Journal of Economics and Sustainable Development www.iiste.org
ISSN 2222-1700 (Paper) ISSN 2222-2855 (Online)
Vol.7, No.20, 2016

Determining Potential Volume of Raw Dried Seaweed Kappaphycus Alvarezii Based on Land Suitability as Agribusiness Management Plan

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Abstract
This study aims to determine the potential volume of raw dried seaweed *Kappaphycus alvarezii* in Parigi Moutong District, Central Sulawesi Province, Indonesia. The determination based on the analysis of land suitability for seaweed farming, using: (1) Geographic Information Systems (GIS); and (2) Analysis of Waters Carrying Capacity. Satellite imagery used were Aquamodis 2013 and LANDSAT 8. Subsequent processing using the software of ENVI 4.5 and ArcView GIS 10.2. Thematic maps were produced then overlayed to get the land suitability of seaweed farming. The results then analyzed to produce the water's carrying capacity of 106,989.53 hectares. If the area converted in the form of a long line raft measuring 50 x 50 m, amounted to 190,204 units, consisting of: (1) 19,020 units of nurseries, and (2) 171,183 units of cultivation raft. If the average production of 0.545 tons drymaterials/raft/crop, the potential volume of raw dried materials amounting to 93,194.14 tons/crop.
Keywords: Volume of raw dried seaweed, land suitability, seaweed *Kappaphycus alvarezii*, agribusiness

1. Introduction

Marine waters area of Parigi Moutong District, Provincial of Central Sulawesi, Indonesia, has the characteristics of the deep waters. Consists of many islands, sandy sea bed, and there are many coral reefs. This area has considerable potential for the development of agribusiness seaweed *Kappaphycus alvarezii*. Seaweed agribusiness development will have an impact on employment, poverty reduction and the improvement of the local economy.

However, the development of seaweed agribusiness in the district of Parigi Moutong nowadays still faceseveral obstacles, especially the availability of raw materials. Potential production of raw dried seaweed farming still can not be predicted as well. This condition must be very influential on the sustainability of the seaweed agribusiness.

Agribusiness management requires comprehensive and integrated strategy, from planning to implementation level (Paramu et al., 2011). In order to operate properly, then the policy makers, need to control the whole event, from production planning, inventory, distribution to marketing in the form of supply chain management (Beamon, 1998; Voulgaris dan Lemonakis, 2013; Tsolakis et al., 2014). One of the important components in the supply chain management is determine the amount of raw material. Thus, there should be conducted the determination of the potential volume of raw dried seaweed *Kappaphycus alvarezii* as the basis for agribusiness management plan.

2. Materials and Method

2.1 Analysis of Geographic Information Systems (GIS)

The study was conducted in October 2014 until March 2015. Satellite imagery is used LANDSAT 8 and Aquamodis 2013.The initial stage of satellite image processing is the process of geometric , radiometric and atmospheric correction, respevtively (Hasyim et al., 2012). The primary data obtained from direct measurements at predetermined sample location, while secondary data obtained from the information that published by the relevant agencies. Primary data was taken from the seaweed cultivationarea which represents the northern, central and southern of Parigi Moutong District, i.e: (1 Ogotion Village, Mepanga Subdistrict, (2) Silampayang Village, Kasimbar Subdistrict, and (3) Tumpapa Indah Village, Balinggi Subdistrict. At each site , samples were taken from 5 stations. the distance of each station is 25 is approximately 25 m, while the distance 1 station within 50 m from the coastal line.

The results were compared with secondary data, then processed using ENVI (The Environment For Visualizing Images) 4.5 and Arc View GIS 10.2. Outcomes of the processing were thematic maps of physical and chemistry parameters, i.e: water current, water surface temperature, acidity (pH), salinity, depth of water, nitrate concentration, phosphate concentration, chlorophyll–aconcentration, waters substrate, mangrove ecosystem and dissolved oxygen concentration. The determination of the land suitability was conducted by using overlaying of each thematic maps and weighting techniques based on Avianti (2015) methods.

