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FARM MECHANIZATION AND ITS IMPACT ON LABOUR USE AMONG RICE FARMING HOUSEHOLDS: AN EXPERIENCE FROM THAI BINH PROVINCE IN VIETNAM

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A R T I C L E   I N F O

A B S T R A C T

This study uses the primary data collected from 40 rice farming households in Thai Binh province principles to evaluate the current situation of farm mechanization and its impact on labour use in rice farming households. By combining quantitative and qualitative methods, this study bases on the small sample of rice farming households to analyze the situation of rice production including rice cultivation area, rice yield, production cost, and machinery application in rice farming activities. Moreover, with the application of a multiple regression model, this study affirms that farm mechanization encourages households to enlarge their rice farming scale as it helps to compensate for the shortage of farm labour as well as increase land productivity. At the same time, the movement of labour from the farm sector to the non-farm sector and land consolidation are some of the driving forces that speed up the farm mechanization process. In Thai Binh province, farm mechanization also plays a significant role in increasing farmer income as it supports family labourers to spend less time on farming but more time in doing off-farm work with higher earnings. Finally, based on the results of the analysis, this paper provides four policy implications that expect to the development of farm mechanization in Thai Binh particularly as well as in Vietnam generally.

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INTRODUCTION

Farm mechanization implies the use of various power sources and improved farm tools and equipment. The purpose of farm mechanization is to reduce the drudgery of human beings and draught animals, enhance the cropping intensity and the precision, timeliness and efficiency of various crop inputs, and reduce the losses at different stages of crop production. In other words, the objective of farm mechanization is to enhance overall productivity and lower the cost of production (Verma, 2006). There are two types of labour in agricultural production: family farm labour and hired labour. Mechanization affects both sources of labour, but in slightly different ways (Schmitz and Moss, 2015).

Vietnam has experienced rapid growth in agricultural mechanization lately. In other words, the use of agricultural machinery in Vietnam has seen positive progress in recent years. However, the level of mechanization remains low in comparison with other countries in the region such as Thai Land, China, and South Korea. In rice production, the level of comprehensive mechanization of cultivation stages is rather low and concentrated only on land preparation, threshing, water pumping and rural transportation. Likewise, the level of mechanization in the transplanting, sowing and reaping stages is also low (Nguyen, 2019).
Thai Binh is one of the 10 provinces in the Red River Delta and has the largest area of paddy rice. Annual

statistical data in 2020 shows that the area of paddy rice in Thai Binh is 78 thousand hectares in the summer season and 76.2 thousand hectares in the spring season; the average productivity is about 7.1 tons per hectare which is higher than the rice productivity of other provinces in the Red River Delta (Thai Binh Statistical Office, 2020). Despite the large rice area and high productivity, labour in rice production in Thai Binh has gradually decreased due to the movement of labourers from farm to non-farm sectors. This movement results in the shortage of farm labour, and so it has strongly promoted the mechanization of rice farming. According to the Thai Binh Department of Agriculture and Rural Development, in the past ten years mechanization of agricultural production has achieved many positive results, gradually improving economic efficiency for farm households, especially for those in rice production under the context of family farm labour shifting more and more to off-farm activities. Nevertheless, the promotion of farm mechanization in Thai Binh is still facing many difficulties due to the limited capital for machinery investment and the fragmentation of rice fields (Department of Agriculture and Rural Development of Thai Binh, 2019).

Taking into account all the facts mentioned above, this paper aims to clarify the current situation of farm mechanization in rice farming and its effects on the labour use of rice farming households in Thai Binh province. Based on this current situation, this paper is expected to propose solutions for increasing farm mechanization to improve rice farming economic efficiency as well as overcome the shortage of agricultural labour in rice farming households. Except for the introduction section, the following sections of this paper include a literature review; research methodology; results and discussion; and conclusion.

LITERATURE REVIEW

Farm mechanization is commonly observed among emerging economies in which rapid industrialization is occurring as in the Asia region (Sakata, 2020). In most Asian agriculture-dependent economies, the role of farm mechanization in improving land productivity, labour productivity, crop yield and farmers' income is undeniable and recognized in many studies. For example, there was a study implemented by Orawan (2012) and his colleagues in Thailand that investigated the effect of the adoption of farm mechanization on

labour use, rice yield and labour productivity. Using multivariate analysis of variance, the authors found strong evidence that "small farms have the highest labour usage while large farms have the lowest average labour usage per hectare" (Srisompun *et al.*, 2019) . Also related to rice production, in the research on the mechanization of small-scale farms in South Asia, Aryal *et al.* (2021) and his colleagues used a primary dataset collected from a survey of 2528 rice farm households in Bangladesh, India, and Nepal from 2013 to estimate a multivariate probit model to identify the factors affecting the adoption of farm machinery by farmers. According to the authors, "farmers use different types of farm machinery concurrently to cope with the scarcity of labour, especially during the period of a labour shortage; as a result, their choices of farm machinery are likely to be correlated" (Aryal *et al.*, 2021). There was another research on rice farming was conducted in Nepal to investigate the impacts associated with the adoption of mini-tillers for land preparation on smallholder rice yield. In this research, the authors used "an endogenous switching regression that accounts for both observed and unobserved sources of heterogeneity between mini-tiller adopters and non-adopters". Consequently, they found that "rising on-farm rural wage rates and an emerging decline in draft animal availability are driving adoption of the mini-tiller" (Paudel *et al.*, 2019).

