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Analysis of Seaweed Farmer Terms of Trade in North Dullah Island District, Tual City, Maluku

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ABSTRACT

Seaweed farming is an important livelihood for coastal households in Tual City, but farm feasibility does not necessarily reflect household economic capacity. This study aimed to analyze the socioeconomic and farm characteristics of seaweed farmers, revenue and cost structures, net income, farm feasibility, the farming-income terms-of-trade index, and the Seaweed Farmer Terms of Trade (NTPR) in North Dullah Island District, Tual City, Maluku Province. A quantitative descriptive approach with a cross-sectional survey design was applied to all 39 active farmers using saturated sampling. Data were collected through structured interviews and field observations, and all economic components were standardized to an annual period. Farmers were predominantly aged 50 years and older, with an average farming experience of 17.51 years, while seed shortage was the main constraint (53.85%). Average annual farm revenue was IDR 28,544,808, total farm cost was IDR 8,212,885, and net income was IDR 20,331,923. An R/C ratio of 3.48 and a farming-income terms-of-trade value of 347.56 showed that farm revenue exceeded farm costs. However, after farm costs and household consumption were included, total household expenditure reached IDR 47,457,500 per year and NTPR was only 60.15, indicating that recorded revenue was insufficient to cover total farm and household consumption expenditures. Improving NTPR requires stronger seed systems, greater cost efficiency, higher productivity and product quality, stronger market access and institutions, and diversification of household income.

INTRODUCTION

Seaweed is an increasingly important aquaculture commodity in the marine economy because it is used as a raw material for food, hydrocolloids, cosmetics, pharmaceuticals, and various biomass-based products. According to FAO (2024), global production of algae reached 37.8 million tonnes in 2022, of which 36.5 million tonnes were produced through aquaculture. Asia accounted for approximately 97% of global algae production, demonstrating the dominant role of the region in global algae production. For an archipelagic country such as Indonesia, the availability of extensive aquatic resources provides substantial opportunities to develop seaweed farming as an economic activity that is well suited to coastal areas. However, increases in production and business expansion cannot be assessed solely on the basis of commodity volume; the economic benefits received by farming households must also be measured directly to ensure that aquaculture development contributes meaningfully to the welfare of primary producers.

This context is particularly relevant to Tual City, Maluku Province. Regional statistics show that aquaculture production in Tual City reached 126,216.13 tonnes in 2024, while North

Dullah Island District recorded 26,775.58 tonnes of aquaculture production and 111 aquaculture households, underscoring the importance of aquaculture to the local economy (Badan Pusat Statistik Kota Tual, 2025). At the farm level, seaweed productivity is influenced by land tenure, production facilities, the number of production cycles, and the ability to manage farming assets (Adhawati *et al.,* 2024). Competitiveness studies also indicate that seaweed farming may possess comparative and competitive advantages; however, commodity competitiveness alone does not explain how much economic benefit is actually available to farming households (Shaifarahma *et al.,* 2023).

The economic challenges faced by seaweed farmers do not arise solely from the production process. Studies of seaweed agribusiness systems have identified problems in both upstream and downstream subsystems, including seed quality, declining production, capital constraints, and institutional weaknesses (Fatonny *et al.,* 2023). Value-chain studies have shown that seaweed marketing governance can be buyer-driven and captive, thereby limiting farmers' market access and bargaining space in price negotiations (Aeni *et al.,* 2023). In marketing chains in Southeast Sulawesi, power is also unevenly distributed among actors, placing farmers and other small-scale actors in weaker bargaining positions than larger downstream actors (Nuryadi *et al.,* 2024). In addition, production risks related to environmental conditions, seasonality, farming disruptions, and management decisions can affect the stability of yields and income across production cycles (Fariyanti *et al.,* 2024).

Accordingly, assessments of farmers' economic conditions need to distinguish between farm feasibility and household economic capacity. The R/C ratio describes the relationship between farm revenue and production costs and is therefore useful for assessing whether farming activities generate revenue greater than their operating costs. In contrast, farmer terms of trade assess the ability of revenue to cover a broader range of expenditures, including household consumption needs, and therefore provide a household perspective that is not captured by farm-feasibility indicators alone (Hadie *et al.,* 2018). A study of seaweed farmers in Peling Seasa reported a terms-of-trade value of 147.41, indicating that revenue was sufficient to cover expenditures in that study context (Dawaso *et al.,* 2021). A recent study of fish farmers in Bandung Regency likewise showed that a farm terms-of-trade value above 100 was associated with stronger economic capacity, although its magnitude depended on local farm and household characteristics (Aulya *et al.,* 2025).

Previous studies have provided an important foundation, but their analytical focus has generally been fragmented. Some studies have emphasized productivity and farm structure (Adhawati *et al.,* 2024), others have examined income and its determinants, such as working capital and selling price (Masela *et al.,* 2025), while other research has focused on business development, institutions, and strategies for increasing production (Fatimah & Situmorang, 2023). Income analyses in other farming areas also show that business performance is shaped by the combination of production, costs, and management capacity, indicating that income should be interpreted together with the expenditure structure (Salim *et al.,* 2023). Meanwhile, terms-of-trade studies in aquaculture have more often focused on other commodities or regions (Adrian *et al.,* 2023; Aulya *et al.,* 2025). Empirical evidence that simultaneously links operational farm feasibility with the revenue capacity of seaweed-farming households in North Dullah Island District remains limited.

This gap defines the position of the present study. Its novelty lies in integrating socioeconomic characteristics, farm scale, farming revenue and costs, household consumption expenditure, the R/C ratio, and the Seaweed Farmer Terms of Trade (NTPR) within a single annual analytical framework covering the entire verified population of active seaweed farmers. This approach allows farm-feasibility outcomes to be directly compared with household economic capacity, making it possible to identify situations in which the farm appears profitable while recorded revenue remains insufficient to meet total household economic needs. The results were subsequently used to formulate descriptive recommendations linking constraints related to seed availability, production facilities, farmer capacity, marketing, and income diversification with the components that determine NTPR.

This study aimed to analyze the socioeconomic and farm characteristics of seaweed farmers; examine the structure of revenue, farm costs, net income, the R/C ratio, the farming-income terms-of-trade index, and NTPR; and formulate recommendations for improving NTPR based on socioeconomic conditions, farm structure, government assistance, training participation, and farming constraints in North Dullah Island District, Tual City, Maluku Province.