2.2 Waters Carrying Capacity

The results of land suitability analysis will be the basis for the calculation of the waters carrying capacity, conducted using Rauf (2007) methods as follows:

Waters Capacity (WCap), is the percentage of area that can be utilized for the cultivation of seaweed, withthe formulation as follows:

$$WCap = \frac{L2 - L1}{L2} \text{ X } 100 \%$$

$$= \frac{(p2 \text{ x } l2) - (p1 \text{ x } l1)}{(p2 \text{ x } l2)} \text{X } 100 \%$$

where:

WCap	=	Waters Capacity (%)
L1	=	Extensive cultivation unit managed (m^2)
p1	=	Length of cultivation unit managed (m)
l1	=	Width of cultivation unit managed (m)
L2	=	Extensive cultivation of the appropriate unit (m^2)
p2	=	Appropriate length of cultivation unit (m)
	=	p1 + width of canoe's and out rigger counter weight
l2	=	Appropriate width of cultivation unit (m)
	=	l1 + wide of canoe's out rigger counter weight

carrying capacity of seaweed cultivation based on the waters capacity, as follows:

WCCap = Sareax WCap

where:

WCCap	=	Waters Carrying Capacity for Seaweed Cultivation(ha)
Sarea	=	Suitable Area for Seaweed Cultivation (ha)
WCap	=	Waters Capacity (%)

extensive seaweed cultivation unit (LUBRL), as follows:

ESC = LC x WC

where:

ESC	=	Extensive Cultivation Unit (ha)
LC	=	Length of Cultivation Unit (m)
WC	=	Widht of Cultivation Unit (m)

seaweed cultivation raft unit, as follows:

$$SCR = \frac{WCCap}{LUBRL}$$

where:

SCR	=	Amount of Seaweed Cultivation Raft Unit(unit)
WCCap	=	Waters Carrying Capacity for Seaweed Cultivation(ha)
ESC	=	Extensive Size of One Unit Seaweed Cultivation (ha)

2.3 Potential Volume of Raw Dried Seaweed

Determining potential volume of raw dried seaweed conducted by calculating the harvest result of cultivation raft production/unit/crop. Primary data were obtained from the study site, including: (1) shape and size of cultivation media, (2) length, number and spacing of rope spans, and also the distance between the "tie-tie" ring ropes, (2) initial seedling weight, average daily growth (ADG), ammout of total harvest at days of culture – 45, and conversion weight from wet to dry.

3. Result and Discussion

3.1 Analysis of Geographic Information Systems (GIS)

Thematic maps produced can be seen in the figure as below :

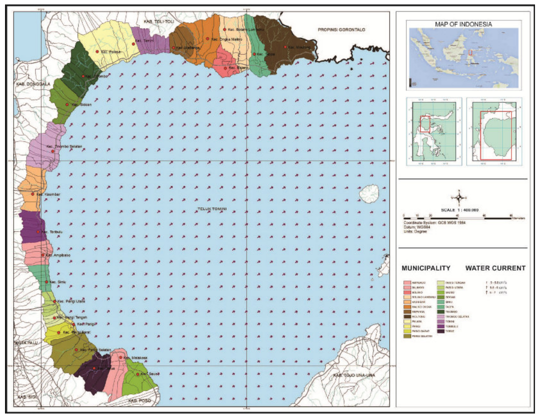

Figure 1. Western water current

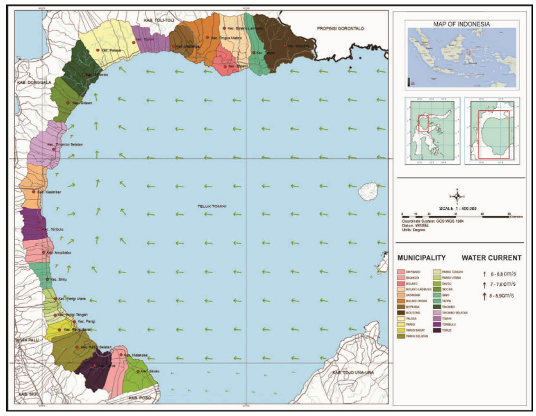

Figure 2. Eastern water current

Water current movement at the site of research is strongly influenced by western and eastern seasons. In west season, current speed range from 5-7 cm/sec, while the east season 6 to 8.5 cm/sec. On site measurements indicate the curent velocity at the Ogotion village range 5-8 cm/sec, Silampayang Village 2-4 cm/sec and Tumpapa Indah village range 4-6 cm/sec. These results are consistent with research conducted by BPPBAP Maros (2011), stating the current speed range of 0-30 cm/sec. These results indicate the water flow is quite good for seaweed cultivation. Water curent itself, is important in the transport of nutrients to the growth of seaweed (McHugh, 2003).

