Jurnal Teknologi Perikanan dan Kelautan
Vol. 17 No. 1, February 2026: 104-113
ISSN: 2087-4871
EISSN: 2549-3841
DOI: https://doi.org/10.24319/jtpk.17.104-113

POLICY ANALYSIS OF SEAWEED FARMING DEVELOPMENT (*Eucheuma cottonii*) IN WAKATOBI

ANALISIS KEBIJAKAN PENGEMBANGAN BUDIDAYA RUMPUT LAUT (*Eucheuma cottonii*) di WAKATOBI

Sutaman[1*], Alin Fithor[2], Heru Kurniawan Alamsyah[3], Kusnandar[3]
[1]Aquaculture Department, Faculty of Fisheries and Marine Science, Universitas Pancasakti Tegal, Halmahera km 01, Mintaragen, East Tegal 52121, Indonesia
[2]Coastal Resources Management, Research Center of Hydrodynamic Technology, National Research and Innovation Agency-BRIN, Grafika Sekip 2, Mlati, Sleman, Yogyakarta 55284, Indonesia
[3]Aquatic Resources Management, Faculty of Fisheries and Marine Science, Universitas Pancasakti Tegal, Halmahera km 01, Mintaragen, East Tegal 52121, Indonesia
*Corresponding author: sutaman@upstegal.ac.id

(Received July 15, 2025; Revised January 13, 2026; Accepted February 18, 2026)

ABSTRACT

Seaweed is an important commodity with high economic value and significant benefits for human life. Besides being a food ingredient, seaweed is also a raw material for the pharmaceutical, cosmetics, and other industries, thereby increasing demand for it both domestically and for export. In 2021, Indonesia's export volume was 225,000 tons, while China's, Indonesia's main competitor, was 148,306.9 tons. Indonesia is the second-largest seaweed exporter after China, with HS codes 121221 (for human consumption) and 121229 (for industrial use). The purpose of this study was to analyze the policy for the development of seaweed (*Eucheuma cottonii*) farming in the Wakatobi conservation area. Data used in this study were collected through structured interviews, direct observations of seaweed farming activities and the surrounding environment, and the farming community. The method used in this study was a SWOT analysis. The results of this study explain that seaweed farming in Wakatobi is profitable but still requires significant support from various parties.

Keywords: export, seaweed, SWOT analysis

ABSTRAK

Rumput laut merupakan komoditas penting yang memiliki nilai ekonomi yang cukup tinggi dan manfaat yang sangat besar bagi kehidupan manusia. Selain sebagai bahan pangan, rumput laut juga sebagai bahan baku dalam industri farmasi, kosmetik, dan industri lainnya, sehingga kebutuhan pemanfaatan rumput laut semakin meningkat, baik untuk konsumsi dalam negeri maupun untuk permintaan ekspor. Pada tahun 2021, volume ekspor Indonesia sebanyak 225 ribu ton, sedangkan volume ekspor Cina sebagai pesaing utama Indonesia sebanyak 148.306,9 ton. Indonesia merupakan negara pengekspor rumput laut terbesar kedua setelah Cina, dengan kode HS 121221 (untuk konsumsi manusia) dan 121229 (untuk pemanfaatan industri). Tujuan penelitian ini adalah untuk menganalisis strategi kebijakan pengembangan budidaya rumput laut (*Eucheuma cottonii*) di kawasan konservasi Wakatobi. Data yang digunakan dalam penelitian ini dikumpulkan melalui wawancara dengan bantuan kuesioner terstruktur dan melakukan observasi terhadap usaha budidaya rumput laut, lingkungan, dan masyarakat pembudidaya. Metode analisis yang digunakan dalam penelitian ini adalah analisis SWOT. Hasil yang diperoleh dalam penelitian ini menjelaskan bahwa budidaya rumput laut di Wakatobi menguntungkan, namun masih memerlukan banyak dukungan dari berbagai pihak.

