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PRODUCTIVITY AND DEVELOPMENT STRATEGY OF KAPPAPHYCUS ALVAREZII SEAWEED (*Eucheuma Cottonii*) IN BANTEN BAY WHICH VULNERABLE TO ENVIRONMENTAL CHANGES

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ABSTRACT

Seaweed is a fishery commodity with significant economic value and generates substantial foreign exchange. Its relatively low production costs and promising market prospects make it a sought-after product. However, the production of seaweed fluctuates, and not all aquatic locations can sustain seaweed cultivation throughout the year. Environmental changes and alterations in water structure have led to a drastic decline in seaweed production in Banten Bay. The objective of this study is to analyze the productivity and development strategy of Euchema Cotonii seaweed cultivation in Banten Bay. The research location is the coastal and aquatic areas of Banten Bay. Data collection methods include field measurements, observations, interviews, and focus group discussions. The research method is quantitative descriptive. Data analysis is conducted using SWOT (Strengths, Weaknesses, Opportunities, and Threats) analysis, with data processing done using SPSS version 25 and Excel. The results show that water quality is suitable for seaweed growth. Production in 1987 was approximately 5000 tons per year but has declined annually. Production from 2020 to 2022 was around 1500 tons per year. The development strategy aims to increase seaweed productivity by expanding potential areas with applied technology, competent human resources, the use of superior seeds, and reducing environmental pollution from industries and sand mining.

Keywords: Commodity; Fishery; Potential; Production; Sea

INTRODUCTION

One of the fisheries sector that has significant economic value with relatively low production costs and can generate good profits is seaweed. The national production in 2017 was 9,746,044.67 tons with a value of Rp. 21,189,049.00 billion, and in 2022 it was 7,837,858.78 tons with a value of Rp. 38,700,508.00 billion. The production volume decreased by 24.34%, but the economical value increased by 82.64% (KKP Statistics, 2024).

Seaweed has several uses as food due to its protein, fat, mineral, and vitamin content, and it also serves as a natural antioxidant (Kumar *et al.,* 2021). In the past, seaweed also used as medicine for its health benefits. It contains bioactive compounds, phytochemicals, polysaccharides, fiber, ù-3 fatty acids, and essential amino acids, along with almost all vitamins and minerals such as calcium, potassium, sodium, and phosphorus (Oucif, 2020). Different types of seaweed also contain varying active ingredients (Chye, 2018). Based on the pigment classification of seaweed, there are three groups: brown (Ochrophyta, Phaeophyceae), green (Chlorophyta), and red (Rhodophyta) seaweeds, which contain fucoxanthin, chlorophyll a, chlorophyll b, phycocyanin, and phycoerythrin, respectively (Chye, 2018). Rhodophyta is the most widely used group of seaweed because it contains agar-agar, carrageenan, porphyran, furcellaran, and phycobilin pigments consisting of phycoerythrin and phycocyanin (Alamsjah *et al.,* 2010). One of the common Rhodophyta species cultivated by seaweed farmers is *Kappaphycus alvarezii* (*Euchema cottonii*) (Antari *et al.,* 2021).

The development and production of seaweed in Banten Bay varies greatly with environmental changes.

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In 1987, seaweed cultivation was widely practiced on one of the islands in Banten Bay, namely Lima Island and Pisang Island. However, by 1992, production had started to decline and gradually ceased. From 1995 to 2009, seaweed was extensively cultivated on Panjang Island, even becoming the main livelihood of the community in Panjang Island, which consisted of one village. Development in the western region, utilizing Banten Bay, and sand mining on the eastern side of the bay made seaweed cultivation inefficient and unproductive. In 2007, farmers began to attempt cultivation along the coast of Banten Bay in Lontar Village, Pontang District. Currently, production is also fluctuating. In other parts, the number of islands in Banten Bay is more than 10, with a coastline of around 29 KM. In this regard, it is necessary to study the development of seaweed cultivation in Banten Bay.

MATERIAL AND METHODS

The research location is in the seaweed cultivation waters of Lontar Village, Pontang District, Serang Regency, and Banten Bay. The research period is from July to August 2023. The location is as shown in Figure 1.

