

# **POWER AVAILABILITY AND REQUIREMENTS FOR SMALL-SCALE RICE FARM OPERATIONS: A CASE IN RIAU PROVINCE, INDONESIA**

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## **Abstract**

The objective of this study was to identify the power availability and requirement for small-scale rice farming operations in Riau Province. Primary and secondary data were gathered from different sources. A total of 120 farmers were interviewed to collect data primarily from two selected rice centers in two regencies of the province during the 2008 rainy cropping season. As a result, the availability of farm power still is very low, although showing an increasing trend during a period of 1997-06 primarily for mechanical power unit. During the same period, the stage of rice mechanization process has also been relatively low and still below the take-off stage in critical point of the mechanization process. Under these conditions, it was analyzed that the increased number of farm power has no effect on total cultivated area and yield of rice over the years. The main sources of farm power practiced by rice farmers are human labor and mechanical power, while draught animal was not used in Riau rice farming operations anymore. Mechanical power is just used to perform land preparation, threshing and milling operations, while other farm operations are still done completely by manual. The total power required per hectare of rice farm operations was 418 kW (561 hp) on average. Although mechanized farm operations need more power, the total operation hours would decrease significantly. The results suggest that efforts should be taken to continuously encourage farmers to adopt mechanical power technologies in order to carry out farm operations timely and short period, and to make rice production process more productive and efficient.

**Key words:** Power availability and requirement, Small-scale rice operation, Human power, Animal power, Mechanical power

## **Introduction**

Mechanization has well recognized as an important input to modernize agricultural production system. It involves the provision and use of all forms of principal power sources from human, draught animal and to mechanical power (Sahay, 2004; Sims and Kienzle, 2006; Bishop, 2007). The appropriate choice and use of farm machinery and equipment have a direct effect on the area under cultivation, the timeliness of operation and the effective use of others input (Bishop, 1997). Therefore, many developing countries have made the extra effort to mechanize farming by increasing use of mechanical power technologies. However, human being and draught animal power still play a vital role in many farming systems especially on smaller and poorer farms in Asia (Lawrence and Pearson, 2002). While in Indonesia and other developing countries of South and Southeast Asia, about 60% to 70% of the rice area is prepared manually by human labor and harvested by knife or sickle. From Asian countries was also reported that 30% of land is cultivated by hand, 30% by draught animals, and 40% by tractors (FAO, 2008).

The general purpose of farm mechanization is to replace human muscle and animal power with mechanical power (Saegusa, 1975). Based on the past experience, mechanization transition from hand tools through animal-drawn implements until the application of mechanical power was not a simple process. The transition process becomes difficult and needs time because it has to involve a number of technical, economic and social problems (Sakai et al., 1986). Gego (1986) studied that it would take some 30 to 50 years to undergo these development processes. In addition, Depeng et al. (1983) stated that agricultural condition, farm management, management scale, economic condition, technical level of manufacture, farmer's experience, etc. affect the use and development of mechanical power.

The degree of mechanization used in agriculture is greatly different among the various countries of the world. In Indonesia, the use of mechanical power in agriculture especially in domain of mechanization for rice cultivation has been showing an increasing trend, although the pace is slow. In the early 1980s, for instance, the rice farming has been mainly dependent on animal and human power with limited use of power tillers and mechanical threshers (Singh, 1984). About ten years later, the power input has still come from human and animal power with an increased use of mechanical power (Salokhe and Hendriadi, 1995). Currently, the level of mechanization in the country varies from low to high primarily in rice cultivation, ranging from 10% to 90% depends on the intensity of the farming system and common figure indicates its average level of 30% (Handaka, 2005).

In Riau province, mechanizing rice farming, which is predominantly small-scale farmers and subsistent level in production (Paman, et al, 2010), remains to be a priority concern of provincial

government in order to provide staple food for majority of population of the province. Although rice mechanization has seen a rather slow progress, currently, mechanical power is gradually taking over mainly the power-intensive farm operations such as land preparation, threshing, lift irrigation, drying, and milling. It is important that the adequate availability of power sources in rice farming is very crucial for successful and timely operations. The purpose of this study is to identify the power source and requirement for small-scale rice farming operations in Riau province.

