

Research Journal of Pharmaceutical, Biological and Chemical Sciences

Spatial Multi Criteria Analysis to Determine the Suitability of the Area for Sea Cucumber Cultivation (*Holothuria sp.*) In the Waters of Hatta Island, Banda Neira, Maluku.

Aditya Putra Basir*, Sri Andayani, and Abu Bakar Sambah.

Faculty of Fisheries and Marine Sciences, Universitas Brawijaya, Jl. Veteran, Malang 65145, Jawa Timur Province, Indonesia.

ABSTRACT

Sea cucumbers are one of the aquatic organisms potential for cultivation. Selection of appropriate location is the initial stage to support the success of cultivation of sea cucumbers. This study was conducted in March 2017 in the waters of Hatta Island, Banda Neira, Maluku Province. This study aims to map suitable marine areas for the cultivation of sea cucumbers (*Holothuria sp.*). Data collection is conducted by survey method, by observing environmental parameters, socio-infrastructure, and limiting factors. The observed data is then processed using a multi-criteria spatial analysis. The result of spatial analysis shows that of the total potential area (256 Ha) in Hatta Island waters, the area belonging to the most suitable category is 58.92 Ha, suitable category is 92.23 Ha, suitable is 32.70 Ha and the not suitable category is 37.95 Ha. The area categorized as limiting factor is 34.21 Ha, which consists of tourism sites and protected areas. The results of this study can be used as a reference by the Regional Government for the preparation of regional spatial plans, especially in the waters of Hatta Island, Banda Neira as the area of Aquaculture and Tourism.

Keywords: SMCA, suitability of the marine area (for cultivation), sea cucumber

*Corresponding author

INTRODUCTION

Sea cucumbers are one of the sea products with significant economic value of the Hatta Island. Sea cucumbers in Hatta Island are collected through traditional fishing activities. Excessive utilization by simply expecting natural stock recovery causes the low availability of sea cucumber in nature. To avoid the scarcity of sea cucumbers, farming activities must be done [1]. The waters of Hatta Island have a flat water area of 256 Ha which is potential for cultivation activities with the technique of kurungan tancap.

One aspect to consider in starting the cultivation of sea cucumbers is the suitability of the area to be used. The cultivation area should meet water quality standards for organisms to live there, free from pollution, safe, and easy for marketing the cultivated products. This study aims to analyze the carrying capacity of the waters and to identify the level of land suitability to determine the extent of waters that can be utilized for the cultivation of sea cucumbers in the waters of Hatta Island, Banda Neira, Maluku. To determine water suitability is done by Spatial Multi Criteria Analysis (SMCA). SMCA serves to assist policy makers in selecting several alternatives of simulation model results available on a priority scale [2]. Spatial integration of multiple analytical criteria in the context of geographic information systems is helpful in the decision making process [3].

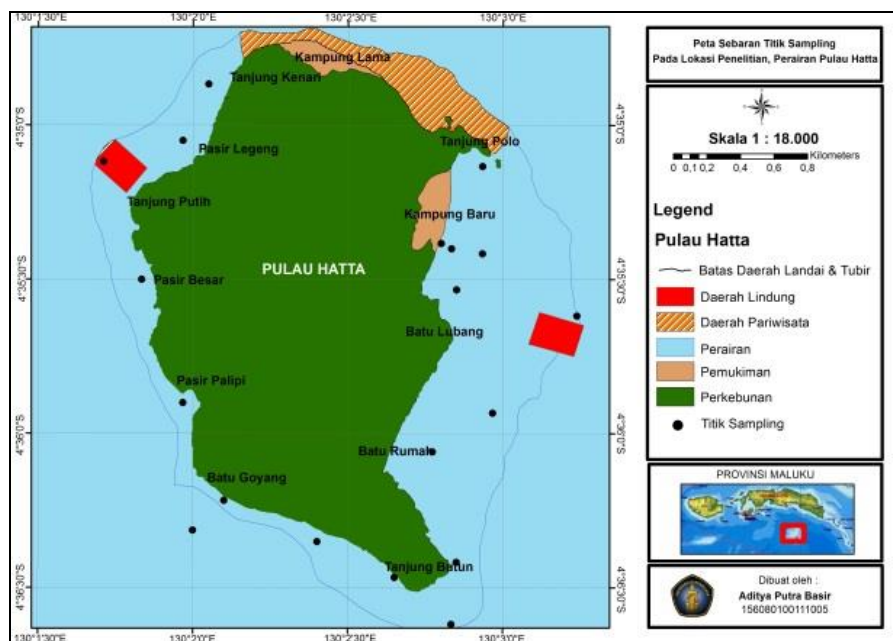
The results of this study are expected to provide an overview of the suitability level of Hatta Island Waters in connection with the determination of the location as a cultivation area of sea cucumbers.

