

Economic Aspects of Rice Combine Harvesting Service for Farmer in Northeast Thailand

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Abstract

Rice combine harvesting is popular among farmers due to a labor shortage and high wage labor. This condition impacts on the rapid expansion of business of rice combine harvester service. The objective of this research was to evaluate the service characteristics of rice combine harvester for farmer and factor affecting the use of combine harvester. Primary data was collected purposively 85 operators and randomly 729 farmers with statistic analysis. Results of the study indicated that the harvesting cost of 798.48 THB/rai for using a combine harvester in wet season is smaller than the cost of manual harvesting of 1,542.17 THB/rai. The important factors affecting the use of combine harvest were farmers' education, farm size and family size. Net return from this service business is over 250 THB/rai or over 35 % of total profit that it is economic benefit for operators. But, the operators faced high cost of fuel and of repair and maintenance cost due to unskilled operation. Thus, the government should establish a network of harvester service operators as well as encourage more maintenance training for local operator in order to high utilization efficiency in rice combine harvester. Also, the government should support farmer to expand their farm sizes by the establishment of a group farmer to easy access the use of rice combine harvester and should give wider farmer awareness education for higher adoption of combine harvester use.

Keywords: combine harvester, wet and dry season, service business, manual harvesting

1. Introduction

In Thailand, mechanization has played a key role in agricultural production, especially for rice combine harvesters due to labor shortages in rice harvesting. The combine harvester is economic and less labor machinery (Tahir et al., 2003) compared to manual harvesting that is laborious and costly (Hossain, 2015). The number of rice combine harvesters showed a significant increase from 6,780 machines in 2003 to 1,582,613 machines in 2013 (National Statistic, 2015) that more than 99% of rice combine harvesters are operated on custom-hire service basis (Thepent, 2014). Similarly, the numbers of combine harvesters in Viet Nam, Banglades and Sri Lanka have shown an increasing trend because of a high outflow of rural labor to urban areas leading to be a labor scarcity in rice harvesting period (Hossain et al., 2015; Shin Norinsha Co., 1971; Troung, 2010). For Northeast area, rice crop is one of the most important foods and economic crop covering approximately 38.9 million rais, or around 53.7% of agricultural area in the region and rice made up 42.3% of agricultural products from the Northeast area in 2014. In the same period, it was found that approximately 50.9% of rice production in the Northeast area was wet-season rice (over 80% of rice products in the Northeast area as jasmine rice) (Thai Rice Exporters Association, 2015). Rice harvesting in area is a significant issue for farmers because of labor scarcity and high labor costs leading to increase production costs during at the time of rice harvesting. In these regards, the number of agricultural labor has declined from 57.71% in 2001 to 36.30% in 2011 (Office of the National Economic and Social Development Board, 2014) because of the migration of agricultural labor to industrial sector and entering aging society; as a result, rice combine harvester services are popular among farmers. Rice combine harvester services have played an important role for harvesting wet-dry season rice in the Northeast area from rice harvester operators in local areas and other provinces. Some service operators from other regions would provide rice combine harvester services across the region, especially for farmers in the Northeast area because of the low competition and limited number of rice combine harvesters there (Chinsuwan, 2008). The use of rice combine

harvester helps to reduce the cost of labor in the process of harvesting and threshing significantly (Krishanaseranee, 1992; Hossain et al., 2015), and to reduce the loss of productivity if harvested at the right time (Chinsuwan et al., 1997). Based on the preliminary survey, recently, over 70% of farmers used the rice combine harvester in their paddy field in order to reduce cost and timely harvesting. This shows that farmers more adopt the use of rice combine harvester. Regarding, the adoption of technology in agriculture relies on socioeconomic characteristics and personal factors including age, years of education and size of the farm that make farmers' decision to use a technology (Rogers, 1995; Ouma et al., 2006; Feder et al., 1985). Moreover, the number of rice combine harvester has increased resulting in the high growth of business of rice combine harvester services. The harvesting operation depended on a custom-hire service basis (Tomohiro & Masayuku, 2002). Rice combine harvesters for service in surrounding villages, municipalities, and districts in rural Northeast area Thailand are small machines which can process an average of 10-30 rais per day depending on the condition of the rice, while rice combine harvesters from other areas such as Nakhon Sawan, Uthai Thani, Phichit, and Suphan Buri province are bigger and can process up to 40-50 rais per day. Therefore, it can be deducted that the business of rice combine harvester services can give high income for farmers who have been the operator of a combine harvester with high rate service charge. In the last year, the rice combine harvester's owner got, which was 800 THB per rai for wet-season rice and around 500-550 THB per rai for dry-season rice. The price difference is due to the level of difficulty in harvesting and the condition of rice. Normally, wet-season rice is more expensive because the rice is tall and difficult to harvest. In other words, it can be concluded that the service business of rice combine harvester has positive impacts to economic of operators in this areas.

