

Gender Dynamics in Seaweed Farming: Roles, Opportunities and Challenges in the Coastal Philippines

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Abstract

This study examined socioeconomic and demographic characteristics, the attribution of roles and opportunities in seaweed farming and the challenges faced by men and women farmers in Santa Fe, Romblon, Philippines. A descriptive cross-sectional survey was conducted among 104 registered seaweed farmers selected through gender-stratified random sampling (52 men and 52 women). Frequency counts and percentages described the attribution of roles and opportunities to men, women, or both. Two-sided exact binomial tests compared attributions between men and women after excluding responses categorized as both men and women. Mann-Whitney U tests then compared challenge domain scores between men and women. Men-only attribution was significantly more frequent than women-only attribution for 11 of the 14 cultivation roles, 6 of the 8 processing roles, 8 of the 12 marketing roles and 33 of the 35 opportunity indicators ($p < 0.05$). In contrast, challenge ratings did not differ significantly by gender across the economic, environmental, social, or market domains ($p = 0.250-0.956$; effect size $r = 0.006-0.113$). The results indicate that respondents perceived unequal access to many productive and decision-making roles and opportunities, although several activities were viewed as shared. Gender-inclusive programs should expand women's direct access to training, technology, finance, markets, leadership and the decisions that drive outcomes, while still addressing the environmental and economic challenges that affect seaweed producers and farmers.

Keywords: Coastal Livelihoods, Coastal Philippines, Gender Dynamics, Gender Roles, Seaweed Farming.

Introduction

In many tropical coastal communities, seaweed farming is a major source of income because it can be carried out at the household level, requires only relatively simple equipment and enables people in remote areas to access food, hydrocolloid, agricultural and industrial markets. Comparative evidence from developing countries also shows that the economic performance of seaweed cultivation varies by farming system, production costs, market arrangements and access to inputs (1). In the Philippines, this form of farming is closely associated with family labor systems in which production, post-harvest handling, trading and other household responsibilities are carried out together. The advantages and risks of seaweed farming depend not only on production levels and income but also on who performs each task, who owns the productive resources, who interacts with buyers and who participates in training and collective decision-making. Research in Bantayan, Philippines, shows that women contribute significantly to seaweed production but differ from men in their level of involvement, earnings and

degree of empowerment (2). Moreover, comparative studies indicate that farm management, market linkages and production methods influence small-scale farmers' profits. Women contribute to production, post-harvest activities, marketing and unpaid household work, yet their contributions often receive less public recognition than men's (3). In Samoa, women in the seaweed value chain perform seed preparation, processing, record-keeping, quality control, sales and unpaid reproductive work (4). Stakeholders' perceptions and local knowledge systems also shape gendered recognition and the allocation of responsibilities within the Philippine seaweed industry. Furthermore, a social-network analysis in the Philippines showed that access to information and institutional relationships is unevenly distributed throughout the industry (5). This uneven distribution limits women's access to credit, equipment, technologies, leadership roles and higher-value markets, while also keeping women's labor less visible, even though it is essential to continuing farm operations and

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household well-being. This shows that the kinds of work people do, their mobility, their authority and their control over resources, with men carrying out offshore activities that are physical, demanding, technical and market-oriented, shape gender expectations. Seaweed farming involves a series of interrelated tasks, including selecting sites, preparing lines or nets, obtaining seedlings, planting, performing maintenance, harvesting, drying, processing, transporting, negotiating and selling. These tasks vary by location, physical demands, timing, access to boats and equipment, interactions with buyers and control over money. As a result, both women and men participate, but they often receive unequal recognition or access to profitable positions and decision-making roles. In Tanzania, climatic variability has disrupted production and led farmers to adopt coping and adjustment strategies (6). In Zanzibar, participation in seaweed aquaculture is linked to women's economic opportunities but remains shaped by unequal control over the benefits (7). Evidence from Chile and Zanzibar also indicates that participation and the benefits obtained depend on access to productive assets, markets, technology, mobility and decision-making power (8). It is therefore necessary to consider the challenges alongside the roles and opportunities involved.

