

The Role of Coastal Women in Seaweed Cultivation and Their Contribution to Household Income in Pantai Amal, Tarakan City

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Abstract. Pantai Amal, Tarakan City, is a coastal area where seaweed cultivation supports local livelihoods and provides income-generating opportunities for women. This study aimed to examine the roles of coastal women in seaweed cultivation and their contributions to household economies in Pantai Amal. A descriptive qualitative approach was employed using field observations, in-depth interviews, and documentation. Informants were purposively selected based on their direct involvement, experience, and knowledge of seaweed cultivation. Data were analyzed using the interactive model of Miles, Huberman, and Saldaña, comprising data condensation, data display, and conclusion drawing and verification. The findings revealed a distinct gender-based division of labor. Women played a predominant role in seedstock tying during preproduction and actively participated in drying and cleaning during postharvest handling, whereas men predominantly undertook offshore planting, maintenance, and harvesting. Women's involvement in seedstock tying and postharvest activities generated wage-based income that helped meet household needs, particularly when primary household earnings fluctuated due to changes in production, weather conditions, and seaweed prices. These findings highlight the important economic contributions of coastal women within the seaweed cultivation value chain and their role in supporting the livelihoods of seaweed-farming households in Pantai Amal.

Keywords: coastal women, seaweed cultivation, household economy, gender division of labor, Pantai Amal.

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INTRODUCTION

Coastal areas are complex socioeconomic environments characterized by a high dependence on marine resources. Coastal communities primarily rely on marine and fisheries activities, including fishing, aquaculture, fish trading, and seafood processing. Consequently, the availability of marine resources, environmental conditions, seasonal variability, and market access significantly influence the economic activities and livelihoods of coastal communities. Seaweed is an important commodity in the marine and fisheries sector, and its cultivation plays a significant role in supporting coastal economies, particularly as global demand continues to increase (Zhang *et al.*, 2022).

Global seaweed production remains dominated by Asian countries, with Indonesia ranking among the world's leading producers after China (Zhang *et al.*, 2022). Seaweed has considerable economic value because it can be processed into various food and non-food products, including alginate, carrageenan, and agar. Its applications also extend to pharmaceuticals, cosmetics, biofertilizers, bioenergy, and other biorefinery-based products (Farghali *et al.*, 2023). Furthermore, the high carbohydrate content of seaweed indicates its potential as an alternative raw material for sugar production (Zaenab *et al.*, 2020). In Indonesia, seaweed cultivation has been widely developed because its cultivation techniques are relatively simple, do not require additional feed, and generally involve less complex technologies than many other aquaculture activities (Zainuddin, 2023). Beyond generating household income, seaweed cultivation also creates employment opportunities and facilitates the economic participation of coastal women (Mengo *et al.*, 2023).

Seaweed cultivation involves several stages, including seedling preparation and tying, maintenance, harvesting, and postharvest handling. Coastal women play important roles throughout these activities, particularly in production support and postharvest operations. Their participation extends beyond traditional domestic responsibilities to productive activities that generate economic value. Mengo *et al.* (2023) demonstrated that women participate in various stages of seaweed cultivation, with gender-based divisions of labor reflected in differences in occupational responsibilities, working hours, and remuneration between women and men. These findings highlight the important contributions of women to seaweed production systems and associated value chains.

Women's involvement in seaweed cultivation also provides opportunities to generate additional income and strengthen the economic conditions of coastal households. Their participation in production and postharvest activities demonstrates that their contributions extend beyond supporting roles and have direct economic significance. Mengo *et al.* (2023) emphasized the relationship between women's participation, occupational roles, remuneration, and their positions within seaweed production systems. Similarly, Azzahra *et al.* (2024) reported that women's participation in seaweed cultivation contributed to increased household income and supported the fulfillment of household economic needs. These findings suggest that women's productive activities constitute an important component of coastal household economies.

Previous studies have highlighted the importance of women's participation in marine and fisheries activities, including seafood processing, marketing, capture fisheries, and seaweed cultivation. However, existing research has largely examined coastal women's economic roles in broader contexts or focused on seaweed cultivation in other geographical areas. Studies specifically investigating the roles of coastal women in seaweed cultivation and their contributions to household economies in Pantai Amal, Tarakan City, remain limited. This research gap is particularly relevant because Pantai Amal is an important seaweed cultivation area in North Kalimantan, where *Kappaphycus alvarezii* is a major cultivated species and seaweed farming activities are generally organized within family-based enterprises. Understanding women's involvement in these activities is therefore essential for identifying their productive roles and economic contributions within coastal households. Accordingly, this study aimed to analyze the roles of coastal women in seaweed cultivation and their contributions to household economies in Pantai Amal, Tarakan City, Indonesia.

