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Agribusiness Performance of Milkfish and Vannamei Shrimp in a Polyculture System

Dea Azhari[1], La Ode Alwi[2], La Ode Jabuddin[3], Haji Saediman[4]*
Halu Oleo University, Kendari
Corresponding Author: Haji Saediman saediman@yahoo.com

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ABSTRACT

This study analyzes the agribusiness performance of milkfish-vannamei polyculture in Asingi Village of South Konawe District. Data were collected from 15 pond farmers through surveys and direct observation in 2024. Descriptive and financial analysis (Revenue/Cost or R/C ratio) were employed to evaluate the viability of the farming system. The results show that, on average, each farmer produced 4,063 kg of milkfish and 1,737 kg of shrimp per season, generating total revenue of IDR 138.54 million against production costs of IDR 42.44 million. The average net income was IDR 96.1 million per season, yielding an R/C ratio of 3.26, which indicates a highly profitable enterprise. These findings demonstrate that milkfish and vannamei shrimp polyculture is economically feasible. However, analysis of farming practices revealed some suboptimal input management. Improvements in management, such as following best-practice guidelines for input use and risk mitigation, could further enhance productivity and sustainability. With appropriate support and farmer training to optimize input use and manage risks, this integrated farming system can be further developed to improve coastal livelihoods and strengthen the regional aquaculture sector.

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INTRODUCTION

Aquaculture has become a cornerstone of Indonesia's fisheries sector, contributing significantly to national fish production and rural livelihoods. Indonesia's aquaculture output reached 15.37 million tons in 2020 (worth approximately IDR 153 trillion) and was projected to exceed 20 million tons by 2024 (Kemenko Bidang Kemaritiman dan Investasi, 2021). Within this sector, milkfish and shrimp are particularly important commodities. Milkfish is a traditional staple of brackish water pond culture with a stable market demand and price. Meanwhile, Pacific white shrimp (vannamei) has boomed as a high-value export product, appreciated for its fast growth and marketability (Salim et al., 2025). Vannamei shrimp is also protein-rich and relatively affordable, driving increased consumption domestically. The cultivation of these species in coastal ponds provides employment and income for many communities, and the government has targeted substantial increases in shrimp production in the coming years (Dao, 2023).

Instead of monoculture, many Indonesian farmers practice polyculture (Hassan et al., 2021), raising milkfish and shrimp together in the same ponds. Polyculture is defined as the integration of two or more species in one production system to optimize resource utilization and economic return (Erwiantono et al., 2020; Samidjan & Rachmawati, 2018). In traditional Indonesian pond systems (tambak), milkfish are often grown alongside shrimp (and sometimes other organisms like crabs or seaweed) in a mutualistic setup (Darmansah et al., 2017; Hendrajat et al., 2018; A. Putri et al., 2018). Such systems can enhance productivity and profitability for small farmers (Erwiantono et al., 2020). Ecologically, polyculture can improve water quality and nutrient recycling. Economically, the practice diversifies outputs, reduces risk, and often increases total yield per area, thereby raising farmer incomes (Erwiantono et al., 2020). Erwiantono et al. (2020) demonstrated that adopting shrimp-fish polyculture significantly boosted smallholders' income in Indonesia, recommending this practice as a strategy for poverty alleviation and environmental sustainability (Erwiantono et al., 2020). Recognizing these advantages, Indonesia's Ministry of Marine Affairs and Fisheries has promoted integrated farming models (including Integrated Multi-Trophic Aquaculture or IMTA) that combine species at different trophic levels for more sustainable production (Cahya et al., 2021).

Milkfish-vannamei polyculture is an important source of livelihoods in Southeast Sulawesi, although they are not yet included as a priority commodity (Saediman, 2015). Asingi Village, located in Tinanggea Sub-District of South Konawe District in Southeastern Sulawesi, offers a representative case of milkfish-vannamei polyculture. This coastal village possesses extensive brackishwater ponds and favorable conditions for aquaculture, including abundant seawater supply and a suitable climate (Jaya et al., 2024). In fact, the region's aquaculture output has grown markedly in recent years. Milkfish production in Tinanggea rose from about 2,907 tons in 2020 to 5,185 tons in 2024, while shrimp production increased from 56 tons to 214 tons over the same period. This significant growth underscores the area's potential as an aquaculture hub. Despite this, there has been limited formal study on the performance of polyculture farms in this specific region. Much of the available literature on milkfish-shrimp farming in Indonesia focuses on Java or other provinces (e.g., Bekasi, West Java (Dhewantara et al., 2022); Lamongan, East Java; or Bulukumba, South Sulawesi (D. A. R. C. Putri et al., 2024). Recent evidence from the Tinanggea District of South Konawe indicates that vannamei shrimp output is jointly and significantly shaped by six factors, namely stocked postlarvae, pond area, feed, fertilizer, labor (work-days), and husbandry techniques. However, when examined individually, only the number of postlarvae stocked and labor input exert statistically significant effects on production, whereas pond area, feed, fertilizer, and husbandry technique do not show independent significance (Yuni et al., 2018).

