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Lobster Puerulus Trading and Cultivation in Situbondo: A Financial Feasibility and Risk Analysis

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ABSTRACT

Lobster (Panulirus spp.) aquaculture holds significant economic potential for coastal Indonesia, including Situbondo, East Java, relying heavily on wild puerulus harvest. However, developing sustainable cultivation and trading ventures faces considerable financial uncertainties due to biological, market, operational, and policy risks. This study assesses the economic feasibility and identifies key financial risks for lobster cultivation and puerulus trading in Situbondo. An integrated framework combining financial analysis with Monte Carlo Simulation for risk assessment was used, utilizing primary data and secondary sources. Probabilistic analysis identified key risk factors impacting profitability through sensitivity analysis. The financial modelling and analysis resulted positive valuation for both trading (48 billion rupiah NPV, B/C ratio 1.12) and cultivation (0.99 billion rupiah NPV, B/C ratio 1.52). The risk analysis identified 4 main risk factors: selling price, survival rate, exchange rate, and interest rate. Ultimately, this risk-integrated feasibility assessment provides crucial insights for investors, farmers, and policymakers, supporting informed decisions for sustainable lobster aquaculture development in Situbondo.

INTRODUCTION

Among the globally significant marine commodities, Lobster (*Panulirus spp*) has a strong demand and high economic value, especially in the Asian market. The international market size of lobster is substantial and significantly growing annually, with total transactions reaching billions of dollars [1]. Indonesia plays a major role in the global seafood trade, especially in the lobster export, enabled by its geographic characteristics of a large archipelagic nation blessed with extensive marine resources [2], [3]. The primary species that support the economic significance of Indonesian lobster fisheries and aquaculture are the scalloped spiny lobster (*Panulirus homarus*) and the ornate spiny lobster (*P. ornatus*) [4], [5], [6], [7], [8] alongside others like *P. penicillatus* and *P. longipes,* which are also commercially harvested [9].

The interest in using aquaculture as a strategy to improve supply and meet the increasing demand has been stimulated by the growing concerns on the long-term viability of wild-lobster populations amid the intense fishing pressure and overexploitation risks [10], [11]. Meanwhile, lobster farming, particularly within Indonesia and Vietnam, is significantly dependent on capturing pueruli from the wild, due to the limited availability of hatchery technology. Indonesia has an extensive natural availability of settling pueruli, with a potential yield exceeding 100 million annually along the southern coastlines of Java, Bali, Lombok, and Sumbawa – a resource

considerably larger than that of Vietnam [5], [12]. This condition offers a distinctive prospect for pursuing a large-scale lobster aquaculture sector.

However, realizing this potential is challenging due to Indonesia's dynamics and contradictory fishery policies. Historical and contemporary governmental regulations have encompassed prohibitions on the harvesting of undersized lobsters and pueruli to safeguard wild populations [10]. These regulatory efforts faced difficulties in implementation and enforcement, leading to resistance from the economic imperatives of coastal communities whose livelihoods depend on puerulus collection [13], [14]. Consequently, a substantial illegal trade in pueruli has continued, primarily supplying the Vietnamese aquaculture industry, thereby reducing prospective economic advantages for Indonesia [4]. Realizing the persistent smuggling activities, the government reopened the legal export channel for pueruli to Vietnam market by implementing Ministry Regulation no 7/2024 [15]. However, some complexities within Indonesian fisheries governance, including issues of inter-agency coordination and conflicts among varying levels of government and stakeholder groups, also impact the sector's advancement [3], [9].

The cultivation of lobster also faces numerous challenges and risks that extend beyond mere policy ambiguity. Biological vulnerabilities include a susceptibility to diseases, elevated mortality rates, and instances of cannibalism if stocking densities are excessive or nutritional provisions are inadequate [16], [17]. Maintaining optimal water quality within cultivation systems, such as floating net cages (KJA), is also important [17]. Physical infrastructures like cages, are susceptible to damage from environmental elements [7]. Moreover, market-related risks, including significant price fluctuations for both juvenile lobsters and market-sized adults, introduce an additional dimension of financial instability for cultivators [10], [13].

