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Suitable Sea Characteristics for Seaweed (*Kappaphycus alvarezii*) Farming Using the Off-Bottom Method in Atauro Island by Utilizing the Geographic Information System.

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ABSTRACT

This research was done to analyze the condition of environmental factors of seaweed (*Kappaphycus alvarezii)* farming area and the ideal water characteristic that is suitable for seaweed farming seen from the physical and chemical parameters in Atauro Island, Dili, Timor-Leste. This research was conducted under the descriptive method, employing survey technique and insitu measurement toward the parameters related to the condition of the water in the coast line of Atauro Island. The data obtained from the measurement were then evaluated based on the quality standards and were analyzed using the Geographic Information System (GIS). The results ot the measurement on the distribution of the water quality along the coast line of Atauro Island showed: temperature 29.5 – 30.5^{0}C, salinity 33-34 ppt, pH 8 – 8.3, brightness 1.22 – 6.4 m, depth 1.22 – 6.4 m, sea surface current 24.05 – 25.15 cm/s. Based on the result of this study, it can be concluded that 914 hectares of the water in Atauro Island is most suitable (S2) to use for seaweed farming, and 81 hectares is considered suitable (S2) for seaweed farming.

Keywords: *Ideal water, seaweed farming, Atauro Island, GIS*

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INTRODUCTION

The sea and coast line of Atauro Island have unique characteristic for having various marine potencies which attract local, national, regional and international tourists to visit the island. Those potencies include coral reefs, seagrass, mangrove, various protected fish and various type of fish to consume, great seaweed farming resource and other potencies as sustainable eco-tourism spot, (Gomes, 2014). In addition, Wong, *et al.,* (2004) and CI-TL, (2014) stated that Atauro Island owns massive types of coral reefs and seagrass that grow along the coast line. Moreover, the existence of good Mangrove condition makes the island a good place for nature conservation.

The characteristic of Atauro Island sea has driven the local people to perform seaweed farming. They employed off-bottom seaweed farming method. The seaweed was firstly brought to the island from Kisar Island (Indonesia) in 2003, and he second one was taken from the same island in 2008. The species of the seaweed is the *Kappaphycus alvarezii.* The Cottonii group brought another *Kappaphycus alvarezii* seaweed from Sulawesi (Indonesia) in 2012 since the previous seaweed was indicated to suffer from diseases. Seaweed in Atauro Island is one of major income for the people living in coast line. Safitri, *et a.,* mentioned that the southern part of Timor sea has high ecosystem productivity that improves the economy of people living along the coast line.

It is stated by FAO, (2009) that the area for seaweed farming in Atauro Island in 2007 was around 22 hectares and expanded up to 30 hectares with the total production for each reaching 37.000 kg and 100.000 kg. The product were exported to Asia countries especially to Vietnam which held the highest seaweed export amount compared to other countries. The government of Timor-Leste identified the fact that seaweed farming appeared to contribute high revenue for the region with the total export revenue of around US$ 19.130,00, (NDFA 2010; NDFA and WFC, 2011 in CTI-CFF, 2014). The data of seaweed export from the certificate of marine product *(origem do Produto pescado)* of the Directorate General for Fisheries Timor-Leste, 2015, the total export in 2010 reached (152.839 kg), 2011 (43.862 kg), 2012 (80.438 kg), 2013 (50.648 kg), and 2014 (109.700 kg), whilst in 2015, there were no export activities for seaweed. The fluctuation of those numbers was not yet thoroughly investigated from the physicals and chemical parameters, the suitability of the area, and other environmental factors that affect the seaweed farming.

Environmental factors and the ecology of the water affect the growth and the seaweed quality which should be put under consideration in improving the production. Dahuri (1998) explained that carrying capacity appears to be the major obstacles for the biota toward the envinronmental factors. Analysis on the area of potency seen through the appropriateness of the environment and the farming area carrying capacity is necessary to conduct in order to enhance the development and increase the seaweed production, (Rimalia, *et al:,* 2013). According to Arthana, *et al.,* (2012), potency mapping and geographical analysis using Digital Imaging System or Geography Information System (GIS) should be done to improve the seaweed production.

