


INVESTIGATING FARM MACHINERY BREAKDOWNS AND SERVICE SUPPORT SYSTEM CONDITIONS IN RAINFED RICE AREAS IN RIAU PROVINCE, INDONESIA

 Ujang Paman^{a†}

 Khairizal^b

 Selvia Sutriana^c

^{a,b}Department of Agribusiness, Faculty of Agriculture, Islamic University of Riau, Pekanbaru, Riau, Indonesia.

^cDepartment of Agrotechnology, Faculty of Agriculture, Islamic University of Riau, Pekanbaru, Riau, Indonesia.

✉ pamanu@agr.uir.ac.id (Corresponding author)

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ABSTRACT

Farm machinery breakdowns are the most common problems farmers face in field operations. The problems can cause losses of time, power, and money and must therefore be prevented. This research investigates farm machinery breakdowns and loss of machine power, as well as service support conditions in Riau Province, Indonesia. Most data were collected from secondary sources published by the Food Crop and Horticulture Services of Riau Province and the Statistical Bureau of Riau Province. The data on service support facilities were obtained through field visits to service support sites in the province. The number of farm machines, farm power, and machine breakdowns increased during the period 2010–2021. There were different breakdown rates among farm machines and regencies. The highest annual growth was 17.03 percent for water pumps, followed by power threshers (14.41%), and 2-wheel tractors (14.32%). Rokan Hilir Regency had the highest level of machinery breakdowns, reaching 26.93 percent annually. The total loss of machine power was 9,553 hp per year on average or 15.76 percent of the total power of 61,357 hp per year. The availability of service support facilities like workshops and storage sheds was very limited and remained inadequate. A lack of spare parts and mechanics was also found in the surveyed areas of the province.

Contribution/Originality: This study contributes to the implementation of farm machinery management policies to improve the associated maintenance and service support systems to prevent machinery breakdowns in the field and thereby aid farmers.

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1. INTRODUCTION

Mechanization is required to improve the productivity and efficiency of the agricultural system. Mechanization is one of the essential inputs to increase labor and land productivity and reduce drudgery (Mottaleb, Rahut, Ali, Gérard, & Erenstein, 2017; Mujawamariya & Kalema, 2017; Sims & Kienzle, 2016). Currently, mechanization technologies

have changed from technologies requiring human power or animal power to those based on mechanical power. Mechanical-power technologies, such as farm machines and associated implements, represent the highest level of mechanical technology (Houmy, Clarke, Ashburner, & Kienzle, 2013), and this is the highest level of mechanization technology commonly used in agriculture (Gifford, 1992). Therefore, farm machines have become more and more dominant in farming practices today, particularly in rice farming operations. The tractor, for example, has become an important source of power for mechanizing tillage operations (Afsharnia, Asoodar, Abdeshahi, & Marzban, 2013; Khodabakhshian & Shakeri, 2011; Oluka, 2000). Hence, a shortage of farm power can be a major constraint to the development of an agricultural system (Paman, Inaba, & Uchida, 2014). Machine power has replaced many farm jobs formerly carried out by manual labor or by working animals (Poozesh, Mohtasebi, Ahmadi, & Asakereh, 2012; Zhou, Ma, & Li, 2018). This is because farm machinery can produce more power and carry out necessary tasks more efficiently and effectively than either manpower or animal power.

Farm machinery has become indispensable to farming practice (Zhang, Hao, & Sun, 2017), particularly in large-scale commercial production systems (Yousif, 2016). Smallholder farmers often have difficulty raising sufficient funds for the necessary investment in farm machinery (Sims & Kienzle, 2015). This is because farm machinery is costly to purchase (Calcante, Fontanini, & Mazzetto, 2013; Kay, Edwards, & Duffy, 2019), so it requires a major investment in the farming system (Al-Suhaibani & Wahby, 2017). It requires as much as 40 percent of total agricultural investment (Henderson & Ghericke, 1983). Nevertheless, small-scale farms, which dominate the agricultural sector in developing countries (Gifford, 1992), utilize farm machines in their farming operations to increase production and productivity. Governments in developing countries consistently support the application of mechanical power in farm operations; however, the use of farm machinery has been growing at a relatively low rate.