Therefore, there are little researches which have been conducted on this issue in Northeast area Thailand. Thus, this study focuses on the service of rice combine harvesters for farmers that it is a challenging issue in the economic aspect and factor affecting farmers' use rice combine harvester. These results will be important for policy makers, extension officers and related agents to improve this business for farmers' benefits and use.

2. Method

2.1 Study Area and Sampling Procedure

The study areas were all 14 provinces in Northeast area Thailand. The data used were collected in two periods in wet season (November – December 2014) and dry season (April-May 2015) through a questionnaire distributed to smallholding farmers. The operators of rice combine harvester service and farmers were identified and selected through the multistage sampling technique. In the first stage, sub-district of each province in 14 provinces where the rice fields have been harvested through rice combine harvester services and where farmers harvested rice fields by labor was purposively selected on the advice of each Provincial Agricultural Officer in all 14 provinces. In the second stage, a village of each sub-district in all 14 sub-districts was purposively chosen due to a large number of operators who service rice harvesting in the rice field by rice combine harvester and a number of farmers who have harvested by either combine harvester or manual harvesting in wet season. In case of dry season, a village of each sub-district in 7 sub-districts where grew a lot of rice was chosen. In the final stage, four operators in wet season and three operators in dry season were randomly selected from each village that totaled 85 operators. Also, farmers who use a manual harvesting have been interviewed from 15-16 farmers of each village that total 229 farmers only in wet season. Moreover, farmers who use a combine harvester in rice harvesting have been randomly selected 14-15 farmers of each village in wet season that totaled 326 farmers and in dry season 16-17 farmers of each village were randomly sampled that totaled 174 farmers. Thus, there was a total sample size of 85 operators and of 729 farmers that total 814 farmers. Data analysis was done by using simple statistical analysis and t-test analysis.

In this study, in order to determine the factors affecting farmers' use rice combine harvesting the logit model was used and the model is specified as:

$$Y = \ln\left(\frac{P_i}{1-P_i}\right) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \varepsilon \quad (1)$$

Where

Y = dependent variable (1= using combine harvester, 0= not using combine harvester)

X_1 = the farmer's gender

X_2 = the farmer's age

X_3 = education level

X_4 = family size

X_5 = farm size

ε = the disturbance term

Positive coefficient of the independent variable (X_i) indicated the increasing use of rice combine harvester technology including male, older farmers, higher education levels and larger farm sizes while larger family size will have a negative impact on the adoption of the technology.

3. Results

3.1 The Characteristics of Rice Combine Harvester Service

In the Northeast area, rice combine harvester service can be divided into two groups: individual operators and group operators. First, individual operators of rice combine harvester services can be classified into two types (1) Rice combine harvester service operator from areas outside the Northeast area such as Uthai Thani, Prachin Buri, Ang Thong and Suphan Buri; the number of these operators has decreased to around 10% during the production year 2014/2015. This is due to the government policy of controlling service rates which has made transportation costs unviable for removing rice combine harvesting machinery in this area. In order to provide removing rice combine harvesters the brokers are needed to assist in gathering a large number of agricultural areas of rice harvesting for the operators because there are only 30-35 days of harvest for wet-season rice each year. The brokers play an essential role in this business, providing information for the decision making of operators to remote rice combine harvesters. Moreover, the role of the brokers affects the income of service providers from areas outside the Northeast as shown in Figure 1.

