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BUSINESS FEASIBILITY ANALYSIS AND ECONOMIC COMPARISON OF CONVENTIONAL AND HYDROPONIC PAK CHOI CULTIVATION IN NORTH ACEH REGENCY

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Abstract
This study aims to analyze and compare the productivity, profitability, and business feasibility (Break-Even Point and R/C Ratio) between conventional and Nutrient Film Technique (NFT) hydroponic pak choi cultivation systems on a controlled 200 m^2 land area in North Aceh Regency. A comparative experimental method was utilized with a medium-term investment projection spanning 36 months (3 years). The results demonstrate that the hydroponic system yielded a fresh weight of 246 g/plant (a 290.48% increase compared to the conventional method). Financially, the hydroponic system recorded a net profit of IDR 1,310,824/cycle with an R/C Ratio of 1.18 and reached its Payback Period in the 13th cycle. Conversely, the conventional system generated a net profit of IDR 385,000/cycle with an R/C Ratio of 1.10. The production volume BEP analysis revealed that the hydroponic system (465.07 kg) maintains a higher risk safety buffer (14.98%) than the conventional system (268.33 kg; 8.73%). Cumulatively, the hydroponic system boosts medium-term profitability by 141.28%, establishing it as a highly prospective agribusiness model for lowland regions.

Keywords: Agribusiness, Break-Even Point, Hydroponics, Conventional, Pak Choi, Business Feasibility.

INTRODUCTION

The paradigm shift toward healthy lifestyles has triggered a sharp surge in the demand for premium-quality pak choi (*Brassica rapa* L. ssp. *chinensis*) in North Aceh Regency and Lhokseumawe City. For local farmers, this trend presents a lucrative investment opportunity; however, selecting an efficient production technology given limited land availability and the challenging hot lowland climate remains a primary constraint (Asmara & Saputra, 2025). Two dominant cultivation systems currently prevail: conventional soil-based farming and hydroponic Nutrient Film Technique (NFT). Hydroponics is capable of generating up to 2.5 times higher yield tonnage per m^2 (Pratama & Wardani, 2023; Wardani, 2024), yet it requires a substantial initial capital investment. On the other hand, the conventional system persists due to its exceptionally low barrier to entry regarding capital requirements (Asmara & Saputra, 2025). Given that hydroponic materials experience structural depreciation under high lowland temperatures within a 36 to 60-month timeframe (Sastro, 2020), a medium-term evaluation of business feasibility is critical. This study aims to compare the productivity, profitability, and Break-Even Point (BEP) of both systems within a controlled land area of 200 m^2.

LITERATURE REVIEW

This comparative feasibility study is rooted in the Theories of Production Efficiency and Capital Investment. Spatial efficiency dictates the marginal return boundaries of land utilization (Nugroho & Siregar, 2023). The conventional system is inherently constrained by the construction of raised beds, which absorb up to 30% of the total arable area (Wibowo & Utami, 2025), whereas hydroponics maximizes plant population density through high-spatial utilization (Setiawan & Pratama, 2024).

In addition to accelerating the vegetative growth phase (Handoko & Utama, 2024), hydroponic farming in the region benefits from integration into premium market segments, driven by its crisp texture and soil-free cleanliness (Fahmi & Rizal, 2024). In contrast, conventional pak choi farmers frequently encounter severe price fluctuations due to their dependence on traditional middleman supply chains (Ramadhan, 2025). To guarantee investment certainty, cumulative economic and BEP analyses are indispensable tools (Lestari & Wijaya, 2024).

METHOD

This study employed a comparative experimental approach conducted on two research plots, each measuring 200 m^2, located in North Aceh. Agronomic data were harvested from an active crop cycle, while financial feasibility was projected across a 36-month (3-year) horizon based on the economic lifespan of PVC piping networks (Adnan & Wijaya, 2021). The economic variables were systematically analyzed using the following mathematical formulations (Gittinger, 1982; Saparinto, 2013; Suhardiyanto, 2011):

$$\Pi_{\text{total}} = \sum_{i=1}^{n} (Q_i \times P) - [\text{CapEx} + (n \times \text{OpEx})]$$

$$\text{Depreciation Cost/Cycle} = \frac{\text{CapEx}}{\text{Total Cycles } (n)}$$

$$\text{BEP}_{\text{Production (kg)}} = \frac{\text{Operational Cost + Depreciation per Cycle}}{\text{Selling Price per kg}}$$

Where: Π_{total} = cumulative net profit over 36 months; Q_i = yield volume per cycle (kg); P = market selling price (IDR/kg); CapEx = initial capital expenditure; OpEx = operational expenditure per cycle; n = total production cycles within 36 months; $\text{BEP}_{\text{Production}}$ = break-even volume threshold (kg).

RESULTS AND DISCUSSION

Agronomic Productivity

The vegetative growth parameters recorded during a single active production cycle are structured in Table 1.

