

# Seaweed farmers' socio-economic conditions, practices, and local perception of seaweed-based liquid extract utilization in Pagadian City, Zamboanga del Sur

<sup>1</sup>Angel Lyn P. Mirayo, <sup>1</sup>Maria Luisa S. Orbita, <sup>2</sup>Ronaldo R. Orbita,  
<sup>1</sup>Maria Lourdes Dorothy G. Lacuna, <sup>3</sup>Amabelle A. Embornas,  
<sup>4</sup>Sheila L. Dagondon

<sup>1</sup> Department of Marine Science, College of Science and Mathematics, Mindanao State University-Iligan Institute of Technology, Tibanga, Iligan City, Philippines; <sup>2</sup> Department of Professional Education, College of Education, Mindanao State University-Iligan Institute of Technology, Iligan City, Philippines; <sup>3</sup> Department of Sociology, College of Arts and Social Sciences, Mindanao State University-Iligan Institute of Technology, Iligan City, Philippines; <sup>4</sup> Department of Biological Sciences, College of Science and Mathematics, Mindanao State University-Iligan Institute of Technology, Iligan City, Philippines,  
Corresponding author: M. L. S. Orbita, marialuisa.orbita@g.msuiit.edu.ph

**Abstract.** This study examines the socio-demographic factors influencing the adoption of seaweed-based fertilizers among farmers in Pagadian City. It reveals that gender, age, marital status, farm ownership, and years of experience significantly shape farmers' perceptions of the use, sustainability, and profitability of these fertilizers. Male farmers generally appreciate the environmental benefits, while women focus on more localized tasks. Younger farmers rely on experiential learning methods, while middle-aged farmers combine practical knowledge with physical capability for sustainable practices. Married couples and farm owners tend to invest in these fertilizers due to greater financial stability and long-term perspectives. Experienced farmers, particularly those with 11-15 years in the industry, exhibit a deeper understanding of the fertilizers' environmental and economic benefits, contributing to sustainable farming practices in the region.

**Key Words:** *Kappaphycus* farming, livelihood, organic fertilizer, seaweed industry.

**Introduction.** Seaweed farming has emerged as a promising practice for numerous coastal communities globally, offering potential solutions to a variety of environmental, climate, and socio-economic challenges (Valderrama et al 2015; Ginigaddara et al 2018; Hossain et al 2021). In developing countries, it plays a crucial role in the livelihoods of seaweed farmers, providing employment, ensuring food security, and alleviating pressure on wild fish stocks (Rimmer et al 2021). The scale of seaweed farming has expanded significantly in recent years, with algal production growing at an annual rate of approximately 7.3% from 2010 to 2020 (FAO 2022). Projections suggest that this growth will accelerate to 14% annually, resulting in a total production of 500 million tons of dry weight by 2050. This expansion is expected to increase the world's food supply by 10%, while also creating new markets and business opportunities, particularly in biofuels, animal feed, and other industrial applications (Nakhate & Van der Meer 2021; Islam et al 2022).

The Philippines holds the distinction of pioneering eucheumatoid cultivation (Valderrama et al 2015) and ranks as the third-largest producer of dried seaweed, following Indonesia and China. Much of this production originates in the southern provinces, particularly within the Zamboanga Peninsula, a prominent hub for seaweed farming (Philippine Statistics Authority 2019; Tahiluddin et al 2023). Among the

cultivated species is *Kappaphycus alvarezii*, crucial for the production of kappa-carrageenan, widely used in food, pharmaceutical, industrial, and biotechnological applications for its gelling, viscosity-enhancing, texture-modifying, and cell-immobilizing properties (Bixler 1996; Ask & Azanza 2002; Villanueva et al 2011).

Given the economic and industrial importance of *K. alvarezii*, efforts to enhance sustainable yields have driven various industrial and ecological studies aimed at developing techniques to support and improve its production (Buschmann et al 2017; Araújo et al 2021). One such technique is nutrient enrichment, widely embraced by farmers in both terrestrial and aquatic agronomy, as it helps meet economic demands and boost crop productivity (Jacobsen et al 2013).

The use of fertilizers in seaweed farming has been shown to enhance algal growth, seedling proliferation, and nutrient uptake (Loureiro et al 2010). It also helps control pests and diseases, and aids in stress management, as demonstrated in studies on *K. alvarezii* and *K. striatus* using *Ascophyllum* Marine Plant Extract Powder (AMPEP) (Ali et al 2018), which showed increased nitrogen assimilation compared to untreated conditions.

