Research article

Economic Analysis of Small-scale Pumping Machines Operated in Rice Production in Chum Kiri District, Kampot, Cambodia

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Abstract Water scarcity has become abnormally serious across the year, so timely irrigation aid is strongly required for healthy crop growth. Therefore, this paper aims to explore the characteristics of farmers' preferences over pumping machines in rice production and to analyze their break-even points. The study was performed during the period from January to June in 2015, by randomly selecting 80 pump owners from one farming commune in Chum Kiri District, Kampot Province, Cambodia. The data were collected using household interviews, in-depth interviews and a group discussion. The data were analyzed by utilizing descriptive statistics and the break-even formula to investigate repair costs, annual pumping hours and standard farm sizes. The result shows that water pumps were highly in operation during dry season to maintain the crop-water balance and were annually operated about 412 hours. The engine capacity of pumping machines, frequently purchased, ranged from 5.5 to 8 horsepower. The pumps lasted for five full-operational years and depreciated 25 dollars on an annual basis. Japanese-brand pumps were best-selling, still farmers were subjected to have excessive spending on annual repairs because of less care and little maintenance knowledge. Although water pumps were widely utilized across the studied area, each household only cultivated on an average of 1.20 hectare-farmland, whereas the break-even land was calculated to be at least 6 hectares of cultivated land, so that the pumps were fully operated, economically and effectively. In conclusion, though operated on a small land, water pumps have made a contribution toward improvement in crop production. However, they remained minimally useful in case of scarce water sources. Therefore, irrigation sources should also be considered and constructed, so crop production might be double or diversified with the presence of pumping machines.

Keywords dry season, operational hours, farmland, break-even point

INTRODUCTION

Water is crucial for cropping systems in Cambodia. However, rice is mostly cultivated once a year largely due to rainfall dependency. Thus, annual rice yields are even low during water scarcity. In comparison, annual rice crops are cultivated two or three times in Thailand and Vietnam because of the involvement of mechanization making the two nations become leaders in rice exports. In this case, usage of pumping machines is deemed an effective tool in adequate water irrigation (MAFF, 2012). In terms of rural economies, water for irrigation has nurtured approximately 500 million family farms

worldwide in the form of rainfall and water sources, while contributing toward securing world food adequacy for rural households. In fact, small farms—either irrigated or non-irrigated—are also managed by almost 60% of Cambodian farmers who rely mostly upon rice farming. Thus, farm mechanization is widely known as a driving force of agricultural transformation and development (Chhim Chhum et al., 2015). For this reason, watering innovation in obtaining irrigation water is required to improve rice production and yield along with technical support on agricultural machinery (FAO, 2014).

Furthermore, due to high demographic growth in Cambodia, rice cultivated areas have been expanded enormously and increased from about 2 million hectares in 2003 to roughly 3 million hectares in 2013. The expansion of farmland has resulted in higher machinery purchase increasing the number of power tillers from 13,700 units to 128,800 units and the number of pumps from about 100,000 units to 232,000 units over the same period of time (Saruth et al., 2014). The rising numbers of purchased pumping machines may either bring benefits to the nation or pose new challenges to rural mechanization in Cambodia when technical assistance is not widely available. Machines are heavily imported without providing adequate vocational training on mechanics to local distributors (Chhim Chhum et al., 2015). In this case, rural skills including economical operation of farming machinery are necessarily the best choice in enhancing rural economies (ADB, 2015), as Cambodian people that reside in the countryside possess relatively low skills and low educational achievement. Besides, technical skill shortages are largely apparent in countryside people. Due to the importance of machinery involvement and necessary skills relevant to the operation of machinery, especially small-scale water pumps, this study aims to explore the characteristics of farmers' preferences over pumping machines in rice production and to analyze their break-even points. By doing so, the optimum cultivated farmland may be found out.

METHODOLOGY

Site Selection and Sampling Procedure

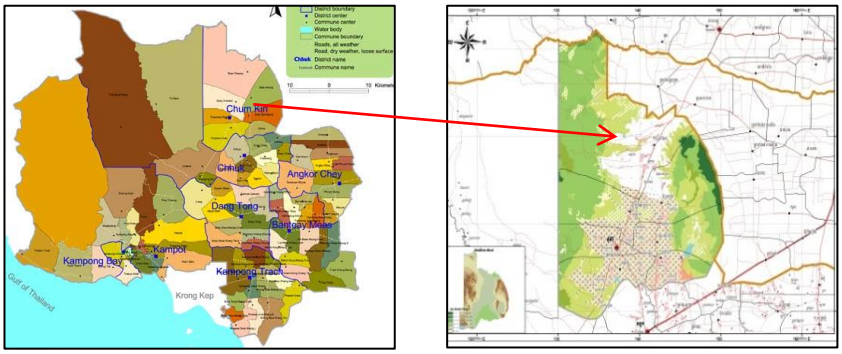

Fig. 1 Map of the studied area in Chompouvorn Commune, Chum Kirir District

Farmers who utilized pumping machines for irrigation were randomly selected from Chompouvorn Commune, Chumkiri District, Kampot Province, where rainy-season rice is mostly cultivated. To understand how portable water pumps are used to suit the current situation of the cropping systems, the farmers from two different villages were categorized into two low and high pump usages and then were sampled using Yamane Taro's (1992) formula (Israel, 2013), as shown below:

$$n = \frac{N}{1+N.e^2} \quad (1)$$

Where n is a number of selected samples; *N* represents a population of farmers operating pumping machines in the two villages; and *e* is the level of significance and accounts for 10%.