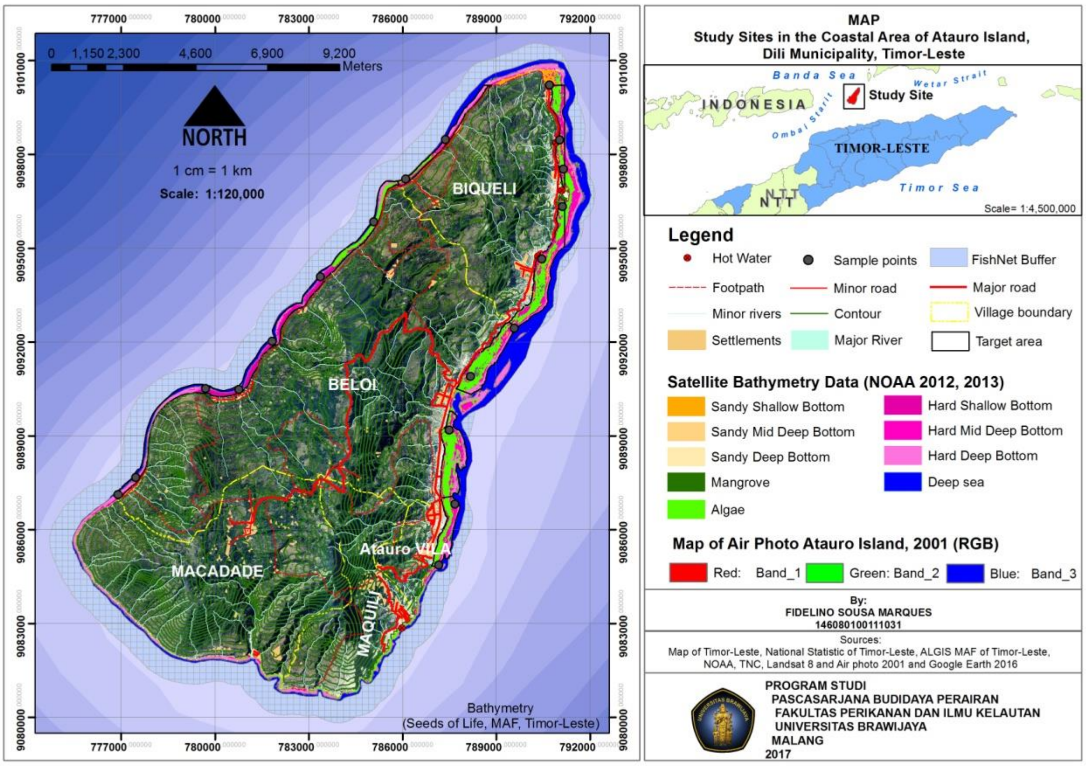
The objectives of this research were to see the conformity values of physicals-chemical parameters and to see the idealities of the coast for seaweed farming in Atauro Island.

MATERIALS AND METHODS

Research Setting

This research was conducted in Atauro Island, Dili, Timor-Leste in Maret – April 2016. The samples of this research were taken from 19 stations or observation points (Figure 1). Those stations consisted of two parts; stations 1-9 were located in the western part of the island while the station 10-19 were in the eastern part. Stations 1-7 and 15-17 were located in the sea of Beloi Village, and the stations 8-14 were in Biqueli Village, while the stations 18-19 were in Atauro Vila Village.

Figure 1: Research Setting in Atauro Island, Dili Municipalty, Timor-Leste



MATERIALS AND EQUIPMENTS

Table 1: Materials and Equipements Used in this Research

No	Parameter	Unit	Tool	Note
Physicals				
1.	Temperature	^{0}C	Thermometer	*Insitu*
2.	Brightness	M	*Secchi disk*	*Insitu*
3.	Depth	M	*Digital Sonar*	*Insitu*
4.	Sea surface current	m/s	Argo float	*Insitu*
Chemical				
1.	Salinity	ppt	*Refractometer*	*Insitu*
2.	pH	-	pH meter	*Insitu*
Others				
1.	Observation poits	-	*GPS*	*Insitu*
2.	Transportation	-	Motor boat	*Insitu*

Research Method

This research employed a descriptive method and survey technique administered to the target area for seaweed Kappaphycus alvarezii production. The coordinate position of each station, observation, and sample measurement were determined usin the Geography Information System (GPS). Motor boat was used as the transportation during the sample measurement. The measurement of the physicalal parameters (temperature, brightness, depth, sea surface current) and chemical (salinity and pH) was done using insitu method. Temperature measurement was done using Hg thermometer. Manual Secchi disk was used to measure the brightness, while depth was measuremd using Digital Sonar tool and the sea surface current was measured manually using two mineral water bottles of 360 ml (one bottle was filled with water, and the other was empty) then the spped was counted using stopwatch. Salinity test was administered using Hand-held Refractometer and the pH was measured using pH meter.

