Sustainable Marine Structures
https://journals.nasspublishing.com/sms

ARTICLE

Characteristics of Farmers and Extension Services Affecting the Sustainability of Seaweed Cultivation in Polewali Mandar, Indonesia

***Husniah* [1,2]*, *Anna Fatchiya* [3], *Siti Amanah* [3], *Pudji Muljono* [3]**

[1] *Development Counseling (PPN), IPB University, Bogor 16680, Indonesia*

[2] *Faculty of Social and Political Sciences, Universitas Sulawesi Barat, Majene 91315, Indonesia*

[3] *Development Extension Science, IPB University, Bogor 16680, Indonesia*

ABSTRACT

This study aimed to examine the influence of farmer characteristics and extension services on the sustainability of seaweed cultivation in three districts of Polewali Mandar Regency, West Sulawesi, namely Polewali, Binuang, and Wonomulyo. A total of 267 seaweed farmers were surveyed using a questionnaire, and the data were analyzed through multiple linear regression. Informed consent was obtained in writing from all participants before data collection. The results showed that farmer characteristics and extension services had a positive and significant effect on seaweed farming sustainability. These findings highlight the importance of strengthening both human capital and institutional support. Key farmer characteristics, such as education level, farming experience, motivation, and openness to innovation, play a vital role in sustaining seaweed businesses. Enhancing these competencies through training, formal and non-formal education, and capacity-building programs will improve farmers' ability to adopt sustainable practices, adapt to environmental changes, and increase productivity. Similarly, the significant role of extension services demonstrates the need for continuous technical assistance, knowledge transfer, and institutional backing. Improving extension systems by deploying

*CORRESPONDING AUTHOR:
Husniah, Development Counseling (PPN), IPB University, Bogor 16680, Indonesia; Faculty of Social and Political Sciences, Universitas Sulawesi Barat, Majene 91315, Indonesia; Email: unyunsamks@yahoo.com

ARTICLE INFO
Received: 16 July 2025 | Revised: 31 July 2025 | Accepted: 4 August 2025 | Published Online: 10 October 2025
DOI:https://doi.org/10.36956/sms.v7i4.2469

CITATION
Husniah, Fatchiya, A., Amanah, S., et al., 2025. Characteristics of Farmers and Extension Services Affecting the Sustainability of Seaweed Cultivation in Polewali Mandar, Indonesia. Sustainable Marine Structures. 7(4): 1–8. DOI: https://doi.org/10.36956/sms.v7i4.2469

more qualified field officers, conducting regular farm visits, and tailoring content to local contexts can bridge the gap between innovation and practice. Participatory extension models that engage farmers directly can further promote peer learning and community cohesion. At the policy level, this study supports integrating farmer capacity development and extension strengthening into regional agricultural and fisheries strategies to ensure long-term sustainability of seaweed farming.

Keywords: Seaweed Farmer Characteristics; Extension; Business Sustainability

1. Introduction

Seaweed is a fishery export commodity with great potential to be developed due to the significance as a source of large foreign exchange for the country. Duarte [1], showed that cultivation contributed 51% of the global seaweed production and has continued to develop every year. Seaweed is commonly used in food, cosmetics, and industrial raw materials [1–3].

In general, seaweed is traded in the dried form that is consumed directly, and hydrocolloid products including carrageenan, agar-agar, and alginate. Among the total world seaweed production, 65% can be consumed directly, 15% are hydrocolloid materials, and 20% comprise fertilizer, paper, or biofuel [4–7]. Seaweed is considered macroalgae that can be used as food, feed, biofuel, cosmetics, and pharmaceuticals [8].

Seaweed production (dry) tends to fluctuate, estimated at 1,191.50 tons in 2016, and 1,316.00 tons in 2017. In 2018, it decreased to 1,276.43 tons but increased to 1,289.89 tons in 2019, 1,437.73 tons in 2020, and 1,471.62 in 2021. Meanwhile, in 2022, production decreased again to 1,444.65 tons [9]. The decreased production (dry) in 2018 and 2020 can be attributed to the low competence of the seaweed farmers. Competence is a basic characteristic possessed by individuals which is a benchmark for the size or criteria related to successful individual activities. Simamora stated that characteristics are traits or properties that exist in individuals, including age, education, and experience. These characteristics can either be carried from birth or result from interaction with the environment [10].

