothuria scabra*) di Perairan Pantai Desa Sorue Jaya Kecamatan Soropia Kabupaten Kendari Sulawesi Tenggara," *undergraduate thesis*, Universitas Haluoleo, Kendari, 2002.
- [5] A. Anggoro, E. Sumartono, V.P. Siregar, S.B. Agus, D. Purnama, Supriyono, D. A. Puspitosari, T. Listyorini, B. Sulisty, and Parwito. 2018, "Comparing object-based and pixel-based classification for benthic habitats mapping in Pari Island," *IOP Conference Series: Journal of Physics: Conf. Series* 1114, 012049
- [6] B. Sulisty, The Accuracy of the Outer Boundary Delineation of Coral Reef Area Derived From the Analyses of Various Vegetation Indices of Satellite Landsat Thematic Mapper, *Biodiversitas*, vol. 18, no 1, pp. 351-358, 2017.
- [7] B Sulisty B, The Effect of choosing three different c factor formulae derived from NDVI on a fully raster-based erosion modeling, *2nd International Conference of Indonesian Society for Remote Sensing (ICOIRS)*, Published under licence by IOP Publishing Ltd, IOP Conference Series: Earth and Environmental Science, Vol. 47, No 1, 2016.
- [8] R. J. Eastman, *Idrisi Andes: Guide to GIS and Image Processing*, Clark Labs, Clark University, Worcester, USA, 2006.
- [9] B. Song B and S. Kang, A Method of assigning weights using a ranking and nonhierarchy comparison, *Advances in Decision Sciences*, vol. 1, no. 1, pp. 1-9, 2016.

- [10] U. Wulandari, B. Sulistyono and D. Hartono, Aplikasi SIG Untuk Kesesuaian Kawasan Budidaya Teripang Pasir (*Holothuria scabra*) Dengan Metode *Penculture* di Perairan Teluk Kiowa, Desa Kahyapu Kecamatan Enggano, *Jurnal Enggano*, vol. 1, no. 1, pp. 57-73, 2016.
- [11] D. Marizal, Y. V. Jaya, and H. Irawan, Aplikasi SIG Untuk Kesesuaian Kawasan Budidaya Teripang *Holothuria scabra* dengan Metode *Penculture* di Pulau Mantang, Kecamatan Mantang, Kabupaten Bintan. *Marine Science and Fisheries*, vol. 3, no. 6, pp. 1-8, 2012.
- [12] M. N. DeMers, *Fundamental of Geographic Information Systems*, John Wiley & Sons, New York, 2008.
- [13] D. S. Hadmoko, Toward GIS-based integrated landslide hazard assessment: a critical overview, *The Indonesian Journal of Geography*, vol. 39, no. 1, pp. 87-95, 2007.
- [14] B. Sulistyono, T. Gunawan, Hartono, and P. Danoedoro, Toward a fully and absolutely raster-based erosion modeling by using RS and GIS, *The Indonesian Journal of Geography*, vol. 41, no. 2, pp. 149-170, 2009.
- [15] B. Sulistyono, T. Gunawan, Hartono, P. Danoedoro, and N. Listyaningrum, Absolute Accuracy of the Erosion Model of DEM-NDVI and it's Modification, *International Journal of Geoinformatics*, vol. 13, no. 2, pp. 23-34, 2017.
- [16] B. Sulistyono, D. Purnama, M. Anggraini, D. Hartono, M. D. Wilopo, U. Wulandari, U., and N. Listyaningrum, Refining The Suitability Modeling of Sea Cucumber (*Holothuria scabra*) Using Fully Raster-Based Data, *Forum Geografi*, vol. 31, no. 2, pp. 119-130, 2018.
- [17] M. Aral, *Environmental Modeling and Health Risk Analysis (Act/Risks)*, Business Media BV, Springer Science, London, 2010.
