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Harnessing Community-Based Aquaculture for the Sustainable Development of Small Scale Fishery

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Abstract. This study examines how the principles of sustainable development can be realistically applied to community-based aquaculture in small-scale fisheries. Using the case of the Simbuco Aqua-Marine Multi-Purpose Cooperative (SAMMPC) in Kolambugan, Lanao del Norte, this research explores the socio-economic and ecological dimensions of aquaculture activities and their broader implications for sustainability in small-scale fisheries. The study is framed within key Sustainable Development Goals (SDGs), particularly SDG 14 (Life Below Water) and SDG 8 (Decent Work and Economic Growth), highlighting how SAMMPC's initiatives align with global sustainability efforts. A mixed-methods approach was employed, integrating quantitative surveys with qualitative key informant interviews (KII) and focus group discussions (FGD). Findings indicate that SAMMPC has significantly improved members' livelihoods through diversified income streams, enhanced credit access, and strengthened social cohesion. Notably, the cooperative fosters inclusivity by promoting women's participation in aquaculture, contributing to SDG 5 (Gender Equality). However, challenges such as environmental degradation, resource depletion, and market instability highlight the complexities of balancing economic growth with ecological sustainability. While SAMMPC serves as a model for cooperative-based aquaculture, the study underscores the broader need for sustainable practices across small-scale fisheries. The research advocates for biodiversity-friendly aquaculture methods, climate-adaptive strategies, and improved waste management systems to mitigate environmental risks. By integrating these approaches and fostering multi-stakeholder partnerships, community-based aquaculture can be a viable pathway for sustainable development, ensuring both economic viability and ecological resilience.

Keywords: Community-based aquaculture; Small-scale fisheries; Seaweed, Sustainable development; Well-being.

1.0 Introduction

Community-based aquaculture (CBA) is a participatory approach that involves the local community in the planning, implementation, and management of aquaculture (Ateweberhan et al., 2018). It has been an integral part of the Philippines aquaculture sector since the 1970s (Agbayani, 2008). CBA has been seen as a viable or complementary means of generating income with the aim of establishing the wellbeing of impoverished small-scale fisheries (SSF) households (FAO, 2022).

SSF encompass a range of activities throughout the fisheries resource value chain which are undertaken typically by individuals and households with low levels of technology or capital investment and small fishing vessels (if any), making short fishing trips, close to shore, for local consumption (FAO, 2022). SSF provides around 40% of the world's fishery products hence they play a vital role in ensuring food security, nutrition, and livelihoods for millions of people worldwide. The Philippine Statistics Authority Fisheries Situation Report 2022 reveals that the total volume of SSF production amounted to 4,339.89 MT, with an uptick of 2.2% from the previous year. Aquaculture accounted for 54% of the total production, with seaweeds, milkfish, tilapia, and shrimps/prawns being the major cultured species. Furthermore, the marine municipal fisheries contributed 21.8% to the total fisheries production in the country. This highlights the significant role of small-scale fisheries in the country's seafood production.

SSF faces critical challenges from local threats and global pressures, including overexploitation, climate change, and inadequate governance. Community-based enterprises focusing on aquaculture cooperatives is advocated as a viable or complementary means for the sustainable development of SSF coastal communities (Fajardo, 2021). This phenomenon of adopting community-based and cooperative-led aquaculture as an enterprise to deal with the challenges brought on by small-scale fisheries can be observed in the Simbuco Aqua-Marine Multi-Purpose Cooperative. The Department of Agriculture (DA), through BFAR, launched the Special Area for Agricultural Development Program (SAAD) to support small-scale fishers (SSF) in impoverished coastal communities with high poverty rates, focusing on community-based enterprises to enhance resilience and sustainability. The Simbuco Aqua-Marine Multi-Purpose Cooperative (SAMMPC) in Lanao del Norte, established in 1993 by 20 fisherfolk as a seaweed farming group, grew to almost 200 members but faced significant setbacks due to environmental challenges, significantly decreasing seaweed production beginning 2018. As a SAAD beneficiary since 2019, SAMMPC shifted to milkfish production, achieving a gross income of Php10.3 million over three years with a 21% return on investment. This success underscores the potential of community-based aquaculture to strengthen SSF while raising the need to evaluate its broader ecological, social, and economic impacts.

As previously articulated, the CBA is an approach that empowers the small-scale fishery communities to ensure their sustainable livelihoods and wellbeing as enshrined in the Sustainable Development framework. This approach aligns with SDG 14's emphasis on conserving marine ecosystems while also supporting SDG 8's goals of inclusive economic growth and decent work (Fondo et al., 2024). By integrating material, relational, and subjective dimensions of wellbeing, CBA not only aims to improve household resources and social networks but also seeks to uplift perceptions of quality of life, ultimately contributing to the sustainability of SSF communities (Isaacs, 2019). This study examines whether the CBA approach of SAMMPC effectively addresses the economic, environmental, and social dimensions of sustainable development for its small-scale fisherfolks.

2.0 Methodology

2.1 Research Design

This research adopted a descriptive mixed-methods design, integrating qualitative and quantitative approaches to provide a comprehensive understanding of the case under study. This approach involved the simultaneous and equal collection and analysis of both qualitative and quantitative data (Creswell & Plano Clark, 2018). Qualitative analysis was conducted using thematic analysis and document review, allowing for a deep exploration of stakeholders' perceptions and challenges. This method enabled the identification of recurring patterns and themes, offering a contextualized understanding of the key issues (Braun & Clarke, 2006). Quantitative data were analyzed using descriptive statistics, which provided numerical insights and visual representations of variables such as local awareness, perceptions, participation, knowledge, and socio-economic conditions. These statistical analyses supported the qualitative findings by providing empirical data and quantifying the scope and significance of various phenomena (Field, 2017). Together, the qualitative and quantitative analyses offered a balanced and detailed portrayal of the research topic.