METHOD

Study Area, Design, and Respondents

The study was conducted in 2026 in North Dullah Island District, Tual City, Maluku Province, covering Dullah Laut, Fiditan, Lebetawi, and Ngadi. A quantitative descriptive approach was applied using a survey method and a cross-sectional design. The unit of analysis was the seaweed-farming household because NTPR measurement links farm revenue, cultivation costs, and household consumption expenditure within the same period.

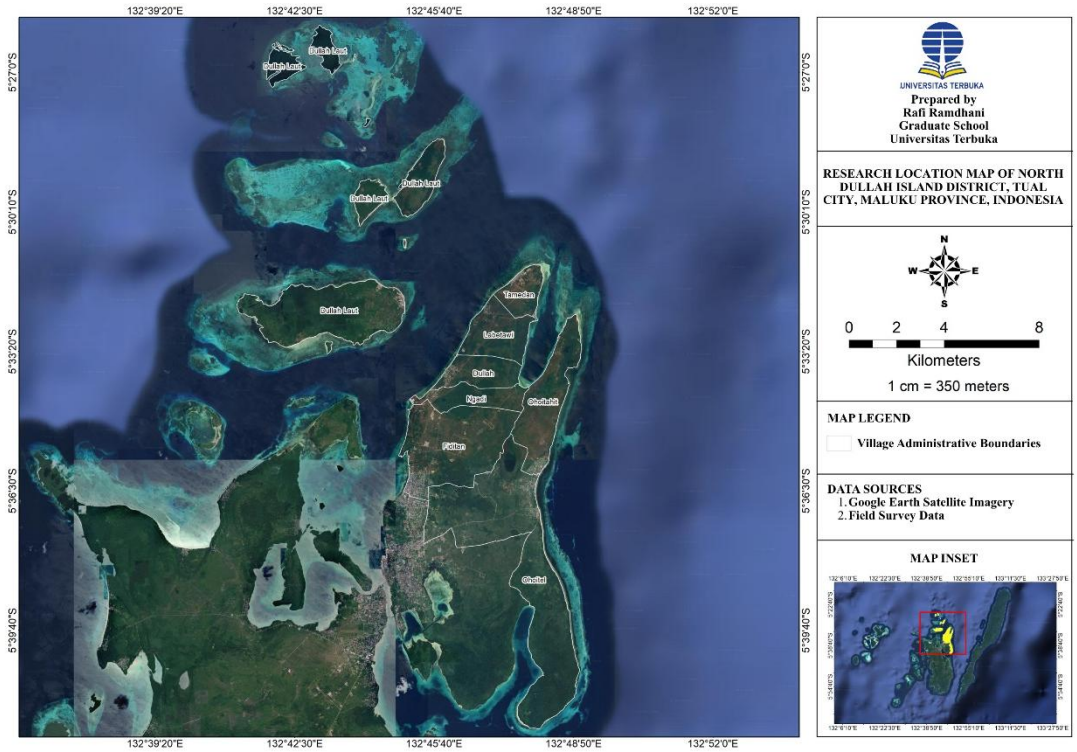


Figure 1. Map of the Study Area

The actual study population comprised all active seaweed farmers verified at the time of the survey, totaling 39 individuals: 21 in Dullah Laut, 10 in Fiditan, 6 in Lebetawi, and 2 in Ngadi. The entire population was included as respondents using saturated sampling, or a census approach. Eligible respondents had to be actively engaged in seaweed farming, reside in or operate a farm within North Dullah Island District, have knowledge of production, farm economics, and household expenditure, and be willing to participate in an interview.

Data Collection and Quality Control

Primary data were collected through face-to-face interviews using a structured questionnaire and were supported by field observations. Recorded variables included socioeconomic characteristics, farming experience, cultivated area, number of long lines, harvest and sales frequencies, sales weight, selling price, variable costs, fixed costs, food expenditure, non-food expenditure, government assistance, training participation, and major farming constraints. Field observations were used to assess the plausibility of information on

farming conditions and production facilities rather than as the primary source of economic calculations.

Reference periods were adjusted to the characteristics of each variable. Production, selling price, revenue per transaction, and variable costs referred to the most recent cycle or transaction; harvest and sales frequencies referred to the previous year; and food and non-food expenditures referred to the previous 30 days and were subsequently converted to annual values. All economic components were standardized to a one-year period so that numerators and denominators could be compared consistently. Data quality control included editing, coding, data entry, cleaning, tabulation, unit checking, reference-period consistency checks, and verification of arithmetic totals. Missing data were not automatically coded as zero; zero values were used only when respondents explicitly stated that the component was absent.

Data Analysis

Respondent and farm characteristics were analyzed using frequencies, percentages, means, and ranges as appropriate. Gross revenue per transaction was calculated from the quantity of seaweed sold (Q) and the selling price per kilogram (P), while annual gross revenue was calculated using the annual sales frequency (Fj). The revenue formula and cost-income analysis followed the financial-analysis approach used for seaweed farming enterprises (Pratama *et al.,* 2025).

$$TRs = Q \times P; \quad TRt = TRs \times Fj$$

Annual total farm cost (TC) was calculated as the sum of annual total variable cost (TVC) and annual total fixed cost (TFC). This total-cost structure, combining variable and fixed costs, is used in financial analyses of seaweed farming enterprises (Pratama *et al.,* 2025). Fixed costs were calculated through depreciation of durable assets using the straight-line method; the application of the straight-line method for depreciation of fisheries business assets is described by Rafiqie (2019).

$$TC = TVC + TFC$$

$$\text{Annual depreciation} = (\text{acquisition cost} - \text{residual value}) / \text{economic life}$$

Farm net income (π) was calculated as the difference between annual gross revenue and total farm cost, while operational feasibility was assessed using the R/C ratio, defined as the ratio of total revenue to total cost. These profit and R/C ratio formulations are used in financial-feasibility analyses of seaweed farming (Pratama *et al.,* 2025).