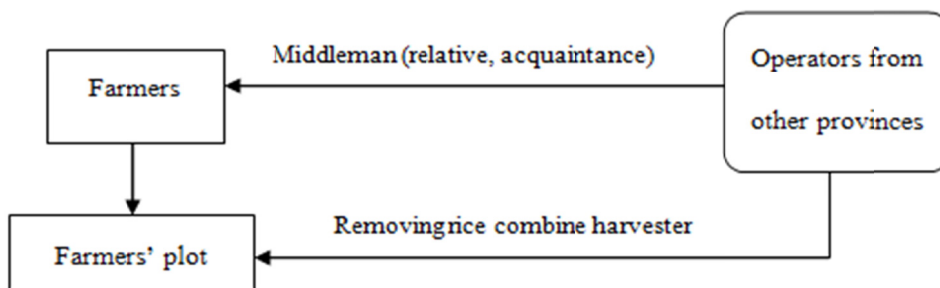


Figure 1. Service processes of operators from other provinces

(2) Rice combine harvester service operators from local areas: they do not have to tout businesses since the demand for this service has seen as increase in this area. However, in the beginning of harvesting season, these operators need to go to rice farms themselves to accumulate farmers' plots that need rice combine harvester services and also use the strategy of word of mouth to spread the news about their service among farmers. Service operators should thus more efficiently manage their harvesting areas in order to reduce costs of rice combine harvester transportation since the cost of fuel in the 2014/2015 production period was high. Also, these operators have to compete of with those from nearby areas (villages), nearby districts, and areas outside (provinces) the region. This competition is rather rare because local operators do not often cross each other's business lines unless farmers hire service operators from other areas to harvest their rice product. Moreover, the rice combine harvester operators' business depends on the farmer's demand for a rice combine harvester and their satisfaction toward the service operator. Farmers' satisfaction depends on the service given by each service operators and almost farmers find an operator who provides adequate service and then continually hires the same operator. There are no middlemen in these cases, but farmers directly and independently contact service operators. Second, rice combine harvester services community group means that rice combine harvester machinery is supported by government sectors in order to reduce costs for farmers of the rice community group in case of labor shortages in the harvesting process. The establishment of the rice community group was begun by gathering shares from farmers interested in investing and living surrounding community, each share costing 100 THB. A member cannot hold more than 20 shares (share restrictions are set by the group). As for now, there are 30 group members. This committee group acts as a broker in the rice combine harvester service business for members and non-members and the service rate is fixed by the government's policy. The driving of the combine harvester is managed by the committee and member group that must be transparent and verifiable. Dividends are given to members according to the net balance after expenditure in each harvesting period.

3.2 Hiring Mechanisms and Conditions of Rice Combine Harvester Service

There are two types of hiring mechanisms which are as follows: (1) hiring directly from service operators and (2) hiring through a broker. First, hiring directly from a service operator takes local operator gathering farmers who require rice combine harvester services in the beginning of the harvesting season (October) and spread the news about the services by word-of-mouth. Farmers contact local operators directly in order to secure their place on the queue. Farmers normally contact a local operator same as previous year because they have hired them previously and have been satisfied with the service. In some cases, when harvest is urgently needed, farmers choose new operators who can immediately respond to their needs. Generally, most local operators can harvest the rice at least 10-15 rais (1 rai = 6.25 ha) per day with their small or medium sized harvester machinery that they must harvest rice in time because they face competition with large harvesters sized operators who live outside village that can harvest up to 40-60 rais per day. Second, hiring through a broker is different from the first type because there is a negotiation between farmers and brokers. The brokers have played a role of gathering the rice fields and managing the queue for the service operators. Medium to large sized harvester can harvest between 20 and 40 rais per day, depending on the rice stalks in each field. The brokers have to be able to gather harvesting areas of at least 15-20 rais per day. Specialized drivers, who can take good care of the harvesters, harvest quickly and get high quality rice product, are also needed. For this type of hiring, the commission rates of middlemen fall under two conditions which are as follows: (1) If the brokers are able to collect the rice fields needing harvest according to the agreement, they will receive a commission of 30 THB per rai, with no other responsibilities, such as providing accommodation or food for the operator. (2) If the middleman charged with both collecting the rice fields to be harvested and preparing accommodation, food, and preparation of the service queue for the farmer and collection then the service rate will be 50 THB per rai.