2.2 Research Locale

The study was conducted in Simbuco, Kolambugan, Lanao del Norte, a barangay strategically located along the coastline of Panguil Bay, a major fishing ground for Kolambugan's fisherfolk. It is the largest fishing community in Kolambugan per capita, with 70% of its households (210 out of 305) engaged in fishing activities. Simbuco, Simbuco Aqua-Marine Multi-Purpose Cooperative, was chosen as the study site due to its significance as one of

Kolambugan's largest fishing communities, its recent involvement in the DA-SAAD Phase I program, and its longevity as a community-based aquaculture enterprise. It initially focused on seaweed production but now diversifying into milkfish farming and other income-generating activities. Over the decades, the membership of SAMMPC has steadily grown, with the cooperative now accepting members from other barangays.

2.3 Research Participants

In this research, the inclusion criteria for survey respondents were a) involvement in either artisanal/capture fisheries, seaweed farming, milkfish production, and c) membership in SAMMPC for at least five years. There are currently 189 members of SAMMPC in 119 households. The sample size was determined using established statistical principles. A margin of error of 5% and a confidence level of 95% were applied to ensure precision in the findings. While the ideal sample size of 119 at a 95% confidence level and a 5% margin of error was 54, the study achieved 40 valid responses after data cleaning. This reduced sample size slightly increases the margin of error. However, the confidence level of 95% is retained, and the findings remain robust due to the representativeness of the sample and the use of a mixed-methods approach, which supplements quantitative results with qualitative insights for a comprehensive understanding. Five key-informant interviews (KII) targeted individuals with expertise, experience, or strategic positions related to the research subject. Key informants included SAMMPC leaders, BFAR representatives, local government officials. Meanwhile, in-depth interviews were conducted to at least five members of SAMMPC who presented valuable information during the survey. Furthermore, a focus group discussion (FGD) was held with nine individuals who were selected based on their involvement in seaweed and milkfish production and their active participation in SAMMPC. The FGD facilitated dynamic interactions, allowing participants to discuss shared experiences, challenges, and adaptation strategies in aquaculture. Together, the KIIs, in-depth interviews, and FGDs provided a rich contextual understanding, complementing the quantitative findings and enhancing the overall depth and reliability of the research.

2.4 Research Instrument

This study utilized several instruments to gather relevant quantitative and qualitative data. To obtain quantitative data, a five-part survey questionnaire was partly adapted from the work of Mengo et al. (2023). It collected data on participants' profiles, fisheries experience, and seaweed culture patterns influenced by climate change, and adaptation practices. A five-point Likert scale was used to rate statements, providing comprehensive insights into farmers' perceptions of SAMMPC as the main avenue by which CBA is enacted. The validity of the survey instrument was assessed using the Content Validity Ratio (CVR), and its reliability was confirmed with a Cronbach's alpha score of 0.9, indicating a high level of internal consistency. Likewise, the research tools also included guide questions for in-depth interviews, key informant interviews, and focus group discussions. Questions were tailored based on the specific objectives of the study, focusing on participants' experiences, challenges, and strategies in seaweed and milkfish production, as well as their perceptions of SAMMPC's as a CBA.

2.5 Data Gathering Procedure

The data gathering procedure was conducted in a systematic manner. Initially, the questionnaires used in the study were validated and tested for reliability to ensure the accuracy and consistency of the collected data. Data collection took place between January and August 2024. Courtesy calls and letters were sent to the Mayor of Kolambugan, the Barangay Chair of Simbuco, Chair of SAMMPC, and other concerned offices to obtain approval and support for the research. Informed consent was obtained from all participants, where each individual was presented with an informed consent form, had the contents explained to them, and voluntarily agreed to participate. Participants were given the option to skip any questions they did not wish to answer. Throughout the process, confidentiality was strictly maintained to protect the privacy of the respondents. After the data was collected, it underwent a thorough cleaning and analysis process before being used to draw conclusions and write the final report.

2.6 Ethical Considerations

The research adhered to ethical guidelines, including obtaining informed consent, ensuring confidentiality, and respecting cultural norms. Participants were informed about the study's purpose, procedures, and their right to withdraw at any time. Ethical considerations extended to data dissemination, with findings presented responsibly and respectfully.

3.0 Results and Discussion

3.1 Socio-demographic Profile and of SAMMPC members

As shown in Table 1, the socio-demographic profile of the participants reveals a predominantly middle-aged group, with 72.5% aged between 31-59 years, and a significant proportion being female (67.5%). Most participants are married (79%) and belong to small households, with 82.5% having 1-3 members. A majority (85%) have children involved in fisheries, reflecting the intergenerational nature of fishing livelihoods. Educational attainment is modest, with 55% completing high school and 27.5% having only elementary-level education, indicating limited access to advanced education. Membership in SAMMPC is driven mainly by economic opportunities, such as seaweed trading (40%) and access to credit (32.5%), with family and social influences accounting for 17.5%. Notably, 90% of participants are registered fisherfolk under the Municipal Fisherfolk Registration System, indicating active engagement in formalized fisheries activities. This shows the importance of inclusive programs targeting this demographic (Fajardo, 2021). Research on small-scale fisheries suggests that economic vulnerability and limited educational attainment are common barriers in coastal communities, impacting access to financial resources and decision-making autonomy (FAO, 2022). The predominance of women in the cooperative aligns with global trends in small-scale fisheries where women play a crucial role in processing and marketing but are often underrepresented in governance structures (Mengo et al., 2023). This shows the importance of inclusive programs targeting this demographic.

