International Journal of Agricultural Technology 2024 Vol. 20(3):1097-1110
Available online http://www.ijat-aatsea.com
ISSN 2630-0192 (Online)

Cost-return and technical efficiency of rice production in the Ban Nong Saeng Rice Mill Community Enterprise, Chachoengsao Province, Thailand

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Kerdsriserm, C. and Suwanmaneepong, S. (2024). Cost-Return and technical efficiency of rice production of Ban Nong Saeng rice mill community enterprise in Chachoengsao Province, Thailand. International Journal of Agricultural Technology 20(3):1097-1110.

Abstract The research findings showed that to attain a break-even point, farmers needed to consider strategies to augment yield by approximately 70 kilograms per rai. The evaluation of technical efficiency revealed a varied range of levels amongst farmers, spanning from 0.28 to 0.99, with an average of 0.32. These values indicated that farmers were only partially harnessing the potential of their production factors and the opportunity to enhance their overall production efficiency. In conclusion, the study advanced to understand rice production economics within the context of community enterprises. The insights gained from the analyses contributed to discussions surrounding optimal resource allocation, enhancing production efficiency, and identifying strategic interventions to improve the profitability and sustainability of rice production.

Keywords: Cost-return, Technical efficiency, Rice, Community enterprise

Introduction

Over the years, advancements in technology have consistently influenced the course of agricultural development in various regions. Thailand is no exception, with its varied geography and rich agricultural landscape (Jeerat *et al*., 2022; Marome *et al*., 2022). An apparent transformation is taking place in the eastern regions, with former agrarian landscapes giving way to expanding industrial and residential areas (Marome *et al*., 2022). The National Economic and Social Development Plan No. 13 of Thailand articulates its vision, stating that this is not just a trend but a deliberate plan. The strategy emphasises a radical aspiration and transforming the eastern areas into pillars of high-quality food production that meet worldwide standards (Ngammuangtueng *et al*., 2019; Nguyen *et al*., 2022).

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Chachoengsao is one of the key provinces for agricultural production (Suwanmaneepong *et al*., 2020). Its identity is closely related to the vast rice fields covering 764,764 rai, or a substantial 34.06% of the province's total agricultural area. It has long been regarded as a crucial agricultural central hub. In this setting, rice is more than just a crop—it represents the socioeconomic and cultural diversity of the province. Initiatives led by the Chachoengsao Provincial Agriculture and Cooperatives Office have gained attention due to the importance of rice in the region's economic landscape. The efforts of the province have highlighted the potential of organic farming, ranging from promoting more affordable rice production to setting the standards for agricultural goods (Chachoengsao Provincial Agriculture and Cooperatives Office, 2019).

While these projects provide a promising path toward sustainable and safe rice farming, they are set against various challenges (Ebers *et al*., 2017; Ngammuangtueng *et al*., 2019). For instance, there is a considerable variation in the methods used for production management, particularly regarding soil conservation and fertiliser use. Despite the long history of farming and the accumulation of tacit agricultural knowledge, many farmers still face challenges while adopting modern agriculture. This conflict arises from the gap between traditional and modern agriculture—whether in terms of soil management, careful seed selection, or reacting to changing market dynamics, which has consequences. This impacts potential revenue and underscores the urgent need for a deeper understanding of efficient rice production practices. Aside from maximising profits, leveraging Chachoengsao Province's intrinsic strengths in rice cultivation and harmonising them with today's innovations is essential. By investigating community enterprises like Ban Nong Saeng rice mill, the study aimed to understand the cost-return of rice farming and technical efficiency in improving rice production.

Materials and methods

Study area

Chachoengsao Province in Thailand is recognised as an essential region for promoting production, with a distinct emphasis on fostering a holistic organic rice production management system. Serving as a benchmark for areas within the eastern zone, its model is hailed and cited by the Thai Health Promotion Foundation (2017). The Sanam Chai Khet District within Chachoengsao Province spans a vast area of 666,000 rai. A significant portion (83%) is dedicated to agriculture. Although a major part of this agricultural land is committed to cultivating perennial rubber trees, a sizeable 83,038 rai is allocated exclusively for rice farming, as the Land Development Department reported in 2018.