Kata kunci: analisis SWOT, ekspor, rumput laut

INTRODUCTION

Seaweed is a type of plant found in coastal and marine areas. Usually, seaweed is used as a dessert, such as a pudding mix or seaweed candy, and is even processed into a very popular snack, a wide, very thin sheet. Therefore, seaweed is also often processed into various basic food ingredients, making it a target for culinary lovers (Gorr-Pozzi *et al.* 2023; Wagey *et al.* 2020). Indonesian seaweed is known for its good quality and is in great demand by the industry because it contains a fairly high source of carrageenan, agar-agar, and alginate, and is suitable for use as a raw material for the food industry, flavor softener, ice cream crystallization inhibitor, and medicine (Farias *et al.* 2023; Kanishchev *et al.* 2022). In 2020, Indonesia produced 9 million tons of seaweed, of which 195 thousand tons were exported (Wagey *et al.* 2020; Weinberger *et al.* 2021). Seaweed exports in 2020 were 65% raw, while processed seaweed accounted for 35%, split between semi-refined carrageenan powder, agar-agar, and refined carrageenan.

Indonesia is the world's number one producer of *Eucheuma cottonii* seaweed and controls more than 80 percent of the world's supply, and has succeeded in developing it with tissue culture technology (Chlomoudis *et al.* 2024; Bennett *et al.* 2021). In 2021, Indonesia's export volume was 225 thousand tons, while China's export volume, as Indonesia's main competitor, was 148,306.9 tons. Indonesia is the second largest seaweed exporter with HS codes 121221 (for human consumption) and 121229 (industrial use) (Sarinastiti and Wicaksono 2020). Although seaweed is a strategic commodity with high economic value and Indonesia is a major global exporter, most previous research has focused on production, export volume, and macroeconomic potential. Studies integrating seaweed farming development policies within conservation areas are relatively limited. The welfare, adaptive capacity, and economic resilience of coastal communities in seaweed farming in conservation areas have not been explored in depth.

Seaweed farming is one of the fastest-growing businesses in Indonesia. This business is generally carried out by fishermen or farmers who have fairly large land or coastal areas (Frohlich *et al.* 2023). This seaweed farming business can be carried out traditionally or modernly, depending on the level of technology and capital owned.

In the seaweed farming business system, business actors must also pay attention to environmental sustainability aspects in farming management in order to maintain productivity and environmental quality. Business actors can also utilize technology and innovation in business management, such as the use of business management information systems, waste management, and energy management to optimize business productivity and efficiency (Dimick *et al.* 2025). This study aims to analyze the policy for the development of seaweed (*Eucheuma cottonii*) farming in the Wakatobi conservation area.

METHODS

Location and time of research

This research was conducted in the Wakatobi Conservation Area from January 1, 2025, to February 20, 2025. Furthermore, the collected data were processed using purposive sampling (Table 1) and then analyzed using a descriptive approach and success indicators.

Table 1. Sampling criteria and characteristics of research respondents (purposive sampling).

Amount Respondent	Jobdesk of Respondent	Sampling Criteria (Purposive)	Reason for Selection
15	Fishpond Business Owner	• Fishpond business operates in the culinary sector • Operating for > 3 years • Experienced a > 30% decrease in turnover during the pandemic	The owner is most familiar with the direct impact and strategies implemented
35	Employee/Manager	• Working for >1 year • Directly involved in daily operations/marketing	Understands the technical details of operational changes in the field
50	Loyal Customer	• Has purchased before and during the pandemic	Understands changes in behavior patterns and service quality
100	Respondent		

Source: Research analysis (2025)

Data analysis

The data used in this study are the results of interviews with the help of structured questionnaires and observations regarding seaweed farming efforts, the environment, and farming communities. The methods used in this study were SWOT analysis and an analysis of business income using the RC ratio. SWOT analysis (table) is carried out to obtain an overview of the problems that occur so that the right strategy can be found in business development efforts that affect the socio-economics of farmers (Khan *et al.* 2024; Wirahayu *et al.* 2019).

Seaweed farming methods

In general, seaweed farming methods refer to the position of the plants in relation to the bottom of the water. Basically, this method is the same as the off-bottom method; only the position of the floating plants on the surface follows the tidal movement (Wang *et al.* 2025). To keep the raft from drifting, a ballast of stone or anchor is used, and for efficiency, several rafts can be made into one line, and each raft is given a distance of 1 m to facilitate maintenance. The seeds are tied to a plastic rope and/or to each knot of the net that has been stretched on the raft, with a size ranging from 100–150 g/bunch. There are three farming methods commonly used by people in Indonesia for seaweed, namely:

