Research article

Profitability and Economic Viability of Upscaled Mussel Hatchery Operations

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Abstract Mussels are bivalve species with established ecological and economic importance. They are known to provide essential supporting services such as nutrient recycling and storage, structural habitat, substrate, and food web modification, and are also used as environmental monitors; regulating services such as water purification (biofiltration); and provisioning and cultural services, including their use as a food source, for making tools and jewelry, and for spiritual enhancement. Mussel hatcheries are crucial for ensuring a stable supply of mussel seeds, supporting the growing global demand, and contributing to sustainable aquaculture practices. This study evaluated the profitability and economic viability of an upscaled mussel hatchery in Miagao, Iloilo, Philippines. Primary and secondary data were used to analyze the project profitability and financial viability. Six business revenue models were considered in the study: (1) invest in housing and produce 1-mm spats, (2) invest in housing and produce 1-cm spats, (3) invest in housing and grow 1 mm-spats until 1 cm, (4) no investment in housing - produce until 1-mm, (5) no investment in housing - produce until 1 cm, and (6) no housing—produce 1 cm-spats from the until 1 mm. The indicators used include total revenue, net profit, gross profit margin, net profit margin, return on investment, net present value, internal rate of return, breakeven volume and price, and payback period. The results showed that the upgraded mussel hatchery requires an investment of approximately PhP. 3 million. The most profitable business model involves producing mussel spats of up to 1 mm. Investment in mussel hatchery is capital intensive. In the short run, existing or unused hatcheries owned by State Universities and Colleges (SUCs) and government institutions can be rehabilitated to increase production. Meanwhile, to increase profitability, existing R&D efforts can be extended to improve survival rates, particularly at the pediveliger to early spats and 1-mm to 1-cm stages.

Keywords mussel hatchery, economic viability, profitability analysis, upscaling, sustainable aquaculture

INTRODUCTION

Mussels are bivalve species with established ecological and economic importance. They are known to provide essential supporting services such as nutrient recycling and storage, structural habitat, substrate, and food web modification, and they are also used as environmental monitors; regulating services such as water purification (biofiltration); and provisioning and cultural services including their use as a food source, in the creation of tools and jewelry, and for spiritual enhancement

(Vaughn, 2018). Mussel farming has been found to enhance nutrient regeneration in coastal lagoons (Jansen, et al., 2019), and their role in cycling and storage of nutrients in the Oligo-, Meso-, and Cultivation areas has been extensively reviewed (Jansen et al., 2019). Mussels also support biodiversity, serve as a food source for various species, and help maintain the balance of aquatic ecosystems by controlling phytoplankton biomass (Dolmer & Frandsen, 2002).

Mussels are ecologically and economically important. Mussel farming is a sustainable practice that supports local economies by providing food and employment opportunities (Shumway et al., 2003). Globally, aquaculture's role in meeting the global demand for fish has increased (Tran et al., 2022), and the demand for mussels is rising (Market Research Future, 2024); (Global Information, Inc., 2024); (Global Marketing Insights, 2024); (Global Information, Inc., 2024); (Global Marketing Insights, 2024). The continuously growing demand is attributed to the rising interest in healthy and sustainable food choices (Global Information, Inc., 2024), increasing popularity of value-added mussel products offering a unique profile to consumers (Global Information, Inc., 2024), and their applications in indirect consumption, processed foods, animal feeds, and nutraceuticals (Global Marketing Insights, 2024).

While mussels are vital for ecosystem health and economic sustainability, their populations are declining, necessitating conservation efforts to maintain their ecological and economic roles in the ecosystem. Mussel Philippines (2017) reported that production has been declining due to the following factors: low product value, limited market demand, poor sanitary quality, occurrence of red tides, and unpredictable supply. Hatcheries eliminate variability and uncertainty associated with environmental factors and overexploitation of natural seeds (Helm et al., 2004), support industry expansion by producing seeds all year round, thus facilitating greater flexibility in production cycles (Salomon and Holm, 2013), and enable controlled breeding programs focusing on selected traits such as faster growth rates, disease resistance, and tolerance to environmental stressors (Vu et al., 2020). Hence, they are essential for improving the performance of bivalve species in aquaculture (Gjedrem and Rye, 2018) and support sustainable aquaculture practices by promoting responsible resource management and minimizing negative environmental impacts (Nascimento-Schulze et al., 2021). Thus, upscaling hatchery operations is essential to ensure a consistent supply, improve product quality, and reduce reliance on wild seed collection.

