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SUSTAINABILITY ANALYSIS OF SEAWEED FARMING IN WEST KUPANG DISTRICT OF KUPANG REGENCY, INDONESIA

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ABSTRACT
The purpose of this study is to evaluate the suitability of land/waters for seaweed farming activities, and analyze the sustainability status of grass business in the coastal area of West Kupang district. The method used in this study was a survey method; respondents were taken as many as 50 people from three sample villages, namely Tablolong, Tesabela and Oenaek villages, West Kupang District. Analysis of land/water suitability for aquaculture using two methods, namely land suitability matrix and weighting, while the sustainability of seaweed farming activities is analyzed statistically multivariate with Multidimensional Scaling (MDS) approach, and Rapid Assessment Techniques for Fisheries (RAPFISH) method. The results of the study found that the area suitable for seaweed cultivation in the study area was in the waters of West Kupang District with very suitable class criteria covering an area of 407.6 ha, appropriate class criteria covering an area of 856.93 ha and inappropriate class criteria covering an area of 2665.78 ha, in general the level of sustainability of seaweed cultivation activities in West Kupang District, Kupang Regency was in the category of quite sustainable, unless the technology dimension falls into the category of less sustainable. It is recommended that more in-depth research be carried out on assessment and addition of dimensions and attributes in the sustainability analysis of seaweed farming activities in order to provide input on more specific management recommendations.

KEY WORDS
Seaweed, sustainability, aquaculture, management, PARFISH.

Seaweed is one of the strategic commodities in the fisheries revitalization program in addition to shrimp and tuna. Indonesia has an area for seaweed cultivation activities of 1,110,900 ha, but the development of seaweed cultivation only utilizes an area of 222,180 ha (20% of the potential area). Based on data from the Marine and Fisheries Service of East Nusa Tenggara province in 2020, the potential and level of seaweed production in Kupang Regency ranks first compared to other districts / cities in East Nusa Tenggara Province, where the potential for seaweed cultivation is 100,354.07 ha, while those that have been utilized are 1,035.41 ha with a total production of dried seaweed of 16,566.51 tons (DKP NTT Province, 2021). One of the sub-districts in Kupang Regency whose people use the sea as a place for seaweed cultivation is West Kupang District. This seaweed cultivation activity was chosen by the community because it has several advantages including a relatively short harvest period of about 45 days, without using fertilizer, has high economic value, does not damage the environment, the cultivation method is easy, the cost is low and the availability of markets (Ma'ruf, 2025). This causes the community to use every inch of coastal area in West Kupang District for seaweed cultivation activities up to 2 km towards the sea without taking into account the principle of land suitability and environmental carrying capacity. If this continues, it is likely that there will be environmental degradation that can reduce the productivity and quality of seaweed produced. So that this seaweed cultivation activity, which is the foundation of new hope for coastal communities in West Kupang District to improve their welfare, can be threatened by its sustainability. Therefore, research with the aim of evaluating the suitability of land/waters for seaweed cultivation activities, and analyzing the sustainability status of seaweed business in coastal areas in West Kupang District, Kupang Regency needs to be carried out.

MATERIALS AND METHODS OF RESEARCH

This research used a survey method, and was carried out in West Kupang District, Kupang Regency, East Nusa Tenggara Province, considering that West Kupang District is the largest seaweed producer in Kupang Regency, (DKP Kupang Regency, 2021) (figure 1). The study will be conducted from June to September 2023. The data used are primary data and secondary data. Secondary data were obtained through literature studies and documents from several institutions related to research. Meanwhile, primary data are obtained through observation, direct measurements in the field as well as analysis in the laboratory and the results of interviews with respondents. The population of this study is seaweed cultivators, and the number of respondents in this study amounted to 50 people with details of 20 respondents from Tablolong village, 19 respondents from Tesabela village, and 11 respondents from Oenaek village.