3.3 Characteristics of Rice Combine Harvester Service Operators

Approximately 95.7% of service operators are local rice combine harvester service operators. Since labor costs were high, most operators decided to buy rice combine harvester machinery for household usage and for providing services. 4.3% of service operators were from other areas, contracting and providing service through relatives and brokers. They have an experience of service business of an average of 5.2 years. It was also shown that 50% of service operators were directly contracted by farmers in order to request service in the area while another 25% and 25% were service operators who contracted farmers through relatives or brokers and a village leader respectively. Around 25.8% of rice combine harvesters were small-sized harvester (500-800 kg.) that can harvest 14.1 rais/day. A 37.6% of mid-sized rice harvesters (1,200-1,500 kg.) can harvest 25.1 rais / day. The remaining was large-sized, with 2,800-3,000 kg. which can harvest up to 31.4 rais per day. The harvesting capability per year for all sizes in wet season is larger than in dry season (Table 1). It can be seen that the income from wet-season rice harvesting is higher than that for dry-season rice harvesting, since dry-season rice in the Northeast can only be grown in certain areas where water supply is sufficient. Moreover, the average number of drivers hired per harvesting period was around 1-2 people. The average number of additional laborers used was two laborers, whose main duties were rice filtering and binding rice sacks. Laborers were also used to maintain the machine, repair damaged parts, inspecting the rice farm together with farmers, and clearing the way for harvesting. Service operators harvested from October to December that the period with the highest demand was November.

Table 1. Rice harvesting capability sizes of rice combine harvesters

Item	Small-sized combine harvester	Mid-sized combine harvester	Large-sized combine harvester
Working capability (rai/day)	14.1	25.1	31.4
Working capability (rai/year)	636.6	860.7	1,028.9
Harvesting in wet season rice (rai/year)	597.4	578.3	689.4
Harvesting in dry season rice (rai/year)	39.2	282.4	339.5

3.4 Service Rates of Rice Combine Harvesters during the 2014/2015 Production Period

Generally, the service rate for this harvesting period would be lower than the service charge set by the rice combine harvester service controlling policy. However, in some case it was found that the rate was higher than the service charge estimated and set by the government because bent rice stalks are difficult to harvest and

farmers had to pay higher rates according to the agreement made by the farmer and service operators. In some case where the rate was higher than the charge estimate, it was due to the agreement between service operators and farmers which allowed the service operators to be able to quickly harvest their rice on time. The average service price of bent rice stalks was 714.51 THB per rai and for standing rice stalks was 630.64 THB per rai. The average service price of dry-season rice was 566.66 THB per rai and of wet-season rice was 542.85 THB per rai.

3.5 Harvesting Service Costs of the Rice Combine Harvesting Operators during the 2014/2015 Production Period

The estimated cost is over 360 THB/rai for all sizes that a large size combine harvester shows the smallest portion in both wet and dry season. It was found that the highest cost variable for all sizes of harvesters was fuel (Diesel) that of total variable cost it shows around 52.3%, 40.13% and 35.53% for small size, medium size and big size machinery respectively. The labor cost was the second highest cost variable for small and medium harvesters and the maintenance cost was the second highest cost variable for big harvesters. The net benefit is over 230 THB/rai for all size; in other words, the operators can obtain the net benefit over 35% of total benefit. Thus, it can be concluded that the service business of combine harvester is economical impact for operators (Table 2).

Table 2. Harvesting service cost of the rice combine harvesting operator during production year 2014/15

Items	Small-sized combine harvester	Mid-sized combine* harvester	Large-sized combine harvester
Variable cost (THB)	98,267.09	135,499.04	198,417.65
Repair and maintenance	13,446.33	39,436.84	40,400.00
Fuel (Diesel) for harvesters	51,410.00	54,378.95	70,501.35
Commission brokers including accommodation and food	-	-	4,625.00
Commission brokers excluding accommodation and food	2,541.67	-	1,925.00
Maintenance for handler	3,516.67	3,789.47	9,376.20
Fuel for handler	1,225.00	4,033.26	8,222.60
Wage labor including driver	11,889.92	19,134.21	24,287.50
Food	9,883.33	8,889.47	12,055.00
Wage of extra workers	4,354.17	5,836.84	27,025.00
Fixed variable (THB)	170,378.23	191,070.66	178,391.99
Depreciation of combine harvesters	126,757.93	110,649.12	133,512.47
Depreciation handlers	20,819.47	27,320.65	29,050.02
Interest rate	16,166.67	45,693.00	7,600.00
Taxes and insurance	4,190.83	3,523.68	1,480.00
The lubricant	2,443.33	3,884.21	6,749.50
Total costs (THB/year)	268,645.32	326,569.70	376,809.64
Average total cost (THB/rai)	422.20	379.42	366.23
Average total profit (THB/rai)	655.97	619.86	620.38
Net profit (THB/rai)	233.77	240.43	254.16