It can be said that many of the debates surrounding mechanization in countries with a large share of rural populations concern the impact of tractors on labour issues. In a society where there are both large and small farmers, tractors can be essential for expanding the aggregate area cultivated by large farms, for whom hired labour represents a high proportion of their production cost. As a result, the first tractor owners in most developing countries are typically larger farmers, who also provide hiring services to non-owners when it helps them maximize their tractors' utilization (Diao and Takeshima, 2020).

In addition, tractors permit seasonal shortages of labour to be overcome and they release labour in critical periods for other productive tasks or they reduce the cost of hiring seasonal labour (Ellis, 1993). For example, mechanized ploughing significantly reduces the amount of labour required for land preparation and typically results in small decreases in the labour required for weeding and harvesting in rice production (Pingali *et al.*, 1988). When the scarcity of hired labour, especially in

peaking season, increases the share of production costs, even small farmers must apply mechanization technology to reduce their labour and total production costs. A study in Ghana found that hired labour represents 40% of paid input costs compared to 28% for fertilizers, such a large share of hiring labour cost forces farmers to the high demand for mechanization (Diao and Takeshima, 2020). In other words, machinery is commonly used in agricultural production throughout developing countries instead of hired labour. As a supplementing factor of family and hired labour in agricultural production, mechanization can impact the labour usage of farm households.

In Vietnam, some previous studies have examined the factors which facilitate the use of agricultural machines (Liu *et al.*, 2016; Takeshima *et al.*, 2019). Most of the current literature is concerned with the economic and technical efficiency of machines adoption in crop production, and factors affecting machines adoption by farmers like non-agricultural wage, farm size, land productivities, education of household heads, etc

(Sakata, 2020).

However, there is still a lack of analysis on the relationship between farm mechanization and labour usage in rice production in the Red River delta, while the Red River delta is a rice basket of the country. To fill this gap, the main purpose of this paper is to examine how to farm mechanization impacts the use of labour in rice farming households in Thai Binh province.

MATERIALS AND METHODS
Study area and its description
Thai Binh is one of the 10 provinces in the Red River delta of Vietnam where agricultural production still plays an important role. According to the Thai Binh statistical office, compared with the remaining 9 provinces in the Red River Delta, the agricultural sector contributed the greatest amount to the provincial GDP of Thai Binh in 2019 (Figure 1). Among crops, rice occupied more than 58 percent of the total production value of crop production in Thai Binh (Thai Binh Statistical Office, 2020).
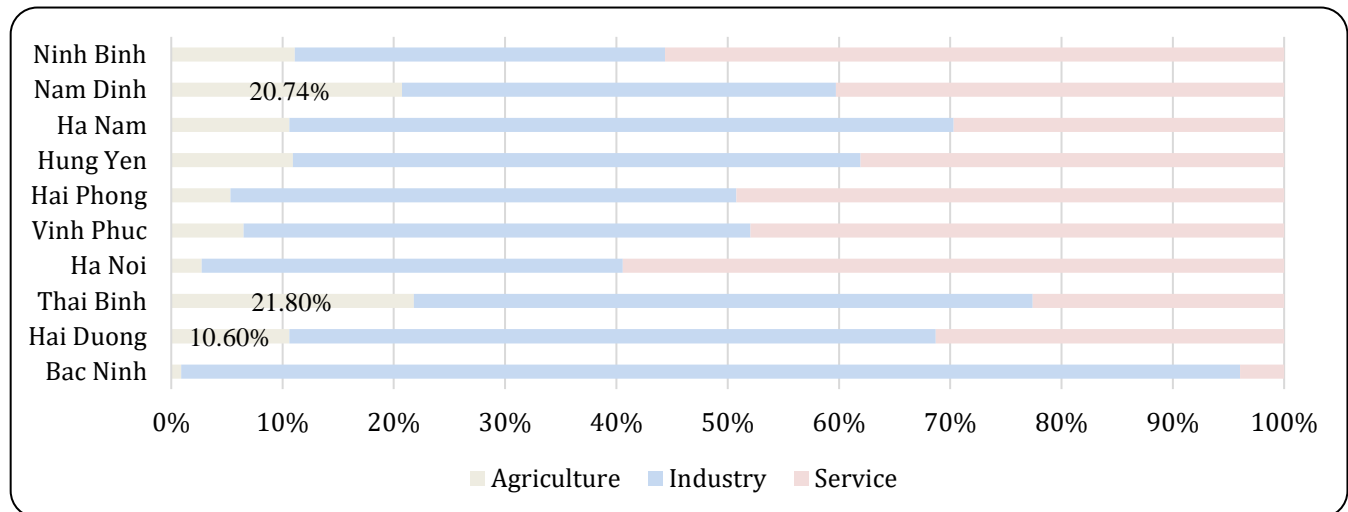

Figure 1. The GDP share of Thai Binh and other provinces in the Red River delta in 2019.

