Applied Economics Journal 17 (1): 70-92

ISSN 0858-9291

Two Decades of the Rice Economy of Thailand

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Abstract This paper investigates the transitions in Thai rice economy and farm household income structure. It also describes the impacts of the changes on income inequalities and poverty indices during 1987/88 and 2007/08 crop years. The cost of rice production has continuously increased over time, contributing to declining returns despite increasing yields. This suggests that the most effective way to raise farmer income is to reduce their production cost without reducing yields. Practices should be promoted that reduce production costs and maintain yields, especially in the use of seed and fertilizer. As to household income structure, the non-agricultural sector contributed a significant and increasing proportion of the farm household's income, except in irrigated areas where rice farming still contributes the major part of the total income of households. Income inequality increased over the two decades. This inequality occurred in the income from rice farming, but other sources of inequality were in the other farm income and agriculture hired labor income. Despite this growing inequality, there was an improvement in poverty situation during the period. The incidence of poverty was lower in irrigated development villages than in the other villages.

Keywords: rice, income distribution, poverty reduction

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วารสารเศรษฐศาสตร์ประยุกต์ 17 (1): 70-92

ISSN 0858-9291

เศรษฐกิจข้าวไทยในสองทศวรรษ

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สมพร อิศวิลานนท์ สถาบันคลังสมองของชาติ

บทคัดย่อ บทความนี้อธิบายถึงการเปลี่ยนแปลงในภาคการผลิตข้าวของไทยและโครงสร้างรายได้ของครัวเรือนเกษตรกร รวมถึงผลกระทบจากการเปลี่ยนแปลงที่มีต่อการกระจายรายได้และความยากจนในช่วงปีการผลิต 2530/31 ถึง 2550/51 ทั้งนี้พบว่าแม้ผลผลิตข้าวเพิ่มขึ้นมาโดยตลอด แต่ต้นทุนการการผลิตก็เพิ่มขึ้นอย่างต่อเนื่องเช่นกัน ส่งผลให้ผลตอบแทนลดลง ดังนั้นการหาทางลดต้นทุนการผลิตโดยไม่ทำให้ผลผลิตลดลงเป็นแนวทางที่จะเพิ่มรายได้ให้กับเกษตรกร จึงควรส่งเสริมวิธีปฏิบัติในการลดต้นทุนการผลิตโดยไม่ทำให้ผลผลิตลดลง โดยเฉพาะการใช้เมล็ดพันธุ์และปุ๋ยเคมี เมื่อพิจารณาโครงสร้างรายได้ของครัวเรือนพบว่า แหล่งรายได้จากนอกภาคเกษตรนับว่ามีความสำคัญและมีสัดส่วนเพิ่มขึ้นเป็นลำดับ ขณะที่การปลูกข้าวยังเป็นแหล่งรายได้หลักของครัวเรือนในเขตพื้นที่ชลประทาน ส่วนการกระจายรายได้มีความไม่เท่าเทียมมากขึ้นในช่วงสองทศวรรษที่ผ่านมา โดยพบทั้งในรายได้จากข้าว รายได้จากการการเกษตรอื่นๆ และรายได้จากการรับจ้างในภาคเกษตร แต่ภาวะความยากจนของครัวเรือนเกษตรกรลดลง โดยในเขตพื้นที่ชลประทานอยู่ในภาวะที่ดีกว่าพื้นที่อื่นๆ

คำสำคัญ: ข้าว การกระจายรายได้ ภาวะความยากจน

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Introduction

Rice production in Thailand has been going through a continual state of change since the Green Revolution in the 1960s. The initial impetus for the change was the development of the irrigation system, especially in the Central Plain region, which is also called the zone of Chao Phraya Project. With reliable irrigation water supply, modern rice varieties (MVs) became widely and rapidly adopted. The main attraction for farmer adoption was their high yield, fertilizer responsiveness under irrigation, and early maturity. The latter quality allowed two or three crops a year; this higher cropping intensity triggered a higher demand for hired labor. At the same time, the rapid expansion of the non-farm sector as a result of economic development pushed wage rates higher thus inducing labor migration from the rural to the urban areas. This created a scarcity of farm labor. The declining rate of agricultural labor to total labor caused an adjustment in labor market between the agriculture and non-agriculture sectors, inducing a rise in agricultural wage rate. A higher wage rate and the shortage of hired labor in agriculture consequently drove farmers to mechanize farm operations (Isvilanonda, Ahmad, and Hossain, 2000). Farm machinery and labor saving innovations such as the use of pre-germinated direct seeding technique in irrigated farmlands were widely adopted.

The adoption of MVs (also referred to as HYVs or high yielding varieties) over the past few decades has created many changes in rice production. The application of new technologies, increased use of chemical fertilizers and higher cropping intensity led to higher average rice yields in both wet and dry seasons. The average wet season yield increased from 267 kg per rai[1] in 1971-75 to 370 kg per rai in 2001-05, while the dry season yield increased from 514 kg per rai in 1971-75 to 674 kg per rai in 2001-05. The MVs were meant to increase production and income. However, the adoption of MVs was concentrated in irrigated areas of the Central Plain where water supply is less a constraint (Srisawasdilek, Adulavidya, and Isvilanonda, 1975). This adoption pattern widened the yield gap between favorable and unfavorable rice production environments, which widened the differences in productivity and income from rice farming between the rice growing regions.

This paper investigates the transitions in Thai rice economy and the changing farm household income structure. The changes in characteristics of sample households, farm size and land use,

[1] 1 rai = 0.16 ha; 6.25 ha = 1 rai

and rice production during 1987/88 and 2007/08 crop years are observed. The study also describes the impacts of the changes on income inequalities between different agro-ecosystems over a time period. The next section is the conceptual framework, followed by the method and data, result and discussion. The conclusions and major findings are recapitulated in the last section.