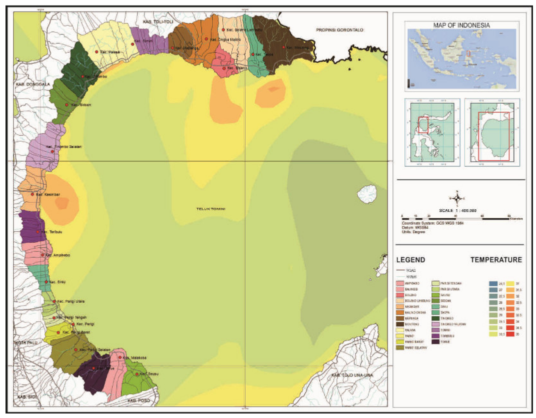

Figure 3. Water surface temperature

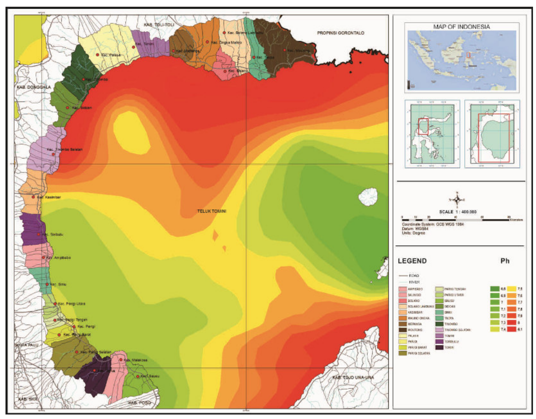

Figure 4. Acidity (pH)

Water surface temperature ranges from 28 to 33°C. Meanwhile, On site measurements shown that in the Ogotion Village from 30.40 to 31.40 °C; Silampayang Village from 30.40 to 31.30 °C, and Tumpapa Indah Village 31.10 to 31.40 ° C. This is consistent with research have done by BPPBAP Maros (2011), which shows the water surface temperature ranges from 28.94 to 33.56 °C. The other research also states that the water temperature surface in this district range from 30.5 to 32 °C with a mean value of 31.70 °C (Sallata, 2007). These results indicate that the water temperature surface relatively good for the *Kappaphycus alvarezii* cultivation.

The pH waters ranging from 6.9 to 8.1. The results of On site measurements shown that pH in Ogotion village ranged from 7.41 to 7.87; Silampayang Village 7.11 to 7.92 ; and Tumpapa Indah Village 7.54 to 7.89. These results are consistent with research conducted by Sallata (2007) which states that the pH level ranged from 7.1 to 8.4 with a mean of 8.05. Meanwhile, seaweed *Kappaphycus alvarezii* can grow optimally at pH near 8 (Glenn and Doty, 1990). Thus, it shown that the pH of the water is still quite good for seaweed cultivation .

