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# Farm power status and requirement for small-scale rice farm operations: A case in Riau Province, Indonesia

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**Successful operation of a farming system is determined greatly by availability of farm power. The objective of this research was to examine the farm power status and requirement for small-scale rice farming operations in Riau Province. Primary and secondary data were gathered from various sources. A total of 120 farmers were interviewed to collect data primer from two selected rice centers in two regencies of the province during the 2008 rainy cropping season. The main source of farm power practiced by small rice farmers is human labour and mechanical power. The total power available is still very low and remains under the minimum requirement for an efficient agriculture. The stage of the rice mechanization process is also relatively low and still below the take-off stage of the critical point of the mechanization process. Under these conditions, the availability of farm power has no effect on total cultivated area and yield of rice over years. The total energy required per hectare of rice farm operations was 418 kW-h (561 hp) on average. Although mechanized farm operations need more power, the total operation hours would decrease significantly. The efforts should be taken to continuously encourage small farmers to adopt mechanical power in order to carry out timely farm operations and make the rice production process more productive and efficient.**

Keywords: Farm Power, Small-scale rice farm, Human power, Animal power, Mechanical power

Mechanization has been understood to be the application of mechanical engineering for agricultural production. It involves the provision and use of all forms of principal power sources from human, draught animal and to mechanical power (Bishop 1997, 32; Sahay 2004; Sims and Kienzle 2006, 20). 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, 32). 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, 99-110). 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, 26).

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, 11-19). Gego 1986, 11-21 reported that it would take some 30 to 50 years to undergo these development processes. In addition, Depeng et al. (1983, 44-48) stated that agricultural condition, farm management, management scale, economic condition,



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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, rice farming has been mainly dependent on animal and human power with limited use of power tillers and mechanical threshers (Singh 1984, 39-44). About ten years later, the power input was still mainly from human and animal power though with an increased use of mechanical power (Salokhe and Hendriadi 1995, 29-32). 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, 21-24).

In Riau province, mechanizing rice farming, which is predominantly carried out by small-scale farmers and at subsistent level (Paman et al. 2010, 43-48), remains to be a priority concern of provincial government in order to provide staple food for the majority of the 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 research is to examine the farm power status 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 was 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 of Riau Province (1998, 2001, 2004, 2007). The data included population of farm machines on farm (unit), rice harvested area (ha), rice yield (tonne/ha), and annual rice production (tonne). Data were tabulated and afterward analyzed using descriptive analyses.

## Results and discussion

### Farm power sources and availability

According to Figure 1, the significant development of major farm machines in Riau Province such as tractors, water pumps, power threshers, and rice milling units started in 2001 when farmers began 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.

The increasing use of mechanical power becomes increasingly important amid the increasing average age of farmers and decreasing human labor availability due to the reduce attraction of the young generation in

agricultural activities. Moreover, Jacobs and Harrell 1983 claimed that the number of people employed in agriculture production has declined with the improvement of mechanization technology. These conditions would cause the human labour to become more and more scarce and costly in rice production systems.

According to Herdt (1983), four critical points 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 entered the early stage with nearly 2.0 hand tractors/1000 ha on average (Figure 2a and 2b). Thereafter, the mechanization stage increased significantly with a 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.