The use of farm machines in small-scale farming systems remains low because it faces multiple challenges. One of the crucial challenges to managing and employing farm machines and implements on small-scale farms is field breakdowns. Machinery breakdowns lead to field stoppages due to sudden and random failure of a part (Hunt, 1983); thus, the events are unpredictable and bring a high risk. Breakdowns can be very expensive (Afsharnia et al., 2013; Bukhari, Soomro, Rajper, & Sewar, 1984; Jacobs, Harrell, & Shinn, 1983) due to loss of working time and profits and the cost of repairing the defect. Continual random failures in a machinery system can also cause the machine's performance to drop (Bala, Govinda, & Murthy, 2018). Breakdown problems have been shown to cause about 26 percent and 15 percent loss of potential main season working time in Thailand and Malaysia, respectively (Chancellor, 1971). It has also been reported that about 53 percent of total machine expenses in developing countries were due to repairs of machinery after breakdowns (Afsharnia, Asoodar, & Abdeshahi, 2014).

Given the conditions outlined above, the availability of service support systems is becoming increasingly crucial because these support systems, which consist of workshops, mechanics, and a supply of materials and spare parts (FAO, 1992), are expected to prevent machinery breakdowns, making them less likely to occur. They can also ensure that machinery breakdowns are immediately inspected and repaired. They allow preventive maintenance, involving inspection, servicing, and repairing or replacing physical components of machines, to be performed following a prescribed schedule (Khodabakhshian & Shakeri, 2011). In many cases, however, mechanical-power technology in the form of farm machines is adopted without adequate planning for infrastructural and institutional support (Gifford, 1992). The absence of service support facilities may lead to large numbers of farm machines and equipment remaining unserviced for long periods and, eventually, cause a loss of machine power available for farm works. Besides inadequate service support facilities, farm machine breakdowns are more likely to occur under rough field conditions (Paman, Uchida, Inaba, & Kojima, 2007), such as those found in the rainfed paddy field areas of Riau Province. This research thus investigates farm machinery breakdowns and the loss of available machine power due to breakdowns, as well as the service support conditions in Riau Province, Indonesia.

2. METHODOLOGY

2.1. Study Area

The study was conducted in Riau Province, which comprises ten regencies: Kampar, Indragiri Hulu, Indragiri Hilir, Bengkalis, Rokan Hulu, Rokan Hilir, Kuantan Singingi, Siak, Pelalawan, and Kepulauan Meranti, and two cities: Dumai and Pekanbaru, see Figure 1. The province is located in the center of Sumatra Island, and the total land area is approximately 87,023,660 km². Based on data from the Statistical Bureau of Riau Province (2020), the area extends from the Bukit Barisan slope up to the Malacca strait, lying between 01°05'00" S and 02°25'00" N with temperatures varying between 19.8° C and 36.8° C. The rainfall and rainy days vary between 23 mm and 347 mm and 3 days and 23 days, respectively. There are two seasons, namely the rainy and dry seasons, and the rainy season is the main season in which food crops are grown – especially rice.

Although rice is not the main crop of Riau Province, it is an important crop for the livelihoods of many people and the staple food of Riau's population. This crop is mostly cultivated in rainfed areas across the province (Paman, Bahri, Khairizal, & Wahyudy, 2018). Of the total arable land for agriculture, 740,148 hectares, 96,912 hectares are classed as paddy fields, of which 51 percent are in rainfed areas (Food Crop and Horticulture Services of Riau Province, 2019). Most of the rainfed areas can be cultivated only once a year during the rainy season due to the limited water supply. During the dry season, most of the rainfed areas are cultivated with seasonal crops like corn, soybeans, peanuts, etc. Small farm machines are mostly used by small farmers to mechanize rice farming operations in the rainfed areas.