MATERIALS AND METHODS

Study Site

This study was conducted in the waters of Hatta Island which is part of the waters of Banda Sea. The study sites were located between 4o36' LS dan 130o01' – 130o03' BT (Figure 1).

Figure 1: Samplings at the Study Site



Data Identification

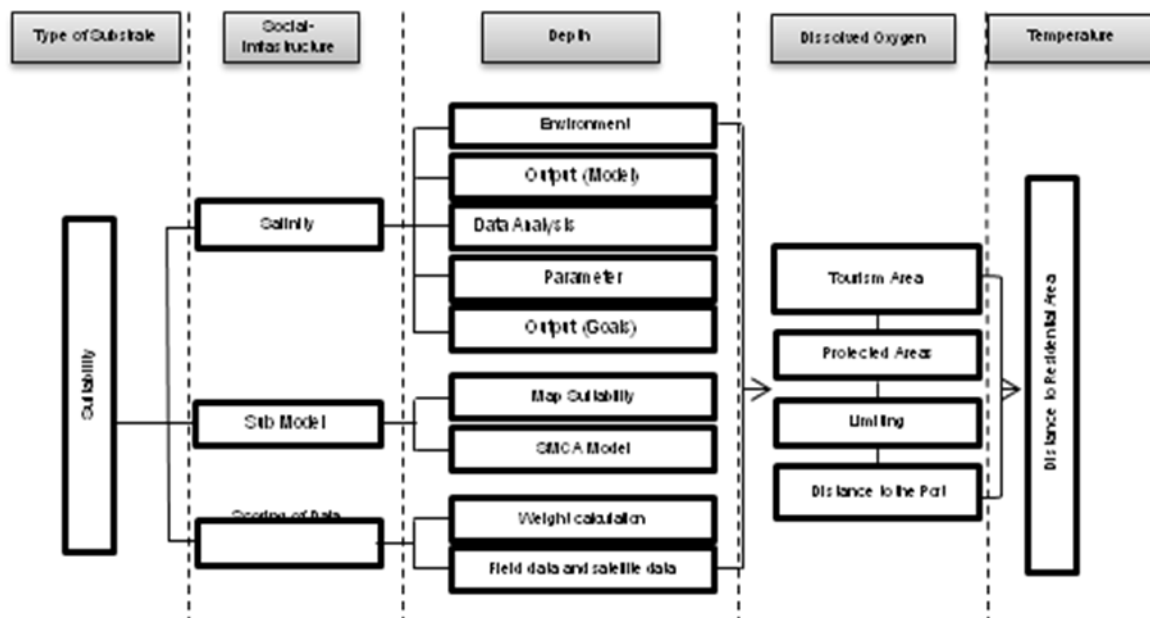
The suitability of area for the cultivation of sea cucumbers in the waters of Hatta Island is prepared based on a hierarchical model [4]. The hierarchical model divides the entire criterion into a more specific part (parameter) with the ultimate goal of final output (Goal) [5]. The land suitability classification in this study is

based on environmental and social-infrastructure criteria. The criteria consist of the eight main parameters to be identified. The parameters are grouped as both supporting and limiting factors [6].