Data Collection Method

The data collection method involves direct observation at the research location to determine the biophysical characteristics of the waters used for cultivation. Biophysical parameter measurements are taken at 12 observation points using purposive sampling, considering the seaweed cultivation activities. Water quality, seaweed cultivation environment, and coastal data are collected through direct measurements on-site. Interviews are conducted in the form of focus group discussions and questionnaire distribution with several seaweed cultivation stakeholders.

Data Analysis

The data is analyzed using SWOT (Strengths, Weaknesses, Opportunities, and Threats) analysis, calculated using SPSS version 25 and Excel. Analyzing the seaweed cultivation development strategy plan involves weighting and scoring the SWOT analysis. This includes combining several variables to formulate strategies and integrating them with productivity analysis and water conditions.

RESULTS AND DISCUSSION

Seaweed Production

In the 1990s, seaweed became one of the main sources of income for coastal communities in Banten Bay. The cultivation of *Eucheuma Cottonii* began in 1987 on Lima Island, managed by a company, but production declined, and the operation was eventually closed. Subsequently, around 1997, cultivation development on Panjang Island was undertaken by the community, with around 250 units covering the southern side of Panjang Island. Around 2009, there was a decrease in production, and there were no longer any cultivators. Since 2007 until now, cultivation has been developed only at Lontar Beach.

Figure 1. Map of the Research Location

According to the DKPP (*Dinas Ketahanan Pangan dan Perikanan*/Food Security and Fisheries Agency) Serang (2023), there are 15 groups of cultivators comprising 150 individuals. The coastline of Lontar is 5,856 meters long, with a total area of 117.12 hectares, of which 37.5 hectares are used for seaweed cultivation (DKPP, 2023). Harvesting is done in 5 cycles every year. The trend graph of seaweed growth is shown in Figure 2. The production value in 2020 and 2022 is relatively similar due to the seaweed price fluctuation in the market.

Seaweed production in Banten Bay tends to stagnate because it is concentrated in one location, namely the coastline of Lontar Village. Cultivation on Lima Island and Panjang Island was closed due to slow seaweed growth, thallus shedding, and sediment cover. Efforts to revive seaweed cultivation are ongoing, focusing on implementing appropriate strategies. There are 10 islands with diverse aquatic characteristics, making it possible to cultivate seaweed species with high economic value, such as *Gracilaria* spp. and *Gelidium* sp.

Cultivation Method

The cultivation method used is the floating method using driven pole structures. Based on observations, this method is more suitable due to the contour and texture of the sandy seabed, with a depth of around 1 meter. The growth rate of Kappaphycus alvarezii (*Eucheuma cottonii*) using the floating method shows better growth (Damayanthi, 2019; Kotta, 2020). Similarly, the determination of the cultivation method should be adjusted to the marine conditions, including the initial weight determination, which will affect seaweed growth (Antari *et al.,* 2021).

Water Quality Measurement

The results of water quality measurements in seaweed cultivation at Lontar, Banten Bay, are as shown in Table 1. Suspended solids (TSS) that are good for marine cultivation are <25 mg/L (KLH, 1988). TSS is sediment that causes turbidity, hindering sunlight for photosynthesis (Risnawati *et al.,* 2018). Suitable parameters for *Kappaphycus* are temperature 26–32°C, salinity 28–34 mg/L, pH 7–8.5 (SNI 2010; Kotta, 2020). Good, dissolved oxygen (DO) for seaweed cultivation is >4 gr/L (Sulistiawati *et al.,* 2020; Susanto *et al.,* 2021). Water purity is an important factor for seaweed growth as it affects photosynthesis. *Kappaphycus alvarezii* has chlorophyll for capturing long-wave light and phycoerythrin as a short-wave light captor used for energy, making its photosynthesis more efficient.