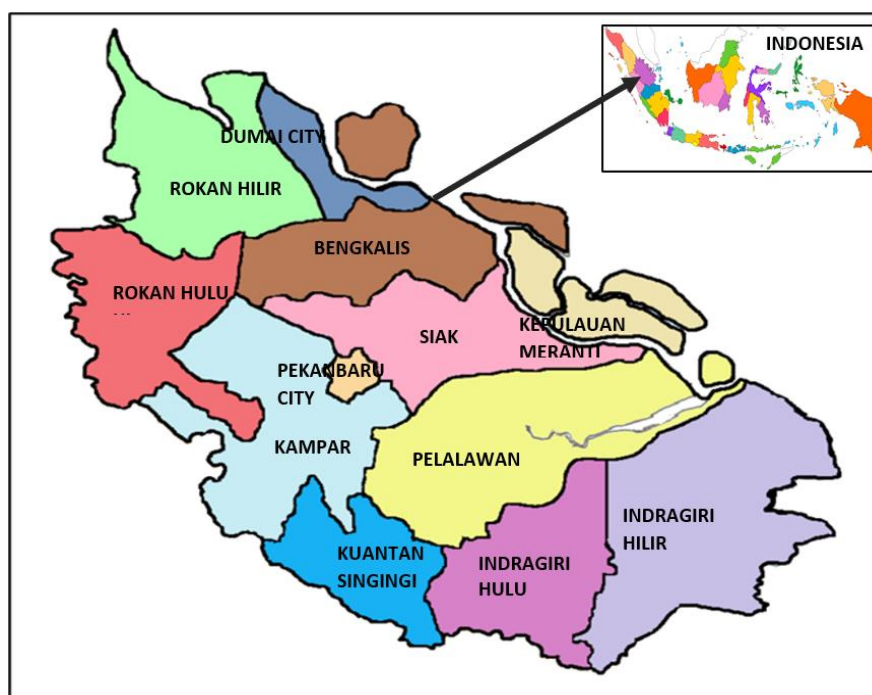


Figure 1. Map of the study areas in Riau Province.

The geographical area of Riau Province is large enough and sufficiently representative for this research topic. The utilization of farm machines in the province remains low, although a similar mechanization program has also been developed in other provinces across the country. This is an indication that the management of farm machines in the province is facing serious problems. The farm machines mostly operate on rainfed paddy fields that often experience dryness, primarily during the dry season. Moreover, the agricultural infrastructure and facilities are inadequate to support the effective and efficient use of the machines.

2.2. Data Sources and Collection

The main data for this research were obtained and collected from secondary sources, namely the Food Crop and Horticulture Services of Riau Province, the Statistic Bureau of Riau Province, and other related sources. Time-series data for the period 2010–2019 were used. The data consisted of the number of farm machines, number of tractor breakdowns, harvested rice areas, and rice yields. Field visits were also conducted to investigate the conditions of the service support systems, which provide maintenance and repair services in case of machinery breakdowns. The investigation was carried out in three regencies where service support was available, namely Kamar, Indragiri Hulu, and Siak. The collected data were then tabulated for analysis with relevant statistical tools. Simple descriptive techniques were used to analyze the data, such as means and percentages, among others.

3. RESULTS AND DISCUSSION

3.1. Number of Farm Machines and Power Availability

The most common types of farm machinery used for rice farming operations in Riau Province include 2-wheel tractors, 4-wheel tractors, power threshers, water pumps, dryers, and rice milling units (RMU). The farm machines are mostly small types, except the 4-wheel tractor. These machinery types are suitable for rice farming conditions characterized by small scale, poor technical skills of farmers, and low economic ability of farmers. Two-wheel tractors, for example, are most popularly used for land preparation in semi-irrigated and rainfed rice-growing areas in the province (Paman, Inaba, & Uchida, 2015).

The majority of the above machines are managed and operated by custom hire service providers, with aid from the local government as well as the Ministry of Agriculture. Custom hire service providers are farm machinery businesses that are managed by either a group of farmers or an individual farmer (Paman et al., 2014). This management method ensures that farm machines can be widely accessed by small farmers. The local government continually encourages and supports small farmers to mechanize their farms to enhance production and productivity. For those purposes, the local and central governments, through the Ministry of Agriculture, directly contribute to various types of small farm machines for farmers through mechanization programs for rice farming. Therefore, the number of farm machines available on a farm depends greatly on the government aid that is budgeted every year.

Table 1. Trends of farm machinery development in Riau Province.

Type of farm machine	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Annual growth (%)
2-wheel tractor	1.082	1.978	1.611	1.721	1.906	2.096	2.481	2.730	2.753	2.846	14.52
4-wheel tractor	31	35	24	29	28	24	46	102	130	160	27.61
Power thresher	799	1.109	1.281	2.195	2.288	2.216	2.126	2.272	2.083	1.693	11.39
Water pump	3.080	4.674	1.431	2.910	2.930	2.556	2.708	2.888	2.491	3.105	10.79
Dryer	45	50	51	12	17	20	20	19	16	14	-4.15
Rice milling unit	764	927	818	995	1.102	991	991	1.008	841	937	3.16

Source: Food Crop and Horticulture Services of Riau Province (2015) and Food Crop and Horticulture Services of Riau Province (2020).