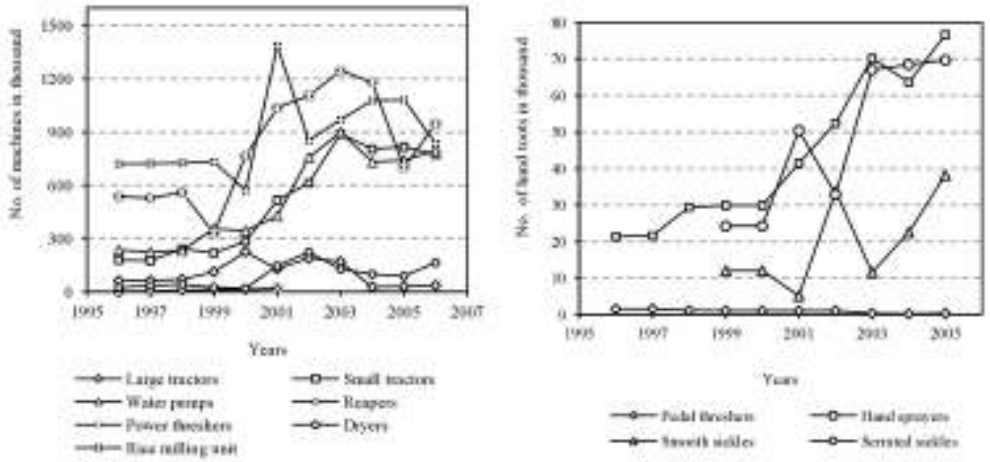


**Figure 1:** Number of major farm machines (a) and hand tools (b) on farm, 1996-06.

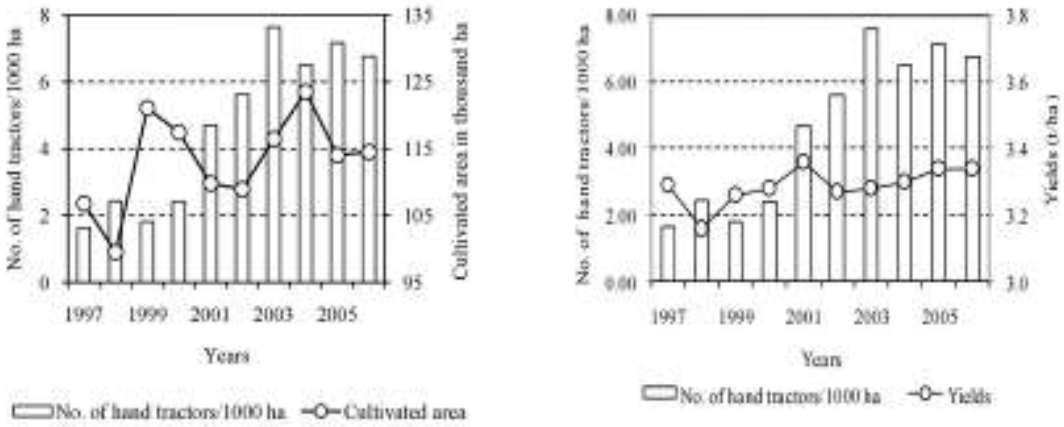


**Figure 2:** Number of hand tractors per 1000 ha versus cultivated area (a) and yields (b) of rice over times

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 $ha^{-1}$ over the years) did not increase when the number of hand tractors/1000 ha increased. It means that farm power and equipment availability failed to realize their potential. This may have been caused by the ineffective use of the machines as a result of breakdowns, fragmented land, and poor farm infrastructure (irrigation and farm road) and service support systems. A Survey conducted by Paman et al. 2007, 43-48 reported that the tractor breakdowns were a major problem found in the province.

By assuming that the power available from one person is 0.075 kW, draught animal about 0.373 kW and a commonly used engine of 6.338 kW 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 0.28 $kW.ha^{-1}$ in 1997 to 0.35 $kW.ha^{-1}$ in 2006 with an average growth of 5,09% per annum. Although showing an increasing trend over the years, the total power available per annum was only 0.34 $kW.ha^{-1}$ 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 0.6 $kW.ha^{-1}$ (Jain 1979, 31-34).

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 animals have the potential power for performing various farm operations, their use decreased continuously during last two decades in the Riau province primarily after farm machines were extensively introduced to farmers. In present farming practices, draught animals rarely used by farmers for good reason, such as low efficiency and slow work rates.

**Table 1:** The farm power sources for rice cultivation in Riau province ($kW.ha^{-1}$), 1997-06.

| Power sources | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | Ave. growth (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Human * | 0,10 | 0,13 | 0,10 | 0,18 | 0,21 | 0,13 | 0,13 | 0,10 | 0,12 | 0,13 | 8,39 |
| Animal | 0,07 | 0,07 | 0,06 | 0,04 | 0,05 | 0,05 | 0,05 | 0,05 | 0,05 | 0,05 | -3,15 |
| Machine | 0,10 | 0,12 | 0,08 | 0,10 | 0,21 | 0,18 | 0,19 | 0,18 | 0,17 | 0,16 | 10,49 |
| Total | 0,28 | 0,33 | 0,25 | 0,32 | 0,47 | 0,36 | 0,38 | 0,34 | 0,34 | 0,35 | 5,09 |

