Optimization of Long Line Management in Seaweed Farming: Strategies for Increasing Farmers' Group Income in Pinrang Regency, Indonesia

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Abstract

This research aims to explore the role of the long-line method in increasing the income of seaweed farmers in Pinrang Regency, South Sulawesi, Indonesia, while examining the challenges they face and the strategies they employ to overcome them. The study employs a qualitative case study approach, involving 15 seaweed farmers from various coastal villages within Pinrang Regency, representing diverse demographic backgrounds and experiences. Data collection was conducted through semi-structured interviews, allowing for an in-depth understanding of the participants' farming practices and challenges. The findings indicate that seaweed farmers increase their income by optimizing resources, collaborating within farmer groups, and adapting to environmental and market changes. Strategies such as space optimization, material reuse, and knowledge sharing among farming communities significantly enhance productivity and sustainability. Furthermore, farmers employ adaptive techniques to mitigate environmental risks and market volatility, including using durable materials and processing seaweed into higher-value products. The implications of these findings are crucial for policymakers and development organizations, as they highlight the potential of sustainable farming practices in improving the livelihoods of coastal communities. Policymakers are encouraged to develop support programs that promote resource optimization, foster community-driven farming networks, and train farmers in adaptive strategies. However, the study's limitations, including the small sample size and reliance on self-reported data, may affect the generalizability of the results. Future research should incorporate larger, more diverse samples and objective measures to enhance the robustness of the findings, and explore the long-term impacts of the long-line method on income and sustainability.

Keywords: *Long-Line Method, Seaweed Farming, Income Improvement, Sustainable Agriculture, Coastal Communities.*

Introduction

Seaweed farming has emerged as one of the fastest-growing sectors in global aquaculture, contributing not only to food security but also to the sustainability of marine ecosystems. Globally, seaweed production plays a vital role in supporting various industries, ranging from food and pharmaceuticals to biofuels and cosmetics. Countries such as China, South Korea, and Japan are leaders in seaweed farming, supplying large quantities to meet international demand (Iqbal, 2022; Wale, 2022). With increasing interest in sustainable aquaculture and the rising global demand for eco-friendly, natural resources, seaweed is recognized as an environmentally beneficial crop due to its ability to absorb carbon and promote ocean health (Kaur, 2020; Troell, 2023, Yong, 2022). The economic benefits of seaweed farming extend beyond national economies, offering coastal communities around the world opportunities to improve their livelihoods. However, the success of seaweed farming is highly dependent on the methods and management practices used, particularly in ensuring both high yields and sustainable farming practices. Among these methods, long line farming has gained prominence as an efficient and adaptable approach, particularly in regions with varying sea conditions (Zhao, 2020; Zhu, 2021). Effective management of long line systems can significantly increase productivity and income for small-scale farmers, who make up a large portion of seaweed producers globally (March, 2022; Rimmer, 2021).

As one of the world's largest archipelagic countries, Indonesia has become a key player in global seaweed production, particularly in Southeast Asia. Indonesia's extensive coastline and tropical waters provide an

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ideal environment for seaweed cultivation, making it the second-largest seaweed producer in the world after China. Seaweed farming has become a lifeline for many coastal communities, offering a sustainable income source and contributing to the country's economic growth. In coastal areas like Pinrang Regency, located in South Sulawesi, seaweed farming has gained prominence as a primary livelihood. With the rise of seaweed production in Indonesia, farmer groups in these regions have adopted various techniques to optimize their yields, including the long line method. This method, which involves suspending seaweed on lines anchored in the ocean, has proven to be effective in maximizing water circulation and nutrient absorption, leading to increased crop growth (DeAngelo, 2023; García-Poza, 2020; Pereira, 2024) . However, despite its growing use, the success of long line seaweed farming depends largely on how well it is managed by local farming groups.