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Data Analysis

Analysis on the sea of Atauro Island suitability using the quality standards and conformity test for seaweed farming Kappaphycus alvarezii is presented in Table 2.

Table 2: Quality standards and evaluation system of the conformity of coasts for seaweed Kappaphycus alvarezii farming

Parameter	Range	Value (A)	Loading Factor (B)	Score (AxB)	Score Max	Score Min	Source
Fisiska							
Suhu (°C)	26 – 32 20 – 25 <20 dan >32	5 3 1	2	10 6 2	10	2	National Standard of Indonesia, (2011); Setiyanto, *et al.*, (2008)
Kecerahan (m)	>1 0.2-1 <0.2 dan >5	5 3 1	2	10 6 2	10	2	*Dirjenkan Budidaya*, (2005)
Kedalaman (m)	1.15-3 0.2-1 & 3.05-4 <0.2 dan >4	5 3 1	2	10 6 2	10	2	National Standard of Indonesia, (2011)
Kecepatan Arus (cm/s)	20 – 30 10-19 dan 31 – 40 < 10 dan > 40	5 3 1	2	10 6 2	10	2	*Dirjenkan Budidaya,* (2005)
Kimia							
Salinitas (ppt)	32.2 – 34 30 – 32 < 30 dan > 34	5 3 1	1	5 3 1	5	1	National Standard of Indonesia,, (2011); Gazali (2013)
pH	6,5-8,5 4 – 6,4 dan 8,5 – 9 <4 dan >9,5	5 3 1	1	5 3 1	5	1	Gazali (2013)
Total Score					**50**	**10**	

Notes:

1. The scoring criteria stated by *DKP,* (2002); Schaduw, *et al*., (2015); Kangkan, (2006), Mudeng, *et al*., (2015) and Anonymous, (2002) are: 5: Good 3: Medium 1: Poor
2. The score weighing considering the dominant parameters.

Score is $S = \sum ai.Xn$

Where: S= Value of the score *ai*= Loading factor *Xn*= Value of conformity

Steps done to analyze the suitability of coastal areas included; (a) Scoring determination toward the quality standard parameters; (b) Measuring the interval class based on the maximum score obtained minus minimum score, divided by the number of the class of expected water suitability; and (c) determining the range of score and the level of water suitability based on the score and class interval.

In this research, the class of water suitability for seaweed *Kappaphycus alvarezii* farming is grouped into four classes; (S1) most suitable, (S2) suitabile, (S3) less suitable and (N) unsuitable. The formulation used in the determination of class interval suitability parameters was:

$$I = \frac{(\Sigma ai.Xn) - (\Sigma ai.xn)_{min}}{k}$$

Where: I = Class interval of water suitability

k = Number of water suitability class

Table 3: Assessment on the suitability of the sea for seaweed *Kappaphycus alvarezii* farming

