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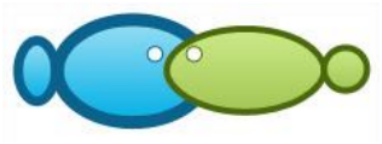

Seaweed (*Gracilaria* sp.) industry - exploring the dynamics of a developing industrial zone and declining bio-ecoregion support

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Abstract. Brebes Regency is the most prominent *Gracilaria* producing center on Java Island, Indonesia. This research aimed to analyze the current bio-ecoregion situation of *Gracilaria* supply in Brebes Regency as associated to the opportunity to link it to the Brebes Industrial Zone (KIB) development. The research method used is quantitative description. The research data used primary data and secondary data. Research was carried out from February 2020 to January 2021. The technique of taking respondents used purposive sampling. 30 respondents were selected. A bio-ecoregion of *Gracilaria* supply scenario was first outlined using a descriptive analysis, followed by a SWOT analysis. The data used for these analyses were primary and secondary data, including three bio-ecoregion elements (ecological, economic, and sociocultural aspects) and KIB related factors that can determine prospects of implementing the bio-ecoregional framework. Primary data were collected through interviews and secondary data were obtained from relevant published materials. The results showed that with unexpandable cultivation areas, the development of the *Gracilaria* industry in Brebes can benefit from ongoing KIB development only if it is sustained by supply from neighboring areas belonging to the same bio-ecoregion. The SWOT analysis showed that three strategies could be proposed: (1) encourage the development of a *Gracilaria* based industry by relying on the supply of raw materials produced in expanded bio-ecoregions; (2) this industry emphasizes the establishment of agar processing plants by optimizing the capacity of local economic players; (3) this industry is encouraged to bring up derivative industries based on *Gracilaria*.

Key Words: Brebes, government policy, regional development, sustainability, SWOT.

Introduction. Brebes Regency has the largest concentration of *Gracilaria* seaweed aquaculture on Java Island, Indonesia. People in Brebes have cultivated seaweed on the regency's northern coastal areas since 2006 (Priono et al 2012; Data and Information Center 2013). On these coastal areas, shrimp ponds in Randusanga Wetan, Randusanga Kulon, Prapag Lor and Prapag Kidul villages have been converted to *Gracilaria* ponds, either in monoculture or in mixed-culture involving and milkfish (*Chanos chanos*), and sometimes shrimp. In less than 10 years, *Gracilaria* related businesses emerged as important economic activities for the communities in Brebes. The Data and Information Center (2013) and the Brebes Fisheries Service (2018) reported that the total production of dried *Gracilaria* reached 62057 tons in 2017 (Pusdatin 2013), which was equivalent to a direct economic value of IDR 372 billion (26570 USD). This value did not include margins received by other related parties, such as cultivation labors, handling labors, transportation providers, etc. For cultivation and handling only, no less than 45 workers participate in the line processes equivalent to 1 ha of seaweed cultivation (Sugiyatno et al 2013). Considering the total potential of seaweed ponds of 12678 ha (Julianto & Badrudin 2014), *Gracilaria* related businesses contribute significantly in terms of money generation and employment.

Recently, a new opportunity has come that allowed the *Gracilaria* industry in Brebes to progress even further. This opportunity is the emerging Brebes Industrial Zone

(KIB) project, which includes *Gracilaria* industry. Brebes is designated as the third industrial zone in Central Java Province (Ministry of Law and Human Rights 2019). Within the framework of KIB, various new businesses based on *Gracilaria* will certainly have a chance to further develop. With respect to *Gracilaria*, processing factories and overseas shipping activities currently concentrated in West Java and East Java can be prospectively moved to Brebes KIB. In its design, KIB will cover an area of 3976 ha (Regional Planning Agency 2019), which is designated to accommodate various types of factories and business facilities. While *Gracilaria* businesses traditionally have a strong root among local economic players, establishing a *Gracilaria* processing plant and other associated business facilities is a big possibility.

