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ANALYSIS OF SUITABILITY AND CARRYING CAPACITY OF WATERS FOR SEAWEED (*EUCHEUMA COTTONII*) CULTIVATION BUSINESS IN MANDAR BAY, WEST SULAWESI OF INDONESIA

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ABSTRACT

This research was aimed to analyze the water suitability and environmental carrying capacity for seaweed (*Eucheuma cottonii*) cultivation business in Mandar Bay of West Sulawesi. The results of this research are expected to be a reference to consideration in the management of sustainable seaweed cultivation business. This research is an explorative research using the method of direct survey and measurement in the field. The data collected were analyzed spatially with geographic information system (GIS) approach and then outlined descriptively. Based on the spatial analysis results (*overlay*) of the water suitability for seaweed cultivation in Mandar Bay of West Sulawesi, it was obtained that the total water area in Polewali District reached 1,252.66 ha, covering the suitable water area of 65.39 ha and the conditionally suitable water area of 1,187.27 ha. If divided based on the subdistrict area, the water suitability area of the five coastal subdistricts in Polewali District respectively was as follows: 1) Polewali Subdistrict's suitable water area of 13.16 ha (1.05%) with the water carrying capacity of 2.6 ha, the number of cultivation units reaching 5.2, and the production rate of 3.9 tons per year; 2) Wattang Subdistrict's suitable water area of 0 ha (0%); 3) Lantora Subdistrict's suitable water area of 11.3 ha (0.9%) with the water carrying capacity of 2.26 ha, the number of cultivation units reaching 4.52, and the production rate of 3.39 tons per year; 4) Takatidung Subdistrict's suitable water area of 39.85 ha (3.18%) with the water carrying capacity of 7.97 ha, the number of cultivation units suitable to developed of 15.94, and the current production level of 11.95 tons per year; and 5) Manding Subdistrict's suitable water area of 1.08 ha (0.09%) with the water carrying capacity of 0.22 ha, the number of cultivation units to be developed of 0.44, and the current production rate of 0.33 tons per year.

KEY WORDS

GIS, land suitability, land carrying capacity, *Eucheuma cottonii*, seaweed, chemistry.

Polewali Mandar is one of the regions producing seaweed in West Sulawesi. The production of seaweed (*Eucheuma cottonii*) in Polewali Mandar Regency has decreased (DKP Polman, 2015). This potential needs to get prioritized for its handling so that the opportunity to increase the production of aquaculture in the future will be even greater. An identification of water resource feasibility for the development of aquaculture is highly important in the framework of spatial planning that is in line with its allocation to avoid conflicts of interests of the marine and fishery sector with other sectors. An identification of suitable locations can also be used as an initial indicator of the success of a cultivation business in accordance with the type of commodity and the cultivation technology to be applied (Dahuri, *et al.*, 2001).

Coastal development for seaweed cultivation activities cannot be separated from the water suitability factor. The main factors that become obstacles for the development of seaweed cultivation in Indonesia are the incompatibility of water locations and the unsuitable parameter data of water quality. Besides, the determination of cultivation locations is often based on people's feeling (Hartoko and Helmi, 2004). Determination of water suitability is highly significant to know because it will make certain about the water locations that are suitable for the allocation of cultivation business so that the locations can be utilized as maximally as possible. Furthermore, Hardjowigeno (2001) stated that land suitability is the

feasibility of lands for a specific purpose of use by determining the land value (class) and the land use pattern associated with the potential of its territory so that a more targeted land use for cultivation business and its sustainability can be managed.

One of the alternative analytical approaches used to facilitate people in knowing the water suitability in a large territory or area is by using Geographic Information System (GIS) technology (Hambali, 2012). It is further said that using the spatial analysis with Geographic Information System (GIS), it will be obtained the class of water suitability for seaweed cultivation (Longdill, *et al.*, 2008).

This research was aimed to analyze the water suitability and environmental carrying capacity of seaweed (*Eucheuma cottonii*) cultivation business in Mandar Bay, West Sulawesi. The results of this research are expected to be a reference to consideration in the management of sustainable seaweed cultivation business.

METHODS OF RESEARCH

This research was conducted in a seaweed production area of Mandar Bay, located at 119° 22' 03,971" - 119° 17' 34,744" E dan 03° 23' 23,616" - 03° 26' 33,581" S Polewali District, Polewali Mandar Regency, West Sulawesi Province, Indonesia from October to December 2015.