Seaweed farmers also face warming waters, disease, epiphyte infestations, typhoons, declining water quality, price fluctuations, limited working capital and weak bargaining power. These pressures can reduce yields, damage farm structures, disrupt cultivation cycles and require additional labor and capital to resume production. Although men and women may farm in the same coastal area, their ability to predict, absorb and recover from shocks may differ because access to boats, savings, credit, information, extension services, household labor and alternative income sources is not always equal. A social-network analysis of the Philippine seaweed industry also showed that access to information, institutions and market actors affects participation and influence throughout the value chain (9). Therefore, it is more helpful to examine specific activities than to label seaweed farming as women's work, men's work, or a shared livelihood. A gender-responsive analysis should distinguish between constraints that affect the system as a whole and the

inequalities that determine who controls resources and who benefits from adaptation or market interventions.

Although earlier studies have deepened our understanding of gender in the fisheries and aquaculture sectors, important limitations remain. Much of the existing literature is qualitative, focuses on specific stages of the value chain, or reports participation without statistically testing whether men's and women's roles differ. When an activity is shared, descriptive predominance can be overstated. Gender equality in aquatic-food systems also includes access to resources, agency, recognition, institutional support, workload and control over benefits, not just participation (10). Gender norms can affect access to capital, mobility, market information, networks and business decisions (11) and women's work in fisheries is often underreported or invisible (12). Furthermore, shared participation does not necessarily imply equal time, pay, authority, or control over income. These differences matter when research findings are used to determine who the beneficiaries should be, provide technical training, arrange financing, distribute equipment, or offer enterprise support.

To address these gaps, the present study examined the socioeconomic and demographic characteristics of registered seaweed farmers; assessed whether cultivation, processing and marketing roles, as well as available livelihood opportunities, were carried out by men, women, or both; tested whether the frequencies of attributing these roles and opportunities solely to men or solely to women differed significantly; and evaluated whether the economic, environmental, social and marketing challenges cited by men and women varied. The study thus included both descriptive frequencies and inferential tests, while keeping the shared-response category as a key descriptive measure.

The study provides original quantitative data at the community level for Romblon, a region underrepresented in research on gender and aquaculture. Its contribution lies in distinguishing among men-only, women-only and shared attributions; conducting exact binomial tests only for the mutually exclusive men-only and women-only responses; and using a nonparametric test to compare the distributions of challenges. This approach prevents treating a small descriptive difference as evidence of gender predominance.

Instead, it provides context-specific evidence to inform inclusive extension, financing, technology, market and leadership initiatives.

Methodology

Study Design

A descriptive, quantitative, cross-sectional design was used to examine gender-related roles, opportunities and challenges at a single point in time. This design was appropriate because the study sought standardized community-level descriptions and statistical comparisons rather than causal inference. The categorical attribution format preserved respondents' perceptions of men-only, women-only and shared responsibility, while domain scores summarized reported challenges.

Study Area and Participants

The study was conducted in five coastal barangays: Agmanic, Guinbirayan, Danao Norte, Magsaysay and Tabugon in Santa Fe, Romblon, Philippines, where seaweed farming is a well-established livelihood. The municipal center of Santa Fe is situated at about 12.1552° N and 121.9943° E. The approximate central coordinates of the barangays sampled are 12.1228° N and 122.0038° E for Agmanic; 12.1739° N and 122.0358° E for Guinbirayan; 12.1906° N and 122.0328° E for Danao Norte; 12.1588° N and 122.0117° E for Magsaysay; and 12.1363° N and 122.0159° E for Tabugon. These coordinates refer to the approximate positions of the barangay centers, not the locations of individual respondents or farms. Eligible participants were registered farmers at least 18 years old, living in the selected barangays and having participated in at least one production cycle, either for commercial cultivation or processing. Inactive registered farmers, those not living in the barangays, those not involved in cultivation and those unwilling to participate were excluded.

Sample Size and Sampling Procedure

The list of respondents consisted of 142 seaweed farmers recorded in official local documents. It was divided by gender into separate lists for men and women to ensure balanced representation. By means of simple random sampling within each group, 52 men and 52 women (giving a total of N=104) were selected. Eligibility required that respondents were seaweed farmers who were at least 18 years old, currently involved in farming

and had given consent to take part; unregistered respondents who were not active in farming were excluded.

Research Instrument and Reliability

A detailed, validated questionnaire, reviewed by experts in gender and development and the social sciences, was used to collect data. The questionnaire includes sections on respondent characteristics and involvement in cultivation, processing and marketing; opportunities related to resources, income, decision-making, value addition, markets, education and training and social capital; and the economic, environmental, social and marketing challenges they face. The questionnaire was pretested before administration. Internal consistency coefficients for the challenge areas were 0.804 for economic, 0.749 for environmental, 0.728 for social and 0.655 for marketing. The lower marketing coefficient was retained and interpreted with caution because the domain consisted of only five items.

