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The Impact of Pier Construction on the Income of Seaweed Farmers in Bandar Batauga Village, Batauga Subdistrict, South Buton Regency

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Abstract

This study aims to analyze the impact of pier construction on seaweed farmers' income and to identify the diversification of farmers' income sources in Bandar Batauga Village, South Buton Regency. The study was conducted from January to February 2026 using a quantitative approach. The research location was selected purposively, while a sample of 101 seaweed farmers was chosen using *simple random sampling* based on the Slovin formula. Data were collected through observation, interviews using questionnaires, and a literature review. Data analysis included income analysis, changes in income, and *a paired-sample t-test*. The results showed that average seaweed production decreased from 3,057 kg/year to 3,013 kg/year, while average income decreased from Rp48,910,891/year to Rp48,213,861/year. Average total costs also decreased from Rp16,680,156/year to Rp14,487,406/year due to a reduction in the scale of cultivation. Nevertheless, farmers' average total income increased from Rp33,399,052/year to Rp41,780,911/year, representing a change of Rp8,380,838.84/year. The results *of the paired-sample t-test* showed a significance value of 0.001 < 0.05, indicating a statistically significant difference in income before and after the construction of the pier. This increase in income does not entirely reflect an improvement in aquaculture conditions but is also influenced by the diversification of income sources. The number of farmers engaged in other businesses increased from 5 in 2021 to 34 in 2025, including fishing, construction, gardening, loading and unloading services, and driving. Thus, the construction of the pier increased farmers' total income but also led to adjustments in the scale of cultivation and encouraged the diversification of income sources among coastal communities.

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Keywords: pier construction, income, seaweed farmers, other businesses, coastal communities

INTRODUCTION

Indonesia is an archipelagic nation with vast potential in marine and coastal resources. This geographical condition makes marine biological resources one of the strategic sectors supporting the economy of coastal communities. One commodity of significant economic value is seaweed. In addition to serving as a source of income for coastal communities, seaweed has broad market prospects because it is utilized in various industries. Arman et al. (2024) explain that Indonesia's marine biodiversity holds great economic potential if managed optimally and sustainably. Indonesia's seaweed production has fluctuated in recent years, with a decline during the 2019–2021 period to 1,301,481 metric tons, followed by an increase during the 2022–2023 period to 1,008,187 metric tons. In 2024, Indonesia's seaweed export volume reached 241,070.7 metric tons, with destination countries including Japan, China, and South Korea (Central Statistics Agency, 2025). These conditions indicate that seaweed plays a strategic role, both as an export commodity and as a source of livelihood for coastal communities.

Southeast Sulawesi Province is one of Indonesia's major seaweed-producing regions. Seaweed production in this province varies across regencies and cities. In 2023, Muna Regency had the highest production at 98,376 metric tons, followed by Central Buton at 38,189 metric tons, South Konawe at 36,626 metric tons, Wakatobi at 33,290 metric tons, and Kolaka at 29,709 metric tons. Meanwhile, South Buton Regency produced 1,532 metric tons (Southeast Sulawesi Provincial Central Statistics Agency, 2025). Although its production is not yet as high as that of several other regencies, seaweed cultivation remains one of the economic activities of coastal communities in South Buton Regency, including in Bandar Batauga Village.

Table 1. Seaweed Production by Regency/City in Southeast Sulawesi in 2023

Regency/City	Volume (metric tons)
Muna	98,376
Central Buton	38,189
South Konawe	36,626
Wakatobi	33,290
Kolaka	29,709
North Buton	26,523
Bombana	20,368

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Baubau City	18,865
West Muna	2,934
Buton	1,627
South Buton	1,532
North Kolaka	1,008
Konawe Islands	3.23

Source: Southeast Sulawesi Provincial Central Statistics Agency (2025).

For seaweed farmers in Bandar Batauga Village, cultivation is a major source of household income. This makes changes to the coastal environment and development activities around cultivation sites a potential threat to the sustainability of their businesses and their incomes. One significant change was the construction of a pier in 2022, aimed at improving connectivity and accessibility between regions in South Buton Regency. However, this construction has also altered the spatial patterns of coastal communities' activities. The number of active seaweed farmers, which previously stood at 145, has now decreased to 135. Some farmers have also had to relocate their cultivation sites to more distant areas due to vessel activity around the pier. These conditions indicate a shift in cultivation patterns that could potentially affect farmers' income.