Over time, the Philippines has adopted fertilizer use in seaweed farms to compete with China and Indonesia, major seaweed producers (Buschmann et al 2017; Tahiluddin et al 2022). Recent research from Central Sulawesi, Indonesia, suggests that the green alga *Ulva* sp. can serve as an alternative fertilizer, containing growth-regulating components that may enhance biomass and growth rates of *Gracilaria verrucosa* (Nasmia et al 2021). These advancements in eco-friendly bio-fertilizers are crucial for meeting the demand for high-value seaweed products and improving seaweed farming practices to accommodate a growing global population.

According to Chen et al (2020), community engagement is essential for the successful implementation of projects and innovations. In the context of seaweed farming, social perception significantly influences public attitudes, acceptance, and involvement in this emerging industry (Rostan et al 2022). Understanding and addressing the concerns, expectations, and preferences of stakeholders such as coastal communities, seaweed farmers, environmental groups, and consumers are critical for the successful adoption of seaweed farming innovations (Spillias et al 2022).

This study focuses on assessing the current state of the seaweed industry, farming practices, and the perceptions of seaweed farmers regarding the use of seaweed-based liquid extracts for cultivation in Pagadian City, Zamboanga del Sur. Specifically, it aims to explore participants' perspectives on the economic value and sustainability of seaweed farming, as well as the challenges they face and their views on the use of organic fertilizers in their communities.

## Material and Method

**Study area.** The study took place in the coastal area of Pagadian City, situated in the northeastern part of Western Mindanao. It is bordered by Tigbao and Dumalinao to the southwest, Lakewood to the west, Labangan to the east and northwest, and Midsalip to the north, covering a total area of 33,380 hectares or 333.80 square kilometers. Seaweed farming was introduced in this region in the late 1900s and quickly became a popular livelihood among coastal communities, providing income for households reliant on fishing.

According to recent data from the Municipal Agriculture Office, Pagadian City hosts approximately eight seaweed farm areas, with only four currently active throughout the year. These areas are located in Barangay Bomba (7°48'18.97"N and 123°25'40.67"E), Barangay Muricay (7°48'42.66"N and 123°28'5.97"E), Barangay Poloyagan (7°47'38.55"N and 123°25'54.71"E), and Barangay White Beach (7°48'45.34"N and 123°26'46.40"E). Seaweed cultivars are grown continuously in these farming areas (Figure 1). It is estimated that there are a total of 635 seaweed farmers in Pagadian City, though this number varies across different areas.

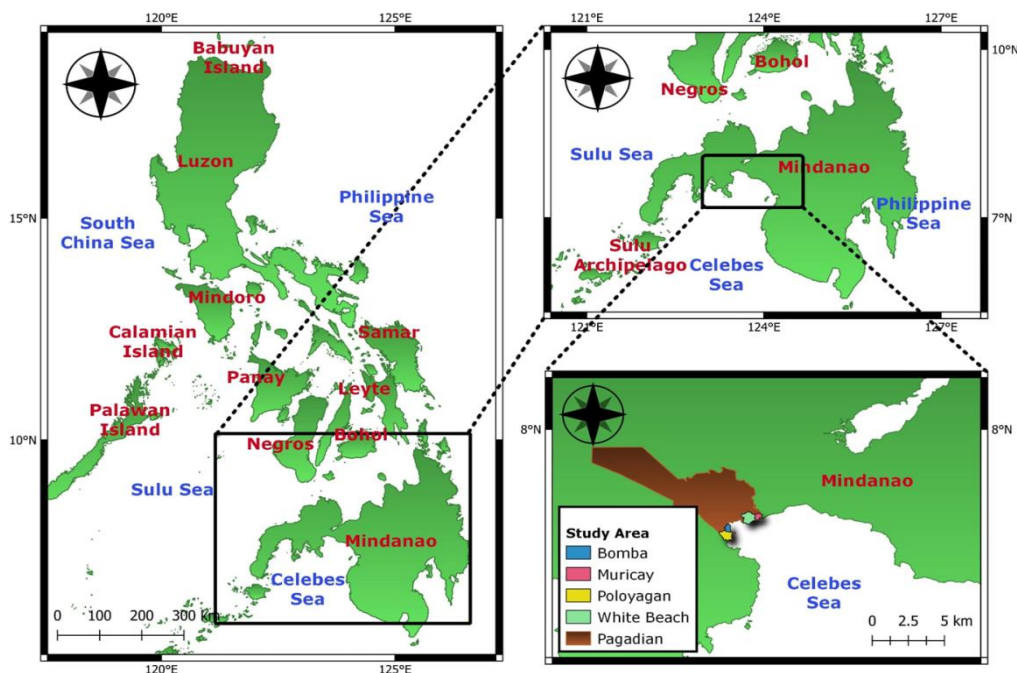


Figure 1. Map of the study area and location of the sampling stations.