This research is a type of explorative research by carrying out a direct survey and measurement in the field using a quantitative approach with hypothesis testing for collecting actual data and information in the research location related to the seaweed cultivation activities in Mandar Bay (Sugiyono, 2008).

The sampling was conducted on 12 stations (Figure 1) using purposive sampling with the consideration of the seaweed cultivation business activities. Each of the observed locations was very likely to represent or describe the state of the waters. According to APHA (1998), prior to undertaking a measurement and sampling, it should first determine the coordinate points using Global Positioning System (GPS).

Figure 1 – Sampling Location

Biophysical data such as temperature, salinity, brightness, depth, current velocity, pH, dissolved oxygen, COD, BOD, nitrate, phosphate, and pest were obtained through direct observation and measurement. Besides, interviews and questionnaires were also used to obtain the data in relation to the seaweed farmers.

The suitability analysis was done on the basis of limiting parameters according to its utilization in terms of the ecological aspect. The initial criteria include ecological factors such as temperature, salinity, brightness, water depth, current velocity, pH, dissolved oxygen, COD, BOD, nitrate, phosphate (Hartoko and Kangkan, 2009; Anwar and Burhanuddin, 2016; Semedi, *et al.*, 2016). Furthermore, the water carrying capacity was eventually determined by the results of GIS analysis in the form of the locations and water area that were suitable with the required criteria.

Based on the feasibility assessment system according to Bakosurtanal (1996) and DKP (2002), the feasibility for seaweed cultivation is categorized into four classes covering *Highly Suitable* for the score range of >92 – 115, *Suitable* for the score range of >69 – 92, *Conditionally Suitable* for the score range of 46 -69, and *Not Suitable* for the score range of < 46.0.

The stages in determining the analysis of environmental carrying capacity based on the water capacity for seaweed cultivation using a long line system according to Rauf (2007)'s formula are as follows:

Determination of water suitability area is obtained from the results of suitability analysis using GIS.

Determination of water capacity value uses the following formula:

$$KP_{RL} = \frac{(p_2 \times l_2) - (p_1 \times l_1)}{(p_2 \times l_2)} \times 100 \%$$

Where: KP_{RL} = Water Capacity (%); p^1 = Length of managed cultivation unit (m); l_1 = Width of managed cultivation unit (m); p^2 = Length of suitable cultivation unit (m); l_2 = Width of suitable cultivation unit (m).

Calculation of the carrying capacity of seaweed cultivation uses the following formula:

$$DD_{RL}KP = LPS_{RL} \times KP$$

Where: $DD_{RL}KP$ = Carrying capacity of seaweed cultivation (ha); LPS_{RL} = Suitable water area for seaweed cultivation (ha); KP = Water capacity (%).

Area Determination of seaweed cultivation units uses the following formula:

$$LUB_{RL} = PUB_{RL} \times LUB_{RL}$$

Where: LUB_{RL} = Area of cultivation unit (ha); PUB_{RL} = National standards-based length of seaweed cultivation unit (m); LUB_{RL} = National standards-based width of seaweed cultivation unit (m).

The number of seaweed cultivation units can be determined using the following formula:

$$JUB_{RL}KP = DD_{RL}KP / LUB_{RL}$$

Where: $JUB_{RL}KP$ = Number of seaweed cultivation units (unit); $DD_{RL}KP$ = Water carrying capacity of seaweed cultivation (ha); LUB_{RL} = Area of one seaweed cultivation unit (m²).

RESULTS AND DISCUSSION

The measurement results of water quality parameters obtained a temperature range of 30.0 – 30.6⁰ C, salinity range of 29.6 – 30.6 ppt, brightness range of 0.5 – 9.6 m, depth range of 0.7 – 15.8 m, current velocity of 3.5 – 8.3 cm/s, pH range of 7.28 – 7.96, DO range of 2.05 – 2.45 ppm, nitrate range of 0.00010 – 0.00315 mg/l, phosphate range of 0.0069 – 0.1607, BOD range of 1.85 – 9.79 mg/l, and COD range of 31.04 – 118.83 mg/l.