- [18] Murniati, "Pengaruh Tingkat Kombinasi Kotoran Ayam dan Pasir Sebagai Substrat Terhadap Pertumbuhan dan Kelangsungan Hidup Teripang Pasir (*Holothuria scabra*, *Jager*) yang Diberi Pakan Buatan," *undergraduate thesis*, Universitas Haluoleo, Kendari, 2001.
- [19] Supriharyono, *Pengelolaan Ekosistem Terumbu Karang*, Djambatan, Jakarta, 2000.
- [20] H. Weatherley, *Growth and Ecology of Fish Population*, Academic Press, New York, London, 1979.
- [21] H. Effendi, *Telaahan Kualitas Air Bagi Pengelolaan Sumberdaya dan Lingkungan Perairan*, Kanisius. Yogyakarta, 2003.
- [22] Firstyananda, "Komposisi dan Keanekaragaman Makrozoobenthos di Tiga Aliran Sungai," *undergraduate thesis*, Universitas Airlangga, Surabaya, 2011.
- [23] M. I. Effendi, *Biologi Perikanan*, Yayasan Pustaka Utama, 1997.
- [24] Jasmadi, Growth and Ecological Aspects of Sandfish *Holothuria scabra* in Pen Culture Lairngangas Coast, South East Moluccas, *Jurnal Ilmu dan Kelautan Tropis*, vol. 10, no. 2, pp. 317-331, 2018
- [25] D.G. Louhenapessy, Pengaruh Substrat Berbeda Terhadap Pertumbuhan Teripang Pasir (*Holothuria scabra*), Triton, *Jurnal Manajemen Sumberdaya Perairan*, vol. 9, no. 1, pp. 26-32, 2013.
- [26] R. W. Afrely, M. I. Rosyidi, and S. Fajariyah, Keanekaragaman jenis holothuroidea di Zona Intertidal Pantai Pancur Taman Nasional Alas Purwo, *Jurnal Ilmu Dasar*, vol. 16, no. 1, pp. 23-28, 2015.
- [27] K. Sabilu, "Pengaruh kombinasi ampas sagu dan kotoran sapi terhadap pertumbuhan teripang pasir (*Holothuria scabra jager*)," *undergraduate thesis*, Universitas Haluoleo, Kendari, 2002.
- [28] R. Komala, Keanekaragaman teripang pada ekosistem lamun dan terumbu karang di Pulau Bira Besar, Kepulauan Seribu, Jakarta, *Jurnal Biodiversitas Indonesia*, vol. 1, no. 2, pp. 222-226, 2015.
- [29] H. Yokoyama, Growth and Food Source of The Sea Cucumber *Apo stichopus Japonicus* Cultured Below Fish Cages Potential for Integrated Multi-Trophic Aquaculture. *Aquaculture*, vol. 38, no. 28, pp. 372-375, 2013.
- [30] P.G. Navaro, S.G. Sanz, and J.M. Barrio, Feeding and Movement Patterns of the Sea Cucumber *Holothuria sanctori*. *Marine Biology*, vol. 16, no. 11, pp. 2957-296, 2013.

- [31] L.N. Zamora, and A.G. Jeffs, Feeding, Selection, Digestion and Absorption of the Organic Matter from Mussel Waste by Juveniles of the Deposit-Feeding Sea Cucumber, *Australostichopus Mollis*, *Aquaculture*, vol. 317, no. 1, pp. 223-228, 2011.
- [32] R. Wahab, *Teripang di Perairan Pasarwajo, Pulau Buton, Sulawesi Tenggara*, Pusat penelitian Oceanografi-LIPI. Jakarta, 2001.
- [33] J.N. Martoyo, Aji, and T.J. M. Winanto, *Seri Agribisnis: Budidaya Teripang*, Jakarta: Penebar Swadaya, Surabaya, 2007.
- [34] J.N. Martoyo, Aji, and T.J. M. Winanto, *Budidaya Teripang*, Penebar Swadaya, Jakarta, 2002.