However, given the limited pond area availability, the development of new or more varied businesses based on *Gracilaria* in Brebes will likely be limited by environmental or natural factors. These factors have recently been found to cause interruptions of supply of fresh *Gracilaria* to Brebes traders or middlemen. Drought or heavy rainfall, for example, occurred and caused too high or too low salinities (Riyaldi et al 2005; Lideman et al 2016), conditions which are not favorable for the growth of *Gracilaria* (Priono et al 2012). Other factors frequently reported are pollutants, poor pond maintenance, and tidal flooding (Julianto & Badrudin 2014). Facing this challenge, traders or middlemen in Brebes often have to rely on supply from neighboring regencies, like Kendal, Semarang and Indramayu (Anggadiredja et al 2006). Sometimes, traders or middlemen face severe shortages, which cause the proportion of supply from other regencies to reach 70% (Anggadiredja et al 2006). The coastal areas of these neighboring regencies have similar bio-ecoregional characteristics, but with varying local conditions, which cause their ability to cover this shortage to vary as well.

Considering the great opportunity for *Gracilaria* based industrial development by taking advantage of the existence of KIB on one hand and its consequences in terms of environmental challenges on the other hand, prescriptions regarding development in the coastal region become very relevant. Relevant prescriptions can be referred, for example, to Campell (1996), who emphasized that environmental aspects should receive particular attentions. Randolph (2004) and Bryant & Wilson (1998) stated that every development planning must address environmental aspects while considering community welfare. Meanwhile, in the Indonesian context, the ministry's Zoning Plan of Coastal Areas and Small Island must be considered, because it underlines sustainability and covers social, cultural, economic, and natural order aspects (Nurhayati & Purnomo 2018).

A development concept that emphasizes even more on both environmental and human aspects as mentioned above is bio-ecoregion-based development (Nurhayati & Purnomo 2017). This concept seems to fit best the case of Brebes *Gracilaria* seaweed industry, where an industrial zone is considered the development model where *Gracilaria* business players have encountered increasing environmental challenges. The development of seaweed industry in this regency will be benefit if it is linked to the KIB. Given the current condition, it should optimize the existing bio-ecoregion circumstances.

This research aimed to analyze the current bio-ecoregional situation of *Gracilaria* supply in Brebes Regency as associated to the opportunity to link it to the KIB development. The results of this research are expected to contribute to a robust scientific background necessary for the development of *Gracilaria* industry in Indonesia in general, and Brebes more specifically.

Material and Method

Research location. This research was conducted in Indramayu, Pekalongan, Berebes and Kendal Regency, Indonesia, from May to November 2020. This research followed the cross-sectional methodological approach (Arikunto & Suharsimi 2002).

Data source. The data used in these analyses were primary and secondary data, which included three bio-ecoregion elements, namely ecological, economic, and sociocultural components, and factors potentially determining prospects of implementing the bio-ecoregional framework. Primary data were collected through expert consultation and/or

interviews with respondents; meanwhile, secondary data were compiled through literature studies. Respondents were knowledgeable people selected purposively from local policy makers, agricultural extension workers, seaweed cultivators, seaweed collectors, seaweed processors or seaweed traders. The interview was structured after a set of interview guides and structured questionnaires. Data processing mainly included descriptive statistics.

SWOT analysis. Operationally, this approach was set forth in the following two stages of work. First, a bio-ecoregional *Gracilaria* supply development scenario was outlined using a descriptive analysis (Nurhayati & Purnomo 2018). Secondly, implementation strategies of this scenario within the KIB framework were analyzed using a SWOT analysis (Rangkuti 2001).

In this context, strengths are natural resources, the skill level of the workforce, or other advantages related to competitors, and the market needs of an organization. Strength relates to financial resources, image, market leadership, buyer/supplier relationships, and other factors (Pearce & Robinson 1991). Organizational strength consists of organizational competencies that play an active role in achieving organizational goals. Weakness represents aspects that are not owned or done by the organization, or with a poor performance compared to others; or in an adverse condition (Thompson & Strickland 1989). In this context, weakness is a limitation or deficiency in resources, skills and abilities that will hinder organizational performances, such as limited facilities, limited financial resources, limited management capabilities, limited marketing skills, and poorly designed brands (Pearce & Robinson 1991).