Source: Thai Binh statistical office (2020)

Rice is popularly cultivated in seven districts of Thai Binh province. Of these districts, Thai Thuy is the one having an advantage in land for producing rice. It is the largest district of Thai Binh with over 13,000 hectares of rice cultivation area (Figure 2). However, it locates at a distal end of the province, which is far from the economic centre and is limited in infrastructure for developing industry. Therefore, people in this district

have fewer opportunities to work off-farm, and agricultural production, especially rice cultivation, is still important for their living.

The author selected this district to conduct the study with the expectation that the lower the chance for farmers to work off-farm, the higher the probability for them to work manually on the family farm without machines adoption.
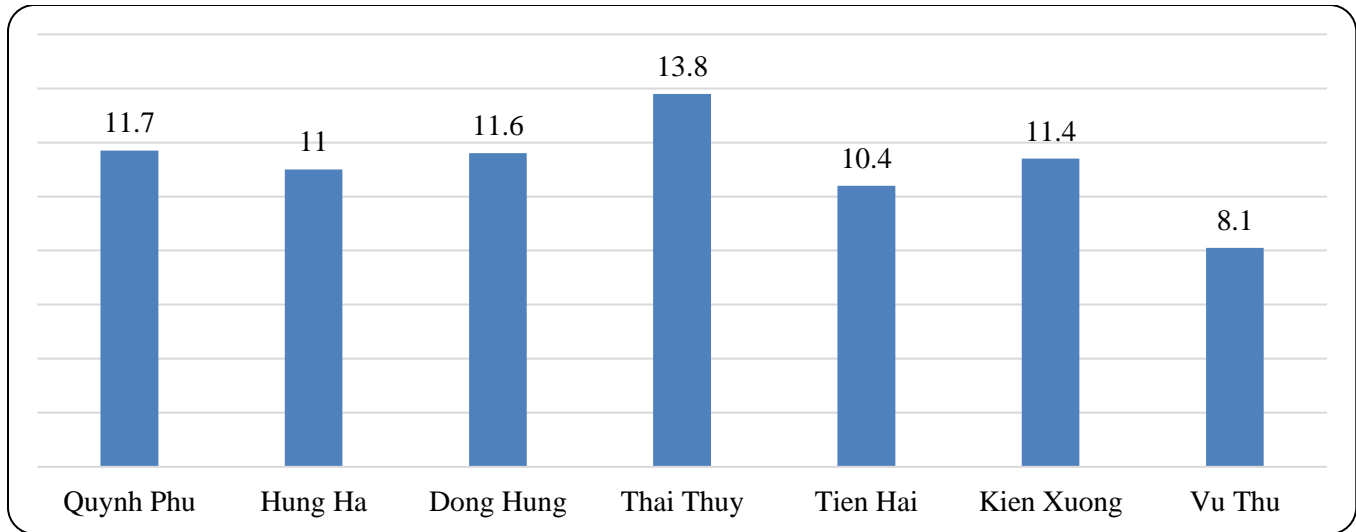
Figure 2. Distribution of rice land area (thousand ha) in Thai Binh province in 2020.

Source: Thai Binh statistical office (2020)

In contrast with Thai Thuy, the Vu Thu district locates just about 7 km from Thai Binh city. The transportation system there is convenient to develop non-farm activities. The total rice production area of Vu Thu is about 8,000 hectares (Figure 2). The means of living of people there are a combination of non-farm activities and rice cultivation. Because of such contrast, Vu Thu is selected in the study to test the hypothesis that the more farmers engage in off-farm activities, the more machines they tend to adopt in rice production.

Sample selection and sample size
The sample size is a significant feature of any empirical study in which the goal is to make inferences about a population from a sample. To generalize from a random sample and avoid sampling errors or biases, a random sample needs to be of adequate size (Taherdoost, 2017). What is adequate depends on several issues which often confuse people doing surveys. This is because what is important here is not the proportion of the research population that gets sampled, but the absolute size of the sample selected relative to the complexity of the population, the aims of the researcher and the kinds of statistical manipulation that will be used in data analysis. This study applies both qualitative and quantitative methods to examine the impacts of farm mechanization on labour use in rice farming households, therefore the sample size used is relatively small but enough to have significant statistical results.
Among rice farming households in the Thai Thuy and Vu

Thu districts, a total of 40 rice farming households were opted for interviewing. Of them, 20 households are from the Thai Thuy district and 20 others are from Vu Thu. The author selected 20 households in each district using simple random sampling. Simple random sampling is a method that which the selection is made purely by chance. In other words, the probability of a person being selected is independent of the identity of the other people selected (Fox *et al.*, 2009). Based on the list of rice farming households provided by local leaders, these 40 households were also selected by their rice-farming areas and separated into a large-scale group with more than 0.29 hectare (8 'sao') of rice plots and a small-scale one (less than or equal to 0.29 hectare). This threshold of 0.29 hectares is selected based on research findings of Hegazy *et al.* (2013) who identified that the average farm size of rice farming households in Vietnam is 0.2 hectares (Hegazy *et al.*, 2013). After the selection, the survey sample in Thai Thuy consists of 9 large-scale and 11 small-scale rice farming households; the survey sample in Vu Thu has 5 large-scale and 15 small-scale rice farming households. The number of small-scale households is more than the number of large-scale households is because small-scale households contribute the larger proportion of total rice farming households in these two districts.

