International Journal on Advanced Science Engineering Information Technology

Vol.8 (2018) No. 3
ISSN: 2088-5334

Farm Machinery Development and Utilization System Policies for Small-Scale Rice Farming

Ujang Paman[#], Saipul Bahri[#], Asrol[#], Khairizal[#], Hajry Arief Wahyudy[#]

[1]*Department of Agribusiness, Faculty of Agriculture, Islamic University of Riau*
Jl. Kaharuddin Nasution No. 113 P. Marpoyan, Pekanbaru Riau 28284, Indonesia
E-mail: pamanu@agr.uir.ac.id, bahri_sp@agr.uir.ac.id, asrolmkh67@yahoo.com, khairizal@agr.uir.ac.id, hajry@agr.uir.ac.id

***Abstract*—The use of farm machinery as a source of power in Kampar Region, Indonesia has become increasingly important and dominant for effective and efficient farm operations. This paper attempted to highlight the farm machinery development and utilization system policies for small-scale rice farming in the region. Data were collected through field surveys in the selected rice production centers from 20 districts in Kampar Region. The interviews with involving farmers, government extension staff, and machinery suppliers were conducted in September and October 2015. The results showed that the agricultural mechanization program run by Government in Kampar region has dramatically accelerated the development of farm machinery use from year to year. On the other hand, the low purchasing power, limited government budgets, and limited farmers' access to agricultural credit have decelerated the development of farm machinery on the farm level. To increase farm machinery utilization among small farmers, the local government has developed machinery-hiring schemes to provide farm machinery for the small farmers. Recommendations for the future development of increasing the use of farm machinery in the region are also proposed.**

***Keywords*— farm machinery; utilization system; small-scale rice farming; Kampar Region**

I. INTRODUCTION

The development of agricultural mechanization has made a significant contribution to the success of modernization process of the agricultural system in many developing countries today. It is because the agricultural mechanization is an essential element to modernize agriculture [1] and then becomes a crucial input in agricultural production process [2]. The mechanized operations of agriculture have helped to increase the primary productivity of land and labor, to reduce production costs and drudgery on the farm labors, and to improve the timeliness and quality of farm works [1], [3]–[8]. The mechanized farming system is also expected to make agriculture more attractive and reduce the rural-urban drift. However, the successful implementation of the mechanization program requires a considerable effort by policymakers, institutions and extension workers, and then introduces new mechanical techniques, and adapts the techniques in agricultural production process [9].

Farm mechanization refers to the use of tractors and other engine power and equipment for carrying out farm operations [10], which later replaces human labor and animal power used in agricultural operations. The use of machinery as a leading source of farm power will continue to be more dominant in the future because of the machine power has highly influential and makes more effective and efficient farm operations. Machine power will also be useful to meet the agricultural productivity and production goals. It is because the use of the power input into the agricultural process has a direct and significant contribution to production, productivity, and profitability of agricultural farms. Therefore, the use of farm machinery has become the highest level of mechanization in agriculture today.

Currently, the level of mechanization adoption of farming practices can vary widely across countries, regions, and farm areas. The full mechanized system has completed in most developed countries, while many developing countries have been striving to achieve the high level of the mechanization adoption. The adoption of mechanization by farmers has followed an evolutionary process which is influenced by a set of country-specific agro-climatic factors, economic factors, and social conditions for which the government's policy choices have an impact [11]. Furthermore, many factors are affecting the utilization and development of machines, such as agricultural conditions, farming requirements, farm management scales, economic conditions, the technical level of manufactures, and farmer's experience [12].

Agricultural mechanization particularly the adoption of farm machinery evolves to follow various stages, starting

from the use of mechanical power for power-intensive operations that require a little control, followed by control-intensive operations and finally to automation of production [13]. In Indonesia, the use of farm machinery as a source of power for farm work operations has become one of the vital programs of the local government with the aim of increasing productivity and production of small-scale rice farming. Both small and medium farm machines will continue to dominate for the prospect of farm mechanization in the country [14]. For the effective and efficient use, the size (or capacity) and some farm machines must match to the power required by the various cropping operations within specified time periods with the minimum cost [15].