Infrastructure development in coastal areas can have both positive and negative impacts on community economic activities. On the negative side, increased vessel activity and changes in aquatic environmental conditions have the potential to disrupt seaweed cultivation activities. Golubkov and Golubkov (2022) indicate that infrastructure development may be linked to changes in water quality, which in turn affect cultivation activities. These conditions are critical for seaweed farmers because productivity and product quality are highly dependent on aquatic environmental conditions. Conversely, the construction of a pier can also improve connectivity, expand trade activities, and open up new business opportunities. Bennett (2019) explains that infrastructure development can boost economic activity by improving access and connectivity, although under certain conditions it may also lead to a shift in existing business activities. Syawaludin and Alfiyani (2025) found that the construction of the Kijing International Port created new business opportunities in the fields of trade, transportation, logistics, the food industry, and employment for the surrounding community.

This phenomenon has also begun to emerge in the Bandar Batauga Village. Some seaweed farmers affected by the pier's operations have started developing alternative businesses—both goods- and service-based—to meet their household needs. This situation

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indicates that changes resulting from development can be seen not only in the decline or increase in income from seaweed cultivation but also in the farmers' ability to diversify their income sources. The subdistrict government has sought to provide assistance in the form of equipment for affected farmers, but this assistance has not yet been fully implemented. Thus, the construction of the pier has the potential to alter the community's livelihood structure through a reduction in seaweed farming activities alongside the emergence of alternative income sources.

Previous research has examined the relationship between infrastructure development and the socioeconomic conditions of communities. Nurhalimah et al. (2017), for example, analyzed the impact of the construction of the Tamperan Coastal Fishing Port in Pacitan on the socioeconomic conditions of the surrounding community, particularly income, employment opportunities, and business activities. That study showed that infrastructure development can bring about changes in the economic activities of communities in the surrounding area. However, research specifically examining changes in seaweed farmers' income alongside the contribution of alternative businesses that emerge after pier construction remains limited. Most studies focus more on the impact of infrastructure on the general socioeconomic conditions of communities without linking it to income diversification strategies for seaweed farmers.

These limitations constitute *a research gap* in this study. The novelty of this research lies in its analysis of the impact of pier construction on seaweed farmers' income, taking into account the contribution of alternative businesses as a form of economic adaptation among coastal communities. This approach allows the study not only to examine changes in income from cultivation activities but also to identify new sources of income that emerge following infrastructure development.

Based on this description, the construction of the pier in Bandar Batauga Village is important to study because it relates to the sustainability of seaweed cultivation, changes in livelihoods, and farmers' household income. Therefore, this study aims to analyze the impact of the pier construction on seaweed farmers' income and to analyze the contribution of alternative livelihoods to the income of seaweed farmers in Bandar Batauga Village, South Buton Regency. The results of this study are expected to provide an empirical picture of the impact of infrastructure development on the economy of coastal communities and to serve as a basis for consideration in development planning that prioritizes the sustainability of community livelihoods.

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METHOD

This study employs a quantitative approach using a survey method to analyze the impact of pier construction on seaweed farmers' income in Bandar Batauga Village, Batauga Subdistrict, South Buton Regency. The study was conducted from January to February 2026. The research location was selected using *purposive* sampling, considering that Bandar Batauga Village is a seaweed cultivation area, serves as the site for the pier construction, and the majority of its residents work as seaweed farmers on approximately 80 hectares of cultivation land.

The study population consisted of all 135 active seaweed farmers in Bandar Batauga Village. The sample was selected using simple random sampling because the population characteristics were relatively homogeneous. The sample size was calculated using the Slovin formula with a 5% precision level, as described by Rianse and Abdi (2008), resulting in 101 respondents.

