Research article

Rice Yield Variation Associated with Time-dependent Shifts in Area Cultivated by Farmers in Northeast Thailand

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Abstract The rice area cultivated by individual farmers in Northeast Thailand has gradually decreased since the 2010s. As Northeast Thailand is a major rice-growing region in Thailand, this trend might suggest a potential decline in total rice production at the national level. In order to examine this concern, we investigated fluctuations in the scale of rice production among individual farmers in Northeast Thailand from 2010 to 2019, focusing on the relationship between cultivated area and rice yield. This study used household panel data collected by Thailand Vietnam Socio-Economic Panel project. We compared 445 farmers who reduced their rice cultivation area with 208 who expanded it, comparing rice yield, production disposal, and input usage. The results indicate a decrease in the number of farmers cultivating a rice area of more than 3.2 ha and an increase in those cultivating less than 1.6 ha during the period. The farmers who enlarged their rice cultivation area had a higher yield in 2010 than those who reduced it, but their unit yield fell below that of the reducing group by 2016. This finding suggests difficulties for farmers who increase the area under rice production in sustaining the intensity of production over time.

Keywords rice farmer, farm size strata, rice yield, agricultural inputs, Northeast Thailand

INTRODUCTION

Thailand ranks among the world's leading producers and exporters of rice, holding the sixth position in production and the second position in exports in 2020 (FAO, 2022). However, the rice productivity of Thailand lags behind that of competing countries in the international market. Thailand's rice productivity was 2.7 tons/ha, with that of India (4.1 tons/ha), Pakistan (3.8 tons/ha), and Vietnam (6.0 tons/ha) higher than Thailand in 2020-2021 (USDA, 2022). Even though other countries kept increasing their rice yield, Thailand's yield stagnated in the 2010s. To keep the competitiveness of Thailand as a rice exporter, improving rice productivity is an urgent issue.

In this regard, rice farmers in Northeast Thailand should be a major target. In Thailand, there are two major rice ecosystems: rainfed lowland rice and irrigated lowland rice. Rainfed lowland rice is mainly produced in the region, just in the wet season (Jun-Nov). Irrigated lowland rice is mainly produced in Central Thailand, in both wet- and dry-season (Feb-May). Coverage of rainfed lowland rice reaches around 80% of total rice paddies in Thailand. The yield of rainfed lowland rice is persistently lower than irrigated lowland rice due to frequent strikes of drought and flood. While the yield of dry-season rice has stagnated over the past 30 years, the yield of wet-season rice has continued to increase (Suwanmontri et al., 2020). Notably, Northeast Thailand accounts for more

than half of the country's wet-season rice production (OAE, 2022). The region has experienced significant progress in the commercialization of rice farming in recent decades. Marketing channels for rice have been established, connecting rice farmers in Northeast Thailand directly to the international market. This offers farmers more opportunities for rice sales (Suebpongsang et al., 2020). Farmers are increasingly obtaining high-yield seeds and chemical fertilizers through market channels and using them widely (Promkhambut et al., 2023). Additionally, rapid mechanization of farmwork is occurring to address labor shortages (Baird et al., 2022). These facts suggest that the rainfed lowland rice has greater potential for yield growth compared to the irrigated lowland rice.

However, the data disclosed by the Office of Agricultural Economics (OAE) indicated that the rice area cultivated by individual farmers in Northeast Thailand kept decreasing over the last decade (Toyama et al., 2022). Previous studies mentioned the trend of the stratum structure of rice production scale by individual farmers (Shigetomi, 2015; Inoue, 2015). The studies found that the upper stratum of rice farmers diminished, and the rice farm size became standardized to the middle scale. However, the discussion was based on the census data up to the 2000s. The trend observed in the OAE data during the 2010s, which generally shifted towards lower strata, clearly deviated from the earlier trend of mid-size farms. It is expected that if farmers withdraw from rice production and the cultivated area of rice decreases, maintaining total rice production will be challenging. However, detailed evidence is necessary to validate the feasibility of this concern.

OBJECTIVE

The objectives of the current study are twofold: 1) understanding the changes in cultivated area and unit yield of rice production by individual farmers in Northeast Thailand in the 2010s based on household panel data, and 2) investigating the relationship between changes in cultivated area and rice yield.