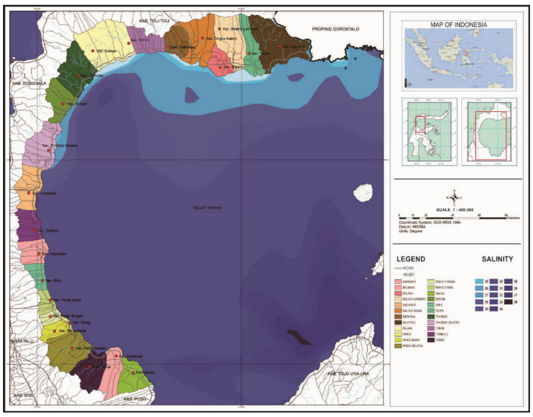

Figure 5. Salinity

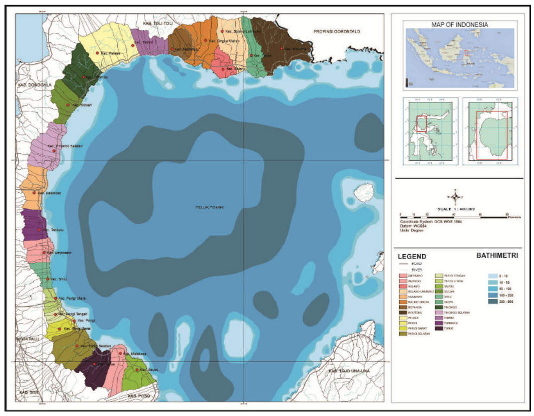

Figure 6. Depth of waters

Salinity ranges from 25 to 34 parts per thousand (ppt) . On site measurements indicate that salinity in Ogotion village ranged from 30.00 to 31.00 ppt ; Silampayang Village from 28.00 to 30.05 ppt , and Tumpapa Indah 29.50 to 31.00 ppt . Study conducted by BPPBAP Maros (2011) shown that salinity in study site range from 22.85 to 33.56 with a mean of 32.95 ppt. Other research also shown that salinity ranges from 30-34 ppt with a mean of 33.42 ppt (Sallata, 2007). Meanwhile, *Kappaphycus alvarezii* grow normally at 30-35 ppt, which is 32 ppt in the optimal value (Glenn and Doty, 1990; Ask and Azanza , 2002). Thus, the salinity in the study area is still quite good for seaweed cultivation.

On site measurements of water transparency shown that at the Ogotion Village ranged from 10.00 to 12.00 m , Silampayang Village 10.50 to 12.25 m and Tumpapa Indah Village 10.50 to 12.25 m . These results are consistent with research of BPPBAP Maros (2011), which showed that the transparancy range between 0.5 and 35.0 m with a mean of 12.51 m. Water transparency is one of the important parameter, indicated that seaweed grows optimally in the range of 30-50 cm from the surface of the sea (Ask and Azanza, 2002). These results indicate the water tranparancy in the research location is quite good for seaweed cultivation *Kappaphycus alvarezii*.

Water depths in study site ranging from 0-900 m, meanwhile, the study BPPBAP Maros (2011) suggests that the potential of seaweed farming is at a depth ranging from 0.5 to 160.0 m. Water depththat optimal for the seaweed *Kappaphycus alvarezii* cultivation ranges from 1-10 m below sea level (Avianti et al., 2015). The entire data shown that some areas of coastal waters has a depth that suitable for the cultivation of seaweed.