METHODS

Research Location and Period

Data collection was conducted in Pantai Amal, East Tarakan District, Tarakan City, North Kalimantan, Indonesia, an area known for the cultivation of *Kappaphycus alvarezii* seaweed. The study was carried out from January to July 2024 through field observations, in-depth interviews, and documentation of seaweed cultivation activities undertaken by local communities. The data collected covered the stages of seaweed cultivation, the division of labor between men and women, women's involvement in preproduction, production, and postharvest activities, wage systems, seaweed prices and quality, and the contribution of women's productive activities to household economies.

Research Design and Data Sources

This study employed a descriptive qualitative approach to examine the roles of coastal women in seaweed cultivation and their contributions to household economies in Pantai Amal, Tarakan City. This approach was adopted to obtain a comprehensive understanding of the phenomenon based on the actual conditions, activities, and experiences of informants in the study area (Villamin *et al.*, 2025). The study utilized both primary and secondary data. Primary data were obtained directly through field observations and interviews with research informants (Sugiyono, 2021). Informants included coastal women, seaweed farmers, workers involved in seedling tying and drying activities, and seaweed collectors. Informants were selected purposively based on their direct involvement, experience, and knowledge of seaweed cultivation activities and the associated value chain. This selection approach was intended to obtain information relevant to the research objectives (Ahmad & Wilkins, 2025; Villamin *et al.*, 2025).

The information collected included cultivation and postharvest activities, gender-based divisions of labor, women's participation in preparation, maintenance, harvesting, and drying activities, work arrangements and wage systems, marketing practices, seaweed prices and quality, and the economic contributions of women's productive activities to their households. In this study, women's contributions to household economies were examined qualitatively, focusing on income earned from seaweed cultivation activities and its role in supporting household needs. Accordingly, economic contributions were assessed based on the role of women's earnings in household economic activities rather than by calculating the proportion of women's income relative to total household income. Women's participation, divisions of labor, and wage arrangements were also examined from a gender perspective, consistent with the discussion of gender roles in seaweed cultivation (Mengo *et al.*, 2023).

Secondary data were obtained from documented sources, including government reports and publications, books, scientific articles, and other relevant documents. Document analysis was used to complement primary data and provide a broader understanding of the research context (Morgan, 2022). The secondary information covered the geographical and socioeconomic characteristics of Pantai Amal, seaweed cultivation practices, the socioeconomic conditions of coastal communities, and previous studies concerning women's roles in seaweed farming.

Data Collection Methods

Data were collected through field observations, in-depth interviews, and documentation. Field observations were conducted to directly examine seaweed cultivation activities in Pantai Amal, covering preproduction, production, and postharvest stages, with particular attention to women's participation and the division of labor between men and women (Sugiyono, 2021).

In-depth interviews were conducted with purposively selected informants who had direct experience and knowledge of seaweed cultivation processes, labor arrangements, wage systems, seaweed prices and quality, and women's contributions to household economies (Ahmad & Wilkins, 2025). The number of informants was not predetermined because data collection was conducted progressively throughout the study period. Informants were selected based on the relevance of their knowledge, experience, and involvement in seaweed cultivation activities.

Data trustworthiness was strengthened through source triangulation by comparing information obtained from different informants and cross-checking it against field observations and documentary evidence. Documentation complemented the observational and interview data through field notes, photographs of cultivation activities, official reports, and other relevant documents (Morgan, 2022). Informants' identities were not disclosed in the presentation of research findings to protect the confidentiality of their personal information.

Data Analysis

The data were analyzed using the interactive analysis model described by Miles *et al.* (2020), comprising three interconnected stages: data condensation, data display, and conclusion drawing and verification.

1. Data Condensation

Data condensation involved selecting, focusing, simplifying, and categorizing information obtained from field observations, interviews, and documentation according to the research objectives. This process was intended to identify relevant information concerning women's roles in seaweed cultivation and their contributions to household economies.