Conceptual Framework

The adoption of MVs was concentrated in irrigated areas. This adoption pattern widened the yield gap between favorable and unfavorable rice production environments, which widened the differences in productivity and income from rice farming between the rice growing regions. The farmers in non-irrigated areas often faced severe drought, which greatly reduced production and income from rice production to a level that could not support household expenditure. The farmers' adaptation strategy was to seek non-agricultural activity to earn more income. Therefore, the sources of income inequality come from (a) rice production and (b) non-farm activities. Figure 1 illustrates the conceptual framework of rice in transition, income inequality and poverty reduction in Thailand.

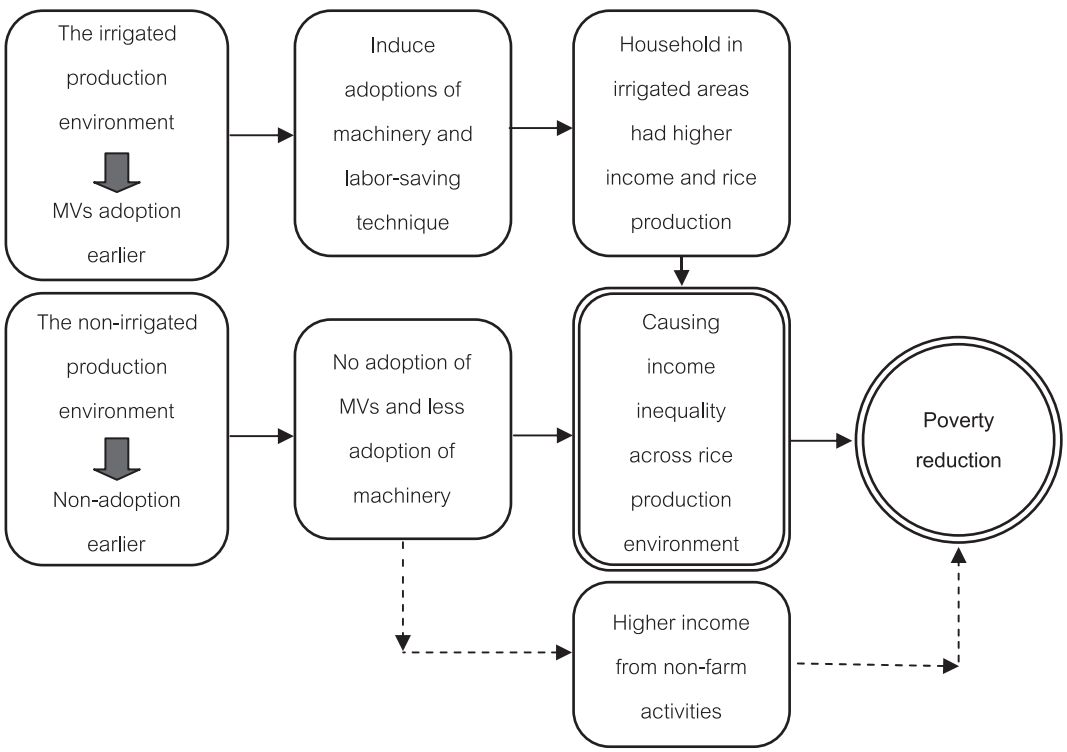

Figure 1 Rice in transition, income inequality and poverty reduction framework

Methods and Data

The income inequality index was calculated by applying the Gini decomposition by income sources (Lerman and Yitzhaki, 1985). This approach has the advantage of demonstrating the effect of a particular income source on income inequity. The Gini coefficient is expressed by equation 1:

$$G = \sum_{k=1}^{k} S_k G_k R_k \quad (1)$$

where G is the Gini coefficient for total inequity

S_k represents the share of source k in total income, which reflects the importance of the income source with respect to total income. And k is each source of household income such as rice income, other farming income, agriculture hired labor income, non-farm income, and remittance.

G_k represents the source Gini corresponding to the distribution of income from source k. This variable thus indicates whether equal or unequal distribution of income source.

R_k is the Gini correlation of income from source k with the distribution of total income. That is $R_k = \text{Cov}\{y_k, F(y)\}/\text{Cov}\{y_k, F(y_k)\}$, where F(y) and $F(y_k)$ are the cumulative distributions of total income and of income from source k.

For poverty measurement we used three major poverty measures that are in the class of measures proposed by Foster, Greer, and Thorbecke (1984). These are headcount ratio, poverty-gap ratio and squared poverty gap ratio. Their definition and formulae are described below.

The headcount ratio (H) is the ratio of the number of poor people to the total population. This definition is expressed as equation 2:

$$H = q_i/N \quad (2)$$

where q_i is the number of poor individuals and N the number of individuals in the sample. Thus, the headcount ratio reflects the incidence of poverty by indicating the proportion of the individual in a sample deemed to be poor, where poverty is defined by per capita relative to a poverty threshold.

The poverty-gap index (PG) is the average, over all people, of the proportionate gaps between poor people's living standards and the poverty line (as a proportion of the poverty line), expressed as equation 3:

$$PG = \frac{1}{N}\sum_{i=1}^{N}\frac{G_i}{Z} \quad (3)$$

where G_i is the poverty gap; $G_i = (z - y_i) * I(y_i < z)$, I is the income gap ratio, y_i is actual income of household i, and z is the absolute poverty line. In evaluating the impact of a developmental initiative on poverty alleviation, the poverty gap is usually the preferred measure since it is based on the aggregate poverty deficit of the poor relative to a given poverty line.

The squared poverty gap index (P_2) is a weighted sum of poverty gaps (as a proportion of the poverty line), where the weights are the proportionate poverty gaps themselves. The index is similar to the poverty gap index, but it puts more weight on those that fall well below the poverty line. This measure is advantageous for comparing policies that are intended for the poorest segment of the population. The formula of this index is as follows:

$$P_2(y,z) = \frac{1}{N}\sum_{i=1}^{q}\left(\frac{G_i}{z}\right)^2 \quad (4)$$

As for data use in the study, the panel data of six rice villages in 1987/88 and 2007/08 crop years were employed. The benchmark survey was conducted in 1987/88 crop year by the Faculty of Economics, Kasetsart University in collaboration with the International Rice Research Institute under the project "The Differential Impact of Modern Rice Technology across Production Environments in East Asia" (DIS project); 295 farm households were surveyed. The samples surveyed in 2007/08 crop year under the project "The Dynamics of Thailand's Rice Production Economy and the Future Outlook" were the same to those surveyed in 1987/88 under the DIS project. Table 1 shows the different production environments for the study representing by sample villages.