a. Bottom method
   Planting with this method is done by tying the cut plant seeds to coral or cement blocks and then spreading them on the bottom of the water. The basic method is a method of farming seaweed using seeds with a certain weight.
b. Off-bottom method
   This method can be done on the bottom of the waters consisting of sand, so it is easy to stick stake. The method is difficult to do on the bottom of the waters that are rocky with seeds tied with raffia rope, which is then tied to a plastic rope that is stretched on a wooden or bamboo stake. The distance between the bottom of the water and the seeds to be planted ranges from 20 to 30 cm. The seeds to be planted are 100–150 g in size, with a planting distance of 20–25 cm. Planting can also be done with a net measuring 2.5×5 m^2 with a mesh width of 25–30 cm and stretched on the stake, then the seaweed seeds are tied to the knots.
c. Floating/longline method
   The method is suitable for waters with rocky and wavy bottoms. Planting uses bamboo/rope rafts (rope ris), with the size of each raft varying depending on the availability of materials, but generally a size of 2.5×5 m^2 is used to facilitate maintenance.

RESULTS AND DISCUSSION

Overview location

Wakatobi Regency is a division of Buton Regency under the constitution of the Republic of Indonesia, number 29 of 2003, dated 18 December 2003. Wakatobi Regency is a district in Southeast Sulawesi Province, with the capital city located on Wangi-Wangi Island. The total area of Wakatobi Regency is 19,200 km^2, consisting of 823 km^2 of land (around 3%) and 18,377 km^2 of water (97%). Wakatobi is also the name of a national park area established in 1996, with a total area of 1.39 million hectares, concerning marine biodiversity, scale, and condition of coral, which occupies one of the priority positions, the highest level of marine conservation in Indonesia.

When it was first formed, Wakatobi only consisted of five sub-districts, namely Wangi-Wangi District, South Wangi District, Kaledupa District, Tomia District, and Binongko District. In 2005, through the Regional Regulation of Wakatobi Regency Number 19 of 2005, the South Kaledupa District was formed, and through the District Regional Regulation of Wakatobi Regency Number 20 of 2005, was formed in the East Tomia District. In 2007, through the Regional Regulation of Wakatobi Regency Number 41 of 2007, the Togo district was established, bringing the number of districts in Wakatobi Regency to 8. Divided into 100 villages and sub-districts (25 sub-districts and 75 villages). Policy reference amendment in the Indonesian policy.

Overall, the assessment results indicate that the non-technical conditions of seaweed farming in Wakatobi are considered good (average score of 3.1). Compared with previous conditions, there have been significant improvements in community interest, accessibility, and gender roles. However, several aspects still need to be strengthened, particularly the availability of superior seeds, the development of processing facilities, and price stability and marketing institutions. Improving institutional capacity and supporting local government policies are key to achieving sustainable and highly competitive seaweed farming (Table 2).

Table 2. Quantification score of non-technical parameters for seaweed farming in Wakatobi Regency.

No	Non-Technical Parameters	Quantification (Score)	Information
1	Land Status (Water)	3	Still in the local utilization zone of Wakatobi National Park (TN), its utilization must be with a Memorandum of Understanding (MoU).
2	Accessibility	3	The location can be reached by sea and land routes, although departure and arrival times for sea routes are limited.
3	Environmental Conditions	3	The water quality is supportive, but in some locations, there is still coral excavation for building sand, and it is close to the residents' sea transportation routes.
4	Availability of Labor	3	Quite available, because most of them are seaweed farmers and fishermen.
5	Public Interest	4	Very interested in farming seaweed but still needs guidance from the department
6	Seed Source	2	Some farmers can grow their own seeds, but sometimes they still experience difficulties, especially in certain seasons.
7	Warehouse and Processing Plant	3	Currently, farmers can still cope with storing dried seaweed before selling it to agents, but if there is an increase in production, a warehouse and processing plant will be needed.
8	Institutional	3	The existing institutions in Wakatobi Regency are sufficient to support the development of sustainable farming, but there needs to be guidance from related agencies.
9	Marketing	3	There are local agents available who can accommodate and purchase dry seaweed production from farmers, but prices are still fluctuating.
10	Gender Engagement	4	All family members (husband, wife, and children) play a very important role in seaweed farming efforts.
	Total Value	**31**	**-**
	Average Value	**3.1**	**Good**

Source: Field analysis (2025)

Non-technical aspects are crucial factors in determining the sustainability of seaweed farming activities, particularly those related to the social, economic, and institutional conditions of coastal communities. Based on the assessment of ten non-technical parameters, a total score of 31 was obtained with an average score of 3.1, which is categorized as good.