With the availability of community enterprises, Chachoengsao Province has been purposefully chosen as the study case. This choice finds its roots in prior research by Petcho *et al*. (2019), highlighting the province's thriving community businesses in the central region. Amongst these enterprises, the Ban Nong Saeng rice mill community enterprise shines prominently, having established a robust network of collaborations with myriad institutions within the Sanam Chai Khet precinct and beyond (Cavite *et al*., 2021). The Ban Nong Saeng rice mill community enterprise, located in Chachoengsao Province (Figure 1), boasts a membership of 46 individuals. These members focus on cultivating two primary rice varieties: the aromatic Jasmine Rice (KDML 105) and the nutrient-rich rice berry. The enterprise's farmland stretches over 600 rai, producing a combined yield of 101,325 kilograms from its diligent farmer members.

A purposive sampling strategy was employed to gather information and generate insights for the study. The Ban Nong Saeng rice mill community enterprise members were central to this research, serving as the primary informants. Their firsthand experiences and intricate knowledge of rice cultivation practices provided an invaluable dataset for the study. In total, 46 individuals from this enterprise participated as core respondents, ensuring a comprehensive and nuanced exploration of the topic under study.

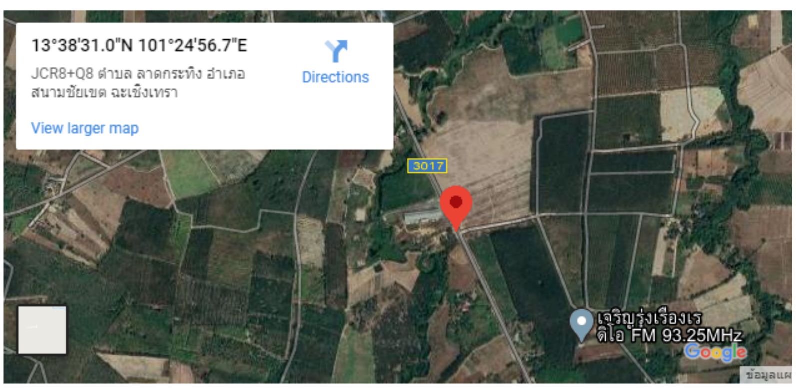

Figure 1. Location of the study area in Ban Nong Saeng rice mill community enterprise, Chachoengsao Province, Thailand

Data collection and analysis

Data were collected through personal interviews with selected farmers, utilizing a structured questionnaire. The questionnaire comprised three key sections. The first section explored the farmers' household characteristics and other demographic details. The second section focused on gathering data related to the cost and return associated with rice production and technical efficiency during the 2020–2021 cropping year. The analysis of the collected data spanned three main segments, starting with the Demographic Analysis. This segment involved a comprehensive examination of the demographic characteristics of the farmers, utilizing descriptive statistics to provide a vivid portrayal.

Cost and return analysis of rice farming

Cost and return analysis were adopted as recommended by Durga and Suresh (2013), Abera *et al*. (2019), and Suwanmaneepong *et al*. (2020) to assess the cost components of rice production. Following the guidelines set by Nwahia (2021), costs were composed of fixed costs (FC) and variable costs (VC). The total cost (TC) represents the cumulative value of both cash and noncash inputs by farmers during the entire cropping cycle. It is worth noting that while FC remain constant, VC change based on output levels (Dwivedi, 2016). These costs were further distinguished into cash (explicit) and noncash (implicit) categories. The total revenue (TR) denotes the entire monetary gain for rice farmers during the specific cropping cycle. The TC needs to be subtracted from TR to derive the profit. The subsequent percentage of profit is obtained by dividing the profit by TR. Break-even analyses provided insights into the equilibrium point where TR equals TC. All cost values were expressed per area in rai. The associated formulas are:

$$TC = TVC + TFC \quad (1)$$

$$TR = TR - TC \quad (2)$$

$$Break - even\ yield = TC/Price \quad (3)$$

$$Break - even\ price = TC + TQ \quad (4)$$

Technical efficiency estimation

Farell's seminal work from 1957 postulated a two-fold composition of firm efficiency: technical and allocative. Technical efficiency refers to the firm's ability to maximise output from an input set using the available technology (Parichatnon *et al*., 2015). This study employed Stochastic Frontier Analysis (SFA) to estimate this efficiency (Coelli and Walding, 2006). Several empirical studies, especially those focusing on agro-expansion, have leveraged the Cobb-Douglas functional form of SFA (Battese and Coelli, 1995). Hence, the Cobb-Douglas stochastic frontier production function was employed, represented as:

$$\ln(Y) = \ln\beta_0 \sum_{i=1}^{4} \beta_i \ln X_i + v_i - u_i \quad (5)$$

Wherein $\ln(Y)$ = natural logarithm of rice (kg), $\ln X_1$ = natural logarithm of farm size (rai), $\ln X_2$ = natural logarithm of seed (kg), $\ln X_3$ = natural logarithm of fertilizer (kg) and $\ln X_4$ = natural logarithm of labor (hours). Moreover, v_i is an error term accounting for the effects of unmentioned explanatory variables, while u_i, ranging from zero and one, accounts for technical inefficiencies in production (Shavgulidze *et al.*, 2017).

Results

Sociodemographic characteristics of farmers

The socioeconomic characteristics of rice farmers from the Ban Nong Saeng rice mill community enterprise in Chachoengsao Province, Thailand, indicated that men constituted a slight majority within the rice farming community, accounting for 54.35%, with women representing the remaining 45.65%. The gender distribution showcased an almost balanced engagement between genders in the rice farming sector. Moreover, the age profile indicates the broader demographic shift occurring in farming communities throughout Asia. The average age of a farmer in this community was at 57.32 years. Notably, a considerable portion (41.30%) were over 60 years old, underscoring the ageing narrative within the farming community.

In terms of educational attainment, the farming community exhibited a particular trend. A notable 56.52% of the farming household heads was completed their primary education. The majority showed the importance of basic education within the community. Regarding family dynamics and involvement, rice farming appeared to be a collective effort. On average, one or two members from each family are actively engaged in the cultivation process. Most families in this sample size, specifically 56.52%, comprised four or five members. However, it is important to note that in 52.17% of these households, only two members bear the primary responsibility of rice cultivation.

On the other hand, farms are tended to be on the smaller side. A significant 45.65% of the farmers managed plots of 10 rai or less, equivalent to around 1.6 hectares. Experience is often viewed as a valuable asset in farming varies within the community. On average, farmers in the study area are involved in rice cultivation for an impressive 33.71 years, while half, precisely 50% with less than two decades of experience (Table 1).

Table 1. Socioeconomic characteristics of organic rice farmers

Characteristics	Frequency (n)	Percentage (%)
Gender		
Male	25.00	54.35
Female	21.00	45.65
Age (mean = 57.32)		
less than 40	4.00	8.70
41 – 50	9.00	19.57
51 – 60	14.00	30.43
more than 60	19.00	41.30
Educational level		
less than primary school	3.00	6.52
primary school	26.00	56.52
junior high school	6.00	13.04
senior high school	4.00	8.70
undergraduate diploma	7.00	15.22
Family size (average 4.06 persons)		
3 and fewer than 3	13.00	28.26
4 – 5	26.00	56.52
≥ 5	7.00	15.22
Family labor (average 1.65 persons)		
1	20.00	43.48
2	24.00	52.17
> 3	2.00	4.35
Farm size (mean = 13.73 rai*)		
≤ 10	21.00	45.65
11 – 20	20.00	43.48
> 20	5.00	10.87
Experience (average 33.71 years)		
1–20 years	23.00	50.00
21–40 years	10.00	21.74
More than 40 years	13.00	26.26