The seabed is sandy, with a current speed of 8-20 cm/second and a depth of about 1 meter. There are two types of substrates for seaweed habitat: soft

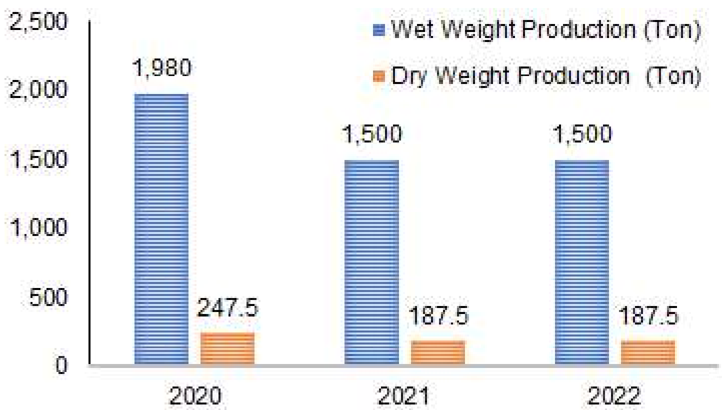

Figure 2. Seaweed Production Graph from 2020 to 2022 (DKPP Serang Regency, 2023)

Table 1. Water Quality Parameters at Lontar, Banten Bay.

No.	Parameters	Station			
		1	2	3	4
1	Temperature (°C)	30	32	32	34
2	pH	7	7,2	7	7,5
3	Nitrite (NO_2^-) (mg/L)	0,05	0,02	0,01	0,02
4	Salinity	34	32	33	33
5	Purity (cm)	38	41	42	40
6	TSS (Total Suspended Solid) (mg/L)	7,5	11,9	10,4	11,6
7	Current Speed (cm/s)	8 – 20	10-12	10 -20	8-15

substrates covering mud, sand, or a mixture of sand and mud, and hard substrates covering dead coral, live coral, and rocks (Ferawati *et al.,* 2014).

SWOT Analysis

Reliability and Validity Test

The questionnaire data collected underwent validity testing to determine whether respondent data is considered valid or not, while reliability testing determines the reliability of the measurement. Validity and reliability testing was conducted using SPSS version 25. A sample size of 30 respondents was taken. This number was used in the formula to calculate the critical r value = N-2, with N being the sample size, so the critical r value = 30-2 = 28. The result showed that the critical r value at a 5% significance level is 0.3016. Data is considered valid if it is greater than the critical r value. Reliability testing resulted in a Cronbach's Alpha value of .759 or 75.9%. A result >0.5 indicates reliability.

Reliability Statistics

If the Cronbach's Alpha value is greater than 60%, then the questionnaire or indicator is considered reliable (Budiastuti & Bandur 2018). The Cronbach's Alpha value is 75.9%, which is >60%, indicating reliability. Invalid and unreliable data was removed, resulting in the extraction of internal and external factors as shown in Table 2.

Next, the questionnaire was distributed. The total population is 75 people, so the sample size taken using the Isaac and Michael method (1981) with a significance level of 5% is 67 people. The results were tabulated to obtain ratings as shown in Table 3.

Calculation of Internal Factor Ratings

The measurement of internal factors is calculated based on the questionnaire results indicating the level of importance. Ratings range from 1, indicating not important, to 4, indicating particularly important. Table 3 shows the calculation of internal and external factor ratings.

The coefficient calculation starts from a scale of 0.00 (not important) to 1.00 (particularly important), and these coefficients are summed up to not exceed a total score of 1.00. Table 4 shows the calculation of internal factor coefficients.

Calculation of Internal Factor Coefficient

In calculating the coefficient of external factors that originate from outside the environment of cultivators and stakeholders. Table 5 shows the calculation results of external factor coefficients.

Table 2. Internal and External SWOT Variables

Internal Factor			
NO	Strengths	NO	Weakness
S1	The aquatic land is quite extensive.	W1	Not all labour is willing to work in seaweed cultivation.
S2	There are 10 islands	W2	The availability of superior seaweed seedlings is limited.
S3	Marketing is relatively available and competitive.	W3	Supervision of the implementation of regulations and legislation is weak.
S4	Labour is available in the local community.	W4	There is no Coastal Zoning Plan (RUTR) yet.
S5	Facilities and infrastructure for seaweed cultivation are easily obtained.	W5	Changes in ocean currents that carry pollutants.
		W6	Frequent changes in coastline usage.
External Factor			
NO	Opportunity	NO	Threat
O1	Mapping of potential and land suitability.	T1	Conversion of coastal land into industria areas, settlements, and others
O2	Assistance with facilities and infrastructure.	T2	Environmental pollution from industries anc sand mining.
O3	Improving human resource competence through education and training.	T3	Market competition that tends towards monopoly.
O4	Cultivation assistance through fisheries extension services.	T4	Disposal of domestic and industrial waste.
O5	Available applied technology	T5	Un-environmentally friendly development ir coastal areas.
		T6	Changes in water quality due to seasona influences.