Supporting factors are environmental and socio-infrastructure parameters that have an effect on the success of sea cucumber cultivation, while limiting factor is the specific condition limiting in the field or location that cannot be used for cultivation activities [7]. In this study, the so-called limiting factors are waters that have been utilized as coastal tourist areas and protected areas.

The main data used in this study include field survey data, maps, and satellite data. Data collection was conducted in March 2017. The sampling point distribution was designed using purposive sampling approach, based on the consideration of equality of water character, ease, efficiency of time and cost based on initial interpretation of research location [8]. Environmental data collected include salinity, water temperature, dissolved oxygen, water depth and substrate type [9]. The measurement of social-infrastructure data includes the distance from the sampling point to the residential location [10], and the distance from the sampling point to the port [11]. Flow chart of suitability of cultivation area is presented in Figure 2. The value of point of measurement result in the field is converted to area (polygon) through interpolation process using Inverse Distance Weighted [12], so it can be used in spatial analysis.

Figure 2: Flow chart of suitability of cultivation area of sea cucumbers



Scoring and Weighting

Scoring for land suitability in this study used a score system of 1-4 [13]. The figure 4 means very suitable and 1 means not feasible for the cultivation of sea cucumbers. Scores of each criterion are determined based on their suitability to the cultivation of sea cucumbers.

The weights of each criterion are determined using the analytical hierarchy process (AHP) as the decision support system [14]. The importance of each criterion is based on the results of the questionnaire given to the experts and the literature study. Weight calculation is done by using Expert Choice 11 software. After all score and weight are determined, the next step is to conduct a spatial analysis of the suitability of the area.

Table 1: The Results of Scoring and Weighting of Each Parameter Based on the Suitability of the Cultivation Area

Parameter	Criteria	Score	Weight	Score
Salinity(‰)	33-35	7	1	7
	30-32	5		5
	24-29	3		3
Temperature (°C)	<24. >35	1	1	1
	26-31.6	7		7
	23-35	5		5
	20-22	3		3
DO (Mg/l)	<20. >31.6	1	1	1
	6-8	7		7
	4-5	5		5
	2-3	3		3
Depth (m)	<2. >8	1	4	1
	1-1.5	7		28
	0.7-0.9	5		20
	0.5-0.6	3		12
Substrate	<0.5 dan >1.5	1	2	4
	Pasir & pecahan karang	7		14
	Pasir			
	Pasir & lumpur	5		10
Distance to residential areas (m)	Lumpur	3	4	6
	<1000	1		2
	1000-2000	7		28
Distance to the port (m)	2000-3000	5	1	20
	>3000	3		12
	>1000	1		4
	700-1000	7		7
	500-700	5	1	5
	<500	3		3
		1		1

Source: Wulandari et al., 2016; Nayak et al. 2014; Radiarta et al., 2012; Hossain et al., 2009.

Overlay Analysis

After obtaining the weight and scores of each criterion, an overlay analysis is then performed to combine information from the environmental and social-infrastructure maps. The final result of the overlay analysis is the land suitability map of the cultivation area of sea cucumbers in the waters of Hatta Island, Banda Neira, Maluku.

Class of Suitability

The following formula is used to determine the total score:

$$N = \frac{\sum BI \times Si}{Total\ Weight}$$

In which:

- N = Total score
- Σbi = Weight on each criterion
- Si = Score on each criterion

To determine the class suitability of the cultivation area, the following formulas are used:

$$N.min = \frac{Weight\ on\ Each\ Criterion}{Total\ Weight}$$

$$N.max = \frac{Total\ Score}{Total\ Parameter}$$

$$Class\ Interval = \frac{N.max - N.min}{Number\ of\ Class}$$

Here are the class intervals resulted from the calculation using the above formula:

Table 2: Class Interval on the Suitability of Cultivation Area and Weight

Weight	Suitability Level	Range of Scores
4	Very suitable	83-94
3	Suitable	71-82
2	Quite Suitable	59-70
1	Not Suitable	47-58

Note:

- 4 Very suitable: ideal for the cultivation of sea cucumbers.
- 3 Suitable: the location can be used for the cultivation of sea cucumbers with little cost and time.
- 2 Quite suitable: the location can be used for cultivation of sea cucumber, but requires rather big energy, cost, and time.
- 1 Not suitable: the location can be used for cultivation of sea cucumber, but requires big energy, cost, and time.