While considerable research has been conducted on the technical aspects of seaweed farming, there is a lack of qualitative studies exploring how small-scale farmers in developing countries like Indonesia manage long line systems to increase their income. Most studies focus on the economic potential of seaweed farming on a macro level or the technical efficacy of different farming methods, but they fail to capture the nuanced, everyday management practices of local farmer groups (Collins, 2022; Msuya, 2022; Sultana, 2023; Vance, 2023). Understanding how these groups collaborate, make decisions, and overcome challenges in managing long line systems is critical to improving their economic outcomes. Moreover, despite the economic importance of seaweed farming in coastal Indonesia, there has been limited investigation into the local knowledge, strategies, and challenges faced by farmer groups in maximizing their income through effective management of long line systems. Filling this gap in the literature is essential to developing more tailored and sustainable practices for seaweed farming in the region.

This study seeks to address this gap by conducting a qualitative investigation into the long line management practices of seaweed farmer groups in Pinrang Regency, Indonesia. Through interviews with local farmers, the research aims to explore how these groups use long line methods to increase their income, the specific challenges they encounter, and the strategies they develop to enhance their farming operations. By focusing on the experiences and practices of the farmers themselves, this research provides valuable insights into the relationship between long line management and income generation in seaweed farming. The findings are expected to contribute not only to improving seaweed farming practices in Pinrang but also to broader discussions on sustainable aquaculture and economic development in coastal communities globally.

How do seaweed farmer groups in Pinrang Regency manage long line farming systems to increase their income?

What challenges do these farmer groups face in the management of long line systems, and what strategies do they employ to overcome them?

Research Method

Research Design

This research employs a qualitative case study approach aimed at exploring how the seaweed farmers' group in Pinrang Regency, South Sulawesi, Indonesia, utilizes the long-line method to increase their income. Additionally, it seeks to examine the challenges faced by the farmers and the strategies they adopt to overcome these challenges. The qualitative approach is particularly suited for this study because it allows for a deep understanding of the experiences, perspectives, and practices of the seaweed farmers. By engaging directly with the farmers, this method facilitates the collection of rich, detailed data that can capture the complexity of the farming process, the socio-economic conditions, and the environmental factors influencing their livelihoods.

Research Participants

The participants in this research consist of 15 seaweed farmers from various coastal villages within Pinrang Regency, South Sulawesi, representing a wide range of demographic backgrounds, experiences, and roles

within their respective farming groups. The participants were selected using purposive sampling to ensure a diverse mix of gender, age, education levels, and years of experience in seaweed farming. This diversity is critical for capturing the full spectrum of perspectives on how the long-line method is applied and the challenges encountered.

The group includes both male and female farmers, with ages ranging from 29 to 60 years. Their education levels vary from primary school to high school, and their experience in seaweed farming spans from 5 to 30 years. This range of experience allows the study to explore both the insights of seasoned farmers, such as a 60-year-old woman with 30 years of experience (P11), and the perspectives of younger farmers with more recent involvement in seaweed farming, like a 29-year-old male with 5 years of experience (P4). Participants also hold different roles within their farming groups, including group leaders and members, which adds further depth to the study. For instance, group leaders, such as a 45-year-old male with 15 years of experience (P1) and a 55-year-old female with 25 years of experience (P7), offer insights into decision-making and strategic planning, while members provide a more hands-on perspective of day-to-day farming activities. These participants come from various coastal villages (Coastal Village 1, Coastal Village 2, and Coastal Village 3), allowing the study to consider geographical differences within the region. By including farmers from different locations, the research can account for how local environmental and social factors might influence the application of the long-line method and the challenges faced by the farmers. The detailed demographics of the participants are presented in Table 1.

Table 1. Demography of Participants

Participant ID	Gender	Age	Education Level	Experience in Seaweed Farming (Years)	Role in Farming Group	Location
P1	Male	45	Primary School	15	Group Leader	Coastal Village 1
P2	Female	38	Secondary School	10	Member	Coastal Village 2
P3	Male	50	Secondary School	20	Group Leader	Coastal Village 1
P4	Male	29	High School	5	Member	Coastal Village 3
P5	Female	42	High School	12	Member	Coastal Village 1
P6	Male	33	High School	8	Member	Coastal Village 2
P7	Female	55	Primary School	25	Group Leader	Coastal Village 3
P8	Male	41	High School	13	Member	Coastal Village 1
P9	Female	37	Secondary School	9	Member	Coastal Village 2
P10	Male	48	Primary School	18	Group Leader	Coastal Village 1
P11	Female	60	High School	30	Member	Coastal Village 3
P12	Male	35	Secondary School	7	Member	Coastal Village 2
P13	Female	52	High School	22	Group Leader	Coastal Village 1