Data collection
Secondary data: Secondary data about rice farming and mechanization in rice farming are collected from

previously published studies and reports of Thai Binh province, and of Thai Thuy and Vu Thu districts.

Primary data: Primary data about mechanization in agriculture and its impacts on labour use in rice farming households were collected by interviewing householders with questionnaires and in-depth interviewing several rice farming householders and local leaders who in charge of the agricultural sector with a check-list.

At first, the draft questionnaire was developed. The draft questionnaire was then be pre-tested through interviews of 2 rice farming households in Thai Thuy for its appropriateness. Pre-testing aims to test the questionnaire to find out if questions are understood and the questions are in a logical order (Shoo, 2011). The questionnaire was then revised and adjusted based on the responses during the pretesting. Some questions were reformulated to make them easier to understand.

After having a standard questionnaire, the author gathered primary data through a field survey of 40 rice farming households. The survey was performed in April, missing information was gathered more in May 2020. The main purpose of this field survey was to gather both qualitative and quantitative information on (1) general information of the households such as gender, age, and education of householders, family size, farm size, type of households by income levels (poor, medium or better-off) and by farming activities (only farming or mix of farming and non-farming); (2) rice production of the farm households including many rice land plots, rice land area, rice yield, rice production investment and cost, etc.); (3) labour use and machines adoptions in rice farming (working hour, type of machines, renting price, etc.).

In addition to the field survey, in-depth interviews using a checklist were performed with 2 rice farming householders and 2 local leaders in each district. In-depth interviewing is a qualitative research technique that involves conducting intensive individual interviews with a small number of respondents to explore their perspectives on a particular idea, program, or situation. The primary advantage of in-depth interviews is that they provide much more detailed information than what is available through other data collection methods, such as surveys (Boyce and Neale, 2006). Thus, in-depth interviews were applied in this study with aim of understanding rice farming householders' attitudes towards the impact of farm mechanization on labour usage. Furthermore, in-depth interviews with local leaders helped the author get their ideas on the advantages and disadvantages of farm mechanization in the study sites.

Data analysis

The collected data was entered into SPSS files, and then checked and cleaned by going through each questionnaire. Missing values were also checked by running frequencies on each variable. After cleaning the data, the author started to analyse data using the descriptive statistics method and some statistical tests. T-test and Mann Whitney U-test are used to test the difference in the mean between the two rice farming groups. Mann-Whitney U test is the non-parametric alternative test to the independent sample t-test. It is a non-parametric test that is used to compare two sample means that come from the same population and used to test whether two sample means are equal or not. Usually, the Mann-Whitney U test is used when the data is ordinal or when the assumptions of the t-test are not met.

Empirical Model

Econometric methods such as a regression model can help to overcome the problem of complete uncertainty and provide guidelines on planning and decision making (Asteriou and Hall, 2016). In other words, the statement of a "model" typically begins with an observation or a proposition that one variable "is caused by" another, or "varies with another," or some qualitative statement about a relationship between a variable and one or more covariates that are expected to be related to the interesting one in question (Greene, 2012).

As mentioned in the literature review section, many studies in farm mechanization have applied econometric models to quantify the correlation between farm mechanization and other factors such as land productivity, labour productivity, labour use, crop yield, farm size, etc. Among these econometric models, the author follows the multiple regression model used by Rahman *et al.* (2011) which helped him to identify the factors affecting the labour requirement for wheat cultivation in Bangladesh (Rahman *et al.*, 2011). To explore the impact of farm mechanization on labour use in rice production at households in Thai Binh, the author employs this multiple regression model as follows:

$$Y = a + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5$$

Where;

Y: Labour use (hours/ha), including family and hired labour working hours (8 hours equivalent to 1 man-day)
X_1: Machine use (hours/ha), the hours' use of machines per farm household
X_2: Output (millions Vietnam dong/ha), the total value of rice produced by a farm household
X_3: Input (millions Vietnam dong/ha), the costs incurred on inputs were measured in terms of the prices paid by respondents for each input
X_4: Dummy (1 for large scale, 0 for small scale)

X_5: Dummy (1 for Thai Thuy, 0 for Vu Thu)
Not only applying the quantitative method, but the author also uses qualitative analysis based on stories that are told by the farmers themselves to emphasize the influence of mechanization on labour use in each rice farming household.

RESULTS AND DISCUSSION
Farm mechanization in rice farming households
Current situation of rice farming in the study sites

Table 1. General information on rice farming of surveyed households.