Data Collection and Analysis

The data were analyzed using IBM SPSS Statistics, version 20.0. Frequencies and percentages summarized demographic characteristics and the roles and opportunities for men, women, or both. For each role or opportunity indicator, a two-sided exact binomial test assessed whether the proportions of responses indicating men-only or women-only roles or opportunities differed from an equal 0.50 distribution. Responses listing both men and women were included for descriptive purposes only and excluded from the test. The challenge-domain scores were summarized using medians, interquartile ranges and mean ranks and compared by sex using the Mann-Whitney U test, since the ordinal scores were not assumed to be normally distributed. Effect size was calculated using the formula $r = |Z|/\sqrt{N}$ and statistical significance was defined as $p < 0.05$. With 52 respondents in each gender, the comparison between the two groups could detect approximately moderate standardized differences, although small effects might still go undetected. The power of each exact binomial test depended on the number of men-only and women-only responses after the exclusion of the 'both' responses. Therefore, non-significant results indicate insufficient evidence of a difference and should not be taken as proof of equivalence.

Ethical Considerations

Participation in the study was entirely voluntary and informed consent was obtained before administering the questionnaire. Respondents' confidentiality and anonymity were maintained. The collected data were securely stored and used solely for research purposes in accordance with the Philippine Data Privacy Act of 2012.

Results

Socioeconomic and Demographic Characteristics

Table 1 presents the socioeconomic and demographic characteristics of the registered seaweed farmers who participated in the study.

Table 1: Socioeconomic and Demographic Characteristics

Socioeconomic and Demographic Characteristics	Category	Frequency	Percentage (%)
Age	18–32 years	9	8.7
	33–47 years	37	35.6
	48–57 years	24	23.1
	≥58 years	34	32.7
Sex	Male	52	50.0
	Female	52	50.0
Education	Elementary level	28	26.9
	High School level	59	56.7
	College level	12	11.5
	Vocational level	4	3.8
	Master's level	1	1.0
Civil Status	Single	35	33.7
	Married	65	62.5
	Widowed	4	3.8
Main Livelihood	Seaweed culture only	72	69.2
	Seaweed + capture fishing	22	21.2
	Seaweed + non-fishing activity	10	9.6
Farming experience	5 years and below	26	25.0
	6 – 10 years	26	25.0
	11 – 15 years	20	19.2
	16 -20 years	11	10.6
	21 -25 years	9	8.7
	26 – 30 years	3	2.9
	31 – 35 years	2	1.9
	36 years and above	7	6.7
Main Capital Source	Family	78	75.0
	BFAR	16	15.4
	Other/multiple sources	10	9.6

Note: n = number of respondents, N = total sample (104)

Among the 104 respondents, 55.8% were at least 48 years old, whereas only 8.7% were 18–32 years old. The sample included equal numbers of men and women, as required by the stratified sampling design. Most respondents had completed high school, were married and relied exclusively on seaweed farming. Farming experience was evenly split between those with 10 years or less and those with more than 10 years. Most respondents used personal or family resources as their primary source of farming capital. The instrument did not collect information on household composition,

income amount, cooperative membership, or farm size, as shown in Table 1.

Gender Attribution of Cultivation Roles

Men-only attribution was significantly more frequent than women-only attribution in 11 of the 14 cultivation activities. It was strongest for preparing the cultivation area, selecting the farming site, transferring seedlings, installing cultivation structures, monitoring seaweed growth and harvesting. In contrast, tying seedlings, attaching the main rope and performing routine maintenance showed no statistically significant differences between men and women. Tying

seedlings was the most gender-balanced activity, with 39 respondents attributing it to men, 40 to women and 25 to both. These results indicate that cultivation activities were generally perceived as

associated with men, although several activities were considered balanced or shared, as shown in Table 2.