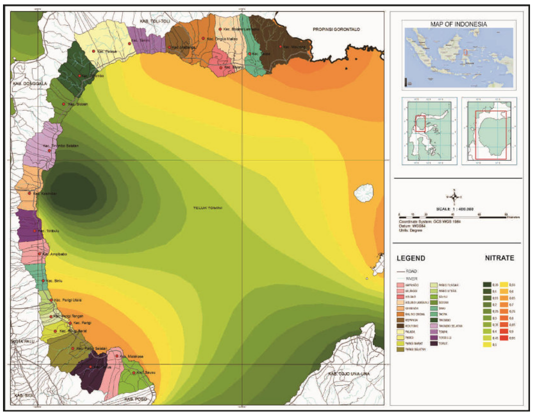

Figure 7. Nitrate concentration

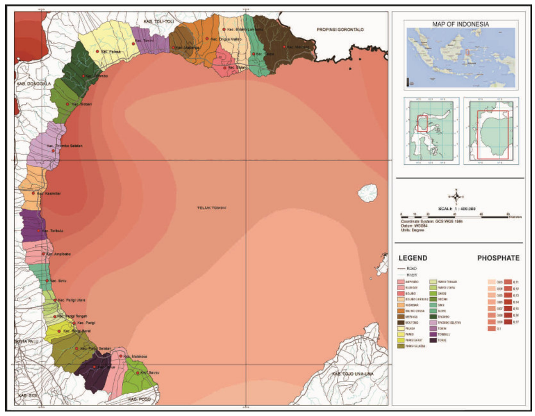

Figure 8. Phosphate concentration

Distribution of nitrate concentrations ranging from 0.05 to 0.95 mg/L . These results are higher than research conducted by BPPBAP Maros (2011) which shown that the nitrate content in the form of NO3, ranging from 0.0241 to 0.2891 mg / L. Sallata (2007) shown that the nitrate content of waters ranged from 0.032 to 0.326 mg/L, even in certain areas reached 0.11 mg/L . Seaweed *Kappaphycus alvarezii* require nitrate in the range from 0.002 to 0.004 mg/L (Glenn and Doty, 1990). These results suggest that some areas in coastal waters have nitrate content that suitable for seaweed farming.

Concentration of phosphate in the form of PO4 ranges from 0.03 to 0.17 mg/L. Good location for the cultivation of *Kappaphycus alvarezii* require phosphate concentration ranging from 0.1 to 0.2 mg/L (Avianti et al., 2015). Meanwhile, Glenn and Doty (1990) states that phosphate needs for seaweed Kappaphycus alvarezii ranged from 0.0005 to 0.0001 mg/L. Thus, the concentration of phosphate in some regions in the area of the study sites are still suitable for seaweed farming.

Chlorophyll-a concentration range from 0.02 to 0.3 mg/L. Meanwhile, a fairly good area for cultivation of *Kappaphycus alvarezii* have chlorophyll-a concentration ranging from 0.2 to 3.5 mg/L (Avianti et al., 2015). Referring to the results, some regions have good fertility for seaweed cultivation.

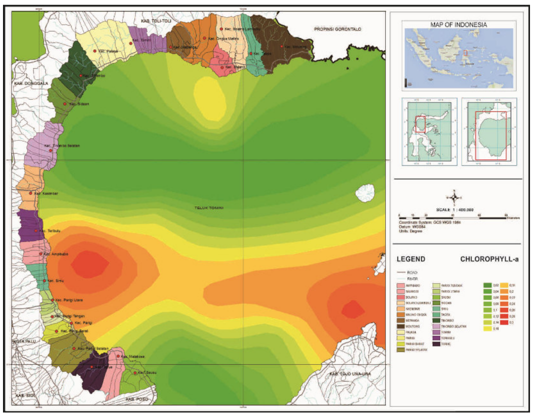

Figure 9. Chlorophyll –aconcentration

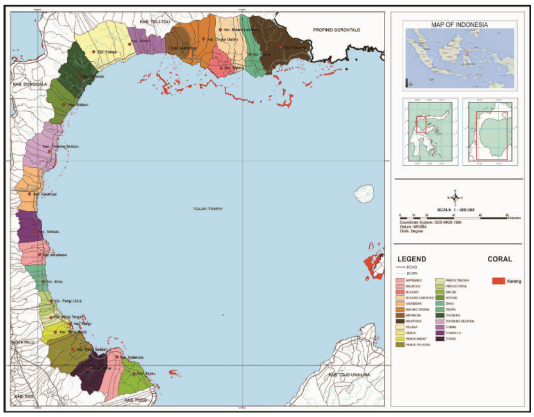

Figure 10. Waters substrate

Distribution of the coral reefs in the study site in the form of spots were separately to each other. Coral reefs in study site are generally within 2 to 20 m into the sea with a depth of 5 to 25 m (Sallata , 2007). Other studies in reasearch site have shown that the percentage of waters substrate i.e: (1) coral sandy 6% ; (2) 17% of the muddy sand; (3) sludge 8% ; (4) sand 14% ; (5) sludge coral 1%; (6) sandy mud 8% ; (7) rocky sand 1%; (8) rocky sand 15 % ; (9) coral 27%; and (10) sand seagrass 3% (BPPBAP Maros, 2011). One of the criteria for a suitable location for the seaweed *Kappaphycus alvarezii* cultivation, that have a waters substrate which dominated by coral rubble or sand (Glen and Dotty, 1990). In addition to the waters substrate, the overlay process also considers the mangrove areas; since mangroves are provide a physical habitat and nursery grounds for a wide variety of marine animals such as birds, reptiles, fish and mammals (Nagelkerken et al., 2008). Considering mangroves are highly critical and fragile ecosystems, therefor should be protected and conserved (Farnsworth & Ellison, 1997; Maguire et al., 2000).

