International Journal of Agricultural Technology 2026 Vol. 22(4):1969-1980
DOI: https://doi.org/10.63369/ijat.2026.22.4.1969-1980
Available online http://www.ijat-aatsea.com
ISSN 2630-0192 (Online)

Cost structure and profitability analysis of integrated rice-aquaculture farming: A comparative study of landowners and tenants in Chachoengsao province, Thailand

Temprom, T., Suwanmaneepong, S.*, Mankeb, P. and Kerdsrisem, C.

School of Agricultural Technology, King Mongkut's Institute of Technology Ladkrabang, Bangkok, Thailand.

Temprom, T., Suwanmaneepong, S., Mankeb, P. and Kerdsrisem, C. (2026). Cost structure and profitability analysis of integrated rice-aquaculture farming: A comparative study of landowners and tenants in Chachoengsao Province, Thailand. International Journal of Agricultural Technology 22(4):1969-1980.

Abstract The study was compared the costs and profits of a mixed rice-fish farming system between landowners and land tenants in Chachoengsao province, Thailand. At the farm level, the average total production cost was 6,118 THB per farm (averaging 20.46 rai), with variable costs accounting for 65.8% and fixed costs accounting for 34.2%. The main cost components included seed costs (416 baht per rai), chemical fertilizers (577 baht per rai), and land-related costs (opportunity costs for owners and rental costs for tenants) (1,535 baht per rai). Profitability analysis found that an average yield of 0.81 metric tons per rai, sold at 16.16 THB per kilogram, a net profit of 12,743 THB per rai, with a breakeven point of 233 kilograms per rai. There was not significantly differed in the overall performance indicators of the two clusters, namely total production cost per rai ($p = 0.869$), yield per rai ($p = 0.823$), net profit per rai ($p = 0.241$), and income per rai ($p = 0.246$). However, there were significantly differed in landowners who used more on seeds ($p=0.029$), whereas tenants incurred higher cash costs ($p=0.004$) and land rent ($p<0.001$) which obtained better market prices ($p=0.027$).

Keywords: Cost structure analysis, Integrated rice-aquaculture, Land tenure comparison, Economic performance

Introduction

Rice is a key crop and a major driver of the Thai economy, playing an important role in both the local food supply and export revenues (Ministry of Commerce, 2023). However, Rice farmers face significant challenges due to rising production costs. The Department of Agricultural Extension (2023) reported that in the 2022/23 season, the average cost of paddy production was 5,616 baht per rai (THB = Thai baht; about 30 baht = 1 US dollar), an increase of 3.0% per year from 2019 to 2023. Materials, such as seeds, fertilizers, and pesticides, account for about 40.51% of the total cost, and labor costs account for

* **Corresponding Author:** Suwanmaneepong, S.; **Email:** ksuneeporn@gmail.com

38.10% (Pongklang, 2016). The greater the dependence on chemicals for pest control, the higher these costs. This often leaves agricultural households with insufficient net income to survive (Zhou *et al.*, 2025).

In addition, climate change is increasing these economic pressures. This poses a serious risk to the global agricultural sector, especially in Southeast Asia (Robinson, 2024). Problems such as rising sea levels lead to saltwater penetration. This results in ecosystem degradation and threatens traditional monocrop farming (Grigorieva *et al.*, 2023). In this context, integrated rice-aquaculture (IRA) farming has become a potential approach to adaptation. This system not only helps solve economic problems but also solves other problems. It also helps address environmental problems and improve food security. (Ibrahim *et al.*, 2023). The IRA system can produce animal protein without reducing the quality and quantity of staple rice production, thus generating additional income alongside staple crops (Choowaew *et al.*, 2019; Reddy and Kishori, 2019). As a result, these integrated systems are more common in Asian countries than in Western countries (Reddy and Kishori, 2019). However, this approach is also risky. For example, Choowaew *et al.* (2019), found that the effects of saltwater intrusion during the dry season are severe and affect households that cultivate rice and fish farming in parallel. This necessitates the development of adaptation strategies to increase salinity(Tarolli *et al.*, 2024).