P14	Male	40	Secondary School	11	Member	Coastal Village 3
P15	Female	36	High School	10	Member	Coastal Village 2

Research Instrument

The primary instrument used in this research is the interview, specifically the semi-structured interview format. This method was chosen for its flexibility, allowing the researcher to explore key topics while giving participants the freedom to elaborate on their experiences. Semi-structured interviews offer a balance between structured and open-ended questions, ensuring that the research objectives are met while providing space for deeper insights. The interview questions were carefully developed after reviewing relevant literature on seaweed farming, income generation methods, and challenges in coastal farming communities (Gavrilescu, 2021; Massa, 2020; Fernandes, 2020; Lim, 2021; Ndlela, 2021; Spijker, 2020). This review helped identify key themes, such as the use of farming techniques, economic impacts, and coping strategies, which were incorporated into the interview design.

In this study, questions regarding the approach used to increase income include: *How has the long-line method impacted your seaweed farming operations?, What specific techniques or practices do you use to maximize seaweed production?,* and *How has your income changed since adopting the long-line method, and what factors contributed to this change?* To explore challenges and strategies to overcome them, questions such as: *What are the main challenges you face in using the long-line method?, Have you encountered difficulties related to climate, market prices, or resource availability? How do you manage these challenges?,* and *What strategies or innovations have you implemented to address these challenges?* are asked. These questions allow the researcher to gather comprehensive data on the farmers' experiences, challenges, and adaptive strategies, providing valuable insights into the dynamics of seaweed farming in the region.

Data Analysis

The collected data was analyzed using thematic analysis, a method that allows for the identification, analysis, and interpretation of patterns or themes within the data. This approach is particularly suitable for qualitative research, as it enables the researcher to systematically explore key themes that emerge from the participants' responses, providing insights into their experiences, challenges, and strategies. Thematic analysis offers flexibility, allowing both a detailed and broad exploration of the data, making it ideal for understanding the complexities of the seaweed farmers' practices and the impacts of the long-line method on their livelihoods.

The analysis follows a structured process, which typically involves at least five stages. First, the researcher becomes familiar with the data by reading and re-reading the interview transcripts. Second, initial codes are generated, systematically identifying significant features across the dataset. Third, these codes are grouped into broader themes that capture patterns in the data. Fourth, the themes are reviewed and refined to ensure they accurately represent the data and are coherent. Finally, the themes are defined, named, and interpreted, allowing the researcher to draw meaningful conclusions that align with the research objectives. This multi-stage approach not only ensures a rigorous and systematic analysis but also provides the flexibility to uncover unexpected insights, making thematic analysis a robust tool for exploring the diverse experiences of the seaweed farmers.

Findings

The findings of this study address two key issues based on the formulated research questions. The first pertains to how seaweed farmer groups in Pinrang Regency manage long-line farming systems to increase their income. The second focuses on the challenges these farmer groups encounter in managing long-line systems and the strategies they use to overcome them. A detailed explanation of each finding is provided in their respective subsections.

How Seaweed Farmer Groups Manage Long-Line Farming Systems to Increase Their Income

In line with this issue, there are three main themes emerged during the interview section: efficient use of resources, collaboration and knowledge sharing within the group and adaptation to environmental and market conditions.

Efficient Use of Resources

The seaweed farmers place a strong emphasis on optimizing the resources available to them, particularly materials and space, in order to maximize their farm yields. P1 points out that proper spacing of the lines has significantly improved water circulation, which led to a 20% increase in production in the last season, demonstrating the impact of small but effective changes. P3 discusses the reuse of old materials like ropes and floats, as well as resource pooling among group members to reduce equipment costs and improve profit margins. This practice highlights their focus on sustainability and cost-efficiency. P10 mentions rotating the placement of the lines in different parts of the sea to avoid nutrient depletion, ensuring the seaweed grows more effectively. Their responses from the interview session are outlined below.

