Jurnal Ilmu Kelautan
SPERMONDE (2023) 9(2): 22-28

P-ISSN: 2460-0156
E-ISSN: 2614-5049

ANALYSIS OF THE OCEANOGRAPHIC CONDITIONS OF MEOSBEKWAN ISLAND (RAJA AMPAT DISTRICT) FOR THE SUITABILITY OF SEAWEED CULTIVATION

Mahatma Lanuru[1*], Khairul Amri[1], Supriadi Mashoreng[1], Dahlan[2],Yunus P. Paulangan[3]

Submitted: July 15, 2023   Accepted: Septenber 3, 2023

[1]Department of Marine Science, Faculty of Marine Science and Fisheries, Hasanuddin Universitas
[2]Aquaculture Study Program, Yapis University Papua
[3]Marine Science Study Program, Cenderawasih University
Corresponding Author:
*Mahatma Lanuru
E-mail: mahatma.lanuru@unhas.ac.id

ABSTRACT

Seaweed cultivation is an alternative community livelihood that potentially helping to reduce pressure on coral reefs in the area of Raja Ampat Archipelago. This study was aimed to conduct an oceanographic analysis of the waters of Meosbekwan Island (Raja Ampat Regency) for the suitability of seaweed cultivation. Oceanographic data collection was carried out at three points (M1, M2, and M3) on the western side of Meosbekwan Island. Analysis of suitability for aquaculture was initiated with an analysis of key parameters, i.e., depth, protection and shipping traffic. The suitability analysis was followed by an analysis of the oceanographic parameters of the waters by weighting them using a ranking system. Furthermore, the final stage of suitability analysis was to evaluate the feasibility level of seaweed cultivation. The results showed that the depth of the waters on the western side of Meosbekwan Island ranged from 1.3 m – 5.8 m with an average depth of 1.5 m in the south (M1), 2.2 m in the middle (M2), and 3.9 m to the north (M3). Wave height during the study ranged from 0.1 – 0.3 m with an average value of 0.25 m at all points. The velocity of the water currents ranged from 0.08 – 0.25 m/s. The salinity of the waters was relatively homogeneous (30 - 31 o/oo). Water temperature also has small and relatively homogeneous variations with a range of 30 - 31˚C. The brightness of the waters ranged from 2.5 – 3.5 m. The bottom of the waters on the west side of Meosbekwan Island generally consists of coarse sand, rubble, and seagrass vegetation *Enhalus acoroides* and *Cymodocea* sp. In general, the oceanographic conditions of the waters are suitable for the life and growth of seaweed. The results of the location suitability evaluation indicated that the waters on the western side of Meosbekwan Island were technically feasible to serve as a location for seaweed cultivation.

Keywords: Oceanography, substrate, seaweed, culture, Raja Ampat

INTRODUCTION

The Raja Ampat Archipelago has a very high biodiversity when compared to some other areas in the world. For example, coral reefs are the heart of the world's coral triangle, where the coral triangle is an area that has the largest coral biodiversity. The large wealth of coral reefs in Raja Ampat Regency is a great capital for developing the area and for improving the welfare of the community, especially those whose lives are very dependent on coastal ecosystems. It is hoped that the fisheries and marine tourism sectors will become the main drivers of the Raja Ampat Regency economy.

However, exploitation of coral reef resources that are not environmentally friendly has occurred, such as the use of explosives, cyanide, and the extraction of coral for building materials. As a result, these activities have caused damage as indicated by a decrease in the diversity of species of reef fish and other biota associated with these coral reefs.

One effort to reduce pressure on coral reefs is to provide alternative livelihoods for the community. Seaweed cultivation is an alternative livelihood that may help reduce pressure on coral reefs. Seaweed is a type of commodity that has competitive market economic value because apart from functioning as food, it is also caused by the diversification of seaweed products which have various uses.