In analyzing the "performance" of an agribusiness, we adopt a holistic view that examines the entire value chain from input provision to farming processes to marketing. Agribusiness is a system comprised of several interrelated subsystems: the upstream subsystem (provision of production inputs), the on-farm subsystem (cultivation or farming process), the downstream subsystem (post-harvest handling and processing), and the marketing subsystem (Hidrawati et al., 2022). Performance (or keragaan agribisnis) refers to how well these subsystems function together to yield desirable outcomes (productivity, profitability, sustainability, etc.). Hidrawati et al. (2022) describes agribusiness performance as a composite picture of technical, economic, and social aspects of the farming system, including input availability, cultivation techniques, post-harvest handling, and marketing efficiency. Key indicators commonly used to evaluate economic performance at the farm level include production output (yield), cost of production, revenue from sales, net farm income, and benefit-cost ratio. One widely used metric is the Revenue-Cost Ratio (R/C ratio), which is the ratio of total revenue (TR) to total cost (TC) (Saediman et al., 2019; Saediman, Astuti, et al., 2021). For example, Dhewantara et al. (2022) reported an R/C ratio of 3.5 for traditional milkfish-vannamei polyculture in Bekasi, implying that the farm revenue was 3.5 times the costs; this is a clear sign of high profitability. Similarly, (Hidayat et al., 2023) found an average R/C around 3.19 for revitalized traditional polyculture ponds in South Kalimantan, well above the unity threshold (Hidayat et al., 2023). These figures suggest that integrated milkfish-shrimp systems, when managed well, can yield substantial economic returns.

Several research findings provide context for what drives success in milkfish-shrimp farming. Laily et al. (2019) observed that in polyculture ponds, seed and feed are often the largest cost components, highlighting the importance of stocking strategy and feed management in cost efficiency. Suyoto et al. (2022) examined technical efficiency in brackish polyculture ponds (combining tilapia, milkfish, and vannamei) using a stochastic frontier approach. They found an average technical efficiency of 76.5%, indicating that while the polyculture system was fairly efficient, there remained about 23.5% potential output gains if all farms operated at the frontier of best practices. On the risk side, D.A.R.C. Putri et al. (2024) conducted a risk analysis of milkfish-vannamei polyculture in Bulukumba and found that vannamei shrimp are more susceptible to high-impact risks (especially disease outbreaks) than milkfish. According to their study, disease is the most critical risk factor for shrimp survival, whereas for milkfish, the feed supply (and its cost) is a primary concern (D. A. R. C. Putri et al., 2024). These insights underscore the need for careful health management and cost control in feed and seed for successful polycultures.

This research aims to produce a comprehensive analysis of the agribusiness performance of milkfish and vannamei shrimp polyculture in Asingi Village, Tinanggea District. Specifically, the study will: (1) describe the production input utilization and cultivation practices in comparison to recommended standards; (2) quantify the production outputs (fish and shrimp yields) and revenues; (3) detail the cost structure and profitability of the polyculture operation; and (4) assess the financial feasibility of the enterprise using the R/C ratio criterion.

LITERATURE REVIEW

Agribusiness performance refers to the effectiveness and efficiency with which an agricultural or aquacultural enterprise manages its entire system of operations. In the context of aquaculture, a well-performing agribusiness is one that reliably accesses quality inputs, employs sound farming techniques, produces competitive outputs, and markets its products profitably. According to Intyas & Abidin (2018), fisheries agribusiness encompasses vertically-linked activities starting from the provision of inputs (seed, feed, equipment, etc.), through the farming or grow-out phase, and onward to post-harvest processing and distribution to consumers.

For aquaculture enterprises, financial performance metrics are particularly important. These include gross revenue, total production cost, net income (profit), and profitability ratios. The Revenue/Cost (R/C) ratio is one widely used measure in farm management studies to summarize financial viability. Many agribusiness analyses of fish farming use this metric to conclude feasibility. Beyond economics, another aspect of performance is technical efficiency, which is essentially how well inputs are converted into outputs (Saediman et al., 2023). In small-scale aquaculture, inefficiencies can arise from suboptimal feeding, improper stocking densities, or poor pond maintenance. Suyoto et al. (2022) found an average technical efficiency of 0.765 (76.5%) among 30 pond farmers in Lamongan, East Java. This means that farmers were achieving roughly 76% of the output that would be possible if they were fully efficient with the given technology and inputs. The study highlighted that there was room (23%) to increase output by adopting best practices more consistently. Key factors affecting production in that polyculture system included land area, seed quantity, labor usage, fertilizer, feed, and the use of probiotics. Another relevant dimension is risk management performance, especially for ventures involving shrimp. Vannamei shrimp are prone to disease outbreaks (such as White Spot Syndrome Virus), which can cause sudden losses. Putri et al. (2024) emphasize that in milkfish-shrimp polycultures, risk profiles differ by species: shrimp carry a higher probability and impact of risk events (particularly diseases), whereas milkfish are hardier and their main risks are more related to feed and market price fluctuations. Effective performance, therefore, also means mitigating these risks through biosecurity measures, water quality control, and diversification (which polyculture inherently provides to some extent).