Table 3. Calculation of Internal Ratings

No	Strengths	Rating			
		1	2	3	4
S1	The aquatic land is quite extensive.	1	1	21	44
S2	There are 10 islands	11	11	25	20
S3	Marketing is relatively available and competitive.	14	13	19	21
S4	Labour is available in the local community.	4	7	17	39
S5	Facilities and infrastructure for seaweed cultivation are easily obtained.	17	9	22	19
No	**Weakness**				
W1	Not all labour is willing to work in seaweed cultivation.	11	10	24	22
W2	The availability of superior seaweed seedlings is limited.	2	5	31	29
W3	Supervision of the implementation of regulations and legislation is weak.	7	17	19	24
W4	There is no Coastal Zoning Plan (RUTR) yet.	17	24	12	14
W5	Changes in ocean currents that carry pollutants.	15	23	12	17
W6	Frequent changes in coastline usage.	11	27	17	12
No	**Opportunity**				
O1	Mapping of potential and land suitability.	2	5	19	41
O2	Assistance with facilities and infrastructure.	7	14	25	21
O3	Improving human resource competence through education and training.	6	11	21	29
O4	Cultivation assistance through fisheries extension services.	7	21	20	19
O5	Available applied technology	2	12	21	32
No	**Threat**				
T1	Conversion of coastal land into industrial areas, settlements, and others	14	21	11	21
T2	Environmental pollution from industries and sand mining.	3	7	19	38
T3	Market competition that tends towards monopoly.	20	16	12	19
T4	Disposal of domestic and industrial waste.	7	14	23	23
T5	Un-environmentally friendly development in coastal areas.	9	10	20	28
T6	Changes in water quality due to seasonal influences.	21	23	14	9

Table 4. Calculation of Internal Factor Coefficient

No	Strengths	Value	Weight
S1	The aquatic land is quite extensive.	242	0,24
S2	The aquatic land is quite extensive.	188	0,19
S3	There are 10 islands	181	0,18
S4	Marketing is relatively available and competitive.	225	0,22
S5	Labour is available in the local community.	177	0,17
	Total Strengths	1013	1,00
No	Weakness		
W1	Not all labour is willing to work in seaweed cultivation.	191	0,17
W2	The availability of superior seaweed seedlings is limited.	221	0,20
W3	Supervision of the implementation of regulations and legislation is weak.	194	0,18
W4	There is no Coastal Zoning Plan (RUTR) yet.	157	0,14
W5	Changes in ocean currents that carry pollutants.	165	0,15
W6	Frequent changes in coastline usage.	164	0,15
Total Weakness		**1092**	**1,00**
Total internal factors		**2105**	

Table 5. Calculation of External Factor Coefficient

No	Opportunity	Value	Weight
O1	Mapping of potential and land suitability.	233	0,22
O2	Assistance with facilities and infrastructure.	194	0,19
O3	Improving human resource competence through education and training.	207	0,20
O4	Cultivation assistance through fisheries extension services.	185	0,18
O5	Available applied technology	217	0,21
Total Opportunity		1036	1,00
No	**Threat**		
T1	Conversion of coastal land into industrial areas, settlements, and others	173	0,16
T2	Environmental pollution from industries and sand mining.	226	0,20
T3	Market competition that tends towards monopoly.	164	0,15
T4	Disposal of domestic and industrial waste.	196	0,18
T5	Un-environmentally friendly development in coastal areas.	201	0,18
T6	Changes in water quality due to seasonal influences.	145	0,13
Total Threat		1105	1,00
Number Of External Factors		2141	

Calculation of Coefficient and Rating Matrix

Calculation of Internal Strategic Factors Analysis Summary (IFAS) Matrix

The IFAS matrix calculation is used to determine the coefficient, rating, and score, where the total coefficient does not exceed 1.00, and the rating for each factor is calculated using a scale from 1 (below average/not important) to 4 (particularly good). Table 6 shows the calculation results of the IFAS matrix.