Seaweed business management must be oriented toward increasing production and sustainability. This is closely related to the characteristics possessed by farmers, which differ from one another. Farmers believe seaweed cultivation is not difficult, but as the business progresses, many problems or difficulties often occur. Characteristics such as motivation, rationality, and innovation affect seaweed production, quality, and business sustainability. Consequently, farmers need continuous guidance by active extensionists. To advance the community, effective support from extension institutions is needed [11]. Fisheries extension services including assistance, technical guidance, as well as intensive and sustainable management are needed [12]. Therefore, this study aimed to determine the influence of seaweed farmer characteristics and extension on business sustainability in Polewali Mandar Regency, West Sulawesi.

2. Methods

This study was conducted across three districts in Polewali Mandar Regency, namely Polewali, Binuang, and Wonomulyo. The three districts are coastal areas where many seaweed farmers are found. Data collection was carried out by field survey using questionnaires and the total number of samples was 267. This study was conducted across three districts in Polewali Mandar Regency, namely Polewali, Binuang, and Wonomulyo. The three districts are coastal areas where many seaweed farmers are found. The research approach used in this research is a quantitative method based on surveys and direct field observations. The selection of respondents was carried out using the Purposive Sampling technique, adjusting to the criteria required by the researcher, such as business duration, age of farmers, and others. The number of samples used in this study after validation is 267. The number of questionnaires distributed was 340, and after verification, there were 73 samples that did not meet the criteria due to incomplete information (many unanswered questions), outliers, and unreliability (after testing for reliability and validity). The invalid data were not used, leaving only 267. The number of respondents, 267, is sufficient and even exceeds the number recommended by several researchers. Among them, a sample size of 225–450 is recommended for the maximum likelihood

(ML) estimation technique, and it is considered that the larger the sample size, the better it represents the population. In addition, anticipating the possibility of samples being invalidated or not used due to incomplete information or data.

The variables examined include seaweed farmer characteristics, extension, and business sustainability as shown in **Table 1**. The questionnaire was tested using validity and reliability tests based on the calculated r-value > r table (0.1200).

Table 1. Study variables and indicators.

Variable	Indicator	r_{Count}	r_{Table}	Significant	α	Dec.
Characteristics	Motivation	0.959	0.12	0.00	0.05	Valid
	Rationality	0.963	0.12	0.00	0.05	Valid
	Pen_Innovation	0.978	0.12	0.00	0.05	Valid
Extension	Material	0.962	0.12	0.00	0.05	Valid
	Method	0.946	0.12	0.00	0.05	Valid
	Kem_Extension	0.959	0.12	0.00	0.05	Valid
	Duk_Facilities	0.951	0.12	0.00	0.05	Valid
	Duk_Cooperation	0.932	0.12	0.00	0.05	Valid
Sustainability	Keb_Economic	0.947	0.12	0.00	0.05	Valid
	Keb_Social	0.963	0.12	0.00	0.05	Valid
	Keb_Environment	0.952	0.12	0.00	0.05	Valid
	Keb_Human Resources	0.952	0.12	0.00	0.05	Valid

All study items were tested for reliability and the basis for making decisions is:

1. If the Cronbach alpha value is > 0.6 then the variable is reliable
2. If the Cronbach alpha value is < 0.6 then the variable is not reliable

Table 2 shows that all variables have a Cronbach alpha value > 0.60, suggesting significant reliability.

Table 2. Test results for each variable.

Variable	*Cronbach alpha*	Standard	Description
Characteristics	0.939	0.6	Reliable
Extension	0.962	0.6	Reliable
Sustainability	0.962	0.6	Reliable

The data obtained were analyzed using multiple regression analysis. The SPSS 22 program was used to support data analysis.

3. Multiple Regression Analysis Results

Table 3 and **Table 4** show the results of multiple regression analysis. More specifically, **Table 4** shows that all study hypotheses are accepted. Therefore, the sustainability of seaweed cultivation was positively and significantly influenced by farmer characteristics (ß = 0.317, Þ = 0.000) and extension (ß = 0.233, Þ = 0.000)

Table 3. The relationship between the sustainability of seaweed cultivation, farmer characteristics, and extension Model Summary.