2. Data Display

Data display involved organizing the analyzed information into narrative descriptions, tables, and matrices to illustrate gender-based divisions of labor and women's involvement in the various stages of seaweed cultivation. This process facilitated the identification of patterns and relationships among the findings.

3. Conclusion Drawing and Verification

Conclusion drawing and verification involved identifying patterns and relationships among the findings and examining their consistency across the collected and analyzed data. Conclusions were developed through interpretation of the overall findings, supported by comparisons among interview results, field observations, and relevant documentation.

RESULTS AND DISCUSSION

Overview of Coastal Women in Pantai Amal

The economic activities undertaken by women in fishing households are strongly influenced by the availability and characteristics of surrounding natural resources. Consequently, their livelihood activities are generally concentrated in the marine and fisheries sectors, which are closely connected to their daily lives and household economic needs.

Pantai Amal is a coastal area in Tarakan City where many residents depend on marine resources, particularly the cultivation of *Kappaphycus alvarezii* seaweed. Some community members also engage in fishing activities, especially when seaweed prices decline. Coastal women in Pantai Amal play important roles in the seaweed cultivation value chain, from seedstock preparation and maintenance to postharvest handling. However, their contributions are often perceived as supplementary to household livelihoods, resulting in insufficient recognition of their productive roles within the coastal economy.

Field observations and interviews revealed that coastal women in Pantai Amal actively participated in productive, domestic, and social activities within both their households and seaweed farming communities. These findings are consistent with Wulandari *et al.* (2022), who reported that coastal women simultaneously perform economic, domestic, and social roles. Their involvement demonstrates that women's contributions extend beyond household responsibilities and constitute an important component of coastal livelihood systems.

Roles of Coastal Women in Seaweed Cultivation Activities

1. Preproduction Stage

1.1 Cultivation Site Selection and Seedstock Procurement

During the initial stages of seaweed cultivation in Pantai Amal, Tarakan City, particularly cultivation site selection and seedstock procurement, men generally played a dominant role. Site selection requires technical considerations regarding water suitability, including water quality, current velocity, depth, substrate characteristics, and surrounding environmental conditions. Furthermore, cultivation activities must be conducted within marine areas designated or permitted for aquaculture under applicable government regulations. Within this context, women's participation remained relatively limited, particularly in technical decisions concerning cultivation locations and seedstock selection.

Men also played a greater role in seedstock procurement, particularly when locally available seedstock in Pantai Amal became insufficient and additional supplies had to be obtained from other areas. This process required knowledge of seedstock quality, supply sources, and transportation procedures to maintain seedstock suitability before cultivation.

The suitability of cultivation sites is an important factor influencing seaweed production and quality. [Simatupang et al. \(2021\)](#) demonstrated that the production and quality characteristics of *Kappaphycus alvarezii*, including carrageenan content, gel strength, and viscosity, varied among cultivation locations in Indonesia. Similarly, [Pratama et al. \(2024\)](#) emphasized that seaweed cultivation site selection should consider ecological, technical, hygienic, and economic factors, as well as environmental carrying capacity, spatial planning, and applicable regulatory requirements to support sustainable cultivation.

These findings indicate that coastal women's limited involvement in site selection and seedstock procurement reflects a gender-based division of labor within seaweed cultivation activities. These stages require technical considerations and access to information concerning cultivation areas, seedstock availability, and marine spatial regulations. Nevertheless, the observed division of responsibilities should not necessarily be interpreted as a difference in technical capabilities between men and women, as women's access to information and participation in decision-making were not independently assessed.

1.2 Seedstock Tying

Coastal women in Pantai Amal played a dominant role in seaweed seedstock tying activities. This process involves attaching seaweed seedstock to cultivation lines and is generally performed in shaded areas, such as beneath raised houses or under tarpaulin shelters. These locations are used to help maintain seedstock condition before transportation to cultivation sites while protecting workers from direct sunlight.

The substantial involvement of women in seedstock tying reflects a gender-based division of labor within seaweed cultivation. This finding is consistent with [Haeruddin et al. \(2022\)](#), who reported high levels of women's participation in seedstock tying activities. Similarly, [Langford et al. \(2024\)](#) found that women in Indonesia's seaweed industry frequently undertake preparation and postharvest activities near their homes, including attaching seaweed seedstock to cultivation lines.