## **Materials and Methods**

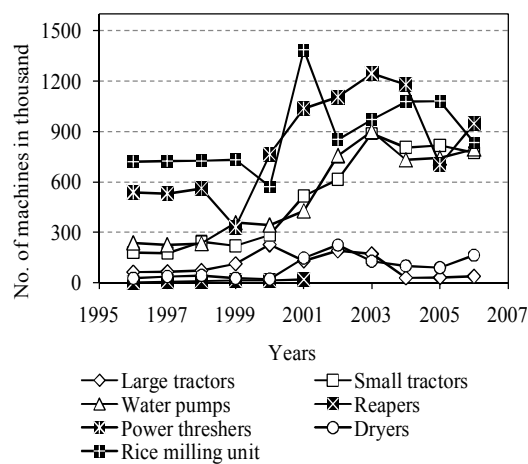
Two rice production centers from two regencies in Riau province, namely; Bunga Raya in Siak Regency and Bangkinang Seberang in Kampar Regency were selected as the survey areas. Both locations were purposively selected to represent an average condition of the most intensive farming system of the rice production and the highest level of mechanization adopted in the province. A sample of 60 farmers from each survey location or 120 farmers for total were chosen randomly and interviewed personally by using the structured questionnaires. The farmers in the survey areas own land and use farm machines for performing in some rice operation works. The survey was carried out during 2008 rainy cropping season which is the main season for rice growing in the province. During the season (September – February), the growing of rice on 90 to 100% area is possible (Khan, 1996).

This study used primary and secondary data. Primary data consisted of cropping patterns, time and power requirement for each rice operation of rice cultivation. Furthermore, secondary data were obtained from Food Crops Service and Statistical Bureau of Riau province. The data included population of farm machines on farm (unit), rice harvested area (ha), rice yield (ton/ha), and annual rice production (ton). Data were tabulated and afterward analyzed using descriptive analyses.

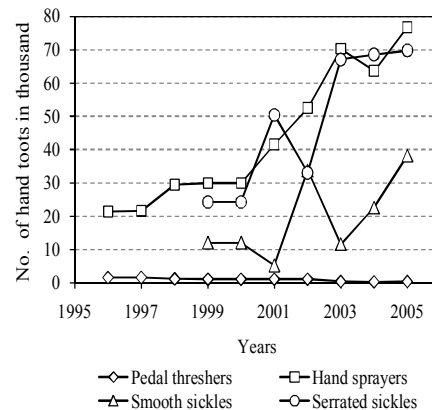
## **Results and Discussion**

### **Availability of Farm Machines and Power**

According to figure 1, the significant development of major farm machines in Riau Province such tractors, water pumps, power thresher, and rice milling unit has been started in 2001 when farmers begin to purchase the machines individually and use them on their rice farms. The increased availability of farm machines in the province has brought about the changing trends in the use of mechanization technology from manual tools to mechanical power. The number of pedal thresher, for example, decreased constantly during a period of 1997-06 replaced by power thresher which increased during the same period.



(a)



(b)

Fig 1. Number of major farm machines (a) and hand tools (b) on farm, 1996-06.

The increasing use of mechanical power becomes increasingly important amid increasing average age of farmers and decreasing human labor availability due to less attracted of young generation in agricultural activities. Moreover, Jacobs and Harrell (1983) claimed that the number of people employed in agriculture production has declined as improved mechanization technology. These conditions would cause the human labor becomes more and more scarce and costly in rice production. According to Herdt (1983), four critical point in the mechanization process are the initial stage; the early stage with about 2.5 hand tractors/1000 ha; the take-off stage with about 20 hand tractors/1000 ha; and the full mechanization with about 1000 hand tractors/1000 ha. Starting in 2000, mechanization of rice farming in Riau Province was entering the early stage with nearly 2.0 hand tractors/1000 ha on average (Figure 2a and 2b). Thereafter, the mechanization stage increased significantly with peak number of about 7.6 hand tractors/1000 ha in 2003, but the average stage considered relatively low to about 4.7 hand tractor /1000 ha of cultivated area and below the take-off stage in critical point of the mechanization process. The result indicates that farm mechanization development in the province has seen a rather slow progress over the years.