P1: *"We learned how to properly space the lines so that the seaweed gets enough water circulation. This small change increased our production by almost 20% in the last season."*

P3: *"We reuse old materials like ropes and floats, and we pool resources among group members to reduce costs. This way, we save money on equipment and increase our profit margins."*

P10: *"By rotating the placement of lines in different parts of the sea, we ensure that the seaweed grows better and faster without depleting one area of nutrients."*

Collectively, these strategies demonstrate how the farmers utilize their resources efficiently to improve yields and profitability. However, resource management is not the only factor contributing to the success of these farmers. Equally important is the collaborative effort and exchange of knowledge within the community, which fosters innovation and adaptation to ongoing challenges.

Collaboration and Knowledge Sharing within the Group

Collaboration and knowledge sharing among seaweed farmer groups play a crucial role in improving the management of long line systems, ultimately leading to higher yields and increased income. P2 emphasizes the importance of regular group meetings, where members exchange ideas and solutions to common problems, allowing individuals to enhance their harvests through shared experiences. P6 further elaborates on this by highlighting how group leaders hold workshops to teach better line management techniques, such as tying methods and optimal harvesting times. This collective learning ensures that all members stay informed and continuously improve their practices. Additionally, P12 mentions the practice of monitoring each other's lines, where members help correct any issues they observe. This cooperative approach minimizes errors and promotes consistent improvements in yield for the entire group. Below are selected quotes from the respondents.

P2: *"We meet regularly as a group to discuss any problems we have with the lines. Someone always has an idea that can help the others. Sharing tips has helped me improve my harvest."*

P6: *"The group leaders often hold workshops on how to better manage the lines, from tying techniques to knowing the right times for harvesting. This collaboration keeps us ahead."*

P12: *"We take turns monitoring each other's lines, and if we see something wrong, we help fix it. This reduces errors and helps everyone improve their yields."*

This cooperative approach not only minimizes errors but also fosters a supportive environment where farmers can continually refine their techniques, leading to consistent improvements in yield for the entire group. By working together, they are able to solve problems more effectively and implement best practices across the board. However, managing their operations efficiently also requires farmers to adapt to external factors beyond their control.

Adaptation to Environmental and Market Conditions

Adaptation to environmental and market conditions is a key factor in the success of seaweed farmers. P4 highlights the importance of monitoring weather and water conditions, adjusting the height of the lines when strong waves are expected to prevent damage to the seaweed. This proactive approach helps protect their crop from environmental risks. P7 focuses on market fluctuations, noting that when seaweed prices drop, the group prioritizes improving the quality of their crop by maintaining cleaner lines. This strategy allows them to sell higher-quality seaweed, which fetches better prices even in a challenging market. Similarly, P9 mentions the flexibility to switch to more in-demand seaweed varieties, despite the need for increased maintenance. This adaptability enables the group to capitalize on market trends, ensuring higher profits. The following are quotes shared by the respondents.

P4: *"We pay close attention to the weather and water conditions. When we know strong waves are coming, we adjust the height of the lines to avoid damage to the seaweed."*

P7: *"Sometimes the price of seaweed drops. When this happens, we focus on improving the quality of our crop by keeping the lines cleaner. Higher-quality seaweed sells better, even when the market is tough."*

P9: *"If we notice that a certain type of seaweed is in higher demand, we switch the lines to grow that variety. It requires more maintenance, but the profits are much higher."*

In nutshell, this flexibility allows them to navigate market challenges while optimizing their long-line systems. Through these strategies, the farmers ensure sustainable income growth despite external pressures.

Challenges in Managing Long-Line Systems and Their Solutions

The second key finding of this research addresses the challenges faced by farmer groups in managing long-line systems and the strategies they employ to overcome them. We identified three main themes related to this issue: environmental challenges, financial constraints and market and price volatility.