The research data consisted of primary and secondary data. Primary data were obtained through direct interviews using a questionnaire and field observations, while secondary data were obtained from the Central Statistics Agency, the local government, the subdistrict office, and relevant literature. The data collected included production, selling prices, production costs, income from seaweed farming, and income from other businesses before and after the construction of the pier.

Data analysis was conducted using quantitative descriptive methods by comparing farmers' income before and after the construction of the pier. Income was calculated based on the difference between total revenue and total costs (Nainggolan et al., 2025), using the following equation:

$$\Pi = TR - TC$$

Total revenue is calculated based on the quantity produced multiplied by the selling price, while total costs are the sum of fixed costs and variable costs:

$$TR = P \times Y$$
$$TC = FC + VC$$

Notes:

Π = Revenue (Rp/year)

TR = Total Revenue (Rp/year)

TC = Total costs (Rp/year)

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P = Production (kg/year)
Y = Selling price (Rp/kg)
FC = Fixed costs (Rp/year)
VC = Variable costs (Rp/year)

The impact of the pier construction on revenue is calculated based on the change in revenue before and after construction using the following equation:

$\Delta\Pi = \Pi post - \Pi pre$
Explanation:
$\Delta\Pi$ = Change in farmers' income (Rp/year)
$\Pi post$ = Farmers' income after the wharf construction (Rp/year)
Πpre = Farmers' income before the wharf construction (Rp/year)

A positive value indicates an increase in income, while a negative value indicates a decrease in income. Next, the difference in income before and after the construction of the pier was tested using a paired-sample t-test with SPSS at a 5% significance level (Mashuri, 2023). This test was used because the measurements were taken from the same respondents at two different points in time. Prior to the analysis, a normality test was conducted to ensure the assumptions of the analysis were met. The hypotheses tested were H_o: there is no difference in seaweed farmers' income before and after the construction of the pier; and H_1: there is a difference in seaweed farmers' income before and after the construction of the pier. H_o is rejected if the significance value is < 0.05.

In addition to income from seaweed farming, the study also calculated income from other businesses operated by farmers after the construction of the pier. This income was calculated based on revenue minus operating costs over one year to determine its role as an alternative source of income for farmers' households.

RESULTS AND DISCUSSION

Income Components of Seaweed Farmers

Seaweed farmers' income is an economic indicator reflecting the net profit derived from seaweed cultivation and other business activities over a specific period, influenced by production, prices, revenue, as well as fixed and variable costs.

Based on interview results, prior to the pier's construction, seaweed cultivation activities

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in the surrounding area were relatively stable because there was not yet a high volume of vessel traffic; consequently, water conditions supported seaweed growth, and cultivation activities were generally influenced only by changes in input prices. After the pier was built, increased vessel activity led to changes in water conditions—including waves, currents, and turbidity—that had the potential to disrupt seaweed growth and damage cultivation facilities. These conditions prompted some farmers to adapt by upgrading production facilities, reducing the area under cultivation, and relocating to waters considered safer. These changes in aquaculture activities subsequently affected the production, revenue, costs, and income earned by seaweed farmers.

Table 2. Average Fixed Costs, Variable Costs, Labor Costs, and Total Costs of Seaweed Farming Before and After the Construction of the Pier

Cost Type	Description	Average	
		2021	2025
Fixed Costs (IDR/Year)	Bamboo	6,222,574	5,070,495
	Ris Rope	226,533	235,111
	Tie-down Straps	232,673	210,866
	Buoys	197,380	133,701
	Engines	772,500	771,094
	Boats	393,133	393,133
	Tarps	656,389	656,389
	Total	**8,098,472**	**6,876,489**
Variable Costs (Rp/Year)	Labor Costs	187,377	180,907
	Seeds	7,010,396	5,928,713
	Sacks	203,713	286,446
	Transportation Costs	1,180,198	1,214,851
	Total	**8,581,684**	**7,610,916**
Labor Costs (Rp/HOK/Year)	Lowest	105,455	101,000
	Highest	345,000	508,333
	Average (Rp)	**187,377**	**180,907**
Total Cost (Rp/Year)	Lowest	10,289,022	8,703,422
	Highest	24,771,736	23,985,139
	Average (Rp)	**16,680,156**	**14,487,406**