In Suphan Buri province, Wang Yang (SP1) was representative of irrigated area, Sra Ka Jom (SP2) of rainfed and drought prone area, and Jorakhe Yai of flood-prone area (SP3). Three more villages were selected in Khon Kaen province namely; Khokna-ngam (KK1) as the representative of irrigated area; Kai Na (KK2) of rainfed area, and Ban Meng (KK3) of rainfed and drought-prone area.

Table 1 The number of samples by production environment, 1987/88 and 2007/08 crop years

Villages	Production environment	The sample household of rice farming in 1987/88 (households)	The sample household of rice farming in 2007/08[1/] (households)	% change of rice farming household
Suphan Buri province (SP)				
Wang Yang (SP1)	Irrigated	45	40	11.11
Sra Ka Jom (SP2)	Rainfed and drought-prone	56	36	35.71
Jorakhe Yai (SP3)	Flood-prone[2/]	41	35	14.63
Total sample in SP		142	111	21.83
Khon Kaen province (KK)				
Khokna-ngam (KK1)	Irrigated	49	42	14.29
Kai Na (KK2)	Rainfed[3/]	54	41	24.07
Ban Meng(KK3)	Rainfed and drought-prone	50	34	32.00
Total sample in KK		153	117	23.53
Total sample		295	228	22.71

Note: [1/] The data survey in 2007/08 crop year indicated that some farmers in the 1987/88 crop year survey partially engaged in other occupation and did not entirely change occupation.

[2/] In SP3, the adoption of MVs and the change in the rice calendar gave the farmers the opportunity to grow two rice crops per year only in dry season 2007/08 crop year.

[3/] Urban expansion drove up the price of the land in suburb area and induced the farmers in KK2 to sell their land; some used the proceed from land sale to buy rice lands in the irrigated area. Thus, the most rice land in KK2 changes to irrigated rice production land in 2007/08 crop year.

Source: The data in 1987/88 crop year were from the DIS project and 2007/08 from the survey.

Results and Discussion

The survey data indicate that the number of farm households was 295 in 1987/88, of which 228 households remained in rice farming in 2007/08 crop year or 76 percent of the sample households in 1987/88. The decrease mostly occurred in the rainfed and drought-prone production environments (SP2 and KK3) in Suphan Buri and Khon Kaen. The main reason for abandoning rice farming in those areas were a severe drought, which greatly reduced production and income from rice production to a level that could not support household expenditure. The farmers' adaptation strategy was to seek non-agricultural work to earn more income.

Household Characteristics, Land Holding and Cropping Pattern

The household head plays an important role in decision-making regarding production and household resources. The average age of household heads in the agriculture sector has been increasing; it was 53.16 years in 1987/88 and 58.34 years in 2007/08, indicating that the work force in the agriculture sector is getting older. Most of the younger people have sought employment in the non-agricultural sector. The "ageing" of the Thai farmers and the movement of the younger family members of the farm household to the non-agriculture sector has led to an increasing use of hired labor. These two phenomena, the ageing of Thai farmers and decreasing family labor force, have had negative impacts on labor use in rice production in Thailand; there is now a scarcity of family labor. In 2007/08, the family sizes of the sample farm households in the study area have decreased; household size contracted from 6.34 to 4.45 persons (Table 2).

Table 2 Characteristics of sample households by production environment, 1987/88 and 2007/08 crop years

Crop year	Suphan Buri			Khon Kaen			Total
	SP1	SP2	SP3	KK1	KK2	KK3	
Average age of household head							
1987/88	51.31	53.39	60.34	51.71	51.07	51.12	53.16
2007/08	56.40	56.89	60.54	59.07	58.12	59.26	58.34
Average number of years of education of household head							
1987/88	3.71	2.84	3.66	3.76	3.87	3.76	3.60
2007/08	5.18	3.92	4.86	5.33	4.51	5.71	4.92
Household size (no.)							
1987/88	5.36	6.04	6.49	6.90	6.74	6.46	6.34
2007/08	3.90	4.17	4.29	4.98	5.20	4.00	4.45

Source: The data in 1987/88 crop year were from the DIS project and 2007/08 from the survey.

The education level of household heads has increased due to the extension of compulsory education from Grade 4 to 6. This extended the schooling period of household heads from 3.60 years in 1987/88 crop year to 4.92 years in 2007/08 crop year. Farmers in non-irrigated areas have the lowest average education level; in the village of SP2, for instance, the household heads were in school for 2.84 years in the 1987/88 crop year and 3.92 years in the 2007/08 crop year. TDRI (1988) found that the farm household members who have attained a higher educational level left the farm to work in the non-agricultural (ie. industrial, commercial and service) sectors. This has resulted in a severe shortage of agricultural labor and higher farm wages.

The cultivated land area over two decades decreased from 25.84 rai in 1987/88 to 21.90 rai in 2007/08. The villages that recorded the highest reduction are SP2 and KK2. Urban and industrial expansion along with an unstable climatic pattern made the farmers in the area sell their rice fields as well as their upland farm. Some farmers in KK2, however, used the money from land sale to buy lowland irrigated rice fields. The cultivated areas in SP1 and SP3 increased because the farmers were able to grow two rice crops a year. Some farmers rented land to grow rice from the ones who had stopped farming. The majority of farm lands in the study area were rice farms, which comprised 87.7 and 88.9 percent of the total cultivated area in 1987/88 and 2007/08 crop years, respectively (Table 3). The farmers in the irrigated area had a higher proportion of rice cultivated area than those in the other production environments.