Technical criteria and land suitability analysis

The success and sustainability of seaweed farming are largely determined by both technical and non-technical factors. The sustainability of marine farming businesses/ activities, especially seaweed, is largely determined by technical factors as well as non-technical factors (Dragani *et al.* 2021).

Integrated upstream-downstream seaweed farming development system

The development of integrated seaweed farming from upstream to downstream is one of the planned and measurable efforts to increase production and increase community income. This system will further ensure the availability of quality seed sources through tissue culture, which are expected to be suppliers of seeds in the seed gardens that will be developed. With the availability of seed gardens, the need for seaweed farmers' seeds will not experience obstacles, both in quantity and quality, so that production will increase (Narwal *et al.* 2024). The abundance of seaweed farming production is the main source of seaweed raw materials for seaweed processing manufacturers, which, in turn, facilitates marketing and price stability at the farmers' level (Blok *et al.* 2023; Mandela *et al.* 2021).

SWOT analysis

Based on the alternative strategies developed through the relationship between internal and external factors of the SWOT matrix, there are strategies that are prioritized in seaweed farming in Wakatobi Regency. The assessment is carried out by considering the

scores obtained from each alternative strategy. The higher the score obtained, the higher the priority of the strategy as shown in Table 3.

Based on the results of the SWOT analysis of seaweed farming development in Wakatobi Regency (Yuliastuti *et al.* 2023), 19 alternative strategies were obtained by considering internal and external factors and the relationship between factors.

IE evaluation matrix (internal, external)

The internal-external matrix is used to determine the position of seaweed farming development in Wakatobi Regency based on a combination of IFE and EFE matrices in 9 cells. This matrix consists of 2 dimensions, namely the total score of the IFE matrix on the x-axis and the EFE matrix on the y-axis. Based on the results of the IFE and EFE table calculations, the IFE value is 3.67, and the EFE value is 3.35, as shown in Table 4.

Both of these values, when entered into the IE matrix diagram, are located in quadrant i. Quadrant i means that the development of seaweed farming in Wakatobi Regency is entering the growth and build phase, namely growing and building. The strategies that can be carried out in this phase are intensive strategies or integrative strategies. Intensive strategies are carried out by market penetration by minimizing production costs in order to increase profits, market development, and product development through the diversification of seaweed farming results (Chlomoudis *et al.* 2024; Dewi and Kurniati 2022).

Discussion

Wakatobi Regency is an archipelago that stretches southeast of Sulawesi. The land area of Wakatobi Regency is estimated to be ± 823 km², while the water area, the sea area, is estimated to be ± 18,377.31 km², almost 96% of its area is water. The water area generally has a limestone-based substrate (former dead coral) and sand so that the water environment is very clean and has low turbidity.

As a marine national park area, which is also an area with very high coral diversity, its aquatic ecosystem is relatively stable. Although this area is protected, the government still provides local utilization zones that can be accessed by the community to improve their welfare (Buchori *et al.* 2018; Mutia 2020). Meanwhile, if seen from the potential of farming land, there is still quite a large area of land that has not been utilized. As a marine national park area, which is also an area with very high coral diversity, its aquatic ecosystem is relatively stable. Although this area is protected, the government still provides local utilization zones that can be accessed by the community to improve their welfare. Meanwhile, if seen from the potential of farming land, there is still quite a large area of land that has not been utilized.

As a protected area, Wakatobi National Park still provides access to seaweed farmers in the area. Granting access must be based on a cooperation agreement between the farmer and the national park manager (Pratiwi *et al.* 2022; Priadi *et al.* 2024). The strength of the Wakatobi waters is that, ecologically, the waters are very suitable for the development of seaweed farming (Apriliyanti *et al.* 2019). This is also supported by the potential of land that is still available. As a national park area, the area is protected from fishing activities (Yanfika *et al.* 2020).

The weakness of the farmers is the use of ropes for farming, using poor-quality rope materials so that the ropes for farming are easily damaged, when the planting season starts, the community breeds the seeds first, so that a month is used for seed propagation (Mandela *et al.* 2021; Tegar and Gurning 2018). This is due to the lack of capital to buy seeds in large quantities. Often, farmers bring in seeds from outside the district. The grass harvested in Wakatobi is marketed either through collectors near the farming area, in Bau-Bau, or in Makassar. Thus, the opportunity in the market for seaweed commodities is still wide open. If we look at the available land in this area, it still has potential to be developed, as 1,570.98 ha remain undeveloped. The harvest of seaweed from Wakatobi is marketed either through collectors near the farming location, in Bau-Bau, or in Makassar (Rahmaningsih 2017). Thus, the opportunity in the market for seaweed commodities is still wide open. If seen from the potential of the available land in this area, the land still has potential to be developed because there are still 1,570.98 ha that have not been utilized.