Summing up from references, the following descriptors were used: pond location, wind current, pond bottom, turbidity, pH, salinity, temperature, record of *Gracilaria* farming, precipitation, water quality as related to the level of pollution, pattern of human interaction with nature. The condition of each bio-ecoregional descriptor mentioned above reflects its capacity in shaping the prospects for the development of the *Gracilaria* aquaculture in the concerned location. Based on objective measurements made by the knowledgeable persons, each descriptor was given a scale associated with its suitability for *Gracilaria* cultivation. The scoring guide for the descriptors has been prepared similar to the one developed by Rohman et al (2018):

I. Pond location allows sufficient supply of sea water and fresh water in less than 6 months per year (1), in 6-8 month per year (2), throughout the year (3).

II. Strong winds that interfere with cultivation occur more than 7 months per year (1), 5-7 months per year (2), less than 5 months per year (3).

III. The bottom is composed of mud without sand (1), muddy sand with a thickness of less than 15 or more than 20 cm (2), muddy sand with a thickness of 15-20 cm.

IV. Brightness is less than 0.3 m (1), between 0.3 and 0.5 m (2), more than 0.5 m (3).

V. pH is less than 5.5 or more than 9.5 (1), between 5.5 and 6 or between 9 and 9.5 (2), between 6 and 9 (3).

VI. Salinity is less than 15 ppt or more than 25 ppt (1), between 12 and 15 or between 25 and 30 ppt (2), between 15 and 25 ppt (3).

VII. Temperature is less than 24 or more than 35°C (1), between 22 and 25°C or 33 and 35°C (2), between 26 and 33°C (3).

VIII. *Gracilaria* was cultivated no more than one year or more than one year, but it does not exist anymore (1), *Gracilaria* still grows in the pond, but it is not harvested/traded (2), *Gracilaria* is cultivated intensively and traded (3).

IX. Rainfall is below 2000 mm $year^{-1}$ (1), between 2000-3000 mm $year^{-1}$, with more than 3 dry months (2), 2000-3000 mm $year^{-1}$, with 2-3 dry months (3).

X. Pollution is severe and does not allow cultivation (1), pollution exists, but it is not too disturbing for the cultivation (2), no significant pollution (3).

XI. People are very unconcerned with nature/environmental health (1), people have awareness, but no real action exists (2), people have a high awareness, which is implemented in real actions (3).

XII. Current has a speed of less than 0.1 or more than 0.5 m s^{-1} (1), between 0.1 and 0.2 or 0.4 and 0.5 m s^{-1} (2), between 0.2 and 0.4 m s^{-1} (3).

Results and Discussion

Bio-ecoregional context of Gracilaria aquaculture in Brebes and neighboring areas. Brebes is a regency of Central Java with regional autonomy, covering a geographical area of 1662.90 km^2 (Data and Information Center 2013; Dinas PMPTSP 2018; Regional Planning Agency 2019). Brebes Regency is located at 6°44'-7°21'S latitude and 108°41'-109°11'E longitude. The coastline in the Brebes Regency region is 55 km long and the sea area 12 miles from the mainland reaches 1037 km^2. Topographically, the landscape of Brebes Regency varies from sea to mountains at altitudes between 1-2000 m above sea level. Beach borders along the north coast from Brebes District to Losari District have an area of 497 ha (Regional Planning Agency 2019). The supply of raw materials for *Gracilaria* related businesses in Brebes is currently dependent on neighboring areas (Regional Planning Agency 2019). It is likely that, in time, the locations of supply will expand to other neighboring coastal potential areas. Therefore, the following bio-ecoregional presentation will cover coastal locations of Indramayu, Brebes, Pemalang, Pekalongan, Kendal, Semarang, Jepara and Demak.