Item	Large scale	Small scale	Mean Different	T-test
	Thai Thuy			
Rice area (ha)	0.52	0.26	0.26	1.37*
Yield (tons/ha)	5.75	5.70	0.05	1.50
Production cost (mil. Vietnam dong/ha)	23.74	21.40	2.43	2.12**
Machinery hired	8.61	6.95	1.66	1.75***
(mil. Vietnam dong/ha)	(36.26%)	(32.47%)	(3.79%)	-
	Vu Thu			
Rice area (ha)	0.45	0.21	0.24	1.12**
Yield (tons/ha)	5.70	5.67	0.03	0.90
Production cost (mil. Vietnam dong/ha)	24.13	22.57	1.56	3.29**
Machinery hired	7.67	6.51	1.16	1.91*
(mil.VND/ha)	(31.78%)	(28.84%)	(2.94%)	-

Source: Survey data (2020)
Note: ***, **, and * indicate significance at 1, 5, and 10 percent respectively.

In Thai Binh province, there are 277 communes and towns where people are farming. On average, the agricultural land area of each commune is about 500 hectares and the rice production area is 0.17 hectares per household (Thai Binh Statistical Office, 2020). However, the actual rice farming area of a household may be higher or lower than the average number, because many households lend or rent their plots out to others due to different reasons (e.g. several households lack labour, some others do not want to cultivate but still want to keep their rice land) (Lee and Lan, 2011). In the Thai Thuy district, the rice farming area of a household in the large-scale group is 0.52 hectares which are twice as large as the area of a household in the small-scale group; a similar happens in the Vu Thu district (Table 1). In both districts, households who rent more land to produce rice are the ones producing on large scale (about 60 percent of the interviewed householders replied that they rented additional plots from others to

cultivate rice).
They think that they can expand because rice cultivation is now not as hard as before. Since land consolidation in Thai Binh had been completed, it was more convenient to use machines in agricultural production. That helps farmers to reduce labour use and encourages them to extend cultivation areas. In both Thai Thuy and Vu Thu, the cost of renting machines occupies over 30 percent of the total rice production cost. Especially, it occupies 36 percent of the production cost of households in the large-scale group in Thai Thuy. Moreover, there is a statistically significant difference in the machine renting cost of the large-scale and the small-scale groups. That indicates the role of mechanization in expanding production areas in the surveyed households.

Machines application in rice farming households
Agricultural production in general and rice production, in particular, includes many activities such as land

preparation, planting, applying fertilizer, watering and harvesting. Currently, there are about 9,500 manual tractors (2-wheel) and mid-size tractors (4-wheel), which assure that 100 percent of rice production areas are ploughed by machines. Besides, watering for 100 percent of the rice areas is actively controlled by pumping stations and harvesting of all areas is done by

combined harvesters. Results are endorsed by Reardon *et al.* (2014) who pointed out that 100 percent of land preparation and harvesting works are done by tractors and combined harvesters in the Mekong delta (Reardon et al., 2014). In another study, there is an estimation that 70 percent of rice farming areas in Vietnam are ploughed by tractors (Takeshima *et al.*, 2019).

Table 2. Distribution of households applying machines in rice farming.

	Thai Thuy		Vu Thu	
Rice farming activities	Large scale (n=9)	Smale scale (n=11)	Large scale (n=5)	Smale scale (n=15)
Plouging	100%	100%	100%	100%
Transplanting	30%	0%	0%	0%
Weeding	0%	0%	0%	0%
Irrigation	100%	100%	100%	100%
Pesticide spraying	0%	0%	0%	0%
Fertilizer applying	0%	0%	0%	0%
Harvesting	100%	100%	100%	100%

Source: Survey data (2020)

In the past, many steps in rice cultivation were performed manually such as seed steeping and incubation, planting baby rice plants, plucking baby plants and bringing them to plots for transplanting. Nevertheless, such manual steps are currently being replaced by machine transplanting or in-row sowing in many places in Thai Binh. The application of machines for transplanting is observed differently amongst districts of Thai Binh. In the summer crop of 2020, only 30 percent of the surveyed households in Thai Thuy used machine-transplanting services while 100 percent of the households in Vu Thu still sowed manually (Table 2). Farmers in Vu Thu explained that they sow by themselves to reduce production costs because the cost of machine-transplanting service is relatively high (250 thousand Vietnam dongi per 'sao'). According to farmers, sowing takes fewer man-days than manually transplanting, which helps farmers in Vu Thu save their time for doing off-farm jobs. On the one hand, sowing saves farmers time and labour costs. On the other hand, local leaders in Vu Thu say that sowing prevents farmers from well pesticide spraying and weeding and so reducing rice productivity.

> Sowing is a long-standing practice in rice farming of farmers in Thai Binh, it's suitable with natural conditions and

labour costs. In the Vu Thu district, farmers have a custom of sowing rice directly on the field to save labour. In the past three years, farmers in Vu Thu have been applied hand-drawn sowing machines and sowing machines combined with tractors. As a result, there are more than 100,000 tools to sow in rows and about 10 percent of the total rice area applies this technology' (Indeep-interview Vu Duc Van, male, director of Vu Tien cooperative, Vu Thu district, Thai Binh province).