Indonesia is one of the developing countries where the development of machine powers in agriculture is still relatively low. Consequently, farm power availability on the farm is always insufficient for accomplishing farm operations that are difficult to be performed without mechanical aids. One of the critical problems associated with farm power in the country is a shortage of available farm machines, so the level of mechanization adoption remains low. To promote farm machinery use among small farmers in the country, tractor-hiring schemes have been operated [16] and mostly managed by farmer groups [17]. The method has been adopted by farmers in some developing countries [18]–[24] and become a viable business [17]. The use of farm machines on custom hire basis could help in accelerating mechanization process in agriculture [9]. The availability of custom hire business has become essential to hasten the mechanization process and generate an additional income among farmers [25]. The last findings revealed that we find hiring in tractor services significantly increased the returns to scale in agricultural production [26]

Although the agricultural mechanization program in Riau Province has been critically accelerated in current years, its level of overall mechanization development is still relatively low. The development of farm machinery, particularly in Kampar Region, always faces with some inherent drawbacks such as fragmented lands, poor buying capacity of farmers, poor technical knowledge of farmers about machines, limited access to the financial institution (bank), and inadequate business knowledge of machinery management. In the development process of mechanization, a large number of farm machines (power) are required to be accessed and used by farmers to mechanize their farm operations. The limited availability of farm power also becomes a constraint factor for the growth of farm tools and implements [27]. Therefore, it is essential to know the development of farm machines and how to use them for achieving rice production goals. This paper attempts to highlight the farm machinery development and utilization system policies for small-scale rice farming in the Kampar Region, Indonesia.

II. Materials and Methods

Kampar Region, which is located about 60 km south of the capital of Riau Province, Pekanbaru, is one of the rice production centers in the province. The total land area of the region is about 1,128,928 ha, and approximately 66% (744,609 ha) is an agricultural area**.** Most of the agricultural areas is a plantation, and only 0.9% (6.845 ha) is a paddy field area. Palm oil and rubber are main plantation crops that are cultivated by individual farmers and companies in the region. These plantation crops are more economical than food crops, like rice, soybean, and corn.

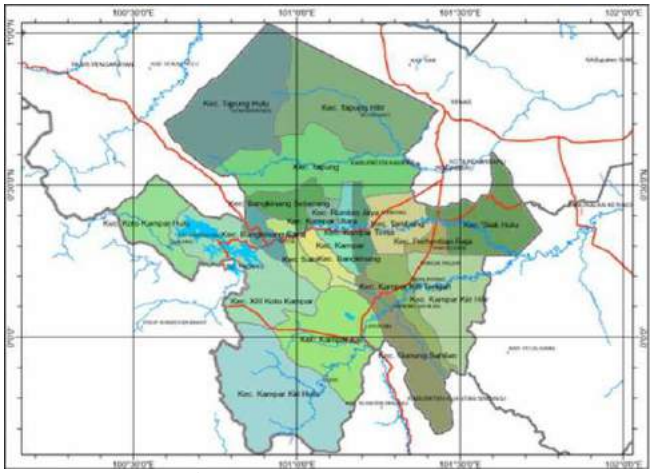

Fig. 1 Map of Kampar Region showing research location

Rice is commonly grown on the lowland area that is mostly rain-fed. The problem appears when there is no rainfall; it makes trying to use machines primarily for the land preparation due to a shortage of available water. Therefore, the rainy season has been a primary season for growing rice in the region which usually falls on September (sometimes October) up to March every year. During the season, paddy field areas have enough water from rainfall, so rice crop is feasibly planted on 100% of the available land area [28]. Also, Kampar region was selected purposively to represent the most intensive rice production system and highest mechanized farming in Riau Province.

Data were collected through field surveys in the selected rice production centers from 21 districts in the Kampar Region (Fig. 1). Primary and secondary data were used and collected during September and October 2015. The personal interviews with involving farmers, group managers, and government extension officers were conducted to obtain primary data using questionnaires. The primary data collected consisted of number and type of farm machines owned by groups, coverage area, and seasonal working area for each machine. Meanwhile, the secondary data were gathered from Statistical Bureau of Kampar Regency, Food Crop and Horticulture Services of Kampar Regency, and other official sources, including cultivated area, harvested area, rice production, and farm machinery population. The data were tabulated and analyzed using simple descriptive techniques including percentage, mean, and graphical methods.