The following table shows the spatial analysis results (overlay) of water suitability for seaweed cultivation in Mandar Bay, West Sulawesi based on the determinants of seaweed growth including water depth, brightness, current speed, temperature, salinity, pH and DO, nitrate, orthophosphate, BOD, and COD.

Based on the table, it is shown that the total water area of Polewali District was 1,252.66 Ha covering the land suitability area of 65.39 Ha and the conditional suitability area of 1,187.27 Ha. If divided based on the subdistrict area, the water suitability area of the five coastal subdistricts in Polewali District respectively consisted of Polewali Subdistrict of 13.16

ha (1.05%), Wattang Subdistrict of 0 ha (0%), Lantora Subdistrict of 11.30 ha (0.9%), Takatidung Subdistrict of 39.85 ha (3.18%) and Manding Subdistrict of 1.08 ha (0.09%). In another side, the locations categorized into the class of Conditional Suitable indicated that the locations had quite heavy limiting factors for seaweed cultivation such as lack of oxygen, minimal nitrate and phosphate level, and the occurrence of pollutions. For more details, it can be seen in Figures 2 and 3.

Table 1 – Water Area, Conditionally Suitable Water Area, Suitable Water Area, Water Carrying Capacity, Number of Cultivation Units and Production in Polewali District

No	Subdistrict	Water Area (Ha)	Conditionally Suitable Water Area (Ha)	Suitable Water Area (Ha)	Area of Water Carrying Capacity (Ha)	Number of Cultivation Units	Production/Dry (ton/year)
1	Polewali	245.05	231.89	13.16	2.6	5.2	3.9
2	Wattang	126.22	126.22	0	0	0	0
3	Lantora	153.42	11.30	11.3	2.26	4.52	3.39
4	Takatidung	382.08	342.23	39.85	7.97	15.94	11.95
5	Manding	345.89	344.81	1.08	0.22	0.44	0.33
	Total	1,252.66	1187.27	65.39	13.5	26.1	19.57

Data after processing, 2016.

Figure 2 – Chart of Water Suitability Area, Water Carrying Capacity Area, Number of Cultivation Unit and Production per Year

It is assumed that the decreased production of seaweed cultivation in Polewali District for the last 2 (two) years was due to the utilization of land that exceeded the capacity of the aquatic environment. If viewed from the level of the utilization of waters in Polewali District, it was found that it exceeded the environmental carrying capacity with the level of water suitability area of 65.39 ha, the water carrying capacity area of 13.05 ha and the cultivation number of 26.1 units. Meanwhile, the level of water utilization reached 595 ha. Here is the more detail explanation if observed from each subdistrict.

Polewali Subdistrict obtained a suitable water area of 13.16 ha (the water utilization level of 60 ha) that could support the management of seaweed cultivation business with a 50 x 100 size-long line method of 2.6 ha in which the number of cultivation units was 5.2 with the production level of 3.9 tons per year.

Wattang Subdistrict obtained a suitable water area of 0 ha (the water utilization level of 25 ha), indicating that this location could not support the activities of seaweed (*Eucheuma cottonii*) cultivation business.

Lantora Subdistrict obtained a water area of 11.3 ha (the land utilization level of 210 ha) and this region had a suitable water carrying capacity of 2.26 ha with the number of managed cultivation units reaching 4.52 and production level of 3.39 tons per year.

Figure 3 – Green Color for Water Suitability Area of Mandar Bay

Takatidung Subdistrict obtained a suitable water area of 39.85 ha (the water utilization level of 150 ha) and this region had a water carrying capacity of 7.97 ha with the number of cultivation units suitable to be developed as much as 15.94 and the current production level of 11.95 tons per year.

Manding Subdistrict obtained a suitable water area of 1.08 ha (the land utilization level of 150 ha) and this region had a water carrying capacity of 0.22 ha with the number of cultivation units suitable to be developed as much as 0.44 and the current production level of 0.33 tons per year.