Influence of mechanization on labour used in rice farming households

Mechanization and working time

As mentioned earlier, land preparation, transplanting and harvesting are stages that the rice farming households in Thai Thuy and Vu Thu perform by using machines (particularly, water control is performed by the agricultural cooperatives). However, they still have to use manual labour in these three stages, because machine renting cost is high (in transplanting and sowing) and machines cannot reach many plots with

elevations too different from the surrounding area (in transplanting and harvesting stages). For such reasons, they have to use do these stages manually and they consume much more time than the ones using machines do. A transplanting machine requires only 2.5 hours for one hectare while manual transplanting takes more than 200 hours. Harvester takes only three hours for one hectare while manual harvesting takes 185 to 190 hours for the same area (Table 3). Considering production scale, the Mann Whitney test shows a statistically significant difference between the large-scale group and the small-scale one in using machines for rice production in both Thai Thuy and Vu Thu districts. The 4-wheel tractors and transplanting machines are more used in the households of the large-scale group because they cannot have adequate labour to manually do all these stages. In general, transplanting machines displace more than 33 percent of man-power in large scale rice farming households. This percentage is higher than the common figure found in various studies that mechanization displaced mainly bullock labour up to about 60 percent in some situations, but its impact on manpower was much less, the displacement is less than 15 percent (Verma, 2006). In addition, using machines brings higher economic efficiency to rice farming households compared to using manpower. According to their calculation, by applying machines the cost reduces by over 400,000 Vietnam doing per hectare for land preparation, over 1,000,000 Vietnam dong per hectare for transplanting or sowing and nearly 700,000 Vietnam dong per hectare for harvesting.

The results found in Thai Binh which are following results in other countries show that machines are used in many stages of rice farming in large farms while small farms still use manual labourers (especially family ones) and that the application of machines in large scale production seems to bring better efficiency (Otsuka, 2013; Hegazy et al., 2013).

Table 3. Distribution of machines used by different farming activities

Item	Machines used (hours/ha)	Large scale (%)	Small scale (%)	Mann Whitney U- Test
		Thai Thuy		
Ploughing				
2 wheels	40	22.22	36.36	0.76
4 wheels	24	77.78	63.64	1.77*
Sowing/Transplanting				
Machine	2.5	33.33	0.00	1.39*
Manual	200	66.67	100	0.51
Harvesting				
Machine	3	100	100	1.60
Manual	180	33.33	36.36	2.15
		Vu Thu		
Ploughing				
2 wheels	37	0.00	40.0	0.21
4 wheels	22	100	60.0	1.42**
Sowing/Transplanting				
Machine	-	0.00	0.00	-
Manual	210	100	100	-
Harvesting				
Machine	3	100	100	-
Manual	195	40.0	53.33	2.32*

Source: Survey data (2020)
Note: ***, **, and * indicate significance at 1, 5, and 10 percent respectively.

Table 4. Type of labour affected by mechanization.

Item	Thai Thuy		Vu Thu	
	Large scale (n=9)	Small scale (n=11)	Large scale (n=5)	Small scale (n=15)
Ploughing				
Family	0	0	0	0
Hired	1 (100)	1 (100)	1 (100)	1 (100)
Sowing/Transplanting				
Family	1.2 (100)	1 (100)	1 (100)	1 (100)
Hired	3.5 (66.67)	1 (18.18)	3 (80)	1 (66.67)
Weeding				
Family	1 (100)	1 (100)	1 (100)	1 (100)
Hired	0	0	0	0
Pesticide spraying				
Family	1 (100)	1 (100)	1 (100)	1 (100)
Hired	1 (44.44)	0	1 (40)	0
Fertilizer applying				
Family	1.4 (100)	1 (100)	1 (80)	1 (100)
Hired	0	0	1 (20)	0
Harvesting				
Family	0	1 (63.63)	0	1.2 (53.33)
Hired	2.3 (100)	1 (100)	1 (100)	1 (100)

Source: Survey data (2020)

Note: The numbers in brackets represent the percentages of rice farming households

Mechanization and labour type

Like many developing countries around the world, rice farming in Vietnam requires more labour than other agricultural activities because of its seasonal factor. In the situation of lacking family labour due to labour mobilization to off-farm sectors, households usually have to hire additional labour, especially during peaking season (Bergstedt, 2012). However, mechanization helps to reduce partly the labour amount households have to hire. In both small and large-scale household groups, for stages where machines are mainly used such as land preparation and harvesting, hired labourers are to operate the machines. For transplanting, hired labour amount is usually three to four persons per household because most households still keep traditional manual transplanting habits, especially in plots where machines cannot reach. To minimize production costs, most of the surveyed households in Thai Thuy and Vu Thu use family labour in weed removal, fertilizer and pesticide application stages. In addition, they suppose that the rice production scale of households in Thai Binh is not large enough to apply machines in fertilizer and pesticide spraying like rice farming households in the Mekong delta do.