In relation to the climate that occurs in Wakatobi, the waters are influenced by the west and east seasons, where during the west season, the water mass comes from the Flores Sea, which is relatively warm and less clean, so that it is not suitable for farming, and many farming activities are stopped (Kalagy *et al.* 2025; Meyer *et al.* 2025). During the east season, the water mass comes from the Banda Sea and has a relatively cold temperature, which is very suitable for the development of seaweed farming, so that in seaweed farming

in Wakatobi, the planting season is only six months in one year. Meanwhile, another obstacle that must be faced by farmers is the scarcity of seeds at the beginning of the planting season. Another threat that arises is that, in general, the land for drying seaweed harvests is very limited, so that if the rainy season occurs, the seaweed takes a long time to dry. Although seaweed is recognized as a strategic commodity with high economic value and Indonesia plays a significant role as a global exporter, existing studies have predominantly concentrated on production performance, export volumes, and macroeconomic contributions. Consequently, research that integrates seaweed farming development policies within conservation areas remains limited. In particular, the welfare conditions, adaptive capacity, and economic resilience of coastal communities engaged in seaweed farming in conservation areas have not yet been examined comprehensively (Innocenti 2025).

Table 3. SWOT Matrix and development strategy formulation for seaweed farming in Wakatobi Regency.

Internal Factor	**Strength**	**Weakness**
	The strategic factors that contribute to the development of seaweed farming in Wakatobi Regency include the following: 1. It has a fairly large land potential and supports the development of seaweed farming. 2. Community motivation for seaweed farming is high. 3. The number of seaweed farmers' human resources is sufficient. 4. Institutionally (pokdakan), it is very adequate for the development of seaweed farming. 5. Seaweed farming has great prospects because it is easy to adapt to the environment and grows quickly. 6. Seaweed farming technology is easy for the community to master. 7. Seaweed farming facilities and infrastructure are adequate.	Strategic factors that are weaknesses in seaweed farming in Wakatobi Regency include the following: 1. The quality of rope for seaweed farming is still low. 2. The utilization rate is still low. 3. There is no processing center for superior seaweed products yet. 4. The availability of seaweed seeds in terms of quality and quantity is still inadequate. 5. Capital for developing seaweed farming is still limited. 6. Support from capital institutions is still not optimal. 7. The marketing scale of seaweed production is still to meet local-scale needs. 8. Limited drying area. 9. Long marketing chain.
External Factors		
Opportunity 1. Strategic factors that provide opportunities for seaweed farming in Wakatobi Regency include the following: 2. Marketing opportunities, both locally and internationally, are still wide open. 3. Opportunities for collaboration with investors are wide open. 4. Increasing employment opportunities and community income, as well as state foreign exchange. 5. Improvement of open farming technology. 6. Farming location according to spatial planning. 7. Cooperation between stakeholders is quite good.	**The SO strategy** was obtained by utilizing the internal strengths of seaweed farming development to take advantage of existing opportunities. The strategies that can be applied include: 1. Making a seaweed seed garden. 2. Increasing investor networks for the creation of storage warehouses, processing plants, and export warehouses. 3. Assistance of fisheries experts/ extension workers for program sustainability. 4. Masterplan making. 5. Preparation of digital engineering design for tissue culture laboratory.	**The WO strategy** is used to overcome internal weaknesses of Wakatobi seaweed farming, utilizing external opportunities. The strategies that can be applied include the following: 1. Improving quality farming facilities. 2. Development of a tissue culture laboratory. 3. Increasing cooperation with banks and cooperatives. 4. Preparation of the seaweed drying land. 5. Construction of a storage warehouse. 6. Construction of a processing plant. 7. Formation of a nursery management group (cooperative).

Table 3. SWOT Matrix and development strategy formulation for seawed farming (continued).