Technically the Raja Ampat area has potential waters for the development of seaweed cultivation businesses. In addition, the government's policy to make Raja Ampat Regency a center for seaweed cultivation and the existence of wide-open seaweed market opportunities, both domestic and foreign (export) markets, is a big capital for the development of seaweed cultivation businesses in Raja Ampat waters. Currently, there are not many studies that examine the oceanographic conditions of Raja Ampat waters for the suitability of seaweed cultivation even though the oceanographic conditions of the waters such as current speed, wave height, depth, temperature, salinity, water brightness, and water bottom substrate are technical aspects that determine the success of the seaweed aquaculture (Numberi et al, 2020; Soejarwo and Indra, 2020; Nashrullah et al, 2021. This paper presents the results of an analysis of the oceanographic conditions of Meosbekwan Island which is included in the territorial waters of Raja

Ampat Regency for the suitability of seaweed cultivation.

MATERIALS AND METHODS

This research was conducted in October – November 2006 in the coastal waters of Meosbekwan Village (Meosbekwan Island) Raja Ampat Regency, West Papua Province (Figure 1).

Figure 1. Map of the Study Location

Research Procedure

Oceanographic data collection (depth, wave height, bottom substrate, salinity, current velocity, brightness, and water temperature) was carried out at three points, namely the southern (M1), central (M2) and northern (M3) parts of the west side of Meosbekwan Island. In addition to oceanographic parameters, it was also observed the fertility of the waters and the presence of herbivores at the sampling location. Both of these parameters are needed for the analysis of the feasibility of the waters for seaweed cultivation.

Current velocity was measured using a drift float. Current velocity was calculated by dividing the distance traveled by the drift float by the time and was expressed in meters/second. Measurement of wave height was done by reading the crests and troughs of the waves on a scale pole that was plugged in at the level before the waves break. Wave height units are expressed in meters. The wave observations were elaborated with the results of interviews with island communities regarding wave and weather conditions at certain times.

Depth measurements were carried out using a depth meter. This tool was immersed in water on the surface with the sensor position facing down. The depth of the water at that time was determined from the digital value on the equipment. Water samples on the surface of the waters were taken using a container for measuring temperature and salinity. Water temperature was measured using a thermometer and salinity was measured using a hand refractometer.

Observation of brightness was carried out using a Secchi disk. The Secchi disk was lowered into the water, then records the depth where the disc was not visible. The disc was still lowered slightly and then slowly raised again. The depth at which the disk begins to show again was recorded. The average results of recording the first and second depths were the brightness of the waters.

The bottom substrate and water fertility were directly observed in the field. The existing bottom substrate was identified by visual observation by looking at the dominant substrate at each observation point. While water fertility was assessed based on the existing indicators such as the presence or absence of vegetation such as seagrass and natural macroalgae. The abundance of herbivorous animals that can eat seaweed, may be known through visual observation and from the results of direct interviews with the island community.

Data Analysis

The preparation of the suitability matrix refers to the guidelines for the management of seaweed cultivation from various references. The parameters studied were the limiting factors (environmental biophysics) of seaweed cultivation. To compile the water suitability matrix, a parameter weighting system based on the ranking method was used which was then modified to determine the suitability of the location for seaweed cultivation. Prior to weighting, the key parameters or first-level parameters were determined as presented in Table 1, if the key parameters were declared inappropriate, the analysis was not continued. The key parameters include depth, protection and shipping traffic. However, if the key parameters are in the appropriate or sufficient category then the analysis is continued at the second level of parameters which include the biophysical characteristics of the waters (Table 2) (DFW, 2005). This second parameter group was weighted using a ranking system (Table 3). The weighting system was obtained by using the following equation:

$$w = \frac{n - Bx + 1}{\sum(n + Bn + 1) + (n - Bn + 1) + \cdots + (n - Bn + 1)}$$

Where; W is the weight, n is the number of parameters to be scored, Bx is the weight, and Bn is the nth weight.