RESULTS AND DISCUSSION

Parameters observed in this study are parameters related to the condition of a location to be used as cultivation area of sea cucumbers. In general, the cultivation of sea cucumbers is done in shallow water areas with a kurungan tancap system.

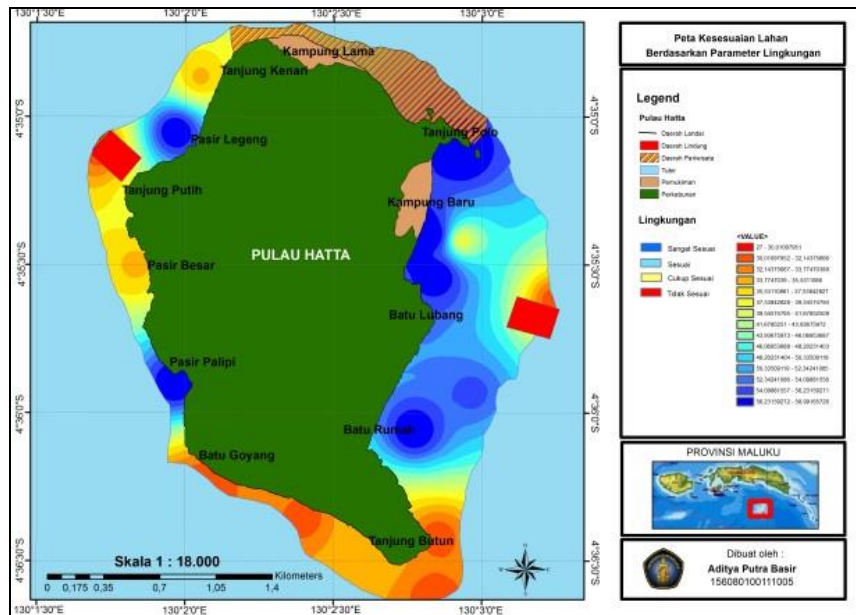
Observations of environmental parameters, social-infrastructure and limiting factors were carried out for approximately one month. Parameter measurements were performed in situ by spreading 21 sampling points representing all shallow waters in the waters of Hatta Island. The results of further measurements are compared with the quality standards and conformity classes of each parameter.

Suitability of Sea Cucumber Cultivation Area Based on Environmental Parameters

Observation of environmental parameters including salinity, temperature, dissolved oxygen, water depth, and substrate type was done from 08.00-16.00 of the local time. The parameter values of aquatic environment were analyzed using Geographic Information System (GIS) method, which produced a thematic map of suitability of the cultivation area based on environmental parameters.

The interpolation result of the environment parameter shows 4 classes of suitability from blue to red. Blue describes the very suitable location, while red represents an unsuitable location for cultivation of sea cucumbers. The suitability class is determined based on the class interval, among others: very suitable to the value of 51-58, suitable to the value of 42-50, quite suitable to the value of 33-41, and not suitable to the value of 24-32. Based on the results of spatial analysis using geographic information system, then the area with very suitable category of 101.39 Ha, suitable of 48.84 Ha, quite suitable of 11.61 Ha, and not suitable of 24.21 Ha.