Table 1 Sample of farmers operating water pumps

Village names	Level of pump utilization	Number of households with pumps (person)	Number of samples (person)
Thmey	High	246	52
Koun Damrey	Low	133	28
Total		379	80

Data Analysis and Break-even Farm Size

Efficient operation of water pumps depends greatly upon how often they are utilized and how big the farmland is. Economically based pump usage is considered important for farm operation as long as profitability is highly aimed. Annual depreciation cost of machinery and break-even farm size, when one pump is purchased and operated, are calculated based on the following formulae:

$$D = \frac{PV-SV}{L} \quad (2)$$

Where *D* is a pump depreciation cost (USD/year); *PV* represents the initial price of one pump (USD); *SV* is known to be the price of pump salvage or 10% of initial price (USD); and *L* is a pump life span and is up to 6 years.

$$B_E = \frac{FC}{P-VC} \quad (3)$$

Source: Patterson and Painter (2011)

Where B_E represents break-even farm size cultivated for efficient pump usage (ha); *FC* is an annual pump ownership cost (USD/year); *P* is custom pump hired rate per hectare (USD/ha); and *VC* covers all operating costs such as fuel, labor, and repairs (USD/ha).

RESULTS AND DISCUSSION

Agriculture in Cambodia is dominated by paterfamiliases, accounting for 84.27% of farming families interviewed in the studied area, while only 15.73% represents materfamilias families. Table 2 indicates that men are still influential in decision-making for purchasing inputs and machinery for agricultural practices. Meanwhile, Cambodian farmers still have low literacy rates as 41.57% of the farmers could only spend a school period of 9 years, while 35% dropped out of school at young age. Dropout cases are very common in rural areas due to low budget and poor schooling infrastructure. However, 23.60% could finish high school. The 25-44 age categories of the rice growers living in the studied area account for about 57%, while 24.72% fall within the 45-60 age category, which means that the majority of the farmers are considered full labor. It is clear that the average age of the rice farmers equals to 42 years. The number of family members averages 4.39 persons per household, with 2 persons considered full labor. Because the active labor category of 1-3 persons accounts for almost 90% of the interviewed farmers, this signifies labor shortages. Furthermore, 65% of the rice farmers cultivate rice on the land that is smaller than 1 hectare, whereas 21.35% own rice fields varying in size from 1 to slightly higher than 2 hectares. In general, the cultivated farmland averages 1.15 hectares. According to the survey, the farmers have had 27 years of farming experience, and by investing an

average sum of 250 USD on land preparation, inputs and harvest; they could earn an annual income of 760 USD to cover all the expenses.

Table 2 Household characteristics of Chompouvorn Commune

Variable description	Frequency (n=80)	Percentage (%)	Mean
Gender of household head			
Male	67	84.27	
Female	13	15.73	
Educational level of household head *(yr)*			
No education	2	2.25	9.00
Primary school	26	32.58	
Secondary school	33	41.57	
High school or higher	19	23.60	
Family status of household head			
Married	62	77.53	
Divorced	18	22.47	
Age (yr) (>=25 years old)			
25 - 44	46	57.30	42.32
45 - 60	20	24.72	
> 60	12	14.61	
Household size *(Person)*			
1 – 4	48	59.55	4.39
5 - 10	32	40.45	
Active labor *(Person)*			
1 – 3	70	87.64	2
>3	10	12.36	
Farmland size *(ha)*			
< 1	63	78.65	1.20
1 – 2	4	5.62	
> 2	13	15.73	
Family experience in farming *(yr)*			27
Total expenses in farming *(USD/yr)*			250
Total income from farming *(USD/yr)*			760

Characteristics of Pump Operation and Its Working Capacity

The pumping machines that farmers commonly use are Japanese brands including Honda, Yamaha, and Yamasaki. Based on Table 3, brand-new pumps are more preferable as they are relatively inexpensive and have a long lifespan. Of all the interviewed farmers, 43.82% have utilized the pumping machines for at least 5 years, while others have owned the pumps for at least 3 years ($p<0.001$). The pumps have small engine horsepower from 5.5 to 6.5 horsepower and account for 70% of the farmers, while 30% select the engines that have 8 horsepower ($p=0.003$). Moreover, the pipes of 50 and 80 mm in diameter ($p<0.044$) are chosen for pumping, representing 61.80% and 38.20%, respectively. Besides that, the rotary speed of 3,600 rpm is preferred, and centrifugal-type pumps are chosen because they are capable to lift water up to 30 m in height. With this height, rice fields that are far away from the canals can be sufficiently irrigated. In terms of convenience, pumps with gasoline engine are best-selling, as they are light and easy to carry, so 77.53% of the farmers choose them. Diesel pumps ($p<0.001$) are still in use, representing 22.47% of the interviewees.