Table 3 Cultivated area, cropping intensity and cropping pattern by production environment, 1987/88 and 2007/08 crop years

Crop year	Suphan Buri			Khon Kaen			Total
	SP1	SP2	SP3	KK1	KK2	KK3	
Cultivated area (rai)							
1987/88	20.06	48.15	41.45	11.38	16.14	17.89	25.84
2007/08	23.70	29.80	53.40	8.95	8.20	11.56	21.90
Proportion of cultivated rice area (%)							
1987/88	84.1	86.0	99.6	94.3	66.0	94.3	87.7
2007/08	79.6	72.3	100.0	96.8	89.6	95.1	88.9
Rice cropping intensities (times per year)							
1987/88	2	1	1.46	2	1	1	1.4
2007/08	2.8	1	2	1.95	1.56	1	1.7
Rice area cultivated in both wet and dry seasons (% of total area)							
1987/88	77	0	0	89	0	0	27.7
2007/08	61	0	100	80	32	0	45.6
Rice area in wet season (rai per household)							
1987/88	17.90	40.81	35.17	10.65	10.66	16.88	21.95
2007/08	17.46	21.56	-	8.66	7.34	10.95	11.06
Rice area in dry season (rai per household)							
1987/88	14.19	-	16.73	6.55	-	-	5.58
2007/08	19.93	-	52.61	7.11	2.64	-	13.20

Source: The data in 1987/88 crop year were from the DIS project and 2007/08 from the survey.

The cropping patterns in the irrigated areas and the non-irrigated areas differ. The lack of water in the dry season has driven the farmers in non-irrigated area to adjust their cropping pattern by growing upland crops instead of dry season rice. The dominant cropping pattern in the 1987/88 crop year in the irrigated areas of the two villages was cultivated rice in both wet and dry seasons. In the non-irrigated area, lack of water and low or no rainfall in the dry season have compelled the farmers to cultivate rice only in the wet season and leave the land idle in the dry season. In some areas, the farmers grow other crops such as sugarcane or cassava. However, the cropping pattern in 2007/08 crop year differed from that in the 1987/88 crop year. There was more rice cultivation in wet season but more other crops in dry season (cultivated rice in wet season and other crops in dry season, especially in SP1. In SP3, the adoption of MVs and the change in the rice production calendar allowed farmers to grow two rice crops per year. The findings show that in the village of SP1, The area which cultivated rice in both wet and dry season still dominated the production in the area with 61 percent of total cultivated area. The rice cropping intensity also increased from 2 to 2.8 per year, induced mainly by the adoption of the short-maturing rice varieties and improved production technology. Among the other field crops grown in the area, water-chest nut is the most popular. Most of the farmers alternate the cultivation of water-chest nut and rice. Some even cultivate water-chest nut all year round.

As for cultivated rice area, it is dramatically declined in wet season (from 21.95 to 11.06 rai per household). In the irrigated area of SP1, there was little change in the area for rice cultivation. However, the area under rice cultivation in the wet season (SP2) decreased from 40.81 rai per household in 1987/88 to 21.56 rai per household in 2007/08. The major cause of reduction was a prolonged dry period. This made some farmers switch to crops that are more tolerant to dry conditions such as cassava and sugarcane. Some farmers sold their land when transportation became more convenient; some others divided their lands into smaller parcels for their children's inheritance. On the contrary, the decrease in water levels in the flood-prone areas in the past allowed the farmers to adopt a new cropping pattern. The yearly rice cultivation could not be continued when runoffs from the mountains and forests inundated the fields. The farmers had to wait until August to November to plant rice. The lower incidence of flooding gave the farmers the opportunity to grow MVs twice a year, both crops in the dry season. Thus, rice is no longer cultivated in the wet season in the village of SP3. In Khon Kaen province, there was an increase in rice cultivation in the villages of

KK1 and KK2, which are in irrigated areas. The village of KK2 cultivates rice in the wet and dry seasons while the village of KK3 does so only in the wet season. The dry season rice area increased (5.58 rai to 13.20 rai). The areas grown to rice in the irrigated area of SP1 and in the flooded area of SP3 were observed to be increasing in the dry season. In Khon Kaen province, land for dry season rice production was seen only in the irrigated area of KK1 and in some parts of the rainfed area of KK2.

Input Use, Factor Price, Cost and Return

Farmers who used the transplanting method used 7 to 11 kg of seed per rai (Table 4). The quantity of seed used by farmers using the transplanting method did not vary much but they tended to use more than the recommendation of experts. As for the seeds used in the broadcasting method, it was found that the quantity of seed used in 2007/08 was higher than in 1987/88. In SP1 and SP3, especially, seed use increased from 18.84 and 15.84 kg per rai, respectively, in 1987/88 crop year to 25 and 20.49 kg per rai in 2007/08 crop year. This finding highlights the higher usage of seed by farmers than the quantity recommended by rice experts. Farmers' changing from the transplanting technique to the pre-germinated broadcasting technique required more seeds in every area. Seeds would become an important cost item if paddy price rose higher, as it did recently. The proper use of seed reduces production cost, especially for farmers who have to buy seeds, which they usually purchase seed from seed dealers or rice millers. Farmers in KK1, KK2 and KK3 were found to use more seeds in 2007/08 compared to crop year 1987/88 crop year (Table 4).

Table 4 Seed and chemical fertilizer application by production environment, 1987/88 and 2007/08 crop years

Item	Suphan Buri			Khon Kaen			Total
	SP1	SP2	SP3	KK1	KK2	KK3	
Seed use in wet season (kg per rai)							
1987/88	18.84	15.84	29.47	10.87	7.60	6.94	14.93
2007/08							
Transplanting	-	-	-	10.77	9.70	-	10.23
Broadcasting	25.00	20.49	-	18.24	13.43	13.04	18.04
Seed use in dry season (kg per rai)							
1987/88	17.67	-	25.82	14.88	-	-	19.46
2007/08	28.03	-	28.90	24.06	22.08	-	25.77

Table 4 (Continued)

Item	Suphan Buri			Khon Kaen			Total
	SP1	SP2	SP3	KK1	KK2	KK3	
Chemical fertilizer (kg per rai)							
Wet season							
1987/88	37.05	1.79	-	23.87	15.02	6.52	14.04
2007/08	48.86	11.26	-	33.77	30.88	25.49	28.90
Dry season							
1987/88	48.98	-	44.20	29.23	-	-	40.80
2007/08	93.21	-	52.02	34.99	38.08	-	54.60

Source: The data in 1987/88 crop year were from the DIS project and 2007/08 from the survey.