**Collection of data.** To describe the perception of seaweed farmers in Pagadian City, a survey and key informant interviews were conducted in April 2024. The survey utilized a structured and semi-structured questionnaire. A total of 160 participants were selected using a random sampling method and were individually interviewed from the four coastal barangays involved in seaweed farming. The survey included questions related to: (1) socio-demographic profiles of respondents, and (2) perceptions towards the application of organic fertilizer in seaweed farming. Additionally, key informant interviews were conducted with stakeholders in seaweed farming using in-depth interviewing techniques. Key informant participants included the Barangay Captain of Barangay White Beach, representatives from the Bureau of Fisheries and Aquatic Resources, City Agriculture Office, officers from Fisherfolks Association, and vendors from the Pagadian market who sell and buy seaweed.

**Statistical analysis.** The effect of gender on the perception of local seaweed farmers in using seaweed-based fertilizer was analyzed using an independent *t*-test, while the effects of age, civil status, farm ownership, and years of farming was analyzed using One-Way ANOVA with a significance level of  $p \leq 0.05$  in SPSS (version 21).

## Results and Discussion

**Socio-demographic profile.** The data revealed that the majority of seaweed farmers in Pagadian City were male, accounting for 63.75% of respondents, while females made up 36.25% (Table 1). This gender disparity could be attributed to the physical strength and technical skills required for tasks such as farm establishment, planting, maintenance, and harvesting. In offshore or deep-water farms, where physical labor, boat navigation, and diving skills are essential, men predominantly carry out these roles. However, in shallow-water areas, women's participation tends to be higher. While women are capable of working in seaweed farming, their involvement is often limited by domestic responsibilities, which they must balance with farm work.

The majority of seaweed farmers in Pagadian City were aged between 34 and 45, an age group that combines physical stamina with a willingness to adopt new technologies (Mengo et al 2023). This age group is the most active in seaweed farming, often due to limited educational opportunities and career options, and the

entrepreneurial potential of seaweed farming as a viable livelihood. Furthermore, seaweed farming is typically a family-based endeavor, with married couples and their children making up the majority of farmers in the area. The involvement of children ensures that farming knowledge and skills are passed down to the next generation, helping to sustain the practice over time. This family approach fosters better coordination, labor distribution, and resource management, leading to enhanced efficiency and productivity.

Table 1

Socio-demographic profile and distribution (percentages) of seaweed farmers in Pagadian City, Zamboanga del Sur

<i>Characteristics</i>	<i>Categories</i>	<i>Distribution (%)</i>
1. Gender	1 = male	63.75
	2 = female	36.25
2. Age group	1 = 22-33 years old	26.25
	2 = 34-45 years old	31.25
	3 = 46-57 years old	29.38
	4 = 58 years old and above	13.12
3. Civil status	1 = single	3.14
	2 = married	89.36
	3 = widowed	7.50
	4 = separated	0.00
4. Educational attainment	1 = none	11.25
	2 = elementary undergraduate	6.25
	3 = elementary graduate	36.25
	4 = high school undergraduate	6.25
	5 = high school graduate	30.63
	6 = college undergraduate	3.13
	7 = college graduate	5.62
	8 = graduate studies	0.62
	9 = vocational	0.00
5. Religion	1 = Catholic	60.00
	2 = Islam	34.37
	3 = others	5.63
6. Residency	1 = the same area	93.75
	2 = outside the area	6.25
7. Ethnicity	1 = Cebuano	65.00
	2 = Muslim	24.38
	3 = Iranon	8.12
	4 = Others	2.50
8. Type of household	1 = nuclear	96.87
	2 = extended	3.13
9. Number of family members	1 = 1-3	22.50
	2 = 4-6	56.25
	3 = 7-9	17.50
	4 = 10 and above	3.75
10. Number of family members involved in seaweed farming	1 = 1	23.13
	2 = 2	55.63
	3 = 3	12.50
	4 = 4 and above	8.74
11. Farm ownership	1 = owned	84.38
	2 = leased	4.38
	3 = others	11.24
12. Years in farming	1 = 5 years and below	4.00
	2 = 6-10 years	21.00
	3 = 11-15 years	48.75
	4 = 16-20 years	25.25
	5 = 21 years and above	1.00