Table 1. Key Parameter Suitability Matrix (First Level Parameters)

Parameter	Range	Analysis Criteria	Source
Depth (m)	1 - 35 < 1 atau > 35	Continued Not Continued	Afrianto dan Liviawaty, 1993; DFW, 2005.
Protection	Protected Unprotected	Continued Not Continued	Afrianto dan Liviawaty, 1993; Aslan, 1998.
Marine Traffic	Not a Cruise Line A Cruise Line	Continued Not Continued	Dit. Tata Ruang Laut & P3K, 2002; Afrianto dan Liviawaty, 1993

Table 2. Second Level Parameter Suitability Matrix

Criteria	Water Suitability Level			Source
	Highly Suitable	Moderately Suitable	Not Suitable	
Depth (m)	2.5 -5	1-2,5 or 5 - 35	< 1 or > 35	Afrianto dan Liviawaty, 1993; DFW, 2005.
Wave Height (m)	0.2 – 0.3	0,1 – 0,19 or 0,31 – 0,4	< 0, 1 or > 0,4	Hidayat, 1990; Aslan, 1998.
Bottom Substrate	Coral	Sandy	Muddy	Dit. Tata Ruang Laut & P3K, 2002
Salinity ($^{oo}/_{o}$)	28 - 32	15 – 27 or 33 - 38	< 15 or > 38	Anggadiredja *dkk*., 2006; Sediadi dan Budihardjo, 2000.
Wave Velocity (m/sec)	0.2 – 0.3	0,31 – 0,4 or 0,1 – 0,19	< 0,1 or > 0,4	Dit. Tata Ruang Laut & P3K, 2002
Transparency (cm)	> 40	30 - 40	< 30	Dit. Tata Ruang Laut & P3K, 2002
Temperature (^{o}C)	28 - 30	26 – 27 or 31 - 33	< 26 or > 33	Djurjani, 1999; Sediadi dan Budihardjo, 2000.
Fertility	Fertil	Quite Fertile	Less Fertile	Indriani dan Sumiarsih, 1992
Herbivore	Few	Moderate	Abundant	Aslan, 1998.

Tabel 3. Rank, Weight and Score of Each Aquatic Biophysical Parameter

Parameter	Rank	Value Limitation	Weight	Score Value
Depth	1.5	Highly Suitable: 5 Moderately Suitable: 3 Not Suitable: 1	0.19	0.95 0.57 0,19
Wave Height	1,5	Highly Suitable: 5 Moderately Suitable: 3 Not Suitable: 1	0,19	0,95 0,57 0,19
Bottom Substrate	3	Highly Suitable: 5 Moderately Suitable: 3 Not Suitable: 1	0,16	0,80 0,48 0,16
Salinity	5	Highly Suitable: 5 Moderately Suitable: 3 Not Suitable: 1	0,11	0,55 0,33 0,11
Current Velocity	5	Highly Suitable: 5 Moderately Suitable: 3 Not Suitable: 1	0,11	0,55 0,33 0,11
Brightness	5	Highly Suitable: 5 Moderately Suitable: 3 Not Suitable: 1	0,11	0,55 0,33 0,11
Temperature	7	Highly Suitable: 5 Moderately Suitable: 3 Not Suitable: 1	0,07	0,35 0,21 0,07
Fertility	8,5	Highly Suitable: 5 Moderately Suitable: 3 Not Suitable: 1	0,03	0,15 0,09 0,03
Herbivore	8,5	Highly Suitable: 5 Moderately Suitable: 3 Not Suitable: 1	0,03	0,15 0,09 0,03

The value for evaluating the feasibility level of seaweed cultivation is obtained by the following formula: PN = Ni/Nm x 100% where, PN is the percentage of eligibility scores, Ni is the score achieved and Nm = Maximum score (5). The percentage of eligibility values is then adjusted to the eligibility level classification with the assessment matrix. Determination of water feasibility class is divided into 4 classes (Table 4).

Table 4. Aquatic Feasibility Level Class for Seaweed Cultivationt

Class	Feasibility Level	Score	Percentage Value (%)
1	Highly Suitable (S0)	5,00	100
2	Suitable (S1)	3,33 – 4,99	66,6 - 99,9
3	Quite Feasible (S2)	1,67 – 3,32	33,4 – 66,5
4	Not Feasible (N)	< 1,67	< 33,4

RESULTS AND DISCUSSION

Oceanographic Condition of Meosbekwan Island

The results of measurements and observations of oceanographic parameters in the waters on the west side of Meosbekwan Island are presented in Table 5. The depth of the waters on the west side of Meosbekwan Island ranges from 1.3 m – 5.8 m with an average depth of 1.5 m in the south (M1), 2.2 m in the center (M2), and 3.9 m in the north (M3). The northern part has a steeper coast than the other parts. Depth data indicates that the west side of the island can be used for seaweed cultivation.