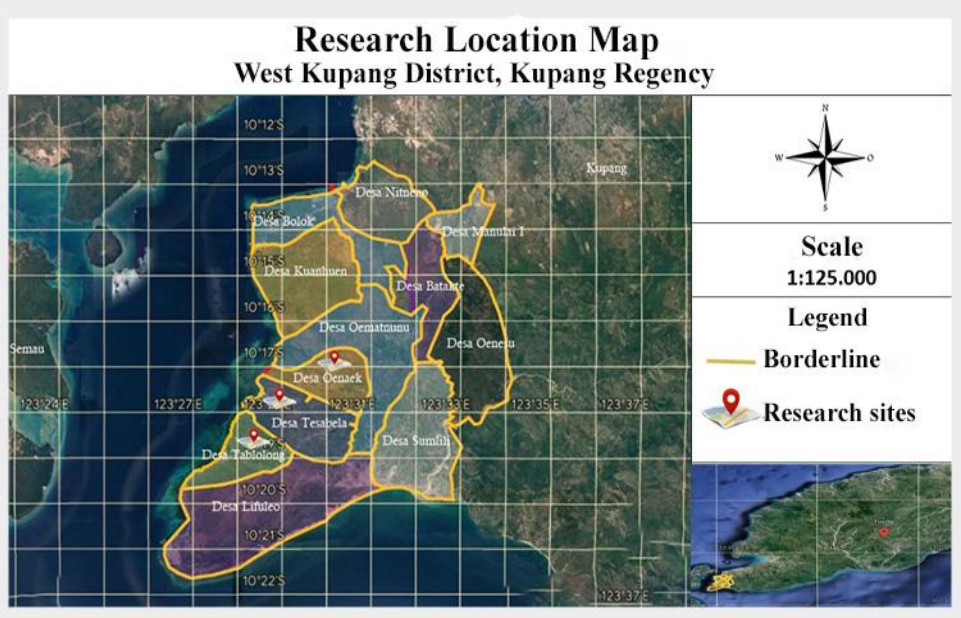

Figure 1 – Research location

Data analysis in this study include: (1) analysis of land/water suitability for aquaculture with two methods, namely land suitability matrix and weighting; (2) Sustainability analysis of seaweed farming activities. The sustainability of seaweed farming activities was analyzed statistically multivariate with a Multidimensional Scaling (MDS) approach. Analysis of the sustainability of seaweed farming activities is aimed at determining the possibility of sustainability of seaweed farming activities for optimal utilization. The sustainability of seaweed farming activities was analyzed using the RAPFISH (Rapid Assessment Techniques for Fisheries) method to assess the sustainability status of seaweed farming.

RESULTS AND DISCUSSION

The analysis of the suitability of waters for seaweed cultivation is based on several requirements regarding the physical chemical parameters of waters in West Kupang District, because it can be a limiting factor for the growth of seaweed for cultivation. Based on the results of the weighting of the suitability of waters for seaweed cultivation, the value for classes with very suitable criteria (SS) ranges from >250 – 300, while for classes with suitable criteria (S) ranges from >150 – 250. The results of the calculation of the suitability area were obtained 152.62 Ha for water areas with very suitable criteria, 213.67 Ha for water areas with suitable criteria for aquaculture activities and 549.41 which were not suitable for seaweed cultivation activities (Table 1).

Table 1 – Suitability of seaweed aquaculture waters in three sub-district villages in West Kupang

No.	Village	Water Area (Ha)		
		Highly Compliant (SS)	Compliant (S)	Non-Compliant (TS)
1.	Tablolong	100,4	140,56	361,44
2.	Tesabela	34,73	48,62	125,01
3.	Oenaek	17,49	24,49	62,96
	Sum	152,62	213,67	549,41

The results of field measurements using GPS, it was found that the area of land or waters in three villages (Tablolong, Tesabela, and Oenaek Villages) of West Kupang District which is currently used for seaweed cultivation activities is 152.61 Ha, from 366.29 Ha or about 41.67% of the potential water area used for seaweed cultivation activities. Thus, there are still about 213.68 Ha of untapped potential waters for seaweed farming activities (Table 2).

Table 2 – Potential area of seaweed aquaculture waters in three villages of West Kupang District

No.	Village	Water Area (Ha)		
		Potential (Very Appropriate + Appropriate)	Already utilized	Untapped
1.	Tablolong	240,96	101,2	139,76
2.	Tesabela	83,35	32,51	50,84
3.	Oenaek	41,98	18,9	23,08
	Sum	366,29	152,61	213,68

Sustainability Seaweed farming activities are considered from five dimensions, namely the ecological dimension, economic dimension, socio-cultural dimension, technological dimension and institutional dimension. Within each dimension there are several attributes that are measured both quantitatively and qualitatively, and then given weights using Multidimensional Scaling (MDS). This analysis was performed using RAPFISH software. The attributes used are modifications of Pitcher *&* Preikshot (2001), Hartono *et al*. (2005), Aziz (2011). The scoring of each dimension is adjusted to the real conditions of seaweed cultivation activities in the coastal area of West Kupang District.