A significant portion (89.36%) of seaweed farmers were married couples, and seaweed farming often functions as a family enterprise. This shared responsibility for investment and sustainability strengthens family bonds and provides a steady income stream, covering living expenses and contributing to the educational needs of children (Mengo et al 2023; San Juan et al 2023; Adhawati et al 2024).

Educationally, the seaweed farmers in Pagadian City generally had low levels of formal education, with most being elementary (36.25%) or high school (30.63%) graduates. Due to limited educational opportunities, many farmers prioritize immediate economic survival over further education (Alderete 2021; Wijayanto et al 2022). As a result, seaweed farming becomes a key livelihood option, offering hands-on learning passed down through generations (Dumilag et al 2023), and providing a means to support their families and improve their quality of life (Mateo et al 2021; San Juan et al 2023).

The majority of seaweed farmers in Pagadian City (60%) were Catholics, which aligns with the region's historical context and the prominence of Catholicism in the Philippines (Arriesgado et al 2023). Most farmers resided near their farms, which offer several advantages, such as easier monitoring and maintenance. Proximity to farms allows for quick responses during unfavorable seasons, helping to minimize damage to crops and prevent drastic changes in seaweed growth (Langford et al 2023; Spillias et al 2023). In other coastal regions, such as Indonesia, living near seaweed farms also enhances security, reduces travel time, and boosts work efficiency (Mariño et al 2019; Rimmer et al 2021).

The majority (65%) of seaweed farmers in Pagadian City were Cebuano, reflecting the strong presence of the Cebuano ethnic group in Mindanao. Ethnic diversity plays a crucial role in the seaweed industry, with various groups integrating their cultural practices with seaweed cultivation (Msuya et al 2022). Similarly, other ethnic groups like the Sama Badjau and Tausug in Tawi-Tawi are also heavily involved in the industry (Navarro 2015; Neish et al 2017).

The nuclear family structure was predominant among seaweed farming households in Pagadian City, comprising 96.87% of farming families. This family model offers several advantages, such as effective labor distribution, financial management, and efficient use of time and resources (Teniwut & Teniwut 2018). During critical farming periods like planting and harvesting, tasks are divided among family members to ensure timely completion, promoting work efficiency and mutual support (Msuya & Hurtado 2017).

Seaweed farming families typically consisted of 4 to 6 members (56.25%), a household size that supports efficient labor distribution. Larger families provide greater labor capacity, increasing potential income generation and enabling better adaptation to risk diversification (Aslan et al 2018; Crawford 2022; Salazar et al 2024).

The study also observed that seaweed farming activities were often carried out jointly by husband and wife (55.63%). Both parents actively engaged in farming, while children participated when they were free from school duties. According to Daris et al (2021), this division of labor allows couples to work together efficiently, often completing multiple tasks at once, such as harvesting, drying, and marketing the seaweed.

Most seaweed farmers in Pagadian City (84.38%) owned their farms, providing them with control over all aspects of the operation and allowing them to retain all profits. However, when farm yields are poor, farmers may seek more suitable locations by renting plots or constructing new farms. Some also engaged in contract farming, where they planted on others' farms in exchange for a share of the profits.

Finally, seaweed farming in Pagadian City was a generational practice, with many farmers starting at a young age and continuing it as their main livelihood throughout their lives. The generational transmission of knowledge is crucial for the sustainability of seaweed farming, with the majority of farmers in the study having been involved in seaweed farming for 11 to 15 years (48.75%). Techniques for pest and disease control, as well as cultivation practices, are passed down from one generation to the next, ensuring the continued success of the industry (Mateo et al 2021).