It can be said that farm mechanization contributes not only to the reduction of working time but also to the reduction of family and hired labour amount required for rice farming. In several households in the large-scale group in Thai Thuy, hired labour is still used much in transplanting (more than three labourers), harvesting (more than two labourers), because the high elevation of rice plots that prevents using machines, and the shortage of machines at peaking moments (Table 4). In the Vu Thu district, because of the smaller production scale of farm households than Thai Thuy, farmers normally do not have to face machine shortages during the peak season so they can easily rent harvesting machines and use fewer hired manual labourers for harvesting than farmers in Thai Thuy do. Nevertheless, large-scale households in Vu Thu also hire manual labour (three persons) for sowing as they explain that the sowing calendar is controlled by the agricultural cooperative which is condensed into three to five days, so they have to hire labour to keep up the sowing schedule.

Table 5. Descriptive statistics of dependent and independent variables.

Variable	N	Mean	Minimum	Maximum	Std. Dev.
Labour use	40	248	80	400	157.18
Machine use	40	35.5	22	40	7.23
Output	40	36.2	32.5	38.8	2.45
Input	40	22.4	21.5	26.8	2.89
Dummy Location	40		0	1	
Dummy Scale	40		0	1	

Source: Survey data (2020)

Regression model analyses factors influencing labour use in rice farming

The earlier analysis reveals that mechanization changes working time, amount and type of labour in many rice farming stages. However, to quantify these changes the author used a multivariable regression model, which measures the variation of working time manual labourers have to spend for rice farming (dependent variable) under the influence of mechanization as well as other input and output factors of one hectare of rice plot. Descriptive statistics of dependent and independent variables are presented in Table 5. The model also compares the change in working time between the small-scale and large-scale rice farming household groups of the Thai Thuy and Vu Thu districts.

The results of modelling show that the time of using machines and rice farming area are the two factors affecting in a statistically significant way the manual working time for rice farming (Table 6). One hour increase of time of using a machine helps to reduce manual working time by more than five hours. Manual working time in large-scale farming households is about 16 hours per hectare less than the one in small-scale farming households is. That can be explained by the fact that large-scale farming households tend to apply machines more in rice farming.

Table 6. Regression estimation of labour requirement for rice farming.

Variable	Coefficient	Standard error	P-value
Constant	202.12	54.70	0.027
Machine use	-5.02	0.43	0.009***
Output	0.13	0.01	0.980
Input	-0.12	0.81	0.185
Dummy Location	1.71	0.75	3.430
Dummy Scale	-16.11	0.76	0.017**
Adjusted R2		0.63	
F-value		35.86***	

Source: Survey data (2020)

Note: ***, **, and * indicate significance at 1, 5, and 10 percent respectively.

Advantages and disadvantages of mechanization in rice farming
Stories telling advantages

In the family of Mrs Nguyen Thi Nga (50-year-old, Thuy Van commune, Thai Thuy district), there are five members including her, her husband, her son and two daughters. The son is a soldier garrisoning in Quang Ninh province. The two daughters got married. They are living in other communes. She and her husband own eight 'sao' of rice plots. They are still in good health condition; therefore, they hire additional plots from neighbours to cultivate rice. In total, they cultivate one hectare of rice, which is considerably large compared to other rice-farming households in the commune.

According to the supporting policy of Thai Binh province, they borrowed money from a bank (50 percent of machine buying value) with a low-interest rate to buy a 4-wheel tractor to prepare land for themselves and to provide ploughing service for other households in the commune. With this tractor, her husband needs just one

day to plough their one hectare. On other days, he ploughs for other households at the rate of 130,000 Vietnam dong per 'sao'. At the end of the land preparation period, he works as a builder with a wage of about 6,000,000 Vietnam dong per month. Mrs Nga takes charge of all works relating to rice farming. She hires one transplanting machine at the rate of 250,000 Vietnam dong per 'sao'. Transplanting her one hectare takes one day. She said that previously when the transplanting machine was not available, it took five days with five hired labourers to transplant her rice plots. Cost to hire labour was higher, time spent was longer, and, sometimes, hired labour was not adequate in peaking seasons. Similarly, at harvesting time, she uses a harvester service. Her one hectare is harvested in one day. She sells rice to a company immediately after harvesting at the field.

> 'With machines, I can alone farm one hectare and spend only about 30 days for one crop. That is a real change from the past when we had to do all rice-farming stages manually. Using machines, I see that rice farming becomes easier, time consumed is less, and especially economic profit is higher. With one hectare of rice production, in the summer crop of 2020, I got a profit of 25 million Vietnam dong which is 1.5 times higher than manual farming. Moreover, the application of machines for rice farming reduces the time consuming of family labour as my husband, so it enhances his opportunity to work an off-farm job and earns more money.'

The story of Mrs Nga's family can be found in comparable farm households in China where mechanization is considered to help farmers to cultivate larger land areas and thus generate higher income (Van den Berg et al., 2007).