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Fixed Costs

The average fixed costs for seaweed farmers decreased after the construction of the pier, from Rp8,098,472/year before construction to Rp6,876,489/year after construction. The decrease was primarily observed in depreciation costs for bamboo, binding ropes, floats, and machinery. Bamboo depreciation decreased from Rp6,222,574/year to Rp5,070,495/year, which is related to the reduction in cultivated area and the number of cultivation rafts. This finding is consistent with Hamid and Kamisi (2012), who stated that bamboo is the primary material used in raft construction; therefore, its usage is directly related to the scale of cultivation. Meanwhile, depreciation costs for binding ropes increased from Rp226,533/year to Rp235,111/year due to changes in input prices. Depreciation costs for boats and tarps remained unchanged at Rp393,133 per year and Rp656,389 per year, respectively. Thus, the decrease in fixed costs more accurately reflects the reduced scale of aquaculture equipment use due to limited operational space around the dock.

Variable Costs

Average variable costs decreased from Rp8,581,684 per year before the pier's construction to Rp7,610,916 per year after construction. This decrease stemmed primarily from a reduction in seedling costs—from Rp7,010,396/year to Rp5,928,713/year—and labor costs—from Rp187,377/year to Rp180,907/year. These conditions are related to the reduction in the area of aquaculture land, which led to a corresponding decrease in the need for production inputs and labor. This is consistent with Yusriadin et al. (2016), who stated that land area is closely related to the use of production inputs. Conversely, the cost of sacks increased from Rp203,713/year to Rp286,446/year, and transportation costs rose from Rp1,180,198/year to Rp1,214,851/year. However, these increases were not sufficient to offset the decrease in seedling and labor costs. Thus, changes in variable costs were primarily influenced by the reduction in cultivation scale, while increases in certain components were related to changes in input prices and distribution requirements.

Labor Costs

Average labor costs decreased slightly from Rp187,377/year before the pier was built to Rp180,907/year after construction. The lowest cost decreased from Rp105,455 to Rp101,000, while the highest cost increased from Rp345,000 to Rp508,333. These changes primarily occurred in the seedling-tying activity, where labor requirements are adjusted based on the number of ris ropes and the area of the cultivation plot. The reduction in cultivation area led to

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a corresponding decrease in labor requirements for this activity. Meanwhile, planting, maintenance, and packaging activities generally rely on family labor, incurring no wage costs, while labor for harvesting is adjusted according to each farmer's specific needs.

Total Costs

The average total cost of seaweed cultivation decreased from Rp16,680,156/year before the pier's construction to Rp14,487,406/year after construction—a 13.1% reduction. The lowest cost also decreased by 15.4%, while the highest cost decreased by 3.2%. This decrease was primarily due to a reduction in the area and scale of cultivation resulting from vessel activity around the pier area, which led to a corresponding decrease in the need for seedlings, production inputs, and labor. Thus, the reduction in total costs does not indicate an increase in production efficiency but rather reflects an adjustment in the scale of operations due to limited cultivation space following the pier's construction.

Table 3. Seaweed Selling Prices

No.	Year	Amount (Rp/kg)
1.	2021	14,000
2.	2025	16,000
Average		15,000

The selling price of seaweed in Bandar Batauga Village increased from Rp14,000/kg in 2021 to Rp16,000/kg in 2025, representing a 14.29% increase. This price increase contributed to higher farmer income despite a decline in seaweed production following the construction of the pier. This finding aligns with Nadhar et al. (2024), who state that higher selling prices can boost income and provide economic stability for farmers. Thus, the rise in selling prices serves as a factor that can mitigate the decline in farmers' income resulting from reduced production scale following the pier's construction.