Table 2: Gender Attribution of Cultivation Roles in Seaweed Farming

Cultivation Indicators	Men n (%)	Women n (%)	Both, n (%)	Binomial p-value
Site selection	76 (73.1)	4 (3.8)	24 (23.1)	<0.001
Preparing the cultivation area	79 (76.0)	4 (3.8)	21 (20.2)	<0.001
Purchase of seedlings, ties, etc.	68 (65.4)	11 (10.6)	25 (24.0)	<0.001
Setting up lines or nets	71 (68.3)	13 (12.5)	20 (19.2)	<0.001
Preparing seedlings for planting	63 (60.6)	27 (26.0)	14 (13.5)	<0.001
Transferring seedlings	74 (71.2)	15 (14.4)	15 (14.4)	<0.001
Tying seedlings to rope or nets	39 (37.5)	40 (38.5)	25 (24.0)	1.000
Attach the main rope to the sea	48 (46.2)	39 (37.5)	17 (16.3)	0.391
Clean the ropes or nets	63 (60.6)	23 (22.1)	18 (17.3)	<0.001
Regular maintenance of the area	45 (43.3)	37 (35.6)	22 (21.2)	0.440
Collect fallen seaweed	70 (67.3)	15 (14.4)	19 (18.3)	<0.001
Nursing seaweed seedlings	71 (68.3)	18 (17.3)	15 (14.4)	<0.001
Monitoring the seaweed	71 (68.3)	12 (11.5)	21 (20.2)	<0.001
Harvesting the mature seaweed	59 (56.7)	11 (10.6)	34 (32.7)	<0.001

Note: n = number of respondents, N = total sample (104). The exact binomial test compares men-only and women-only responses; 'both' responses are descriptive and excluded from the test. $p < 0.05$ indicates a significant difference; $p \geq 0.05$ indicates no significant difference

Gender Attribution of Processing Roles

Men-only attribution was significantly more frequent across six of the eight processing activities. Machinery operation and maintenance, transportation of materials and finished products, technical processing, packaging and labeling and actual seaweed processing received the strongest men-only attribution. Product development had

the highest shared attribution and showed no significant men-women difference ($p = 0.162$). Quality assurance also showed no statistically significant predominance ($p = 0.050$), although its descriptive frequency was higher for men. Thus, processing activities were generally perceived as associated with men, but product development and quality assurance showed more balanced participation, as shown in Table 3.

Table 3: Gender Attribution of Processing Roles in Seaweed Farming

Processing Indicators	Men n (%)	Women n (%)	Both, n (%)	Binomial p-value
Developing new products	37 (35.6)	25 (24.0)	42 (40.4)	0.162
Ensure the quality of processed seaweed products.	47 (45.2)	29 (27.9)	28 (26.9)	0.050
Responsible for packaging/labeling	53 (51.0)	28 (26.9)	23 (22.1)	0.007
Processing seaweed into various products	53 (51.0)	25 (24.0)	26 (25.0)	0.002
Maintenance/operation of machinery	71 (68.3)	19 (18.3)	14 (13.5)	<0.001
Technical expertise in processing.	59 (56.7)	26 (25.0)	19 (18.3)	<0.001
Transporting raw materials and finished products	68 (65.4)	12 (11.5)	24 (23.1)	<0.001
Actual processing of seaweed	55 (52.9)	16 (15.4)	33 (31.7)	<0.001

Note: n = number of respondents, N = total sample (104). The exact binomial test compares men-only and women-only responses; 'both' responses are descriptive and excluded from the test. $p < 0.05$ indicates a significant difference; $p \geq 0.05$ indicates no significant difference

Gender Attribution of Marketing Roles

Among the 12 marketing roles, eight showed significantly more men-only than women-only attribution. Men were more frequently associated with direct selling, price negotiation, distribution, business management, market analysis, product

branding and selling processed products. Distribution had the strongest men-only attribution. Conversely, accounting and record-keeping, packaging design, buyer networking and customer relations showed no significant men-women differences. The results indicate that

strategic and externally oriented marketing roles were mainly attributed to men, whereas administrative and relationship-oriented activities were more evenly attributed, as shown in Table 4.