Note * most are secondhand machinery

3.6 Comparison of Rice Harvesting Cost between Labor-Intensive Harvesting and Rice Combine Harvester Machine

Manual harvesting is labor intensive. Farmers who choose to harvest in-season rice fields by labour have average area of rice cultivation were 14.89 rais with 284 kg/rai under the moisture of 15% that need to use an average of

0.55 rai/hr or consumed 3-4 days/household. From harvesting to threshing and moving the rice into the barn, the number of hours used per household per rice field is 22.94 hours or approximately 1.58 hours per rai. However, farmers who used combined harvesters have an average rice field of 19.09 rais with 383 kg/rai under the moisture of 18-21%. The combine harvesting operation took 1.5 days/household or 2 rais/hr with small machine. Moreover, the average of harvesting cost by manual harvesting shows 1,542.17 THB/rai while in case of rice combine harvester it costs 798.48 THB/rai for wet-season rice and 658.38 THB/rai for dry-season rice (Table 3 and 4). Thus, it confirmed that farmers who use manual harvesting paid significantly higher harvesting cost than farmers who use rice combine harvester ($t = 6.363$, $p < 0.01$) (Table 5).

Table 3. The cost of manual harvesting method

Items	Amount (Baht/rai)	Percentage
Harvesting	822.89	53.4
Heaping in the field	170.07	11.0
Heaping at threshing plot	128.20	8.3
Threshing cost (Thresher)	119.59	7.8
Threshing and carrying to barn (Manual labor)	72.34	4.7
Winnowing and transport from farm to barn	33.61	2.2
Fuel for transporting labor to farm	20.51	1.3
Material cost	11.93	0.8
Food	112.98	7.3
Drinking	50.05	3.2
Total	1,542.17	100

Table 4. The costs of rice combine harvesting method

Items	Average cost for wet season rice (Baht/rai)	Percentage	Average cost for dry season rice (Baht/rai)	Percentage
Harvesting by rice combine harvester	551.69	69.1	530.80	80.6
Extra labor wage	3.99	0.5	1.50	0.2
Heaping at drying plot	28.15	3.5	4.62	0.7
Rice drying wage	72.47	9.1	17.67	2.7
Bagging wage	44.75	5.6	5.80	0.9
Labor wage for carrying rice to sell	6.67	0.8	2.07	0.3
Car service for carrying rice to sell	30.41	3.8	90.27	13.7
Fuel	10.53	1.3	1.06	0.2
Material cost	14.92	1.9	-	-
Food	22.04	2.8	4.38	0.7
Drink	12.79	1.6	0.24	0.04
Total	798.48	100	658.38	100

Table 5. T-test of rice harvesting cost between manual harvesting and rice combine harvester

T-test of harvesting cost	t-ratio	Df	Sig.(2-tailed)	Mean	Std. error difference
Manual harvesting	6.363	352	0.000***	403.36	63.392
Rice combine harvesting					

Note: *** = significant at $p < 0.01$

In other words, the rice combine harvester can minimize the harvesting cost. However, although the rice combines harvester can save cost and is timely harvesting it has problem the grain loss in harvesting. Harvesting by rice combine harvester would lose approximately 1-2 sacks/rai (25-30 kilograms per sack) of rice or around 6-8% compared to manual harvesting of 10-15 kg/rai or around 3-5% that fall into the fields. Moreover, the majority of farmers (58.1 percent) agreed that there was less contamination in the rice that had been harvested by labor. However, 38.3 percent of farmers commented that there was contamination in the in-season rice, and 60.3 percent said that there was contamination in double-cropped rice that had been harvested using combined harvesters. This was due to the fact that double-crop fields had been planted by sowing which resulted in a high probability of contamination by weeds or grass.

3.7 Factors Affecting Farmer's Use of Rice Combine Harvester

The important factors affecting farmers' use of rice combine harvester were farmers' education, family size and farm size. The regression model results explain that education and farm size are positive and significantly (at 1% level). Farmers with higher education were more likely to use a rice combine harvester those with lower education. Also, farmers with larger farms are more likely to use rice combine harvester compared with those with small farmers who devote to harvest in some part of their fields. However, family size is negative and significantly (at 1% level). This indicates that with increasing size of the family, the probability of farmers' adoption of rice combine harvester decreases. The large family size can make more labor to harvest rice in the field (Table 6).