OBJECTIVE

The main objective of this study was to determine the viability of scaling up mussel hatchery operations. Specifically, it aims to determine the investment requirements and the financial and economic viability of scaling up green mussel hatchery operations.

METHODOLOGY

This study used a quantitative analysis involving financial modeling and economic evaluation of the upgraded hatchery design and operations. The results represent a case study of an upscaled mussel hatchery funded by the Philippine Council for Agriculture, Aquatic, and Natural Resources Research and Development (PCAARRD).

Primary data were collected from a scaled-up mussel hatchery established at the University of the Philippines Visayas. Production data were gathered from the scaled-up production runs. Secondary data were obtained from published reports, production data from existing UPV hatcheries, and market price data for mussels.

Six business revenue models were considered: (1) invest in housing and produce 1-mm spats, (2) invest in housing and produce 1-cm spats, (3) invest in housing and grow 1 mm-spats until 1-cm, (4) no investment in housing - produce until 1-mm, (5) no investment in housing - produce until 1 cm, and (6) no housing - grow 1 mm spats to 1 cm.

RESULTS AND DISCUSSION

Cost Structure Analysis

Operating a green mussel hatchery requires a capital of approximately Php 3 million. Of this PhP 3-M capitalization, 16% was allocated to working capital, while the remaining 84% was dedicated to fixed capital investments. The capital assets in this nursery business are hatchery tanks, structures, and facilities. The most significant capital investment in green mussels was the purchase of hatchery facilities (approximately 46%). Hatchery housing comprises 40% of the total investment cost, hatchery tanks account for 12%, and the remaining 4% is allocated to broodstock facilities and breeders.

Table 2 Budgetary requirement for the construction of a green mussel hatchery, 2024

Particulars	Quantity	Unit cost (PhP)	Total cost (PhP)
Hatchery tanks			
Broodstock tanks (250-L)	1	10,000.00	10,000.00
Spawning tanks	1	15,000.00	15,000.00
Larval rearing tanks			
1 ton	3	11,800.00	35,400.00
500-L	1	15,000.00	15,000.00
250-L	14	8,000.00	112,000.00
100-L	30	3,800.00	114,000.00
Total cost for hatchery tanks			301,400.00
Hatchery structures			1,000,000.00
Total cost of hatchery structures			1,000,000.00
Hatchery facilities			
General	10	67,493.00	674,930.00
Algal culture	10	9,201.50	92,015.00
Basic laboratory equipment	10	31,800.00	318,000. 00
Laboratory reagents	10	6,520.00	65,200.00
Total cost of hatchery facilities			1,150,145.00
Broodstock facilities and breeders			
Aeration blower	1	25,000.00	25,000.00
Water pump	1	2,750.00	2,750.00
Aeration system (Aeration pipeline)		21,048.00	21,048.00
Water system (Installation of water pipeline)		56,288.00	56,288.00
Breeders	15	100.00	1,500.00
Water heater (1.8L)	3	800.00	2,400.00
Total cost of broodstock facilities and breeders			108,986.00
Total investment			**2,560,531.00**
Operating cost during the first year of operation			479,470.00
Total capital requirement to start the operation			**3,040,001.00**

Revenue Projections

Attachment 1 (provided on the last page) presents the revenue projections for each revenue model. Other profitability and economic indicators used to assess the viability of each revenue model are also included. Profitability is computed as the difference between revenues and the cost of selling goods. Total revenue was derived as the product of the quantity sold and the price per unit.

The fixed costs of mussel hatchery operations include water, electricity, and other utilities. Variable costs, on the other hand, include breeders, spats (if the revenue model is nursery operations), algal starter feeds, hatchery supplies, and direct labor.

The highest-cost item across all revenue models was labor. The highly technical nature of running a mussel hatchery necessitates hiring workers with advanced degrees and commands relatively higher remuneration. Among the fixed costs, the depreciation of capital assets is a major expense, attributed to the high capital expenditure required to establish a hatchery.