In this research, bio-ecoregional descriptors were used to group potential *Gracilaria* farming locations, which can be expected to secure the continuation of *Gracilaria* based industry in Brebes. These descriptors were derived from those suggested by Nurhayati & Purnomo (2017) and from studies regarding *Gracilaria* cultivation requirements (Priono et al 2012; Julianto & Badrudin 2014; Lideman et al 2016; Rohman et al 2018). According to Nurhayati et al (2016), the descriptors include aquaculture potential, demography, rainfall, salinity, geographical situation, and socio-economic aspects. According to Sugiarto et al (1978), Rohman et al (2018), Lideman et al (2016), and Anggadiredja et al (2006), the conditions for *Gracilaria* cultivation are location of ponds close to sources of sea and fresh water, protection of the pond area from strong wind currents, mainly sandy pond bottom with a thickness of 15-20 cm, low water turbidity for plants to receive sunlight, pH from 7-8.7, salinity from 15-25 ppt, and temperatures from 20-25°C. The suitability of locations for *Gracilaria* farming are presented in Table 1.

Thus, it can be seen that, despite similar bio-ecoregional characteristics, not all locations can be relied upon to supply *Gracilaria* to industries in Brebes. Some of these locations indicate one or more unfavourable local conditions. Locations such as Semarang, Pemalang, and Indramayu had 4 bad characteristics of the 12 descriptors observed. However, it should be noted that the condition of the bad descriptor in certain cases might still be improved, as exemplified by field notes provided by respondents; for example, regarding 'human-nature interaction', a number of respondents indicated that community awareness of the environment could be increased into concrete actions if there were certain interventions. This means that the capacity of the location as a supplier of *Gracilaria* for industries in Brebes can be improved.

Another important field note is that, based on the current practice, even locations with descriptors with low-scale values can apparently still supply *Gracilaria* to Brebes. These locations, for example, are Indramayu and Semarang, which have often been targeted by Brebes traders to cover supply shortages during local bad seasons. Despite higher operational costs, traders in Brebes can still benefit from bringing *Gracilaria* from these locations. Apart from transportation, the cost difference is usually due to the fact that traders have to do extra cleaning or drying for *Gracilaria* from farmers outside Brebes.

Table 1

The suitability of locations for *Gracilaria* farming based on the reading of the descriptors

Location	Descriptor											
	Pond location	*Wind current*	*Pond bottom*	*Turbidity*	*pH*	*Salinity*	*Temperature*	*Record of Gracilaria farming*	*Precipitation*	*Water quality (pollution)*	*Human-nature interaction*	*Water current*
Indramayu	3	2	2	2	2	1	3	1	2	2	1	1
Brebes Losari	2	3	3	2	3	3	3	3	2	2	2	2
Brebes Randusanga	3	2	2	2	3	3	2	3	2	2	3	3
Tegal	3	2	2	3	3	3	1	2	2	2	3	3
Pemalang	3	3	3	1	1	3	1	2	2	1	1	2
Pekalongan Siwalan	1	2	3	2	2	2	2	2	1	2	2	2
Pekalongan Wonokerto	3	2	2	2	3	3	3	3	1	2	3	2
Pekalongan Tirto	3	2	3	2	3	3	3	3	1	2	2	1
Pekalongan Kota	3	3	1	1	3	3	3	2	2	3	1	3
Kendal	2	1	1	2	1	2	3	2	2	2	3	2
Semarang	2	3	3	1	3	2	3	2	1	1	2	2
Demak	3	1	2	2	3	3	2	2	2	2	3	3
Jepara	3	2	2	3	3	3	1	2	2	2	3	3

Note: green - very suitable; blue - less suitable; red - not suitable.