$$\pi = TRt - TC; \quad R/C = TRt / TC$$

In addition to the R/C ratio, the results table presents a farming-income terms-of-trade index on a base of 100 that compares seaweed-farming revenue with farm expenditure. Mathematically, this index is equivalent to the R/C ratio multiplied by 100. The comparison between revenue and costs is used to assess the operational ability of the farm to generate revenue relative to the costs incurred (Pratama *et al.,* 2025).

$$\text{Farming-income terms of trade} = (TRt / TC) \times 100$$

Annual household consumption expenditure (Cyear) was obtained from monthly food and non-food expenditure (Cmonth) converted to a one-year period. A relatively short recall period was used for routine expenditure to reduce potential respondent recall error. Total household revenue (TP) consisted of seaweed-farming revenue plus non-seaweed revenue (PNR) when available and confirmed; total household expenditure (TPG) was the sum of total farm cost (TC) and annual household consumption (Cyear). These revenue/income and expenditure components are consistent with the farmer terms-of-trade framework, which compares revenue capacity with farm and household consumption burdens (Hadie *et al.,* 2018; Dawaso *et al.,* 2021).

$$Cyear = Cmonth \times 12; \quad TP = TRt + PNR; \quad TPG = TC + Cyear; \quad NTPR = (TP / TPG) \times 100$$

NTPR was interpreted using three categories: NTPR > 100 indicated a surplus, NTPR = 100 indicated a balanced condition, and NTPR < 100 indicated a deficit in the capacity of revenue to cover expenditure during the same period (Dawaso *et al.,* 2021). Non-seaweed income or revenue was included in TP only when it was available and confirmed. Because non-seaweed income sources were not completely recorded, NTPR interpretation was limited to revenue that was explicitly confirmed in the research dataset.

RESULTS AND DISCUSSION

The results were based on all 39 verified active seaweed farmers in North Dullah Island District. The discussion distinguishes descriptive results, interpretation of farm economics, household economic capacity, and policy implications. Because the study used a cross-sectional descriptive design, the relationships discussed are not interpreted as causal; comparisons with previous studies are used only to place the findings within a broader empirical context.

Socioeconomic Characteristics of Seaweed Farmers

The distribution of respondents showed that Dullah Laut had the highest concentration of seaweed farmers, with 21 respondents (53.85%), followed by Fiditan with 10 (25.64%), Lebetawi with 6 (15.38%), and Ngadi with 2 (5.13%). This distribution indicates that the respondent base was unevenly distributed across the four locations, meaning that farming dynamics in Dullah Laut contributed substantially to the aggregate picture of the study. Nevertheless, the entire verified population was covered through a census; therefore, the distribution reflects the characteristics of the study population rather than a consequence of sample selection.

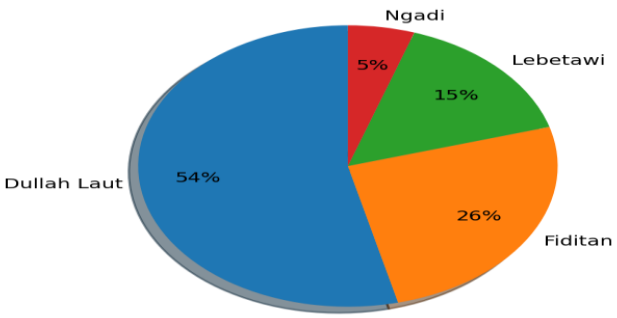


Figure 2. Distribution of Respondents by Location
Source: Primary data processed, 2026.

The age structure was dominated by farmers aged 50 years and older. Farmers aged 50–59 years accounted for 14 respondents (35.90%), while those aged ≥60 years accounted for 12 (30.77%); only 3 respondents (7.69%) were younger than 40 years. The dominance of older farmers may represent an asset because accumulated field experience can strengthen understanding of seasonal patterns, site selection, farm maintenance, and market behavior. In a study conducted in Seriwe, age was also identified as a factor associated with income; however, that result was derived from regression analysis in a different context and cannot be transferred as a causal relationship to the present study (Saville *et al.,* 2025). At the same time, the low proportion of younger farmers raises an important regeneration issue because long-term continuity requires not only experience but also the capacity to adopt technology, maintain business records, and expand market access.

Respondents' educational attainment ranged from elementary to senior high school, with senior high school representing the largest group at 18 respondents (46.15%), followed by elementary school at 15 (38.46%) and junior high school at 6 (15.38%). This composition

indicates heterogeneity in formal educational capacity that should be considered when designing extension programs.

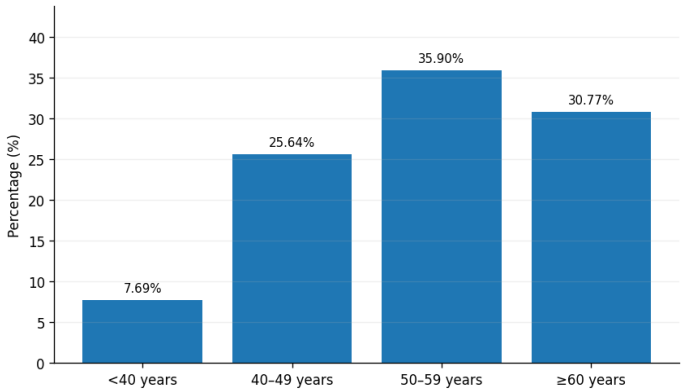


Figure 3. Age Distribution of Seaweed Farmers
Source: Primary data processed, 2026.

Pratama et al. (2025) identified low farmer education as one of the weaknesses in developing the seaweed industry in Poleang, while Fatonny et al. (2023) positioned human-resource quality as an important component of the agribusiness subsystem. Therefore, training materials in North Dullah Island should not rely solely on lectures, but should also incorporate demonstrations, visual materials, simple record-keeping tools, and repeated mentoring so that the content can be applied across different educational backgrounds.

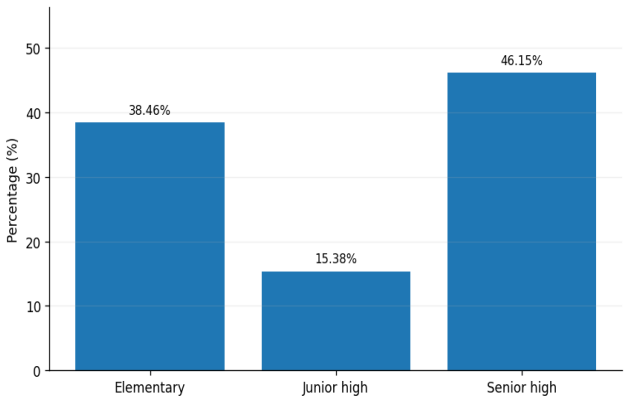


Figure 4. Educational Attainment of Respondents
Source: Primary data processed, 2026.