Table 4. Seaweed Production, Farmers' Revenue, and Income Before and After the Construction of the Pier in Bandar Batauga Village

Variable	Description	Amount	
		2021	2025
Production (kg/year)	Lowest	2,500	2,200
	Highest	5,000	5,000

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	Average (kg)	**3,057**	**3,013**
Revenue (Rp/Year)	Lowest	40,000,000	35,200,000
	Highest	80,000,000	80,000,000
	Average (Rp)	**48,910,891**	**48,213,861**
Income (Rp/Year)	Lowest	24,629,792	21,663,988
	Highest	56,352,225	67,231,571
	Average (Rp)	**33,399,052**	**41,780,911**
Farm Income (Rp/Year)	Lowest	24,629,792	21,663,988
	Highest	56,352,225	59,122,128
	Average (Rp)	**32,230,736**	**33,726,455**

Production and Revenue

Average seaweed production experienced a slight decline following the construction of the pier, from 3,057 kg/year in 2021 to 3,013 kg/year in 2025. The lowest production level decreased from 2,500 kg to 2,200 kg, while the highest production level remained at 5,000 kg/year. This decline is believed to be related to the reduction in cultivation space due to vessel activity around the pier. Saleky et al. (2020) explain that the presence of shipping lanes can limit cultivation space, thereby affecting production capacity. In addition to land area, aquatic environmental conditions and disease outbreaks such as *"ice-ice"* can also affect seaweed production yields (Emola et al., 2021).

Average income from seaweed farming also experienced a slight decline, from Rp48,910,891 per year in 2021 to Rp48,213,861 per year in 2025. The lowest income decreased from Rp40,000,000 to Rp35,200,000 per year, while the highest income remained at Rp80,000,000 per year. These changes in revenue are influenced by seaweed production and selling prices. Although average production has declined, the increase in the selling price from Rp14,000/kg to Rp16,000/kg helps offset the decline in revenue. Thus, the change in revenue following the construction of the pier results from the interaction between reduced production and higher selling prices.

Farmers' Income and Farming Operations

Average farmer income increased from Rp33,399,052 per year before the pier's construction to Rp41,780,911 per year after construction, representing an increase of Rp8,381,859 per year. The lowest income decreased from Rp24,629,792 to Rp21,663,988 per year, while the highest income increased from Rp56,352,225 to Rp67,231,571 per year. This

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average increase in income occurred despite a decline in seaweed farming production and revenue. This situation is primarily due to a greater reduction in production costs compared to the decline in revenue, as well as additional income from other businesses undertaken by some farmers. Thus, the increase in income following the construction of the pier does not solely indicate an improvement in farming conditions but also reflects changes in the scale of operations and the diversification of farmers' income sources.

Income derived specifically from seaweed farming increased from an average of Rp32,230,736 per year before the pier's construction to Rp33,726,455 per year afterward. The lowest income decreased from Rp24,629,792 to Rp21,663,988 per year, while the highest income increased from Rp56,352,225 to Rp59,122,128 per year. This increase in average farming income occurred because the decline in production costs was greater than the decline in revenue. This situation indicates a contraction in the scale of operations—specifically, a reduction in cultivation area and production, accompanied by a decrease in input use and production costs. Therefore, the increase in farming income cannot be directly interpreted as an improvement in cultivation conditions but rather indicates that cost reductions were able to offset the decline in revenue following the construction of the pier.

Table 5. Income from Other Businesses Owned by Seaweed Farmers in Bandar Batauga Village

Income	2021		2025	
	n (People)	$\bar{X}$ (Rp/Year)	n (People)	$\bar{X}$ (Rp/Year)
Fishermen	5	23,600,000	30	24,283,333
Construction Workers	0	0	1	24,000,000
Gardening	0	0	1	26,000,000
Loading and Unloading	0	0	1	15,000,000
Car Driver	0	0	1	20,000,000

There was a diversification of seaweed farmers' income sources from other businesses before and after the construction of the pier. In 2021, only 5 respondents had other businesses, all of whom were fishermen with an average income of Rp23,600,000 per year. Meanwhile, in 2025, the number of farmers with other businesses increased to 34 respondents. These businesses included 30 fishermen with an average income of Rp24,283,333 per year, 1

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construction worker earning Rp24,000,000 per year, 1 gardener earning Rp26,000,000 per year, 1 loading and unloading worker earning Rp15,000,000 per year, and 1 car driver earning Rp20,000,000 per year.