Based on the situations described above, to guarantee *Gracilaria* supply from the expanded bio-ecoregion, a scenario can be applied based on prioritization of locations in the proposed expanded bio-ecoregion. Referring to the observations from Table 1, the locations of Brebes Losari, Brebes Randusanga, Tegal, Pekalongan Wonokerto, Pekalongan Siwalan, Pekalongan Tirto, Demak and Jepara can be classified as priority locations. Other locations, namely Indramayu, Tegal, Pekalongan City, Pekalongan Siwalan Kendal, and Semarang are classified as backup locations. According to traders, *Gracilaria* at these locations is of acceptable quality. In certain cases, the poor quality is due to imperfect handling, owing to skill variation between locations. Figure 1 shows the bio-ecoregional scenario of *Gracilaria* production that can be made available for sustaining *Gracilaria* based industries in Brebes.

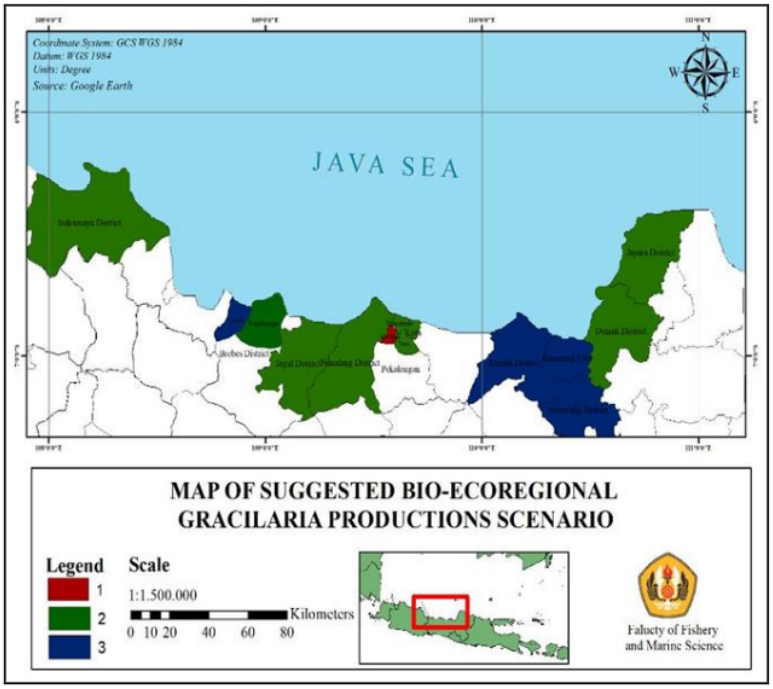

Figure 1. Suggested bio-ecoregional *Gracilaria* production scenario; priority locations are marked with green, anchor locations with blue, and not recommended locations with red.

Industrial context of Brebes Gracilaria and the relevance of its integration to the KIB. Based on the Regency Regulation No. 2 of 2011 concerning the Brebes Spatial Planning 2010–2030 (Government of Brebes Regency 2011; Government of Central Java Province 2016), Brebes Regency is spatially divided into protected areas and cultivation areas. By definition, protected areas are those allocated to preserve the environment, including natural and artificial resources. Meanwhile, cultivation areas are those assigned for production, taking into account conditions and potential of natural, human, and artificial resources. Among the cultivation areas are aquaculture areas, which are divided into brackish water aquaculture ponds and freshwater aquaculture ponds. Brackish water aquaculture ponds with the size of 12748 ha are located along the northern coast, covering 5 coastal districts (Government of Brebes Regency 2011). Based on the contribution to the regency's total *Gracilaria* production, among available brackish water aquaculture areas in Brebes Regency, *Gracilaria* ponds in the Sub-districts of Brebes and Losari are the most important ones.

The currently prepared KIB project in this regency opens opportunities for massive industrial development, including *Gracilaria* based industries. Based on existing documents (Government of Brebes Regency 2011; Ministry of Law and Human Rights 2019), three districts, namely Losari, Tanjung, and Bulakamba are projected to be the centers of economic growth for Brebes Regency. Relevant physical and social infrastructure will be built in this district in line with the KIB design. In the KIB design, other areas are considered buffer areas, including *Gracilaria* cultivation locations in Randusanga Village of Brebes Sub-district. This village accounts for 77% of *Gracilaria* production in Brebes Regency (Caroline 2009; Government of Central Java Province 2016; Dinas PMPTSP 2018).