					Change Statistics				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	F Change	df1	df2	Sig. F Change
1	445[a]	0.198	0.192	5.195	0.198	32.518	2	264	0.000

Predictors: (Constant), Counseling, Characteristics

Table 4. The Coefficient for the relationship between the sustainability of seaweed cultivation, farmer characteristics, and extension Coefficients.

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig	Correlations			Collinearity Statistics	
	B	Std. Error	Beta			Zero-order	Partial	Part	Tolerance	VIF
(Constant)	21.627	2.158		10.024	0.000					
Characteristics	0.271	0.049	0.317	5.508	000	0.385	321	304	0.916	1.092
Extension	0.143	0.035	0.233	4.043	0.000	0.325	241	0.223	0.916	1.092

Dependent Variable: Sustainability

As shown in **Table 3**, the coefficient of determination (R^2) value is 19.8%. Therefore, the characteristics and extension together affect the business sustainability variable by 19.8% while the rest (100% – 19.8% = 80.2%) can be attributed to other variables outside this regression equation.

3.1. The Influence of Farmer Characteristics on the Sustainability of Seaweed Business

The results showed that the characteristics of seaweed farmer and business sustainability had a significant positive linear correlation of 0.271 or 27.1% (**Table 4**). This implies that when the characteristic value increases by one unit, then business sustainability also rises by 0.271, or when the characteristic value by 100 units sustainability will rise by 27.1 units. The higher the characteristics of seaweed farmer, the more potential for business sustainability.

Success in managing a business depends on the ability of farmer as the main workers. With good characteristics, farmer will be able to overcome problems faced and take advantage of opportunities to ensure sustainable seaweed production. In general, characteristics refer to traits present in individuals and reflected in thoughts, behavior, and actions in the environment. The characteristics of farmer examined in this study include motivation, rationality, and innovation. Individuals aged 40–50 years old in the coastal areas of Polewali Mandar Regency generally work as seaweed farmer. This age range is included in the productive category of farmer who quickly receive information and are physically strong enough to manage seaweed cultivation business. A study by Managanta found that the age of farmer has a positive and significant effect on the level of productivity and sustainability of the business [13]. Arita et al. also explained that younger farmer, despite not having experience are often more motivated to quickly and easily accept innovation [14].

Seaweed farmer have formal education ranging from Elementary School to Junior High School, Senior High School, and Higher Education. Farmer with low education often show limited critical thinking and knowledge which ultimately affects the production. On the other hand, farmer with higher education tend to have a more sophisticated way of thinking, with broader insights, which in turn leads to improved knowledge, skills, and attitudes. Education reflects the level of ability to improve knowledge, skills, and attitude changes. It is a process of learning to improve the standard of living. According to Mardikanto, education is a process carried out by individuals in a planned manner to improve knowledge and attitudes. This process helps to build insight into objects that ultimately lead to better decision-making [15].

Most farmer running their businesses are experienced on average. This can be attributed to hereditary inheritance from parents which affects seaweed production. A study by Widiyanti and Nabilah, explained that the more experience farmer gain in managing their businesses, the better the knowledge and the more solutions in dealing with problems related to seaweed production [16]. The average seaweed farmer in Polewali Mandar Regency has 10 years of experience in cultivation. Previous analyses [16,17], showed that 10 years of experience or above in managing a business can help farmer become better at sustainable management. An experience in cultivation influences the decision-making process [18]. The longer a farmer runs a farm, the

higher the level of experience [19].

The motivation to manage seaweed business has a significant effect on sustainability. Several farmers explained that the motivation to run a business is to fulfill family needs, including living expenses and children's school fees. Seaweed cultivation is perceived by farmer as a noble job, presenting an opportunity to become entrepreneurs. In addition, the business can absorb labor, for both family and neighbors. Barbutto and Bird also mentioned that motivation is related to individual needs. However, based on observations in the field, seaweed production has fluctuated, and leading to frequent losses which have forced farmer to work double jobs [20,21].

Rationality has a significant effect on business sustainability. This implies that farmer who think rationally are more sustainable in managing the cultivation business. Rational farmer are critical, can meet needs, and dare to take risks. During the interviews, farmer stated that seaweed cultivation was not difficult, but the fluctuating prices have affected income, leading to a reduction in expenses. Basic needs such as food and children education cost more compared to buying new clothes and vacations. This shows that seaweed farmer can meet living needs in various circumstances.