Polyculture of milkfish and penaeid shrimp has long been practiced in Indonesia and other Southeast Asian countries, with early evidence from the Philippines showing that combining species could improve pond productivity and reduce environmental impacts compared to intensive monoculture. In Indonesia, the practice has attracted renewed interest as a response to shrimp disease problems and the need for more sustainable production systems. Recent empirical work has reinforced its economic and ecological potential. For example, research in Bekasi by Dhewantara et al. (2022) demonstrated that traditional milkfish–vannamei systems can be highly profitable, with an R/C ratio of 3.5 and a payback period of only a few months, while also highlighting the importance of improved infrastructure and farmer training to sustain returns. Other work underscores the role of management intensity in determining outcomes. Amsari (2021), for instance, found that milkfish–tiger shrimp polyculture was technically feasible but less profitable than intensive monoculture, mainly because extensive systems yield less despite higher marginal returns on input costs. Studies have also explored innovations to strengthen polyculture systems. Baedlowi (2020) incorporated seaweed (Gracilaria) into milkfish–shrimp ponds, demonstrating that it can act as a biofilter, improve water quality, and generate an additional product without compromising fish and shrimp growth, thereby raising total system productivity. Beyond farm-level economics, the broader socio-economic implications are also significant. Using a large farmer survey, Erwiantono et al. (2020) showed that households adopting shrimp–fish polyculture earned higher incomes than those practicing monoculture, leading the authors to recommend it as a pathway for both poverty alleviation and mangrove conservation in coastal communities. Collectively, these findings confirm that while outcomes depend on input management and local conditions, milkfish–shrimp polyculture offers a robust model that combines profitability with ecological and social benefits.

METHODOLOGY

Research Site and Respondents

This research was conducted in Asingi Village, Tinanggea District, South Konawe Regency, located in the province of Southeast Sulawesi, Indonesia. Asingi is a coastal village characterized by extensive brackishwater ponds traditionally used for fish farming. The village lies at approximately 4°16′S latitude and 122°17′E longitude, with a tropical climate (annual temperatures 25–32 °C) suitable for year-round aquaculture. The site selection was purposive: Asingi was chosen because it is a center of milkfish and shrimp polyculture in the region and exemplifies the farming system under study.

The target population was pond farmers in Asingi who cultivate milkfish and vannamei shrimp together (polyculture). We identified 15 farmers meeting this criterion, and all 15 farmers were included as respondents (a census of the polyculture farmers). The relatively small number of farmers is due to the niche nature of polyculture in the village; while many villagers engage in aquaculture, not all integrate shrimp with milkfish

Data Collection

Primary data were collected through structured interviews, field observations, and review of farm records during the January–March 2025 period. A structured questionnaire was used in interviews to obtain information on: farmers' demographic profile (age, education, experience), pond characteristics (area, ownership status), input use (type and quantity of seeds, feeds, fertilizers, lime, pesticides, labor, etc.), cultivation techniques (pond preparation steps, stocking densities, feeding frequency, water management, pest/disease control measures), production output (harvest quantities of milkfish and shrimp, harvest timing), and economic data (input costs, output prices, marketing channels). To ensure accuracy in financial data, farmers were asked to refer to their expense logs or their memory of expenditures for the last completed production cycle.

Secondary data were gathered to support analysis and discussion. This included local aquaculture statistics (from district fisheries office reports), technical guidelines and regulations, and relevant literature. For instance, we referred to Ministerial Regulation No. 75/Permen-KP/2016, which provides general guidelines for vannamei shrimp culture, and to the Standard Operating Procedure (SOP) for Milkfish Grow-out (KKP 2020) for recommended practices in milkfish farming.

Data Analysis

The analysis is primarily descriptive and financial. We broke down the analysis into the following components:

1. Production Input Analysis: We examined the types and quantities of inputs used by farmers and evaluated their usage against recommended best practices. For each major input (land, seed, fertilizer, lime, feed, pesticide, equipment, and labor), we documented farmers' actual use. Where applicable, we categorized usage as "compliant" or "non-compliant" with official recommendations.
2. Cost Structure Analysis: We computed the total production cost per season for each farmer and then averaged across all farmers to get representative cost figures. Costs were segmented into variable costs and fixed costs. Variable costs are those that change with the level of production, including seed (fingerlings and postlarvae), feed, fertilizers, pesticides, and hired labor. Fixed costs are those that do not vary with output in the short term – mainly depreciation of equipment (nets, water pumps, boats, harvesting tools, etc.) and land tax. Depreciation was calculated using the straight-line method based on the estimated useful life of each piece of equipment as reported by farmers. All costs were standardized to a per-season basis (one production cycle, which in Asingi typically lasts about 4–6 months).

