INTERNATIONAL JOURNAL OF MULTIDISCIPLINARY: APPLIED BUSINESS AND EDUCATION RESEARCH
2026, Vol. 7, No. 3, 1469 – 1477
http://dx.doi.org/10.11594/ijmaber.07.03.33

Research Article

Characterization and Risk Analysis of Seaweed Farming Ventures in Sorsogon, Philippines

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Article history:
Submission 28 February 2026
Revised 16 March 2026
Accepted 23 March 2026

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ABSTRACT

Seaweed farming, a crucial part of the blue economy in Sorsogon, Philippines, operates in a dynamic and frequently unpredictable environment. This environment is vulnerable to various factors that can affect its economic viability and long-term sustainability. These challenges include fluctuating market prices, environmental risks like climate change and disease outbreaks (such as the "ice-ice" disease), and operational inefficiencies. For small-scale farmers, these risks can be particularly devastating, threatening their livelihoods and hindering the sector's growth. This study analyzed seaweed farming operations and risks using Risk Management Theory. Data from a survey of 115 farmers in Sorsogon City and Castilla, along with interviews with stakeholders, and experts, revealed a sector dominated by small-scale and medium-scale ventures, primarily cultivating *Kappaphycus alvarezii* through fixed-bottom long lines. While all farmers accessed government propagules, only 20% received direct financial support, highlighting a liquidity gap. Environmental hazards, particularly typhoons and "ice-ice" disease, drove yield volatility. To mitigate these risks, the study recommends Risk Avoidance through the mandatory conversion of unviable farming systems, and Risk Reduction via the distribution of climate-resilient genotypes. These findings provide a strategic roadmap for policy interventions aimed at transforming Sorsogon's seaweed industry from a subsistence activity into a resilient commercial enterprise.

***Keywords**: Kappaphycus alvarezii, Risk Analysis, Seaweed Farming, Sorsogon, Sustainable Livelihoods*

How to cite:
Bongalonta, M. M. (2026). Characterization and Risk Analysis of Seaweed Farming Ventures in Sorsogon, Philippines. *International Journal of Multidisciplinary: Applied Business and Education Research. 7*(3), 1469 – 1477. doi: 10.11594/ijmaber.07.03.33

Background

Seaweed farming has emerged as a significant livelihood and economic activity for coastal communities worldwide, including Sorsogon, Philippines. The province has a long history of seaweed harvesting and cultivation, with local communities possessing traditional knowledge of seaweed resources. Existing research on seaweed farming has primarily focused on its biological and environmental aspects with limited attention paid to its risk mitigation strategies. This research aimed to provide a thorough understanding of seaweed farming ventures in Sorsogon, highlighting their economic, environmental, and social significance. By doing so, it sought to promote the sustainable growth of the industry and contribute to the socio-economic development of coastal communities in the province.

This research characterizes these ventures—focusing on farm size, methods, and subsidies—and examines the associated risks through a risk management lens. By bridging the gap in localized data, this study provides a foundation for evidence-based policy interventions in the Bicol Region's aquaculture sector. The study is anchored on these primary theoretical pillars: Risk Management Theory, used to identify, assess, and prioritize risks (environmental, market, and operational) followed by the application of resources to minimize or control the probability of unfortunate events, and Sustainable Livelihoods Framework was used to conceptualize how farmers utilize their "capitals" (natural, physical, human, financial, and social) to achieve livelihood outcomes despite the "vulnerability context" of the seaweed industry.