Figure 3: Suitability Map of Sea Cucumber Cultivation Area Based on Environmental Parameters

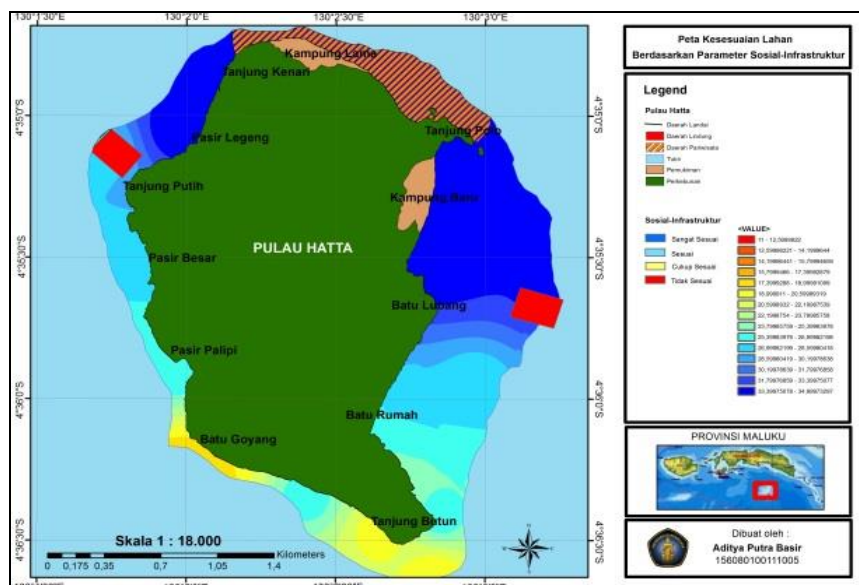


Suitability of Sea Cucumber Cultivation Area Based on Social-Infrastructure Parameters

Social-infrastructure criteria covering distance to residential and proximity to the port; these two factors can directly affect the cultivation of sea cucumbers in the waters of Hatta Island. The location of cultivation close to the residential area will facilitate the monitoring activities of cultivated organisms so that it is safe from theft and destruction and is easier in terms of labor supply [15]. In contrast, the location of sea cucumber cultivation should not be adjacent to the port, because the high activity in the port produces a lot of waste in the form of oil, garbage, and other industrial wastes derived from ships or industrial activities at the port. Distance of cultivation location to port area should be not less than 1000 meter [3].

The result of interpolation of social-infrastructure data shows that the area that is very suitable for the cultivation of sea cucumber is 118.39 Ha with a class interval of 29-35. The suitable area is 103.40 Ha with a class interval of 22-28. The quite suitable area is 27.56 Ha with a class interval of 15-21.

Figure 4: Suitability Map of Sea Cucumber Cultivation Area Based on Social-Infrastructure Parameters



Limiting Factors

Coastal areas have diverse characteristics and can be accessed by everyone. This causes coastal areas to face various issues including the one related to spatial planning [16]. Land used as a cultivation area of sea cucumbers should not be used as a fishing ground, shipping lanes, or tourism areas [17].

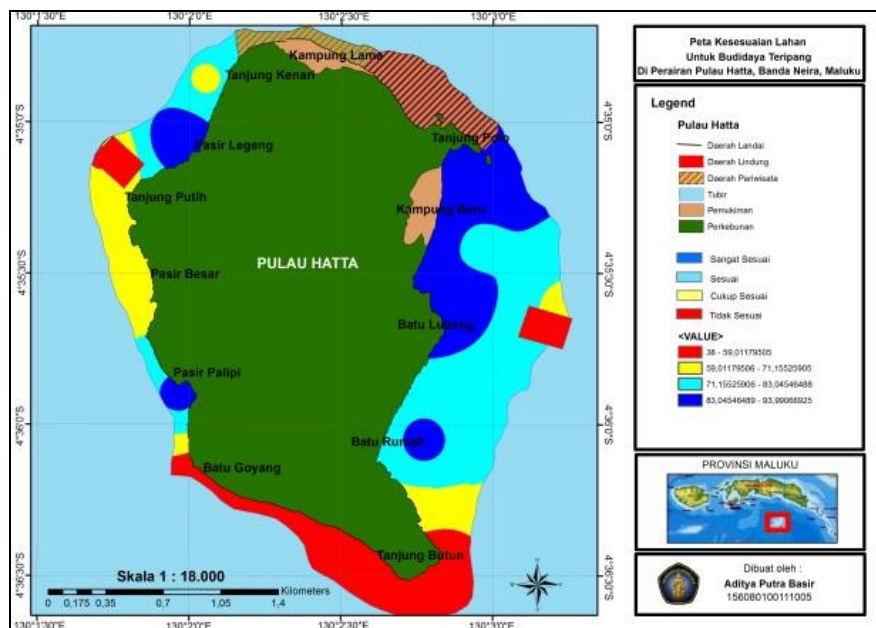
Based on the survey results in the waters of Hatta Island, the area has been used as tourism area (beach and diving). The location is located on the coast of Kampung Lama to Tanjung Polo with an area of 24.21 Ha. In addition, the people of Hatta Island have local wisdom for the utilization of water resources in Hatta Island, known as sasi. Based on the customary rules, there are territorial waters serving as a protected area. Protected areas are areas with coral reefs for spawning various species of reef fish and Lola (*Truchus niloticus*). The area of land used as a protected area is 10 Ha (Figure 5). The protected areas and the tourism area are categorized as limiting factors for the cultivation of sea cucumbers in the waters of Hatta Island.