3. Production and Revenue Analysis: For outputs, we calculated the average production of milkfish and shrimp per farmer per season (in kilograms). Each farmer's production volume was recorded at harvest; we then took the mean of all 15 farms. We also noted the range (min–max) to understand variability. Using the production volumes and the selling prices reported by farmers (IDR per kg), we computed total revenue per farmer. Milkfish and shrimp are typically sold at the farm-gate to local traders or middlemen. In 2024, the average price realized was about IDR 17,000 per kg for milkfish and IDR 40,000 per kg for vannamei shrimp. These prices were relatively stable across farmers, as most sold to the same market channel. Revenue from milkfish = (milkfish yield) × (milkfish price), and similarly for shrimp. We then summed to get the total gross revenue per season for the polyculture.
4. Income and Feasibility Analysis: The core financial performance was assessed by calculating net income (profit) and the R/C ratio (Saediman, Merlina, et al., 2021; Surni et al., 2020). For each farmer, net income = total revenue – total cost. We averaged the net income across farmers to report an "average profit per season". More importantly, we computed the Revenue-Cost ratio = total revenue ÷ total cost for each farm, and then averaged the ratio (since R/C is a ratio, we also cross-checked by using aggregate mean values, which should give a similar result if the distribution is not skewed). An average R/C ratio for the polyculture system was thus obtained. To interpret it, we applied the feasibility criteria: R/C > 1 indicates the farming is profitable and worth continuing; R/C < 1 would indicate it's not economically viable.

RESULT AND DISCUSSION

Farmer Characteristics and Input Utilization

All 15 polyculture farmers in Asingi Village can be considered small-scale operators, managing their ponds largely with family labor and traditional knowledge. The pond sizes varied from about 3 ha up to 12 ha, with the majority (53%) of farmers operating medium-sized ponds of 5–10 ha. About one-quarter (27%) had ponds smaller than 5 ha, while a minority (20%) controlled ponds larger than 10 ha. These figures indicate that most farmers run moderate-scale operations – not tiny homestead ponds, but also not huge commercial estates. In terms of experience, the respondent group was quite seasoned: over half (approximately 53%) had more than 10 years of fish farming experience, and all respondents were within the productive working age (no retirees managing ponds). This experience likely contributed to their ability to handle the polyculture system, as many had started as milkfish farmers and later incorporated shrimp when vannamei became available.

Farmers are largely following established practices in some areas (feeding, liming, basic pond prep), but there are notable gaps in others (pest control methods and seed stocking consistency). The use of chemical insecticides by all farmers is a point of concern. The recommended practice to control pond pests (like predatory crabs, snails, and insects) is to use saponin (derived from plant sources such as tea seed cake), which is biodegradable and less harmful to the environment. Instead, farmers used commercial pesticides like "Bestnoid" and "Agus" (a molluscicide and an insecticide, respectively) applied at approximately 1 kg/ha and 5 bottles/ha doses. While effective at killing pests, these chemicals could leave residues or negatively affect pond ecology. Farmers likely choose them for convenience and immediate effectiveness, indicating an area where training and access to eco-friendly inputs could improve practices.

On stocking densities, the fact that 53% of farmers did not follow the guidelines suggests a divergent understanding or risk strategy. Discussions with farmers revealed two reasons: (a) Some farmers overstocked shrimp (going above 30k PL/ha), hoping to compensate for expected mortalities, essentially a hedge against disease or predation losses. (b) A few farmers understocked both milkfish and shrimp because they faced cash or fry availability constraints at stocking time. Both scenarios reflect how farmers' risk perceptions and resource limitations drive their decisions. Overstocking can lead to crowding, poor water quality, and ultimately lower survival or growth, which might negate the intended benefit. Understocking, on the other hand, means not fully utilizing the pond's carrying capacity, leading to lower total output (though possibly higher survival and growth of those stocked). The net effect in our sample is that yields varied, and some efficiency was likely lost due to non-optimal stocking. These findings mirror observations by Suyoto et al. (2022) that suboptimal input allocation (like too many or too few seeds) is a factor in less-than-full technical efficiency.