Table 5. Average Value of Measurement and Observation Results of Oceanographic Parameters in the Waters of the West Side of Meosbekwan Island.

Parameter	Southern (M1)	Middle (M2)	Notherna (M3)
Depth (m)	1.5	2.2	3.9
Wave Height (m)	0.25	0.25	0.25
Bottom Substrate	Coarse Sand, rubble, seagrass	Coarse Sand, Seagrass	Coarse Sand, Seagrass
Salinity (‰)	31	31	30
Wave Velocity (m/sec)	0.14	0.16	0,18
Brightness (m)	2.5	3.5	2,5
Temperature (ºC)	31	30.5	30,5
Fertility	fertil	fertile	fertile
Herbivore	less	less	less

According to Aslan (1998), a suitable depth for seaweed cultivation is 0.6 – 2.1 m. However, this range with a maximum depth of 2.1 m is only for practical purposes in planting, rearing and harvesting. If the depth is greater, the floating method (raft) may be applied as long as other environmental parameters support it. Depths that are less than the specified criteria will affect seaweed plants, for example they are very easy to be reached by benthic herbivores or become dry at low tide. However, if it is too deep it will make it difficult to plant, maintain and harvest and can increase operational and investment costs.

Wave height during the study ranged from 0.1 – 0.3 m with an average value of 0.25 m at all stations. This value is a very suitable value for seaweed growth as stated by Indriani and Sumiarsih (1992) that the wave height should not be more than 0.3 meters. Waves are very necessary for the growth of seaweed, especially to help accelerate the entry of nutrients into plant cells. However, waves may cause damage to seaweed plants and cultivation construction if their height exceeds the specified criteria. In addition, waves that are too strong can cause the bottom of the waters to stir up so that the waters become cloudy and inhibit the process of photosynthesis. Conversely, waves that are too small (less than the criteria) will inhibit the growth of seaweed. The bottom of the waters on the west side of Meosbekwan Island generally consists of coarse sand. Especially in the southern part (M1) a mixture of coarse sand and coral fragments (rubble) was found. At the bottom of the waters, seagrass vegetation of the *Enhalus acoroides* and Cymodocea sp. This bottom water substrate is very good for seaweed growth (Anggadiredja et al., 2006). Locations like this usually have moderate currents, allowing plants to grow well and are not easily threatened by environmental factors and cultivation constructions can be installed easily (Aslan, 1998). The bottom substrate as found at the research location is also helpful in strengthening the stakes used in the off-bottom method. This method is used by the seaweed farming community on Meosbekwan Island.

The results of salinity measurements during the study ranged from 30 - 31 $^{o}/_{oo}$. The range of values obtained is relatively homogeneous. This is because the location of Meosbekwan Island is very far from the mainland so that the influence from rivers and other fresh water sources is very small. As explained by Nontji (1987) that the distribution of sea salinity is influenced by several factors such as the supply of fresh water from rivers, rain and evaporation. The measured salinity values on Meosbekwan Island are included in the category suitable for seaweed cultivation. Aslan (1998) states that the appropriate salinity for seaweed cultivation is 28 – 30 $^{o}/_{oo}$. Meanwhile, according to Sulistijo (1996), the best salinity is 30-34 o/oo. However, the salinity of 28 – 34 $^{o}/_{oo}$ is still a fairly good range for seaweed cultivation, especially for *Eucheuma* species.

The current velocity of the Meosbekwan Island waters ranges from 0.08 – 0.25 m/s, with an average of 0.14 m/s in the south (M1), 0.16 m/s in the middle (M2) and 0.16 m/s in the middle (M2). 18 m/s on the north side (M3). This value is included in the category quite suitable for seaweed cultivation. According to Anggadiredja et al., (2006), the most suitable current speed for seaweed cultivation locations is 0.20 – 0.40 m/s because it will facilitate the replacement and absorption of nutrients needed by plants, but not damage the plants. In addition, Sulistijo (2003) explained that currents are also needed to clear plants of attached biota. White spot disease (ice-ice) is a disease that usually appears when the sea is calm and the current is weak.