The increase in the number of farmers engaged in other businesses indicates a diversification of income sources following the construction of the pier. This situation suggests that some farmers are no longer entirely dependent on seaweed farming but are taking advantage of other economic opportunities emerging around the pier area. This diversification can serve as a strategy for farming households to maintain their income when the space and activities related to seaweed cultivation undergo changes due to port operations. Thus, the existence of other businesses also contributes to an increase in the total income of farming households following the construction of the pier.

Impact of Pier Construction on Seaweed Farmers' Income.

Seaweed farmers' income is derived from the difference between total revenue (TR) and total costs (TC) over the course of one year. To determine changes in income following the construction of the dock, a comparison was made between farmers' income before and after the dock's construction. The change in income was calculated based on the difference between income after the dock's construction and income before the dock's construction. A positive value indicates an increase in income, while a negative value indicates a decrease in income.

Based on the calculations, the average income of seaweed farmers increased by Rp8,380,838.84 per year following the construction of the pier. This increase indicates that farmers' total income after the pier's construction was higher than before construction. This change is not only related to income from seaweed farming but is also influenced by the emergence of other sources of income pursued by some farmers, such as fishing, loading and unloading services, driving, construction work, and gardening.

To determine whether the difference in income before and after the pier's construction is statistically significant, a *paired-samples t-test* was conducted because the data came from the same respondents across the two observation periods. The results of the analysis using SPSS are presented in Table 6.

Table 6. Results of the Paired-Samples t-Test for Seaweed Farmers' Income Before and After the Construction of the Pier

Variable	Mean Difference (Rp)	t	df	Sig. (2-tailed)
Income before – after	-8,380,838.84	-7,859	100	0.001

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Based on Table 6, the *mean difference* of -Rp8,380,838.84 indicates that the average income after the construction of the pier was Rp8,380,838.84 higher per year compared to before construction. The calculated t-value of -7.859, with a significance level of 0.001 < 0.05, indicates that there is a significant difference between farmers' income before and after the construction of the pier. Thus, H0 is rejected and H1 is accepted.

This increase in income requires further analysis because it does not stem entirely from improved seaweed farming performance. The research findings show that average production actually decreased slightly from 3,057 kg/year to 3,013 kg/year, while production costs also decreased due to a reduction in the scale of cultivation. At the same time, some farmers began to earn income from other businesses. Thus, the increase in farmers' total income is more closely related to the diversification of income sources following the construction of the pier. This situation indicates that farmers made economic adjustments to changes in cultivation space and activities by taking advantage of other business opportunities that emerged around the pier area.

CONCLUSION

Based on the research findings, it can be concluded that the construction of the pier in Bandar Batauga Village has brought about significant changes to seaweed farmers' income. Following the construction of the pier, average seaweed production decreased slightly from 3,057 kg/year to 3,013 kg/year, and average income decreased from Rp48,910,891/year to Rp48,213,861/year. Average total costs also decreased from Rp16,680,156 per year to Rp14,487,406 per year, primarily due to a reduction in the scale and area of cultivation caused by vessel activity around the pier. Nevertheless, farmers' average total income increased from Rp33,399,052/year to Rp41,780,911/year, with a difference of Rp8,380,838.84/year.

The results of the paired-sample t-test showed a significance value of 0.001 < 0.05, indicating a significant difference between income levels before and after the pier's construction. This increase does not fully reflect an improvement in seaweed farming conditions but is more influenced by a reduction in production costs and diversification of income sources. This is evident from the increase in the number of farmers engaged in other businesses—from 5 people in 2021 to 34 people in 2025—including fishing, construction, gardening, loading and unloading services, and driving. Thus, while the pier's construction has economically increased farmers' total income, from a cultivation perspective, it has led to a narrowing of farming space and adjustments to the scale of seaweed production.

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The government needs to balance coastal infrastructure development with the protection of cultivation areas by regulating vessel activities, providing supporting facilities, and offering guidance to seaweed farmers. Farmers are advised to enhance their cultivation adaptation strategies while developing alternative businesses to strengthen household income resilience. Future research could examine the social and environmental impacts of pier construction, including changes in water quality, damage to aquaculture facilities, farmers' adaptation strategies, and the contribution of non-aquaculture businesses to household income.

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