Suitability for Sea Cucumber Cultivation

The result of combining all parameters from environmental criteria, socio-infrastructure and limiting factor with overlay technique, then the suitability map for the cultivation of sea cucumbers in the waters of Hatta Island could be made (Figure 5). Of the total potential land area for the cultivation of sea cucumbers (256 Ha), the very suitable category is 58.92 Ha, the suitable category is 92.23 Ha, the quite suitable category is 32.70 Ha, and the unsuitable category for cultivation of sea cucumber is 37.95 Ha. The extent of land categorized as limiting factor is 34.21 Ha which consists of tourism and protected areas.

Locations with very suitable category are generally supported by excellent water and environmental conditions, as well as adequate social and infrastructure conditions. Locations with very suitable categories are concentrated in the Kampung Baru waters area to Batu Lubang, Batu Rumah, Pasir Palipi, and Batu Legeng. Unsuitable locations are affected by insufficient environmental conditions and social-infrastructure. Conditions of the waters are too deep and open, which directly opposite the Banda Sea causing the waters are not suitable for cultivation of sea cucumbers. Unsuitable locations are in the location of the waters of Tanjung Butun to Batu Goyang waters.

Figure 5: Suitability Map for Sea Cucumber Cultivation in Hatta Island, Banda Neira, Maluku.



CONCLUSION

The result of measurement of environmental parameters, social-infrastructure, and limiting factor in Hatta Island waters shows that the water quality condition is very suitable for the cultivation of sea cucumber, but the water depth and substrate type at some locations are not in accordance with the land suitability value, so it is not recommended to be used as location of cultivation. It is expected that the results of this study can provide input to the Regional Government of Central Maluku as a reference for the preparation of Regional Spatial Planning, especially in the waters of Hatta Island as aquaculture and marine tourism in Banda Neira Islands.

ACKNOWLEDGMENT

My gratitude goes to the Institute of Education Fund Management (LPDP) of the Ministry of Finance of the Republic of Indonesia which has funded the study. I also thanked the team of NGO Locally Managed Marine Area (LMMA) Hatta Island who had assisted in the process of collecting data during the research.