Given the substantial capital investment required and the multifaceted risks inherent in lobster cultivation and puerulus trading [7], [13], [18], robust financial feasibility studies are essential for informed decision-making. Previous economic analyses in Indonesia have sometimes indicated marginal profitability, often constrained by high seed costs, inefficient feeding practices, and market fluctuations [10], [19]. Traditional deterministic financial models often fail to capture the full spectrum of uncertainty associated with aquaculture ventures [20]. Incorporating stochastic risk analysis techniques, such as Monte Carlo simulation, is crucial to evaluating the impact of variability on key parameters like survival rates, input costs, and market prices on overall profitability and investment viability.

Therefore, this research aims to conduct a comprehensive financial feasibility study specifically examining lobster puerulus trading and subsequent cultivation (focusing on P. homarus and P. ornatus) within Situbondo, East Java. This study modeled the uncertainty surrounding economic variables by utilizing standard financial metrics integrated with a Monte Carlo simulation for risk analysis. This research contributes to providing detailed and risk-informed economic insights for potential investors, farmers, and policymakers in the Situbondo region. By evaluating financial viability under uncertainty, the findings will contribute to developing sustainable management strategies for lobster aquaculture in East Java, filling a knowledge gap by applying a rigorous economic and risk analysis approach to this locality.

MATERIALS AND METHODS

This study employed an integrated framework as shown in Figure 1. The method integrated traditional financial feasibility analysis and probabilistic risk assessment through Monte Carlo Simulation (MCS). This integrated system brings the evaluation of the project viability beyond deterministic point estimates by including all uncertainty involved in aquaculture practices [21].

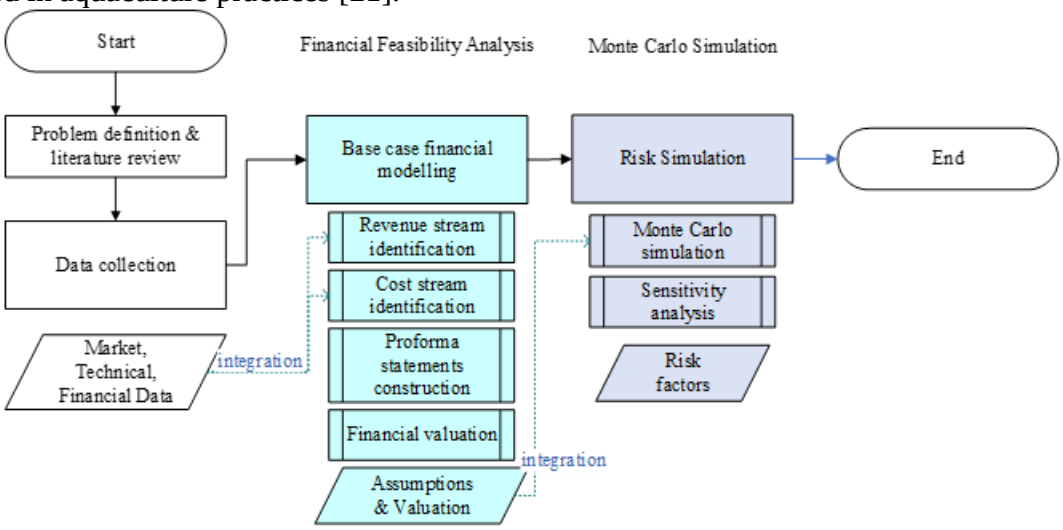

Figure 1. Research Method Flowchart (adapted from Ronyastra et.al., 2024)

This research specifically examined Situbondo Regency located in East Java of Indonesia, because of its potential as an area of lobster aquaculture production and puerulus trading activities. The first phase considered problem definition & literature reviews, and then scope setting (financial feasibility and risk assessment of lobster cultivation and puerulus trading), objectives, and reviews of past works related to existing issues of lobster bio-economics, aquaculture practices, and market dynamics on a regional basis.

Comprehensive data collection was conducted between January and March 2025. This involved gathering diverse data types by combining primary and secondary data sources, essential for financial and risk modelling, including market, technical, and financial data. Using the data obtained, a deterministic base case financial model for both puerulus trading and grow-out cultivation scenarios was prepared. This stage involved revenue and cost stream identification, proforma statements construction, and financial valuation.