The ecological dimension with seven attributes that have been analyzed using RAPFISH resulted in a sustainability index value of 58.58 with a fairly sustainable status. The attributes that are estimated to affect the level of sustainability in the ecological dimension consist of nine attributes, namely (1) protection, (2) current speed, (3) depth, (4) brightness, (5) seed quality, (6) seed availability, and (7) area suitable for seaweed cultivation. Of the six attributes based on *Leveraging analysis,* it was found that the attributes that are quite sensitive to this dimension are (1) brightness, and (2) depth.

The sustainability status in the economic dimension is quite sustainable with an index value of 53.42. The attributes that affect this dimension consist of five attributes, namely (1) feasibility of seaweed cultivation, (2) seaweed farming advantages, (3) contribution to Regional Original Income, (4) seaweed marketing chain, and (5) number of markets.

The sustainability index value for the socio-cultural dimension is 52.89 with a fairly sustainable status. Attributes that are estimated to influence the level of sustainability of the socio-cultural dimension are (1) level of education, (2) number of seaweed farming households, (3) social system in seaweed cultivation management, (4) independence of farmers, (5) family participation in seaweed farming activities, (6) job socialization, (7) alternative businesses other than planting seaweed, and (8) level of community empowerment. Based on the results of *leveraging analysis*, three attributes were obtained that are sensitive to the value of the socio-cultural dimension sustainability index, namely (1) family participation in seaweed farming activities, (2) job socialization and (3) the number of RTs of seaweed farmers (Figure 3). These attributes need to be managed properly so that the value of the socio-cultural dimension sustainability index increases in the future.

The sustainability status of the six attributes of the technology dimension gives a sustainability index value of 46.14 with a less sustainable status. Attributes that have a role in this dimension include (1) support for facilities and infrastructure, (2) seaweed quality

standardization, (3) level of mastery of seaweed cultivation technology, (4) availability of information technology, (5) availability of seaweed product processing industry, and (6) availability of seaweed databases. Leverage analysis was conducted to see the sensitive attributes that influence the value of the sustainability index of the technology dimension, the results obtained three attributes that are most sensitive to influence, including (1) standardization of seaweed quality, (2) level of mastery of seaweed cultivation, (3) availability of seaweed product processing industry.

The institutional dimension with seven attributes that have been analyzed using RAPFISH resulted in a sustainability index value of 56.85 with a fairly sustainable status. The attributes that are estimated to influence the level of sustainability of the institutional dimension are (1) Availability of seaweed cultivator group institutions, (2) availability of coastal land use zoning, (3) Availability of Regional Regulations (Perda), (4) Availability of customary rules and religion/beliefs, (5) the existence of respected role models, (6) Availability of financial/social institutions, and (7) The existence of extension centers for seaweed cultivation. The results of *the leveraging* analysis conducted to see sensitive attributes contributing to the value of the sustainability index in the institutional dimension obtained the two most sensitive attributes including (1) availability of local regulations, (2) availability of land use zoning in coastal areas.

This analysis with MDS produces the status and sustainability index of seaweed farming activities. The intended sustainability status is how the sustainability status of seaweed cultivation activities in the coastal area of West Kupang District based on the five dimensions studied and the index obtained is shown in figure below.