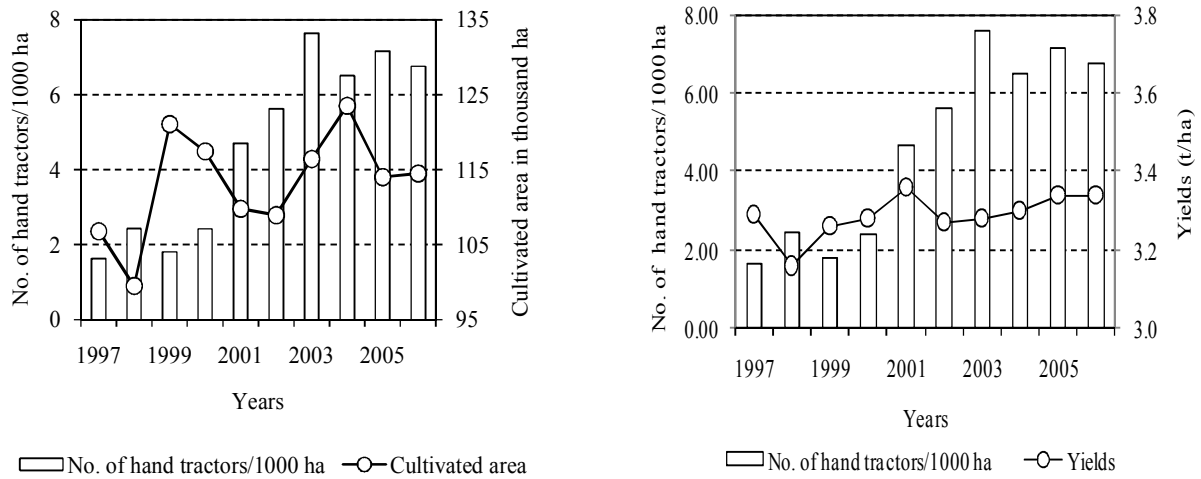


Fig 2. Number of hand tractors per 1000 ha versus cultivated area (a) and yields (b) of rice over times

The increasing number of farm machines, in fact, was not followed by increasing cultivated area and yield per hectare over the years. Figure 2a shows that the annual fluctuation of the cultivated area (ranging from 100 thousand to 124 thousand ha over the years) did not reflect the increasing number of hand tractors on farm in the province. Similar conditions were also found on yields as presented in Figure 2b. Rice yields (ranging from 3.20 t to 3.36 t ha<sup>-1</sup> over the years) did not increase when the number of hand tractors/1000 ha increased. It means that farm power and equipment available failed to realize their potential. This may be caused by ineffective use of the machines as a result of breakdowns, fragmented land, and poor farm infrastructure (irrigation and farm road) and service support systems. Survey conducted by Paman et al. (2007) reported that the tractor breakdown was a major problem found in the province. While the frequency of tractor and implement breakdowns was one of causes of low total annual usage of tractors (Kolawale, 1972).

By assuming that the power available from one person is 0.1 hp, draught animal about 0.5 hp and a commonly used engine of 8.5 hp for hand tractor, the availability of farm power in Riau province is presented in Table 1. The total power available per hectare of rice cultivated area increased from 0.37 hp in 1997 to 0.47 hp in 2006 with an average growth of 4.97% per annum. Although showing an increasing trend over the years, the total power available per annum was only 0.45 hp.ha<sup>-1</sup> on average during the period. This power availability is very low and difficult to increase productivity of rice. Because the total power availability remains under the minimum power requirement for an efficient agriculture. A world wide study has concluded that for optimum yields, there is a need for a power input of at least 0.8 hp.ha<sup>-1</sup> (Jain, 1979).

The highest growth was occurred on machine power to reach 10.49% per annum and followed by human power 8.39% per annum, whereas draught animal power decreased by 3.15% per annum during the same period. Although draught animal has potential power for performing various farm operations, its use decreased continuously during last two decades in the Riau province primarily after farm machine is extensively introduced to farmers. In present farming practices, draught animal was very rare to be used by farmers with some reasons. The low efficiency and very slow in doing work are main reasons for not using draught animal by farmers.

Table 1. The farm power sources for rice cultivation in Riau province (hp ha<sup>-1</sup>), 1997-06.