The number of family dependents was dominated by the category of ≤3 persons, reported by 20 respondents (51.28%), followed by 4–5 persons for 13 respondents (33.33%). Household dependency structure is important because household needs form the expenditure side of NTPR. Thus, two households with similar farm revenue may have different economic capacities if the number of dependents and their education, health, transport, and consumption needs differ. The farmer terms-of-trade concept is intended to broaden assessment from farm performance alone to the capacity of revenue to meet both production and household consumption expenditures (Hadie *et al.,* 2018).

The number of children showed a pattern consistent with the dependency structure. A total of 19 respondents (48.72%) had ≤2 children and 14 respondents (35.90%) had 3–4 children, while households with larger numbers of children accounted for smaller proportions.

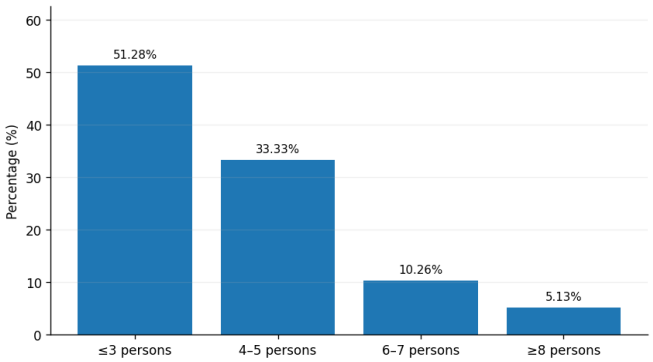


Figure 5. Number of Family Dependents
Source: Primary data processed, 2026.

These data were not used to infer a causal relationship with welfare, but they provide important context for variation in household needs. In the NTPR analysis, education expenditure and other non-food needs are components that can maintain pressure on household expenditure even when seaweed farming generates positive net income.

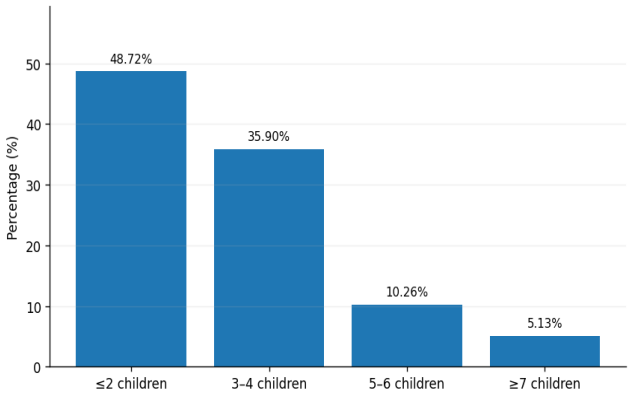


Figure 6. Number of Children in Seaweed-Farming Households
Source: Primary data processed, 2026.

Farming Experience, Farm Scale, and Production Intensity

Farming experience was extensive: 33 respondents (84.62%) had cultivated seaweed for 16–20 years, with an average of 17.51 years, a minimum of 8 years, and a maximum of 23 years. This long experience indicates that seaweed farming is a well-established economic activity, but experience alone does not guarantee high income. Masela et al. (2025) showed that working capital and selling price play important roles in seaweed-farmer income, while Saville et al. (2025) found that cultivated area, capital investment, and selling price were important determinants of income in another study location. Therefore, experience in North Dullah Island is more appropriately understood as human capital that must be supported by production capital, market access, and institutional capacity.

Farm area varied widely. A total of 20 respondents (51.28%) operated areas larger than 10,000 m^2, with an average area of 16,750.18 m^2, a minimum of 300 m^2, and a maximum of 50,000 m^2. A larger area provides room for increasing production capacity but cannot be interpreted as a stand-alone indicator of productivity. Adhawati et al. (2024) showed that seaweed-farming productivity is related to land-tenure status and asset management, while Saville et al. (2025) indicated that cultivated area should be interpreted together with capital investment and selling price. In the present study, the very wide variation in farm area should therefore be considered together with the number of long lines, seed availability, harvest frequency, and the actual ability to utilize the available area.

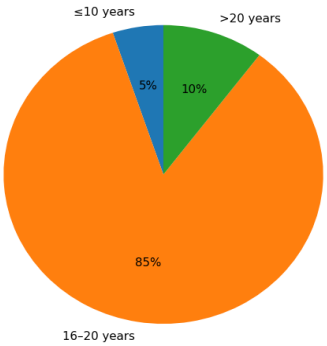


Figure 7. Length of Seaweed-Farming Experience
Source: Primary data processed, 2026.

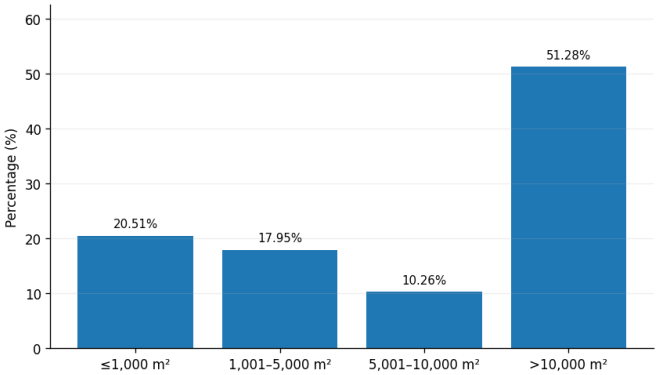


Figure 8. Cultivated Area of Seaweed Farms
Source: Primary data processed, 2026.

The number of long lines also demonstrated substantial heterogeneity in production capacity. The largest group used 21–30 long-line units (43.59%), while the observed range extended from 2 to 220 units. This range indicates that the technical scale of farming was not homogeneous among respondents. Large farming areas without sufficient long lines, seed, floats, labor, and post-harvest facilities may prevent potential capacity from becoming actual production capacity. This finding supports the need for production-facility assistance based on measured capacity gaps rather than uniform distribution to all farmers. Development of the seaweed industry in other locations has likewise shown that limitations in capital, facilities, and institutions can constrain the optimization of production potential (Pratama *et al.,* 2025).