METHODOLOGY

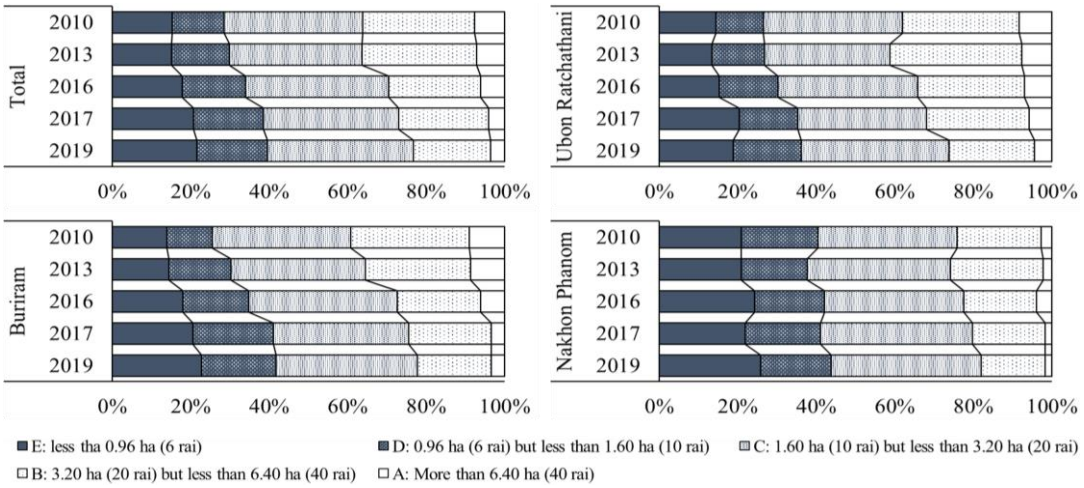
This study used household panel data collected by the Thailand Vietnam Socio-Economic Panel project (TVSEP, 2015a). Upon registration, we received the requested data free of charge. The household survey was implemented with a sample of 2,186 households (HHs) in 220 villages in 3 provinces (Ubon Ratchathani: 970 HHs, Buriram: 819 HHs, and Nakhon Phanom: 397 HHs) in Northeast Thailand. The sampling procedure consisted of a 3-stage cluster sampling design (TVSEP, 2015b). We used the data from 5 surveys in 2010, 2013, 2016, 2017, and 2019. While the survey included non-farm households, this study focuses specifically on rice farmers. Therefore, from the 2,186 surveyed households, 1,051 households that engaged in rice production between 2010 and 2019 were selected as the "rice farmer" sample (Ubon Ratchathani: 468, Buriram: 405, Nakhon Phanom: 178). We excluded 1,135 households because they were not targeted in one or other surveys (TVSEP, 2015b) or had no rice production in the period.

Firstly, we observed the general trend of rice areas cultivated by individual rice farmers and tracked how the rice farmers changed the area from 2010 to 2019. Then, we selected the farmers enlarging and reducing their rice-cultivated area. To categorize farmers in the enlarging group, we selected those whose rice-cultivated area in 2010 was less than the average of five surveys and in 2019 exceeded the average. For the reducing group, we identified farmers whose area in 2010 surpassed the five-survey average and in 2019 fell below the average. As a result, 208 and 445 farmers were selected as the enlarging and reducing farmers, respectively.

RESULTS AND DISCUSSION

Change of Rice-Cultivated Area by Surveyed Farmers in Three Provinces

Figure 1 shows the changes in rice area cultivated by individual farmers from 2010 to 2019. We classified the rice-cultivated area into five strata (strata A-E, from the largest to smallest). The boundaries for farm strata were defined at 0.96 ha (or 6 rai, "rai" being the local unit of area in Thailand with 1 rai = 0.16 ha), 1.60 ha (10 rai), 3.20 ha (20 rai) and 6.40 ha (40 rai), in line with the statistical data of the Office of Agricultural Economics (OAE) in Thailand. The trend in rice-cultivated areas in the TVSEP data was almost the same as in the OAE data. The ratio of stratum B (more than or equal to 3.20 ha but less than 6.40 ha) decreased in all provinces, and the ratio of strata D (more than or equal to 0.96 ha but less than 1.60-ha) and E (less than 0.96-ha) increased clearly in Buriram and Ubon Ratchathani.