On a positive note, feeding practices were uniformly good. Farmers adhered to giving feed twice daily – morning and afternoon – which is recommended to avoid overfeeding and to match fish/shrimp feeding rhythms. The feed used ("Violet Sp"), being a certified feed with 22–24% protein, is beneficial. Milkfish in traditional systems often rely on natural food (algae, plankton) for a substantial part of their diet, but supplemental feeding (especially for the shrimp) is necessary. The farmers all reported that they primarily fed the shrimp; the milkfish would graze on natural productivity and leftover shrimp feed. This approach makes sense and indicates the polyculture advantage: the milkfish effectively utilize the natural food web enhanced by fertilization, while shrimp get the higher-protein feed, and very little goes to waste. The high compliance in feeding suggests that farmers are aware of the importance of consistent feeding for shrimp growth. It also reflects that feed, while a cost, is not prohibitively expensive in extensive to semi-intensive setups.

Fertilization and liming were moderately practiced. The somewhat conservative use of lime and fertilizer by some farmers could be due to cost-saving motives. Urea and phosphate fertilizers are relatively expensive inputs; one farmer mentioned that chemical fertilizer prices have risen, causing him to cut back slightly on application. This might result in less natural food (lab-lab, diatoms) for milkfish, potentially slowing their growth. However, none of the farmers skipped fertilization entirely. They understand that without it, the pond would not bloom and fish growth would suffer. The compromise some make is using organic manure (like chicken manure) in addition to or instead of costly inorganic fertilizer. While our survey captured mainly the use of urea/SP-36, a few mentioned adding chicken manure from local poultry farms to fertilize ponds. This is a traditional practice and can be effective, though it requires availability and can introduce variability. Overall, fertilization practices in Asingi seem adequate to ensure baseline productivity.

In terms of labor and equipment, these farmers operate in a low-mechanization, labor-intensive paradigm. The heavy reliance on family labor reduces cash outlays (wages) but it also means the farming scale is constrained by family capacity. During critical periods like harvest, additional hands were hired, typically paying neighbors or local youth a daily wage to help seine the pond. Labor cost thus enters the cash flow mainly at harvest time and occasionally during pond preparation (for tasks like mud removal or dike repairs that require more manpower). The equipment ownership data shows only a couple of farmers had motor pumps. Those two had slightly deeper ponds inland that needed pumping to fill/drain efficiently. The rest, being closer to tidal channels, use tidal flow for water exchange. This indicates zero or minimal energy costs for water management in most farms, which is a benefit of traditional design (but also means less control over water quality compared to pumped systems). The lack of aerators or other modern equipment is notable. Oxygen levels are managed by keeping stocking densities low and maintaining algae growth.

Production Results and Yields

Despite some variations in practices, the production outcomes for the milkfish-shrimp polyculture in Asingi have been encouragingly strong. Over the last completed season (2024), each farm harvested both milkfish and shrimp. Table 1 presents the average production and revenue figures per farm.

Table 1. Average Seasonal Production and Revenue per Farm (Milkfish–Shrimp Polyculture, Asingi Village)

Commodity	Average Harvest Quantity (kg/season)	Average Farm-Gate Price (IDR/kg)	Average Revenue (IDR/season)
Milkfish (Bandeng)	4,063 kg	17,000	69,076,667
Vannamei Shrimp	1,737 kg	40,000	69,466,667
Total/Average	*6,093 kg*	–	138,543,333

Notes: Prices are weighted averages of farm-gate prices received by farmers. US$1 = IDR 15,000

Source: Primary data (2024 season) compiled from 15 farms

Each farm produced on average 6.1 tons of biomass per season, comprised of roughly 4.06 tons of milkfish and 1.74 tons of shrimp. The combined production generated an average gross revenue of IDR 138.54 million per farm per cycle (approximately US$9,200 at 2024 exchange rates). It is striking that milkfish and shrimp contributed almost equally to revenue: about IDR 69 million each. This is somewhat coincidental but can be explained by the contrasting yield and price dynamics. The milkfish volume was higher but at a lower unit price, whereas shrimp volume was lower but at a much higher price. In fact, milkfish accounted for 67% of the total harvest weight but, due to its low price, contributed 50% of the revenue. Shrimp, only 33% of the weight, contributed the other 50% of revenue. This balance underscores the risk-spreading benefit of polyculture: even if one crop had a bad outcome, the other can buffer the income. To put the yield figures in perspective, these numbers translate to productivity per hectare (assuming average pond area 7 ha as earlier estimated): roughly 580 kg/ha of milkfish and 240 kg/ha of shrimp per season. These yield densities confirm that the system is extensive to semi-extensive. For comparison, an intensive vannamei shrimp farm might yield 5,000–10,000 kg/ha in a crop, and an intensive milkfish monoculture (inorganically fertilized and perhaps aerated) might yield 1,500–2,000 kg/ha. The Asingi system's yield is an order of magnitude lower, reflecting the lower input regime and reliance on natural productivity.