According to interview respondents, a woman could tie approximately 10–15 cultivation lines per day, with each line measuring 20–26 meters in length. The number of lines completed depended on seedstock availability and the time at which work commenced. Seedstock tying generally took place from morning until late afternoon, depending on the schedule for transporting seedstock from the sea and the quantity requiring preparation.

These findings demonstrate that women's participation in seedstock tying is not merely supplementary work but an integral component of the seaweed production process. Their activities contribute to preparing seedstock for cultivation and may support consistent spacing along cultivation lines and the maintenance of seedstock condition before deployment at sea ([Figure 1](#)). The economic importance of women's

participation in these activities is also supported by [Haeruddin et al. \(2022\)](#), who identified seedstock tying and seaweed drying as productive activities undertaken by women that contribute to household livelihoods.

Overall, the findings highlight the importance of coastal women in the preproduction stage of seaweed cultivation, particularly through their involvement in seedstock preparation. Although technical decisions regarding cultivation sites and seedstock procurement were predominantly undertaken by men, women contributed substantially to the labor required to prepare cultivation lines. This division of responsibilities illustrates how gender-based labor arrangements shape participation in seaweed production and reinforces the importance of recognizing women's productive contributions within coastal household economies.



Figure 1. Tying Seaweed Seedlings to Cultivation Lines.

1.3 Planting

Seaweed cultivation in the coastal waters of Pantai Amal, Tarakan City, employs the *long-line* method. The planting process begins with loading seaweed seedstock that has been attached to cultivation lines onto boats. The seedstock is then transported to the respective farmers' cultivation sites, where the lines are installed and stretched across the designated cultivation areas. During installation, both ends of each cultivation line are secured to main ropes connected to stakes or anchors. The lines must be maintained at an appropriate tension and depth because excessive slackness may cause the seedstock to sink too deeply, potentially inhibiting seaweed growth ([Ndun et al., 2025](#)). These activities require considerable physical effort, particularly when lifting and transporting seedstock, pulling and tensioning cultivation lines, and securing them to anchoring structures. Consequently, men generally play a more dominant role in these planting activities.

Male dominance during the planting stage is associated not only with the physical and technical demands of the work but also with local sociocultural norms that tend to associate physically demanding and highly mobile activities with men. This pattern is consistent with the concept of gender stereotypes, in which particular characteristics and social roles are associated with specific gender groups, shaping expectations regarding activities considered appropriate for men and women ([Eagly & Koenig, 2021](#)). Nevertheless, women continue to provide important support by preparing seedstock, arranging cultivation lines, and managing household activities during the planting process. Although women are less directly involved in the main offshore planting activities, their contributions remain essential to supporting the overall cultivation process.

2. Production Stage

2.1 Care and Maintenance

Following planting, seaweed is vulnerable to damage caused by unpredictable environmental conditions. Although these factors cannot be entirely controlled, regular

maintenance is necessary to support cultivation success, maintain the stability of cultivation structures, and reduce the risk of disease. Maintenance activities include periodic inspections, removing mud, shellfish, sediment, and organic or plastic debris attached to cultivation lines and seaweed, and checking ropes, floats, and anchors to ensure that they remain functional. Regular cleaning of mud and epiphytes attached to seaweed is an important cultivation practice that, in *Kappaphycus alvarezii* farming, may be performed once or twice a week (Simatupang *et al.*, 2021).

Field observations and interviews indicated that maintenance activities in Pantai Amal were predominantly undertaken by men. These activities require boat-handling skills, considerable mobility, and physical effort, particularly when repairing damaged ropes, stakes, or anchors. Most respondents reported that women were rarely directly involved in routine offshore maintenance, as these activities were generally performed by men. Nevertheless, women continued to contribute to other cultivation activities, particularly those conducted on land, including seedstock tying, drying, and sorting harvested seaweed.

The observed labor arrangements reflect a gender-based division of responsibilities within coastal household production systems. Gender differences in seaweed cultivation can be observed through the types of activities performed and the degree of participation of men and women at different production stages. Mengo *et al.* (2023) identified distinct gender-based divisions of labor in seaweed cultivation, reflected in differences in occupational responsibilities, working hours, remuneration, and participation in decision-making. Similarly, Susilowati (2021) reported that coastal women involved in seaweed cultivation tended to participate in activities requiring less mobility, whereas men predominantly performed tasks involving greater physical effort and movement. The findings from Pantai Amal demonstrate a comparable pattern, in which men's offshore responsibilities and women's land-based activities complement one another within household seaweed production systems.