Chachoengsao Province in Thailand represents a relevant case study for examining IRA systems (Agritech and Innovation Center, 2023). Here, the farming process is highly adaptable to seasonal water changes. The cycle begins in June–December when the river water becomes fresh. Farmers prepare the fields by flushing water to reduce soil salinity for 2–4 weeks. After planting, farmers grow 30-day-old rice seedlings that are co-cultivated with aquatic animals such as lobsters or sea bass. The rice is harvested at 120 days (November–December). Subsequently, during the dry season (January–July), seawater enters the river system. Farmers then transition the same fields to aquaculture: they plow the rice stubble, flush the fields again, and introduce saltwater to raise species such as sea crabs and sea bass until they are mature for harvest. Farmers can get a steady income stream from a single plot of land through this intricate cycle throughout the entire year.

In the face of these economic and environmental challenges, analyzing the cost structures and profitability of IRA systems is crucial for providing evidence to support both the farmers' and the related organization's decisions. This study breaks down production costs and profitability for different farmer groups, including landowners and tenants. Understanding the financial returns from IRA farming is critical for effective production planning and boosting income (Ahmed and Garnett, 2011). The findings aimed to provide evidence-based

guidelines to support farmers, address localized problems, and strengthen knowledge exchange within agricultural communities to develop workable solutions.

Materials and methods

Study area

The study area is in Khao Din sub-district, Bang Pakong district, Chachoengsao province, Thailand. A total of 37 farmers who registered for IRA farming for the 2023/24 crop year (Department of Agricultural Extension, 2023) participated in the study. The agricultural cycle in this area adapts to seasonal hydrological changes, enabling farmers to cultivate both rice and aquatic species on the same land year-round, as shown in Figure 1.

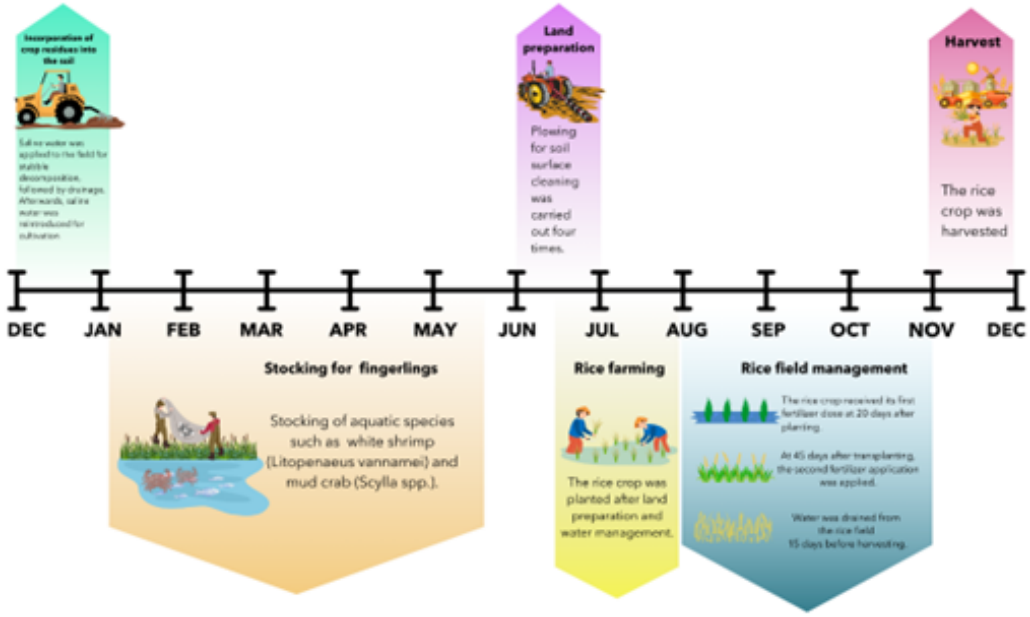

Figure 1. Integrated rice-aquaculture farming process

Data collection

Primary data were collected using structured questionnaires developed based on a review of relevant literature and theories aligned with the objectives of the research (Kerdsriserm and Suwanmaneepong, 2024; Mankeb, 2016). The questionnaire was designed to capture the following information:

Part 1: Social and economic characteristics of farmers. This section includes variables such as gender, age, education level, number of household members, and farming experience. It also records the status of land tenure (landowner or tenant), farm size (number of acres under an IRA), agricultural resources, and other details. Membership in agricultural organizations and the number of household workers working in agriculture.