Table 1. *Socio-demographic profile of the participants*

Variables	N	%
Age		
≥ 60	10	25.0
31-59	29	72.5
18-30	1	2.50
Sex		
Male	13	32.5
Female	27	67.5
Civil Status		
Single	2	17.2
Married	30	79.0
Widow	4	1.10
Cohabitating	6	2.30
Household size		
1-3 members	33	82.5
4 + members	7	17.5
Children involved in fisheries		
1-3	34	85.0
4-5	6	15.0
Educational Attainment		
Elementary Level	11	27.5
High School level	22	55.0
Vocational	3	7.50
Higher Education	4	10.0
Reason for joining SAMMPC		
Seaweed trading	16	40.0
Source of credit	13	32.5
Influence of family/friends	7	17.5
Others	4	10.5
Registered fisherfolk*		
Yes	36	90.0
No	4	10.0

**Based on the Municipal Fisherfolk Registration System or FishR*

Table 2 and Figure 1 indicates a significant shift in fisheries activities among SAMMPC members before and during their membership. Prior to joining SAMMPC, 92.5% of respondents were engaged in fisheries, with the majority (56.8%) participating in both seaweed farming and artisanal fishing. During SAMMPC membership, 100% of respondents reported involvement in fisheries, with a notable increase in diversified activities. Seaweed farming remained predominant, either as a sole activity (35%) or combined with artisanal fishing (60%). The SAAD project further enhanced this diversification, with 55% benefiting from both seaweed farming and fish pen activities, and 12.5% engaging in post-harvest processing.

Table 2. *Fisheries activities before and during SAMMPC membership (Pre-SAAD and SAAD)*

Variables	N	%
Involvement in Fisheries before SAMMPC membership		
None	3	7.50
Yes	37	92.5
Type of fisheries activity before SAMMPC membership		
Artisanal/ capture fishing only	1	2.70
Fish pen/cage only	1	2.70
Seaweed farming only	11	29.7
Seaweed farming, Artisanal/capture fishing	21	56.8
Seaweed farming, Fish pen/cage, Artisanal/ capture fishing	3	8.10
Fisheries activity during SAMMPC membership (pre-SAAD)		
No	0	0
Yes	40	100
Type of fisheries during SAMMPC membership (pre-SAAD)		
Seaweed farming only	14	35.0
Seaweed farming, Artisanal/ capture fishing	25	60.0
Seaweed farming, Fish pen/cage, Artisanal/ capture fishing	1	5.00
SAAD Project directly benefited in		
Fish pen only	2	5.00
Seaweed farming only	11	27.5
Seaweed farming, Fish pen	22	55.0
Post-harvest processing (bangus, seaweed)	5	12.5

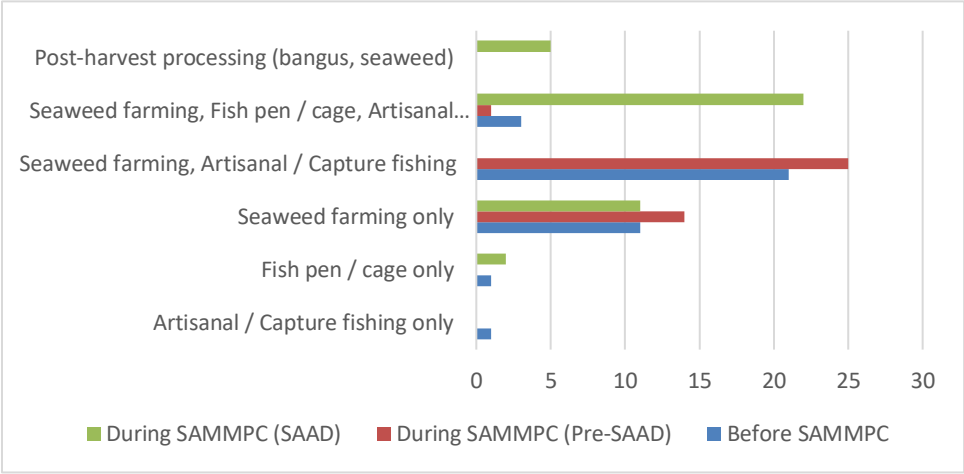

Figure 1. *Fisheries activities before and during SAMMPC membership (Pre-SAAD and SAAD)*

This diversification aligns with studies emphasizing the importance of alternative livelihoods in enhancing resilience among small-scale fishers. The Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries (SSF Guidelines) highlight the need for livelihood diversification to mitigate risks associated with environmental variability and market fluctuations (FAO, 2023). SAMMPC's support for fish pen aquaculture and post-harvest processing reflects a broader strategy to stabilize incomes while addressing seasonal declines in seaweed production (Fajardo, 2021).

Table 3 reveals that 70% of SAMMPC seaweed farmers engage in alternative livelihoods alongside aquaculture, with skilled labor (25%) and agriculture (21.43%) being the most common options. Meanwhile, 30% of farmers do not pursue additional livelihoods, potentially increasing their vulnerability to economic shocks. Economic literature suggests that small-scale fishers often rely on diversified income streams to cope with climate variability and resource fluctuations (Weeratunge et al., 2013). The fact that a significant proportion of SAMMPC members engage in secondary livelihoods highlights their adaptability but also raises concerns about labor burden and sustainability.