Stories telling disadvantages

In recent years, agricultural mechanization in Thai Binh province came from the demand of individual households or individual households' investment for hire. That was a lack of management from the local government. So, investments for mechanization for every production stage of rice farming were not synchronous and machine power did not meet the requirements of large-scale rice production. In provinces of the Red River delta in general and Thai Binh in

particular, necessary conditions for agricultural mechanization are not adequate, for example, the unequal elevation of plots, inconvenient field transportation system, and lack of capital for farmers to buy machines.

> 'I have eight "sao" but on two separated plots in different areas. The larger plot is near the main road. It is convenient for machines to enter. The other is smaller and located at a higher location. Thus, only 2-wheel tractors but not a 4-wheel tractors, transplanting machines and harvesters can get in. I have to cultivate manually on that plot. Moreover, its high elevation causes difficulty for automatic irrigation control. Therefore, sometimes I have to pump water by myself. Even though the larger plot location is convenient, I cannot always hire machines for it. The tractor is easier to hire than the transplanting machine and harvester. Tractor owners can easily arrange their machine schedule to plough for many households because the land preparation period is long. In reverse, the transplanting schedule of the commune is normally very short, while the number of transplanting machines is limited. Thus, sometimes I cannot hire the machine. For harvesters, we farmers cannot always hire. The machine owners already had a deal that each owner provides service in a certain area. The owner in this commune cannot provide his service to farmers in other communes. Therefore, even though I know many harvester owners, I cannot hire them to harvest my plot but only wait for the arrangement of the owner in my commune. That makes me have a lot of difficulties because I need rice harvested and cannot wait long. Sometimes, I have to hire people to manual harvest because my cultivation area is not too large. However, for households having large farms, it is very challenging for harvesting. To face this difficulty, I and my wife are thinking of buying a combined harvester but it's very costly. Even though we may get a little support from the local government but our financial situation still can not afford to invest in it. Moreover, the procedure for applying for a loan to buy high power tractors or harvesters at a bank is quite

complicated, so farmers have little opportunity to access this loan' (Vu Huu Binh, male farmer in Hong Dung commune, Thai Thuy district, Thai Binh province, 2020).

Similar to many other rice-farming households in Thai Binh province, Mr Binh is facing one of the challenges to access mechanization namely "cost of machinery". In many developing countries, farmers cannot afford to buy machines and financial support through subsidies is limited (Van Loon et al., 2020). Moreover, many studies have concluded that the financial–service sector avoids providing credit to small farm households as they lack eligible collateral for loans (Sims and Kienzle, 2016; Mottaleb *et al.*, 2016).

Policy implications
Under the context of deepening integration into the world economy, the development of new technologies is bound to affect agriculture and the application of machinery in agricultural production by enhancing productivity and quality while reducing costs and increasing value-added for farmers, making it an urgent issue in Vietnam. Based on what has been analyzed so far, the author mentions some policy implications for enhancing farm mechanization in rice production in Thai Binh province as well as in Vietnam as follows:

Firstly, the above analysis shows that mechanization is very important for rice farming in Thai Binh province. However, farmers still lack the capital to buy machines. Therefore, the Thai Binh provincial government should issue more preferential credit policies to support farmers investing in machinery (including both low power and high-power machines). Currently, the provincial government only supports a low-interest rate loan for farmers to buy high power machines, but the chance to access this financial source is also difficult due to procedural barriers at banks. Hence, it is necessary to ease the loan procedures for farmers at the bank, for example, farmers do not need to mortgage their land using the right certificates to get a loan for buying farm machines. Secondly, to overcome the situation of excess machinery in one commune but not being able to provide services in another commune, the local authorities need to assist farmers in controlling and distributing machinery services appropriately. So that when farm households need to rent machines, they will be able to access the machine's owners at affordable prices. Thirdly, although the land consolidation has

created lots of advantages for mechanization in rice farming, many farm households still own small rice plots, or rice plots have a higher elevation than others. This impedes the use of high-power machines (like 4-wheels tractors, harvesters). To solve these obstacles, the local government needs to improve the in-field transportation system to allow machines to enter these rice fields or allow farmers to exchange small rice plots with others for larger plots.

CONCLUSION AND RECOMMENDATIONS
The appearance of farm mechanization in Vietnam can more simply be defined as the use of any machine to accomplish a task or a stage involved in agricultural production. Such tasks include reduction in human drudgery, improvement in the timeliness and efficiency of various agricultural operations, and bringing more land under cultivation (Odigboh, 2000; Azogu, 2009). In Thai Binh province, mechanization is commonly applied in rice farming households for three tasks which include ploughing, transplanting, sowing and harvesting. In general, farm mechanization leads to a decrease in the number of man-days that rice farming households use as it increases the productivity of farm labour. Farm mechanization increases rice production in terms of larger scale and profitability on account of timeliness of operation and higher economic efficiency as reducing the production cost. Additionally, farm mechanization in rice farming households in Thai Binh reduces both families and hired labour use for rice farming, increasing off-farm labour and more income from off-farm activities.

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[i] *23,000 Vietnam dong equivalent to 1 US dollar.*