Table 6. Factor affecting farmers' use of rice combine harvester

Explanatory variable	β	SE	Sig.	Wald	Exp (β)
Constant	1.627	0.566	0.004***	8.270	5.091
Sex	0.167	0.175	0.341	0.908	1.181
Age	0.002	0.008	0.824	0.049	1.002
Education level	0.849	0.232	0.000***	13.389	0.428
Family size	-0.210	0.072	0.003***	8.627	0.810
Rice cultivated area	0.027	0.007	0.000***	14.619	1.027
Chi-square				36.671***	
Overall cases collectly				69.80	
Nagelkerke R ²				0.469	
Number of observation				729	

Note: *** = significant at $p < 0.01$

3.8 Problems and Obstacles of Rice Combine Harvester Service Basis

There are a number of problems and obstacles in this type of business. Service operators are faced with the high cost of fuel (Diesel) and high labor costs for skilled laborers. Moreover, they are also faced with obstacles in terms of unsuitable farming areas. These problems and obstacles have affected their services as follows: 1) Service operators who provide rice combine harvester services have faced a lack of skilled labor to efficiently drive the harvesters, and improper operation of the combined harvester can result in damage or a break down. 2) The wages, which have increased according to the agreement between service receivers and operators, are not in accordance with the criteria announced by the government. 3) The small sizes of rice farms have made it difficult to drive the rice combine harvester. The rice fields are small, rendering it difficult to turn the harvester. This is different from the lowlands in the central part of Thailand, where fields are large, easy for harvesting, and combined harvesters can be easily maneuvered. The small fields cause frequent break downs and damage to the combine harvesters and therefore, high repair costs as well. 4) Harvesters have come upon unexpected stub, which farmers neglected to inform service operators before harvesting. 5) Finally, the high cost of replacement parts and longer time. When equipment has broken, it has spent more money and taken time to repair because of a lack of proficient local mechanics.

3.9 Approach of Development of Rice Combine Harvester Service Basis in Northeast

The development of the combined harvester service business in the Northeastern region of Thailand is considered essential because its business is currently autonomous and non-systematic, and there is a high degree of competition. If there were systematic guidelines, aimed towards developing a combined harvester service business that could reach out to the farmers in all of the rice field areas, strength and sustainability for the combined harvester service business could, therefore, be created as shown in the development system (Figure 2). A system has been established by creating a network of rice harvester contractors at the Northeastern regional level that consists of combined harvester contractors on provincial, district, and sub-district levels. The purposes of the system are as follows: 1) to compile data on harvesting areas in the area, 2) to carry out the timely harvesting plans, 3) to provide zoning for the combined harvester operators in each area, and 4) to establish harvesting queues, as well as service rates. In order to be clear about which operators conduct business in which areas, operators in the Northeastern region will need to register and set up groups within each province, district, and sub-district.