Table 3. *Alternative sources of livelihood*

Variables	N	%
Other livelihood sources	12	30
No		
Yes	28	70
Government/Community Roles	5	17.8
Skilled Labor	7	25.0
Entrepreneurship	5	17.8
Agriculture (Copras)	6	21.4
Service Jobs	3	10.7
Other	2	7.14

As shown in Table 4, the improvements in housing, credit access, and healthcare coverage among SAMMPC members indicate tangible benefits of cooperative participation. Healthcare insurance coverage increased from 40% before membership to 100% during the SAAD period, reflecting the positive impact of financial security and institutional support. Similarly, ownership of essential household appliances, such as refrigerators and washing machines, improved significantly, demonstrating increased purchasing power and quality of life. These findings are consistent with research highlighting how cooperative membership can improve socio-economic conditions in rural communities. A study on calamansi farmers in the Philippines found that cooperative participation significantly increased household expenditures on education and health, suggesting improved economic stability (Jimenez & Digal, 2019).

Table 4. *Changes in living conditions*

Indicators	Before SAMMPC		SAMMPC Member (Pre-SAAD)		SAMMPC Member (SAAD)	
	N	%	N	%	N	%
Housing						
Main housing material						
Combination of wood and nipa	32	80.0	10	25.0	12	30.0
Combination of semi-concrete, wood, galvanized iron	6	15.0	26	65.0	24	60.0
Combination of concrete, steel, galvanized iron	2	5.00	4	10.0	4	10.0
Housing Ownership Status						
Owner	29	72.5	33	82.5	35	87.5
Renter	4	10.0	4	10.0	2	5.00
Caretaker	7	17.5	3	7.50	3	7.50
Water, Sanitation, Healthcare						
Source of drinking water						
"Flowing"/ Natural Spring (Fetched)	39	97.5	38	95.0	32	80.0
Bottled Mineral Water	1	2.50	2	5.00	4	10.0
SAMMPC Pump*					4	10.0
Source for washing/cleaning:						
"Flowing"/ Natural Spring (Fetched)	40	100.0	40	100	36	90.0
SAMMPC Pump					4	10.0
Type of Toilet						
Water sealed	38	95.0	39	97.5	39	97.5
Antipolo system	2	5.00	1	2.50	1	2.50
Usage of toilets						
Family only	30	75.0	31	77.5	31	77.5
Common	10	25.0	9	22.5	9	22.5
Healthcare insurance						
Yes	16	40.0	35	87.5	40	100
No	24	60.0	5	12.5	0	0
Home Appliances, Access, and Acquisition						
Tangible assets - appliances at home**						
Refrigerator	9	23.0	30	75.0	28	70.0
TV	10	25.0	29	72.5	16	40.0
Washing Machine	3	8.00	16	40.0	20	50.0
Others	2	5.00	8	20.0	8	20.0
Acquisition of tangible assets - appliances at home						
Cash	12	30.0	18	45.0	14	35.0
Loan/Installment	13	32.5	17	42.5	23	57.5

Given	0	0.00	5	12.5	3	7.50
Access to Electricity						
Yes	36	90.0	40	100	40	100
No	4	10.0	0	0	0	0
Main source of credit						
SAMMPC Lending	17	42.5	28	70.0	35	87.5
Other lending companies	16	40.0	2	5.00	3	7.50
Family or friends	6	15.0	10	25.0	2	5.00
Food and Recreation						
How often do you eat/day:						
3+/day	38	95.0	40	100	39	97.5
1-2x/day	2	5.00	0	0	1	2.50
Subsistence agriculture*						
Raise livestock like hogs, chicken, etc.	29	72.5	29	72.5	26	65.0
Plant vegetables	27	67.5	28	70.0	31	77.5
Budget for Recreation						
Yes	33	82.5	37	92.5	19	47.5
No	7	17.5	3	7.50	21	52.5

**Non-existent before SAAD*
*** Respondents marked all applicable (multiple responses)*

3.2 SAMMPC Aquaculture Practices and Challenges

As shown in Table 5, the predominance of the Floating Longline method (97.5%) highlights the cooperative's reliance on efficient yet environmentally sensitive cultivation techniques.

Table 5. *Seaweed aquaculture description*

Variables	N	%	Mean	Median	SD
Method of seaweed culture					
Bottom Longline or Monoline method	1	2.50			
Floating Longline or Monoline method	39	97.5			
Farm Size					
Length (m)			95.6	100	37.0
Width (m)			21.5	17.5	15.9
No. of lines or rows of seaweed frames (*kutay*)			18.2	13.5	13.0
Distance per propagules tied (in inches)			4.73	5	1.62
Farming site depth (m)			4.16	4	2.22
Farm to coastline distance (m)			286	200	284
Total number of seaweed farmers needed (prep phase)*			3.82	4	1.82
Demographic breakdown (per farm)					
Adult females			1.94	2	.906
Adult males			1.83	2	.971
Children			1.78	2	.972
Family member involvement in seaweed culture					
Yes	34	85.0			
No	6	15.0			
Duration of main seaweed farming cycle during the high season (days)			42.9	45	6.15
Do you farm several different seaweed varieties?					
Yes	32	80.0			
No	8	20.0			
First preference - cultivated variety during the high season					
Cottonii	30	75.0			
Spinosum	2	5.00			
Vanguard	8	20.0			
Second preference - cultivated species variety the high season					
Vanguard	31	77.5			
Cottonii	8	20.0			
Spinosum	1	2.50			
Seaweed buyer					
SAMMPC	39	97.5			
Others	1	2.50			

** The total number of seaweed farmers is based on overall estimates for the preparation phase and does not represent the sum of demographic categories*

However, concerns about environmental degradation and fluctuating seaweed yields remain pressing challenges. Previous studies in the Philippines have documented declining seaweed productivity due to temperature variations, pollution, and genetic diversity (Orbita, 2013). Financially, the high reliance on loans (45%) for initial investments suggests that many farmers face capital constraints, reinforcing the need for accessible and affordable credit mechanisms. Child labor, with an average wage of ₱75, highlights socio-economic vulnerabilities that necessitate stricter regulatory oversight and alternative educational support for young workers (FAO, 2023).