The adoption of innovation has a significant effect on business sustainability. Consequently, farmer in Polewali Mandar Regency pursue seaweed cultivation as their main job. This is evidenced by the number of plots owned, reaching at least 300 plots per farmer with experience averaging more than 10 years. Seaweed farmer prefers to experiment with technology first before adoption. For example, many farmer adopted seaweed drying tool introduced by an extensionist, due to ease of use, clear benefits, and visible results. According to Van den Ban and Hawkins, farmer are quicker to adopt technology that can be tried on a small scale [22]. Indraningsih added that factors that influence farmer to adopt technology include appropriateness and clear benefits [12].

As shown in **Table 3**, R^2 value of 19.8% implies that farmer characteristics explain 19.8% variation in business sustainability. The remaining 80.2% is attributed to other factors not analyzed in this study. The low value suggests that the sustainability of seaweed business is not optimal. However, when farmer characteristics increase, sustainability can be significantly enhanced across economic, social, environmental, and human resource dimensions. The skills and insights related to seaweed cultivation activities can be developed by conducting extension, socialization, and training. According to Rusdi et al., the ability and willingness of farmer to understand and implement every suggestion conveyed by extensionists through mentoring, training, and discussion will help improve business sustainability [23].

Retang explained that the factors influencing the sustainability of seaweed cultivation business include (1) characteristics of farmer including education, age, and gender, (2) social factors from interactions between farmer, villages, government, private parties, and NGOs, (3) technical factors affecting the area of land, cultivation facilities, infrastructure, and smooth cultivation information, as well as (4) economic factors reflected in the farmer ability to prepare seaweed seeds, the availability of facilities, market access, and land area [7].

3.2.The Influence of Extension Activities on Business Sustainability

The regression analysis showed that extension and business sustainability had a significantly positive and linear correlation with a variance of 0.143 or 14.3% (**Table 4**). This implies that a unit rise in extension will increase business sustainability by 0.143, or when the extension rises by 100 units, sustainability increases by 14.3 units. In other words, the higher the extension activity, the better the business sustainability. Conversely, the lower the extension activity, the weaker the business sustainability. The influence of extension activities carried out by extensionists is reflected in the sustainability of seaweed business.

Fisheries extensionists have a significant contribution to improving the ability of farmer for sustainable cultivation. Extension is a non-formal education for farmer and families carried out through a learning process to improve expertise, knowledge, and skills. According to Harinta, extension is a face-to-face process of transferring information related to the problems experienced by clients [24]. Extensionists, as educators and

motivators should focus on educating farmer to develop the cultivation business. Extension indicators consist of materials, methods, extensionist abilities, support facilities, and cooperation support.

The results proved that the correlation value of extension with business sustainability was lower, namely 0.143 or 14.3% compared to characteristics with business sustainability of 0.271 or 27.1% (**Table 4**). This is because seaweed cultivation methods applied by farmer are not the same as those conveyed by the extensionists. The process of learning seaweed cultivation is obtained from parents as an hereditary legacy. One farmer explained that the extension was effectively carried out at the beginning of seaweed planting following the instructions received from extensionists. Moreover, there was good interaction between extensionists and farmer, with the extensionists acting as mentors. As the function of extension weakened, farmer rarely received good learning from extensionists. Various problems faced include pests, quality, and decreasing production. A previous study by Wibowo et al., emphasized that good extension services depend on the relevance to the client's needs and the appropriateness of the material, methods, extensionist capabilities, supporting facilities, and cooperation support [25].

Extension materials have a significant impact on business sustainability. These materials must be well delivered for easy understanding. Extensionist knowledge of seaweed cultivation techniques is evident when answering questions asked by farmer. In addition, extensionists must have sufficient mastery of the material when responding to farmer problems. Effendi et al. and Rusdy & Sunartomo stated that materials should preferably be easy to understand, and adjustable to the needs of farmer as well as the conditions of the cultivation location [26,27]. Extensionists are the parties tasked with bridging or connecting farmer with the government regarding the needs and complaints [26].