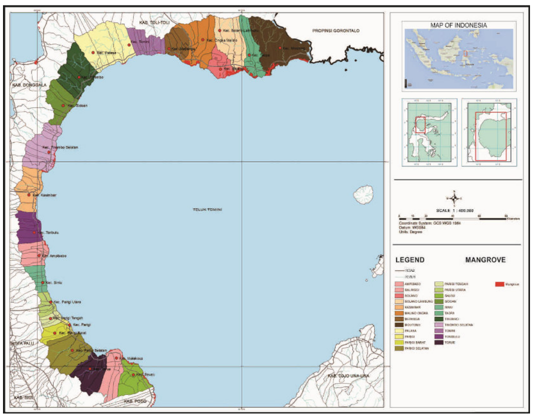

Figure 11. Mangrove areas

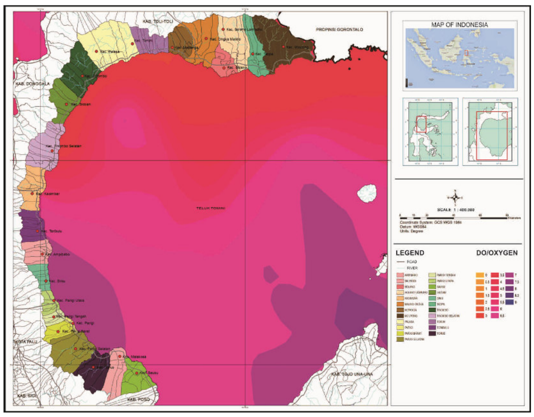

Figure 12. Dissolved oxygen concentration

Dissolved oxygen ranges from 4.5 to 8.0 mg/L. On site measurements of dissolved oxygen in Ogotion village ranged from 5.25 to 5.99 mg/L; Silampayang Village 5.25 to 5.99 mg/L , and Tumpapa Indah Village 5.12 to 5.68 mg/L. These results are consistent with research conducted by Sallata (2007) that also stated that the dissolved oxygen near water surface ranged from 6.8 to 7.3 with a mean of 6.9 mg/L. The results shown that dissolved oxygen content area suitable for seaweed *Kappaphycus alvarezii* cultivation.

The result of overlaying process of thematic maps can be seen in the image below.