**Local perception of the use of seaweed-based fertilizers among seaweed farmers in Pagadian City.** As shown in Table 2, gender had a significant effect on the environmental impact of seaweed-based fertilizer use. Male seaweed farmers in Pagadian City tended to view seaweed-based liquid fertilizers positively, recognizing their potential to promote sustainable agriculture. They appreciated the natural composition of these fertilizers, which reduces reliance on harmful synthetic chemicals and enhances water fertility without depleting natural resources (Fernández et al 2024). This approach aligned with their role in managing external factors like water quality, crucial for long-term agricultural productivity. In contrast, women often focused on more localized tasks like planting, harvesting, and processing, which are traditionally tied to their household and community roles. This focus can limit their broader understanding of the impact of seaweed-based fertilizers in farming (Mirera et al 2020).

Table 2  
Effects of gender on local perception of seaweed-based liquid extract utilization in Pagadian City, Zamboanga del Sur (mean±S.D.)

<i>Independent variable</i>	<i>Dependent variables</i>	<i>d.f.</i>	<i>t-statistics</i>	<i>p value</i>
Gender	Environmental impact	478	1.478	0.007*
	Effectiveness and quality	478	0.160	0.331
	Sustainability and profitability	478	1.344	0.023*
	Interest in seaweed extract use	478	1.007	0.082

Note: \* represents significant differences at  $p < 0.05$ .

The age of farmers significantly influenced the sustainability and profitability of using seaweed-based fertilizers (Table 3). In Pagadian City, the majority of farmers were aged between 34 and 45 years old, and in this study, this age bracket was considered middle-aged. Younger farmers often relied on trial-and-error approaches, which may initially affect the quality and effectiveness of fertilizers. However, over time, this approach can optimize resource use (Langford et al 2023). Middle-aged farmers typically combine practical farming knowledge with physical capability, allowing them to use fertilizers sustainably and maximize profits (Mariño et al 2019). In contrast, older farmers might lack access to digital tools or training programs, leading them to rely on time-tested methods. While this ensured steady profitability, it might result in more moderate returns. This knowledge gap influences their perspectives on the impact of seaweed-based fertilizers for sustainable and profitable seaweed farming (Mariño et al 2019).

Table 3  
Effects of age group, civil status, farm ownership and years of farming on local perception of seaweed-based liquid extract utilization in Pagadian City, Zamboanga del Sur (mean±S.D.)

<i>Independent variables</i>	<i>Dependent variables</i>	<i>d.f.</i>	<i>F-statistics</i>	<i>p value</i>
Age group	Environmental impact	3	1.150	0.328
	Effectiveness and quality	3	0.339	0.797
	Sustainability and profitability	3	2.523	0.057*
	Interest in seaweed extract use	3	0.814	0.487
Civil status	Environmental impact	3	0.407	0.666
	Effectiveness and quality	3	0.681	0.507
	Sustainability and profitability	3	3.105	0.046*
	Interest in seaweed extract use	3	0.871	0.419
Farm ownership	Environmental impact	3	1.750	0.175
	Effectiveness and quality	3	7.051	0.001*
	Sustainability and profitability	3	7.713	0.001*
	Interest in seaweed extract use	3	4.453	0.012*

Years of farming	Environmental impact	3	3.531	0.015*
	Effectiveness and quality	3	3.860	0.010*
	Sustainability and profitability	3	6.001	0.001*
	Interest in seaweed extract use	3	6.591	0.000*

Note: \* represents significant differences at  $p < 0.05$ .

Civil status also played a role in the adoption of seaweed-based fertilizers. The majority of farmers in Pagadian City were married, which often provided greater financial stability compared to single individuals. This stability encourages couples to invest in sustainable practices like seaweed-based fertilizers, viewed as long-term investments in farm productivity (Kiriti & Tisdell 2004; Parappurathu et al 2023). Additionally, the shared responsibilities in a partnership allowed for greater risk-taking in adopting innovative farming techniques, with both partners sharing potential rewards and challenges. Emotional support from a committed relationship can also positively influence attitudes toward sustainability and profitability, encouraging the adoption of practices like using seaweed-based fertilizers.

Seaweed farm ownership significantly affected the use of seaweed-based fertilizers, and the majority of farmers in Pagadian City owned their farms. Farm owners view fertilizers as a long-term investment in seaweed health and productivity, aligning with their sustainable farming practices (Sugumaran et al 2022). Ownership provides greater autonomy in decision-making, making owners more likely to invest in high-quality inputs. In contrast, renters often prioritize short-term cost-effectiveness due to limited tenure security (Neish et al 2017). Farm owners also exhibit a stronger sense of stewardship, prioritizing sustainability and environmental health (Neish et al 2017; Ciravegna et al 2023). Renters, however, are more risk-averse, focusing on immediate returns over long-term sustainability due to uncertainties about future tenure (Alin et al 2015). Overall, ownership encourages a longer-term perspective, making owners more inclined to adopt practices like seaweed-based fertilizers, benefiting both the environment and long-term profitability (Satria et al 2017; Rimmer et al 2021; Garrity 2023).