It is noteworthy that milkfish yields of 4 tons per farm are quite high in absolute terms for traditional ponds. Many farmers harvested milkfish at sizes around 300–500 g each, meaning they took out roughly 8,000–12,000 fish. This suggests that milkfish survival and growth were good, potentially because milkfish face fewer disease issues and can utilize natural food efficiently. Some farmers mentioned that milkfish growth benefitted from the presence of shrimp feed – essentially, milkfish were "cleaning up" any excess feed or organic matter, turning it into additional fish flesh. This is a form of mutualism: milkfish improve water quality by eating algae and detritus, which helps shrimp, while shrimp feeding inadvertently feeds milkfish. Such interactions are a classic rationale for polyculture (Erwiantono et al., 2020).

Shrimp yields averaged 1.7 tons per farm, which could correspond to around 1.5–2 million shrimp pieces (assuming harvest size 15–20 g each). Not all postlarvae stocked made it to harvest; farmers reported shrimp survival rates in the range of 50–70%. For instance, one farmer stocked 200,000 PL and harvested 100,000 marketable shrimp. Survival was variable, with some disease or predation losses noted (birds and crabs were mentioned as minor predators). However, a survival of >50% in traditional ponds is actually decent, given no aeration or intensive care. The shrimp that survived grew to table size (20 g each) over about 4 months. These growth and survival figures align with extensive farming expectations and indicate that the vannamei crop, while smaller in volume than milkfish, was successful enough to command high revenue.

The variability among farms in output was present but not extreme. The highest producing farm achieved around 8,000 kg of milkfish (in a larger pond) and 2,500 kg of shrimp, whereas the lowest achieved 2,500 kg of milkfish and 1,000 kg of shrimp. Factors for variability included pond size, stocking densities, and luck with weather/disease. During the season, there were no major disease outbreaks (like WSSV) reported in Asingi; a crucial factor that allowed farmers to realize these outputs. In less fortunate seasons, shrimp disease could drastically cut yields (which is why risk management is key). It's possible that polyculture itself helps mitigate disease severity by not pushing shrimp density to intensive levels and by maintaining water quality through bioturbation by milkfish.

Marketing and revenue realization: Farmers sold milkfish and shrimp through a single marketing channel. All respondents indicated there is essentially one dominant buyer group, namely local fish collectors who come to the pond at harvest. Typically, harvest is coordinated such that a middleman brings a team and equipment (boxes, ice) to the pond, buys the entire harvest on the spot, and transports it to markets (nearby towns or the provincial capital Kendari). The prices (IDR 17k/kg for milkfish, IDR 40k/kg for shrimp) were agreed beforehand, often reflecting prevailing market rates minus the collector's margin. Farmers in Asingi do not usually have direct access to distant markets, so they accept slightly lower farm-gate prices in exchange for the convenience of the collector handling transport and sales. The fact that all farmers reported basically identical prices suggests a price-taking situation. They have little bargaining power and rely on the existing market structure (Taridala et al., 2013, 2021). Fortunately, those prices were still profitable. It is worth noting that milkfish pricing is relatively stable (demand for milkfish as a food fish in Indonesia is steady, and supply is domestic), whereas shrimp pricing can be more volatile as it is tied to export markets and international demand. During 2024, shrimp prices were favorable (IDR 40k/kg is a good price for pond-gate vannamei of 20 g each), likely due to strong export orders. If shrimp prices dip, the balance of revenue could skew more towards milkfish. This diversification is again beneficial for the farmer as it hedges against any one species' price risk.

Cost Structure and Profitability

The cost structure of the milkfish-vannamei polyculture reveals how farmers allocate their expenditures and which inputs weigh most on the budget. Table 2 presents the average costs per farm per season, broken down by component, along with each component's share of the total cost.

As shown in Table 2, variable costs dominate (95%), with fixed costs minimal (5%), reflecting the low-capital nature of extensive aquaculture. Fixed costs mainly cover land tax and small equipment depreciation, with only farmers using water pumps facing higher depreciation. Furthermore, seed provided the largest expense (50% of total, IDR 21.15 million/cycle). Seed supply is a critical cost driver; profitability hinges on seed quality and survival. Farmers' deviations from recommended stocking densities are often linked to this cost: some overstock to offset mortality, others understock to reduce risk.

The second-largest cost (14.5%, IDR 6.17 million) is from fertilizer. Farmers rely heavily on urea and SP-36 to stimulate natural food, reducing formulated feed needs. This strategy aligns with low-input polyculture, trading higher fertilizer spending for lower feed costs. Further, feed provides a relatively small share (10%, IDR 4.23 million). Mostly used for shrimp, with efficient feed conversion (FCR 1.2–1.5). Natural productivity and milkfish presence further reduce feed demand, contrasting with semi-intensive systems where feed may reach 50–60% of costs.