Calculation of External Strategic Factor Analysis Summary (IFAS) Matrix

The calculation of the EFAS matrix is similar to the IFAS matrix. The analysis results of the EFAS can be seen in the following Table 7. Therefore, the total scores of the IFAS and EFAS matrix calculations are as follows:
Total score of strengths = 1.58.
Total score of weaknesses = 1.68.
Total score of opportunities = 1.67.
Total score of threats = 1.67.

SWOT Matrix

The tool used to formulate alternative strategies can be the SWOT matrix. Formulating alternative strategies involves alternatives that can be used to increase seaweed productivity. To analyze strategy opportunities, combinations of S-O, W-O, S-T, and W-T are used. An example is shown in Table 8.

Based on the Cartesian diagram showing the coordinate line (-0.05, 0.0) and the limited difference between strategies, the formulated strategy should focus on integrating high-scoring strategies to improve seaweed productivity through the expansion of mapped potential and land suitability areas with applied technology, competent human resources, the

Table 6. Calculation of Internal Strategic Factor Analysis Summary (IFAS) Matrix

No	Strengths	Weight	Rating	Score
S1	The aquatic land is quite extensive.	0,11	4	0,46
S2	The aquatic land is quite extensive.	0,09	3	0,27
S3	There are 10 islands	0,09	2	0,17
S4	Marketing is relatively available and competitive.	0,11	4	0,43
S5	Labour is available in the local community.	0,08	3	0,25
Total Strengths		**0,48**		**1,58**
No	**Weakness**			
W1	Not all labour is willing to work in seaweed cultivation.	0,09	3	0,27
W2	The availability of superior seaweed seedlings is limited.	0,10	4	0,42
W3	Supervision of the implementation of regulations and legislation is weak.	0,09	4	0,37
W4	There is no Coastal Zoning Plan (RUTR) yet.	0,07	3	0,22
W5	Changes in ocean currents that carry pollutants.	0,08	2	0,16
W6	Frequent changes in coastline usage.	0,08	3	0,23
Total Weakness		**0,52**		**1,68**
Total internal factors (IFAS)		**1,00**		**3,25**

Table 7. Calculation of External Strategic Factor Analysis Summary (EFAS) Matrix

No	Opportunity	Weight	Rating	Score
O1	Mapping of potential and land suitability.	0,11	4	0,44
O2	Assistance with facilities and infrastructure.	0,09	3	0,27
O3	Improving human resource competence through education and training.	0,10	4	0,39
O4	Cultivation assistance through fisheries extension services.	0,09	2	0,17
O5	Available applied technology	0,10	4	0,41
Total Opportunity		**0,48**		**1,67**
No	**Threat**			
T1	Conversion of coastal land into industrial areas, settlements, and others	0,08	3	0,24
T2	Environmental pollution from industries and sand mining.	0,11	4	0,42
T3	Market competition that tends towards monopoly.	0,08	2	0,15
T4	Disposal of domestic and industrial waste.	0,09	3	0,27
T5	Un-environmentally friendly development in coastal areas.	0,09	4	0,38
T6	Changes in water quality due to seasonal influences.	0,07	3	0,20
Total Threat		**0,52**	0,45	**1,67**
Total external factors (EFAS)		**1,00**		**3,34**

Table 8. Matrix Planner for Quantitative Strategy Combinations

IFAS EFAS	**Strength (S)**	**Weakness (W)**
Opportunities (O)	Strategy S-O: Using strengths to exploit opportunities = 3.25	Strategy W-O: Minimizing weaknesses by exploiting opportunities = 3.34
Threats (T)	Strategy S-T: Using strengths to overcome threats = 3.84	Strategy W-T: Minimizing weaknesses and avoiding threats = 3.35

use of superior seedlings, and reducing environmental pollution from industries and sand mining (S1, S4, S5, W2, O1, O3, O5, T2) with a value = 0.46 + 0.43 + 0.25 + 0.42 + 0.44 + 0.39 + 0.41 + 0.42 + 0.38 = 3.6.