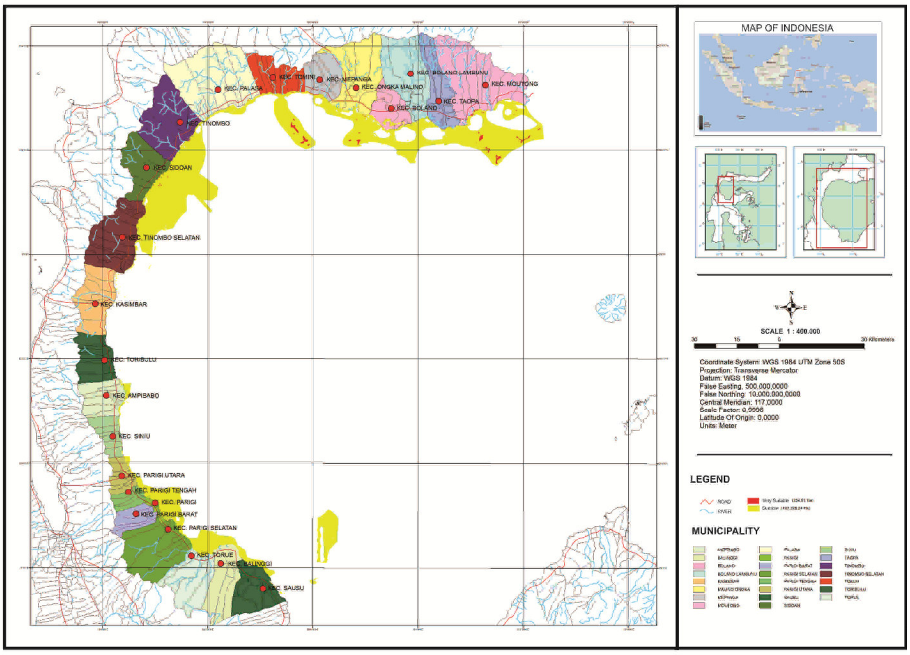

Figure 13. Land suitability for cultivation of seaweed *Kappaphycus alvarezii*

Overlaying results indicate the potential areas that suitable for the cultivation of seaweed *Kappaphycus alvarezii* of 192,581.15 ha, consisting of very suitable (S1) = 254.91 Ha, and suitable (S2) = 192,326.24 Ha. The results has shown that not all areas along the coastal line of Parigi Moutong District has the potential land that suitable for the cultivation of seaweed Kappaphycus alvarezii. The overlaying figure shown that the land is suitable for seaweed cultivation is concentrated in the north and the south, while in the middle tend is not appropriate suitable for seaweed *Kappaphycus alvarezii* cultivation.

Land suitability analysis using satellite images also shown that the GIS software can be used for various purposes. It is given that GIS has the ability to monitor large areas periodically. In addition, the use of GIS greatly simplify data processing with complex structures and large quantities (Nirmala et al., 2014). Using satellite image processing and GIS, particularly in high resolution, will produce quick information, also efficient and effective ways to the decision making process (Kafadar and Genc, 2015).

3.2 Waters Carrying Capacity

Seaweed farming of *Kappaphycus alvarezii* in the study site generally use the raft with long line method. Each raft measuring 50 x 50 m, that consist of polyethylene rope. However, the development of cultivation media often ignore the operational point for other uses. This condition has a big potential conflict in the use of coastal space. Therefore, calculation of land supporting for seaweed farming based on the approach to water capacity, using traditional shapes and sizes raft that regard several pathways for other uses such as shown in the figure below.

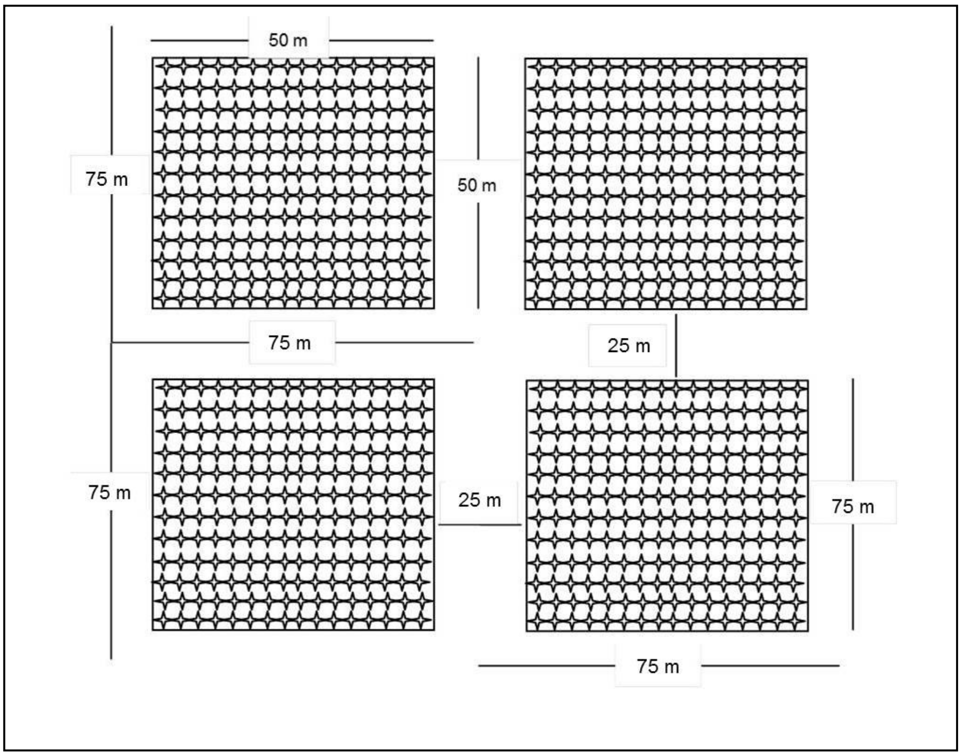

Figure 14. Shapes and sizes of raft for seaweed *Kappaphycus alvarezii* farming using long line