*Source: Household panel data in Thailand was collected by the TVSEP project. Remark) *1 rai = 0.16 ha.*

Fig. 1 Changes in the rice area cultivated by farmers from 2010 to 2019

Table 1 Movement of farmers between rice-cultivated area strata from 2010 to 2019

All

	Strata*	2019 A	B	C	D	E	Total
2010	A	17	35	17	8	4	81
	B	16	121	**102**	27	33	299
	C	2	**35**	197	**78**	**60**	372
	D	0	4	**41**	51	43	139
	E	3	12	**33**	26	86	160
	Total	38	207	390	190	226	1051
Delta (2010-19)		-43	-92	18	51	66	-

All (%**)

	Strata	2019 A	B	C	D	E	Total
2010	A	2	3	2	1	0	8
	B	2	12	**10**	3	3	28
	C	0	**3**	19	**7**	**6**	35
	D	0	0	**4**	5	4	13
	E	0	1	**3**	2	8	15
	Total	4	20	37	18	22	100
Delta (2010-19)		-4	-9	2	5	6	-

Reduce

	Strata	2019 A	B	C	D	E	Total
2010	A	6	34	16	8	4	68
	B		35	79	27	33	174
	C			42	54	53	149
	D				8	26	34
	E					20	20
	Total	6	69	137	97	136	445
Delta (2010-19)		-62	-105	-12	63	116	-

Reduce (%**)

	Strata	2019 A	B	C	D	E	Total
2010	A	1	8	4	2	1	15
	B		8	18	6	7	39
	C			9	12	12	33
	D				2	6	8
	E					4	4
	Total	1	16	31	22	30	100
Delta (2010-19)		-14	-24	-3	14	26	-

Enlarge

	Strata	2019 A	B	C	D	E	Total
2010	A	2					2
	B	10	18				28
	C	2	29	33			64
	D	0	4	34	4		42
	E	3	11	29	15	14	72
	Total	17	62	96	19	14	208
Delta (2010-19)		15	34	32	-23	-58	-

Enlarge (%**)

	Strata	2019 A	B	C	D	E	Total
2010	A	1					1
	B	5	9				13
	C	1	14	16			31
	D	0	2	16	2		20
	E	1	5	14	7	7	35
	Total	8	30	46	9	7	100
Delta (2010-19)		7	16	15	-11	-28	-

Source: Same as Table 1.

*Remarks: *The ranges of each stratum are the same as in Figure 1; **Dividing the number of farmers in each column by the total number of farmers in each category.*

Table 1 illustrates the major flows of farmers between the strata from 2010 to 2019. The most significant flow of farmers was from B in 2010 to C (more than or equal to 1.60 ha but less than 3.20 ha) in 2019, namely, 102 farmers, or almost 10% of all surveyed farmers. Regarding flows to lower strata, flows from C to D and C to E were larger than others. On the other hand, farmers moving to the upper strata were observed in the following paths: from C to B, D to C, and E to C. As a result, the number of farmers in strata A and B (more than or equal to 3.20 ha) decreased and the number of farmers in strata C, D, and E increased. We made the same kinds of tables for the reducing and enlarging groups of farmers. The major flows in both groups were similar to the table of all surveyed farmers. In the reducing group, the numbers of farmers in strata A, B, and C decreased and the number of farmers in strata D and E increased. In contrast, in the enlarging group, the numbers of farmers in strata A, B, and C increased and the number of farmers in strata D and E decreased.

The shift from the upper strata (A and B) to the lower strata (D and E) can be attributed to two primary factors: declining family farm labor and the fragmentation of farmland through inheritance. The decline of family farm labor is a general trend among farmers in Northeast Thailand, driven by population aging and outflow to urban areas (add source). As farmers struggle to secure sufficient labor, reducing rice-cultivated areas might be one of the coping strategies. Additionally, the region's custom of dividing farmland among children upon inheritance has led to the gradual fragmentation of holdings over generations. This phenomenon likely influences individual farmers' decisions regarding their rice-cultivated area.