Table 4: Gender Attribution of Marketing Roles in Seaweed Farming

Marketing Indicators	Men n (%)	Women n (%)	Both, n (%)	Binomial p-value
Direct selling of raw and dried seaweeds	72 (69.2)	11 (10.6)	21 (20.2)	<0.001
Marketing and negotiating seaweed products	57 (54.8)	19 (18.3)	28 (26.9)	<0.001
Accounting and record-keeping	45 (43.3)	38 (36.5)	21 (20.2)	0.510
Designing the packaging	48 (46.2)	33 (31.7)	23 (22.1)	0.119
Managing small-scale seaweed processing businesses	59 (56.7)	31 (29.8)	14 (13.5)	0.004
Analyzing market trends	69 (66.3)	22 (21.2)	13 (12.5)	<0.001
Negotiating sales pricing/agreements	69 (66.3)	18 (17.3)	17 (16.3)	<0.001
Distribution of processed seaweed products	79 (76.0)	16 (15.4)	9 (8.7)	<0.001
Engage in networking activities to build relationships with buyers	52 (50.0)	37 (35.6)	15 (14.4)	0.137
Branding development	60 (57.7)	24 (23.1)	20 (19.2)	<0.001
Responsible for managing customers	47 (45.2)	33 (31.7)	24 (23.1)	0.146
Involved in direct selling of processed seaweed products	59 (56.7)	21 (20.2)	24 (23.1)	<0.001

Note: n = number of respondents; N = total sample (104). The exact binomial test compares men-only and women-only responses; 'both' responses are descriptive and excluded from the test. $p < 0.05$ indicates a significant difference; $p \geq 0.05$ indicates no significant difference

Gender Opportunities in Seaweed Farming

Men-only attribution was significantly more frequent than women-only attribution for 33 of the 35 opportunity indicators. This pattern favored men-only attribution across access to productive resources, income-generating activities, decision-making, value addition, market participation, education and training and social capital. The greatest disparities were observed in access to technology, market diversification, production and harvesting decisions, involvement in regional and

national markets and conflict negotiation. There were no significant differences between men and women regarding opportunities to acquire farming skills and knowledge and to share farming ideas (in both cases, $p = 0.097$). Although the women's empowerment indicator had the highest level of women-only attribution, sole attribution to men was still significantly more common ($p = 0.038$). In general, respondents believed that men had greater access to most livelihood and enterprise opportunities, while learning and the exchange of knowledge were seen as relatively accessible to both sexes, as shown in Table 5.

Table 5: Gender Opportunities in Seaweed Farming

Statements	Men n (%)	Women n (%)	Both, n (%)	Binomial p-value
Access to Resources				
Lease or acquire land	55 (52.9)	23 (22.1)	26 (25.0)	<0.001
Purchase high-quality	57 (54.8)	24 (23.1)	23 (22.1)	<0.001
Financial resources	61 (58.7)	30 (28.8)	13 (12.5)	0.002
Adopt new technologies	66 (63.5)	20 (19.2)	18 (17.3)	<0.001
Attend workshops	57 (54.8)	34 (32.7)	13 (12.5)	0.021
Access to Income Generation Opportunities				
Sell harvested seaweed	56 (53.8)	24 (23.1)	24 (23.1)	<0.001
Value-added seaweed products	61 (58.7)	29 (27.9)	14 (13.5)	0.001
Sell seaweed products in markets	55 (52.9)	29 (27.9)	20 (19.2)	0.006
Diversify other seaweed species	57 (54.8)	28 (26.9)	19 (18.3)	0.002
Integrate seaweed farming with eco-tourism activities	51 (49.0)	30 (28.8)	23 (22.1)	0.026

Access to Decision-Making Power				
What to plant, when to harvest	68 (65.4)	14 (13.5)	22 (21.2)	<0.001
Species of seaweed to cultivate	65 (62.5)	26 (25.0)	13 (12.5)	<0.001
Farming practices	66 (63.5)	21 (20.2)	17 (16.3)	<0.001
Expanding farming operations	63 (60.6)	19 (18.3)	22 (21.2)	<0.001
Market and sell seaweed products	58 (55.8)	27 (26.0)	19 (18.3)	0.001
Participation in Value Addition				
Engage in processing seaweed into value-added products	57 (54.8)	22 (21.2)	25 (24.0)	<0.001
Participate in developing new seaweed-based products	53 (51.0)	31 (29.8)	20 (19.2)	0.021
Ensure the quality of processed seaweed products	58 (55.8)	30 (28.8)	16 (15.4)	0.004
Design packaging for products	56 (53.8)	29 (27.9)	19 (18.3)	0.005
Diversify product range	61 (58.7)	20 (19.2)	23 (22.1)	<0.001
Access to Market				
Diversify markets	65 (62.5)	23 (22.1)	16 (15.4)	<0.001
Understands consumer preference	49 (47.1)	30 (28.8)	25 (24.0)	0.042
Utilize e-commerce platforms	62 (59.6)	31 (29.8)	11 (10.6)	0.002
Explore opportunities in accessing regional and national markets	56 (53.8)	28 (26.9)	20 (19.2)	0.003
Participation in trade fairs	59 (56.7)	18 (17.3)	27 (26.0)	<0.001
Education and Training				
Learning skills and knowledge	49 (47.1)	33 (31.7)	22 (21.2)	0.097
Availability of training programs	58 (55.8)	30 (28.8)	16 (15.4)	0.004
Raise awareness about sustainable seaweed farming	55 (52.9)	31 (29.8)	18 (17.3)	0.013
Promote the adoption of new technologies	56 (53.8)	30 (28.8)	18 (17.3)	0.007
Fostering the exchange of ideas	49 (47.1)	33 (31.7)	22 (21.2)	0.097
Social Capital				
Bring community members together in seaweed farming	54 (51.9)	28 (26.9)	22 (21.2)	0.005
Requires cooperation among farmers	62 (59.6)	27 (26.0)	15 (14.4)	<0.001
Provide social support to members	61 (58.7)	28 (26.9)	15 (14.4)	0.001
Negotiate to resolve conflicts	61 (58.7)	27 (26.0)	16 (15.4)	<0.001
Empower women	57 (54.8)	36 (34.6)	11 (10.6)	0.038