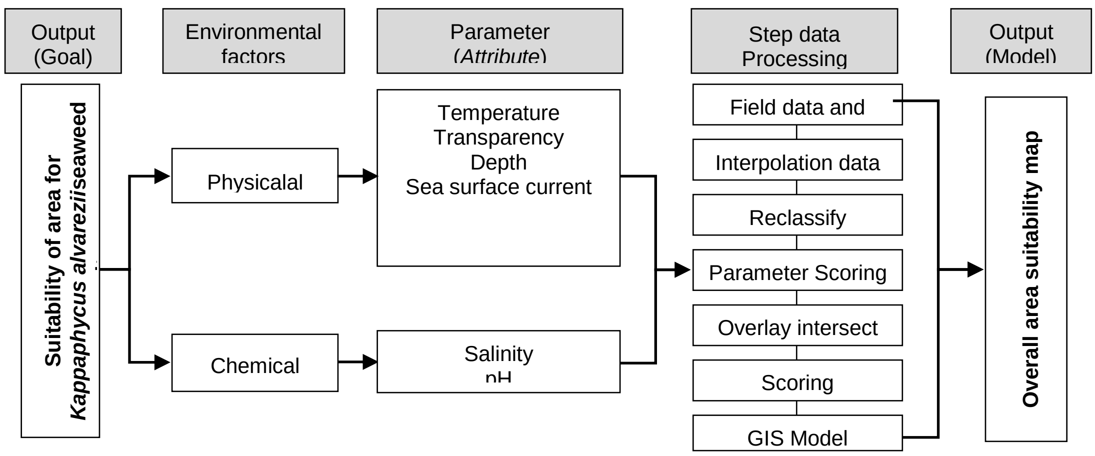
No.	Range (Score) [1]	Level of suitability [2]	Class/S
1	>40	S1	Most suitable
2	30 – 40	S2	Suitable
3	19 – 29	S3	Less suitable
4	<19	N	Non suitable

Notes: 1): Modified. 2): Anonymous (1996) and Balitbang KP, (2013)

GIS Analysis

The data obtained from the field in the form of decimal degree coordinates was then transformed into geographical coordinates using data management tools into WGS 1984 UTM Zone 51S. Before the data was converted into raster data, it had been added with digital images which became the basic map for the sampling points. The satellite digital image used in this study was from the Landsat 8 taken in 28 June 2016. The raster sampling points of each parameters were interpoled using the Inverse Distance Weighted (IDW). The result of the interpolation was then reclassed and converted to polygons. Score and weight determination for each parameter were made based on the quality standards and water suitability assessment system for seaweed Kappaphycus alvarezii farming is presented in Table 2. After that, an overlay intersect analysis was administered. Steps in GIS analysis using the overlay intersect are illustrated in Figure 2.

Figure 2: Steps in GIS analysis using the overlay intersect



RESULTS

Results and Measurement of Physical and Chemical Parameters

The result of observation and measurement on the physical and chemical parameters in each sampling point is explained in detail in Table 4.

Table 4: Value and score of physical and chemical parameter distribution in every station in Atauro Island sea

Stadium	Latitude	Longitude	Temperature (°C)	Salinity (ppt)	pH	Transparency (m)	Depth (m)	Surface current (cm/s)	Total score
1	8° 15.037'S	125° 30.810'E	30.5	34	8.1	5.7	5.7	25.13	34
2	8° 14.741'S	125° 31.115'E	30.4	34	8.1	6.4	6.4	25.14	34
3	8° 13.189'S	125° 32.321'E	30	34	8	3.81	3.81	24.41	42
4	8° 13.206'S	125° 32.899'E	30.2	34	8.1	3.66	3.66	24.36	42
5	8° 12.363'S	125° 33.477'E	30.2	34	8	3.05	3.05	24.14	42
6	8° 11.242'S	125° 34.309'E	30.2	34	8.1	4.97	4.97	24.67	38
7	8° 10.284'S	125° 35.230'E	30.1	34	8.1	3.32	3.32	24.22	40
8	8° 9.537'S	125° 35.784'E	30.1	34	8.1	2.29	2.29	24.12	50
9	8° 8.851'S	125° 36.472'E	30.3	34	8.1	4.27	4.27	24.58	38

10	8° 7.890'S	125° 38.274'E	30.3	34	8.1	1.22	1.22	24.05	50
11	8° 8.840'S	125° 38.457'E	30.5	34	8.1	1.22	1.22	24.05	50
12	8° 9.349'S	125° 38.527'E	29.8	34	8.1	1.34	1.34	24.15	50
13	8° 10.000'S	125° 38.518'E	29.5	34	8.1	2.87	2.87	24.58	50
14	8° 10.907'S	125° 38.163'E	30	34	8.1	1.65	1.65	24.57	50
15	8° 12.113'S	125° 37.688'E	30	34	8.1	3.05	3.05	24.69	42
16	8° 12.953'	125° 36.935'E	30	33	8.2	2.74	2.74	24.68	50
17	8° 13.883'S	125° 36.570'E	30	33	8.3	2.13	2.13	24.67	50
18	8° 15.167'S	125° 36.678'E	30	34	8.1	1.98	1.98	25.15	50
19	8° 16.229'S	125° 36.400'E	30	34	8.1	3.96	3.96	25.02	46
Average			30.11	33.89	8.11	3.14	3.14	24.55	45.79
Minimum			29.5	33	8	1.22	1.22	24.05	38
Maximum			30.5	34	8.3	6.4	6.4	25.15	50