2.2 Harvesting

Seaweed cultivated in the coastal waters of Pantai Amal is generally harvested approximately 40–55 days after planting. Harvesting age is an important factor influencing carrageenan characteristics in *Kappaphycus alvarezii*, including yield, moisture content, ash content, sulfate content, viscosity, and gel strength (Firdaus *et al.*, 2021).

During harvesting, cultivation lines containing mature seaweed are lifted from the water. This activity is generally performed by men because it involves substantial physical effort. Harvesting activities include pulling cultivation lines from the sea, lifting seaweed onto boats, transporting the harvested material to shore, and removing seaweed from the cultivation lines.

In addition to physical strength, these activities require endurance and technical skills in operating equipment in marine environments. Environmental conditions, particularly currents and waves, may further increase the difficulty of harvesting operations. These characteristics contribute to men's greater involvement in offshore harvesting, while women generally participate more extensively in land-based activities during the preproduction and postharvest stages. This division of labor illustrates the complementary responsibilities of men and women within the seaweed cultivation system in Pantai Amal.

2.3 Drying and Cleaning

After harvesting, seaweed is generally removed from the cultivation lines and spread evenly over plastic sheets or tarpaulins to facilitate uniform drying. In several locations in Pantai Amal, farmers also employ a suspended drying method, in which harvested seaweed remains attached to cultivation lines that are hung directly on drying racks or poles. Both methods represent postharvest handling practices that rely primarily on solar energy for drying.

Drying activities generally involve both women and men and typically require approximately 3–7 days, depending on weather conditions and the moisture level

required by buyers. During drying, seaweed is also cleaned to remove sand, coral fragments, mud, and other debris collected during harvesting. The degree of dryness is an important factor influencing the selling price because it is closely related to the moisture content of the dried seaweed. Generally, seaweed with lower moisture content commands a higher selling price, although buyers also consider cleanliness and overall physical quality when determining purchase prices.

The drying process is highly dependent on weather conditions. During the rainy season, drying periods become longer, and under certain circumstances, seaweed farmers in Pantai Amal sell their products while they still contain relatively high moisture levels. This observation is consistent with [Orilda *et al.* \(2021\)](#), who reported that heat-based seaweed drying processes generally require considerable time. In addition, open-air sun drying presents potential risks to product quality. [Purwanti and Nansi \(2024\)](#) explained that drying seaweed under direct sunlight on plastic sheets or tarpaulins may expose the product to contamination from dust, sand, and other foreign materials. Such conditions may reduce the quality of the resulting dried seaweed ([Figure 2](#)).



Figure 2. Seaweed Drying Process at Amal Beach.

Table 1. Moisture Content and Selling Prices of Seaweed Sold by Farmers in Pantai Amal, Tarakan City

No.	Moisture Content (%)	Selling Price (IDR/kg)
1	50–60	6,500–7,500
2	45–50	8,000–9,500
3	41–44	10,000–11,000

The moisture content of seaweed sold by farmers in Pantai Amal varied considerably. Seaweed with relatively high moisture content generally ranged from 50% to 60%, while moderately dried seaweed had moisture levels of approximately 45–50%. Seaweed with lower moisture content ranged from 41% to 44%. As presented in [Table 1](#), seaweed with lower moisture content tended to command higher selling prices. According to information obtained from traders and collectors, seaweed purchased from farmers generally required additional drying and cleaning before being marketed to subsequent buyers.

Farmers frequently sold seaweed with relatively high moisture content because of immediate financial needs, limited drying facilities, and unfavorable weather conditions, particularly cloudy or rainy periods. These circumstances could prevent farmers from achieving the desired moisture levels before selling their products. Consequently, seaweed with higher moisture content generally received lower selling prices than drier and cleaner products. These findings highlight the importance of postharvest handling and drying practices in determining the market value of seaweed produced by coastal households.