Note: n = number of respondents, N = total sample (104). The exact binomial test compares men-only and women-only responses; 'both' responses are descriptive and excluded from the test. $p < 0.05$ indicates a significant difference; $p \geq 0.05$ indicates no significant difference

Gender Challenges in Seaweed Farming

Both men-only and women-only groups gave environmental challenges the highest median score (Md = 3.31). For the economic (U=1343.50, $p=0.956$, $r=0.006$), environmental (U=1265.50, $p=0.571$, $r=0.056$), social (U=1179.50, $p=0.258$, $r=0.111$) and market challenges (U=1176.50,

$p=0.250$, $r=0.113$), there were no statistically significant gender differences. The effect sizes were negligible or small. Although these results show that there is insufficient evidence of gender differences in the overall ratings of the challenges, they should not be taken to mean that men and women had the same experiences, as shown in Table 6.

Table 6: Differences in the Challenges Experienced by Men and Women

Challenges	Men, Median (Q1-Q3)	Men Mean Rank	Women, Median (Q1-Q3)	Women Mean Rank	Mann- Whitney U	Z	p-value (r)
Economic	3.00 (2.59-3.50)	52.34	3.00 (2.67-3.42)	52.66	1343.50	-0.056	0.956 (0.006)
Environmental	3.31 (3.00-3.71)	54.16	3.31 (3.07-3.57)	50.84	1265.50	-0.566	0.571 (0.056)

Social	2.79 (2.50-3.00)	49.18	2.87 (2.59-3.17)	55.82	1179.50	-1.132	0.258 (0.111)
Market	2.81 (2.67-3.00)	55.88	2.70 (2.33-3.00)	49.13	1176.50	-1.151	0.250 (0.113)

Note: Effect size $r=|Z|/\sqrt{N}$. $p<0.05$ indicates a significant difference; $p\geq 0.05$ indicates no significant difference

Discussion

The demographic findings indicate that seaweed farming in Santa Fe is managed by mature, married farmers with basic or secondary education and is largely financed by households. The low presence of younger farmers raises concerns about livelihood continuity and the transmission of knowledge to the next generation. In contrast, a multi-center study in the Philippines found that most farmers were between 21 and 50 years of age (13) and a study in Tawi-Tawi and Sulu showed a similar age distribution (14). In mainland Tanzania, about 89.9% of participants in the seaweed supply chain were in the 26 to 50 age group (15), suggesting that the farming population in Santa Fe is relatively older. The lack of vocational and higher education may limit access to technical knowledge, financial management, digital marketing, value addition and climate-adapted practices. In Indonesia, seaweed farming has helped meet household needs for education, transportation, housing and other basic requirements (16) and farmers in Palawan intended to continue farming despite economic losses and operational difficulties (17). Overall, the results point to weaknesses in youth involvement, livelihood continuity, access to finance and dependence on family capital. However, the balanced gender representation does not reflect the broader farming population and the study did not include information on household composition, income, cooperative membership, or farm size, as shown in Table 1.