III. Results and Discussion

A. Development of Farm Machinery

In Kampar region, the majority of farmers hold small-scale farms, so the powerful machines and equipment used for rice farming operations in the region are the small type of farm machines. Hand tools like a hoe, hand sprayer, sickle, pedal thresher etc. are still used primarily farmers who are not able to purchase and hire farm machines from hire

service providers. They are also farmers who have enough labor from their family members to perform rice farming operations. However, the number of family members who are interested in working on rice farming managed by their parent has decreased significantly nowadays. Besides continuing education to university in the city, the young villagers prefer to find a job in the city than in their villages. This has been a general tendency of labor mobility in the developing countries that has caused a shortage of agricultural labor in the rural areas. Consequently, the number of old farmers in survey areas have regularly increased that may threaten rice productivity in the future without using machines.

Furthermore, the use of the small machines as a source of power has become an urgent need as instead of the hand tools and drawn-animal implement for increasing production, productivity, and profitability of rice farming. It is because the small type of farm machines is especially suitable to field conditions in most areas which are dominated by small-scale farms. The principal farm machines which are mostly available and used in rice farming in Kampar region included power tillers, water pumps, power threshers, and rice milling units (RMU). Power tillers are tillage machine which consisted of three types, i.e., moldboard plows, rotary tillers, and hydro tillers. It is reported that these farm machines are used under different field conditions [28]. Interview with farmers revealed that hydro tillers showed the best performance and the lowest operational costs. Table 1 shows the development of the significant farm machines in the Kampar Region from 2009 to 2015.

TABLE I
DEVELOPMENT OF MAJOR FARM MACHINES DURING A PERIOD AF 2009-2015

Machinery Types	2009	2010	2011	2012	2013	2014	2015	Annual Growth (%)
Power Tiller	103	150	170	165	165	165	196	12.47
Water Pump	31	25	25	164	164	211	254	97.61
Power Thresher	27	34	34	37	37	37	133	49.03
Rice Milling Unit	20	69	69	61	61	64	81	44.15

Sources: Food and Horticulture Crops Services of Kampar Regency.

Generally, the rate of annual development of the farm machines on the rice farm differed among machine types and ranged from relatively low to high. The most extensive development was found for water pumps to reach 97.61% annually and the rate tended to increase more quickly, while the lowest one was power tillers of about 12.47% annually. The water pumps were required a large number due to an increasing drought as a result of climate change occurred in the area. The machine is used to pump water from available well or river into the paddy field especially during dry season. In the season, irrigation canal becomes dry, and water must be supplied from other sources.

The number of farm machines in the region reached 664 units in 2015 or increased from 181 in 2009. The rate of annual increase differed across machine types. They consisted of 196 power tillers, 254 water pumps, 133 power threshers, and 81 RMUs (Fig. 2). The increased trend is expected to affect significantly of increasing use of farm machines among small farmers. Thus, the increased number of farm machines may increase an available power on the farm. Eventually, the mechanization level becomes higher. The high level of mechanization reflects the success of technological transformation from traditional (tools) to modernization (machinery) in the farming system.

The farm mechanization programs in Kampar region have been shown by increasing adoption of farm machines such as power tillers, water pump, power threshers, and RMUs (Fig 3). They have spread widely over the 14 districts which are central areas of rice cultivation in the region (Table 2). Tambang district found the most substantial number for both power tillers (23 units) and water pumps (52 units). Furthermore, Bangkinang and Kampar Timur districts were found the most significant number of power threshers and RMUs, respectively. The machines have not spread evenly, although the specific larger area can be found more available of the machines. There is a need to increase the number of farm machines on the farm and equally distribute them over the rice areas.

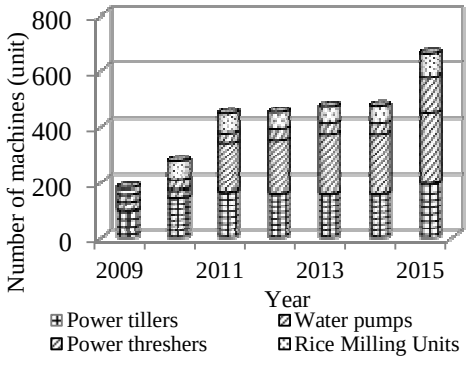

Fig. 2 Development of significant farm machines during a period of 2009-2015

Fig. 3 Farm machines used in rice farming operations

These will facilitate farmers to access farm machines when they require them efficiently. The power tillers are required at the beginning of growing season for performing land preparation and sometimes together with the water pump. The water pump is used to assist farmers for supplying water into paddy field primary on dry season. Rice harvested by sickle and afterward directly threshed by using power threshers on paddy field area. The rice milling is used to mill rice when it is needed to be consumed or sold by farmers.