Table 2. Gender-Based Division of Labor Across Seaweed Cultivation Stages in Pantai Amal, Tarakan City

Stage	Activity	Women's Role	Men's Role	Predominant Involvement
Preproduction	Site selection and seedstock procurement	Limited involvement	Select cultivation sites and procure seedstock	Men
Preproduction	Seedstock tying	Attach seedstock to cultivation lines	Assist with preparation	Women
Production	Planting	Provide supporting assistance	Transport and install cultivation lines at farming sites	Men
Production	Maintenance	Limited involvement	Inspect and maintain cultivation structures	Men
Production	Harvesting	Limited involvement	Lift and transport harvested seaweed	Men
Postharvest	Drying and cleaning	Actively participate in sun drying and cleaning	Assist with drying and postharvest handling	Shared

As presented in [Table 2](#), the division of labor in seaweed cultivation in Pantai Amal demonstrates a distinct pattern of gender-based participation. Men predominantly undertake offshore activities, including planting, maintenance, and harvesting, whereas women are more actively involved in land-based activities, particularly seedstock tying, drying, and cleaning harvested seaweed. These differences are associated with the characteristics of the tasks performed, including physical demands, mobility requirements, technical skills, and working environments at different cultivation stages.

The findings indicate that women's and men's roles are complementary within household-based seaweed cultivation. Women play important roles in seedstock preparation and postharvest handling, while men are primarily responsible for offshore production activities. This pattern is consistent with the concept of the *gender division of labor*, which recognizes that occupational responsibilities are influenced by task characteristics and sociocultural norms, including gender stereotypes that shape expectations regarding women's and men's participation in production activities ([Mengo et al., 2023](#)).

Economic Contributions of Coastal Women to Seaweed-Farming Household Economies in Pantai Amal, Tarakan City

The economic contributions of coastal women in Pantai Amal are reflected in their participation in productive activities that support the livelihoods of seaweed-farming households. In addition to performing domestic responsibilities, women participate in various economic activities associated with seaweed cultivation. Their involvement demonstrates that women contribute to sustaining household enterprises dependent on seaweed production. This finding is consistent with [Daris et al. \(2021\)](#), who reported that women in seaweed-farming households participated in productive activities such as seedstock tying, drying, and marketing, while household income was closely associated with family welfare.

[Azzahra et al. \(2024\)](#) similarly demonstrated that women's participation in seaweed cultivation contributed to household income and strengthened their economic roles within coastal communities. Comparable conditions were observed in Pantai Amal, where women's involvement in seaweed-related activities provided opportunities to generate additional income. These contributions are particularly relevant because household income from seaweed cultivation is subject to fluctuations associated with seasonal variability, weather conditions, and changes in seaweed selling prices.

Household welfare is determined not only by income levels but also by the ability to meet basic needs and maintain economic stability. Among seaweed-farming households in Pantai Amal, income generally increased when production was abundant and selling prices were favorable. Conversely, household earnings tended to decline when market prices weakened, unfavorable weather disrupted cultivation activities, or pests and diseases affected production. Under these circumstances, women's participation in seaweed-related economic activities represented an important household strategy for coping with financial pressures.

[Azzahra et al. \(2024\)](#) emphasized that income generated through women's involvement in seaweed cultivation can support household needs, strengthen women's economic independence, and contribute to the economic resilience of coastal communities. In Pantai Amal, women's economic contributions were particularly evident in seedstock tying during cultivation preparation and in drying and cleaning activities during the postharvest stage. These activities not only demonstrate women's participation in the seaweed production chain but also provide income that helps support the economic needs of seaweed-farming households.

Economic Contributions of Coastal Women Through Seedstock Tying in Pantai Amal, Tarakan City

The economic contributions of coastal women to seaweed cultivation in Pantai Amal are particularly evident in seedstock tying activities. This work involves attaching seaweed seedstock to cultivation lines before planting and provides additional income for seaweed-farming households. Wages are calculated according to the number of cultivation lines completed. Therefore, women's participation in seedstock tying represents not merely unpaid family assistance but also an income-generating activity with direct economic value.

During the study period, wages for seedstock tying ranged from IDR9,000 to IDR12,000 per cultivation line, depending on seaweed prices and the length of the lines used. Women in Pantai Amal generally completed approximately 10–15 cultivation lines per day when working from morning until late afternoon. Reported daily earnings were approximately IDR90,000–150,000. However, weekly and monthly earnings fluctuated because employment opportunities depended on the frequency of cultivation activities and the number of lines available for preparation.