The deterministic model is very limited in its ability to capture real-world variability. Hence, risk simulation using MCS was conducted to address uncertainties. The MCS process involved defining uncertain assumptions, assigning probability distributions, and performing a Monte Carlo simulation. The outputs of MCS were examined to understand the project's risk profile. This stage further explains other factors differentiating average profitability from those driving future financial successes or failures.

RESULTS AND DISCUSSIONS

Data collection and assumptions list

The data collection in this research is done for the two main business groups, i.e., the pueruli trading and the lobster cultivation, which are interrelated as the cultivation

business is a compulsory requirement to obtain the license to export pueruli. The pueruli trading was focused on the export market to Vietnam. Meanwhile, data on the cultivation business was obtained, focusing on local supplies. The data collection was done using primary data, such as contacting suppliers and vendors, and secondary data analysis from published statistical data sources. The data collected includes market-related data such as pueruli selling price, technical data such as warehouse rentals, and financial data such as interest rates. A total of 42 data points that will be used as basic assumptions in building the financial model were collected. The summary is displayed in Table 1.

Base case financial modelling

The financial model consists of several consecutive processes with the final objective of obtaining the feasibility valuation of the project. At the beginning, the revenue streams were constructed. Simple calculations were performed to calculate revenue, i.e., multiplying the selling price by the selling quantity. For pueruli trading, the selling quantity was set at 100.000 heads per week with a selling price of 38.000 Vietnamese Dong (VND). The export activities were assumed to happen weekly; thus, in each month, 400,000 heads were assumed 400.000 be exported. Meanwhile, for the cultivation business, the revenues only happen once every 6 months because the cultivation duration is assumed to be a minimum of 6 months. With 1000 seeds in each cycle, an 80% survival rate, 75 grams of monthly growth, and an initial weight of 30 grams, it was estimated to yield around 384 kilograms of mature lobsters to be sold every 6 months. The second step was to construct the cost stream for each line of business. The pueruli trading costs mainly consist of procurement (such as buying price from the fisherman) and supply chain costs (such as transport costs). Other costs, such as equipment and operational support costs, were also calculated. For the cultivation business, the main cost stream was the setup and feed costs. The setup costs include procuring equipment, seed, and a license.

The proforma statements can be constructed by starting with proforma income statements where the revenues were subtracted by the costs to obtain the net income for each forecasting period (in this case monthly). The pueruli trading was estimated to generate around 1 billion rupiah monthly for the whole 60-month projection period. The snapshot of the first two months of the proforma income statement is shown in Table 2. On the other hand, the lobster cultivation business's revenue was only generated every 6 months, as shown in Table 3. Furthermore, the cash-to-cash cycle of lobster cultivation is longer than the pueruli trading, implying that higher investment in working capital is also required to cover the costs for the 5 months without any revenue.

After the proforma statements were fully constructed, the valuation process can begin. The valuation requires calculating free cash flow (FCF) during the projection period. The cash flows were then used to calculate the NPV, IRR, and DPP. The discount rate used in the calculation, or the minimum attractive rate of return (MARR), was 10.70% per year or 0.89% per month, which was derived based on the weighted average cost of capital (WACC), which reflected the portion of own funds and loans used to fund the project. The MARR value also includes a 3% additional hurdle rate to the WACC. The summary of the base-case financial modeling results is shown in Table 4. It is observed that the NPV for both businesses is in positive territory, indicating the projects were financially feasible.