Evaluation on the Suitability of Off-Bottom Seaweed Farming Area

The result of conformity test and the average score on the observed parameter based on the quality standards and assessment system are presented in Table 2 int the form of value, weight, and score as seen in Table 5. Based on the result of measurement on the suitability of Atauro Island sea as presented in Table 4, it can be seen that the temperature, sea surface current, salinity, and pH in every observation points or stations obtained score 5 (suitable) for seaweed farming. This result shows that there is no need to apply any technology or environment modification. It is also suggested that cultivation is done in March and April since the environment parameters in those months have been known to be supportive for seaweed farming. The depth and transparency of the eastern part of Atauro Island sea obtained score 5 (suitable) including the station 8 which was located in the western part of the island. Yet, the transparency found in station 3, 4, 5, 6, 7, 9 and 15 showed score 3 (less suitable), while the station 1 and 2 obtained score 1 (unsuitable). Fortunately, even though the transparency of the water does not appear to be a serious obstacle since the sunlight could still reach the bottom of the sea, providing enough sunlight for photosynthesis. According to Mudeng, et al., (2015), high transparency is good for photosynthesis. Thus, the station 3, 4, 5 and 7 suffer from a small problem since they obtained score 3 for the transparency. Unfortunately, the station 1, 2, 6 and 9 deals with a serious problem for obtaining score 1 (unsuitable) for the transparency. Those results show that the western part of Atauro Island which obtained low score for the transparency need to apply technology and environment modification to optimize the seaweed farming. SNI (2011) stated that the ideal sea depth for seaweed farming using the off-bottom method is around 4 m at the highest tidal rise, and 0.2 m at the lowest tide.

Table 5: Evaluation on the conformity score of Atauro Island Sea for seaweed (Kappaphycus alvarezii) farming using the off-bottom method

Parameter	Range	Average value	Value (A)	Weight (B)	Score (AxB)
Physicals					
Temperature (°C)	26 – 32 20 – 25 <20 and >32	30.11	5	2	10
Transparency (m)	>1 0.2-1 <0.2 dan >5	3.14	5	2	10
Depth (m)	1.15-3 0.2-1 & 3.05-4 < 0.2 and >10	3.14	3	2	6
Sea surface current (cm/s)	20 – 30 10-19 and 31-40 <10 and >40	24.55	5	2	10
Chemical					
Salinity (ppt)	32.2 – 34 30 – 32 <30 and >34	33.89	5	1	5
pH	6,5 – 8,5 4–6,4 and 8,5–9 <4 and >9,5	8.11	5	1	5
Total score					**46**

Based on the score evaluation on the suitability of the coastal area for seaweed farming based on the average score of the observation on physicals and chemical parameters as seen in Table 5, it can be seen that the total conformity score obtained is 46. This shows that the coastal areas of the island which obtained a score >6 are included in the first class S1 (most suitable).

Therefore, seaweed farming using the off-bottom method is applicable to conduct in Atauro Island sea since there was no serious obstacle that gives real impact on the seaweed (*Kappaphycus alvarezii*) farming. However, it was necessary to conduct an analysis using the GIS to determine the width and the suitability of the parameter distribution in the coastal area of Atauro Island. Ratnasari, *et al.,* (2014) mentioned that GIS is an alternative for special analysis to determine the suitability of an area for seaweed farming.