Environmental Challenges

The farmers noted that environmental challenges pose significant obstacles, affecting both their yields and income. P5 notes that during the rainy season, strong waves and currents often damage the lines, leading to crop losses. In response, the group has started using stronger, more durable ropes to minimize the damage, reflecting a proactive approach to handling weather-related issues. P8 mentions the problem of algae growth on the seaweed, which reduces its quality. To counter this, farmers have learned to monitor their lines more frequently and remove algae as soon as it appears, ensuring the health and quality of their crop. P11 highlights the sudden changes in water temperature that affect seaweed growth, prompting the group to relocate some lines to deeper waters where temperatures are more stable. Here are their responses from the interview session.

P5*: "During the rainy season, the strong waves and currents often damage the lines, causing a loss in crops. We have started using stronger, more durable ropes to minimize the damage."*

P8: *"Sometimes, algae grows on the seaweed, which reduces its quality. We've learned to monitor the lines more frequently and remove any algae as soon as it appears."*

P1: *"The water temperature changes suddenly, affecting the growth of the seaweed. We've had to relocate some lines to deeper waters where the temperature is more stable."*

In a nutshell, these strategies demonstrate the farmers' resilience and adaptability in dealing with environmental challenges, allowing them to mitigate losses and sustain their production. However, while their ability to adjust to environmental factors is commendable, the farmers also face significant challenges related to financial constraints, which further complicate their operations.

Financial Constraints

Financial constraints pose significant challenges for the seaweed farmers, particularly due to the rising costs of materials and equipment. P1 explains that the increasing prices of essential items like ropes, floats, and anchors make it difficult to sustain their farming operations. To address this issue, the group buys materials in bulk and shares them among members, effectively reducing individual costs. P3 highlights the difficulty in obtaining loans to expand their farms. To mitigate this, the group has implemented a savings system, setting aside part of their earnings for reinvestment in new lines, allowing them to grow without relying on external funding. P14 discusses the need to cut back on farming operations due to financial constraints, focusing instead on maintaining and repairing existing equipment to keep the farm operational without incurring additional expenses. Presented below are quotes from the respondents.

P1: *"The cost of buying new ropes, floats, and anchors keeps rising. To overcome this, we buy materials in bulk as a group and share them among the members, which helps reduce the individual cost."*

P3: *"Getting a loan to expand our farm is difficult. We've started saving part of our earnings as a group so that we can reinvest in new lines without relying on outside funding."*

P14: *"We had to cut down on some farming operations because we couldn't afford all the equipment. Now we focus on maintenance and repairing what we have to keep the farm going without extra expenses."*

These strategies demonstrate how the farmers use resourcefulness and collective effort to navigate financial challenges and sustain their farming activities. However, financial difficulties are only part of the equation. The farmers must also contend with unpredictable market conditions that can further strain their operations.

Market and Price Volatility

Market and price volatility are significant challenges for the seaweed farmers, as fluctuating prices and changing market demands can impact their profitability. P2 explains that when seaweed prices drop, they are forced to sell at lower profits. To counter this, the group has started processing the seaweed into higher-value products, which can be sold at better prices, helping to mitigate the effects of price drops. P10 mentions the difficulty of selling seaweed at the right time due to the fast-changing market. In response, the group is working on establishing partnerships with more stable buyers to secure consistent pricing, ensuring more predictable income. P13 points out that when demand for certain types of seaweed decreases, the group faces financial losses. To address this, they have diversified by planting different seaweed varieties, reducing their reliance on a single crop and providing more resilience against market fluctuations.

P2: *"When seaweed prices drop, we are forced to sell at a lower profit. To manage this, we've started processing the seaweed ourselves to make higher-value products that can sell at better prices."*

P10: *"The market changes so fast, sometimes we can't sell our seaweed at the right time. To overcome this, we are trying to create partnerships with more stable buyers to secure a consistent price."*

P13: *"We lose a lot of money when the demand for certain types of seaweed decreases. Our strategy has been to diversify and plant different varieties so we aren't relying on just one crop."*

These strategies show how the farmers adapt to market volatility by exploring value-added products, securing reliable buyers, and diversifying their crops to ensure stable income.

In conclusion, this study reveals how seaweed farmers in Pinrang Regency increase their income by efficiently managing resources, collaborating, and adapting to environmental and market conditions. Despite facing challenges such as environmental risks, financial constraints, and market volatility, the farmers implement proactive strategies, such as using durable materials, pooling resources, and diversifying crops, to sustain their operations. These findings highlight the farmers' resilience and adaptability in ensuring long-term success and stable income.