Table 6 shows that seaweed farmers predominantly rely on loans for initial investments, with 45% obtaining funding from banks or micro-lenders, and 42.5% using personal savings. The average loan amount is ₱9,033.23, while SAMMPC initial capital support averages ₱3,721.62. Key farm setup costs include nylon (₱1,871.37), polyethylene rope (₱2,856.76), seaweed propagules (₱7,018.42), and farming site leasing (₱19,812.50), which collectively underscore the financial burden of starting aquaculture. Operational expenses highlight maintenance (₱2,005.48) as a major cost, followed by labor (₱1,526.32), with daily wages averaging ₱398.68 for males and ₱338.89 for females, indicating a gender wage gap. Child labor, with an average wage of ₱75, reflects socio-economic vulnerabilities. These findings support need for financial support systems, equitable labor practices, and policy interventions to address high initial investments and operational challenges while promoting inclusive and sustainable aquaculture practices.

Table 6. *Seaweeed aquaculture costs – initial set up and operations*

Variables	N	%	Mean	Median	SD
Source of initial investment					
Government assistance	2	5.00			
Own savings	17	42.5			
Loan (bank, micro-lending)	18	45.0			
Loan (middle man)	1	2.50			
Loan from extended family	2	5.00			
Total	40	100.0			
Start-up Investment					
Amount loaned			₱ 9,033.23	5000	9627.09
SAMMPC Initial capital			3,721.62	2000.	5175.27
Farm Structure					
Nylon used			1,871.37	350	7640.20
Polyethylene rope			2,856.76	1200	3841.97
Soft tie used			485.25	360	426.53
Bamboo poles			370.29	375	367.27
Floaters			759.95	500	756.81
Sinkers			637.50	650	419.08
Area (farming site)			19,812.50	15000	15250.00
Seaweed propagules			7,018.42	4000	6315.44
Boat ownership (non-motorized)			7,805.56	6000	4845.14
Miscellaneous cost			1,333.33	1000	577.35
Operational Costs (Growing and Harvesting phase)					
Cost of fuel			₱ 394.44	135	585.36
Cost of the boat if rented			372.22	300	289.52
Cost of farm's maintenance			2,005.48	1000	2946.44
Total Cost of Labor			1,526.32	2000	1181.62
Daily wage for hired adult males			398.68	400	218.02
Daily wage for hired adult males			338.89	337.50	167.43
Daily wage for hired children			75.00	75	28.68

As shown in Table 7, during the high season, farmers sell an average of 326.25 kg of dried seaweed at a mean price of ₱51.82 per kilogram, though prices vary widely (SD = ₱91.25). Wet seaweed is sold in larger quantities (868.92 kg on average) but at a lower price (₱16.47/kg). In contrast, the low season involves a longer cultivation period (12.26 additional days on average), with smaller harvests (244.88 kg of dried seaweed). However, dried seaweed prices increase to an average of ₱69.16/kg, while wet seaweed prices rise to ₱29.33/kg, albeit with considerable variability. Impact of seasonality on productivity and pricing, with higher market volatility during the low seasons

suggest the need for interventions to stabilize prices and optimize production cycles, ensuring economic resilience for farmers across seasons.

Table 7. *Seaweed yield and prices per season*

Variables	Mean	Median	SD
High season			
Quantity of dried seaweed sold (kg)	326.25	300.00	236.12
Selling/market price of dried seaweed	₱ 51.82	37.00	91.25
Quantity of wet/fresh seaweed sold (kg)	868.92	500.00	1045.81
Selling/market price of wet/fresh seaweed	₱16.47	10.00	12.38
Low Season			
No. of days seaweed culture is longer	12.26	15	7.31
Seaweed harvested during low season cycle (kg)	244.88	100	419.04
Selling/market price of dried seaweed during a typical low season cycle	₱ 69.16	35.00	192.19
Selling/market price of wet/fresh seaweed during a typical low season cycle	₱ 29.33	10.00	77.51

The respondents' feedback highlights a mix of positive and neutral perceptions regarding SAMMPC's aquaculture operations (Table 8). Strong agreement is observed concerning the negative impact of the waning seaweed operations (M = 4.63) and the effectiveness of waste management in fish pen operations (M = 4.20) now that substantial increase of fish pens have emerged in adjacent barangays. However, perceptions about ecological benefits, such as increases in marine species or improved seawater quality, were rated neutral to negative (M = 2.88, 2.73, 1.95). Additionally, while there is agreement that SAMMPC receives support from government and agencies (M = 4.35), respondents are neutral about the sustainability and environmental impacts of the fish pen operation compared to the previous seaweed operations.