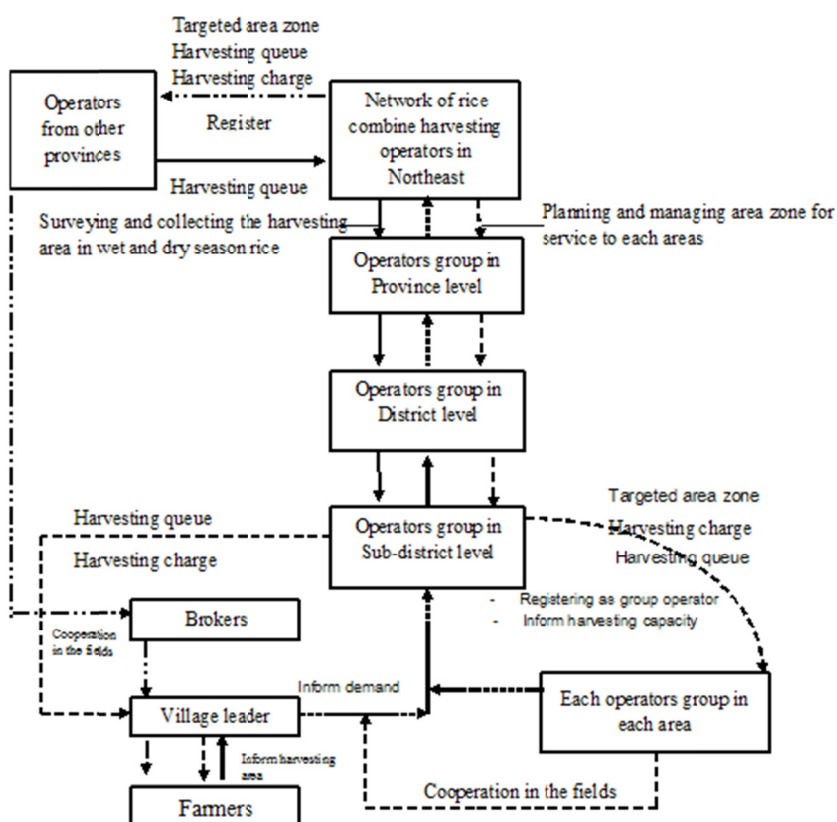


Figure 2. Approach of service business development of rice combine harvester in Northeast Thailand

In order to increase competition, the government should support marketing development for the combined harvester service. This may be accomplished by creating mid-term and long-term credit measures and by registering combined harvester operators in order to create networks. In addition, to set up regional repair and maintenance centers for combine harvesters, there should be support in the form of loans for the private sector. This would reduce repair and maintenance costs for the operators and would allow the operators to immediately use the combined harvesters that had been well maintained, without having to wait for the company representative to come for the repairs. Furthermore, the government should promote operator training on combined harvester repair and maintenance. Also, the advice should be given on suitable engine speed level that should be used while harvesting.

4. Discussion

Based on the result, almost farmers in Northeast area Thailand used the services of rice combine harvester that

the important factors of combine harvester adoption are higher education, larger farm size and smaller family size accordance with the finding of Feder et al. (1985), Mohammed et al. (2000), Truong (2008) and Tiamiyu (2009). This result has given rise to increase the trend of rice combine harvester service business in wet and dry season. This businesses need investment capital that most operators have a revolving fund within their businesses and they also tend to buy either a new rice combine harvester on credit or a secondhand rice combine harvester. The net income for operator of combine harvester service is over 35% for all sized rice combine harvester. It is important to point out that the service charge of combine harvester in wet season more than one in dry season around 20% due to soft-mudded rice fields making harvest difficulty. Regarding, the combine harvester can reduce the labor requirement while manual harvesting is labor intensive like the study of Hossain et al. (2015), Chinsuwan (2001) and Krishnasreni and Kiatwat (1998). In other words, the harvest cost of harvesting for rice combine harvester is lower than manual harvesting consistent with El-Haddad et al. (1995) and Veerangouda et al. (2010). Thus, the cost combine harvesting can be minimized leading to higher net benefit and lower cost compared to manual harvesting associated with El-Haddad et al. (1995), Mohammed (2000) and Praweenwongwuthi et al. (2010). However, the grain loss still has occurred around 6-8% in using combined harvesters that farmers are worried about hastening the combined harvesters resulting in grain losses. This result is in accordance with the study from Kittiya et al. (1990) and Bala et al. (2010), where it was found that the average loss from using combined harvesters in Thailand is 3.63% while it is an average of 6.25 % of losses (Chinsuwan et al., 2001). From the study of Manthamkan et al. (1992) and Kamel (1999), the speed in using the harvester also has an impact on loss. If slow (0.469-0.482 metres per second), grain loss will be 3.75-5.96%. If fast (0.787-0.807 metres per second), grain loss will be 4.85-8.00%. From these viewpoints, it can be concluded that rice combine harvesting is a higher net income and lower cost compared to labor harvesting.

5. Conclusion

The important factors affecting farmers' use rice harvester have included farmer education, farm size and family size. The farmers with higher education, farm size and smaller family size factors affecting in using rice harvesting. Moreover, the service business of rice combine harvester gives a higher benefit for operators in economic impact. This business has shown an increasing trend due to a high demand of farmers who adopt a rice combine harvester to harvest rice fields due to less loss and cost, timely harvesting. However, operators of combined harvesters face the problem of lack of labor to efficiently drive the harvesters, and improper operation of the combined harvester can result in damage or a break down. Operators face rising fuel costs and the small fields that cause frequent break downs and damage to the combine harvesters and therefore, high repair costs as well resulting in their income. Thus, the government should prepare low interest rate of loan money for old and new operators and encourage more training of maintenance machinery for local operator in order to high utilization efficiency in rice combine harvester as well as the establishment of local maintenance center of rice combine harvester. Additionally, a network of Northeastern combined harvester service operators should be formed to create approaches to promote the business in the Northeastern region, to develop organizational strength, and to increase the sustainability of the business in the Northeastern region.

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