External Factors	Strength	Weakness
Threats Strategic factors that pose a threat to the development of seaweed farming in Wakatobi Regency include the following: 1. The bargaining position of farmers towards low seaweed prices. 2. The seaweed planting season cannot be all year round. 3. Seaweed is susceptible to ice-ice disease. 4. During the west season, seaweed farming is not suitable and is often stopped. 5. Sea transportation during seaweed farming activities has the potential to cause marine pollution. 6. Volatility (uncertainty) in demand for seaweed products (inflation, interest rates, disasters, falling prices).	**The ST strategy** is used to reduce and overcome the impact of threats from activities that will be carried out during the development of seaweed farming in Wakatobi Regency by utilizing internal strengths. The strategies that can be applied include the following: 1. Carrying out promotions and increasing export-scale marketing. 2. Seaweed farming location arrangement (memorandum of understanding). 3. Procurement of facilities for managing fish health and farming environment (laboratory). 4. Standardization of seaweed products (product quality testing facilities).	**The WT strategy** is used to reduce weaknesses and avoid threats in the tilapia farming village of Pati Regency. Alternative strategies that can be carried out include the following: 1. There is cooperation with universities and research institutions. 2. CBIB (Good Aquaculture Practices) Training for Seaweed Farming. 3. Seaweed farmer certification.

Source: Result analysis (2025)

Table 4. Nine-cell internal-external (IE) matrix positioning of seaweed farming in Wakatobi Regency.

Strong (3–4)	Average(2–2.99)	Weak (1–1.99)	
I	II	III	High (3–4)
IV	V	VI	Moderate (2–2.99)
VII	VII	IX	Low (1–1.99)

Source: Result analysis (2025)

CONCLUSION

Based on the results of the feasibility study of seaweed farming in Wakatobi Regency, the following conclusions can be drawn: (1) the status of the land utilized by seaweed farming communities, the Wakatobi National Park (TN), needs to be legalized with a mutual agreement (MoU) between the farming group and the national park management; (2) accessibility related to transportation facilities for transporting goods (seaweed) between islands and between districts, both land and sea routes, can still be reached well, although it is still limited by the operating hours of ships; (3) the water condition in the Wakatobi is still very supportive and suitable for the development of seaweed farming; and (4) the availability of human resources working in the seaweed farming sector is still sufficient for the development of farming. From the existing water area in Wakatobi Regency (3,665.63 ha), which is utilized for farming of 351.9 ha, but also does not require a lot of capital, with a selling price that is still profitable, (6) reviewing the aspect of business feasibility, seaweed farming in Wakatobi is very feasible and profitable. In addition to these results, the policy for the development of seaweed farming (*Eucheuma cottonii*) in the Wakatobi conservation area also still requires several aspects of supporting components, such as human resources, cooperation agreements, access, etc.

ACKNOWLEDGEMENT

The authors would like to express their sincere gratitude to the Ministry of Maritime Affairs and Fisheries and the people of Gorontalo for their support and hard work.

REFERENCES

Apriliyanti MS, Sutanti S, Utomo DSC. 2019. Identifikasi Plankton di Kawasan Budidaya Rumput Laut Kabupaten Bantaeng, Sulawesi Selatan dengan Metode DNA Barcoding. *Jurnal Teknologi Perikanan dan Kelautan*. 9(1): 65–72. DOI: https://doi.org/10.24319/jtpk.9.65-72.

Bennett JN, Blythe J, White CS, Campero C. 2021. Blue Growth and Blue Justice : Ten Risks and Solutions for the Ocean Economy. *Marine Policy*. 125: 104387. DOI: https://doi.org/10.1016/j.marpol.2020.104387.

Blok S, van Buuren MW, Fenger HJM. 2023. The Public Value of Citizens' Initiatives: Evidence from a Dutch Municipality. *The American Review of Public Administration*. 53(7–8): 263–279. DOI: https://doi.org/10.1177/02750740231175162.

Buchori I, Pramitasari A, Sugiri A, Maryono M, Basuki Y, Sejati AW. 2018. Adaptation to Coastal Flooding and Inundation: Mitigations and Migration Pattern in Semarang City, Indonesia. *Ocean and Coastal Management*. 163: 445–455. DOI: https://doi.org/10.1016/j.ocecoaman.2018.07.017.

Chlomoudis C, Kostagiolas P, Pallis P, Platias C. 2024. Environmental Management Systems in Greek Ports: A Transformation Tool?. *Environmental Challenges*. 14: 100837. DOI: https://doi.org/10.1016/j.envc.2024.100837.