Currently, the *Gracilaria* industry in Brebes is only limited to the activities of cultivation, harvesting, simple handling (drying and cleaning), packing and shipping to agar-processing plants (Anggadiredja et al 2006). Cultivation activities are carried out by farmers independently or in collaboration with middlemen/traders, in which case the activities are more focused on post-harvest handling. Post-harvest handling carried out by middlemen and traders is intended to meet the quality criteria set by the buyers, in this case the agar-processing factories. Two quality criteria are commonly applied, namely water content and cleanliness (Buschmann et al 1994; Craigie 2011; Lideman et al 2014). Based on these quality criteria, the agar processing plant determines whether *Gracilaria* sent by traders is classified as Grade 1, Grade 2, Grade 3, Grade 4 or rejected.

Regarding industrial practices in Brebes, there are a number of problems constraining the development of the *Gracilaria* industry. The problem is generally rooted in the dependence of Brebes traders on processing factories that are located at long distances, across provinces, namely West Java and East Java. The distance of these factories causes high shipping costs and reduces the chances of traders to get motivational margins. Furthermore, quality assessments practiced by factories also often reduce the potential profitability of traders. For example, *Gracilaria* that traders believe is classified as a certain grade is rated a grade below by the factory. In this regard, traders anticipate it by raising their product's quality standards, for example by drying longer or cleaning more thoroughly, which, subsequently, adds to the cost for traders. Other problems are related to shipping quotas; taking into account their internal financial calculations, processing plants often unilaterally impose restrictions on the volume of shipments for traders, causing traders to incur losses related to extra storage costs.

A plausible option (an opportunity to overcome these problems) is the establishment of agar processing plants in KIB, which can accommodate *Gracilaria* products from local farmers and from other regions within the same bio-ecoregion coverage. Referring to the existing legal document (Ministry of Law and Human Rights 2019), the KIB is generally planned to mobilize investments in a predetermined industrial complex, resulting in high economic growth, not only in Brebes, but also in two neighboring regencies, namely Tegal and Pemalang (the Bregasmalang Area), and the wider regional and national economies. As one of the national strategic projects (PSN), there will be massive capital investments in the region, both from the province and from the state government. In the three districts, many companies representing various sectors have registered or are in the process of licensing, and many investors have already set up factories. *Gracilaria* processing plants at KIB will have several advantages compared to factories in West Java and East Java. Among these advantages are the relatively low district minimum wage of only 128.7 USD per month, a strategic location because it is on the Trans Java Highway crossing, and the easy access to Cirebon's PLB logistic center.

Apart from the positive aspects that support the development of the processing industry in Brebes, there are also a number of challenges. Among those challenges is the absence of a record of significant *Gracilaria* local processing activities. The only activities observed through this research were sporadic household activities that process *Gracilaria* into traditional snacks. The introduction of *Gracilaria* processing equipment had run for some time but did not continue due to the scale of economy. However, these introductory efforts and a number of other intervention trials also provide lessons aimed at improving businesses and economic performances of economic agents in Brebes.

Another challenge that needs to be anticipated is policy consistency. As a result of the Covid-19 outbreak that occurred in 2020, the budget of a number of national government programs was abolished and allocated to other fields. KIB is only one of many priority programs (Ministry of Law and Human Rights 2019). Meanwhile, the need for funds to overcome the direct and indirect impacts of the outbreak is enormous. Traditionally, large programs including the development of industrial zones such as KIB are vulnerable and dispensable (from an authority perspective), the funding being used for other purposes.

Strategy formulation for implementing bio-ecoregion arrangement for Gracilaria based industry in the KIB. With the consideration of bio-ecoregional supply scenarios and industrial context as discussed above, the following analysis is intended to identify an implementation strategy for these scenarios. Both bio-ecoregion and KIB design must work according to their respective goals, and run in harmony, to avoid disturbances. Based on the bio-ecoregion condition and the existing design of KIB development as presented above, a proposed concept that combines the two was established. Summing up the information and analysis presented above, Tables 2 and 3 show the SWOT matrices intended to develop strategies relevant to this purpose.