Table 1. List of Assumptions

No	Business Group	Assumptions	Value	Unit
1	Pueruli Trading	Export delivery target (ex CGK)	100,000	head/week
2		Pueruli purchase price	13,000	Rp./head
3		Freight survival rate	100%	
4		Pueruli selling price	38,000	VND/head
5		IDR to VND exchange rate	0.65	Rp./VND
6		Pueruli selling price	24,700	Rp./head
7		Shipping costs CGK - DAD	2	USD/kg
8		PNBP fees	4,000	Rp./head
9		Vitamin costs	1,000	Rp./ 200 heads
10		Quarantine and visual inspection	1,000	Rp./ 200 heads
11		Tactical fund allocation	3,000	Rp./head
12		Other logistics costs	35,000,000	per delivery
13		Office/warehouse rental	1,000,000,000	Rp./ 5 years
14		Facility renovation & installation	50,000,000	Rupiah
15		Operational car	250,000,000	Rupiah
16		Licensing & legality	200,000,000	Rupiah
17		Private funding portion	40%	
18		Loan portion	60%	
19		Personal funds interest rate	6.76%	per year
20		Interest rate on borrowed funds	8.32%	per year
21		Rupiah exchange rate	16,500	Rp./USD
22	Cultivation	Number of locations	1	location
23		Number of seeds	1,000	head/location
24		Seed purchase price	20,000	per head
25		Survival rate in cages	80%	
26		Cultivation period	6	month
27		Initial weight of seedlings	30	grams
28		Growth	75	grams/month
29		FCR	2	
30		Harvest selling price	600,000	Rp./kg
31		Feed prices	35,000	Rp./kg
32		8-hole floating net cage price	375,000,000	Rp./ location
33		Licensing	500,000,000	Rp./ location
34		Guard house and feed warehouse	50,000,000	Rp./ location
35		Operational boat	100,000,000	Rp./ location
36		Water quality instrument	10,000,000	Rp./ location
37		Solar electrical installation	10,000,000	Rp./ location
38		Monitoring system	10,000,000	Rp./ location
39		Processing and feeding tools	10,000,000	Rp./ location
40		Communication equipment	10,000,000	Rp./ location
41		Security system	10,000,000	Rp./ location

Table 2. Snapshot of proforma income statement for pueruli trading

Income Statement	Month 1	Month 2
Revenue	9,880,000,000	9,880,000,000
Cost of Goods Sold (COGS)		
Pueruli buying costs	(5,200,000,000)	(5,200,000,000)
Logistic costs	(1,832,380,000)	(1,832,380,000)
Total COGS	(7,032,380,000)	(7,032,380,000)
Gross profit	2,847,620,000	2,847,620,000
Operating costs		
Salaries	(43,875,000)	(44,021,250)
Utilities	(10,000,000)	(10,033,333)
Tactical allocation	(1,200,000,000)	(1,200,000,000)
Total operating costs	(1,253,875,000)	(1,254,054,583)
Operating profit	1,593,745,000	1,593,565,417
Depreciation & amortization	(22,916,667)	(22,916,667)
Earnings before interest and taxes	1,570,828,333	1,570,648,750
Interest expenses	(23,475,410)	(23,279,782)
Earnings before taxes	1,547,352,923	1,547,368,968
Tax expenses	(464,205,877)	(464,210,690)
Net profit	1,083,147,046	1,083,158,278

Table 3. Snapshot of proforma income statement for cultivation

Income Statement	Month4	Month5	Month6
Harvest revenue	-	-	691,200,000
COGS	(15,750,000)	(15,750,000)	(15,750,000)
Gross profit	(15,750,000)	(15,750,000)	675,450,000
Operating costs	(30,779,167)	(30,779,167)	(30,779,167)
Operating profit	(30,779,167)	(30,779,167)	660,420,833
Depreciation & amortization	(12,166,667)	(12,166,667)	(12,166,667)
EBIT	(42,945,833)	(42,945,833)	648,254,167
Interest expenses	-	-	-
EBT	(42,945,833)	(42,945,833)	648,254,167
Tax expenses	-	-	(194,476,250)
Net profit	(42,945,833)	(42,945,833)	453,777,917

The DPP for pueruli trading was estimated at 6 months, while for the cultivation, the DPP was 60 months. The long DPP for the lobster cultivation reemphasized the nature of the business, which heavily relied on working capital to fund the zero-revenue months. The working capital was only recaptured on the last projection period (month 60). Usually, the business owner would avoid investing in such a project with a long DPP. Still, the investment would become mandatory if the business owner wants to obtain a license to export pueruli.

Most of the previous researchers used benefit to cost ratio (B/C ratio) as a financial feasibility metric. The B/C ratio was calculated by dividing the revenues with the total costs. This research found the B/C ratio for pueruli trading is at 1.12, while for the cultivation is at 1.52. The B/C ratio indicated that the project is feasible. The value also falls within the range of the other researchers which ranging from 0.9 – 1.65 [1], [10],

[14], [20], which suggested that the calculations made in this research is reasonable without overestimation on both revenue and cost structure.