Power sources	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	Ave. growth (%)
Human *	0.13	0.18	0.14	0.24	0.28	0.17	0.18	0.14	0.16	0.18	8.39
Animal	0.10	0.10	0.08	0.06	0.07	0.07	0.07	0.07	0.07	0.07	-3.15
Machine	0.14	0.16	0.11	0.13	0.28	0.24	0.26	0.24	0.23	0.22	10.49
Total	0.37	0.44	0.33	0.44	0.62	0.47	0.50	0.45	0.46	0.47	4.97

Note: \* Estimated form 10% of cow and buffalo available in the province.

Source: Food Crops Service of Riau Province, 1998, 2001, 2004, 2007.

Figure 3 indicates that rice farming is heavily dependent on human and machine power which constituted 39% and 44% of total power respectively, while the animal power contributed only 17% on average during the period of 1997–06. The contribution of different power sources to the total power fluctuated every year. The human power was fluctuated at a range from 31% in 2003-04 to 55% in 2000. Draught animal contribution declined since 1998 and reached the lowest share to about 10% per annum in 2001, and afterward relatively unchanged up to 2006. Although being also fluctuated over the years, mechanical power increased more rapidly compared to human power during the same period. The increased number of major farm machines since 2001 as shown previous figure caused the increasing mechanical power contribution.

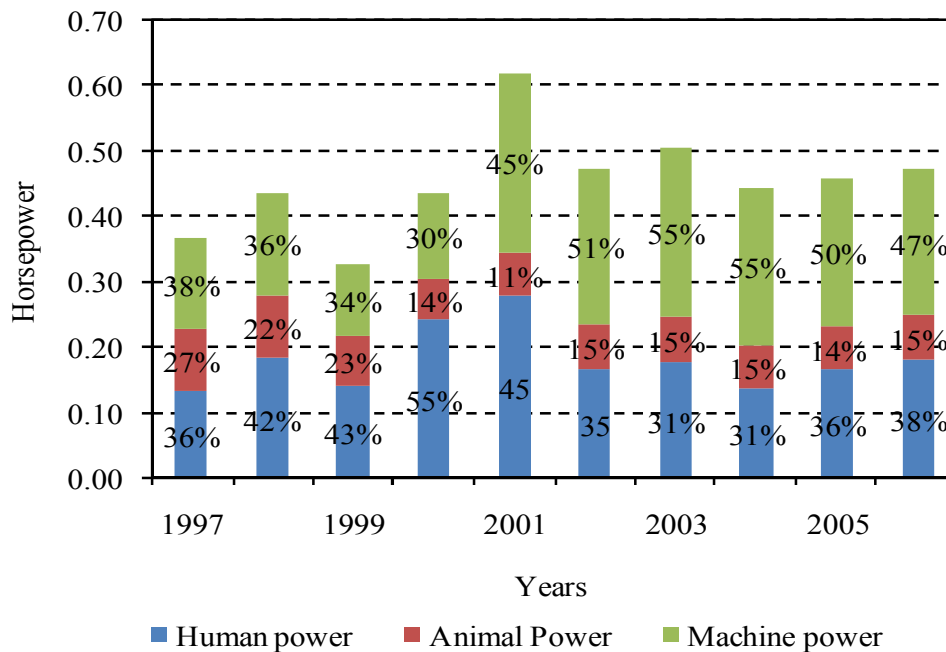


Fig 3. Contribution of different power sources on total power available for rice farming in Riau province, 1997-06.

It was observed that the main cause of the low availability of power for rice cultivation in the province is that most farmers still depend on human muscle who can only generate a maximum power from about 0.075 kW-h (about 0.1 hp-h) (Singh and Siswasumarto, 1988; Sahay, 2004) to 0.15 kW-h (0.2 hp-h) (ASAE, 2006) for an adult human on an average. Under low available power, mainly from human power, yield per hectare will remain at subsistence level (Igbeka, 1984) or land productivity is generally low because of the lack of physical available and the limited range of hand tools (Sims and Kienzle, 2006). Such power shortage would become a constraint not only to increase rice yields, but also to modernize rice farming system in the province.