Table 2

Internal factor matrix

Strength (S)	*Weight*	*Rate*	*Score*
Potential supply of *Gracilaria* from expanded bio-ecoregion	0.35	4	1.4
Knowledge of farmers on bio-ecoregion factors	0.10	2	0.2
Capacity of local economic players to adjust to policy interventions	0.10	3	0.3
Relatively acceptable quality of *Gracilaria* from expanded bio-ecoregion	0.25	4	1
Warehouses availability that can accommodate higher *Gracilaria* production	0.20	3	0.6
Total	1.00		3.5
Weakness (W)			
All regions do not have the same access to production inputs	0.25	4	1
Variation of cultivation skills of farmers between regions	0.20	2	0.4
Variation in *Gracilaria* production record between locations among bio-ecoregion	0.22	3	0.66
No record of local *Gracilaria* processing	0.18	2	0.36
Dependent on current *Gracilaria* processors from other provinces	0.15	1	0.15
Total	1.00		2.57

Table 3

External factor matrix

Opportunity (O)	*Weight*	*Rate*	*Score*
Many have recommended *Gracilaria* accommodated in Brebes Industrial Zone	0.25	4	1
Bio-ecoregion scenario which includes processing centers will promote better price	0.10	3	0.3
Bio-ecoregion based industrial zone will trigger other seaweed-based industries	0.25	3	0.75
Acceptance of bio-ecoregion regulation by local officials	0.20	2	0.4
Sub-optimal condition of *Gracilaria* business will promote openness for improvement	0.20	2	0.4
Total	1.00		2.85
Threat (T)			
Seasonal variability	0.31	4	1.24
Changing development priority in transportation from and to regions	0.15	2	0.3
Inconsistency in planning implementation	0.12	3	0.36
Limited financial support	0.22	1	0.22
Possible changes of official attention to competing commodity (shallot)	0.20	2	0.4
Total	1.00		2.52

Based on the results of the internal and external factors analysis (Tables 2 and 3), four strategy options were identified (Table 4). Alternative strategies come with their respective ranks, based on which it can be concluded that the best strategy is the expansive strategy (Table 4).

Table 4

Ranks of alternative strategies

Quadrant	*Point positions*	*Matrix area*	*Rank*	*Strategy*
I (S-O)	(3.50;2.85)	9.98	1	Expansive
II (W-O)	(2.57;2.85)	7.32	3	Turn around
III (W-T)	(2.57;2.52)	6.48	4	Defensive
IV (S-T)	(3.50;2.52)	8.82	2	Diversification

Note: S - strengths; W - weaknesses; O - opportunities; T - threats.

Referring to the total values of internal and external factors, both positive, the best strategy is considered feasible. In Figure 2, the resultant coordinate position of these factors is denoted by Point A (0.93; 0.33).