Table 1 shows the trends in small machinery development over the last 10 years in Riau Province. The number of farm machines was found to increase during the period but differed by machine type, according to the required farm operations. The small farm machine with the largest number was the water pump, which increased from 3,080 units in 2010 to 3,105 units in 2019, with an annual growth of about 10.79 percent during the period. This machine is important because, as the field area is rainfed, it will always experience water shortages during the growing season, particularly during the dry season. Climate changes will change the weather patterns and will influence the number of rainy days and the rainfall in some areas. It will bring about less rain in some areas, but others will have more rain. A dry area, for example, may become drier, so it will need a water pump to supply water to the field to perform land preparation.

The second most popular farm machine is the 2-wheel tractor with an annual growth of about 14.52 percent, increasing from 1,082 units to 2,846 units over the study period. The machine is very important in land preparation and consists of three types, namely mouldboard tillers, rotary tillers, and hydro tillers (Paman et al., 2015). The type of farm machine with the smallest number was the dryer, the number of this machine decreased by about 4.15 percent per year. Most farmers prefer to dry the rice using solar energy because this method is easy and free, and is available every day if the weather is bright. Finally, the 4-wheel tractor experienced the highest growth, with an average of about 27.61 percent per year or an increase from 31 units in 2010 to 160 units in 2019. This indicates that farmers have gradually begun to shift from small tractors to bigger ones. The bigger farm tractor is more efficient and saves time in land preparation compared to the smaller one.

Table 2. Trends of available farm power, harvested area, and yields in Riau Province.

Item	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Annual growth (%)
Power available (hp)	43.881	64.859	43.118	60.635	64.537	61.883	65.957	71.660	66.618	70.426	7.91
Power per hectare (hp/ha)	0.33	0.56	0.39	0.59	0.68	0.78	0.81	0.89	0.93	1.12	17.69
Harvested area (ha)*	131.263	123.038	117.649	97.796	85.062	86.218	79.475	80.680	71.448	63.142	-7.62
Yield (ton/ha)*	3.87	3.92	3.85	3.97	3.97	4.01	4.10	4.18	3.73	3.66	-0.54

*Source: Food Crop and Horticulture Services of Riau Province (2015) and Food Crop and Horticulture Services of Riau Province (2020).

The mechanization of agriculture requires energy, and this comes from farm power sources (Sims & Kienzle, 2017). In Riau Province, farm machines have today become the main power sources for farm operations, particularly in rice farming, because animal power is no longer used by farmers. Table 2 shows the amount of farm power obtained from farm machines in Riau Province for the period 2010–2019. The total amount of available farm power increased from 43,881 hp in 2010 to 70,426 hp in 2019 with an annual growth of about 7.91 percent. Furthermore, the farm power per hectare, which is a measure of the mechanization level, increased more rapidly, from 0.33 hp per hectare in 2010 to 1.12 hp per hectare in 2019 with an annual growth of about 17.69 percent. The increased farm power was the result of the increased number of farm machines in the province. From 2016 onwards, the available farm power was more than the minimum power needed for an optimum yield, at more than 0.8 hp per hectare (Jain, 1979). The level of mechanization in Riau Province in 2019 was slightly lower than that of the Philippines, which had 1.23 hp per hectare (Cruz, 2018). Increasing the power supply to rice farms is expected to allow field operations to be carried out completely at the right time and greater areas to produce larger quantities of rice.

The increase in available farm power did not result in increases in harvested area or yields. Harvested area and yields decreased 7.62 percent and 0.54 percent per year on average, respectively. This indicates that the increase in the amount of available farm power was insufficient to enhance the harvested area and yields. This may be because the number of farm machines is still small and many of them remained unused for more than a season due to breakdown problems, as shown in Table 3 and Figure 2.