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

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

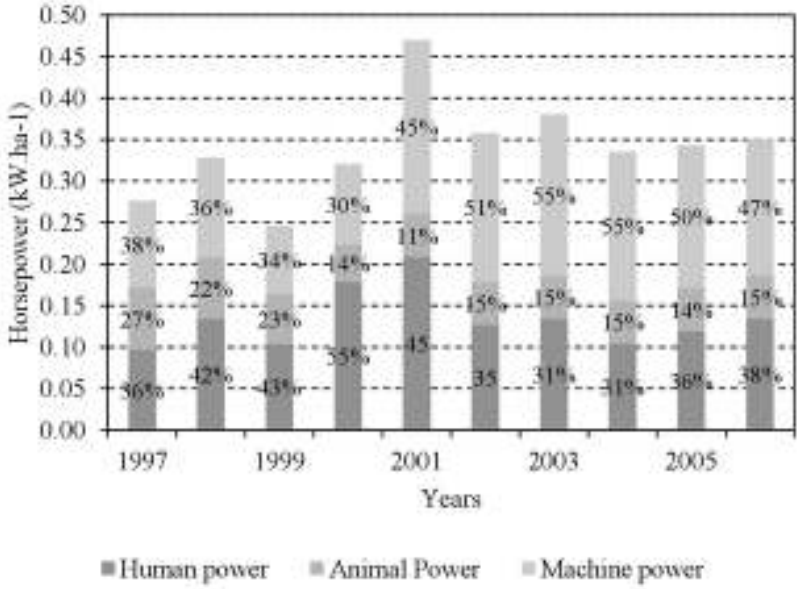


**Figure 3:** Contribution of different power sources on total power available for rice farming in Riau province, 1997-06

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. Human power varied 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 remained relatively unchanged up to 2006. Although it 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 in Figure 1 accounts for the increasing mechanical power contribution.

It was observed that the main cause of the low usage of power for rice cultivation in the province is that most farmers still depend on human muscle which can only generate on an average a maximum power from about 0.075 kW-h (about 0.1 hp-h) (Singh and Siswasumarto 1988, 9-13; Sahay 2004) to 0.15 kW-h (0.2 hp-h) (ASAE 2006;32). Under low available power, mainly from human power, yield per hectare will remain at subsistence level (Igbeka 1984, 27-32) or land productivity is generally low because of the lack of physical availability and the limited range of hand tools (Sims and Kienzle 2006, 20). Such power shortage would become a constraint not only to increase rice yields, but also to the modernization of rice farming systems 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, small paddy fields (< 0.2 ha) are 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, none 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, 135-142). It was found that about 85% of farmers hired hand tractor for land preparation, 64% hired thresher for threshing rice, and all farmers brought their paddy to either a huller or rice milling unit.

Table 2 presents the use of human and mechanical power per hectare for various operations of rice production in Riau province. The total energy requirement for rice operations per hectare in the province under current stage of mechanization was 418 kW-h (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.

**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-h) | | | |
|---|---|---|---|---|
| | 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 0.075 kW-h and an adult woman equal to 0.05 kW-h (Singh and Siswantomarto, 1988).*

## Conclusions

The main sources of the power were human and machine which contributed an average of 39% and 44% of total power respectively, and the rest 17% were draught animal power. The farm power available per hectare of rice cultivated area was only 0.34 kW on average and increased by 5.09% per annum during a period of 1997-06. The total power available is still very low and remains under the minimum power requirement for an efficient agriculture. The stage of rice mechanization process has also been relatively low of about 7 hand tractors/1000 ha of cultivated area and still below the take-off stage which is a critical point of the mechanization process. Under the current level of rice farm mechanization, the use of farm machines has no significant 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 undertaken entirely by human power. Under these conditions, total energy required for rice farm operations per hectare was 418 kW-h (561 hp) on average. Farmers should be encouraged continuously to adopt mechanical power in order to perform timely farm operations and to make the rice production process more productive and efficient.

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