As for fertilizer utilization, most farmers apply fertilizers approximately two times per season. The first application is 7 to 15 days after transplanting or broadcasting, urea (46-0-0) and ammonium phosphate (16-20-0) are popular formulations. The second application is during 75 to 90 days after broadcasting or transplanting, the most popular formulations are 16-16-8, 16-8-8 and 15-15-15. Chemical fertilizer usage was higher during the 2007/08 crop year than the 1987/88 crop year. The average usage was 14.04 kg per rai in the wet season and 40.80 kg per rai in the dry season. The farmers in irrigated areas used more chemical fertilizer than those in the other areas. The data from the survey in 2007/08 found that the average chemical fertilizer usage in the wet season was 25-27 kg per rai, and 54.60 kg per rai in the dry season. The higher application was a result of the adoption of MVs, which are non-photoperiod sensitive and respond better to fertilization. Thus, the use of chemical fertilizer has been increasing rapidly over the last two decades, especially in the irrigated area (SP1) in Suphan Buri province. The survey data in 2007/08 crop year indicated that the usage of chemical fertilizers in this area increased from the 1987/88 crop year in both wet and dry seasons, but especially in the dry season when the application rate was 93.21 kg per rai. In the flood-prone area in the same province (SP3) the rate was 52.02 kg per rai. In KK1 area, the rate of chemical fertilizer application increased from 23.87 kg per rai in 1987/88 crop year to 30-34 kg per rai in 2007/08 crop year. Chemical fertilizer usage in the dry season increased at a lower rate than in the wet season.

The share of agricultural labor in the total labor force declined from 42.15 percent over the last three decades, and the number of workers engaged in rice cultivation dropped from 51 percent of the total labor force to 36 percent over the same period (Office of Agricultural

Economics, 2008). The decline in labor force engaged in rice cultivation started since early 1970s in the Central Plain because of the well-developed infrastructure and its proximity to Bangkok. The other regions also experienced the same phenomenon during the early 1980s (Isvilanonda and Wattanutchariya, 1990). The shortage of hired labor and the diminishing household size including the ageing of the household head drove the adoption of machinery in the rice production sector. The survey in 1987/88 crop year indicated that farmers in the irrigated area (SP1) utilized labor in the wet season for 7.87 man-days per rai. Of this, 63.1 percent was hired labor and the number of machinery hours was 0.57 hour per rai. In the rainfed area (SP2) and flood-prone area (SP3) labor use was 4.84 and 4.24 man-days respectively. Of these numbers, 35 and 62.1 percent were hired labor, respectively (Table 5). Farmers in SP2 used 0.94 machinery-hours per rai and those in SP3 used 0.11 machinery-hours per rai. The survey on labor use in the crop year 2007/08 showed that the labor use dipped further whereas the machinery-hour increased in irrigated SP1 and rainfed area SP2; machinery-hour climbed to 7.27 and 3.78 hours per rai, respectively.

Table 5 Labor use for rice production in wet season, 1987/88 and 2007/08 crop years

Item	Suphan Buri			Khon Kaen		
	SP1	SP2	SP3	KK1	KK2	KK3
1987/88 crop year						
Labor use (man-days per rai)	7.87	4.84	4.24	9.86	9.80	9.16
Machinery hour (hour per rai)	0.57	0.94	0.11	0.66	1.87	1.87
2007/08 crop year						
Labor use (man-days per rai)	1.19	1.95	-	9.65	8.20	4.94
Machinery hour (hour per rai)	7.27	3.78	-	6.84	5.89	4.47

Source: The data in 1987/88 crop year were from the DIS project and 2007/08 from the survey.

As for Khon Kaen province, labor use in the irrigated area (KK1) was 9.86 man-days, of which 32.8% was hired labor and machinery-hour was 0.66 hour per rai. Rainfed area (KK2) and rainfed and drought-prone area (KK3) used 9.80 and 9.16 man-days, respectively, of which 5.9 and 15.5 percent were hired labor, respectively. This shows that rice farming in the Northeast particularly in those three villages in Khon Kaen province utilized household labor mainly. Machinery use however was found in KK2 and KK3, both areas registering 1.87 machinery-hours. When comparing the labor use in 1987/88 crop year with that in 2007/08 crop year, it was found that

KK1, KK 2 and KK3 villages used less labor: 9.65, 8.20 and 4.94 man-days per rai respectively whereas their hired labor increased to 33.7, 27.7 and 34.4 percent, respectively. Machinery use increased as well to 6.84, 5.89 and 4.47 machinery-hours per rai, respectively.

The paddy price in 2007/08 was 7.85 baht per kg, slightly higher than the 7 baht per kg in 1987/88 crop year. The price of dry season paddy was higher in foreign markets. The pledging price offered by the government of 14 baht per kg for paddy with a 15 percent moisture content, was 11-12 baht per kg when adjusted for a moisture content of 15 percent. This is because the rice harvested with a combine has a moisture content of about 22-24 percent. On average the wet season paddy price in 2007/08 was 7.85 baht per kg and adjusted to 11.73 baht per kg in the dry season 2008. It is noted that the paddy price per kg in 1987/88 when converted to the value in 2007/08 averaged at 7 baht, which was close to that of the wet season 2007/08. This implies that the real prices in these two periods were almost the same. However, the input prices increased at a higher rate than paddy price. The average daily wage rate of crop harvesting rose from 82.53 baht per day in 1987/88 crop year to 207.5 baht per day, or by 2.5 times in terms of year 2007 price (Table 6).