B. The policy of Farm Machinery Utilization System

Agricultural mechanization in Kampar Regency has experienced much more progress during the last ten years, although the development level differed across rice areas. These differences can be caused by the disparity of supplying machines and farmers' social-economic conditions. Farm machines for rice farmers are supplied through two methods. Firstly, farm machines are directly aided by government, which is budgeted every year in its annual budgetary.

The supplying number of these farm machines is insufficient depending on government's annual budget. The type of these machines mostly consisted of power tillers, power threshers, and rice milling units. The machines are delivered to farmer groups to be managed and used for group members for providing custom hiring services. All group members can use the services to work their farming operations. The kind of services available depends on the type of machines managed by groups. Now, the available services are just only tillage, irrigating, threshing, and milling operations.

TABLE II
DISTRIBUTION OF MAJOR FARM MACHINERY IN SELECTED DISTRICTS OF KAMPAR REGION IN 2015

Districts	**Paddy Field (ha)**	**Rice Yield (t/ha)**	**Machinery Types**			
			Power Tiller	**Water Pump**	**Power Thresher**	**Rice Milling Unit (RMU)**
Kampar Kiri	250	4.05	19	9	8	5
XIII Koto Kampar	55	3.85	7	5	0	2
Koto Kampar Hulu	90	3.75	2	0	1	1
Kuok	620	4.98	11	8	8	6
Salo	390	5.03	3	2	3	3
Tapung	50	4.50	5	10	1	1
Tapung Hulu	50	NA	1	14	3	4
Bangkinang	568	6.05	19	46	55	6
Kampar	1,894	5.02	14	5	25	13
Kampar Timur	467	4.75	15	9	5	16
Rumbio Jaya	205	4.25	2	4	1	6
Kampar Utara	803	4.85	6	3	4	7
Tambang	937	4.15	23	52	15	1
Siak Hulu	451	3.95	10	4	0	1
Perhentian Raja	15	NA	14	42	0	0
	6,845	-	-	-	-	-

Sources: Food and Horticulture Crops Services of Kampar Regency [31–[37].

Secondly, farm machines which are directly purchased by individual farmers from dealers. They are usually farmers who have money to purchase the machines. The machines are used primarily to work their farming operations, and the excess capacity is offered to other (neighbor) farmers for hiring machinery services. Most farmers offered the services to make full utilization of their machines that are difficult to be achieved due to small farm holding. Table 3 presents the number of farm machines managed by farmer groups and their working areas in selected farmer groups during a cropping season. From a total of 6,845 ha paddy field area in the Kampar Region, approximately 42.2% included into the coverage area of 20 farmer groups.

In case of tillage machine, if the total of the tilled area is divided per machine, the average of working area is only 8.3 ha (Table 3). This figure is still relatively low or underutilized because, for full mechanization, it is required to about 10 ha per machine [38]. Short time for tillage operation, less demand of tillage machine by farmers, and lack of operator skill may cause the low working area. The lack of operator skill in operating farm machinery has been one of the problems of Indonesia farmers [39].

TABLE III
NUMBER OF FARM MACHINES MANAGED BY GROUP FARMERS AND THEIR UTILIZATIONS IN SELECTED FARMER GROUPS IN KAMPAR REGION