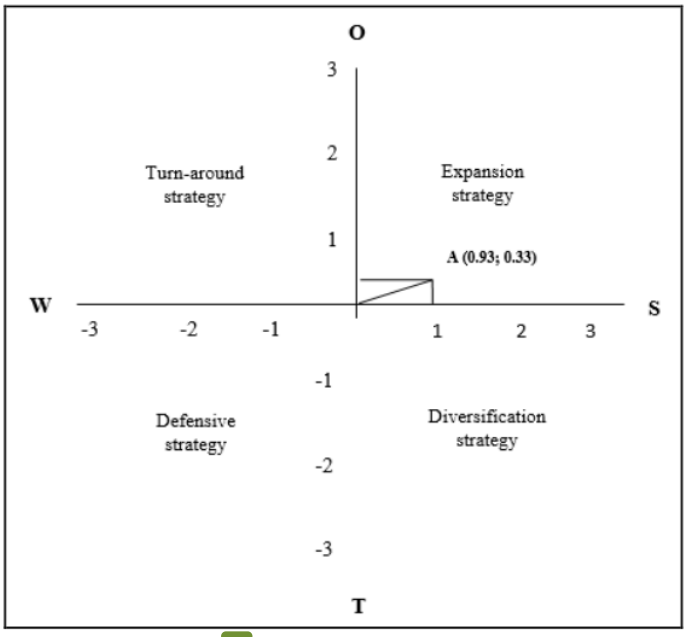

Figure 2. Strategy map; O - opportunities; S - strengths; W - weaknesses; T - threats.

Summing up the results of the best strategy determination and strength and opportunity factors identification, two strategies are worth considering. These strategies are:

1. Encourage the development of a *Gracilaria* based industry by relying on the supply of raw materials (*Gracilaria*) produced in expanded bio-ecoregions.

2. This industry emphasizes the establishment of agar processing plants by optimizing the capacity of local economic players.

This industry is also encouraged to bring up derivative industries based on *Gracilaria*. To implement these strategies, there are a number of detailed plans that cover 6 elements. The six elements are customer, actor, transformation, worldview, owner and environment. Table 5 displays detailed information and policy scenarios for the six elements.

Table 5

Policy scenarios designed for six relevant elements

No.	Element	Information	Policy Scenario
1	C (*Costumer*)	• KIB • *Gracilaria* processing prospective investors	
2	A (*Actor*)	• Brebes Regency Government • Brebes Regency Fisheries Service Office • Fisheries extension worker • Ministry of Maritime Affairs and Fisheries • Central Java Provincial Government • *Gracilaria* cultivators and traders	• Government focuses on 5 aspects: institutional developments, legal frameworks, assessments, proportion/campaign, and coordination
3	T (*Transformation*)	• Procurement of facilities and infrastructure for *Gracilaria* based industry • Preparing people and ponds for *Gracilaria* cultivation in expanded bio-ecoregional locations • Preparing business plan for *Gracilaria* processing factory and other related business in the KIB • Campaigning the prospect of *Gracilaria* based industry in the KIB • Assuring the availability of relevant inputs and capital	• Private sector investment is the key to the development of *Gracilaria* industry in Brebes Regency
4	W (*World-View*)	• The Brebes Regency Government and all relevant market players must understand policies in the development of *Gracilaria* based industrial development and work together in implementing the plans	• Improving the livelihood of cultivators, traders and processors and the economy of Brebes and its surrounding region, more specifically the Bregasmalang Area, which covers Brebes, Tegal, Pemalang regencies
5	O (*Owner*)	• Brebes Regency Government • Brebes Regency Fisheries Service Office • Ministry of Maritime Affairs and Fisheries • Central Java Provincial Government	• Empowerment through knowledge management about *Gracilaria* based industrial development, which integrate KIB design and expanded bio-ecoregion
6	E (*Environment*)	• The dynamics of expanded bio-ecoregion locations and the KIB development	• Sustainable and equitable regional economy which is based on *Gracilaria* industrial development

Conclusions. For Brebes Regency, the ongoing development of the planned Brebes Industrial Zone (KIB) certainly opens a great opportunity to improve the condition of the existing *Gracilaria* industry, as well as the economies of the regency and surrounding areas. The efforts that can be made to realize this opportunity is to place a *Gracilaria* processing plant in KIB. There is indeed a big challenge to make these efforts, namely the limitations of the existing cultivation area, which is estimated to be insufficient to supply raw materials if the processing plant will actually be realized. This condition can be analogue to the surfing between developing the industry on one hand and facing the limited bio-ecoregion support on the other. However, this study suggests that there is an opportunity to address this limitation by introducing an approach called an extended bio-ecoregion. With this approach, locations with the same bio-ecoregional characteristics (the farming suitability parameters) are treated as additional raw material supply areas, integrated with the current supply area.

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Conflict of Interest. The authors declare that there is no conflict of interest.

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