Methods

The study employed a descriptive-analytical design. The descriptive aspect was used to characterize the seaweed farming ventures such as demographics and operational profiles while the analytical aspect was used to examine and categorize associated risks. This study focused on a range of stakeholders involved in the seaweed farming industry in Sorsogon, Philippines as provided by the Bureau of Fisheries and Aquatic Resources, including the seaweed farmers registered and still operating in Sorsogon, 6 processors who handle the harvested seaweeds, 4 traders who facilitate its distribution and sale, local government officials involved in aquaculture regulation and support, and other relevant experts in the field. Specific coastal barangays known for high and medium production of seaweed species (e.g., *Kappaphycus* and *Eucheuma*) were selected to ensure a representative sample of operational ventures. This group consists exclusively of active seaweed farmers who possess: Direct ownership or management of the farm, Complete knowledge of their production cycle, Verifiable financial data for the study period. The geographical scope of the study encompassed the coastal municipalities of Sorsogon where seaweed farming is a prevalent economic activity.

Data were gathered using a combination of methods to ensure a comprehensive understanding of the seaweed farming sector. Structured survey questionnaires were administered to seaweed farmers to collect quantitative data on key variables such as farm characteristics in terms of size, farming methods, cultivated species, number of harvesting cycles, and yields achieved, and access to subsidies/grants. The survey was divided into 2 sections. The first section was about (1) the Respondent and Farm Profile, and then (2) Risks and mitigation. To gather in-depth qualitative data, semi-structured interviews were conducted with key informants, including farmers, processors, traders, and government officials. These interviews explored their experiences, perspectives, impact of seaweed farming on their livelihood capitals, and the risks they face related to seaweed farming. Key informant interviews conducted with BFAR, NSTDC, and other relevant entities were conducted to corroborate seaweed farming trends, production data, and access to subsidy programs in Sorsogon.

A focus group discussion (FGD) was conducted involving 6-8 seaweed farmers in each study site. During the FGD, an open-ended questionnaire was used to encourage open dialogue, explore shared experiences, and gather collective insights on specific topics relevant to the research. Similar answers were grouped and tabulated according to the frequency of answers received, and the summary was presented in a table.

The data from the questionnaires and tablets were encoded and exported into an Excel file and cleaned before the analysis. Data from the survey were analyzed using Excel, while data collected from FGD were qualitatively analyzed and coded.

Result and Discussion

Characterization of Seaweed Farming Ventures in Sorsogon

A comprehensive survey conducted across the major farming sites in Sorsogon Province revealed the characteristics of seaweed farming operations in the region. The characterization was assessed based on five key dimensions: farm size, farming method, cultivated species, number of harvesting cycles, and access to subsidies or grants. A total of 115 seaweed farmers were surveyed, with an average of 5 years of experience. The majority of operations were concentrated in Sorsogon City and Castilla.

Farming Size

The analysis of farm size, defined by the total area dedicated to cultivation, indicated seaweed farming in Sorsogon is predominantly an enterprise of small- and medium-scale operators. As denoted in Table 1, 49.5% of the operations fall into the Small-Scale, and 49.5% Medium-scale category. Small-Scale operations are typically family-managed and often serve as a source of subsistence or supplemental income. They utilized minimal capital and employ simple methods, such as the fixed off-bottom long line method. Conversely, the Medium-Scale category (between 1,000 m^2 and 5,000 m^2), may involve more labor and employ more complex methods, such as floating long-line, or simple raft. Large-scale operations (greater than 5,000 m^2) were marginal, representing only 1% of the total ventures sampled.

Table 1. Characterization of Seaweed Farming Ventures in Sorsogon in terms of Farm Size

Farm Size Category [a]	Area (m^2)	Frequency	Percentage
Small-scale	< 1,000	57	49.5%
Medium-scale	1,000 – 5,000	57	49.5%
Large-scale	> 5,000	1	1.0%
Total		**115**	**100%**

[a] Adapted from *Farming Systems of Eucheumatoid Seaweeds in Western Visayas, Philippines*, by Ledesma and Monteclaro (1).

In **APA 7th Edition**, findings and discussions are presented in a clear, objective tone with specific indentation and citation structures.

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Based on the findings, the seaweed industry in Sorsogon is overwhelmingly structured around small- and medium-scale enterprises. The nearly equal distribution between these two categories, together accounting for 99% of the ventures, signifies that seaweed farming functions primarily as a coastal livelihood activity or micro-enterprise rather than a large-scale commercial operation. This structure is typical of small-scale fisheries and aquaculture sectors across the Philippines, where limited access to capital, reliance on family labor, and restricted tenure access to communal waters constrain farm expansion.