DISCUSSION

The increase in seaweed production can be achieved by providing incentives to seaweed cultivators in the form of production subsidies and the adoption of appropriate technology, as well as ensuring fair prices (Nurcomariah *et al.,* 2020; Erniati *et al.,* 2023). Mapping the potential and analyzing the carrying capacity are also crucial (Rahmadya, 2017). Another effort is to cultivate several types of seaweed that have high economic value (Tiwari *et al.,* 2015). The success of seaweed cultivation depends on several factors such as the environment, seed quality, cultivation methods, nutrient availability, and initial density or weight in cultivation, as well as the use of superior seaweed seedlings (Rusaini, 2017). One of the factors' inhibiting productivity is the presence of fouling algae that cover the surface of E. cottonii thalli (Purbiantoro, 2013).

Development strategies for seaweed cultivation include increasing seaweed production in locations where cultivation activities already exist, expanding the utilization of marine areas, strengthening institutions, implementing appropriate technology, and enhancing human resource competence (Rahmadya, 2017; Damis, 2022; Cokrowati *et al.,* 2023). Another strategy is government policies that support cultivators and the involvement of university experts as facilitators of expertise (Anwar, 2013). Increasing the competence of seaweed cultivators' human resources is important for increasing seaweed productivity (Sitompul, 2022). Improving the availability of seedlings is also crucial, as it can affect the daily growth rate and carrageenan content of seaweed (Pong-Masak, 2018).

CONCLUSION

The suitable cultivation method for Kappaphycus alvarezii is by using floating method. The production of Kappaphycus alvarezii has been the livelihood of the community on Panjang Island, Banten Bay, from 1987 to 2000. The current cultivation location is in Lontar waters with a production quantity of around 1500 tons per year. The water quality is suitable for seaweed growth. Developing cultivation with Strategy S-T, which has a value of 3.84, involves using strengths to overcome threats. The recommendation is to increase seaweed productivity through the expansion of mapped potential and land suitability areas with applied technology, competent human resources, the use of superior seedlings, and reducing environmental pollution from industries and sand mining. The second strategy is Strategy W-O, with a value of 3.34, which involves minimizing weaknesses by exploiting opportunities.

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REFERENCES

Alamsjah, M.A., Ayuningtiaz, N.O. and Subekti, S., 2010. Effect of exposure time on growth and chlorophyll a of Gracilaria verrucosa in indoor cultivation systems.*Scientific Journal of Fisheries and Marine Affairs,*2 (1): 21-28.

Anwar, A. (2013). Analysis of policies and strategies for developing the *Euchema cottonii* seaweed business in Bantaeng Regency (Case study in Bissappu, Bantaeng and Pa'jukukang Districts). *J. Octopus Fisheries Science*(1) 2, 103-109.

Antari, N.P. P.S.D., Watiniasih, N.L., Dewi, A.P.W.K. (2021). The growth of seaweeds (*Eucheuma cottonii*) in different initial weight at Pandawa Beach, Bali. *J. Udayana Biology* (25)2, 122-129.

Budiastuti, D., & Bandur, A. (2018). *Validity and reliability of alidity and reliability Research With Analysis with NVIVO, SPSS and AMOS*. Publisher Mitra Wacana Media ISBN: 978-602-318 Jakarta.

Chye, F. Y., Ooi, P. W., Ng, S. Y. & Sulaiman, M. R. (2018). Fermentation-derived bioactive components from sea- weeds: functional properties and potential applications. *J. of Aquatic Food Product Technology* (27) 2, 144–164.

Cokrowati, N., Risjani, Y., Andayani,S., & Firdaus, M. (2023). The potential and development of seaweed cultivation in Lombok: A Review. *J. Tropical Biology* (23)1, 202–212.

Damis, Armayani, Surianti, Hasrianti, Putri, A.R.S., Muhammad Saenong, M. (2022). Strategy for the Development of Seaweed Cultivation in the Coastal Area, Suppa District, Pinrang Regency).*Journal of Indonesian Tropical Fisheries* (5)1, 27 – 39.

DKPP (Food Security and Fisheries Service) Serang Regency. (2023). *Annual report*. DKPP Serang.

Erniati, E., Andika,Y., Muliani. (2023). Seaweed diversity and community structure on the west coast of Aceh, Indonesia. *Journal Biodiversitas* (24) 4, 2189-2200. Ferawati E, Widyartini DS, Insan I. (2014). Study of seaweed communities on various substrates in the waters of Permisan Beach, Cilacap Regency.*Scripta Biol*1 (1): 57-62. DOI: 10.20884/1.sb.2014.1.1.25.