Table 1. Growth Parameters and Yield Performance of Pak Choi

No	Agronomic Parameter	Conventional	Hydroponic	Increase (%)
1	Fresh Weight/Plant (g)	63	246	290.48%
2	Leaf Width (cm)	17	24	41.18%
3	Leaf Count (blades)	10	22	120.00%
4	Plant Height (cm)	18	20	11.11%
5	Leaf Surface Area (cm^2)	64	83	29.69%
6	Stem Diameter (mm)	6	7	16.67%

The hydroponic system increased the fresh weight per plant by 290.48% due to the continuous and optimized availability of dissolved nutrients directly in the root zone, which enhances cell turgor and accelerates wet vegetative biomass accumulation (Cahyanda, 2022). The highly efficient uptake of Nitrogen stimulates cell division within the apical meristem, resulting in a consistent increase in both leaf surface area and leaf count compared to soil-bound media (Palupi, 2021; Perwitasari *et al*., 2012).

Table 2. Economic Comparison Matrix of Pak Choi Cultivation

No	Economic Analysis Attribute	Conventional System	Hydroponic System
1	Vegetative Cycle Duration	35 Days	30 Days
2	Total Harvest Frequency (3 Years)	30 Cycles	34 Cycles
3	Capital Expenditure (CapEx)	-	IDR 16,700,000
4	Operational Expenditure (OpEx)/Cycle	IDR 4,025,000	IDR 6,950,000
5	Equipment Depreciation Cost/Cycle	-	IDR 491,176
6	Total Production Cost/Cycle	IDR 4,025,000	IDR 7,441,176
7	Total Yield Volume/Cycle	294 kg	547 kg
8	Market Selling Price (per kg)	IDR 15,000	IDR 16,000
9	Total Revenue/Cycle	IDR 4,410,000	IDR 8,752,000
10	Net Profit/Cycle	IDR 385,000	IDR 1,310,824
11	Feasibility Indicator (R/C Ratio)	1.10	1.18
12	Break-Even Point (BEP) Volume	268.33 kg	465.07 kg

Both cultivation systems are empirically proven to be economically viable, as they yield an R/C Ratio greater than 1.00 (Kadir *et al*., 2026; Resdiana *et al*., 2022). However, the hydroponic system demonstrates superior costallocation efficiency ($R/C = 1.18$), returning a higher net profit of IDR 1,310,824 per cycle. Benefiting from a shorter vegetative cycle (30 days), the hydroponic infrastructure optimizes land utilization to achieve 34 cycles over 3 years, surpassing the conventional system which is limited to 30 cycles due to mandatory soil turnaround and tillage intervals (Suratiyah, 2015).

The break-even analysis indicates that the conventional method requires a minimum yield of 268.33 kg/cycle to offset costs, leaving a narrow production safety buffer of 25.67 kg (8.73%). Conversely, while the hydroponic system requires a higher break-even target of 465.07 kg/cycle, its real-world output reaches 547 kg. This yields a significantly wider safety buffer of 81.93 kg (14.98%), mitigating risks against minor crop failures or seasonal disruptions (Resdiana *et al*., 2022).

Over the medium-term horizon (36 months), the conventional system generates a cumulative net profit of IDR 11,550,000 (30 × IDR 385,000). Meanwhile, the hydroponic system amasses a total net profit of IDR 27,868,016 $[(34 \times \text{IDR } 1{,}310{,}824) - \text{IDR } 16{,}700{,}000 \text{ CapEx}]$. The initial CapEx barrier of the hydroponic setup is fully amortized via a short Payback Period achieved within the 13th cycle ($\text{IDR } 16{,}700{,}000/\text{IDR } 1{,}310{,}824 = 12.73$ cycles), validating the rapid asset turnover characteristic of modernized agrotechnology (Sinaga, 2023).

Quality and Market Sustainability

The conventional system remains vulnerable to soil-borne pathogens and moisture instabilities, which cause physical non-uniformity in crops and ultimately cap their market value (Rachmawati, 2021). In contrast, the precision EC/TDS control within the closed-loop hydroponic network produces crisp, highly hygienic vegetables with extended shelf lives (Cahyanda, 2022; Palupi, 2021). Meeting these premium quality indicators ensures a stable, long-term supply chain integration with modern supermarkets at a higher, locked-in price point (IDR 16,000/kg).

CONCLUSION

Pak choi cultivation scaled at 200 m^2 in North Aceh Regency is viable for commercial development under both systems ($R/C > 1.00$). The conventional method remains a practical alternative for smallholders facing capital constraints who seek short-term returns. However, for medium-term investments focused on economic sustainability, the NFT hydroponic framework proves vastly superior, expanding cumulative profitability by 141.28% through yield optimization, accelerated harvest cycles, and premium market positioning.

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