Pumps provide advantages during the peak demand for irrigation, but they may also cause farmers to spend more, when they are broken. The most common pump problems are related to fuel tank, ballast, spark plug, injection nozzle and wearing ring; as farmers utilize their pumps with little care

(p<0.010). New pumps break down occasionally throughout the year, and due to inadequate technical knowledge, farmers have to get them repaired (p<0.001) at mechanical shops, with about 80% of them paying a sum of between 10 and 20 USD. Around 20% pay less than 10 USD.

Table 3 Preferential characteristics of pump utilization in the studied area

Variable description of pump	Frequency (n=80)	Percentage (%)	Chi square	Significance level
Type of pump purchase			-	-
New	80	100.00		
Second-hand	-	-		
Years of pump use			24.32	<0.001***
< 3	6	7.87		
3 – 5	39	48.31		
> 5	35	43.82		
Horsepower *(hp)*			13.60	0.003**
5.5 - 6	28	34.83		
6.5 - 8	52	65.17		
Pipe diameter *(mm)*			04.05	0.044*
50	31	38.20		
80	49	61.80		
Rotary speed *(Round per min)*			-	-
3600	80	100.00		
Total head lift *(m)*			-	-
30	80	100.00		
Suction distance*(m)*			8.83	0.024*
5-7	30	37.50		
8	50	62.50		
Type of pump blade			-	-
Centrifugal	80	100.00		
Type of consumed fuel			24.20	<0.001***
Diesel	18	22.47		
Gasoline	62	77.53		
Broken pump parts			09.23	0.010*
Fuel tank and Ballast	23	28.75		
Spark plug & injection nozzle	29	36.25		
Wearing ring	18	35.00		
pump breakdown			36.45	<0.001***
Occasional	67	84.27		
Often	13	15.73		
Repairs of broken pump			51.20	<0.001***
Self-repair	8	10.11		
Repairman	72	89.89		
Repair spending *(USD/yr)*			28.80	<0.001***
< 10	16	20.22		
10 - 20	64	79.78		
Initial pump price *(USD)*			182.00	
Number of operating hours *(hr)*			415.24	

*Note: ***, **, and * signs mean very highly significant, highly significant, and significant*

Analysis of Break-even Farm Size

Pumps are commonly used during the rainy season. This situation is prevalent in the studied area due to no irrigation systems for water reservation. Accordingly, there is also no rice cultivation during dry

season. In consequence, farmers plant rice during the rainy season and resort to non-farm work during the dry season. Besides that, the price of a new pump is about 182 USD (Table 3) and is usable for 6 years; thus farmers have to incur an annual depreciation cost that is estimated at 25 USD. When the pump is operated on one hectare of land, its owner has to spend 90 USD annually on gasoline, lubricant and repair costs, as shown in Figure 2. So when it is custom-hired to irrigate farmland of one hectare, 15 USD may be charged. Thus, the pump is used to its full capacity, only if farmers have to work on 6 hectares of land per year. This does not mean that they have to possess exactly that size of land, but they can double cultivation, which leads to double usage of the pump, or they may use it in other ways for economic purposes. In terms of farmland, the farm size that each household has amounts for only 1.20 hectares, while the number of pump operating hours per year averages at 415.24 hours (Table 3). These two numbers shows that pumps are used for multi-purpose, not only for irrigation. They may use up their annual working capacity because in general, a pumping machine may be used for 500 hours per year. Therefore, it may be efficient when farmers double their cropping seasons in a case that irrigation systems are potentially available.

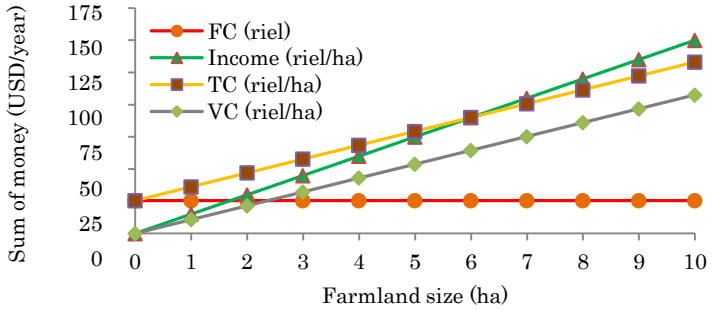

Fig. 2 Calculation of farmland size needed for efficient pump utilization

CONCLUSION

In conclusion, the pumping machines purchased are mostly imported products, but they do not cost much. The farmers possess small plots of farmland with labor shortages. Rice cultivation depends solely upon rainy season rice. This situation results in high depreciation costs and non-efficient pump usage. Besides that, farmers usually experience occasional breakdowns of the pumps and rely upon repairmen to solve the problem because of little mechanical knowledge. As calculated, the optimum farm size that is suitable for pump utilization equals at least 6 hectares, but in reality, available cultivated farmland remains smaller. Thus, all these problems are solvable if pump-repairing training is provided to target farmers to reduce unwanted costs. In addition, more irrigation systems should be built, so that farmers may access water in each season, thereby increasing their cultivation seasons.

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