Part 2: Farm economic data for the crop year. This section contains detailed information on costs and returns. The data includes variable and fixed costs. Seeds, chemical fertilizers, and organic fertilizers. Herbicides and fuels. Fixed costs include land rent, land tax, and equipment depreciation. The total income is obtained from the sale of rice and aquatic products.

Data analysis

Data analysis is carried out using three main methods: descriptive statistics, cost and profit analysis, and inferential statistics. Descriptive statistics are used to analyze the socio-economic characteristics of farmers who own and lease land.

Cost and Profit Analysis: A comparative cost and profit structure analysis was performed between landowner farmers and land-tenant farmers, using the following formula, adapted from Kerdsriserm and Suwanmaneepong (2024),to calculate the economic indicators that are important to the farm:

- Total Cost (TC) = Total Fixed Cost (TFC) + Total Variable Cost (TVC)
- Total Fixed Cost (TFC) = Cash fixed cost + Non-cash fixed cost
- Total Variable Cost (TVC) = Cash variable cost + Non-cash variable cost
- Total Revenue (TR) = Quantity of Output (Q) × Price (P)
- Net Profit (NP) = Total Revenue (TR) – Total Cost (TC)
- Breakeven Yield = Total Cost (TC) / Price (P)
- Breakeven Price = Total Cost (TC) / Quantity of Output (Q)

Inferential statistics: to determine whether the observed differences in economic outcomes between the two groups are statistically significant. Therefore, a t-test with a significance level (p-value) of 0.05 was used to compare the averages of the important continuous variables (e.g., cost per rai, income per rai, net profit per rai). between landowner farmers and land tenant farmers (Mankeb, 2016).

Results

General characteristics of farmers

All 37 IRA farmers in the study area were surveyed. The survey results reveal the different social and economic characteristics between landowners and tenants. As summarized in Table 1.

Table 1. Characteristics of integrated rice-aquaculture farming

Item	Landowners (n = 9)		Tenants (n = 28)	
	Frequency	%	Frequency	%
Gender				
Male	5	55.60	18	64.30
Female	4	44.40	10	35.70
Age				
40 years or under	1	11.10	5	17.90
41–50 years	1	11.10	3	10.70
51–60 years			7	25.00
61–70 years	5	55.60	7	25.00
70 years or older	1	22.20	6	21.40
Education				
Primary	6	66.70	12	42.90
Junior high school	1	11.10	6	2140
Senior high school	1	11.10	7	25.00
Associate degree			3	10.70
Bachelor's degree	1	11.10		
Higher than a bachelor's degree				

Among the nine landowners, the majority were male (55.6%) and aged 61 years or older (55.6%). In contrast, the tenant group consisted of 28 farmers. Within this group, 66.7% were male, with the most common age brackets being 51–60 years and 61–70 years (25.0% each). Furthermore, the highest educational attainment for 42.9% of tenant farmers was primary school.

Cost and return structure of landowner farmers

The average total cost (TC) for landowner farmers was 5,709.39 THB per rai (Table 2). Variable costs accounted for 69.10% of TC 3,945.10 THB per rai), the most significant components of which were chemical fertilisers (565.39 THB per rai, 9.90%), seed costs (485.56 THB per rai, 8.50%), and herbicides (326.67 THB per rai, 5.72%). Labour costs for preparing the planting area amounted to 2,254.32 THB per rai (39.48%), comprising both cash and non-cash components.

Fixed costs represented 30.90% of TC (1,764.29 THB per rai), dominated by the depreciation of tools (1,272.62 THB per rai, 22.29%) and the opportunity cost of land use (491.67 THB per rai, 8.61%). Despite these costs, landowner farmers achieved an average net profit of 10,782.12 THB per rai at a realised rice price of 13.38 THB per kilogram.