Table 2. Average Cost Structure per Season for Milkfish–Shrimp Polyculture Farming

Cost Component	Average Cost (IDR/season)	Share of Total Cost (%)
Seed (Fish & Shrimp)	21,152,000	49.8%
Fertilizer (urea, SP)	6,166,667	14.5%
Feed (pellets)	4,230,000	10.0%
Insecticide & Molluscicide	3,945,000	9.3%
Labor (hired)	4,210,000	9.9%
Lime (agricultural)	2,080,000	4.9%
Variable Cost Subtotal	40,397,000	95.2%
Fixed Costs (Equipment Depreciation + Land Tax)	2,041,055	4.8%
Total Production Cost	42,438,055	100%

Source: Survey data (2024) averaged over 15 farms. Land tax is a nominal annual tax on pond area; depreciation covers nets, pump, boat, etc. Percentages may not sum exactly to 100 due to rounding

Other cost components with a lower percentage are from chemicals, labor, lime, and fixed costs. About 9.3% (IDR 3.95 million) is mainly for pesticides to control crabs, snails, and insects. This cost is notable; replacing chemical use with plant-based alternatives (e.g., saponin) could reduce both expenses and environmental impact. Labor contributes to around 9.9% (IDR 4.21 million). Most labor is family-based, with hired workers mainly for harvest or pond prep. Costs vary (IDR 0–5 million), depending on farm size and reliance on outside labor. Further, the cost for lime is about 4.9% (IDR 2.08 million). Essential for pond pH and soil conditioning; although relatively low-cost, farmers note they would use more if affordable. Finally, fixed costs amounted to IDR 2.04 million (4.8%) on average, covering land tax and equipment depreciation. The small share underscores the low barrier to entry for polyculture farmers once ponds and basic tools are in place.

Now, considering the revenues we discussed earlier (IDR 138.54 million average per farm), we can proceed to calculate the profits and R/C ratio. The average total cost is IDR 42.44 million (Table 2), and the average total revenue is IDR 138.54 million (Table 1). Thus, net income is IDR 96,105,278 per season on average. Essentially, each farmer earned about 96 million rupiahs in profit from one cycle of polyculture. In USD terms, that's roughly $6,400 profit per cycle. If one cycle is 5 months, that annualizes to perhaps $15,000 per year if two cycles can be done (though often only one main cycle is done; sometimes a short second crop of something might be attempted).

The R/C Ratio is 3.26. An R/C of 3.26 is exceedingly high, signifying a very lucrative enterprise. In words, it means that for every IDR 1 spent on production, the farm returns IDR 3.26 in revenue, leaving IDR 2.26 as income (since IDR 1 covers the cost, IDR 2.26 is net). That equates to a 226% return on cost per cycle. It's important to note this is not an annual ROI percentage but a ratio per cycle; however, even as a gross profit margin, it indicates about 69% of the revenue is profit. Such an R/C ratio solidly confirms that the polyculture system is financially feasible and attractive. It far exceeds the threshold of 1. Even if costs were to increase or prices fall somewhat, there is a comfortable cushion. For instance, feed or fuel price spikes, or a drop in shrimp price, would have to erode a large portion of that margin to turn the venture unprofitable.

The R/C ratio of 3.26 is consistent with other studies, such as Dhewantara et al. (2022) who reported 3.5 for a similar polyculture in Bekasi, showing that traditional systems can achieve comparable profitability across regions. It also far exceeds the R/C values typical of monocultures: semi-intensive milkfish farms often reach only 1.2–1.5, while intensive vannamei operations, despite high outputs, usually achieve just 1.1–1.5 due to heavy costs and risks. Thus, although extensive polyculture produces lower absolute yields, it offers much higher margins, supporting arguments that traditional polyculture can be more economically efficient in input–output terms even if it does not maximize per-hectare output. The profit of IDR 96 million per cycle was driven by several factors. First, cost efficiency was achieved through minimal feed use, since natural pond productivity and milkfish recycling of waste reduced the need for expensive inputs. Second, crop health and survival rates were good, with farmers avoiding major disease by keeping shrimp densities low and relying on regular water exchange, though such favorable conditions may not occur every season. Finally, market conditions were supportive: shrimp sold at IDR 40,000/kg and milkfish at IDR 17,000/kg, both strong prices. While shrimp revenues are sensitive to price fluctuations, steady domestic demand for milkfish provides a reliable income base, helping stabilize returns.

Profitability and Future Prospects

The profitability seen in Asingi's polyculture is reflective of an economically optimal use of resources in a traditional system. Among aquaculture ventures, our result is on the high end. Zumail et al. (2017) found that polyculture of bandeng and tiger shrimp yielded R/C 3.5 in Southeast Sulawesi, which is consistent with our vannamei case. Meanwhile, Nurhidayati et al. (2022) reported on vannamei farming under different financing in Lampung, and their R/C ranged about 1.3–1.5. Clearly, low-cost polyculture can give superior R/C because the denominator (cost) is kept very low relative to output. Given the robust profitability metrics, we conclude that the agribusiness performance of the milkfish-shrimp polyculture in Asingi is excellent, and the enterprise is feasible to sustain and even expand. The high R/C ratio (>3) clearly meets the criterion of economic feasibility, since it is well above the threshold of 1 that defines a worthwhile business. All 15 farmers in our study earned profits, and none reported financial losses in the analyzed cycle. This universal profitability suggests a resilience in the farming system, likely tied to its diversified production and moderate intensity.