Most cultivation activities, including site selection, area preparation, input acquisition, structure installation, seedling transfer, monitoring and harvesting, were more often assigned to men. This may be because men have greater mobility, better access to equipment and marine areas and are involved in physically demanding offshore work. This finding aligns with evidence of gender disparities in seaweed aquaculture in Chile (18). However, it contrasts with women-dominated seaweed production in Zanzibar (19) and with the considerable role women play in seed preparation and maintenance in Indonesia (20). Meanwhile,

tying seedlings was almost equally divided between men and women, which aligns with reports of shared participation in Kenyan seaweed communities (21). Similarly, there were no significant gender differences in attaching the main rope or carrying out regular maintenance, showing that a production system generally attributed to men can still include many shared activities.

The findings support the view that gender equality in aquatic-food systems should be evaluated using participation, access to resources, agency, institutional support, workload, recognition and control over benefits, rather than simply by the number of participants (22). Although men primarily handle harvesting, women may still be involved in collecting, sorting, transporting, drying and preparing the harvest. This contrasts with evidence from Tamil Nadu, India, where women played important roles in collecting wild seaweed (23). In seaweed cultivation, gender roles shift with broader cultural expectations, indicating that men do not have exclusive control over women in farming. Hence, future research should include more direct observation, time-use data and qualitative interviews, as well as sex-disaggregated information on ownership, earnings, daily workload and decision-making as shown in Table 2. Seaweed processing was generally perceived as male-dominated, particularly in packaging and labeling, machinery operation and maintenance, technical processing, transportation and product processing. This perception may reflect men's better access to equipment, technical training, capital and mobility, as well as their engagement in physically demanding work. In contrast, in Indonesian coastal enterprises, women took central roles in processing, packaging and marketing, while men handled physically demanding production and procurement activities (24). Yet product development was considered a joint effort and there was no clear gender predominance in quality assurance, suggesting that collaboration was limited to certain areas. Shared product development offers opportunities

to diversify livelihoods, ensure food security and promote gender-inclusive enterprises, as seaweed can be processed into food, fertilizer, feed, cosmetics, pharmaceuticals and other value-added products (25). Evidence shows that processing, marketing and distributing aquaculture products can provide flexible opportunities for women (26). In general, gender-responsive programs should ensure equal access to machinery, technical training, financing, food-safety measures, packaging, quality control, entrepreneurship and digital marketing. However, the findings are based on perceived role attributions rather than direct observations of labor, ownership, income control, workload, or decision-making. Future studies should distinguish between household-based and commercial processing and examine time use, remuneration, ownership, training and authority related to processing activities, as shown in Table 3.

In seaweed marketing, gender roles are unevenly distributed, with men more often engaged in direct selling, price negotiation, distribution, market analysis and business management. This pattern may reflect men's greater public visibility as farm owners, traders, trainees and household representatives rather than the absence of women's contributions. The notion that men are responsible for negotiation and distribution may also stem from the structure of the seaweed market, in which large traders and exporters have more influence over prices than farmers and village traders (27). Nevertheless, evidence from the seaweed value chain in the Philippines shows that women's involvement in trading can lead to better empowerment outcomes (28). The absence of significant differences in accounting, packaging design, buyer networking and customer relations further demonstrates that marketing is not solely a male activity. Therefore, gender-responsive programs should aim to increase women's access to capital, market information, transportation, buyer networks, digital marketing, entrepreneurship training and roles in price negotiations as shown in Table 4.

The opportunity indicators show that access to technology, productive resources, markets, income-generating activities and decision-making in seaweed farming was gender-based. These results reflect respondents' perceptions and do not prove that women are entirely excluded. The belief

that aquaculture is a male-dominated activity can hinder women's involvement and progress (29). Similarly, structural inequalities in land, finance, technology and policymaking can prevent women from accessing, controlling and benefiting from livelihood opportunities (30). Nevertheless, this contrasts with the situation in the Zamboanga Peninsula, where women played a significant role in production, post-harvest activities and marketing, thereby contributing to household income (31). This pattern may reflect men's greater public visibility as farm owners, traders, trainees and household representatives rather than the absence of women's contributions. Both men and women considered learning and knowledge exchange relatively accessible. However, the idea that men are assigned the role of 'empowering women' implies that men may be seen as having control over household and community resources. Gender-sensitive interventions should therefore prioritize including women in technology demonstrations, financing, entrepreneurship training, trade fairs, digital marketing, leadership and strategic decision-making. True gender equality will require not only greater participation but also greater control by women over resources, income, opportunities and the decisions concerning enterprises, as shown in Table 5.