**1 rai = 0.4 acres or 0.16 hectare*

Cost and return of rice production

Ban Nong Saeng rice mill community enterprise in Chachoengsao Province cost structure is associated with rice production. The cost breakdown provided valuable insights into the dynamics of rice farming in the region. The entire production expenses for rice farming are at 3,150.32 THB/rai. Furthermore, VC formed 62.48% of the TC, while FC covered the remaining 37.52%. It emphasised the role of labour within the farming community, as it accounted for a significant 38.95% of the variable expenses. It underscored the labour-intensive nature of farming methods and the indispensable role of manpower in this sector.

The cost of noncash labour, the second-largest noncash cost following the opportunity cost of land, further highlights the labour dependency in agricultural production. This signified the hands-on nature of rice farming and subtly hints at the area's shortage of skilled labour. At the same time, the opportunity cost registered at 305 THB/rai. It reflected the potential earnings farmers forego by cultivating their land rather than leasing it out or pursuing other revenue-generating avenues. The bulk of Ban Nong Saeng farmers were proprietors, thus reinforcing the significance of this cost.

The yield averaged 167.61 kg/rai from a revenue perspective, fetching a selling price of 13.35 THB/kg, translating into a revenue of 2,266.26 THB/rai. In turn, the cost of producing a kilogram of rice equated to 18.79 THB/kg. Labour and seed costs remained the major production inputs, constituting 38.95% and 8.85% of the total production expense, respectively. In terms of profitability, while the expenditure for each farmer averaged 3,150.32 THB/rai, their income was only 2,266.26 THB/rai. It translated into a stark negative gross margin of 884.06 THB/rai. Various factors like natural calamities and climatic fluctuations can adversely impact production conditions. The aftermath of the 2020 natural disaster instilled a heightened risk aversion amongst farming households, especially those with limited assets.

The break-even analysis found a price of 13.35 THB/kg and a 235.97 kg/rai yield. Given these parameters, research entities must innovate and devise techniques that augment productivity, optimise costs, and remained environmentally benign. Such interventions can significantly boost rice production profitability (Table 2).

Table 2. Cost and return of the rice farm community in Chachoengsao Province

Items	Cash	Noncash	Total	Percentage
Variable cost (VC)				
Labor	1,039.91	187.26	1,227.17	38.95
Seed	30.18	248.73	278.90	8.85
Fertiliser	211.21	33.42	244.63	7.76
Pesticides	38.43	-	38.43	1.22
Fuel	126.26	-	126.26	4.01
Maintenance	52.97	-	52.97	1.68
Total variable cost (TVC)	*1,498.95*	*469.40*	*1,968.35*	*62.48*
Fixed costs (FC)				
Land tax	3.48	-	3.48	0.11
Land rent	691.53	-	691.53	21.95
Opportunity cost	-	305.00	305.00	9.68
Depreciation cos	-	181.97	181.97	5.78
Total fixed cost (TFC)	*695.00*	*486.97*	*1,181.97*	*37.52*
Total cost (TVC + TFC)	*2,193.95*	*956.38*	*3,150.32*	*100.00*
Total cost (TVC + TFC) (THB/rai)	3,150.32			
Total revenue (THB/rai) (Q×P)	2,266.26			
Total output (Q) (kilograms/rai)	167.61			
Selling price (P) (THB/kg)	13.35			
Gross margin (profit) (THB/rai)	- 884.06			
Break-even yield (kilograms/rai)	235.97			
Break-even price (THB/rai)	18.79			

Production and technical efficiency estimates

The breakdown of the primary input-output variables of rice production highlighted the differences in farming practices, resource deployment, and productivity in the farming sector. The average rice yield was 185.66 kg/rai, higher than the preliminary figures discussed. It highlighted the region's efficiency and proficiency in rice cultivation techniques. Farm size, and indicative of the scale of operations, were averaged of 13.04 rai. Such a consistent metric served as a testament to the uniformity of farming plots and offering a snapshot into the typical expanse dedicated to rice cultivation in the community.