3.2. Number of Farm Machinery Breakdowns and Power Losses

Table 3 shows the number of farm machinery breakdowns that occurred for each type of farm machine in Riau Province in the period 2010–2019. Most farm machines experienced an increase in breakdowns with different rates of increase for different machine types. The greatest increase of breakdowns was found water pumps, with an increase of

about 17.03 percent per year, followed by power threshers (14.41%) and 2-wheel tractors (14.32%). The number of the annual breakdowns for each machine type was 312 units for water pumps, 369 units for power threshers, and 364 units for 2-wheel tractors. In contrast, the 4-wheel tractor experienced a decreasing trend of about 16.74 percent per year, with the average number of breakdowns totaling 6 units per year. The number of machine breakdowns can be affected by usage intensity, field conditions, and operator skill. However, the rate of farm machinery breakdowns tended to decline slightly over the period 2010–2019, as shown in Figure 2.

Table 3. Number of farm machinery breakdowns in Riau Province.

Type of farm machine	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Annual growth (%)	Average (unit)
2-wheel tractor	200	477	388	362	383	323	355	355	382	413	14.32	364
4-wheel tractor	8	7	7	7	7	9	0	6	6	3	-16.74	6
Power thresher	163	298	323	505	392	380	414	474	353	387	14.41	369
Water Pump	182	315	275	327	715	273	300	233	208	292	17.03	312
Dryer	5	11	12	1	2	2	0	3	2	2	0.51	4
Rice milling unit	86	177	170	188	196	132	134	132	116	115	7.89	145

Source: Food Crop and Horticulture Services of Riau Province (2015) and Food Crop and Horticulture Services of Riau Province (2020).

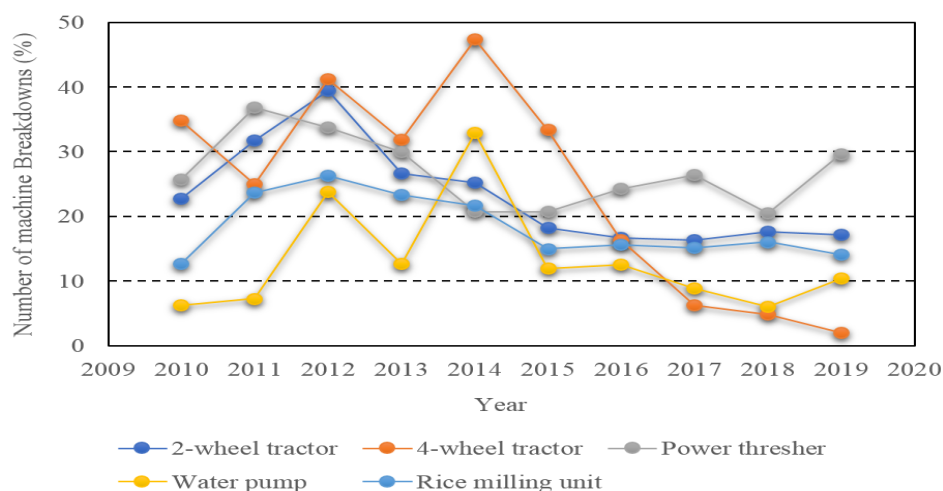


Figure 2. Number of breakdowns for each type of farm machine in Riau Province.

The rate of farm machinery breakdowns was also found to differ among regencies, although it decreased slightly over the period 2010–2019, as shown in Figure 3. The highest breakdown rate was found in Rokan Hilir Regency, where it reached 26.93 percent annually. However, the highest rate in the regency reached 41 percent in 2013 and then declined sharply to 12 percent in 2019. A high breakdown rate was also found in Indragiri Hilir and Rokan Hulu Regencies, with average rates of 21.24 percent and 20.26 percent annually, respectively. Kepulauan Meranti Regency had the lowest breakdown rate; it was 5.44 percent annually on average.