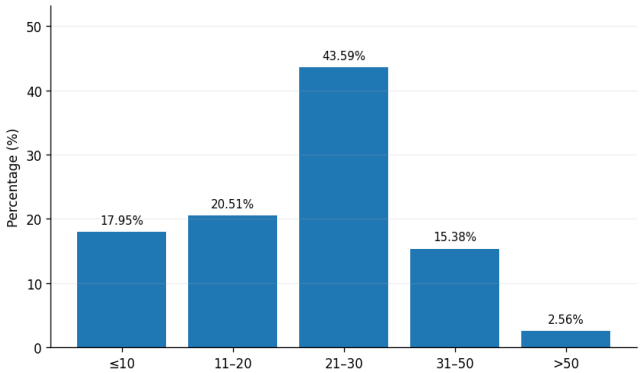


Figure 9. Number of Long Lines Used by Seaweed Farmers
Source: Primary data processed, 2026.

The average harvest frequency was 5.41 times per year, and 61.54% of respondents harvested six times per year. This pattern indicates relatively high production intensity and requires continuity of inputs. Any disruption in seed supply, weather conditions, labor availability, or farming facilities may affect the number of effective production cycles completed during the year. Fariyanti et al. (2024) showed that risk-management practices are related to seaweed-farm production, indicating that harvest continuity should be viewed as an outcome of risk management rather than solely as a function of farm area or experience.

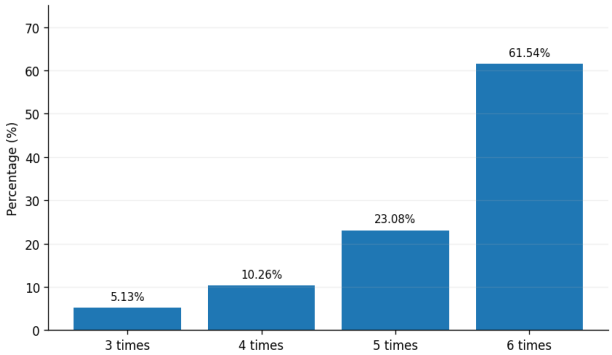


Figure 10. Annual Harvest Frequency
Source: Primary data processed, 2026.

The average sales frequency was 5.26 times per year, and 64.10% of respondents sold their products six times annually. The close correspondence between harvest and sales frequencies indicates that household cash inflows are closely tied to the production cycle. This pattern may be advantageous for cash flow when prices and volumes are stable, but it also makes income sensitive to production disruptions or price changes at each transaction. Consequently, income-stabilization strategies need to combine production management with access to price information and alternative marketing channels.

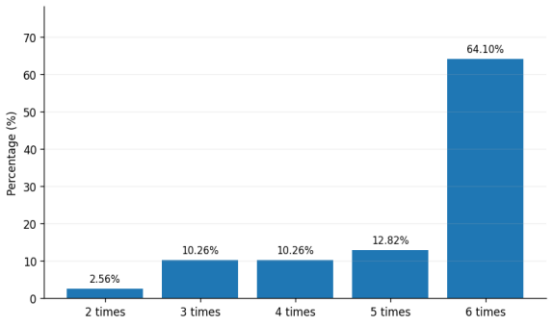


Figure 11. Annual Sales Frequency
Source: Primary data processed, 2026.

Average sales weight was approximately 500 kg per transaction, ranging from 12.5 to 1,000 kg. The 501–800 kg category was the largest group (41.03%), while 25.64% of respondents sold ≤100 kg per transaction. This distribution indicates substantial inequality in output capacity. Farmers with lower sales volumes are more vulnerable to limited revenue, whereas higher-volume farmers do not necessarily obtain optimal margins when prices are determined by buyers. Masela et al. (2025) identified selling price as an important factor in income, while a buyer-driven value-chain structure can constrain the bargaining position of primary producers (Aeni *et al.,* 2023). Therefore, higher production volume should be accompanied by improvements in quality and market access so that additional output is effectively translated into additional revenue.

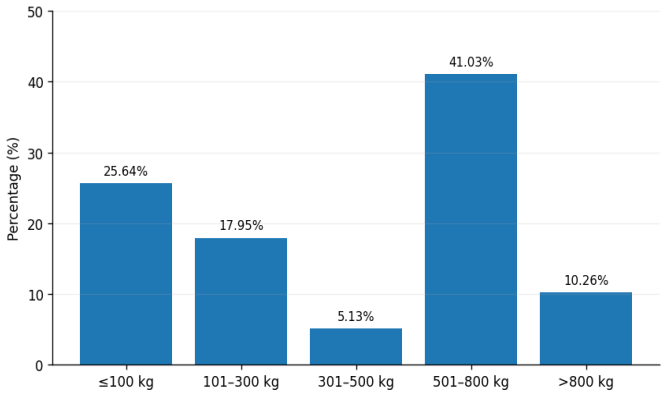


Figure 12. Sales Weight per Transaction
Source: Primary data processed, 2026.

Government Assistance, Training, and Farming Constraints

A total of 27 respondents had received government assistance, whereas 12 had never received assistance or had no recorded assistance. The relatively broad coverage indicates the presence of public intervention, but the remaining unassisted group suggests that equity and targeting remain relevant considerations. Support for production facilities will be more effective when linked to measurable capacity gaps, such as shortages of seed, long lines, boats, drying facilities, or the operating costs that most constrain production. Pratama et al. (2025) emphasized that seaweed-business development requires integrated strengthening of production, human resources, marketing, technology, and institutions.

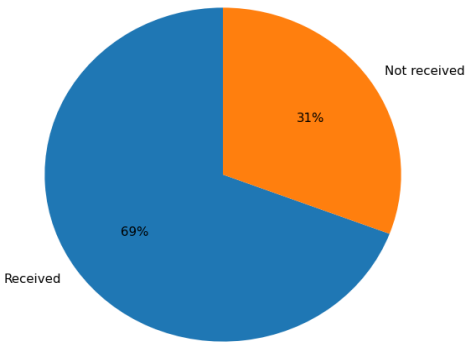


Figure 13. Receipt of Government Assistance
Source: Primary data processed, 2026.