Table 4. Base Case Financial Modeling Results

Category	Financial Metric	Pueruli Trading	Cultivation	Unit
Project Valuation	NPV	48,685,413,124	998,026,508	Rupiah
	IRR	19.88%	1.91%	per month
	DPP	6	60	month

Risk simulation using Monte Carlo simulation

The base-case financial modelling has effectively identified the project's economic viability. However, due to the reliance on estimated data and the nature of uncertainties in the project throughout the projection period, it is necessary to conduct risk simulation. In this research, a Monte Carlo simulation was chosen to simulate the output when there are changes in the values of the input assumptions. The simulation was done in the Oracle Crystal Ball ® add-ins in Microsoft Excel 2019, on a laptop with AMD Ryzen ® 7 processor and 8 GB RAM.

The simulation setup involved assigning a probability density function where most assumptions were set to have a uniform distribution with a value range of ± 10% of the base case value. The triangular distribution was assigned to two assumptions, i.e., cultivation period (minimum: 5, likeliest: 6, maximum: 7) and number of seeds (minimum: 800, likeliest: 1000, maximum: 1200). 7 assumptions were assigned to the normal distribution, including export delivery target, Feed Conversion Ratio (FCR), feed price, freight survival rate, monthly growth rate, harvest selling price, and VND exchange rate.

Two outputs were set as the forecasted value in the simulation setup, i.e., NPV Trading and NPV Cultivation. The input variables' values were changed simultaneously during the simulation based on the random number generated in each iteration. The software recorded every input value, and each iteration calculated (forecasted) NPVs. The simulation was done for 50.000 iterations, which was considered sufficient to generate a data distribution that is stable and convergent. The simulation took 314 seconds to complete on that machine setup. The simulation result for the trading business is presented in Figure 2. The histogram shows that the positive NPVs were observed in around 83% of the total iterations. Meanwhile, positive NPVs were observed in 100% of the cultivation business iterations, as shown in Figure 3. These percentages reflected each business's certainty level to achieve the favorable financial feasibility indicator.