Table 8. *Summary of respondents' views on SAMMPC's aquaculture operations*

Statements	Mean	Interpretation
The waning of seaweed operation negatively affected SAMMPC.	4.63	Strongly Agree (SA)
SAMMPC is effectively managing the waste from the current fish pen operation.	4.20	Agree (A)
The fish pen operation has led to an increase in the population of local marine species.	2.88	Neutral (N)
The fish pen operation has led to the discovery or addition of new marine species in our coastal area.	2.73	Neutral (N)
SAMMPC has received ample support from the from local government unit and other agencies to effectively manage its aquaculture operation.	4.35	Agree (A)
The fish pen operation has not affected the quality of the seawater.	3.33	Neutral (N)
The presence of other private entities with fish pens has negatively impacted the nearby coastal environment.	3.15	Neutral (N)
The seawater quality is better now than it was during the seaweed operation	1.95	Disagree (D)

Legend: *4.50 - 5.00 Strongly Agree (SA); 3.50 - 4.49 Agree (A); 2.50 - 3.49 Neutral (N); 1.50 - 2.49 Disagree (D); 1.00 - 1.49 Strongly Disagree (SD)*

To elaborate on the statement of members feeling the impact of waning seaweed aquaculture interviewees have mentioned several factors that relate the following studies: A 2018 study investigated lead levels in the waters of the Port of Mukas in Kolambugan, Lanao del Norte. The findings revealed an average lead concentration of 0.18 mg/L, surpassing the Department of Environment and Natural Resources' (DENR) allowable limit of 0.05 mg/L for marine waters. The elevated lead levels were attributed to activities such as ship salvaging, which involve the use of paints and welding equipment, as well as discharges from nearby industries and residential areas. (Jimenez et al.,2018) Further, a 2024 review focused on environmental assessments in Panguil and Iligan Bays, highlighting concerns about pollution from rapid industrialization and urban expansion. The study identified contaminants like heavy metals and microplastics in sediments and marine biota. (Macalisang et al., 2024)

3.3 Economic Performance and Benefits of SAMMPC and its Members

Table 9 compares the mean, median, and standard deviation of incomes from fishing, seaweed farming, and alternative livelihood sources. Seaweed farming stands out with a significantly higher mean income of ₱26,918.93 per 45-day cycle, surpassing both fishing (₱6,351.35) and alternative sources (₱6,492.80). Truly, there is great economic potential of seaweed aquaculture in enhancing household incomes. The relatively higher standard

deviation for seaweed income (₱34,493.08) suggests greater variability, possibly due to factors like market price fluctuations and environmental conditions.

Table 9. S*ummary of income statistics across livelihood activities*

Category	Mean	Median	SD
Fishing Income only	₱ 6,351.35	4,000.00	6,664.44
Seaweed Income (Net) *	₱ 26,918.93	11,801.54	34,493.08
Alternative sources **	₱ 6,492.80	5,000.00	6,262.18

** After initial set-up; 45-day period*
*** See Table 3*

Nonetheless, the elevated median income indicates that, for most farmers, seaweed cultivation offers superior financial returns compared to traditional fishing and other livelihoods. These findings are consistent with studies that emphasize the role of seaweed farming in improving socio-economic conditions in coastal communities (Fabro, 2022). The Municipal Agriculture Officer (MAO) reinforced this observation, noting:

"Seaweed was a primary source of income during peak years (2012-2017), with monthly incomes reaching ₱24,000 in a 45-day cycle. However, current production is negligible, with some municipalities like Simbuco ceasing operations entirely."

The results are telling of the urgent need for interventions to revitalize this industry. Addressing environmental and market challenges, such as genetic diversity loss and price fluctuations, could unlock the full potential of seaweed farming to sustain and enhance household incomes. Likewise, these also underlines the importance of exploring alternative livelihoods to complement fishing and mitigate economic risks.

The only available consolidated financial statements of the cooperative were from 2019 to 2023 (see Table 10). During this period, SAMMPC exhibited financial stability and gradual growth despite fluctuations in certain metrics, bolstered by capacity development and external support. The net surplus increased from ₱387,086.00 in 2019 to ₱627,155.96 in 2023, reflecting enhanced profitability, although slight declines were observed in 2021 and 2022. Net sales showed variability, peaking at ₱8,075,426.92 in 2019 and dipping to ₱3,042,708.63 in 2021, with cost of sales following a similar trend. Notably, net sales consistently outpaced the cost of sales, ensuring positive gross margins and indicating effective cost management. SAMMPC's financial performance benefited significantly from capacity development initiatives, including training on financial management and bookkeeping provided by SAMMPC officials and organized by BFAR as part of the SAAD program. Additionally, inputs and investments from the Philippine Rural Development Project (PRDP) and the Kapit-Bisig Laban sa Kahirapan–Comprehensive and Integrated Delivery of Social Services (KALAHI-CIDSS) program from 2020 to 2022 further supported the cooperative's operations, enhancing its financial and operational capacity. These interventions likely contributed to the cooperative's ability to sustain its profitability and maintain a strong financial position. SAMMPC's assets grew steadily until 2021, reaching a high of ₱12,059,492.04, before declining to ₱7,839,785.02 in 2023. Meanwhile, liabilities remained relatively stable, averaging ₱2.3 million annually, contributing to a strong asset-to-liability ratio throughout the period. This favorable financial position underscores SAMMPC's capacity to meet obligations while maintaining a sustainable foundation.