CONCLUSION

Based on the spatial analysis results (overlay) of water suitability for seaweed cultivation in Mandar Bay, West Sulawesi, it is concluded that the total water area in Polewali District is 1,252.66 ha, consisting of the suitable water area of 65.39 ha and the conditional suitable water area of 1,187.27 ha. If divided based on the subdistrict area, the suitable water area of the five coastal subdistricts in Polewali Mandar District respectively is as follows: 1) Polewali Subdistrict's suitable water area of 13.16 ha (1.05%) with the water carrying capacity of 2.6 ha, the number of cultivation units reaching 5.2, and the production rate of 3.9 tons per year; 2) Wattang Subdistrict's water area of 0 ha (0%); 3) Lantora Subdistrict's suitable water area of 11.3 ha (0.9%) with the water carrying capacity of 2.26 ha, the number of cultivation units reaching 4.52, and the production rate of 3.39 tons per year; 4) Takatidung Subdistrict's suitable water area of 39.85 ha (3.18%) with the water carrying capacity of 7.97 ha, the number of cultivation units suitable to developed of 15.94, and the current production level of 11.95 tons per year; and 5) Manding Subdistrict's suitable water area of 1.08 ha (0.09%) with the water carrying capacity of 0.22 ha, the number of cultivation units to be developed of 0.44, and the current production rate of 0.33 tons per year.

REFERENCES

1. Anwar. A and Burhanuddin, 2016. The Parameters Analysis of Physics, Chemistry and Biology in Sealayar Marine For Feasibility Seaweed Cultivation *Eucheuma cottonii*. J. of Oceans and Oceanography V.10 (2): 287-297
2. APHA (American Public Health Association). 1998. Standard Methods for Examination of Water and Wastewater. Twentieth edition. APHA – AWWA - WEF, Washington, DC. 1, 185 pp.
3. Badan Koordinasi Survei dan Pemetaan Nasional, 1996. Pengembangan prototipe wilayah pesisir dan marine Kupang Nusa Tenggara Timur. Pusat Bina Aplikasi Inderaja dan SIG. Jakarta (ID): Bakosurtanal.
4. Dahuri R, J. Rais, SP. Ginting dan MJ. Sitepu. 2001. Pengelolaan Sumberdaya Wilayah Pesisir dan Lautan Secara Terpadu. Jakarta PT. Pradnya Paramita.

5. DKP Polman, 2015. Data Potensi Dan Produksi Perikanan Budidaya Laut. Dinas Kelautan dan Perikanan Kabupaten Polewali Mandar.
6. Departemen Kelautan dan Perikanan, 2002, Modul Sosialisasi dan Orientasi Penataan Ruang, Laut, Pesisir dan Pulau-Pulau Kecil. Ditjen Pesisir dan Pulau-Pulau Kecil. Direktorat Tata Ruang Laut, Pesisir dan Pulau-Pulau Kecil. Jakarta.
7. Hambali, M. 2012. Aplikasi SIG Untuk Kesesuaian Kawasan Budidaya Rumput Laut *Eucheuma cottonii* dengan Metode Lepas Dasar di Pulau Mantang, Kecamatan Mantang. Kabupaten Bintang.
8. Hardjowigeno S. 2001. Kesesuaian lahan dan perencanaan tata guna tanah. Bogor (ID): Faperta IPB.
9. Hartoko. A and M. Helmi. 2004. Development of digital multilayer ecological model for padang coastal water (West Sumatera). J of Coastal Development. 7.(3):129-136.
10. Hartoko.A and Kangkan. 2009. Spatial Modeling For Mariculture Site Selection Based on Ecosystem Parameters at Kupang Bay, East Nusa Tenggara, Indonesia. J of Remote Sensing and Earth Sciences. 6:57-64
11. Longdill, P.C, Terry R.Healy, Kerry P.Black. (2008) An integrated Gis Approach for Sustainable aquaculture Management area Site Selection. Journal homepage. Elsevier. Ocean and Coastal Management. 51: 612-624.
12. Rauf A. 2007. Pengembangan terpadu pemanfaatan ruang kepulauan tanakeke berbasis daya dukung. [disertasi]. Bogor (ID): Institut Pertanian Bogor.
13. Semedi, B, Da Kosta and Mahmudi, M. 2016. Feasibility of Seaweed (*Kapaphycus alvarezii*) Maricultur Using Geografic Information System In Hading Bay, East Flores Indonesia. J of Natural Environment and pollution Technology.15.(4): 1347-1349.
14. Sugiyono. 2008. Metode Penelitian Kuantitatif, Kualitatif dan R&D, Penerbit CV Alfabeta. Bandung.