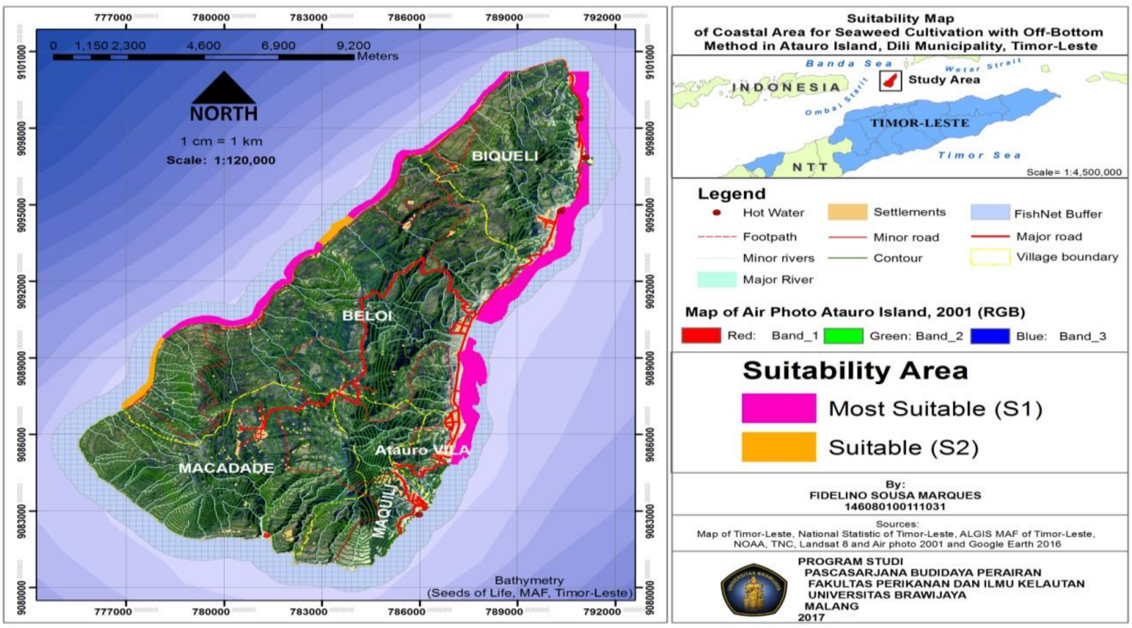
The distribution of both physicals and chemical parameters in 19 stations around Atauro Island have been measured and analyzed using the GIS through some steps as presented in Figure 2 which resulted to a classification on the suitability of the area for seaweed farming as seen in Table 6 and Figure 3. The use of GIS analysis has been considered an appropriate choise since the spasial data of both physicals and chemical parameters were combined and over layed to obtain new output in the form of a map which has high efficiency and high level of accuracy (Ariyati, *et al., 2007)*

Table 6: Suitable area for seaweed (*Kappaphycus alvarezii*) farming in Atauro Island coasts

Class	Sampling Area (Ha)					Total (Ha)
	Atauro Vila	West Beloi	East Beloi	West Biqueli	East Biquely	
Most suitable (S1)	89	213	292	60	260	**914**
Suitable (S2)	-	81	-	-	-	**81**
Less suitable (S3)	-	-	-	-	-	-
Unsuitable (N)	-	-	-	-	-	-
Total (Ha)	**89**	**294**	**292**	**60**	**260**	**995**

The result of the test shows that 914 ha of the area are considered most suitable (S1), 81 ha are suitable (S2), and there were no areas obtained S3 (less suitable) nor N (unsuitable) for seaweed farming. The suitability class of the coastal area for seaweed (*Kappaphycus alvarezii*) farming in Atauro Island is explained in Table 6 and Figure 3.

Figure 3: Map of coastal area suitability for seaweed (*Kappaphycus alvarezii*) farming in Atauro Island, Dili Municipality, Timor-Leste



CONCLUSIONS AND SUGGESTIONS

Conclusion

Atauro Island sea has high natural resource potency that supports seaweed farming. Baed on the result of the assessment on the distribution of physicals and chemical parameters of Atauro Island sea, total score of 46 was obtained which means that 914 ha of the area are most suitable (S1) and 81 ha are suitable (S2) for seaweed farming. The areas which obtained high suitability did not suffer from any serious obstacles, yet the other areas with suitable category obtained low score for the parameter of sea depth.

Suggestions

1. Seaweed (*Kappaphycus alvarezii*) is better to be conducted in locations which are free from any obstacles as determined in this study.
2. It is suggested that off-bottom method is employed in seaweed farming in the selected ideal areas.
3. It is necessary to conduct further research on the contribution of other parameters and other environmental factors which have either direct or indirect effect toward seaweed farming.

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