Table 2 Status of rice production by reducing and enlarging groups from 2010 to 2019

Classified group*	N	Rice-cultivated area (ha/farm)		Total cultivated area (ha/farm)		Area cultivated others (ha/farm)		The ratio of rice-cultivated area (%)		Ratio of home consumption (%)	
		2010	2019	2010	2019	2010	2019	2010	2019	2010	2019
Reducing	445	4.25	1.79	4.72	2.44	0.46	0.65	93	84	40	47
A	68	10.93	3.55	11.51	4.64	0.58	1.09	95	85	29	34
B	174	4.35	2.04	4.68	2.70	0.33	0.66	95	83	36	43
C	149	2.27	1.15	2.84	1.69	0.57	0.54	90	83	43	50
D and E	54	0.96	0.53	1.39	0.85	0.43	0.32	87	85	58	68
Enlarging	208	1.66	3.08	2.15	3.63	0.48	0.56	85	91	52	47
A and B	30	4.32	6.13	4.82	6.36	0.50	0.24	93	96	37	29
C	64	2.06	3.30	2.26	3.83	0.20	0.53	96	94	45	44
D	42	1.17	2.16	1.63	2.46	0.46	0.30	88	93	52	53
E	72	0.49	2.14	1.24	3.01	0.75	0.87	69	84	69	54

Source: Same as Table 1.

*Remarks: *Strata from A-E are the same as in Figure 1; **Most farmers produced KDML105 and RD6 as non-glutinous varieties and glutinous varieties, respectively.*

Yield and Input Use by Farmers Reducing and Enlarging Rice-Cultivated Area

Table 2 shows the status of rice production by individual farmers in the reducing and enlarging groups. Regarding the reducing group, both the rice-cultivated area and the total cultivated area decreased from 4.25 ha to 1.79 ha and from 4.72 ha to 2.44 ha, respectively, but the cultivated area for other crops increased from 0.46 ha to 0.65 ha. Farmers in the enlarging group increased cultivated area for both rice and other crops from 1.66 ha to 3.08 ha and from 0.48 ha to 0.56 ha, respectively. As a result, the ratio of rice-cultivated areas dropped from 93% to 84% in the reducing group and rose from 85% to 91% in the enlarging group. We also examined the ratio of home consumption of rice to total production in each group. Small-scale farmers tended to produce rice for home consumption in both groups. While the ratio in the reducing group rose from 40% to 47%, the ratio in the enlarging group dropped from 52% to 47%. This trend may reflect changes in the purpose of rice production among farmers in each group.

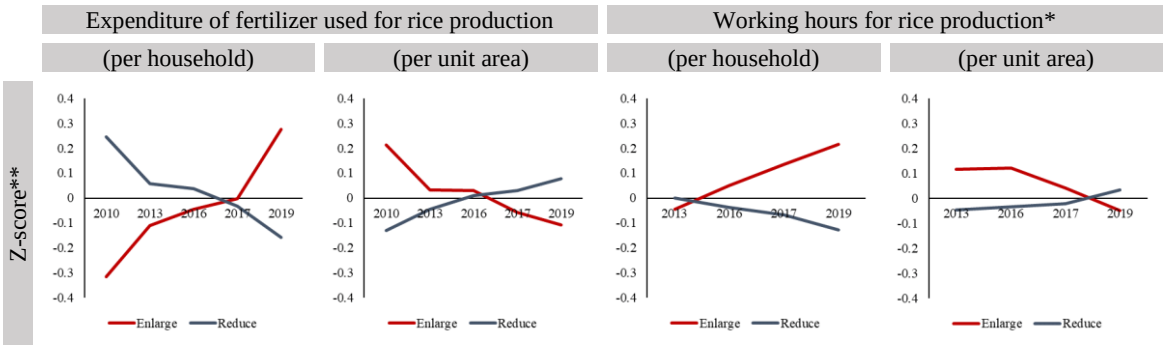
As a general trend among surveyed farmers, rice yield per unit area fluctuated and it was difficult to identify either a decreasing or an increasing trend (Table 3). The average yield for farmers in the enlarging group was lower than the average for all farmers and the average for the reducing group from 2010 to 2019. In 2010, the yield of the enlarging group was significantly higher than the reducing group, but in 2017 and 2019, the yield of the enlarging group was significantly lower than

the reducing group. We also compared Z-scores of the expenditure of fertilizer used and working hours for rice cultivation between the reducing and enlarging groups (Fig. 2). Regarding fertilizer expenditure and working hours, the total input of the reducing group was greater than that of the enlarging group in 2010, but this trend reversed by 2019, with the enlarging group demonstrating higher total input. Conversely, while the input per unit area of the enlarging group exceeded that of the reducing group in 2010, the input per unit area of the reducing group was higher in 2019.