The methods used in extension have a significant effect on business sustainability. Extensionists use discussion methods that can improve farmer knowledge and skills for sustainable development and management. According to some farmer, the implementation of the discussion method is better because it enables direct exchange of information between farmer and extensionists. This method helps farmer to adopt new strategies related to pests and diseases that attack seaweed plants as well as climate problems. In addition, discussions can be carried out anywhere, both at the cultivation location, at home, and at the fish auction. Pangaribuan et al. added that discussions comprising questions and answers were carried out during the presentation of material by extensionists [28]. This implies that extension and communication were carried out according to the expectations of farmer as the target.

The ability of extensionists significantly influences business sustainability. Some farmer express satisfaction with the ability of extensionists as evidenced by attendance. The better the ability of the extensionist, the higher the number of farmer who will attend the extension. Therefore, the ability of farmer has increased which has caused improvement in seaweed production. Some farmers expressed dissatisfaction with the ability of extensionists. Based on the results, not all farmer participated in the extension. This occurred because extensionists from the Marine and Fisheries Service of Polewali Mandar Regency had different scientific specifications from the fisheries business sector managed by coastal communities. The activeness of some farmer was reduced due to dissatisfaction with extension services. Therefore, more competent extensionists with clear work rules are needed. It is also important to foster good cooperation between farmer, and extensionists, as well as other institutions to facilitate information exchange and sustainability.

Facilities and infrastructure significantly affect business sustainability. Based on the results, facilities, and infrastructure used by extensionists in extension are available and affordable. For example, extension is usually carried out in a fish auction site capable of accommodating about 50–60 people with media including stationery (notebooks, paper, and pens), and communication tools (cell phones). Extensionists often use laptops and projectors to provide information according to developments in science and technology.

Cooperation support has a significant impact on business sustainability. Seaweed farmer cooperate with various parties to provide assistance and information.

For example, farmer cooperate with the Fisheries Service to assist with production equipment including seaweed seeds, ropes, buoys, and drying equipment. Farmer are more likely to borrow business capital from traders than cooperatives or banks due to the easy process and interest-free rate. Cooperation could also be in the form of collaborating with universities in seaweed processing practices such as making seaweed chips, *dodol,* and jam.

Tuhumury et al. explained that businesses will be sustainable with continuous improvements and cooperation [29]. Rusdi et al. added that creating regulations related to cooperation and seaweed cultivation activities will help prevent conflicts between farmer capable of damaging marine natural resources [23].

According to Amanah in the extension process, five elements need to be considered, namely (1) learning, (2) having subjects, (3) increasing awareness and competence of group members, (4) resources, and (5) implementing the principle of sustainability from social and economic elements, as well as the benefits of environmental sustainability [30]. Kustiari explained that factors influencing the sustainability of farmer business include (1) poor extension reflected in the low role of extensionists, linear communication, and minimal extension, (2) low characteristics of farmer including formal and non-formal education levels, (3) sub-optimal learning, as evidenced by limited ability in using learning materials, access and relationships with information sources [31]. Sapar et al. showed agricultural extensionists play a significant role in the sustainability of the cocoa business, as reflected in the management ability of farmer, activity in extension and farmer groups, product marketing, financial management, as well as effective communication and planning [32]. According Simamora T's research, "Improvement of Farmers' Competence and Sustainability of Beef Cattle Business in Oebkim Village, Bikomi Selatan District, North Central Timor Regency", the research findings indicate that the factors influencing the sustainability of the business, namely the characteristics of the farmers, have a greater impact compared to extension and the environment, with an R^2 value of 0.207 or 20.7 percent. Meanwhile, 79.3 percent is influenced by other factors outside the scope of the research [10].

4. Conclusion and Suggestion

In conclusion, farmer characteristics have a positive and significant effect on business sustainability. Similarly, extension has a positive and significant effect on the sustainability of seaweed businesses. For sustainable cultivation, the characteristics of farmer, including motivation, rationality, and innovation should be improved through extension, training, education, and access to information. Moreover, extensions should prioritize business sustainability and must be adjusted in terms of methods, materials, and media. The regression equation showed that the magnitude of the diversity was 14.3%. R^2 value indicated that extension can explain 14.3% variation in business sustainability while 85.7% is attributed to other factors not analyzed in this study. The intensity of extension and training for seaweed farmers needs to be increased, starting from the planting process to harvesting. Continuous extension will help farmers understand more effective and efficient cultivation techniques, as well as be able to overcome the challenges faced in the field. The central and local governments also play a role by facilitating field visits or study tours to other regions that have successfully cultivated seaweed. This activity aims to enhance the interest, creativity, and knowledge of farmers in developing their businesses sustainably.