Table 10. *Financial Performance Overview of SAMMPC (2019-2023): Net Surplus, Sales vs. Cost of Sales, and Assets vs. Liabilities*

Particulars	2019	2020	2021	2022	2023
Net Surplus	₱ 387,086.00	508,353.00	450,288.00	393,843.20	627,155.96
Net Sales vs. Cost of Sales					
Net Sales	₱ 8,075,426.92	4,358,055.00	3,042,708.63	5,661,619.78	4,200,467.51
Cost of Sales	₱ 7,551,282.29	3,783,182.00	2,632,732.28	5,037,045.35	3,692,347.77
Assets vs. Liabilities					
Assets	₱ 7,824,906.32	11,252,923.91	12,059,492.04	11,922,104.17	7,839,785.02
Liabilities	₱ 1,874,988.51	2386052.07	2,354,097.69	2,135,159.08	2,374,170.93

Table 11 presents the financial contributions and derived benefits of SAMMPC members, highlighting the varying levels of share capital and corresponding financial returns. Based on the cooperative's December 2023 consolidated financial statement, presented during the April 2024 general assembly, 42.5% of members have invested between ₱500 and ₱5,000, while 25% have contributed ₱25,001 or more. The distribution of financial returns reveals a strong correlation between share capital and benefits, as 62.5% of those receiving the highest

interest and patronage refunds belong to the highest investment bracket. This trend underscores the advantage of greater capital participation in maximizing financial gains within the cooperative framework.

Table 11. *Share capital and derived benefits among SAMMPC members*

Variables	N	%
Current share capital at SAMMPC		
₱ 500 - 5,000	17	42.5
5,001 - 10,000	4	10.0
10,001 - 15,000	3	7.50
15,001 - 20,000	2	5.00
20,001 - 25,000	4	10.0
≥ 25,001	10	25.0
Estimated total interest earned from capital since membership		
₱ 500 - 5,000	5	12.5
5,001 - 10,000	1	2.50
10,001 - 15,000	2	5.00
15,001 - 20,000	2	5.00
20,001 - 25,000	5	12.5
≥ 25,001	25	62.5
Estimated total patronage refund earned since membership		
₱ 500 - 5,000	5	12.5
5,001 - 10,000	4	10.0
15,001 - 20,000	1	2.5
20,001 - 25,000	5	12.5
≥ 25,001	25	62.5

However, ensuring broader financial inclusivity remains crucial. To address this, SAMMPC could introduce flexible capital-building initiatives and financial literacy programs, helping members with smaller investments gradually increase their capital. Such strategies have been successfully implemented in Philippine cooperatives, where targeted reinvestment incentives and structured capital growth programs have improved member participation and equity in financial benefits (Briones et al., 2023).

The data in Table 12 reveals a strong agreement that SAMMPC significantly contributes to economic development and aquaculture productivity. Key strengths include accessible savings mechanisms (M = 4.00), credit availability (M = 4.55), and the high profitability of aquaculture activities (M = 4.53). Respondents also strongly agreed on effective market access (M = 4.63) and the role of DA-SAAD financial assistance in supporting SAMMPC's operations (M = 4.73). Infrastructure and community-based aquaculture activities are seen as enhancing productivity and economic prosperity among members, reflecting SAMMPC's critical role in the sector.

Table 12. *Member perception on the economic development and aquaculture activities*

Statements	Mean	Description
Members have easy access to savings mechanisms facilitated by SAMMPC.	4.00	Agree (A)
Credit/borrowing of money is accessible to members of SAMMPC."	4.55	Strongly Agree (SA)
The profitability of aquaculture activities outweighs the associated costs and investments.	4.53	Strongly Agree (SA)
Access to markets and value chains for aquaculture products is adequately facilitated.	4.63	Strongly Agree (SA)
Adequate infrastructure and farm implement in the cooperative such as fish pen, equipment and gears, and processing facilities enhance the productivity of aquaculture	4.48	Agree (A)
The Department of Agriculture – Special Area for Agricultural Development (DA-SAAD) financial assistance greatly helped SAMMPC.	4.73	Strongly Agree (SA)
The community-based aquaculture has contributed to the overall economic development and prosperity its members.	4.48	Agree (A)

Legend: *4.50 - 5.00 Strongly Agree (SA); 3.50 - 4.49 Agree (A); 2.50 - 3.49 Neutral (N); 1.50 - 2.49 Disagree (D); 1.00 - 1.49 Strongly Disagree (SD)*

3.4 Community Perceptions on Social Inclusion and Wellbeing

As shown in Table 13, the respondents strongly agree that SAMMPC's community-based aquaculture fosters social cohesion (M = 4.55) and effectively resolves conflicts (M = 4.35). If conflicts do arise between concerning SAMMPC and its members or officials, disputes are first handled internally. Should the conflict escalate, appropriate and external channels are called for mediation and arbitration. Documented causes of conflict for this year alone involved member delinquency and shake-ups in the organizational structure. The Provincial

Cooperative Office (PCO) acts as an adviser and action counselor as well during these instances. Women are perceived as playing a pivotal role, both in aquaculture activities (M = 4.63) and decision-making processes (M = 4.58). On this note, the SAAD project director pointed out that ""Women play an active role in seaweed farming, which has been seen as empowering. While the men are involved in the harvesting, the women take on other crucial roles like planting and maintaining the seaweed farms." (Magamano A., 2019)

Table 13. *Summary of respondent's views on SAMMPC's role in social inclusion*

Statements	Mean	Description
The community-based aquaculture in SAMMPC has improved social cohesion (solidarity and cooperation) among members.	4.55	Strongly Agree (SA)
Conflict resolution mechanisms within SAMMPC are effective in addressing disputes and disagreements among members.	4.35	Agree (A)
Women are actively involved in aquaculture within SAMMPC.	4.63	Strongly Agree (SA)
Women are actively involved in the cooperative's decision- making.	4.58	Strongly Agree (SA)
The community-based aquaculture initiative has facilitated the sharing of knowledge and skills among community members.	4.28	Agree (A)
Government agencies play a pivotal role in facilitating the expansion and social integration of SAMMPC's community-based aquaculture initiatives.	4.78	Strongly Agree (SA)