Training participation showed that 26 respondents had attended seaweed-farming training, while 13 had never participated or had no recorded participation. Training that has reached most farmers represents an institutional asset, but its effectiveness cannot be assessed solely from the number of participants. Training content should address the issues that actually emerged from the data, including seed selection and propagation, cost efficiency, drying techniques, revenue-expenditure recording, price information, and risk mitigation. Saville et al. (2025) likewise emphasized the importance of targeted training to strengthen the economic capacity of seaweed farmers.

Seed shortage was the main constraint reported by 53.85% of respondents. A fixed/stable selling price was reported by 17.95%, requests for production-facility assistance by 12.82%, and 15.38% of constraint responses were missing. The dominance of seed-related problems indicates that upstream constraints may constitute a critical bottleneck because seed availability determines the ability to initiate a cycle, the number of lines that can be planted, production continuity, and harvest volume.

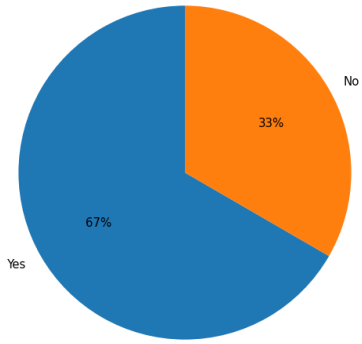


Figure 14. Participation in Seaweed-Farming Training
Source: Primary data processed, 2026.

Fatimah and Situmorang (2023) also identified limited access to quality seed and capital as constraints to production development, while Oedjoe et al. (2023) demonstrated the relevance of selected seed to the growth and production of *Kappaphycus alvarezii*. On the downstream side, price concerns reinforce the need to improve market information and bargaining power because value-chain governance may place farmers in a position of greater dependence on buyers (Aeni *et al.,* 2023; Nuryadi *et al.,* 2024).

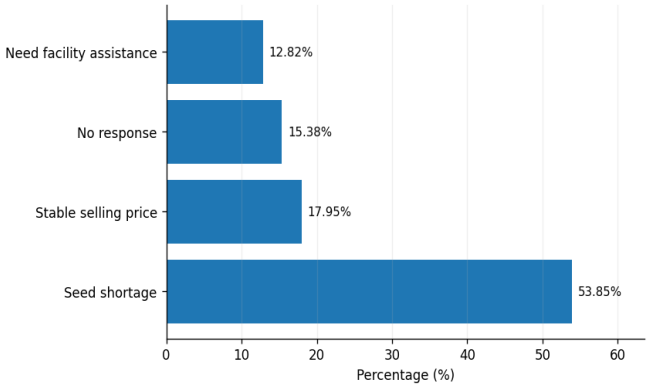


Figure 15. Major Constraints Reported by Seaweed Farmers
Source: Primary data processed, 2026.

Seaweed-Farming Cost Structure

Total variable costs for all respondents reached IDR 277,685,000 per year, with an average of IDR 7,120,128 per respondent per year and IDR 1,291,154 per cycle. Major components included hired labor, tying rope, worker meals, transportation/fuel, and drying. The dominance of recurring costs means that operational efficiency can directly affect net income, but efficiency should not be interpreted as indiscriminate input reduction. Cost cutting that compromises seed quality, maintenance, or drying may instead reduce yields and selling prices. Financial analyses of seaweed farming in other contexts also show that labor and farming inputs are important components of variable costs (Saville *et al.,* 2025).

Table 1. Summary of Variable Costs in Seaweed Farming

Description	Value
Total variable costs for all respondents per year	IDR 277,685,000
Average variable cost per respondent per year	IDR 7,120,128
Average variable cost per cycle	IDR 1,291,154
Average harvest frequency	5 times/year

Description	Value
Major cost components	Hired labor, tying rope, worker meals, transportation/fuel, drying

Source: Primary data processed, 2026.

Total fixed costs for all respondents reached IDR 42,617,500 per year, with an average of IDR 1,092,756 per respondent. Although this value was lower than variable costs, assets such as wooden boats, fiber boats, engines, main long lines, main floats, and drying racks are strategically important because they are prerequisites for utilizing farming areas and for harvesting and drying the crop. Lower fixed costs relative to variable costs do not imply that fixed assets are less important; damaged or inadequate assets may shift pressure to operating costs through repairs, transportation expenses, or efficiency losses. Therefore, production-facility support should account for asset maintenance and economic life rather than focusing only on initial procurement.

Table 2. Summary of Fixed Costs in Seaweed Farming

Description	Value
Total fixed costs for all respondents per year	IDR 42,617,500
Average fixed cost per respondent per year	IDR 1,092,756
Main fixed-cost components	Wooden boats, fiber boats, engines, long lines, main floats, drying racks
General description	Fixed costs were lower than variable costs

Source: Primary data processed, 2026.

Household Food and Non-Food Expenditure

Total food expenditure for all respondents reached IDR 64,180,000 per month. Average food expenditure was IDR 1,645,641 per respondent per month, or IDR 19,747,692 per year. The largest components included rice/sago/tubers, fish/meat/eggs, and oil/sugar/coffee/tea. The magnitude of food expenditure shows that seaweed-farming revenue functions not only as capital for the next production cycle but also as a source of financing for basic household consumption. Within the farmer terms-of-trade framework, this consumption burden must be considered together with farm costs so that household economic capacity is not assessed too optimistically on the basis of production profit alone (Hadie *et al.,* 2018).

Table 3. Summary of Household Food Expenditure

Description	Value
Total food expenditure for all respondents per month	IDR 64,180,000
Average food expenditure per respondent per month	IDR 1,645,641
Average food expenditure per respondent per year	IDR 19,747,692
Largest expenditure components	Rice/sago/tubers, fish/meat/eggs, oil/sugar/coffee/tea
Total food expenditure for all respondents per month	IDR 64,180,000

Source: Primary data processed, 2026.