This finding strongly supports government regulations which established limits for certain categories of seaweed farming operations. A single individual is generally limited to operating a seaweed farm of not more than one hectare, implicitly defining the maximum size for a small, non-corporate venture. Partnerships, associations, corporations, or cooperatives are typically limited to not more than 30 hectares, setting the boundary for large-scale, commercial operations (Rules and Regulations Governing the Gathering and Farming of Seaweeds, 1983).

Based on the Sustainable Livelihood Framework, the equal split between small- and medium-scale farms (99%) demonstrates that seaweed farming in Sorsogon is an asset-constrained livelihood. The prevalence of small and medium farms suggests farmers leverage their natural capital (access to the sea) and human capital (farming skills) but are limited by financial and physical capital. This highlights the vulnerability context where expansion is difficult due to capital scarcity, making these ventures highly susceptible to climate shocks or market price drops.

Farming Method

The majority of seaweed farmers in the study area employ the Fixed Bottom Long Line method for cultivation. As detailed in Table 2, 52% (n=60) of the respondents utilize this traditional technique, which involves planting lines attached to wooden stakes driven into the shallow substrate. The second most prevalent method is the Floating Long-Line (42%, n=48), which is typically employed in deeper waters. The predominance of the fixed bottom system indicates that seaweed farming remains a low-capital, shallow-water enterprise in this region.

Table 2. Characterization of Seaweed Farming Ventures in Sorsogon in terms of Farming Method

Farming Method	Description	Frequency	Percentage
Fixed Bottom Long Line	Staked lines	60	52.0%
Fixed Bottom Long Line, Broadcast	Sometimes staked lines or scattered propagules	2	2.0%
Fixed Bottom Long Line, Net method	Sometimes staked lines or Mesh-tied propagules in nets	3	3.0%
Floating Long Line	Anchored ropes	48	42.0%
Net method	Mesh-tied propagules in nets	2	2.0%
Total		**115**	**100%**

The remaining methods, such as the net technique (2%) and various mixed systems, collectively account for a marginal share of the industry. This is likely due to the higher material costs and labor requirements associated with deeper-water farming (BFAR, 2014; Castaños & Buendia, 1998). The Fixed Bottom Long-Line (FBLL) and Floating Long-Line (FLL) are two variations of the line cultivation technique used for seaweed farming, with the primary difference being the position of the cultivation line in the water column.

Both long-line cultivation methods employ a primary cultivation rope (monoline) upon which seaweed seedlings are secured at regular intervals, typically utilizing plastic "tie-tie" strings. Both methods necessitate the installation of anchors—sometimes using stakes, pegs, or concrete blocks—secured to the seabed to maintain the farm's stability and ensure the tautness of the lines. These cultivation techniques are primarily employed for cultivating commercially significant red seaweeds, such as *Kappaphycus* and *Eucheuma* species, which serve as the primary sources of carrageenan. Both long-line methods generally exhibit ease in installation, maintenance, and harvesting, and are typically more cost-effective for commercial-scale farming operations.

The slightly higher adoption of FBLL suggests that a substantial portion of the Sorsogon farming areas are characterized by sandy or corally bottoms, where stakes can be firmly secured and water depth is suitable for fixed off-bottom lines. Farming sites are relatively sheltered from strong waves and currents, which could otherwise dislodge the stakes or damage the fixed lines (Taw, n.d.).

On the other hand, the substantial use of the FLL method indicates that farmers also exploit areas where water depth changes significantly or where the water is too deep for fixed stakes, necessitating the lines to be suspended by floats. FLL is often chosen as a defense against bottom-dwelling herbivores, suggesting that some Sorsogon farm sites face a risk of grazing damage, while others have concerns about water quality due to silt or muddy bottoms (Taw, n.d.).