Name of Groups	Coverage Area (ha)	Number of Machines and Seasonal Utilization							
		Rotary tiller		Water pump		Power thresher		RMU	
		Unit	Ha	Unit	Ha	Unit	Ha*	Unit	Ha*
Bonca Ukam	160	4	32.0	1	5.0	1	2.9	-	-
Suka Maju	115	9	50.0	2	12.0	1	2.3	1	5.5
Pulau Lestari	125	10	84.0	1	8.0	2	4.1	1	4.5
Karya Bersama	60	2	24.0	-	-	-	-	-	-
Tani Bersama	235	1	12.0	-	-	-	-	-	-
Birandang Jaya	250	2	48.0	-	-	2	4.6	1	7.0
Karya Jaya	70	4	20.0	-	-	-	-	1	6.3
Sinar Tani	215	3	22.5	-	-	-	-	1	6.0
Baliok Imbo	90	2	30.0	-	-	-	-	-	-
Sinar Harapan	145	1	16.0	-	-	-	-	-	-
Nikmat Usaha	241	6	26.5	3	12.0	2	5.6	-	-
Karya Indah	25	2	24.7	-	-	-	-	-	-
Rizki Bersama	130	3	15.0	1	5.0	1	1.9	1	5.0
Sri Rezeki	190	6	41.0	-	-	1	1.5	1	4.5
Titian Rizki	150	3	30.0	1	3.0	-	-	-	-
Tani Maju	400	2	13.0	-	-	1	2.3	-	-
Tunas Harapan	100	2	20.0	-	-	1	3.0	-	-
Zoki Busamo	42	2	9.0	-	-	1	1.8	-	-
Kerja Bersama	85	2	20.0	-	-	-	-	-	-
Pelambaian Indah	58	1	20.0	1	10.0	-	-	-	-
Total for group	2,886	67	557.7	10	55	13	30	7	38.8
Total for region	6,845	196	-	254	-	133	-	81	-
Percentage (%)	42.16	34.18	-	3.94	-	10.23	-	8.64	-

Note: *Rice productivity was assumed to be 4.5 t/ha

According to Table 3 and Fig. 4, the number of farm machines managed by farmer groups was relatively small, ranging from 34% for power tillers to 4% for water pumps. While the power threshers and RMUs were managed for about 20% and 9%, respectively. The most substantial number of power tillers managed by farmer groups indicated

that demand for tillage operation was higher than other operations. It is because tillage operation is a power-intensive operation which requires more labor and high cost. This operation also requires a longer time by using manual tools (hoe). It was found that the operation only needed at a range of 19 to 23 h.ha^{-1} by using power tillers [28], [29]. It means that the machine power can considerably save labor, cost, and time. Interview with farmers revealed that both primary and secondary tillage require at a range of 65 – 75 days.ha^{-1} with hoe. By using power tillers, the cost for tillage operations could be cheaper, ranging from IDR 1.2 – 1.5 million.ha^{-1} (IDR 120 – 150 m^{-1}).