Both men and women seaweed farmers faced similar economic, environmental, social and market problems, though the absence of significant differences does not imply that their individual experiences were identical. Environmental issues were the most important factor for both groups, indicating similar exposure to adverse weather, changing water conditions, diseases, epiphytes, strong waves and damage to farming equipment. This finding aligns with results from Bangladesh, where environmental and production limitations were concerns at both the community and industry levels (32). However, the results contrast with those from Zanzibar, where women faced gender-specific technological, climatic, economic and sociocultural constraints and strong gender stereotypes affected their involvement in seaweed farming (33). Although women had a higher mean rank for social challenges and men had a higher mean rank for market challenges, these differences were not statistically significant. Interventions should therefore address common difficulties by

using climate information, conducting disease monitoring, employing resilient planting materials, providing financing, adding value to products, improving facilities, supporting collective marketing and identifying alternative buyers, while remaining sensitive to possible gender differences in the allocation of resources, responsibilities, participation and decision-making as shown in Table 6.

Limitations of the Study

Although the cross-sectional design can identify patterns and associations, it cannot establish causality. Because the participants were seaweed farmers from five barangays in Santa Fe, Romblon, the results cannot be generalized to unregistered farmers, farmers in other municipalities, or different production systems. The equal number of men and women reflects the stratified selection design rather than the actual gender distribution among the local farming population. The instrument measured perceived attribution rather than recording labor, time use, remuneration, asset ownership, income control, or decision-making authority. It also did not collect information on household composition, income levels, cooperative membership, or farm size. The sample may not have had sufficient power to detect small differences, particularly because many responses fell into both categories. Bias might have arisen from self-reporting and social desirability.

Conclusion

The study revealed a consistent pattern of attributing activities to men across cultivation, processing, marketing and livelihood opportunities in seaweed farming. Men-only attributions were significantly more common than women-only attributions across 11 of the 14 cultivation roles, 6 of the 8 processing roles, 8 of the 12 marketing roles and 33 of the 35 opportunity indicators. Nevertheless, product development and several administrative, relationship-based and maintenance activities showed substantial shared attribution or no statistically significant difference between men-only and women-only attributions. This indicates unequal community views on gendered responsibilities and access to opportunities, but does not prove that women or men are completely excluded from these activities.

There were no statistically significant differences between men and women farmers in their ratings of economic, environmental, social and market challenges, with effect sizes negligible or small. Environmental challenges received the highest ratings from both groups, indicating a shared need for climate information, resilient planting materials, disease monitoring, more robust farm structures, open pricing, accessible financing and better market support. Yet the absence of statistically significant differences should not be taken as proof that men and women have the same workloads, access to resources, or decision-making power.

The results indicate that gender-responsive measures should directly engage local governments, fisheries agencies, cooperatives, educational organizations and private buyers in technical training, technology demonstrations, beneficiary financing and programs, market negotiations, leadership and farm-level decision-making. The study was cross-sectional, relied on self-reported opinions and included only registered seaweed farmers in one municipality. Therefore, qualitative and multisite observational methods could be used to understand actual labor practices among men and women, including resource ownership, perceived workload, income control and decision-making.

Abbreviations

BFAR: Bureau of Fisheries and Aquatic Resources, IBM SPSS: IBM Statistical Package for the Social Sciences, RSU REDI: Romblon State University Research, Extension, Development and Innovation Office.

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Author Contributions

The corresponding author conceptualized the study, developed the methodology, coordinated data collection, analyzed and interpreted the data

and drafted, reviewed and approved the final manuscript.

Conflict of Interest

The author has no conflict of interest.

Ethics Approval

Participation in the study was entirely voluntary and informed consent was obtained before administering the questionnaire. Respondents' confidentiality and anonymity were maintained. The collected data were securely stored and used solely for research purposes in accordance with the Philippine Data Privacy Act of 2012.

Data Availability

The corresponding author will provide the data supporting this study's findings upon reasonable request.

Declaration of Artificial Intelligence (AI) Assistance

While working, Grammarly was used to assist with grammar, spelling and punctuation checks. ChatGPT was also used to assist with drafting, editing, structuring and formatting the manuscript. The author carefully reviewed and edited the content and took full responsibility for the final version. The author conducted the research, designed the study, gathered and analyzed the data, interpreted the results and drew conclusions.

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