Extension agencies play an important role in supporting the success of seaweed cultivation. Therefore, increasing the intensity of extension services should be accompanied by the use of relevant methods that align with the needs and developments of field conditions. Appropriate methods will be more easily accepted and implemented by farmers. As the spearhead in knowledge transfer, the quality of extension workers must be continuously improved. This can be achieved by equipping extension workers with comprehensive knowledge and technical skills related to agriculture and seaweed cultivation. Thus, extension agencies can become strategic partners in promoting the productivity and welfare of seaweed farmers.

Author Contributions

H.contributed to the research design, data collection, analysis, and manuscript preparation; A.F. provided guidance on research design and contributed to data interpretation and manuscript revision; S.A. contributed to the development of the research framework and critical review of the manuscript, and P.M. supported methodological development and assisted in editing and improving the manuscript.

Funding

This research was funded by Beasiswa Pendidikan Pascasarjana Dalam Negeri (BPPDN), Ministry of Education, Culture, Research, and Technology of the Republic of Indonesia

Institutional Review Board Statement

The study was conducted in accordance with ethical standards for social research. Ethical approval was obtained from the Graduate School, IPB University, Bogor, Indonesia. Participation of respondents (farmers and extension workers) was voluntary, and informed consent was obtained prior to data collection.

Informed Consent Statement

Informed consent was obtained from all subjects involved in the study. Participation was voluntary, and respondents were assured of the confidentiality and anonymity of their responses..

Data Availability Statement

The data supporting the findings of this study consist of survey results, interview transcripts, and field observations from seaweed farmers and extension workers in Polewali Mandar, Indonesia. Due to privacy and ethical restrictions, the data are not publicly available. However, they can be obtained from the corresponding author upon reasonable request.

Acknowledgments

The authors are grateful to the Marine and Fisheries Service and all parties who have assisted in the study data collection. The authors are also grateful to the Universitas Sulawesi Barat and the Bogor Agricultural Institute for the facilities provided during the study as well as the Ministry of Education and Culture for funding through the 2018 Domestic Postgraduate Education Scholarship (BPPDN).

Conflicts of Interest

There is no conflicts of interest

References

[1] Duarte, C.M., Bruhn, A., Krause-Jensen, D.A., 2022. A seaweed aquaculture imperative to meet global sustainability targets. Nature Sustainability. 5, 185–193. DOI: https://doi.org/10.1038/s41893-021-00773-9

[2] Hasselström, L., Vischc, W, Gröndahla, F., et al., 2018. The impact of seaweed cultivation on ecosystem services—a case study from the west coast of Sweden. Marine Pollution Bulletin. 133, 53–64. DOI: https://doi.org/10.1016/j.marpolbul.2018.05.005

[3] Wang, X., He, L., Ma, Y., et al., 2020. Economically important red algae resources along the Chinese coast: History, status, and prospects for their utilization. Algal Research. 46, 101817. DOI: https://doi.org/10.1016/j.algal.2020.101817

[4] Astanty, W.F., Arief, A.A., 2014. Analysis of the Role of Coastal Women's Capacity in Seaweed (Eucheuma cottonii) Cultivation Activities in Takalar Regency (Case Study in Punaga Village, Mangarabombang District). JURNAL GALUNG TROPIKA. 3(3), 149–158. DOI: https://doi.org/10.31850/jgt.v3i3.88 (in Indonesian)

[5] Pechsiri, J.S., Thomas, J.-B.E., Risén, E., et al., 2016. Energy performance and greenhouse gas emissions of kelp cultivation for biogas and fertilizer recovery in Sweden. Science of the Total Environment. 573, 347–355. DOI: https://doi.org/10.1016/j.scitotenv.2016.07.220

[6] Aryatikta, R., Sri Winarni, Pramono, S.N.W., 2022. Literature Review on the Potential of Sargassum sp. as a Nutraceutical. Food Scientia : Journal of