It is instructive to note that our findings align with the broader observation by Agam et al. (2024) that agribusiness performance improves when key subsystems, namely input supply, on-farm production, and marketing, are all functioning efficiently. In Asingi, input supply is locally adequate (farmers can get seed, feed, and fertilizers as needed, albeit at some cost); on-farm practices, while imperfect, have been sufficient to yield good outputs; and marketing, though simple, is effective in moving the product to buyers. Thus, the entire chain is relatively well-aligned, resulting in strong overall performance.

To sustain and enhance performance, several considerations emerge. Technical improvements through closer adherence to recommended practices could raise yields and cut costs, provided extension services effectively disseminate knowledge (Saediman, 2025a). Risk management is crucial, as profitability remains vulnerable to shrimp disease; reinvesting profits into monitoring, biosecurity, and improved seed quality would help contain risks (D. A. R. C. Putri et al., 2024; D. S. Putri et al., 2020). Scaling and replication of the Asingi model appear feasible in other coastal areas with brackish ponds and modest inputs, but expansion must respect ecological carrying capacity and maintain the balance between milkfish and shrimp. Finally, market diversification could strengthen returns, for instance by processing milkfish into higher-value products or linking shrimp to export-oriented processors, while collective marketing via cooperatives could help farmers capture greater value along the supply chain (Saediman, 2025b).

In conclusion, the polyculture of milkfish and vannamei in Asingi stands out as a successful agribusiness model. It leverages the ecological compatibility of species and prudent farm management to achieve high profitability with relatively low risk. The integrated analysis shows that each component from input use to marketing contributes to the overall performance. Where there are weaknesses (like partial guideline compliance), they present opportunities for intervention and support.

CONCLUSIONS AND RECOMMENDATIONS

The milkfish-shrimp polyculture system is highly productive and profitable under traditional management, yielding substantial benefits to small-scale farmers. Analysis of production inputs revealed that farmers broadly adhere to conventional practices, with some deviations. The study findings indicate a generally sound input regime with a few areas (stocking strategy and pest control) where practice diverges from ideal. Improving those areas (e.g., through better farmer training or input access) could enhance efficiency, but even under current practices, the inputs are managed well enough to support excellent production.

The polyculture system achieved impressive production outcomes. On average, each farm produced about 4.06 tons of milkfish and 1.74 tons of shrimp per cycle. This combined yield of 6.1 tons per farm translated to significant revenues: milkfish and shrimp sales each contributed roughly IDR 69 million, for a total average revenue of IDR 138.54 million per season. Milkfish and shrimp together provided a balanced income stream. The integration proved mutually beneficial; milkfish thrived on natural pond productivity, while shrimp grew well with controlled feeding, and neither species' performance was compromised by the other. The yields per hectare reflect an extensive culture level, which is by design as farmers did not push densities to intensive levels, prioritizing lower risk and input-saving.

Comparatively, these outputs meet or exceed typical results from similar extensive polycultures reported in other regions. The strong production performance underscores that the Asingi polyculture system is effectively managed within the capacity of the pond ecosystem.

The financial analysis showed a favorable cost structure and outstanding profitability. The total production cost averaged IDR 42.44 million per farm per cycle. Against the revenue of IDR 138.54 million, the net income came to about IDR 96.10 million per season. This is a substantial profit by local standards, indicating that polyculture farming yields far more than the minimum wage or alternative livelihoods in the area. The R/C ratio was calculated at 3.26, meaning every 1 rupiah of cost generated 3.26 rupiahs of revenue. This R/C far exceeds the breakeven threshold and indeed places the enterprise in a very high-return category. Given these outcomes, milkfish and vannamei shrimp polyculture in Asingi Village is a viable and lucrative agribusiness. The integration of the two species allows farmers to maximize utilization of pond resources and market opportunities: milkfish provide a baseline harvest even under less favorable conditions, and shrimp provide additional income that significantly elevates profitability. The current practices, while not perfect, are sufficient to yield high returns, and incremental improvements could further increase productivity and profits. We recommend that farmers enhance stocking management and adopt better pest/disease control to improve survival rates and reduce costs, thereby boosting net income. Additionally, leveraging farmer groups or cooperatives to obtain inputs at lower cost (bulk buying of feed/fertilizer) or to sell products at higher prices (bargaining with buyers) could improve their margins. Continued support for polyculture systems through research, extension, and possibly financial incentives could further improve their performance and encourage wider adoption. There should be an emphasis on disseminating improved techniques for input management and risk mitigation to sustain the high profitability.

FURTHER STUDY

This research still has limitations, so further research on this topic is still needed.

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