Revenue and Net Profits

From Attachment 1, running a hatchery and producing spats until 1 mm generates the highest revenue (Options 1 and 4). In addition to the relatively higher spat price, turnover is high at six cycles per annum when these revenue models are adopted. Nursery operations (buying 1-mm spats and growing them to 1 cm) yielded the lowest revenue (Options 3 and 6). This is explained by the limited maximum production capacity, as the number of spats that can be sold is constrained by the nursery capacity in which an investor invests.

Net profit is highest when producing 1-mm spats without housing investment. Examples include the use of existing hatcheries or facilities operated by research institutions, government agencies, and local government units. Gross profit is highest for Model 1 (housing until 1- mm spats production) and Model 4 (no housing until 1 mm production). Consequently, Revenue Model 4 yields the highest net profit. Although the costs are the same as those in Revenue Model 1, Model 4 does not incur depreciation expenses.

Profitability Ratios

The profitability ratios of the different green mussel hatchery technology revenue models were analyzed using the gross profit margin and net profit margin. The gross profit margin is highest for Revenue Models 1 and 4, at 56.09%, and lowest for revenue options 3 (with housing nursery operations from 1 mm to 1 cm) and 6 (no housing nursery operations from 1 mm to 1 cm).

To be acceptable, the gross profit margin must be between 50% and 70%, which is considered healthy for industries such as retail, manufacturing, and goods production. Other industries, such as financial institutions, have higher benchmarks for healthy gross profit margins. The net profit margin was highest for Option 4 (housing nursery operations from 1 mm to 1 cm) at 48.09%. This is because depreciation was not included in the cost. This model is most applicable to research institutions, local government units (LGUs), and state universities and colleges (SUCs) that have existing or underutilized multispecies hatcheries.

Financial Viability

To determine the ability of the enterprise to generate the required cash flow to meet ongoing operational costs and debt repayments, the investment was subjected to the following standard capital budgeting tools: return on investment (ROI), net present value (NPV), internal rate of return (IRR), and breakeven volume and price. ROI calculates the profits generated by an investment relative to the total cost of the investment. Using ROI as the criterion, all revenue models except Model 3 (nursery operations with investment in housing) are considered to be good investment alternatives.

NPV explains how much an investment is worth throughout its lifetime, discounted to today's value. Comparing the financial viability of the six models based on the NPV criterion, all except the nursery operation, with and without investment in housing (options 4 and 6), yielded positive results. Revenue Models 4 and 6 fail the NPV test because of the volume limitations imposed by nursery-rearing capacities. A hurdle rate of 6% was used to discount the present net value, which is close to the risk-free rate of return. The project duration used in the NPV calculation was 10 years with annual cash flows.

The IRR is the discount rate that makes the NPV equal to zero, serving as a benchmark for comparison against the cost of capital. Investments are acceptable if the IRR is greater than or equal to the cost of the capital. With 10% as the hurdle rate (the current approximate commercial banking rate), Revenue Models 1 (housing until 1-mm spats), 4 (no housing until 1-mm spats), and 5 (no housing until 1-cm spats) are considered sound investment options.

Investing in housing and operating a nursery (1 mm to 1 cm) remains the least viable Model because the IRR was computed to be -8%. This result implies that cash flows from the investment are insufficient to cover the initial investment costs.

The payback period is the time required to recover the investment. Based on the projected income of all six revenue models, potential investors can recover their costs most quickly by exclusively producing 1-mm spats using the old multi-species hatcheries. In this scenario, the investment recovers in one year and four months. In contrast, it would take 35 years to recover the investment in producing 1-mm to 1-cm spats with housing.

CONCLUSION

Profitability varies across the business models. Spat production up to 1 mm in size demonstrated positive profitability, with both housing and no housing factored in the overall project cost. Profitability was highest in the model that produced 1-mm spats without housing. This is understandable, as no depreciation associated with investment in housing was incorporated into the overall cost.

Investment in a mussel hatchery is capital-intensive. In the short run, existing or unused hatcheries owned by State Universities and Colleges (SUCs) and government institutions can be rehabilitated to increase production. Meanwhile, existing R&D efforts can be extended to increase survival rates, particularly during the pediveliger to early spat stages and from 1-mm- to 1-cm.