Discussion

This research aims to explore the role of the long-line method in increasing the income of seaweed farmers in Pinrang Regency, South Sulawesi, Indonesia, and to examine the challenges they face, along with the strategies they employ to overcome them.

The first key finding demonstrates that farmers increase their income using the long-line method through three main approaches. First, seaweed farmers prioritize resource optimization to enhance productivity and profitability. Their strategies reflect a broader trend in sustainable agricultural practices, where efficiency and sustainability are critical drivers of success. Farmers focus on optimizing space, reusing materials, and rotating line placements, aligning with findings in agricultural literature that highlight the importance of resource management in improving productivity and reducing costs. For example, proper line spacing, which enhances water circulation and boosts yields, parallels broader aquaculture practices that emphasize environmental management to maximize crop growth. Studies on seaweed farming emphasize that maintaining optimal water flow and nutrient availability is crucial for enhancing growth rates and preventing diseases (Gavrilescu, 2021; Massa, 2020; Plett, 2020). This focus on proper spacing mirrors key principles in maximizing environmental factors, such as light penetration and nutrient flow, to promote healthy seaweed development (Araujo, 2022; Meghla, 2024).

Second, the emphasis on collaboration and knowledge sharing among seaweed farmer groups underscores the importance of community-driven approaches to improving farming practices and outcomes. This cooperative model not only enhances individual performance but also fosters collective success by promoting the exchange of ideas, skills, and solutions to common challenges. Agricultural development research consistently highlights the value of knowledge sharing in smallholder farming systems. Peer-to-peer learning and group collaboration lead to the widespread adoption of best practices, significantly improving crop yields and sustainability (Baptista, 2021; De Witte, 2023; Singh, 2024). The regular group meetings and workshops described in this context serve as platforms for continuous learning, where farmers exchange insights and refine their long-line farming techniques.

Third, the ability of seaweed farmers to adapt to both environmental and market conditions is a key driver of their success. By proactively adjusting their farming practices in response to weather risks and market changes, they protect their crops, maintain high-quality yields, and capitalize on shifting market demands. These adaptive strategies ensure the sustainability of their operations and enable them to thrive despite external pressures. Economic literature supports this strategy, suggesting that quality improvement is a key factor in maintaining market share and profit margins during periods of price instability (Fernandes, 2020; Lim, 2021; Lu, 2021).

The second key finding of this research focuses on the challenges faced by seaweed farmers and the strategies they employ to overcome them. Farmers encounter significant environmental challenges, such as damage from strong waves, algae growth, and temperature fluctuations, all of which negatively affect yields and income. To mitigate these issues, farmers use durable materials, increase monitoring to manage algae, and relocate farms to more stable waters. These strategies align with sustainable farming and aquaculture practices, emphasizing resilience and adaptability to environmental risks (Boyd, 2020; Efroymson, 2021; Haque, 2021). By proactively addressing these challenges, farmers maintain productivity and secure their income.

In addition to environmental challenges, financial constraints, driven by rising costs of materials and equipment, pose a significant hurdle. To mitigate these, farmers engage in bulk purchasing, resource sharing, and savings systems for reinvestment, while prioritizing equipment maintenance over expansion. These strategies reflect broader agricultural practices of collective action and self-reliance, enabling farmers to sustain and gradually grow their operations despite financial pressures (Ndlela, 2021; Spijker, 2020; Zhang, 2024). Comparative research supports these strategies, showing that collective purchasing lowers costs through economies of scale (Bel, 2021; Chopra, 2021), and savings systems boost financial resilience by reducing reliance on external credit (Pomeroy, 2020; Salignac, 2022). Research on microfinance further highlights how self-reliant savings groups provide capital for growth without the risks associated with formal lending (Dhawan, 2022; Gupta, 2023). Maintaining equipment over expansion reflects operational efficiency, a key resilience strategy in farming, where minimizing resource waste and maximizing existing assets are essential during financial hardship (Onyeaka, 2023; Usmani, 2021).