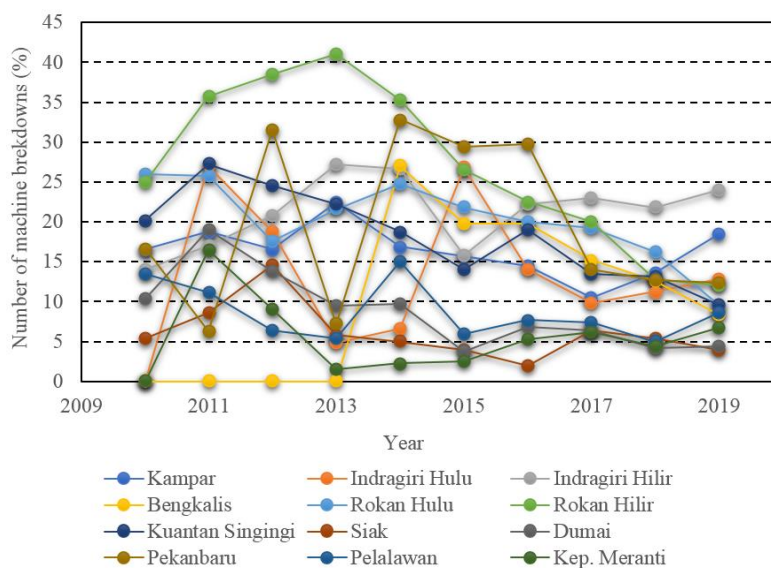


Figure 3. Number of farm machinery breakdowns in each regency of Riau Province.

Farm machinery breakdowns cause significant power loss on farms. Figure 4 depicts the total loss of machine power as a result of breakdowns in Riau Province between 2010 and 2019. The total loss of machine power was 9,553 hp per year on average or 15.76 percent of the total power available, which was an average of 61,357 hp per year during the period. The highest power loss was 22.54 percent in 2012, followed by 19.93 percent in 2014 and 18.41 percent in 2013, while the lowest was 12 percent in 2010. There was a high degree of fluctuation from year to year mainly between 2010 and 2014; afterward, the fluctuation was lower, and the number of machine breakdowns gradually decreased. This indicates an improvement in farm machinery maintenance over the last 5 years.

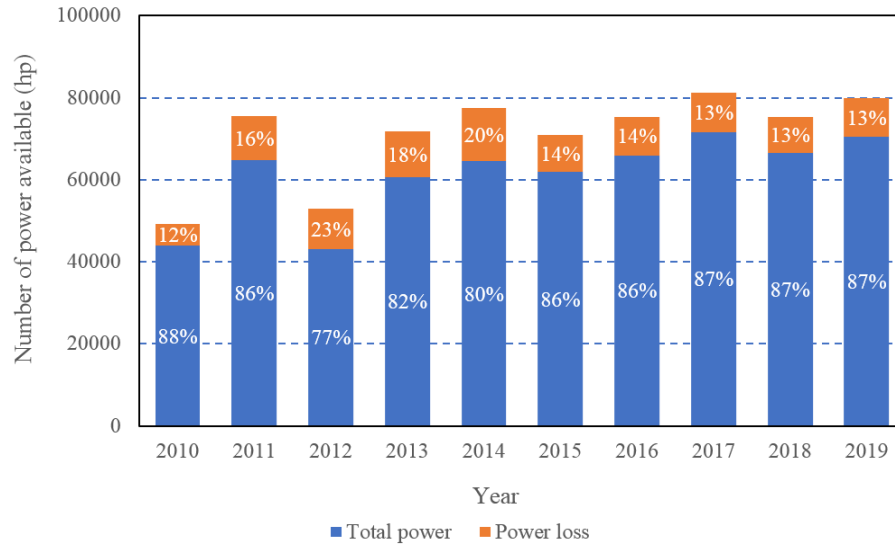


Figure 4. Amount of available farm power and power loss in Riau Province.

3.3. Service Support System Conditions

Service support systems comprise workshops, mechanics, storage sheds, and the supply of materials and spare parts. Workshops are one of the most important service support facilities, both for making repairs in case of breakdowns and for the regular maintenance of farm machines. The availability of workshops, spare parts, and skilled mechanics is crucial to the optimal performance of the farm machinery. Farm machinery storage sheds are also important to protect and keep the machines and tools safe and secure from the weather.

The number of workshops for repairing farm machines and tools in Riau Province is very limited. Although rice-cultivating areas are found in each regency, workshops are only available in three regencies, namely Kampar, Siak, and Indragiri Hulu Regencies, as well as one in Pekanbaru city, see Figure 5. Businessmen are less interested in establishing workshops due to the limited number of farm machines available in the rice field areas. An adequate number of farm machines is required to economically establish a workshop. The establishment of well-equipped workshops and the employment of mechanics does not make economic sense for a small number of machines (FAO, 1992). Fortunately, the supplier of farm machinery and tools in Pekanbaru City also runs a workshop. Serious machinery breakdowns can usually be brought to this dealer for repairs to be carried out and machines to be overhauled.



Figure 5. Workshop sites in Riau Province.