Table 6 Paddy price, wage rate and machinery wage rate (at 2007 price), 1987/88 and 2007/08 crop years

Year	Suphan Buri			Khon Kaen			Total
	SP1	SP2	SP3	KK1	KK2	KK3	
Paddy price (baht/kg)							
Wet season 1987/88	7.73	7.09	7.56	6.64	6.88	6.29	7.00
Wet season 2007/08	7.51	8.54	-	9.96	9.21	10.11	7.85
Dry season 2008	11.07	-	12.13	10.64	10.78	-	11.73
Wage rate in crop harvesting (baht/day)							
Wet season 1987/88	112.0	78.6	98.25	78.60	68.78	58.95	82.53
Wet season 2007/08	-	260.00	-	200.00	183.33	186.67	207.5
Fertilizer price (baht/kg)							
1987/88	9.26	9.79	-	8.96	10.55	10.91	9.57
Wet season 2007/08	16.00	12.19	-	16.07	14.46	12.56	14.29
Dry season 2008	19.90	-	18.26	17.94	17.05	-	18.29

Source: The data in 1987/88 crop year were from the DIS project and 2007/08 from the survey.

Agricultural machineries used in 1987/88 crop year were mainly for land preparation. Irrigated SP1 and SP2 villages used power tillers but farmers in the rainfed area SP2, KK2 and KK3 used tractors for land preparation. Only a small number of power tillers were used. KK2 and KK3 villages also used buffalos in land preparation. Harvesting was not done with the combine harvester, but threshers were used in lieu of buffalo labor. Machinery came into use for rice land preparation and harvesting in the last two decades. In 2007/08 crop year, rice farmers extensively used agricultural machinery for land preparation in the irrigated, rainfed and flood-prone villages. For harvesting, particularly in the irrigated SP1 village and flood-prone SP3 village, farmers used widely the combine harvester but the wage rate imputed on the agricultural machinery is twice that of manual labor particularly for land preparation.

Land rent and production costs have been increasing. The rental price has been increasing with the rice price because most farmers pay the land rent in kind, ie. rice. The rental cost thus increases in corresponding to rice price. As for the cost of production, the irrigated SP1 village in Suphan Buri province increased from 2,813.9 baht per rai in the wet season of 1987/88 crop year to 5,224.6 baht per rai or 85.67 percent in 2007/08 crop year. The costs that increased significantly were machinery, fertilizer and land use. Besides that the farmers in rainfed and flood-prone area in this province incurred higher costs in both wet and dry seasons as well. Comparing the cost per unit of rice production between 1987/88 and 2007/08 crop years, it was found that the farmers in the irrigated SP1 village incurred the higher cost, from 4.8 baht per kg in wet season 1987/88 crop year to 6.86 baht per kg in 2007/08 crop year (Table 7). The costs per rai and per kg also increased in the dry season crop. The cost per kg in rainfed area is higher than in irrigated and flood-prone areas. This is because of a prolonged drought or low rainfall in the area. The rainfed rice farming village (SP2) was reported to have suffered losses from rice farming throughout the two crop years covered by the study.

In light of the above findings, even though the paddy price in the 2007/08 crop year was higher than that of the 1987/88 crop year, the higher increase in production cost than that in the output price decreased the profitability of rice farming in the irrigated areas whereas the farmers in the rainfed rice farming village suffered production losses. However, the income over cash cost of rice production is still greater than zero because most farmers own the land.

Table 7 Cost and return of rice production (at 2007 price), wet and dry season 1987/88 and 2007/08 crop years

Item	1987/88			2007/08		
	SP1	SP2	SP3	SP1	SP2	SP3
Cost and return in wet season (baht/ton)						
Cost per unit	4,800	9,800	6,400	6,860	13,370	-
Net income per unit	2,350	-2,150	820	650	-4,830	-
Net income to cost of production (%)	48.96	-	12.81	9.48	-	-
Cost and return in dry season (baht/ton)						
Cost per unit	4,460	-	4,370	8,660	-	6,790
Net income per unit	2,690	-	2,850	2,410	-	5,340
Net income to cost of production (%)	60.31	-	65.22	27.83	-	78.65
	1987/88			2007/08		
	KK1	KK2	KK3	KK1	KK2	KK3
Cost and return in wet season (baht/ton)						
Cost per unit	5,020	6,230	6,940	10,850	10,340	10,410
Net income per unit	1,460	450	1,510	-890	-1,130	-300
Net income to cost of production (%)	29.08	7.22	-	-	-	-
Cost and return in dry season (baht/ton)						
Cost per unit	4,900	-	-	6,540	6,850	-
Net income per unit	1,580	-	-	4,100	3,930	-
Net income to cost of production (%)	32.24	-	-	62.69	57.37	-

The net return in dry season is higher than in wet season. Farmers in irrigated area still produce rice even though the net profit has been decreasing and remains low. However, rice production in rainfed area is more for food security than income, which gives less consideration to net return. This is evident in rainfed area KK2 and KK3 in Khon Kaen province. Even if the costs of rice production per kg is adjusted from 6.23 baht per kg and 6.94 baht per kg in KK2 and KK3 respectively in 1987/88 crop year, to 10.34 baht per kg and 10.41 baht per kg respectively in 2007/08 crop year, the farmers preferred to keep the harvest for home consumption.

Household Income Level and Structure

The comparison of the household incomes and their growth over time indicated that the average income of rice farming households in all villages increased from 75,831 baht per household in the crop year 1987/88 crop year to 300,521 baht per household in 2007/08 crop year, or 2.96 times higher. SP3 and KK2 villages recorded the highest rise in household income during the study period, by 7.43 and 3.16 times respectively. The village with the lowest income per household was still SP2, a non-irrigated zone that suffered from several drought occurrences and far from any large industrial plant for earning non-farm income. Even though the household income increased from 65,955 to 161,784 baht per household or about 1.5 times in 2007/08 crop year, this was still much lower than incomes in the other rice producing villages (Table 8).