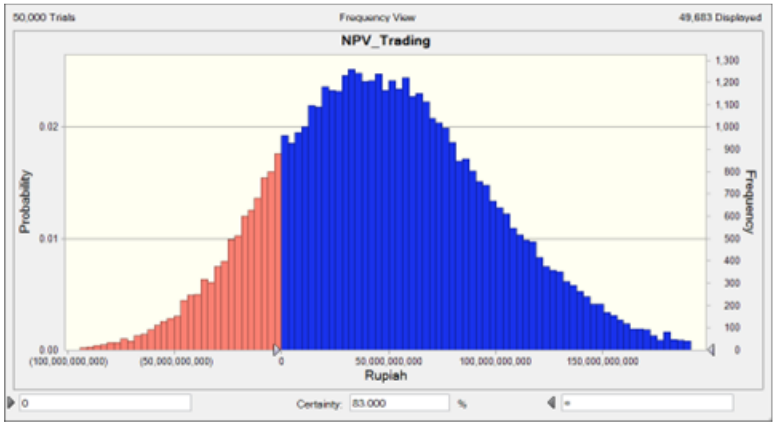

Figure 2. Monte Carlo Simulation Results for Trading

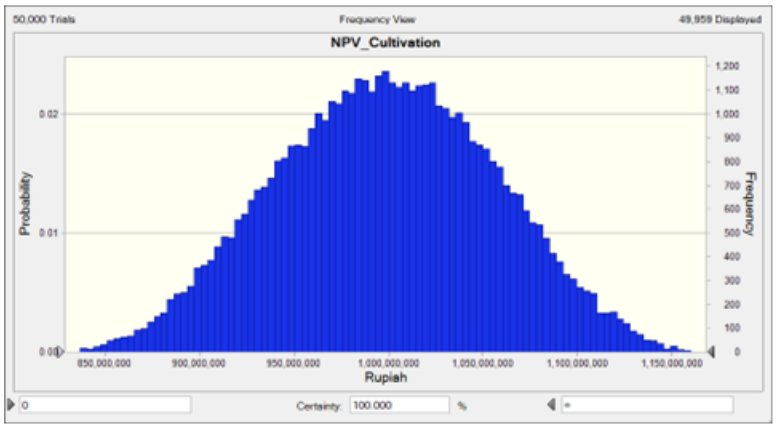

Figure 3. Monte Carlo Simulation Results for Cultivation

Table 5. Sensitivity Analysis Results

	Trading		Cultivation	
No	Assumptions	CTV	Assumptions	CTV
1	IDR to VND exchange rate	40.47%	8-hole floating net cage price	52.73%
2	Freight Survival Rate	40.14%	Interest rate on borrowed funds	26.22%
3	Pueruli selling price	13.87%	Licensing fee	12.42%
4	Pueruli purchase price	3.90%	Personal funds interest rate	7.40%
	Total	98.38%	Total	98.76%

Risk factor identification through sensitivity analysis

Risk factors can be identified by utilizing the Monte Carlo simulation results, i.e., the contribution to variance (CTV) data. The data shows that a particular assumption caused a percentage of the variance or uncertainty in the target forecasts (NPV trading and NPV cultivation). Table 5 lists the four most influential assumptions, i.e., the assumptions with high CTV values.

The data for the trading business indicated that the model is highly sensitive to the VND exchange rate, freight survival rate, pueruli selling and purchase price. The VND exchange rate, freight survival rate, and selling price correlate to revenue. A slight change in the values of those assumptions would have a high impact on the revenue stream. An

increase in the VND exchange rate and selling price would also increase the revenue stream, leading to a higher NPV. On the other hand, the purchase price of pueruli impacts the total business cost, especially on the cost of goods sold. A higher purchase price will increase the costs and lead to a reduction in NPV. These assumptions can be considered as risk factors for the trading business. Most of the risk factors have an impact on the revenue stream. The mitigation ideas may include a better contractual agreement with the buyer to ensure minimal price fluctuation. Other mitigation may include hedging instruments to offset the unwanted decrease in the VND exchange rate.

The risk factors for the cultivation business are the floating cage price, the borrowed funds interest rate, the personal funds interest rate, and the licensing fee. All of these risk factors are impacting the cost stream. Increasing the cage price and licensing fee would increase the total cost, leading to lower profitability and NPV. Higher interest rates would increase the cost and simultaneously the MARR, leading to a significant decrease in the NPV. The mitigation plan for these risk factors may include better sourcing for floating cage vendors and financial loan providers.

The finding of this research is aligned with the findings from previous research, where selling price is among the main risk factors [1], [7], [10], [20]. While this research also considered stocking density [20], survival rate [20], feed price [10], [13], it did not find them as the main risk factors for the financial output. However, due to the limitation of focus on the financial risk factors, the other factors such as weather, diseases, and maintenance [1], [7], [10], [13], were not sufficiently addressed in this research.

CONCLUSION

This study evaluated the need for a complete financial assessment of lobster cultivation (*Panulirus spp*.) and puerulus trading in Situbondo, East Java. This research focused on building a more robust evaluation by integrating financial feasibility analysis with quantitative risk assessment using a Monte Carlo Simulation. The activity of puerulus trading was found to have very good project valuation indicators, with a relatively large positive NPV of around Rp 48.7 billion and a very short DPP of only 6 months. In contrast, lobster cultivation showed positive NPV at approximately Rp 998 million, signifying base case feasibility; however, the DPP was far higher at 60 months (5 years). The Monte Carlo simulation and subsequent sensitivity analysis provided crucial insights into the risk profiles of these projects. It is indicated that the pueruli trading business was highly influenced by the VND exchange and freight survival rates. Most of the risk factors for lobster cultivation were assumptions that impacted the cost stream.

Combining the baseline feasibility with the risk analysis would have great implications for the stakeholders in Situbondo's lobster sector. A risk-adjusted feasibility assessment provides a more realistic foundation for investment decisions of private entrepreneurs and prospective financiers. For local government and fisheries management bodies, the identified key risks provide good data to inform policies relating to support towards sustainable aquaculture development that could focus, for instance, on input/output price stabilization, improving access to quality feed, or enhancing technical support to improve survival rates. This study presents rigorous, risk-focused financial analyses to add knowledge bases for responsible, economically viable lobster aquaculture and trade in Situbondo, East Java. The research can be expanded further in future research

work. For example, considering environmental impacts and socio-economic aspects would provide an all-around view of sustainability.

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