Food Science and Technology. 2(2), 139–159. DOI: https://doi.org/10.33830/fsj.v2i2.3083.2022 (in Indonesian)

[7] Retang, E.U.K., 2022. Analysis of the Factors Affecting the Sustainability of Seaweed Farming in Kaliuda Village, East Sumba Regency. JURNAL EDUCATION AND DEVELOPMENT. 11(1), 330–335. DOI: https://doi.org/10.37081/ed.v11i1.4531 (in Indonesian)

[8] Valderrama, D., Cai, J., Hishamunda, N., et al., 2013. Social and economic dimensions of carrageenan seaweed farming. Fisheries and Aquaculture Technical Paper. 580. Available from: https://www.fao.org/4/i3344e/i3344e.pdf (cited 9 July 2023). (in Indonesian)

[9] Department of Marine Affairs and Fisheries of Polewali Mandar Regency, 2021. Fisheries Statistics Data. Polewali Mandar Regency. Available from: https://dinaskelautan.polmankab.go.id/ (cited 15 July 2025). (in Indonesian)

[10] Simamora, T., 2020. Improving the Competence of Cattle Farmers and the Sustainability of Beef Cattle Farming in Oebkim Village, South Bikomi District, North Central Timor Regency. AGRIMOR. 5(2), 20–23. DOI: https://doi.org/10.32938/ag.v5i2.1007 (in Indonesian)

[11] Sapbamrer, R., Thammachai, A., 2021. A systematic review of factors influencing farmers' adoption of organic farming. Sustainability. 13(7), 3842. DOI: https://doi.org/10.3390/su13073842

[12] Indraningsih, K.S., Ashari, A., Syahyuti, S., et al., 2023. Factors influencing the role and performance of independent agricultural extension workers in supporting agricultural extension. Open Agriculture. 8(1), 20220164. DOI: https://doi.org/10.1515/opag-2022-0164

[13] Managanta, A.A., 2020. The Role of Agricultural Extension in Increasing Competence and Income Rice Farmers. Indonesian Journal of Agricultural Research. 3(2), 77–88. DOI: https://doi.org/10.32734/injar.v3i2.3963

[14] Arita, B., Managanta, A.A., Mowidu, I., 2022. The Relationship Between Farmers' Characteristics and the Success of Maize Farming. SEPA: Jurnal Sosial Ekonomi Pertanian dan Agribisnis. 19(1), 105. DOI: https://doi.org/10.20961/sepa.v19i1.55116 (in Indonesian)

[15] Mardikanto, T., 2009. Agricultural Extension System. Universitas Sebelas Maret: Surakarta, Indonesia. Available from: https://dosen.unmerbaya.ac.id/file/content/2022/03/fullbook_sistem_penyuluhan_pertanian_nurlina.pdf (cited 11 June 2023). (in Indonesian)

[16] Widiyanti, N.M.N.Z., Setiawan, R.N.S., 2024. Analysis of the Factors Affecting Seaweed Farming Income in Seriwe Village, East Lombok Regency. JURNAL AGRIMANSION. 25(1), 265–271. DOI: https://doi.org/10.29303/agrimansion.v25i1.1639

[17] Hermawan, R., 2017. Analysis of the Types and Weights of Marine Debris on the West Coast of Selayar Island, South Sulawesi [Doctoral dissertation]. Bogor Agricultural University (IPB): Bogor, Indonesia. Available from: https://repository.ipb.ac.id/handle/123456789/87897 (cited 1 January 2023). (in Indonesian)

[18] Rogers, E.M., 2003. Diffusion of Innovation, 5th ed. The Free Press: New York, NY, USA.

[19] Pratiwi,E..Riadiani, E., Sudrajat, S. 2012. Farmers' Behavior in Managing Agricultural Land in Landslide-Prone Areas (Case Study of Sumberejo Village, Batur District, Banjarnegara Regency, Central Java). Jurnal Bumi Indonesia. 1(3). Available from: https://www.neliti.com/publications/77058/perilaku-petani-dalam-mengelola-lahan-pertanian-di-kawasan-rawan-bencana-longsor#cite (cited 26 June 2023). (in Indonesian)

[20] Barbuto, J.E., Trout, S.K., Brown, L.L., 2004. IDENTIFYING SOURCES OF MOTIVATION OF ADULT RURAL WORKERS. Journal of Agricultural Education. 45(3), 11–21. DOI: https://doi.org/10.5032/jae.2004.03011

[21] Bird, B.J., 1989. Entrepreneurial Behavior. Scott, Foresman and Company: Glenview, IL, USA.