Table 8 Changes in the structure of household income, 1987/88 and 2007/08 crop years

Item	Suphan Buri					
	SP1		SP2		SP3	
	1987/88	2007/08	1987/88	2007/08	1987/88	2007/08
Household income (baht/year)	141,684	352,709	65,955	161,784	84,479	711,911
Per capita income (baht/person/year)	26,434	90,438	10,920	38,797	13,017	165,947
Source of household income (%)						
Agriculture	84.94	84.56	79.70	72.83	42.75	93.78
- Rice farming	41.30	37.05	58.73	2.96	33.42	83.74
- Other farming[1/]	36.73	36.06	11.02	62.69	6.27	4.42
- Agriculture hired labor	6.91	11.45	9.95	7.19	3.05	5.63
Non-agriculture income	15.06	15.44	20.3	27.17	57.25	6.22
- Non-farm activity	14.01	15.4	17.74	23.57	53.05	5.69
- Remittance	1.05	0.04	2.56	3.60	4.20	0.53
	Khon Kaen					
	KK1		KK2		KK3	
	1987/88	2007/08	1987/88	2007/08	1987/88	2007/08
Household income (baht/year)	61,572	216,209	55,115	229,092	56,883	152,817
Per capita income (baht/person/year)	8,924	43,415	8,177	44,056	8,805	38,204
Source of household income (%)						
Agriculture	45.38	31.76	39.88	33.47	47.22	37.17
- Rice farming	36.06	21.14	25.47	11.22	26.93	11.77

Table 8 (Continued)

Item	Suphan Buri					
	SP1		SP2		SP3	
	1987/88	2007/08	1987/88	2007/08	1987/88	2007/08
- Other farming[1/]	6.74	8.51	13.03	19.83	4.54	23.30
- Agriculture hired labor	2.58	2.11	1.38	2.42	15.75	2.10
Non-agriculture income	54.62	68.24	60.12	66.53	52.78	62.83
- Non-farm activity	49.33	63.24	55.35	62.03	47.19	44.59
- Remittance	5.29	5.00	4.77	4.50	5.59	18.25

Note: [1/] Other farming income include the income from non-rice crop and livestock.

Source: The data in 1987/88 crop year were from the DIS project and 2007/08 from the survey.

As for household income by source, the main income source of most farms households in irrigated area of Suphan Buri province not much change over last two decade, the main household income come from agricultural activity. However, the growth of the manufacturing and service industries has quickly expanded the non-agricultural sector and made non-agricultural income a more significant contributor to the farm household incomes in non-irrigated area (SP2). While, in SP2 village showed a huge decrease in the share of rice income declining from 58.3 percent to 2.8 percent of the total income during the study years. In SP3, the adoption of MVs and the change in the rice calendar gave the farmers the opportunity to grow two rice crops per year only in dry season. This resulted in raise income from rice farming in SP3 village, the share of rice income rose from 33.42 percent to 83.74 percent of the total income in 1987/88 and 2007/08 crop years, respectively.

As for the household income structure in Khon Kaen province showed that the non-agricultural income rose in all villages even as the percentage of the income from rice and agriculture income dipped. For remittance in 2007/08 crop year, KK3 village had the highest percentage of the household income contributed by remittances of family members working in other sectors: 18.25 percent, which was 13 percent higher than during 1987/88 crop year. The other villages in the same province had less remittance as a proportion of the non-agricultural income, because these are located near large industrial plants and are close to the urban zone of the province, which provided more opportunities for earning non-agricultural income. KK3's higher proportion of remittances reflected an intensified labor migration to other provinces as well as more labor migration from the villages in the non-irrigated areas than those in the irrigated areas. The household income structure presents an improvement

in the farmers' income in all the study villages; non-agricultural employment contributed a significant and increasing proportion of the farm household's income. Non-agriculture income contributed even more to households in non-irrigated areas and those living close to large industrial plants and urban zones. Nevertheless, rice farming still contributed the major portion of the total income of households in irrigated areas. They also tend to have higher incomes than the farmers in other areas.

Income Distribution and Poverty

Table 9 shows the result of Gini coefficient by source of household income and total income. The household income distribution has improved over time period; the Gini coefficient of household income distribution is increasing from 0.482 in 1987/88 crop year to 0.517 in 2007/08 crop year. This reflected the wider income inequality in the agricultural sector with economic development. The sources of income which contributed to the high rate of inequality in 1987/88 crop year are remittances, other farm income and non-farm income; the Gini coefficients are 0.910, 0.822 and 0.814 respectively. Inequality of non-agricultural income source tended to be less. The Gini coefficient declined from 0.803 in 1987/88 crop year to 0.599 in 2007/08 crop year. On the other hand, the income distribution of agricultural source worsened. The Gini coefficients of this source are 0.492 and 0.683 in 1987/88 and 2007/08 crop years, respectively. The inequality comes from agricultural hired labor income, other farm income and rice income.

Table 9 The Gini coefficient by income source, 1987/88 and 2007/08 crop years

Source of income	1987/88 crop year			2007/08 crop year		
	Income share (%)	Gini by source (G_k)	Correlation with rank of total income (R_k)	Income share (%)	Gini by source (G_k)	Correlation with rank of total income (R_k)
Agriculture	61.46	0.492	0.759	69.32	0.683	0.918
- Rice farming	38.08	0.473	0.652	43.56	0.796	0.843
- Other farming	16.66	0.822	0.729	19.97	0.847	0.662
- Agriculture hired labor	6.72	0.765	0.238	5.78	0.941	0.559
Non-agriculture income	38.54	0.803	0.816	30.68	0.599	0.447
- Non-farm activity	35.11	0.814	0.818	27.51	0.640	0.462
- Remittance	3.44	0.910	0.594	3.17	0.888	0.032
Total income	100.00	0.482		100.00	0.517	

Source: The data in 1987/88 crop year were from the DIS project and 2007/08 from the survey.