The dominance of both long-line methods (94%) reflects an adaptation to the local natural capital, such as coastal topography and depth, and the limited financial capital of the smallholders. Both methods are technologically simple and are generally considered efficient uses of physical capital (e.g., ropes and stakes), indicating appropriate livelihood strategies adopted by the farmers within their asset constraints.

Cultivated Species

The results demonstrated a significant focus on carrageenophytes, a type of seaweed, primarily driven by the global market's demand for carrageenan. As evidenced in Table 3, Cottonii (*Kappaphycus alvarezii*) emerges as the most prominent cultivated species, utilized by 81% (*n* = 93) of all surveyed farmers. Subsequently, Spinosum (*Eucheuma denticulatum*) is the second most prevalent species, cultivated by 13% (*n* = 15). The remaining species, encompassing edible green seaweeds such as *Gracilaria* spp., collectively account for less than 6% of the cultivated biomass. This observation suggests that the local industry is predominantly focused on the industrial hydrocolloid market rather than the fresh food market (Guerrero, 2001; Hurtado et al., 2017; Rhein-Knudsen et al., 2015; Valderrama et al., 2013).

Table 3. Characterization of Seaweed Farming Ventures in Sorsogon in terms of Cultivated Species

Cultivated Species	Scientific Name	Frequency	Percentage
Spinosum	*Eucheuma denticulatum*	15	13.0%
Agar-agar	*Gracilaria spp.*	7	6.0%
Cottonii	*Kappaphycus alvarezii*	93	81.0%
Total		**115**	**100%**

Harvesting Cycles

The industry standard for *Kappaphycus alvarezii* (*Cottonii*) and *Eucheuma denticulatum* (*Spinosum*) is typically 45 days, or ranging from 30 to 60 days. The categories such as Low, Standard, Optimal, and Intense are an applied grouping of farmer data based on the scientifically and commercially established ≈45-day cycle length that defines tropical seaweed farming (Tahiluddin, 2021).

Table 4. Characterization of Seaweed Farming Ventures in Sorsogon in terms of Number of Harvesting Cycles

Harvest Period Category	**Number of Cycles per Year**	**Frequency**	**Percentage**
Low Frequency	1-2 cycles	7	6.0%
Standard Frequency	3-4 cycles	50	43.0%
Optimal Frequency	5-6 cycles	56	49.0%
Intense Frequency	7+ cycles	2	2.0%
Total		**115**	**100%**

The majority of seaweed farming operations exhibit a standard to optimal annual harvest frequency, indicative of a productive industry with suitable environmental conditions. Specifically, 49% (n = 56) of farmers fall into the 5–6 cycles per year category, establishing this as the prevailing optimal operation (see Table 4). A substantial proportion, 43% (n = 50), achieves a standard frequency of cycles, suggesting that roughly all of the farms operate close to the theoretical optimal cycle of approximately 45 days. Conversely, only 2% (n = 2) report an intense frequency of cycles, while 6% (n = 7) are limited to low-frequency cycles. These lower frequencies are often attributable to external factors such as prolonged typhoon seasons (SEAFDEC, 1995), disease outbreaks (Romero, 2002), or strong seasonality in water quality (BFAR, 2014).

The high harvest frequency (3–6 cycles/year for 92.0%) maximizes the turnover rate of their invested capital and resource space.

Access to Subsidies/Grants

As illustrated in Table 5, the dominant forms of support are non-financial. Specifically, the provision of propagules was the most prevalent intervention, received by 100% (*n* = 115) of respondents, underscoring the focus of aid efforts on ensuring continuous production inputs. Farming equipment (83%) and technical training (70%) were also significant forms of non-financial aid. Financial assistance was less common, with cash grants reaching 20% (*n* = 23) of farmers and loan assistance accessed by 33% (*n* = 38). This distribution highlights a strong preference or programmatic emphasis on in-kind, production-based support over direct financial intervention (Pedrosa et al., 2022).