[22] Van den Ban, A., Hawkins, 1999. Agricultural Extension. Penerbit Kanisius: Yogyakarta, Indonesia.

[23] Rusdi, R., Irwan, I.N.P., Yani, F.I., 2023. Sustainability Status Analysis of Seaweed Cultivation (Eucheuma cottonii) in Barru Regency: Rap-Seaweed Modification Method. Journal of Tropical Fisheries Management. 7(2), 36–44. DOI: https://doi.org/10.29244/jppt.v7i2.49608 (in Indonesian)

[24] Harinta, Y.W., 2011. Adoption of Agricultural Innovations Among Farmers in Gatak District, Sukoharjo Regency. Jurnal Agrin. 15(2), 164–174. Available from: https://jurnalagrin.net/index.php/agrin/article/view/192 (cited 27 February 2023). (in Indonesian)

[25] Wibowo, A.B., Anggoro, S., Yulianto, B., 2015. Sustainability Status of the Ecological Dimension in the Development of a Sustainable Minapolitan Area Based on Freshwater Aquaculture in Magelang Regency. Saintek Perikanan : Indonesian Journal of

Fisheries Science and Technology. 10(2), 107–113. DOI: https://doi.org/10.14710/ijfst.10.2.107-113 (in Indonesian).

[26] Effendi, M., Juita, F., Elkana, V., 2021. The Role of Field Agricultural Extension Workers on Farmers' Satisfaction Level in the Working Area of the Agricultural Extension Center of Barong Tongkok District. Jurnal Pertanian Terpadu. 9(1), 66–80. DOI: https://doi.org/10.36084/jpt..v9i1.309 (in Indonesian)

[27] Rusdy, S.A., Sunartomo, A.F., 2020. The Communication Process in Agricultural Extension of the System of Rice Intensification (SRI) Program. Jurnal KIRANA. 1(1), 1. DOI: https://doi.org/10.19184/jkrn.v1i1.20309 (in Indonesian)

[28] Pangaribuan., Darwin, H. 2018. Development and Utilization of Plant Extract Organic Fertilizer in Organic Farming Cultivation in South Lampung. Jurnal Pengabdian Kepada Masyarakat. 24(1), 603–609. Available from: http://jurnal.unimed.ac.id/2012/index.php/jpkm/article/view/9674 (cited 26 June 2023). (in Indonesian)

[29] Tuhumury, S.F., Bachmid, M., Sangaji, M., 2019. Sustainability Status of Seaweed Cultivation in Negeri Sawai, North Seram District, Central Maluku Regency. TRITON: Jurnal Manajemen Sumberdaya Perairan. 15(2), 82–93. DOI: https://doi.org/10.30598/TRITONvol15issue2page82-93 (in Indonesian)

[30] Amanah, S., 2007. The Meaning of Extension and the Transformation of Human Behavior. Jurnal Penyuluhan. 3(1). DOI: https://doi.org/10.25015/penyuluhan.v3i1.2152 (in Indonesian)

[31] Kustiari, T., Sumardjo, S., Slamet, M., et al., 2017. The Effect of Extension Effectiveness on the Competence of Polyculture Seaweed Farmers in the Northern Coastal Waters of Java Island. Jurnal Sosial Ekonomi Kelautan dan Perikanan. 7(1), 79. DOI: https://doi.org/10.15578/jsekp.v7i1.5738 (in Indonesian)

[32] Sapar, S., Yusuf, Q, M., Haedar, H., 2016. The Relationship Between Agricultural Extension Workers' Performance and Cocoa Farmers' Competence in Increasing Cocoa Productivity in Palopo City, Luwu Regency, North Luwu, and East Luwu. Jurnal Ekonomi Pembangunan STIE Muhammadiyah Palopo. 1(2). DOI: https://doi.org/10.35906/jep01.v1i2.115 (in Indonesian)