Legend: *4.50 - 5.00 Strongly Agree (SA); 3.50 - 4.49 Agree (A); 2.50 - 3.49 Neutral (N); 1.50 - 2.49 Disagree (D); 1.00 - 1.49 Strongly Disagree (SD*

The initiatives also facilitate knowledge and skill-sharing among members (M = 4.28), with government agencies being acknowledged for their significant role in supporting SAMMPC's expansion and social integration (M = 4.78). A gender-focused study in Southeast Asia found that cooperatives with active female participation demonstrated higher financial performance and stronger community engagement (Mengo et al., 2023). This reinforces the need for continued gender-sensitive policies within SAMMPC. This underscores the cooperative's success in promoting inclusivity and community solidarity.

Table 14. *Thematic analysis of FGD on SAMMPC seaweed farmer perspectives on wellbeing*

Section	Theme	Response
Section 1: Exploring General Perspectives about Wellbeing	Well-being Indicators (Positive Attributes)	Hardworking, stable jobs, ability to provide for family, send children to school, social respect, and community involvement
	Well-being Indicators (Negative Attributes)	Laziness, addiction, poverty, and being unable to provide for one's family
	Needs for Well-being in the Coastal Community (Seaweed Farming Context)	Government support for capital or land for housing, and the revival of seaweed farming to improve livelihoods.
Section 2: Assessment of Changes in Wellbeing	Changes in Well-being Over the Last Decade	Declining well-being due to reduced income from seaweed farming, climate change, and debt accumulation.
	Perception of Life's Improvement or Decline	Life improves with good harvests (seaweed/fish) leading to higher income but worsens due to environmental damage and educational costs.
	Impact on Different Groups in the Community	The younger generation is most affected by environmental and livelihood changes. Wealth disparities have grown, with capitalists benefiting.
Section 3: The Linkage Between the Coast and Wellbeing	Hope for the Future of Seaweed Farming and Coastal Resources	Hope for the revival of seaweed farming and marine resources, believing that sustainability and conservation efforts could restore abundance.
	Actions to Improve Coastal Well-being	Cleaning up the sea, managing waste, and community discipline are key to improving coastal well-being and supporting marine resource recovery.
	The Role of Government and Regulations	Government policies and regulations focused on environmental protection are crucial to improving conditions for seaweed farming and fishing.

The thematic analysis (Table 14) of FGD responses highlights the nuanced perspectives of SAMMPC seaweed farmers regarding wellbeing. Farmers associate positive wellbeing with stable jobs, family support, education, and community involvement, while negative attributes include poverty, addiction, gambling, and the inability to provide for one's family. Over the past decade, wellbeing has declined due to reduced seaweed income, climate change, and growing debts. However, good harvests temporarily improve livelihoods, underscoring the critical role of environmental and economic stability. The younger generation is disproportionately affected by livelihood shifts and growing wealth disparities, as capitalists benefit more than local farmers. Farmers express hope for the

revival of seaweed farming through sustainable practices and conservation, linking coastal health directly to community wellbeing. They emphasize the importance of sea cleanup, waste management, and community discipline to restore marine abundance. Government intervention is deemed vital, particularly through supportive policies and environmental regulations that balance ecological protection with economic opportunities. The insights gathered from the FGD highlight the urgent need for policies that recognize the interconnectedness of livelihood improvement and coastal resource sustainability, advocating for a comprehensive framework that supports both economic and environmental objectives (Hill et al., 2011).

4.0 Conclusion

The study draws attention to the unique role of community-based aquaculture, as exemplified by the Simbuco Aqua-Marine Multi-Purpose Cooperative in fostering socio-economic resilience and inclusivity among small-scale fisheries in Lanao del Norte. SAMMPC has substantially improved its members' wellbeing through enhanced financial access, diversified income opportunities, better living conditions, and strengthened social cohesion. Additionally, the cooperative has provided a platform for gender inclusivity, with women actively participating in aquaculture operations and decision-making. Despite these achievements, challenges persist, such as environmental concerns linked to aquaculture practices, market volatility, and inequities in income distribution.

To address these challenges, SAMMPC can adopt biodiversity-friendly aquaculture methods like polyculture to minimize ecological risks and enhance waste management through recycling and proper disposal. Regular site monitoring in collaboration with environmental agencies is essential. Financial and operational support can be strengthened by expanding access to government grants and microfinance, reducing loan dependence. Training in cost-effective aquaculture, feed management, and equipment use, along with a risk management fund, will enhance resilience to natural disasters and market fluctuations. Social inclusion can be improved by offering skill programs for women and youth, standardizing wages to address gender disparities, and promoting safe, age-appropriate roles in aquaculture. Strengthening governance through collaboration with local authorities and enforcing transparency within SAMMPC is crucial. Diversifying income sources through eco-tourism, agro-processing, and market expansion—such as producing seaweed snacks or processed milkfish for export—can enhance profitability and stability. By implementing these strategies, SAMMPC can achieve sustainable aquaculture, balancing economic growth with environmental preservation while serving as a model for community-based fisheries.

5.0 Contributions of Authors

AA – encoding, editing, writing, data analysis
BA –supervising, writing, data analysis
CA – editing, data analysis
DA – editing, data analysis
EA- editing, data analysis

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The study was conducted with no financial grants from any external organizations.

7.0 Conflict of Interests

The authors declare that they have no conflicts of interest regarding this study.

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