The brightness of the waters is an indicator of the penetration power of sunlight into the water column. Sunlight that enters the water will be used for photosynthesis by seaweed and other producers. The average brightness of the waters observed ranges from 2.5 – 3.5 m. The measured brightness value is in the very suitable category for seaweed cultivation. Another important parameter that affects the growth of seaweed is temperature because temperature affects the process of photosynthesis and oxygen solubility in the waters of the cultivation location (Hutabarat and evans, 1984; Aslan, 1998). The results of temperature measurements during the survey on Meosbekwan island showed a range between 30 and 31˚c. This value is in the moderately suitable to very suitable category for seaweed cultivation. According to Afrianto and Liviawaty (1993), the optimal temperature for seaweed cultivation ranges from 26˚c - 33˚c. Meanwhile, according to Anggadiredja et al., (2006) the optimal temperature for seaweed plants is between 26 and 30˚c.

Field observations show that the west side of Meosbekwan Island has good fertility. This is marked by the growth of seagrass vegetation and various species of macroalgae on the bottom of the waters. From the results of direct observations in the field and interviews with the community and seaweed farmers, it can be concluded that there are not too many herbivores such as sea urchins, rabbitfish (Siganidae), turtles and so on in Meosbekwan Island. Thus, this herbivore is not an obstacle in seaweed cultivation. Moreover, if the seaweed cultivation is carried out en masse, then the effects caused by these herbivores can be neglected.

Location Suitability of Meosbekwan Seaweed Cultivation

Analysis of the suitability of cultivation begins with an analysis of the suitability of the key parameters for the suitability of seaweed cultivation, namely depth, protection and shipping traffic. The results of the key parameter analysis show that only the western side of Meosbekwan Island meets the criteria. On the other hand, Meosbekwan Island has shallow waters and is relatively open to waves (Table 6). An example of the condition of the reef flat on the east side of Meosbekwan Island which is exposed (dry) at low tide is presented in Figure 2.

Table 6 Key Parameter Analysis Results on Meosbekwan Island Meosbekwan

Side	Condition	Analysis Status
North	Reef flats are shallow and very wide; associated with the islands of Meos Ros and Meos Tukan; exposed at low tide.	Not continued
East	Open to strong wave and current action, the reef flat is wide and exposed (dry) at low tide	Not continued
South	The influence of big waves, especially wave refraction, relatively narrow reef flat	Not suggested
West	Depth is generally above 1 meter, protected from wave influence, wide reef flat	Suggested

Figure 2. The exposed (dry) east side of Meosbekwan Island at low tide makes it impossible for seaweed cultivation.

The suitability analysis was continued for the west side of the island with second level parameter analysis (see Table 2) which includes the biophysical characteristics of the waters (oceanography) by weighting them using a ranking system (see Table 3). Furthermore, the final stage in this suitability analysis is to evaluate the feasibility level of seaweed cultivation by calculating the percentage of feasibility values. The percentage of eligibility values is then adjusted to the feasibility level classification.

The results of the land suitability evaluation for seaweed cultivation on the waters of the west side of the island showed a score ranging from 4.26 to 4.78 or a percentage of feasibility values of 85.2 to 95.6% (Table 7). The mild limiting factors that exist so that the score does not reach the maximum are the slightly higher temperature in the southern region (appropriate category) and the relatively shallow depth of the waters in the southern and central regions (suitable category). However, in general the total value indicates that the waters of the western side of Meosbekwan Island are technically feasible to serve as a location forseaweed cultivation.

Table 7. Results of Evaluation of the Level of Suitability of Seaweed Cultivation based on Oceanographic Parameters on the West Side of Meosbekwan Island

Station	Total Score	Feasibility Value (%)	Feasibility Criteria
Southern Part (M1)	4.26	85.2	Feasible
Middle Part (M2)	4.40	88.0	Feasible
Northern Part (M3)	4.78	95.6	Feasible

CONCLUSION

The results showed that the oceanographic conditions (depth, wave height, current velocity, salinity, temperature, brightness, and bottom substrate) of the waters on the west side of the island were suitable for the life and growth of seaweed. Water fertility also supports the growth of seaweed. The presence of these herbivores is not an obstacle in seaweed cultivation on the west side of Meosbekwan Island. The results of land suitability evaluation in the waters on the west side of the island show that the waters on the west side of Meosbekwan Island are technically feasible to be used as a location for seaweed cultivation.