The years of experience in seaweed farming, with the majority of farmers in Pagadian City having been in the business for 11-15 years, profoundly shaped their perceptions regarding the use, sustainability, and profitability of seaweed-based fertilizers. Experienced farmers have a deeper understanding of the environmental impacts and long-term consequences of their practices, allowing them to adapt to evolving methods and regulatory changes (Spillias et al 2022). Their experience enables them to assess the effectiveness of seaweed-based fertilizers based on observed changes in growth rates, yield, and plant health (Stuiver et al 2004; Johnson et al 2019). Over time, seasoned farmers become skilled in evaluating the cost-effectiveness of fertilizers through nuanced cost-benefit analyses, balancing financial and environmental sustainability (Serebrennikov et al 2020). Additionally, their awareness of market trends, including the demand for sustainably produced crops, shapes their views on profitability (Yue et al 2020). As a result, experienced farmers often perceive seaweed-based fertilizers not only as environmentally sustainable but also as a strategic investment aligned with their long-term commitment to sustainable farming practices.

**Conclusions.** This study highlights the significant influence of socio-demographic factors such as gender, age, marital status, farm ownership, and experience on the adoption of seaweed-based fertilizers among farmers in Pagadian City. Male farmers generally have a broader understanding of the environmental benefits of these fertilizers, while women's involvement tends to focus on more localized tasks. Younger farmers often rely on experiential learning methods, while middle-aged farmers combine practical knowledge with physical capabilities for sustainable use. Married couples and farm owners, with greater financial stability and long-term perspectives, are more inclined to invest in these fertilizers. Additionally, farmers with more experience, especially those with 11-15 years in seaweed farming, have a deeper understanding of the sustainability and profitability of these practices. The generational transmission of knowledge, family-based labor, and

farm ownership all contribute to the sustainable and profitable use of seaweed-based fertilizers in Pagadian City.

**Acknowledgements.** We would like to thank the DOST-ASTHRD for the scholarship and thesis grant awarded to Angel Lyn P. Mirayo, and the Department of Marine Science, College of Science and Mathematics, MSU - Iligan Institute of Technology for their support in the conduct of this research.

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

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Received: 02 February 2025. Accepted: 12 April 2025. Published online: 10 July 2025.

Authors:

Angel Lyn P. Mirayo, Mindanao State University-Iligan Institute of Technology, College of Science and Mathematics, Department of Marine Science, Iligan City 9200, Philippines, e-mail: angellyn.mirayo@g.msuiit.edu.ph

Maria Luisa S. Orbita, Mindanao State University-Iligan Institute of Technology, College of Science and Mathematics, Department of Marine Science, Iligan City 9200, Philippines, e-mail: marialuisa.orbita@g.msuiit.edu.ph

Ronaldo R. Orbita, Department of Professional Education, College of Education, Mindanao State University-Iligan Institute of Technology, Philippines, e-mail: ronaldo.orbita@g.msuiit.edu.ph

Maria Lourdes Dorothy G. Lacuna, Mindanao State University-Iligan Institute of Technology, College of Science and Mathematics, Department of Marine Science, Iligan City 9200, Philippines, e-mail: marialourdesdorothy.lacuna@g.msuiit.edu.ph

Amabelle A. Embornas, Department of Sociology, College of Arts and Social Sciences, Mindanao State University-Iligan Institute of Technology, Iligan City 9200, Philippines, e-mail: amabell.embornas@g.msuiit.edu.ph

Sheila L. Dagondon, Mindanao State University-Iligan Institute of Technology, Department of Biological Sciences, Iligan City 9200, Philippines, e-mail: sheila.dagondon@g.msuiit.edu.ph

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How to cite this article:

Mirayo A. L. P., Orbita M. L. S., Orbita R. R., Lacuna M. L. D. G., Embornas A. A., Dagondon S. L., 2025 Seaweed farmers' socio-economic conditions, practices, and local perception of seaweed-based liquid extract utilization in Pagadian City, Zamboanga del Sur. *AACL Bioflux* 18(4):1675-1685.