Based on the picture above, the waters carrying capacity as presented in Table 1 .

Table1. Analisys of waters carrying capacity

Parameters	Value	Unit
Suitable area for seaweed cultivation based on GIS	192,581.15	ha
Width of cultivation unit managed	50	m
Appropriate widht of cultivation unit	75	m
Length of cultivation unit managed	50	m
Appropriate length of cultivation unit	75	m
Waters capacity	55.56%	%
Waters carrying capacity	106,989.53	ha
Seaweed cultivation raft	190,204	raft

Table 1indicate that the waters carrying capacity for the cultivation of seaweed *Kappaphycus alvarezii* using rafts long line methods, of 106,989.53 hectares. This area if converted in the form of a raft of measures 50 x 50 m , will be 190,204 units. If the nursery for seaweed seedling is allocated 10% of the total area of cultivation , it will consist of : (1) 19,020 units of nurseries, and (2) 171,183 raft cultivation units.

3.3 Potential Volume of Raw Dried Seaweed

Furthermore, potential of seaweed farming production per raft unit as shown in Table 2 .

Table 2. Production ofraft cultivation unit

Parameters	Value	Unit
Length of rope spans	50	m
Widht of rope spans	50	m
Number of rope spans	48	pieces
Distance between the “tie-tie” ring ropes	0.25	m
Number of “tie-tie” ring ropes in every rope spans	200	pieces
Total amount of “tie-tie” ring ropes	9,600	pieces
Initial seedling weight	0.1	kg
Total amount of initial seedling weight	960	kg
Average daily growth(ADG)	3.5	%
Ammout of total harvest at days of culture - 45	4,362	kg
Conversion weight from wet to dry(1:8)	545	kg

Table 2 shown seaweed production carried out by the farmers at the study site. This is in line with the production of seaweed farming in other tropical regions (Munoz et al., 2004). Potential production of each raft of 4.362 kg/crop, assuming conversion of dry to wet weight is 1:8, there for, average production ofraw dried seaweed of 0.545 tons/raft/crop. Thus, the potential volume of raw dried seaweed *Kappaphycus alvarezii* in Parigi Moutong District of 93,194.14 tonnes/crop.

Potential volumes of raw dried seaweed can be a basic consideration for agribusiness management plan, particularly to the implementation of supply chain management (Lambert and Cooper, 2000). In order that seaweed agribusiness can be conducted in a sustainable things, policy makers should consider the involvement of others stakeholders. In addition, the strategy needs to be developed at the operational level to produce the raw materials with both innovation and intervention. It is no less important is the policy in the form of regulations to encourage the development of agribusiness seaweed (Van der Vorst et al., 2013).

4. Conclusion

Overlaying results indicate the potential areas that suitable for the cultivation of seaweed *Kappaphycus alvarezii* of 192,581.15 ha, consisting of very suitable (S1) = 254.91 Ha, and suitable (S2) = 192,326.24 Ha. Waters carrying capacity for the cultivation of seaweed *Kappaphycus alvarezii* using rafts long line methods, of 106,989.53 hectares. This area if converted in the form of a raft of measures 50 x 50 m , will be 190,204 units. If the nursery for seaweed seedling is allocated 10% of the total area of cultivation , it will consist of : (1) 19,020 units of nurseries, and (2) 171,183 raft cultivation units. Assuming average production of each raft of 0.545 tons/raft/crop, potential volume of raw dried seaweed *Kappaphycus alvarezii* in Parigi Moutong District of 93,194.14 tonnes/crop.

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