ACKNOWLEDGMENT

The author would like to thank Coremap II (Coral Reef Rehabilitation Project) for funding this research and to the people of Meosbekwan Island who have assisted in collecting data in the field.

REFERENCES

Afrianto dan Liviawaty. 1993. Budidaya Rumput Laut dan Cara Pengolahannya. Bhratara, Jakarta.

Anggadiredja, J. A. Jatnika, H. Purwoto, dan S. Istini, 2006. Rumput Laut. Pembudidayaan, Pengolahan, dan Pemasaran Komoditas Perikanan Potensial Seri Agribisnis. Penerbit Penebar Swadaya. Jakarta. 147 pp.

Aslan, L. M., 1998. Budidaya Rumput Laut. Penerbit Kanisius, Yogyakarta.

DFW. 2005. Laporan Akhir Studi Penentuan Areal Pengembangan Karamba Jaring Apung di Perairan Kota Makassar. DFW (Destructive Fishing Watch Indonesia) – Bappeda Kota Makassar, Makassar.

Dit. Tata Ruang Laut & P3K, 2002. Modul Sosialisasi dan Orientasi Penataan Ruang, Laut, Pesisir dan Pulau-Pulau Kecil. Direktorat Tata Ruang Laut, Pesisir dan

Pulau-Pulau Kecil. Departemen Kelautan dan Perikanan, Jakarta.

Djurjani. 1999. Konsep Pemetaan, On The Job Training (OJT) Mengenai Aplikasi SIG Untuk Perencanaan dan Pengelolaan Wilayah Pesisir Secara Terintegrasi di Sepuluh Wilayah MCMA. PUSPICS Fakultas Geografi Universitas Gadjah Mada Bekerjasama dengan Bakosurtanal, Yogyakarta.

Hidayat, A., 1990. Budidaya Rumput Laut. Usaha Nasional, Surabaya.

Hutabarat, S. dan S.M Evans, 1984. Pengantar Oseanografi. Universitas Indonesia Press, Jakarta.

Indriani, H, dan E. Sumiarsih, 1991. Budidaya, Pengelolaan dan Pemasaran Rumput Laut. Penebar Swadaya, Jakarta.

Nashrullah, M.F., 1*, Susanto, A.B., Pratikto, I., dan Emi Yati, E. 2021. Analisis Kesesuaian Lahan Budidaya Rumput Laut Kappaphhycus alvarezii (Doty) menggunakan Citra Satelit Di Perairan Pulau Nusa Lembongan, Bali. Journal of Marine Research 10 (3): 345 – 354.

Nontji, A., 1987. Laut Nusantara. Djambatan, Jakarta.

Numberi, Y., Budi, S, dan Salam, S. 2020. Analisis Oseanografi Dalam Mendukung Budidaya Rumput Laut *(Eucheuma Cottonii)* Di Teluk Sarawandori Distrik Kosiwo Yapen-Papua. URSJ 2 (2): 71 – 75.

Sediadi, A. dan U. Budihardjo, 2000. Rumput Laut. Komoditas Unggulan. Grasindo, Jakarta.

Soejarwo, P.A dan Indra, T. 2020. Penilaian Kesesuaian Kualitas Perairan Untuk Budi Daya Rumput Laut dengan Analisis Multidimensional Scaling (MDS) Di Perairan Pulau Panjang, Banten. Jurnal Segara 16: 1 – 14.

Sulistijo, 1996. Perkembangan Budidaya Rumput Laut di Indonesia *dalam* : Atmadja, W.S., Kadi, A., Sulistijo dan Rachmaniar (eds). Pengenalan Jenis-Jenis Rumput Laut Indonesia. Puslitbang Oseanologi-LIPI, Jakarta.

Sulistijo, 2003. Teknologi, Kendala dan Prospek Pemasaran Rumput Laut di Indonesia. Prosiding Seminar Nasional Penelitian dan Diseminasi Teknik Budidaya Laut dan Pantai