Table 3 Change of unit rice yield by enlarging and reducing group

Category	Strata*	N	2010	2013	2016	2017	2019
Reducing group (N=445)	Total avg.	445	1.78**	1.89	2.39	2.39**	1.91**
	A	68	1.58	1.83	2.13	2.36	1.70
	B	174	1.68	1.74	2.38	2.35	1.87
	C	149	1.89	1.89	2.50	2.41	1.98
	D + E	54	2.04	2.33	2.40	2.43	2.20
Enlarging group (N=208)	Total avg.	208	2.23**	1.96	2.31	2.16**	1.54**
	A + B	30	2.06	1.60	2.21	2.34	1.78
	C	64	2.06	2.02	2.19	1.93	1.43
	D	42	2.03	2.05	2.36	2.13	1.58
	E	72	2.63	1.97	2.42	2.31	1.52

(unit: ton/ha)
Source: Same as Table 1.
*Remarks: *Strata from A-E are the same as Figure 1; **p<0.01 between the enlarging and reducing group examined by the student's t-test.*



Source: Same as Fig. 1.
*Remarks: *Because there was no data on working hours in 2010, we only used the data from 2013 to 2019; **Z-scores of each group's means in all surveyed farmers. The reason for using the Z-score to capture the transition is that the forms of fertilizer and labor input data in the TVSEP survey changed across the years, potentially weakening the data's continuity.*

Fig. 2 Change of fertilizer and family labor use by enlarging and reducing group

These results suggest that farmers in the enlarging group did not maintain the intensity of their rice production during the surveyed period. The following possibilities may explain this observation. First, the farmers in the enlarging group may not be accumulating farmland as a result of the strategic expansion of farm size. In Northeast Thailand, most farmers trade farmland among relatives and neighbors (Shigetomi, 2015). When farmers in the region find it difficult to continue rice farming due to poor health or labor/capital shortages, they tend to look for someone to look after their paddy fields temporarily. If the farmers who look after the others' paddy fields do not aim to increase rice productivity, extensive rice farming may be the most rational practice for them. The high risk of natural disasters also leads farmers to reduce the inputs they use to cultivate rice. As most of Northeast Thailand is a flood and drought-prone area, farmers in the region have to cope with the risk of losing rice yield every year (Kaida et al., 1985). In this situation, investment in rice farming may be limited, especially among farmers with large paddy field areas. The above possible behaviors may be enabled by increasing the off-farm income of rural residents in the region. As the importance of rice farming as an income source gradually declines (Takeuchi, 2010), farmers are potentially induced to adopt such strategies.

CONCLUSION

Based on the household panel data from 2010 to 2019 in 3 provinces of Northeast Thailand, the number of farmers having more than 3.20 ha of rice-cultivated area decreased between 2010 and 2019, and the number of farmers with less than 1.60 ha of rice-cultivated area increased during the same period. To understand the relationship between the trend of cultivated area, yield, and inputs on rice production, we classified farmers into two groups: those who either reduced or enlarged their rice-cultivated area from 2010 to 2019. In 2010, farmers who reduced their rice-cultivated area had lower yields than those who enlarged their area. However, by 2019, the yield of the reducing farmers had surpassed that of the enlarging farmers. Regarding two key agricultural inputs for rice cultivation – fertilizer and labor – farmers who enlarged their rice-cultivated area used higher amounts per unit area in 2010 than those who reduced the area. Interestingly, by 2019, this trend had reversed, with the reducing farmers using more fertilizer and labor per unit area than the enlarging farmers.

The results suggested that while some farmers in Northeast Thailand reduced their rice cultivation area, other farmers increased their rice cultivation area. However, this expansion was associated with a decrease in both yield and input levels per unit area. This raises concerns that farmers who aim to continue expanding rice production may be unable to maintain the intensity of their operations. Several possible explanations exist for this disinvestment among enlarging farmers: customary land transactions among relatives and neighbors, the high risk of natural disasters, and the increasing availability of off-farm income opportunities. To maintain and improve rice productivity in Northeast Thailand, targeted support is needed for these farmers to incentivize them to invest capital and labor into rice production.

A limitation of the current study is that we could not demonstrate the mechanisms behind the reduction of the rice-cultivated area by individual farmers and the decline in rice production intensity among enlarging farmers, based on actual field data. To confirm the hypothesized reasons we discussed above, further studies are needed using data on livelihoods, incomes, land transactions, and social relationships of rice farmers in the region.

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