Table 5. Characterization of Seaweed Farming Ventures in Sorsogon in terms of Access to Subsidies/ Grants

Type of Subsidy/ Grant Received	Category	Frequency	Percentage
Provision of Propagules	Non-financial	115	100%
Farming Equipment	Non-financial	95	83.0%
Technical Training	Non-financial	80	70.0%
Direct Cash	Financial	23	20.0%
Loan Assistance	Financial	38	33.0%

The high access to non-financial support such as propagules, and training is a strong indication of proactive support from transforming structures and processes from the government/NGOs to enhance the farmers' Human, Natural, and Physical Capital. The 100% access to propagules confirms that institutional support is the primary factor sustaining the industry's seed supply, mitigating a significant risk in the vulnerability context.

Risk Profile and Mitigation Strategies

The analysis of risks associated with seaweed farming in Sorsogon, anchored on the Risk Management Theory, confirms that the industry's financial success is heavily exposed to Environmental, Market, and Operational volatility. The interview guides (KII and FGD) are crucial for confirming the perceived severity and frequency of these risks by the farmers themselves.

Table 6. Risk Profile and its Impact on Livelihood Capital

Risk Category	Primary Sources	Impact on Livelihood Capital
Environmental	Typhoons, "Ice-ice" disease, and salinity drops.	Depletion of Natural Capital; total loss of standing crops.
Market	Farmgate price fluctuations and trader monopolies.	Erratic Financial Capital; difficulty in loan repayments.
Operational	Lack of drying platforms and high seedling costs.	Strain on Physical Capital; reduced quality of final product.

Environmental Risk Management

As answered by a farmer to the focused group discussion guide scenario where a disease wiped out 50% of their harvest, what would they do, is that they would have to stop Cottonii and try the Spinosum for a while, even if the price is lower, as they can’t risk everything on one species of propagules. Promotion of Site Diversification and the cultivation of resilient genotypes may be employed as part of Risk Reduction strategy where BFAR/Expert Key Informants must lead in providing disease-resistant Cottonii strains.

Transitioning from fixed off-bottom monolines to floating longline methods in deeper waters. This mitigates "ice-ice" disease by keeping seaweeds in more stable temperatures and higher salinity levels during extreme heat or heavy rains.

Utilizing local LGU and BFAR communication channels to provide 72-hour windows for "emergency harvesting" before predicted typhoons.

Market Risk Management

The FGD confirmed that farmers rely heavily on traders and have minimal control over prices, which are dictated by the volatile global commodity market. This exposes the farmers' Financial Capital to external shocks. The risk is particularly acute for Cottonii producers because their high profits rely heavily on maintaining a premium price.

Farmer X shared that "The price changes and we have no control. A Php 5 per kilo drop means we almost just broke even."

Strengthening seaweed cooperatives to aggregate volume. This allows farmers to bypass small-scale traders and negotiate directly with the 6 processors identified in the study.

Investment in communal solar dryers or mechanical drying sheds, which ensures the seaweed reaches the moisture content required by processors, preventing price deductions for "wet" or "low-quality" crops.

The strategy here involves improving market control which asserts that firms must control output and price to maximize gains. Cooperatives must be formed, and empowered to negotiate forward contracts or implement a centralized quality control system, giving farmers collective leverage to stabilize the price floor and reduce dependence on individual traders. A community-managed fund or LGU-backed subsidy that provides a "price floor" during drastic market crashes also is a good-to-have scenario.

Operational Risk Management

An expert made mention that "A bad season of 'ice-ice' can easily reduce harvest weights by 20% to 30% province-wide. That's our biggest threat to Cottonii viability."

Building local "seedling banks" or nursery is a must, to ensure a steady supply of high-quality, disease-resistant Kappaphycus and Eucheuma cultivars.