The workshops in Riau Province are owned by individuals (privately) or managed by custom hire service providers. Both workshop types are under local government supervision, particularly workshops owned by custom hire service providers. Except for the dealer, most workshops in rural areas are inadequate because they have inadequate tools to make repairs. In addition, they have little space to store broken down farm machinery to be repaired in the workshop. They employ only a single mechanic who is usually either an experienced operator (5-10 years) or a trained farmer. They also do not sell the required spare parts in the workshop due to capital deficiency. Interviews with workshop staff revealed that the lack of mechanics and spare parts are the most serious problems facing machine owners in Riau Province's rice field areas, see [Figure 6](#). Consequently, workshops can only carry out minor repairs, whereas if the breakdown is serious and requires spare parts, the machine is stored in the workshop to await replacement parts, see [Figure 7](#); a few of them are sent to the dealer in Pekanbaru for repairs to be made. Spare parts can take months or even years to arrive, depending on where they are ordered from. This finding suggests that more complete workshops must be established in the vicinity of rice-cultivating areas, so that farm machinery can be repaired, and broken parts can be replaced immediately to restore them to service as soon as possible. The improper handling of machine breakdowns has a chance of causing more serious breakdowns.



Figure 6. Discussion and interview with staff in a farm machinery workshop.



Figure 7. Machinery breakdowns in the workshop waiting for spare parts.

Complete repair and maintenance facilities are required to make spare parts available at low prices (Afsharnia, Asoodar, Abdeshahi, & Marzban, 2015) and then repair minor as well as serious breakdowns. The availability of spare parts for the proper repair and maintenance of machinery is of paramount importance, so that reliability, efficiency, and long life of the machines can be achieved (Maradun, Sanusi, & Akubuo, 2013). In addition, proper servicing can optimize agricultural productivity in farm operations (Nkakini & Etenero, 2019).



Figure 8. Farm machinery storage shed in the survey area.

Furthermore, the proper storage of farm machines is vital to keep the machine in safety, particularly during the off-season. The purpose is to protect farm machines from harsh weather conditions such as rain, wind, and sun. Field investigations found that the farm machinery storage sheds were inadequate for storing the machines during the off-season. The storage sheds were found to lack walls and sometimes also cement floors, see Figure 8. Not all farmers have a farm machinery storage shed. In the case a storage shed is unavailable, farm machines and tools were stored outdoors and only covered with canvas or other types of covers, see Figure 9. This finding suggests that farmers (machine owners) must make sure that their farm machines are stored properly in a storage shed when not in use and during the off-season. The establishment of farm machinery storage sheds is necessary for the above purpose.



Figure 9. Farm machines and tools stored outdoors during the off-season.

4. CONCLUSIONS AND RECOMMENDATIONS

The number of farm machines and associated farm power increased during the period 2010–2021, with different rates of growth for different machines. The total amount of farm power per hectare increased by about 7.91 percent annually during the period. Farm machinery breakdowns also increased during this period, with different rates of growth for different machines. There were also different breakdown rates among the various farm machines. The highest breakdown rate was found for water pumps, with an increase of about 17.03 percent (312 units per year) annually, followed by power threshers with about 14.41 percent (369 units per year) and 2-wheel tractors with about 14.32 percent (364 units per year). The total loss of machine power was 9,553 hp per year on average or 15.76 percent of the total available machine power, which was an average of 61,357 hp per year during the period. The number of service support facilities, such as workshops, storage sheds, and mechanics in the rice field areas, was found to be very limited and hampered by inadequate tools and a shortage of mechanics. The available workshops could only perform minor repairs, and farm machines that suffered serious breakdowns must be sent to dealers in Pekanbaru City or put in long-term storage in the workshops to await the ordered replacement parts.

Based on the results, it is strongly recommended that service support systems like workshops with adequate tools and skilled mechanics, as well as spare part depots, are provided to enable the proper repair and maintenance of farm machinery in rural areas. Farmers should also improve their care and maintenance of farm machines by keeping them in storage sheds, particularly during the off-season.

This research has presented a preliminary investigation of machinery breakdowns without exploring in detail the root cause of the breakdowns or the type of machine parts that frequently broke or failed. Therefore, there is a need to conduct field investigations into the root cause of machinery breakdowns and the machine parts that fail most frequently. Further investigation is also required to identify the competencies required for operators and mechanics to operate and repair machines, respectively.

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