Table 2. Cost and return for landowner-integrated rice-aquaculture farming

Item	Cash Costs		Non-Cash Costs		Total Cost	
	Amount	%	Amount	%	Amount	%
1. Variable costs (THB per rai)	**1,722.83**	**30.18**	**2,222.17**	**38.92**	**3,945.10**	**69.10**
Labour cost for land preparation	517.71	9.07	1,736.61	30.42	2,254.32	39.48
Seed	-	-	485.56	8.50	485.56	8.50
Organic fertilizer	10.56	0.18	-	-	10.56	0.18
Chemical fertiliser	565.39	9.90	-	-	565.39	9.90
Herbicides/pesticides/hormones	326.67	5.72	-	-	326.67	5.72
Fuel	302.69	5.30	-	-	302.69	5.30
2. Fixed costs (THB per rai)	**-**	**-**	**1,764.29**	**30.90**	**1,764.29**	**30.90**
Land tax	-	-	-	-	-	-
Opportunity cost of land use	-	-	491.67	8.61	491.67	8.61
Depreciation cost	-	-	1,272.62	22.29	1,272.62	22.29
3. Total cost (THB per rai)	**1,723.02**	**30.18**	**3,986.46**	**69.82**	**5,709.39**	**100.00**
4. Total revenue (THB per rai)	**11,270.78**					
5. Yield (Kg per rai)	**822.47**					
6. Price per kilogram (THB)	**13.38**					
7. Net Profit (THB per rai)	**10,782.12**					
8. Breakeven yield (Kg per rai)	**680.98**					
9. Breakeven price (THB per kg)	**10.06**					

Cost and returnstructure of tenant farmers

Tenant farmers incurred a slightly higher average total cost of 6,118.20 THB per rai (Table 3). However, their cost structure differed considerably from that of the landowners. Variable costs constituted a smaller proportion of TC at 65.84% (4,028.19 THB per rai). Similar to landowners, major variable costs included chemical fertilisers (577.59 THB per rai, 9.44%), seeds (416.37 THB per rai, 6.81%), and herbicides (277.72 THB per rai, 4.54%).

Fixed costs represented a larger share of total costs for tenants (34.16% or 2,090.01 THB per rai). This was primarily due to explicit land rental costs (470.09 THB per rai, 7.68%) and the depreciation of tools (1,619.92 THB per rai, 26.48%). Tenant farmers realised an average net profit of 12,488.33 THB per rai and received a higher average price for their rice of 16.16 THB per kilogram.

Table 3. Cost and return of tenant-integrated rice-aquaculture farming

Item	Cash Costs		Non-Cash Costs		Total Cost	
	Amount	%	Amount	%	Amount	%
1. Variable costs (THB per rai)	**1,580.88**	**25.84**	**2,447.31**	**40.00**	**4,028.19**	**65.84**
Labour cost for land preparation	444.93	7.27	2,030.94	33.20	2,475.87	40.47
Seed	-	-	416.37	6.81	416.37	6.81
Organic fertiliser	15.00	0.25	-	-	15.00	0.25
Chemical fertiliser	577.59	9.44	-	-	577.59	9.44
Herbicides/pesticides/hormones	277.72	4.54	-	-	277.72	4.54
Fuel	265.64	4.34	-	-	265.64	4.34
2. Fixed costs (THB per rai)	**470.09**	**7.68**	**1,619.92**	**26.48**	**2,090.01**	**34.16**
Land rental	470.09	7.68	-	-	470.09	7.68
Opportunity cost of land use	-	-	-	-	-	-
Depreciation cost	-	-	1,619.92	20.22	1,619.92	20.22
3. Total cost (THB per rai)	**2,050.97**	**33.52**	**4,067.23**	**66.48**	**6,118.20**	**100.00**
4. Total revenue (THB per rai)	**12,981.75**					
5. Yield (Kilogram per rai)	**806.84**					
6. Price per kilogram (THB)	**16.16**					
7. Net profit (THB per rai)	**12,488.33**					
8. Breakeven yield (Kg per rai)	**505.30**					
9. Breakeven price (THB per kg)	**10.28**					

Comparative analysis of costs and returns between landowners and tenants

A comparative analysis of the key economic variables between landowner and tenant farmers is presented in Table 4. Independent samples t-tests revealed statistically significant differences ($p < 0.05$) in several metrics: costs: average seed cost and land rental cost; prices and breakeven points: price per ton, price per kilogram, breakeven yield, and breakeven price.