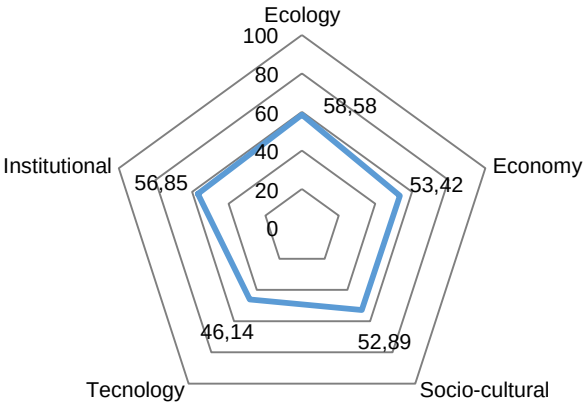

Figure 1 – Sustainability index values from five dimensions of seaweed farming activities in coastal areas of West Kupang District

The results of the RAPFISH analysis obtained a sustainability index for the ecological dimension of 58.58 with a fairly sustainable status, an economic dimension of 53.42 with a fairly sustainable status, an index value for the socio-cultural dimension of 52.89 with a fairly sustainable status, an index value for the technology dimension of 46.14 with a less sustainable status, and an institutional dimension with an index value of 56.85 with a fairly sustainable status. This index describes the sustainability of each attribute based on current management. In this study, the technology dimension is a dimension that is less sustainable, to improve the status to be sustainable, it is necessary to improve the attributes for each dimension in the future. The results of the sustainability index analysis for each dimension of seaweed cultivation activities in West Kupang District, Kupang Regency are generally included in the category of quite sustainable for now. This condition can be improved to be sustainable by paying attention to the sensitive attributes of each dimension. The sustainability status of each sample village in West Kupang District, namely Tablolong Village, Tesabela Village, and Oenaek Village can be seen from the sustainability index value of each dimension as in Table 3.

Table 3 – Index value and sustainability status of seaweed farming activities in each village in West Kupang District

No	Village Name	Sustainability Index Value (%) of Each Dimension					Sustainability Status
		Ecology	Economics	Socio-Cultural	Technology	Institutional	
1	Tablolong	52.58	52.34	55.38	47.26	58.93	Quite sustainable
2	Tesabela	52.08	53.39	56.65	47.68	57.76	Quite sustainable
3	Oenaek	59.36	53.82	54.84	48.22	58.12	Quite sustainable

Based on Table 3, it can be seen that the Technology dimension is in a less sustainable status in the three villages that are the area of the researcher's study. The sensitive attributes of the *leverage analysis* results for ecological, economic, socio-cultural, technological and institutional dimensions in five urban villages can be used as a reference to improve the sustainability status of seaweed farming activities in West Kupang District by maintaining or even improving attributes that have a positive impact and suppress attributes that have a negative impact.

CONCLUSION

The suitable area for seaweed cultivation in the study area is in the waters of West Kupang District with very suitable class criteria covering an area of 407.6 ha, appropriate class criteria covering an area of 856.93 ha and inappropriate class criteria covering an area of 2665.78 ha. In general, the level of sustainability of seaweed cultivation activities in West Kupang District, Kupang Regency is in the category of quite sustainable, unless the technological dimension is included in the category of less sustainable. Based on the results of the study, it is suggested that more in-depth research is needed on assessment and addition of dimensions and attributes in the sustainability analysis of seaweed farming activities in order to provide input on more specific management recommendations.

APPENDIX

Table 1 – Coefficient correlation interpretation

Correlation Coefficient		Interpretation
1	−1	Perfect
0.9	−0.9	Very Strong
0.8	−0.8	Very Strong
0.7	−0.7	Moderate
0.6	−0.6	Moderate
0.5	−0.5	Fair
0.4	−0.4	Fair
0.3	−0.3	Fair
0.2	−0.2	Poor
0.1	−0.1	Poor
0	0	None

Table 2 – Summary of Pearson Correlation Analysis

Predictor	Pearson Correlation	P-value	Remark
Farming area	0.978	0.000	Significant
Rope	0.934	0.000	Significant
Buoy	0.827	0.000	Significant
Wooden peg	0.812	0.000	Significant
Ballast	0.864	0.000	Significant
Boat	0.338	0.218	Non-significant
Seed	0.970	0.000	Significant

Table 3 – Summary of multiple linear regression assumption checking

Assumption	Method	Result	Remark
Normality	Kolmogorov-Smirnov test	Sig. = 0.200	Normal
Non-multicollinearity	VIF	There are predictors which have VIF > 10	Multicollinear
Non-autocorrelation	Durbin-Watson test	D=1.810 dL = 0.814; dU=1.750	No autocorrelation
Non-heteroscedasticity	Glejser test	Sig. = 0.052	Homoscedasticity

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