Consequently, women's earnings were influenced by the intensity of seaweed cultivation activities, including seedstock availability, seaweed prices, labor demand, production requirements, and individual work capacity. These factors indicate that income from seedstock tying is closely associated with the operational conditions of seaweed-farming enterprises.

The characteristics of this employment demonstrate that women's economic participation provides opportunities for flexible work but is also associated with income instability. Employment opportunities arise periodically according to cultivation schedules, while fluctuations in production affect the volume of available work. When seaweed prices decline or cultivation activities are disrupted by pests and diseases, farmers may continue production while reducing the number of cultivation lines deployed to minimize potential losses. As a result, employment opportunities for women may remain available, although the amount of work and income earned becomes more limited.

Income from seedstock tying serves as an additional source of financial support for coastal households, particularly when primary household earnings are unstable. For many coastal women, this activity provides supplementary income used to meet daily household needs. However, in some households, seedstock tying may also constitute an important primary income source, particularly when alternative employment opportunities are limited. These findings are consistent with [Haeruddin et al. \(2022\)](#), who reported that women's income from seaweed cultivation activities contributed to meeting basic household needs, educational expenses, healthcare costs, and other daily expenditures.

Economic Contributions of Coastal Women During the Seaweed Postharvest Stage in Pantai Amal, Tarakan City

Coastal women's economic contributions during the postharvest stage in Pantai Amal are particularly evident in seaweed drying activities. This stage involves both women and men because drying is essential for maintaining the quality and market value of harvested seaweed. For coastal women, drying activities provide opportunities to earn income through a wage system based on the quantity of dried seaweed handled, measured in kilograms (kg).

During the study period, wages for seaweed drying ranged from approximately IDR500 to IDR1,000 per kilogram. Under this payment system, women's earnings depended on the volume of seaweed dried, market prices, the number of farmers requiring labor, and production conditions during a particular period.

Seaweed drying provides employment opportunities for coastal women, particularly when production increases and selling prices are favorable. Under these conditions, farmers tend to expand production activities, increasing the volume of seaweed requiring drying and the demand for labor. Conversely, when production declines because of unfavorable weather, pest or disease outbreaks, or falling selling prices, the quantity of seaweed requiring postharvest handling decreases. Consequently, employment opportunities and potential earnings from drying activities also decline.

These findings demonstrate that postharvest activities provide an important source of income for coastal women, although earnings remain subject to fluctuations in seaweed production and market conditions. Similar findings were reported by [Kahfi et al. \(2023\)](#), who identified women's participation in seaweed drying activities in Palopo as a source of income, although the earnings generated were relatively low. Furthermore, [Azzahra et al. \(2024\)](#) reported that women's involvement in seaweed cultivation contributed to household income and helped families meet daily needs and children's educational expenses.

Income from seaweed drying provides additional economic support to households, particularly when primary earnings are affected by weather variability, seasonal changes, fluctuating selling prices, or production disturbances. Women's participation in these activities not only generates supplementary household income but also provides opportunities to earn income through their own productive labor. Therefore, seaweed postharvest activities represent an important source of economic opportunity for coastal women in Pantai Amal and contribute to supporting the livelihoods of seaweed-farming households.

CONCLUSION

Coastal women in Pantai Amal, Tarakan City, play important roles in the seaweed cultivation value chain, particularly during the preproduction stage through seedstock tying and the postharvest stage through seaweed drying and cleaning. In contrast, offshore activities, including planting, maintenance, and harvesting, are predominantly undertaken by men. This pattern reflects a complementary gender-based division of labor, with women's participation primarily concentrated in land-based activities that support seedstock preparation and postharvest product quality. Women's involvement in seedstock tying and drying also generates additional income through wage-based employment, helping households meet their daily needs and supporting the economic stability of seaweed-farming families, particularly when their primary sources of income are unstable.

AUTHOR CONTRIBUTIONS

The authors declare that the contributions of each author to this work are as follows: A.A., as the principal contributor and corresponding author, was responsible for research conceptualization and design, data collection, analysis and interpretation of results, preparation of the original manuscript draft, development of the scientific content, and coordination of the publication process. S.M., K.K., E.A., E.R.B., A.R.P., H.A.S., N.I.P., and F.J. contributed to data collection and processing, review of research

findings, development of manuscript content, and manuscript editing. All authors reviewed and approved the final version of the manuscript for publication.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest in the conduct of the research, data analysis, or preparation and publication of this article.

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