However, there was no statistically significant difference between other variables, including total farm area, labour costs, chemical fertiliser costs, herbicide costs, fuel costs, total variable costs, depreciation, total fixed costs, total cost, total yield, yield per rai, total revenue, revenue per rai, net profit, net profit per rai, and return over cash cost.

Table 4. Comparison of the costs and returns between landowners and tenants of integrated rice-aquaculture farming

Item	Landowners	Tenants	t-test	Sig
Area (Rai)	19.89 (*10.43)*	20.46*(10.45)*	-0.14	0.887
Labour cost (THB/rai)	2,475.87	2,254.32	0.76	0.452
	(579.53)	*(852.64)*		
Seed cost (THB/rai)	485.56	416.37	2.28	0.029*
	(106.55)	*(68.93)*		
Organic fertiliser (THB/rai)	95.00	420.00	-0.16	0.000
	(0.00)	*(0.00)*		
Chemical fertiliser (THB/rai)	565.39	577.59	-0.16	0.869
	(178.40)	*(195.40)*		
Herbicide cost (THB/rai)	326.67	277.72	1.51	0.139
	(129.59)	*(65.33)*		
Fuel (THB/rai)	302.69	265.64	1.23	0.227
	(82.66)	*(77.47)*		
Total variable costs (THB/rai)	3,945.10	4,028.19	1.34	0.178
	(614.88)	*(923.48)*		
Land rental (THB/rai)	83.33	470.09	-7.43	0.000*
	(250.00)	*(73.47)*		
Depreciation (THB/year)	1,272.62	1,619.92	-0.75	0.460
	(1,106.88)	*(1,423.51)*		
Total fixed cost (THB/rai)	1,764.29	2,090.01	-0.512\	0.612
	(1,185.53)	*(1,250.81)*		
Total cost (THB/rai)	5,703.39	6,118.20	-0.17	0.869
	(1,068.73)	*(1,894.88)*		
Total yield (Ton)	17.33*(11.65)*	16.22*(8.58)*	0.31	0.759
Yield per rai (Ton)	0.82(0.18)	0.81(0.17)	0.23	0.823
Price per ton (THB)	13,377.78	16,157.14	-2.31	0.027*
	(5,023.64)	*(2,294.51)*		
Total revenue (THB)	248,182.20	261,908.63	-0.22	0.830
	(217,379.43)	*(146,916.95)*		
Revenue per rai (THB)	11,270.78	12,981.75	-1.18	0.246
	(5,143.29)	(3,270.38)		
Total Net profit (THB)	244,490.16	258,134.77	-0.22	0.831
	(217,133.53)	*(146,740.08)*		
Net profit per rai (THB)	10,782.12	12,488.33	-1.19	0.241
	(5,138.94)	*(3217.21)*		
Cash cost (THB/rai)	1,723.02	2,050.97	-3.05	0.004*
	(285.44)	*(257.56)*		
Return over cash cost (THB per rai)	2,367.23	2,140.19	0.49	0.631
	(1,054.80)	*(1,268.45)*		
Yield (Kilogram per rai)	822.47	806.84	0.23	0.816
	(184.69)	*(171.05)*		
Price per kilogram (THB)	13.38	16.16	-2.31	0.027*
	(5.02)	*(2.29)*		
Breakeven yield (Kg per rai)	680.98	505.30	2.23	0.032*
	(76.08)	*(71.65)*		
Breakeven price (THB per kg)	10.06	10.28	-2.31	0.824
	(5.02)	*(2.29)*		

**sig≤,01 *sig≤.05, ns = no statistical difference, THB= Thai Baht
Numbers in parentheses represent standard deviation values

Discussion

The study compared the economics of IRA systems between landowner and tenant farmers in Chachoengsao Province, Thailand. The key findings showed that land tenure status had a significant impact on cost structures and breakeven points but did not affect overall profitability. The research compared the economics of systems. An IRA between farmers who own land and those who rent land in Chachoengsao province, Thailand. Significant results found that land tenure status has a significant impact on cost structure and break-even points. But it had no impact on the overall profit.