REFERENCES

- [1] Wulandari, U., B. Sulisty, D. Hartono. Aplikasi SIG Untuk Analisis Kesesuaian Kawasan Budidaya Teripang Pasir (*Holothuria scabra*) Dengan Metode Penculture di Perairan Teluk Kiowa, Desa Kahyapu Kecamatan Enggano. *Jurnal Enggano*, 2016, 1(1): 57-73. EISSN: 2527-5186.
- [2] Wibowo, A., J. Semedi. Model Perencanaan Wilayah Terbangun dengan SMCA (Studi Kasus Di Kota Serang). *Globè*, 2011, 13(1): 50 – 59.
- [3] Nayak, A.K., D. Pant, P. Kumar, P.C. Mahanata, N.N. Pande. GIS-Based Aquaculture Site Suitability Study Using Multi-Criteria Evaluation Approach. *Indian Journal Fish*, 2014, 61(1): 108-112.
- [4] Malczewski, J. On the use of weighte linear combination method in GIS: common and best practice approach. *Transaction in GIS*, 2000, 4: 5-22.
- [5] Radiarta, I.N., A. Saputra, H. Albasri. Pemetaan Kelayakan Lahan Budidaya Rumput Laut (*Kappaphycus alvarezii*) Di Kabupaten Bintan Provinsi Kepulauan Riau Dengan Pendekatan Sistem Informasi Geografis Dan Penginderaan Jauh. *Jurnal Ris. Akuakultur*, 2012, 7(1): 145-157.
- [6] Nath, S.S., J.P. BolteRoss, L.G. Aguilar, J. Manjarrez. Applications of geographical information systems (GIS) for spatial decision support in aquaculture. *Aquacultural Engineering*, 2000, 23: 233-278.
- [7] Radiarta, I.N., A. Saputra, I. Ardi. Analisis Spasial Kelayakan Lahan Budidaya Kerang Hijau (*Perna viridis*) Berdasarkan Kondisi Lingkungan Di Kabupaten Cirebon, Jawa Barat. *Jurnal Ris. Akuakultur*, 2011, 6(2): 341-352.
- [8] Djarwanto dan Subagyo. *Statistik Induktif*. 1990. Penerbit BPFE. Yogyakarta.
- [9] Marizal, D., Y.V. Jaya, H. Irawan. *Aplikasi SIG Untuk Kesesuaian Kawasan Budidaya Teripang *Holothuria scabra* dengan Metode Penculture di Pulau Mantang, Kecamatan Mantang, Kabupaten Bintan. Program Studi Ilmu Kelautan*. 2012. Fakultas Perikanan dan Ilmu Kelautan. Universitas Maritim Raja Ali Haji. Riau.
- [10] Radiarta, I.N., S. Sei-Ichi, A. Miyazono. GIS-Based Multi-Criteria Evaluation Models For Identifying Suitable Sites For Japanese Scallop (*Mizuhopecten yessoensis*) Aquaculture In Funca Bay, Southwestern Hokkaido, Japan. *Aquaculture*, 2008, 284: 127–135.
- [11] Hossain, M.S., S.R. Chowdhury, N.G. Das, S.M.B. Sharifuzzaman, A. Sultana. Integration of GIS and multicriteria decision analysis for urban aquaculture development in Bangladesh. *Landscape and Urban Planning*, 2009, 90: 119–133.
- [12] Johnston, K., J.M. Ver Hoef, K. Krivoruchko, N. Lucas. *Using ArcGIS geostatistical analyst*. 2001. ESRI. USA.
- [13] Giap, D.H., Y. Yi, A. Yakupitiyage. GIS for land evaluation for shrimp farming in Haiphong of Vietnam. *Ocean & Coastal Management*, 2005, 48: 51-63.
- [14] Saaty, T.L. A Scaling Method for Priorities in Hierarchical Structures. *J. of Mathematical Psychology*, 1977, 15: 234-281.
- [15] Kingzet, B., R. Salmon, R. Canessa. *First Nations Shellfish Aquaculture Regional Business Strategy*. 2002. BC central and northern coast. Aboriginal relations and economic measures, Land and Water British Columbia Inc.
- [16] Dahuri, R. *Pendayagunaan Sumberdaya Kelautan Untuk Kesejahteraan Rakyat*. 2000. LISPI-Ditjen P3k, Departemen Eksplorasi Laut dan Perikanan. Jakarta.



- [17] Widodo, A. Budidaya Teripang, Khasiat dan Cara Olah Untuk Pengobatan. 2015. Pustaka Baru Press. Yogyakarta.