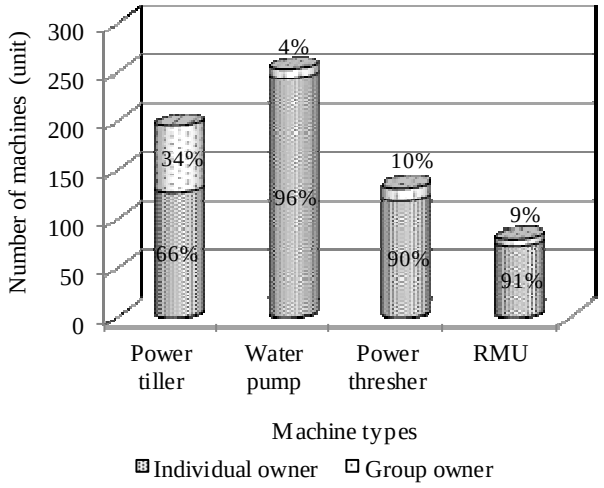

Fig. 4 Number of farm machines owned by individual and group farmers

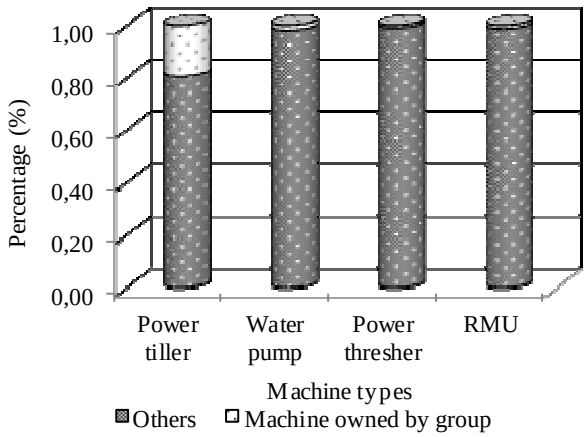

Fig. 5. Percentage of coverage area worked by a machine owned by group farmers

The volume of seasonal work done by the various types of machines managed by farmer groups is still relatively low due to the limited number of owned machines. Based on Fig. 5, power tillers topped the list at 557.7 ha (23.9%) from the total coverage area of 2,886 ha, followed by water pumps of 55 ha (1.9%), and RMUs of 38.8 ha (1.3%)). The smallest one was water pumps of about 10 ha (1.1%). The water pumps were used to pump water from the canal into a paddy field when water in the field is not enough to perform tillage operations. The remaining 2,328.3 ha was performed by individual hiring services or using manual tools (hoe). Farmers, who have the smaller scale of the paddy field area, mostly use manual tools, particularly for tillage operations. During the last ten years, farmers in the region did not use animal power to plow paddy field anymore. They deemed that animal power is not very efficient and slow in doing work. Tillage operations with the animal power required to the time of about 118 hours.ha-1 and 248 hours.ha-1 for dry and rainy seasons, respectively [30].

IV. Conclusions

The development of agricultural mechanization (i.e., farm machinery) in Kampar Region, Riau Province is relatively low. The number of farm machines on the farm, however, was not sufficient to make full mechanized operations of rice farming in the region due to primarily poor buying capacity of farmers, limited government budgets to purchase farm machines, and limited access to the financial institution (bank). To promote utilization farm machines among small-scale farmers, tractor-hiring schemes were adopted to provide farm machinery services under farmer group's management. In farming practices, the utilization of farm machines in each farmer group is not adequate because of limited farm machines availability. Therefore, the results recommend that the number of farm machines be required to be increased for group farmers as well as individual farmers to full mechanized operations of rice farming. The use of farm machines for custom hiring should be encouraged as a business opportunity, and small-scale farmers should be helped to access credit from financial institutions to finance farm machines purchasing.

References

[1] M. Verma and A. Tripathi, "Perspective of the Status of Agricultural Mechanization in the Bihar State," *Int. J. Emerg. Technol. Res.*, vol. 3, no. 3, pp. 10–17, 2016.

[2] J. Kienzle, J. E. Ashburner, B. G. Sims, and F. and A. O. of the U. N. P. P. and P. Division, *Mechanization for Rural Development: A Review of Patterns and Progress from Around the World*. Plant Production and Protection Division, Food and Agriculture Organization of the United Nations, 2013.

[3] A. . Rijk, "The Role of Farm Mechanization in Developing Counties: Experience in Asian Countries," in *Small Farm Equipment for Developing Countries: Proceedings of the International Conference on Small Farm Equipment for Developing Countries: Past Experiences and Future Priorities, 2-6 September 1985*, United States. Agency for International Development, Ed. The Institute, 1986.

[4] G. C. Mrema, D. Baker, and D. Kahan, *Agricultural mechanization in sub-Saharan Africa: time for a new look*. 2008.

[5] S. R. Bello, *Agricultural Machinery & Mechanization: Mechanization, Machinery, Landform, Tillage, Farm Operations*. Createspace Independent Pub, 2012.

[6] a. Abdulquadri and B. Mohammed, "The Role of Agricultural Cooperatives in Agricultural Mechanization in Nigeria," *World J. Agric. Sci.*, vol. 8, no. 5, pp. 537–539, 2012.

[7] B. Sims and J. Kienzle, "Making Mechanization Accessible to Smallholder Farmers in Sub-Saharan Africa," *Environments*, vol. 3, no. 2, p. 11, 2016.

[8] R. Shyam Singh, *Custom Hiring and Scope of Entrepreneurship Development in Farm Machinery*, vol. 44. 2013.

[9] T. ur Rehman, M. U. Khan, M. Tayyab, M. W. Akram, and M. Faheem, "Current status and overview of farm mechanization in Pakistan–A review," *Agric. Eng. Int. CIGR J.*, vol. 18, no. 2, pp. 83–93, 2016.

[10] E. a Ajav, "Animal traction as a source of power for agricultural development in Nigeria," *Distribution*.