The study found that seed costs differed significantly across different types of farmers. Landowners pay 485.56 baht per rai, while tenants pay 416.37 baht per rai. But differences in the purchase method can explain this difference. On the contrary, Landowners may use seeds stored from previous harvests or different varieties, which may require more seeds to achieve a sufficient number of plants. As a result, the cost is higher. This finding contradicts the research by Lanuch *et al.* (2016), which reported that land tenants had higher seed costs, suggesting that the local environment, such as access to certified seed programs, plays an important role in determining farming costs.

On the contrary, Landowners may use seeds stored from previous harvests or different varieties, which may require more seeds to achieve a sufficient number of plants. As a result, the cost is higher. This finding contradicts research reporting higher seed costs for land tenants, suggesting that local factors, such as access to certified seed programs, play an important role in determining the cost of IRA rice farming.

In addition, the composition of cash expenses was significantly differed between the two groups. Farmers who rent land incur higher total cash costs (2,050.97 baht/rai). These differences were mainly due to higher land rent (470.09 baht/rai) and higher machinery depreciation. This finding is consistent with research by Pochanasomboon *et al.* (2020), which found that land rents were significantly financial burden for farmers who rent land (Beladi *et al.*, 2021), potentially impacting long-term sustainability (Naseer *et al.*, 2025).

The break-even analysis results pointed out important strategic differences. Farmers who rent land receive a significantly higher selling price of rice. (16.16 Baht/kg) Compared to the price the landowner can sell for (13.38 baht/kg). Higher prices result in higher break-even points for farmers who rent land while also providing greater profits. The findings suggested that farmers who rent land may have the incentive or ability to access premium markets. Therefore, they use better post-harvest processing or sell a different product (which may be of higher quality) to meet the higher, constant cash requirements. Therefore, trying to make

produce sell at a higher price is an important adaptation strategy to compensate for higher production costs (Ekins and Zenghelis, 2021; Handoyo *et al.*, 2023).

The research by Gao *et al.* (2025) argues that wealth differences between different groups affect how resources are used. This allows this group of farmers to cope during periods when market prices are low. On the contrary, tenant farmers must adopt more flexible business strategies to maintain profitability. The findings show that both groups face challenges beyond production. Market access and pricing power are also important factors that determine farmers' success (Villar *et al.*, 2023).

The t-test did not find any statistically significant differences. It shows that there is no difference in net profit per hectare between the landowner and the tenant. Although the cost structure and market price of the two groups are very different. The results show that farmers, landowners, and tenants both have different but equally effective approaches to developing strategies within the system. Thus, both groups can achieve comparable economic returns.

Interestingly, landowner farmers are accepted lower selling prices for their produce even if they don't have to pay rent. On the other hand, Tenants can sell their produce at a higher price even if they have to pay rent. This shows that, to make a profit from IRAs, farmers focus on market positioning and product sales strategies rather than land ownership status. This finding is consistent with research by Ganeshamoorthy and Serasinghe (2018), which reported no significant difference in profitability between land-owning groups. Access to resources and market trends. In this case, strategic market positioning is what farmers focus on, balancing the cost of land and rent, which is a clear difference between groups (Graubner and Hüttel, 2024).

According to the results of this study, Policymakers are advised to develop specific support programs for each type of land tenure. To accommodate the different strategies of landlords and tenants. Cooperatives should establish a knowledge-sharing platform for learning across land tenure types, and farmers should leverage their own strategic strengths. At the same time, it also explores complementary strategies from another land tenure group.

Acknowledgements

The author would like to express their sincere gratitude to all the farmers in Khao Din sub-district who have given their time and valuable information for this study. This study was conducted in accordance with ethical standards and was approved by the KMITL Human Research Ethics Committee (Project Code: EC-KMITL 68-098).

Conflicts of interest

The authors declare no conflict of interest.

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(Received: 30 September 2025, Revised: 20 May 2026, Accepted: 23 June 2026)