Dewi SP, Kurniati R. 2022. Design Guidelines for Vegetative Approach Application to Mitigate Riverbank Landslides in Mangkang Wetan and Mangunharjo Villages, Semarang Coastal Area, Indonesia. *Pertanika Journal of Science and Technology*. 30(4): 2407–2425. DOI: https://doi.org/10.47836/pjst.30.4.06

Dimick V, Richard T, Muldoon J, Lee Y. 2025. Women's Entrepreneurial Identity: Insights from Agriculturally Intensive Small Island Economy. *International Entrepreneurship and Management Journal*. 21(1): 1–25. DOI: https://doi.org/10.1007/s11365-024-01021-0.

Dragani W, Bacino G, Alonso G. 2021. Variation of Population Density on a Beach: A Simple Analytical Formulation. *Ocean and Coastal Management*. 208: 105589. DOI: https://doi.org/10.1016/j.ocecoaman.2021.105589.

Farias NS, Rave JSM, Siddique I, Müller CMO. 2023. Potential for Conservation of Threatened Brazilian Myrtaceae Through Sustainable Use for Food and Medicine. *Environment, Development, and Sustainability*. 26(11): 27179–27194. DOI: https://doi.org/10.1007/s10668-023-03833-6.

Frohlich M, Fidelman P, Dutton I, Haward M, Head BW, Maynard D, Rissik D, Vince J. 2023. A Network Approach to Analyse Australia's Blue Economy Policy and Legislative Arrangements. *Marine Policy*. 151: 105588. DOI: https://doi.org/10.1016/j.marpol.2023.105588.

Gorr-Pozzi E, García-Nava H, García-Vega F, Zertuche-González JA. 2023. Techno-economic Feasibility of Marine Eco-Parks Driven by Wave Energy: A Case Study at the Coastal Arid Region of Mexico. *Energy for Sustainable Development*. 76: 101299. DOI: https://doi.org/10.1016/j.esd.2023.101299.

Innocenti M. 2025. Biomimicry and AI-Enabled Automation in Agriculture, Conceptual Engineering for Responsible Innovation. *Journal of Agricultural and Environmental Ethics*. 38(2): 1–17. DOI: https://doi.org/10.1007/s10806-024-09939-9.

Kalagy T, Cohen C, Halfon E, Lavee D. 2025. Optimizing Waste Separation in Traditional Minority Communities: A Game Theory Approach for Sustainable Municipal Waste Management. *Environmental Development*. 53: 101105. DOI: https://doi.org/10.1016/j.envdev.2024.101105.

Kanishchev V, Lyamin S, Zhukov D. 2022. Demographic Strategies of the Russian Rural Population: Intersubjective Nonlinearity Versus Economic Viability. *Pertanika Journal of Social Sciences and Humanities*. 30(2): 579–604. DOI: https://doi.org/10.47836/pjssh.30.2.09.

Khan M, Chang YC, Bibi A. 2024. Navigating Pakistan's Maritime Industry Potential in Context of Blue Economy: An Analysis of the Necessity for Ratification of Maritime Labor Convention 2006. *Marine Policy*. 165: 106150. DOI: https://doi.org/10.1016/j.marpol.2024.106150.

Mandela VT, Sudrajat S, Harini R. 2021. Study of the Economic Valuation of Gemah Beach Tourism During the Covid-19 Pandemic in Tulungagung Regency, East Java. *ICST 2021 – The 2nd Geoscience and Environmental Management Symposium*. E3S Web of Conferences. DOI: https://doi.