Isaac,S., & Michael ,WB. (1981). *Handbook In Research And Evaluation*. California: Edits Publishers.

KLH (State Minister of Population and Environment). (1988). *Guidelines for Determining Environmental Quality Standards*. KLH. Jakarta.

Kotta, R. (2020). The Growth of seaweeds Kappaphycus alvarezi using long line cultivation method in different depthon increased weightof seed. *J. Island Marine Science*(3) 1, 46-58.

Kumar, Y., Ayon Tarafdar,A., & Prarabdh C. Badgujar.P.C. (2021). Seaweed as a Source of Natural Antioxidants: Therapeutic Activity and Food Applications. *Hindawi Journal of Food Quality,* Article ID 5753391, 1-17.

Nurcomariah, Hubeis, M., & Wini Trilaksani, W. (2020). Strategy of developing seaweed gracillaria agribusiness in Karangantu, Serang Banten.*J. Small and Medium Industry Development Management*(15)1), 62-69.

Oucif, H., Benaissa, M., Ali Mehidi S., Prego, R., Aubourg, S.P. & Abi-Ayad, S.M.A. (2020). Chemical composition and nutritional value of different seaweeds from the west Algerian coast. *Journal of Aquatic Food Product Technology*, (29)1, 90–104.

Purbiantoro, W., Wida Lesmanawati,W., Hairati Arfah,H. (2013). The effect of the existence of filament algae on *Eucheuma Cottonii* cultivation activity in Kotania Gulf Waters, West Seram, Maluku. *J. Applied Science*(3) 1, 8 – 15.

Pong-Masak, P.R., & Sarira,N.H. (2018). Seaweed selection to supply superior seeds for cultivation. *J. Fisheries, Gadjah Mada University*(20) 2, 79-85.

Rahmadya, A. (2017).*Coastal water management strategy based on seaweed (Eucheuma cottonii) cultivation, case study of the Bontang City Waters area, East Kalimantan*. Thesis. Bogor Agricultural

Institute Postgraduate School.

Rusaini (2017). Growth of Eucheuma cottonii seaweed cultured in vitro with different amounts of thallus.*Proceedings of the IV National Marine and Fisheries Symposium 252 Hasanuddin University*, Makassar, 19 May 2017.

Risnawati, M.K., & Haslianti. (2018). Study of water quality in relation to seaweed growth (*Kappaphycus alvarezii*) on a floating net raft in the waters of Lakeba Beach, Bau Bau City, Southeast Sulawesi.*J. Aquatic Resources Management* (4)2, 155- 164.

SNI (Indonesian National Standard) 7579.2. (2010) *Kotoni seaweed production* (*Eucheuma cottonii*) *metode long-line*. National Standardization Agency. Jakarta.

Sulistiawati, D., Ya'La, Z.R., Mubaraq, D.Z. (2020). Water quality study in several seaweeds culture sites in the post-earthquake-tsunami Palu Central, Sulawesi Province. *J. Phys. Conf. Ser.* (1434) 1: 012035.

Susanto, A.B., Siregar, R., Hanisah, H, Faisal, TM, Harahap, A. (2021). Analysis of the suitability of the water quality of the dam area for seaweed cultivation (*Gracilaria sp.*) in West Langsa District, Langsa City.*J Fish MarRes*(5) 3: 655-667.

Sitompul, J.S. (2022). Potential and strategy for developing seaweed cultivation in Randusangakulon Village, Brebes Regency.*Thesis*. Marine Science Study Program, Faculty of Fisheries and Marine Sciences, Diponegoro University, Semarang.

KKP Statistics (2024) *Fisheries Production*. One data. Ministry of Maritime Affairs and Fisheries, Jakarta, https://statistik.kkp.go.id/home.php?m=prod_ikan_prov&i=2#panel-footer-kpda.

Tiwari, B.K, &Troy, DJ. (2015). *World seaweed utilization*. In: Tiwari BK, Troy DJ (eds.). *Seaweed Sustainability Food and Non-Food Applications*. Academic Press, New York, NY, USA. DOI: 10.1016/B978-0-12-418697-2.00001-5.