Market and price volatility also present challenges, as fluctuating prices and changing demand impact profitability. In response, farmers have begun processing seaweed into higher-value products to secure better returns. This strategy is consistent with product differentiation for enhanced market competitiveness (Francis, 2023; Rua, 2022). Additionally, farmers form partnerships with stable buyers to ensure consistent pricing, aligning with research on reliable supply chains to mitigate market risks (El Baz, 2021; Munir, 2020). Farmers also diversify their crops to reduce reliance on a single product, a well-established risk management strategy in agriculture (Hufnagel, 2020). In aquaculture, species diversification further increases resilience to economic shocks and fluctuating demand (Dumont, 2022; Dumont, 2020; Makate, 2022). In summary, strategies such as value-added processing, stable buyer partnerships, and crop diversification help seaweed farmers manage market volatility while enhancing profitability and resilience.

The findings of this research have important implications for policymakers, development organizations, and seaweed farming communities. By demonstrating the effectiveness of the long-line method in increasing income, this study highlights the potential of sustainable farming practices in improving livelihoods in coastal regions. Policymakers can leverage these insights to design and implement support programs that enhance resource optimization, foster collaborative farming networks, and provide training on adaptive strategies for environmental and market challenges. Additionally, this research emphasizes the importance of community-driven approaches, suggesting that empowering farmer groups through knowledge sharing and cooperative models can significantly improve agricultural outcomes and economic resilience. Development organizations can also use these findings to tailor interventions aimed at enhancing the sustainability and profitability of smallholder seaweed farming in other regions.

Despite its valuable contributions, this research has several limitations that must be acknowledged. First, the study was conducted with a relatively small sample size, which may limit the generalizability of the findings. The use of self-report data from the farmers also introduces the potential for bias, as responses may be influenced by social desirability or recall errors. Additionally, the study focuses on a single region, and the environmental and economic conditions in Pinrang Regency may not fully represent those in other seaweed farming areas, both within and outside Indonesia. As a result, caution should be exercised when applying these findings to different contexts.

To address these limitations, future research should aim to include larger and more diverse samples across different regions to improve the generalizability of the results. Incorporating objective measures, such as productivity data and market performance metrics, could help reduce the reliance on self-reported data and enhance the accuracy of the findings. Longitudinal studies that track the long-term impact of the long-line method on income, sustainability, and farmer resilience would also be beneficial. Furthermore, exploring the role of government policies, technological innovations, and market dynamics in shaping the success of seaweed farming practices could provide deeper insights into how to support the growth and sustainability of this vital industry.

Conclusion

The aim of this research was to explore the role of the long-line method in increasing the income of seaweed farmers in Pinrang Regency, South Sulawesi, Indonesia, while also examining the challenges they face and the strategies they employ to overcome these obstacles. The main findings highlight that seaweed farmers successfully increase their income using the long-line method through resource optimization, collaboration, and adaptability to environmental and market conditions. By optimizing space, reusing materials, and rotating line placements, farmers enhance productivity and reduce costs. Collaboration and knowledge sharing among farmer groups also improve farming practices and outcomes, while adaptive strategies to changing weather and market conditions ensure the sustainability of their operations. Additionally, farmers mitigate challenges such as environmental damage, financial constraints, and market volatility by using durable materials, engaging in collective action, and processing seaweed into higher-value products. The implications of these findings are significant for policymakers, development organizations, and the broader seaweed farming community. The study demonstrates the potential of the long-line method to improve livelihoods through sustainable farming practices, providing a foundation for support programs that focus on resource optimization, community-driven farming networks, and adaptive strategies. Policymakers can use these insights to design interventions that enhance both the sustainability and profitability of smallholder seaweed farming. Despite its valuable contributions, this research has limitations. The relatively small sample size and reliance on self-reported data may affect the generalizability and accuracy of the findings. Additionally, focusing on a single region may limit the applicability of the results to other seaweed farming areas. Future research should include larger, more diverse samples and incorporate objective measures to improve the robustness of the findings. Longitudinal studies and an exploration of the role of government policies and technological innovations would further deepen the understanding of how to support the sustainable growth of the seaweed farming industry.

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