org/10.1051/e3sconf/202132503008.
Meyer J, Weisstein FL, Kershaw J, Neves K. 2025. A Multi-Method Approach to Assessing Consumer Acceptance of Sustainable Aquaponics. *Aquaculture*. 596(1): 741764. DOI: https://doi.org/10.1016/j.aquaculture.2024.741764.
Mutia F. 2020. Kalanganyar River, Sidoarjo Regency, Indonesia as a Natural Urban Catalyst, Living Place or Society Pest Kalanganyar River, Sidoarjo Regency, Indonesia as a Natural Urban Catalyst, Living Place or Society Pest. *The 3rd International Conference on Empathic Architecture (ICEA -2019), 25–27 April 2019, Surabaya, East Java, Indonesia*. IOP Conference Series: Earth and Environmental Science. DOI: https://doi.org/10.1088/1755-1315/490/1/012007.
Narwal S, Kaur M, Yadav DS, Bast F. 2024. Sustainable Blue Economy: Opportunities and Challenges. *Journal of Biosciences*. 49(18). DOI: https://doi.org/10.1007/s12038-023-00375-x.
Pratiwi DY, Nurhayati A, Putra PKDNY. 2022. The Community Perception of Batu Karas Mangrove Forest Preservation in Pangandaran Regency, West Java, Indonesia. *AACL Bioflux*. 15(4): 1737–1747.
Priadi CR, Suleeman E, Darmajanti L, Putri GL, Genter F, Foster T, Willetts J. 2024. Policy and Regulatory Context for Self-Supplied Drinking Water Services in Two Cities in Indonesia: Priorities for Managing Risks. *Environmental Development*. 49: 100940. DOI: https://doi.org/10.1016/j.envdev.2023.100940.
Rahmaningsih S. 2017. Penerapan Teknologi Penggunaan Rumput Laut sebagai Biofilter Alami Air Tambak untuk Mengurangi Tingkat Serangan Penyakit pada Udang Vannamei (*Litopenaeus vannamei*). *Jurnal Teknologi Perikanan dan Kelautan*. 3(1): 11–16. DOI: https://doi.org/10.24319/jtpk.3.11-16.
Regional Regulation of Wakatobi Regency Number 19 of 2005 concerning the Establishment of South Kaledupa District. Wakatobi Regency.
Regional Regulation of Wakatobi Regency Number 20 of 2005 concerning the Establishment of East Tomia District. Wakatobi Regency.
Regional Regulation of Wakatobi Regency Number 41 of 2007 concerning the Establishment of Togo Binongko District. Wakatobi Regency.
Sarinastiti EN, Wicaksono MS. 2020. Mapping Coastal Ecotourism Potential in Panggul District, Trenggalek, East Java. *The 5th International Conference on Tropical and Coastal Region Eco Development, 17–18 September 2019, Semarang, Indonesia*. IOP Conference Series: Earth and Environmental Science. DOI: https://doi.org/10.1088/1755-1315/530/1/012024.
Tegar D, Gurning ROS. 2018. Development of Marine and Coastal Tourism Based on Blue Economy. *International Journal of Marine Engineering Innovation and Research*. 2(2): 128–132. DOI: https://doi.org/10.12962/j25481479.v2i2.3650.
Wagey BT, Boneka FB, Mantiri R. 2020. Status of Marine Biodiversity and Community Perception on Marine Conservation in Mantehage Island, Bunaken National Park, North Sulawesi, Indonesia. *AACL Bioflux*. 13(6): 3830–3839.
Wang T, Zhang H, Huang C, Ben Y, Zhou H, Guo H, Han Y, Zhang Y, Tong P. 2025. Occurrence and Potential Risks of Organophosphate Esters in Agricultural Soils: A Case Study of Fuzhou City, Southeast China. *Journal of Environmental Sciences*. 150: 571–581. DOI: https://doi.org/10.1016/j.jes.2024.03.005.
Weinberger F, Sundt S, Staerck N, Merk C, Karez R, Rehdanz K. 2021. Shifting Beach Wrack Composition in the SW Baltic Sea and its Effect on Beach Use. *Ecology and Society*. 26(4): 43. DOI: https://doi.org/10.5751/ES-12759-260443.
Wirahayu YA, Purwito H, Insani N. 2019. Community-based Tourism Management in Santen Beach, Banyuwangi. *The First International Conference on Environmental Geography and Geography Education (ICEGE), 17–18 November 2018, University of Jember, East Java, Indonesia*. IOP Conference Series: Earth and Environmental Science. DOI: https://doi.org/10.1088/1755-1315/243/1/012059.
Yanfika H, Rangga KK, Viantimala B, Listiana I, Mutolib A, Rahmat A. 2020. Evaluation of the Success of Programs and Strategy for Sustainable Coastal Community Development in Tanggamus Regency. *Young Scholar Symposium on Science Education and Environment 2019, 4–5*

November 2019, Lampung, Indonesia. Journal of Physics: Conference Series. DOI: https://doi.org/10.1088/1742-6596/1467/1/012026.

Yuliastuti N, Okta EV, Haryanti VG, Afif F. 2023. Dimension of Community Capability and its Effect on the Social Vulnerability at Semarang Coastal Area. *Journal of Financial Management of Property and Construction*. 28(2): 164–177. DOI: https://doi.org/10.1108/JFMPC-07-2021-0043.