The farmers sowed 19.19 kg/rai on average, far exceeding the previous cropping cycle and potentially implying a higher seeding rate ensured a denser crop stand and possibly higher yields. Fertiliser application is used to be another critical aspect of farming. In the Ban Nong Saeng rice mill community enterprise, farmers utilised an average of 61.91 kg/rai. This substantial figure was compared to prior data to underscore the importance of nutrient augmentation in achieving optimal crop yields. Rice cultivation is found to be labour-intensive. According to the data, the average labour input was 7.59 hours per rai, and contrasted with earlier estimates. It elevated the number, emphasizing the meticulous care and attention farmers invest in their crops, from planting to harvesting (Table 3).

Table 3. Summary of the input-output variables used in the production model

Items	Unit	Mean	*Std.Dev.*	Min.	Max.
Yield	kilo	185.66	179.85	1.00	650.00
farm size	rai	13.04	8.32	3.00	42.00
Seed	kilo	19.19	4.31	12.50	37.50
Fertiliser	kilo.	61.91	178.63	0.01	2.00
Labor	hour	7.59	6.09	2.00	33.75

The results were derived from the Maximum Likelihood Estimate (MLE) of the stochastic production function for rice cultivation. A deeper exploration of these outcomes yielded valuable insights into the dynamics of rice farming in the Ban Nong Saeng rice mill community enterprise. The results revealed that the influential role of labour and fertiliser in the rice production equation. Both variables were a positive and significant impact on rice productivity. Specifically, the coefficient for labour was 1.497, indicating its pivotal role in production. Similarly, fertiliser, with a coefficient of 0.076, was a significant factor at the 10% level. It suggested that appropriate labour allocation and optimal fertiliser application was substantially boost rice yields under the prevailing production techniques.

On the other hand, farm size and seed variables were not significantly influenced in rice productivity. It indicated that under current practices and technologies, optimising farm size and seed selection might not be concerned the primary determinants of yield enhancement. Overall, through its current practices, the Ban Nong Saeng rice mill community enterprise recognised the indispensable roles of labour and fertiliser in enhancing rice production efficiency. The data emphasised that while factors like planting material would not significantly differ in the technical efficiency of rice production in the studied region, labour practices and optimised fertiliser usage significantly augment the capability of farmers to produce rice proficiently (Table 4).

Table 4. Estimates of the stochastic production function

Variables	Parameters	Coefficient	T-ratio
Production function			
Constant	α_0	-5.551	-1.301
ln Farm size	α_1	-2.186	-1.873
ln Seed	α_2	2.058	1.769
ln Fertiliser	α_3	0.076*	0.957
ln Labor	α_4	1.497**	3.851
Variance Parameters			
Sigma-Squared	α^2		1.897
Gamma	γ		0.890
Log-likelihood			-77.361

*Level of significance ***(p<0.01), ** (p<0.05), * (p<0.10)*

Technical efficiency score distribution

A comprehensive breakdown of the expected technical efficiency (TE) scores amongst the sample of rice farmers showed a nuance of the efficiency dynamics within rice farming in the studied region. The results indicated a remarkable maximum TE score of 0.992 for rice farming. However, it was worth noting that while the peak TE score was impressive, the broader distribution presented a varied landscape.

A significant 65.20% of the farmers showed efficiency scores below 0.40, revealing potential improvement areas. The mean TE across the sample was

0.320, with a standard deviation of 0.280, suggesting the farmers' efficiency level variability. The broad TE spectrum, ranging from 0.002 to 0.992, underscored the community's diverse farming practices and efficiencies. The findings revealed a multifaceted approach for farmers to elevate their rice production levels. Depending on their current efficiency standing, farmers may need to strategically recalibrate their input quantities, either reducing or augmenting them to achieve optimal production outcomes (Table 5).