Total non-food expenditure for all respondents reached IDR 63,365,000 per month, with an average of IDR 1,624,744 per month or IDR 19,496,923 per year. The largest components were education, daily transportation, telephone/internet, and household electricity/fuel. The fact that non-food expenditure was nearly equal to food expenditure indicates that household economic pressure does not arise solely from food consumption. Education, mobility, communication, energy, and health are recurrent needs, some of which are difficult to postpone; therefore, an increase in farm revenue does not necessarily produce a larger household surplus when non-food expenditure is also high. This condition explains why farm-level and household-level indicators need to be interpreted separately.

Table 4. Summary of Household Non-Food Expenditure

Description	Value
Total non-food expenditure for all respondents per month	IDR 63,365,000
Average non-food expenditure per respondent per month	IDR 1,624,744
Average non-food expenditure per respondent per year	IDR 19,496,923
Largest expenditure components	Education, daily transportation, telephone/internet, household electricity/fuel
Total non-food expenditure for all respondents per month	IDR 63,365,000

Source: Primary data processed, 2026.

Farm Revenue and Net Income

Total revenue for all respondents reached IDR 1,113,247,500 per year. Average revenue was IDR 28,544,808 per respondent per year, with an average sales weight of 500 kg per transaction, an average selling price of IDR 11,308/kg, average revenue of IDR 5,449,256 per transaction, and a sales frequency of five times per year. Revenue reflects the interaction between sales volume and price; therefore, higher production will strengthen income only when the product can be sold at an adequate price. Masela et al. (2025) showed that selling price is an important factor in seaweed-farmer income, while Saville et al. (2025) found that cultivated area, capital investment, and selling price were significantly associated with income in another location. The North Dullah Island results therefore point to the need for a dual intervention: increasing production capacity while simultaneously improving bargaining power and product quality so that volume is not the sole source of higher revenue.

Table 5. Summary of Seaweed Harvest Revenue

Description	Value
Total revenue for all respondents per year	IDR 1,113,247,500
Average sales weight per transaction	500 kg
Average selling price	IDR 11,308/kg
Average revenue per transaction	IDR 5,449,256
Average sales frequency	5 times/year
Average revenue per respondent per year	IDR 28,544,808

Source: Primary data processed, 2026.

Average farm net income was IDR 20,331,923 per year, calculated as revenue of IDR 28,544,808 minus total farm costs of IDR 8,212,885. The positive difference indicates that the farm generated a surplus at the production level. However, net income cannot be directly equated with household welfare because households must still finance food and non-food expenditures. Salim et al. (2023) also showed that seaweed-income analysis needs to consider working capital, labor, and business scale, while Fatonny et al. (2023) emphasized that agribusiness problems may arise in both upstream and downstream subsystems. Maintaining net income therefore requires cost control together with production and marketing stability.

Table 6. Summary of Net Income from Seaweed Farming

Description	Value
Average seaweed-farming revenue	IDR 28,544,808
Average seaweed-farming expenditure	IDR 8,212,885
Average net income from seaweed farming	IDR 20,331,923

Source: Primary data processed, 2026.

R/C Ratio and Operational Feasibility

An R/C ratio of 3.48 indicates that every IDR 1 of farm cost generated IDR 3.48 in revenue. A value >1 classifies seaweed farming as operationally feasible. Numerically, this value is higher than the R/C ratio of 1.94 reported for red-seaweed industry development in Poleang (Pratama *et al.,* 2025) and the R/C ratio of 1.84 reported for seaweed farmers in Seriwe (Saville

et al., 2025). These comparisons should not be interpreted as evidence that North Dullah Island is definitively more efficient because time units, analytical scales, cost components, depreciation methods, prices, and market contexts may differ among studies. The R/C ratio in the present study primarily shows that, based on the recorded cost components, farming activities still generated revenue greater than production costs.

Table 7. Summary of the R/C Ratio for Seaweed Farming

Description	Value
Average seaweed-farming revenue	IDR 28,544,808
Average seaweed-farming expenditure	IDR 8,212,885
R/C Ratio	3.48

Source: Primary data processed, 2026.

Farming-Income Terms of Trade and Household NTPR

The terms-of-trade analysis produced two different but complementary perspectives. At the farm level, average farming revenue of IDR 28,544,808 per year compared with average farm costs of IDR 8,212,885 per year produced a farming-income terms-of-trade value of 347.56. This means that every IDR 100 in farm costs was associated with approximately IDR 347.56 in farm revenue; mathematically, this result is consistent with the R/C ratio of 3.48. The value of 347.56, which is far above 100, indicates that seaweed farming generated revenue greater than its production costs. However, this indicator captures only the relationship between revenue and expenditure at the farm-unit level and does not include household consumption needs. When food and non-food expenditure were included, average household consumption reached IDR 39,244,615 per year and total household expenditure increased to IDR 47,457,500 per year. With confirmed household revenue of IDR 28,544,808 per year, NTPR was only 60.15. A value below 100 indicates that recorded revenue was insufficient to cover total farm and household consumption expenditures during the same period. Thus, the value of 347.56 reflects the economic strength of the farming activity at the business-unit level, whereas the value of 60.15 reflects the limited capacity of that revenue when assessed against broader household economic needs.

Table 8. Summary of Seaweed Farmer Terms of Trade

No.	Description	Amount (IDR)
A.	Seaweed-Farming Household Revenue	
	Seaweed Farming	28,544,808
	Non-Seaweed Activities	-
	Total	28,544,808
B	Seaweed-Farming Household Expenditure	
	Seaweed Farming	8,212,885
	Household Consumption	39,244,615
	Total	47,457,500
C	Farmer Terms of Trade (NTP)	
1	Total Household Revenue	60.15
2	Seaweed-Farming Revenue	347.56

Source: Primary data processed, 2026.

The difference between the farming-income terms-of-trade value of 347.56 and the household NTPR of 60.15 is the central result of this study. The former shows that seaweed farming was operationally productive in generating revenue relative to costs, whereas the latter shows that the farm-level surplus was not automatically sufficient to meet the household's entire economic burden. This gap confirms that financial feasibility at the farm level is not equivalent to household welfare. Farmer terms of trade link revenue with the expenditures that farmers must bear and therefore have a broader scope than farm-feasibility indicators, which compare only revenue and production costs (Hadie *et al.,* 2018). Aulya et al. (2025) showed that a farm terms-of-trade value above 100 reflects a stronger capacity of farm

revenue to cover costs, whereas Dawaso et al. (2021) reported a terms-of-trade value of 147.41 among seaweed farmers in Peling Seasa, indicating a surplus in that study context. Compared with those results, North Dullah Island displays a more complex situation: the farm-level indicator was very high, while the household-level indicator remained below 100. This suggests that the economic evaluation of seaweed farmers should be conducted at least at two levels: farm-unit performance and the household's ability to meet expenditure. The difference may be related to consumption structure, number of dependents, production scale, selling price, and other income sources; however, the descriptive design of this study was not used to establish causal relationships among these factors.