[11] X. Diao, F. Cossar, N. Houssou, and S. Kolavalli, “Mechanization in Ghana: Emerging demand, and the search for alternative supply models,” *Food Policy*, vol. 48, pp. 168–181, Oct. 2014.
[12] S. Y. Ademiluyi and O. I. Oladele, “Field performance of VST Shakti power tiller on sawah rice plots in Nigeria and Ghana,” *Bulg. J. Agric. Sci.*, vol. 14, no. 5, pp. 517–522, 2008.
[13] H. Takeshima and S. Salau, “Agricultural mechanization and the smallholder farmers in Nigeria,” 2015.
[14] Handaka, “Towards sustainable agricultural mechanization in Indonesia,” *Tech Monit. Spec. Featur. Sustain. Agric.*, no. Jan-Feb 2009, pp. 38–43, 2009.
[15] A. K. Sinha, A. K. Shrivastava, A. K. Gautam, and S. Ahamad, “A Decision Support System for Farm Mechanization with the Use of Computer Modeling For Soybean-Wheat Crop Rotation,” *Int. J. Innov. Sci. Eng. Technol.*, vol. 3, no. 7, 2016.
[16] U. Paman, S. Inaba, and S. Uchida, “Farm machinery hire services for small farms in Kampar Regency, Riau Province, Indonesia,” *Appl. Eng. Agric.*, vol. 30, no. 5, pp. 699–705, 2014.
[17] U. Paman, S. Inaba, and S. Uchida, “Economic Aspects of Machinery Hire Services Managed by Farmer Groups in Kampar Regency, Indonesia,” *Appl. Eng. Agric.*, vol. 32, no. 2, pp. 169–179, 2016.
[18] B. A. Alabadan and Y. Yusuf, “Tractor hiring schemes in Nigeria: A case study of Federal Capital Territory (FCT),” *African J. Agric. Res.*, vol. 8, no. 47, pp. 5962–5966, 2013.
[19] S. S. Chahal, P. Kataria, S. Abbott, and B. S. Gill, “Role of cooperatives in institutionalization of custom hiring services in Punjab,” *Agric. Econ. Res. Rev.*, vol. 27, no. 2014, 2014.
[20] D. El Pebrian, “Factors affecting farmers’ satisfaction with mechanized rice harvesting in Malaysian paddy fields: A case study of hiring custom operators,” *Agric. Eng. Int. CIGR J.*, vol. 19, no. 2, pp. 120–128, 2017.
[21] M. Milufarzana, A. Rahman, M. M. Alam, and M. R. Ahmed, “Economic parameter of maize sheller for custom hire service in Bangladesh,” *Agric. Eng. Int. CIGR J.*, vol. 17, no. 2, 2015.
[22] P. Kamboj, R. Khurana, and A. Dixit, “Farm machinery services provided by selected cooperative societies,” *Agric. Eng. Int. CIGR J.*, vol. 14, no. 4, pp. 123–133, 2012.
[23] M. Koike, “Custom Hire Systems for Agricultural Machines in Southeast Asia—In a Rural Community in Thailand—,” *Eng. Agric. Environ. food*, vol. 2, no. 4, pp. 144–149, 2009.
[24] S. Singh and S. HS Kingra, “Custom Hiring Services of Farm Machinery in Punjab: Impact and Policies,” *Indian Res. J. Ext. Educ.*, vol. 13, no. 2, pp. 45–50, 2016.
[25] U. Paman, S. Uchida, and S. Inaba, “Economic potential of tractor hire business in Riau Province, Indonesia: A case study of small tractors for small rice farms,” *Agric. Eng. Int. CIGR J.*, vol. 12, no. 1, 2010.
[26] H. Takeshima, “Custom-hired tractor services and returns to scale in smallholder agriculture: a production function approach,” *Agric. Econ.*, vol. 48, no. 3, pp. 363–372, 2017.
[27] J. Dixit, J. N. Khan, and R. M. Shukla, “Farm Mechanization Status and Future Strategies for Major Cereal and Horticultural Crops in Kashmir,” *Ama, Agric. Mech. Asia, Africa Lat. Am.*, vol. 40, no. 4, p. 23, 2009.
[28] U. PAMAN, S. INABA, and S. UCHIDA, “Working Performance and Economic Comparison of Three Power Tiller Types for Small-Scale Rice Farming in the Kampar Region of Indonesia,” *J. Japanese Soc. Agric. Mach. Food Eng.*, vol. 77, no. 5, pp. 363–370, 2015.
[29] U. Paman, S. Uchida, S. Inaba, and T. Kojima, “A Survey on Causes of Tractor Breakdowns in Riau Province, Indonesia A Case Study of Small Tractor Operations,” *Appl. Eng. Agric.*, vol. 23, no. 1, pp. 43–48, 2007.
[30] B. Setiadi, “Prestasi kerja ternak sam dan kerbau dalam membantu efisiensi usahatani pertanian,” *Wartazoa*, vol. 3, no. 2–4, pp. 17–22, 1981.