Table 5. Distribution of the technical efficiency scores

Efficiency scores	Frequency	Percentage
< 0.40	30.00	65.20
0.41 - 0.60	8.00	17.40
0.61 - 0.80	4.00	8.70
0.81 - 1.00	4.00	8.70
Mean	0.320	
Std.Deviation	0.280	
Minimum	0.002	
Maximum	0.992	

Discussion

The study on Ban Nong Saeng rice mill community enterprise's rice production in Chachoengsao Province, Thailand, provides valuable insights into the region's cost-return dynamics of rice farming. The study found the VC to be high, primarily driven by the extensive use of variable inputs. Specifically, labour emerged as a predominant cost driver, constituting a significant portion of the VC in farming practices. The finding resonated with studies by Kookkaew (2019) and Suwanmaneepong *et al*. (2022), highlighting the pivotal role of labour and seed expenditure in influencing Thailand's rice productivity. This emphasis on labour costs is carried implications for both farmers and policymakers. From the farmers' perspective, it implies that labour optimisation, whether through mechanisation or improved farming practices, could be a focal area for boosting profitability (Chand *et al*., 2015). A clear avenue exists for policymakers to support the farming community by devising labour-related subsidies or incentives, especially labour forms that were considered to be chunk of farming expenses. The government can directly impact and potentially reduce production costs by ensuring that farmers have access to affordable labour or technologies that minimised manual labour, improving farmers' profitability (Abebe, 2014; Wu, 2019).

The findings of this study are bolstered by similar observations from a spectrum of research, including studies conducted by Kea *et al*. (2016), Ebers *et al*. (2017), Kerdsriserm *et al*. (2018), and Suwanmaneepong *et al*. (2020). These studies collectively underscored labour and faced critical constituents of production costs. This repeated emphasis across multiple studies suggested a broader industry trend that required attention. The seed costs are also highlighted, interventions promoting research into cost-effective, high-yield seed varieties or bulk procurement support can be pivotal for the community (Faysse *et al.,* 2020; Nguyen *et al.,* 2022). When assessing the TE metrics, the study findings depicted a performance that was closely with other farming ventures in Thailand's rural belt. Notably, Kerdsriserm *et al*. (2018) identified a TE range of 29% to 99% in their research, a bracket within which the metrics from the current study is comfortably resided. Moreover, Suwanmaneepong *et al*. (2022) reported a similar efficiency span for Thailand's provinces and suburbs, oscillating between 40% and 98%. A particularly encouraging revelation arising from the study analysis was significantly found to be efficiency improvement potential amongst most surveyed farmers. The data suggested a potential efficiency growth margin of up to 68%. This underscored the latent capabilities inherent within the Ban Nong Saeng rice mill community enterprise and promised trajectory for rice farming within Chachoengsao Province, provided the right strategies and interventions are employed.

The implications derived from the study are multifaceted. If TE can be leveraged to its full potential, it can revolutionise rice production in the region, making Thailand has more competitive in the global rice market (Amekawa *et al*., 2021; Ebers *et al*., 2017). The academic community has opened up a vast area for further research into the factors that can unlock this potential. On the NGO front, initiatives focusing on training farmers, introducing them to best practices worldwide, or even facilitating technology transfers may possible profound impacts. Community leaders can use these insights to drive internal reforms, and focused on knowledge dissemination and capacity building. In conclusion, it presented the tangible pathways for various stakeholders from farmers to government bodies and from academicians to NGOs to collaborate and set new benchmarks in rice farming, leveraging Thailand's rich agricultural heritage and immensed the potential of its farming community.

Acknowledgments

This study is an integral component of the research project titled "The Potential Development and Value Chain Enhancement of High-Value Products from Rice Community Enterprise in Chachoengsao Province." We express our sincere gratitude to the Program Management Unit for Area-Based Development (PMU-A), Office of the Higher Education Policy, Science, Research, and Innovation, under the Flagship Initiative Plan of the Year 2020, Local Developing Universities [grant no: A13F630015], Research Framework for Local Enterprise Capabilities Development.

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(Received: 25 November 2023, Revised: 1 May 2024, Accepted: 10 May 2024)