Interpretation of NTPR must account for an important limitation: non-seaweed income was not completely recorded. Consequently, the value of 60.15 should not be interpreted as a complete measure of overall household welfare, but rather as an indicator of the capacity of confirmed revenue in the dataset to cover recorded farm costs and household consumption. This limitation also highlights the importance of recording multiple income sources in terms-of-trade studies because coastal households may receive income from activities other than their main commodity. Future research should collect all income sources for each household and analyze NTPR by season so that variations in income and expenditure are not obscured by annual aggregation.

Policy Implications and Recommendations for Improving NTPR

Improving NTPR requires strategies that act simultaneously on both the numerator and denominator. On the numerator side, revenue can be strengthened through continuous seed availability, higher productivity, improved product quality, reduced post-harvest losses, and stronger bargaining power. On the denominator side, farm costs need to be managed through more efficient use of production facilities, asset maintenance, collective input purchasing, and production-cycle planning that reduces unproductive expenditure. A systemic approach is relevant because seaweed agribusiness constraints are interrelated across inputs, production, marketing, financing, technology, and institutions (Fatonny *et al.,* 2023; Pratama *et al.,* 2025).

The first substantive priority is to strengthen the local seed system because seed shortages were reported by more than half of respondents. Local seed gardens, selection of healthy strains, rotation of seed sources, and supply schedules aligned with the planting calendar could reduce production gaps. The use of selected seed has been studied in relation to the growth, production, and carrageenan content of *Kappaphycus alvarezii*, indicating that seed quality should be viewed as a component of productivity and product quality rather than merely physical availability (Oedjoe *et al.,* 2023).

The second priority is to strengthen markets and institutions. The buyer-driven structure of the seaweed value chain indicates that farmers may become dependent on dominant buyers; therefore, access to price information, collective marketing, and direct relationships with processors can expand their bargaining space (Aeni *et al.,* 2023). Analysis of seaweed marketing chains in Southeast Sulawesi also demonstrates the importance of how roles and benefits are distributed among value-chain actors (Nuryadi *et al.,* 2024). Farmer groups or cooperatives can function as volume aggregators, providers of price information, collective input purchasers, and managers of drying-quality standards.

The third priority is to strengthen household managerial capacity and diversify revenue sources. Training should extend beyond farming techniques to include cost recording, cash-flow management, asset depreciation, break-even prices, household-consumption management, and income planning between production cycles. Diversification may be directed toward activities consistent with local competencies, such as seed supply, drying services, simple processing, or other coastal activities with established markets. The objective is not to add activities without economic consideration, but to broaden revenue sources so that households are not entirely dependent on a single commodity price and production cycle.

Table 9. Matrix of Recommendations for Improving Seaweed Farmer Terms of Trade

Key Finding	Recommended Direction	Practical Implication
Seed shortage is the main constraint	Develop local seed gardens and ensure the supply of quality seed	Planting continuity can be maintained and the risk of production decline can be reduced
Recurring operating costs are relatively high	Improve production facilities and farm-cost efficiency	Cost burdens per cycle can be controlled through well-targeted assistance
R/C ratio is positive, but NTPR is low	Increase net revenue and reduce unproductive expenditure	Farm feasibility can contribute more effectively to household welfare
Selling prices are relatively fixed and bargaining power is limited	Strengthen price information, collective marketing, and market institutions	Farmers may gain greater bargaining power in price negotiations
Some farmers have not participated in training	Expand technical training, farm record keeping, and field mentoring	Farm-management capacity and product quality can improve
Household revenue depends heavily on seaweed farming	Develop business diversification and value-added seaweed activities	Household income sources become more diverse and more resilient to price risk

Source: Primary data processed, 2026.

The recommendation matrix shows that improved household welfare cannot be achieved through a single intervention. Seed availability without a strong market may increase production but does not guarantee an adequate selling price; production facilities without management capacity may increase depreciation costs without raising revenue; and a high R/C ratio does not guarantee that households can meet their needs when consumption expenditure greatly exceeds recorded revenue. Therefore, program indicators should simultaneously include productivity, cost per cycle, product quality, selling price, sales frequency, net income, and NTPR.

CONCLUSION

Seaweed farmers in North Dullah Island District were predominantly aged 50 years and older, had elementary-to-senior-high-school education, and had an average of 17.51 years of farming experience. Farm scale varied substantially in terms of cultivated area, number of long lines, harvest frequency, and sales volume, while seed shortage was the main constraint reported by 53.85% of respondents. Average farm revenue was IDR 28,544,808 per year, total farm cost was IDR 8,212,885, and net income was IDR 20,331,923, resulting in an R/C ratio of 3.48. The farming-income terms-of-trade value of 347.56 further confirmed that farm revenue exceeded farm costs and that seaweed farming was operationally feasible. In contrast, after household consumption expenditure was included, total household expenditure reached IDR 47,457,500 per year and NTPR was only 60.15. This value indicates that confirmed revenue was insufficient to cover all farm costs and household consumption expenditure. The difference between the farming-income terms-of-trade value of 347.56 and the NTPR value of 60.15 demonstrates that farm-unit economic performance must be distinguished from household economic capacity.

Improvement of NTPR should focus on strengthening local seed systems, increasing efficiency in production facilities and costs, improving productivity and product quality, developing collective marketing and transparent price information, strengthening farm-management training and institutions, managing production risks, and diversifying revenue sources. The principal limitation of this study was incomplete recording of non-seaweed

income; therefore, NTPR represents only revenue confirmed in the dataset. Future studies should record all household income sources, calculate NTPR at the individual-household level, and evaluate seasonal variation so that household welfare conditions can be described more precisely.

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