Conclusion

Based on the integrated findings from the quantitative metrics and the qualitative thematic analysis, the following conclusions are drawn regarding the seaweed farming ventures in Sorsogon:

1. High Vulnerability of Small-Scale Ventures

The characterization of ventures reveals a sector dominated by micro-plots and traditional off-bottom methods. While these require low initial capital, they offer minimal protection against environmental stressors. The study concludes that the current "low-input" model creates a vulnerability trap, where farmers lack the financial buffer to recover from even minor crop losses or price dips.

2. Economic Fragility and "Price-Taker" Dynamics

The analytical component confirms that farmgate price volatility is the most significant threat to the sector's sustainability. Because farmers lack post-harvest infrastructure such as warehouse to properly store their raw dried seaweeds harvest, they are forced into immediate sales, giving traders disproportionate power. The research concludes that without localized price interventions or drying facilities, the financial viability of these ventures will remain precarious.

3. Misalignment in Institutional Support

The rigorous purposive screening process revealed a significant disconnect between official registries and active practitioners. The prevalence of "proxy" representatives suggests that current subsidy programs may be suffering from leakage or mistargeting. The study concludes that for risk mitigation strategies to be effective, government agencies (LGU/BFAR) must refine their beneficiary lists to prioritize those with direct operational management and verifiable data. Individual application for subsidy should be submitted to the grantor, and before a list is finalized, posting of the list to the barangay hall for a 15-day "validation period" will ensure that the community recognizes the "active" status of the applicants.

4. Need for a Technological Paradigm Shift

Environmental risks, particularly "ice-ice" disease and typhoon damage, are currently managed reactively. The study concludes that a transition from fixed off-bottom to floating longline systems is no longer optional but a necessity for climate resilience. This shift would allow farmers to move crops to safer depths during temperature spikes or high-salinity events.

Seaweed farming in Sorsogon is a highly sensitive livelihood where profitability is precariously balanced against external market and climatic forces. The transition from a descriptive understanding to an analytical risk management approach highlights that resilience is a function of both infrastructure and institutional integrity. Strengthening the sector requires a dual approach: empowering farmers through collective bargaining and protecting crops through climate-smart technology.

Acknowledgments

The completion of this dissertation is a milestone achieved through collective effort and invaluable guidance, cooperation, and support of many dedicated individuals and organizations. My deepest gratitude goes to Dr. Richard V. Dumilag. Your expertise and generosity in sharing your knowledge were instrumental in the development of this study; this work is significantly better because of your input. I am deeply grateful to my dissertation adviser, Dr. Teresita C. Lanuzo. Thank you for your unwavering patience, intellectual rigor, and for providing the steady guidance that helped this research transition from a mere concept to its successful conclusion. To the members of my dissertation panel, Dr. Ma. Christine R. Boduan, Dr. Teresita L. Nacion, Dr. Flor A. Jenkin, Dr. Ramon T. De Leon, and Dr. Arnold E. Barlizo, I want to express my deepest gratitude for your invaluable critical eye and constructive feedback. Your insightful observations have not only challenged my thinking but have also significantly enhanced the quality of my final output. This research would be incomplete without the invaluable contributions of the seaweed farmers of Sorsogon. I am deeply grateful for your warm hospitality and your generous willingness to share your time and rich experiences. You are the true custodians of our coastal resources, and this work is dedicated to your unwavering resilience. A special and heartfelt thank you goes to Sorsogon State University. I am deeply indebted to the administration for the financial assistance they provided and for the privilege of pursuing my doctorate while remaining a part of the university family. I am particularly grateful for the one-year study leave granted to me, which provided the essential time and focus required to write and finalize this dissertation. I want to express my deepest gratitude to the University of Santo Tomas-Legazpi for providing me with the academic environment and resources I need to complete my doctoral degree. Finally, I acknowledge the crucial contributions of the following agencies and projects: Project EDGES and the National Seaweed Training and Development Center (NSTDC) provided the technical resources and specialized support throughout the study. Additionally, BFAR Region V offered the essential data and institutional assistance that grounded my research in regional realities.

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