### Power Requirements in Rice Farming Operations

Farming operations are seasonal with fluctuating power demand on each stage of the operations. In farming practices, mechanical power application is still limited in Riau province. Farm operations which require relatively little power are still performed completely by human power such as seeding, transplanting, weeding, harvesting, and drying. On the other hand, farm operations which require high doses of power input are mostly performed by mechanical power such as land preparation, threshing, and milling. In addition, paddy field which has very small size (< 0.2 ha) is worked

completely by human power with traditional tools, such as hoe for tilling, sickle for harvesting, etc. Of the 120 farmers interviewed in the survey areas, nobody used animal as the draught power.

In order to apply mechanical power, most small farmers resort to custom service organized by individual or group/cooperative farmers for their field operations. Operations, such as land preparation, drying, and milling, are available for such services. Through the custom services, most of the small farmers are able to handle their farm operations on time without the need to purchase or own any machine and related equipment. The services can be paid in the form of cash or installment without any interest borne on the payment delay. The service charge is usually negotiated and decided together prior to farm work performed (Paman et al, 2010). It was found that about 85% of farmers hired hand tractor for land preparation, 64% hired thresher for threshing rice, and all farmers brought rice grain to either huller or rice milling unit for milling it.

Table 2. The use of human and mechanical power per hectare for various operations for rice production in Riau province

Type of Operations	Power requirement (kW)			
	Human		Machine	Total
	Man	Woman		
Land preparation	0	0	164.8	164.8
Seedling	0	1.8	0	1.8
Planting	2.7	8.2	0	10.9
Weeding	2.7	5.8	0	8.5
Fertilizing	1.6	1.6	0	3.2
Pest control	2.0	0.4	0	2.4
Harvesting	4.4	5.9	0	10.3
Threshing	0	0	119.3	119.3
Transportation	3.1	0	0	3.1
Cleaning	0	2.0	0	2.0
Drying	1.7	1.3	0	3.0
Milling	0	0	89.5	89.5
Total	18.2	27.0	373.6	418.8
Percentage	4.3	6.4	89.2	100.0

*\*\* An adult man was assumed to be equivalent to 0.07 kW-h and an adult woman equal to 0.05 kW-h (Singh and Siswasumarto, 1988).*

Table 2 presents the use of human and mechanical power per hectare for various operations of rice production in Riau province. The total power requirement for rice operations per hectare in the province under current stage of mechanization was 418 kW (561 hp) on average. Most of the power (89.2%) came from mechanical power and the rest are from human power. The farm operations which involved mechanical power include only land preparation, threshing, and milling, while other operations are employed entirely by human power. Around 6.4% of human power came from woman and the rest 4.3% were from man power.

According to Table 2, land preparation required more mechanical power which constituted about 39% of total power and followed by threshing (28%) and milling (21%) operations. They



contributed entirely about 88% of total power, and the remaining 12% were human power. On the other hand, the mechanical power operations contributed only 6.6% of total hours and the rest 93.4% were human power. It means that the rice farm operations by mechanical power needed shorter time compared with human power, but required much more power. The result suggests that farmers should be encouraged continuously to use machine power to perform farm operations in order to decrease significantly rice operation hours. The farmers must also be familiar with mechanical power, so the productive capability of farmers increases and their rice production processes become more productive and efficient.

## **Conclusions**

The farm power available per hectare of rice cultivated area was only 0.45 hp on average and increased by 4.97% per annum during a period of 1997-06. The main sources of the power were human and machine powers which contributed an average of 39% and 44% of total power respectively, and the rest 17% were draught animal power which was not used in farm operation practices anymore. During the same period, the stage of rice mechanization process has also been relatively low of about 4.7 hand tractors/1000 ha of cultivated area and still below the take-off stage in critical point of the mechanization process. Under current stage of rice farm mechanization, the use of farm machines had no impact on total cultivated area as well as yield of rice. In farm practices, the farm operations which involve mechanical power include only land preparation, threshing, and milling, while other farm operations are employed entirely by human power. Under these conditions, total power required for rice farm operations per hectare was 418 kW (561 hp) on average. Farmers should be encouraged continuously to adopt mechanical power technologies in order to carry out farm operations timely and short period, and to make rice production process more productive and efficient.

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