The profitability performance observed may not be applicable universally to all regions or hatchery systems. Farmers and investors may gain practical insights into the financial feasibility of expanding hatchery operations. On the other hand, policymakers may benefit from the study's findings by formulating policies and incentives to promote hatchery upscaling and sustainable growth in aquaculture.

Several practical and policy recommendations can be drawn from this study. From this mussel hatchery upscaling profitability study, strategies for optimizing production costs can be explored in the future. Furthermore, it is recommended that the government support mussel hatchery operations. Potential entry points would include subsidies, low-interest loans, and the provision of technical assistance. Finally, research on technological innovations aimed at improving hatchery efficiency, increasing survival rates, and reducing costs is recommended.

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Attachment 1 Proforma income statement and profitability and economic analysis for the six-business model opti

‹	Housing until 1-mm spats production (1)	Housing until 1 cm spats (2)	With housing 1mm to 1 cm (250,000 spat capacity) -3		No housing until 1 mm production (4)	No housing until 1 cm production (5)	No housing 1 mm- 1 cm production (6)
Income							
Income from sale of mussel spats	2,183,792.28		1,574,977.46	1,190,000.00	2,183,792.28	1,574,977.46	1,190,000.00
Cost of goods sold					-	-	
Direct materials- breeders	4,800.00		4,800.00	4,800.00	4,800.00	4,800.00	4,800.00
Direct Materials- 1mm spats			-	1,100,000.00	-	-	1,100,000.00
Algal feeds starters	2,000.00		2,000.00	2,000.00	2,000.00	2,000.00	2,000.00
Fertilizers	6,000.00		6,000.00	6,000.00	6,000.00	6,000.00	6,000.00
Hatchery supplies (Chlorine, detergent, filters, etc.)	12,000.00		12,000.00	12,000.00	12,000.00	12,000.00	12,000.00
Direct Labor	743,520.00		743,520.00	743,520.00	743,520.00	743,520.00	743,520.00
Utilities							
Water	4,800.00		4,800.00	4,800.00	4,800.00	4,800.00	4,800.00
Electricity	185,820.00		185,820.00	185,820.00	185,820.00	185,820.00	185,820.00
Total cost of goods sold	958,940.00		958,940.00	958,940.00	958,940.00	958,940.00	958,940.00
Gross income	1,224,852.28		616,037.46	231,060.00	1,224,852.28	616,037.46	231,060.00
Less: Administrative and Selling Expenses			-	-	-	-	-
Depreciation	256,053.10		256,053.10	141,038.60	156,053.10	156,053.10	41,038.60
Repair of equipment and facilities	5,000.00		5,000.00	5,000.00	5,000.00	5,000.00	5,000.00
Permits and licenses	8,530.00		8,530.00	8,530.00	8,530.00	8,530.00	8,530.00
Miscellaneous	5,000.00		5,000.00	5,000.00	5,000.00	5,000.00	5,000.00
Total administrative expense	274,583.10		274,583.10	159,568.60	174,583.10	174,583.10	59,568.60
Net farm income	950,269.18		341,454.36	71,491.40	1,050,269.18	441,454.36	171,491.40
Net profit margin (%)	43.51		21.68	6.01	48.09	28.03	14.41
No. of cycles per year	6		4	8	6	4	8
Financial viability							
ROI (%)	37.11		13.34	2.92	74.47	28.29	11.81
Payback period (years)	2.69		7.5	34.29	1.34	3.53	8.46
Initial investment requirement (PhP)	2,560,531.00		2,560,531.00	2,451,545.00	1,410,386.00	1,560,531.00	1,451,545.00
NVP (PhP @ 6% hurdle rate)	4,437,079.30		209,786.79	-1,572,710.76	6,102,152.23	1,748,136.98	-34,360.57
IRR (%)	36%		8%	-8%	74%	26%	6%
Breakeven volume	890,100		392,261.21	290,124.25	565,935.74	249,404.07	270,115.63
Breakeven price	0.31		0.47	0.56	0.29	0.43	0.51
Selling Price of spats (Php/piece)	0.55		0.7	0.55	0.55	0.7	0.7
Average selling price of mussel (Php/piece)- 27 pcs. per kg	3.7		3.7	3.7	3.7	3.7	3.7