The sources of income that contributed to inequality of income in 1987/88 crop year were non-farm income, other farming income and rice income, which correlations with the total income are 0.818, 0.729 and 0.652, respectively. In 2007/8 crop year this inequality came from rice income, other farm income and agriculture hired labor income, which correlation with total income are 0.843, 0.662 and 0.559, respectively.

The estimates using different measures of poverty are reported in Table 10. For this study we used the absolute poverty line in income per capita (baht per year) as reported by the Office of the National Economic and Social Development Board. The poverty line used for this study was 14,922 baht per person per annum for 1987/88 crop year (converted into the value in 2007/08 crop year by multiplying it with the CPI=1.9651), and 17,316 for 2007/08 crop year. By applying these standards on the distribution of per capita incomes it was estimated that 68.48 percent of the populations in the study villages were poor in 1987/88 crop year, but sharply decreased to 14.47 percent in 2007/08 crop year. The head count measure thus shows an improvement in poverty situation during the 1987/88-2007/08 periods despite the growing inequality in the distribution of incomes. The incidence of poverty was much lower in the study villages in Suphan Buri province compared to the three villages in Khon Kaen province (more than 80 percent of populations in the KK villages were poor). However, for both provinces the head count measure showed an improvement in poverty situation. This was more clearly defined in Khon Kaen province because of the expanding urban and non-agricultural sectors, which gave the farm households more opportunity to earn non-farm income. The incidence of poverty was also lower in villages that have a well developed irrigation system, namely; SP1, SP3, KK1 and KK2 compared to rainfed and drought-prone villages, which shows that irrigation development would contribute to a poverty reduction.

The measure of the poverty gap index and square poverty gap index is in the same direction as the headcount index. The intensity and the severity of poverty have decreased over time in all villages, especially in Khon Kaen province where farmers can earn more income from non-farm activity. For irrigated development villages (SP3 and KK2), the poverty gap index (intensity of poverty) and square poverty gap index (severity of poverty) have also sharply declined.

Table 10 Measurement of poverty index by production environment, 1987/88 and 2007/08 crop years

Poverty index	Suphan Buri			Khon Kaen			All
	SP1	SP2	SP3	KK1	KK2	KK3	villages
1987/88 crop year							
Headcount ratio index (%)	26.67	60.71	63.42	81.63	87.04	86.00	68.48
Poverty gap index (%)	7.00	29.73	42.86	39.81	50.43	50.10	37.00
Squared poverty gap index (%)	2.88	18.66	31.49	24.39	34.24	33.38	24.33
2007/08 crop year							
Headcount ratio index (%)	10.00	38.89	5.71	7.14	9.76	17.65	14.47
Poverty gap index (%)	2.21	20.76	4.32	9.95	2.40	9.08	7.95
Squared poverty gap index (%)	0.61	17.62	5.58	27.30	0.94	5.82	9.81

Source: The data in 1987/88 crop year were from the DIS project and 2007/08 from the survey.

Conclusion and Recommendations

Rice production in Thailand has been changing continuously over the past two decades. The changes were marked by the adoption of MVs that allowed the planting of two to three crops a year; the rapid expansion in the rice farming area followed by an expanded irrigation service and higher cropping intensity that increased the demand for farm labor; and the adoption of farm machinery and development of labor saving innovations that reduced the use of manual labor. This latter development was spurred by the growing scarcity of labor and increasing wage rates for farm labor as a result of labor migration from the agricultural to the commercial, service and manufacturing sectors. The result was a dramatic decline in the use of manual labor and the sharp increase in machinery use.

The net return from dry season crop is higher than the wet season crop. The benefit from a higher cropping intensity has been the driver for farmers in irrigated area to continue producing rice despite the steadily decreasing profitability of rice farming. On the other hand, rice production in rainfed area is more for household food security than profitability. Even though the paddy price in 2007/08 crop year was higher than that of 1987/88 crop year, the higher increase in production cost than that in the output price lowered the profitability of rice production in the irrigated areas. In the rainfed areas the farmers suffered production loss. However, the income over cash cost of rice production is still greater than zero because most rice farmers own the land.

As for the household income structure, the non-agricultural sector contributed a significant and increasing proportion of the farm household's income. The share of non-agricultural income was higher in households in non-irrigated areas and those living close to large industrial plants and urban zones. Rice farming, however, still contributed the major part of the total income of households in irrigated areas. The same households also tend to have higher incomes than the farm households in the other areas. There was inequality in the distribution of income over time period and this inequality came from differences in incomes from rice, other farm income and agriculture hired labor income. Despite this growing disparity in income distribution, the poverty measurement shows an improvement in poverty situation during the 1987/88-2007/08 period. The incidence of poverty was lower in irrigated development villages compared to other villages, which shows that investment in the development of irrigation would contribute to poverty reduction.

The cost of rice production has been increasing over time, which has contributed to declining returns particularly in rainfed and drought-prone areas. Therefore, the most effective way to raise farmer income is to reduce their production cost. In this regard, the government should promote practices that reduce the cost of production without reducing yields, especially those that reduce the use of seed and fertilizer.

The income from agriculture is one of three major sources of income inequality while irrigation development is a significant factor to reducing farm household poverty. In this regard, investments in the development of irrigation systems in rainfed and drought-prone areas can help reduce poverty and contribute to a more equitable income distribution in the agriculture sector. The expansion of the development of irrigation systems can be one option to reduce poverty and contribute to a more income inequality, but this option takes time and requires a huge capital investment from government. And the water endowment in some areas may not make it technically feasible or economically feasible to establish irrigation systems similar to the one in the Central region. This raises the policy question as to whether it might be more technically efficient for Thailand to concentrate rice production in irrigated areas and encourage farmers in other regions to raise alternative high value crops. If this is not culturally or politically acceptable, a policy option would be to encourage the development of varieties that are even more drought tolerant than the ones now available, and culture systems that enable the use of less water to grow rice.

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