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Agricultural Mechanization and Socio-Economic Factors Shaping Adoption in the Food Estate Area of Central Kalimantan, Indonesia

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Abstract: Agricultural mechanization plays an important role in encouraging the success of agricultural businesses, especially in boosting rice productivity in the food estate area of Central Kalimantan, Indonesia. In order to realize the food estate program, the government supports the provision of agricultural mechanization to increase agricultural production and achieve agricultural modernization. The aim of this research is to determine the level of adoption of agricultural mechanization technology and determine the factors related to the level of adoption of agricultural mechanization technology in food estate areas. This research was conducted in Pulang Pisau Regency and Kapuas Regency, Central Kalimantan Province, which are the locations of the food estate program in 2020. The design used in this study is quantitative. The method employed is a survey conducted through interviews and questionnaires as instruments to collect data from 394 rice farmers involved in the food estate program. Data collection was conducted from July to December 2023.The results of the data were analysed using Structural Equation Modelling-Partial Least Square (SEM-PLS). The study results found that hand tractors (96,19%), power threshers (68,53%), combine harvesters (31,47%), and four-wheeled tractors (17,77%), were the agricultural machines most widely used in the Central Kalimantan food estate area. Meanwhile, the rice transplanter planting tool is a machine that is rarely used by rice farmers in the research location. The findings also revealed that farmers' decisions to adopt agricultural mechanization were significantly influenced by farmers characteristic, socio-cultural conditions, farming characteristics, and innovation characteristics. Meanwhile, the institutional conditions of farmers and agricultural extension services do not influence the adoption of agricultural mechanization. Therefore, this study recommends that the government focus on improving access to infrastructure leading to agricultural land that can be traversed by agricultural machinery. Additionally, specific agricultural machinery designed for swampy areas should be developed. Moreover, policy initiatives should be implemented to facilitate farmers in acquiring agricultural machinery.

Keywords*:* Adoption, Agricultural Mechanization, Food Estate.

1. Introduction

Indonesia is ranked fourth in the world in terms of population, while food production has not been able to meet domestic consumption needs (Supriadi, et al. 2015). One effort to meet these needs is by expanding the food production area through the development of rice production areas in the swampy lands of Central Kalimantan in the Food Estate Program. The Food Estate Program in Central Kalimantan is a strategic effort to increase food production and security in Indonesia by implementing agricultural mechanization (MAPB, 2020). Agricultural mechanization is one of the main pillars in optimizing agricultural production in the Central Kalimantan Food Estate area. This mechanization is not only about replacing human labour with machines, but also implementing modern technology throughout the entire agricultural process, from land preparation, planting, crop maintenance, to harvesting. The level of modernization in agricultural mechanization in Indonesia remains relatively low, with

only 1.30 Horse Power per hectare recorded in 2013. According to the data, one of the agricultural development initiatives involved enhancing farming technology through the widespread adoption of mechanization technology (Sulaiman, et al., 2018).

In the context of addressing the shortage of agricultural labour, the rise in wages due to the migration of agricultural workers, and the increasing necessity of sustainable intensification practices to enhance food production and input efficiency in the agricultural sector, it becomes significantly imperative to elevate the level of agricultural mechanization in developing countries. Several studies have noted the positive impacts of agricultural mechanization, including increased labour and productivity in the agricultural sector, reduced production costs, enhanced agricultural commercialization, and in some instances, decreased greenhouse gas emissions from agriculture to mitigate climate change impacts and adapt to extreme climate change effects on crop yields (Aryal, et al. 2020; Sarkar, 2020; Loon, et al, 2020). Therefore, agricultural mechanization has the potential to increase farmers' household income, enhance food security, and reduce poverty levels, thus contributing to the achievement of Sustainable Development Goals (SDGs) (FAO, 2018). Furthermore, agricultural mechanization can address issues of labour shortages during peak seasons and help reduce the monotonous household chores of farmers, thereby decreasing stress levels during busy periods and potentially improving the health and well-being of agricultural workers. Nevertheless, the consequences of mechanization on labour needs in the agricultural sector can vary and are challenging to predict, as it is related to alternative opportunities available in other economic sectors, not limited to agriculture (Binswanger, 1986). The increase in agricultural production has been achieved through agricultural mechanization, which reduces electricity constraints in farming activities and enhances the intensification of land use (Pingali, 2007; Sarkar, 2020). Mechanization can benefit small-scale farmers in developing countries by helping them overcome labour shortages and enhancing agricultural efficiency (Loon et al, 2020., Pingali, 2019).

Several studies related to factors influencing the adoption of agricultural mechanization, such as the research conducted by Ma *et al*. (2023), found that mechanization adoption is positively influenced by farmers' age, educational levels, health status, farm size, and car ownership. Peng, et al. (2022), investigated the correlation between the degree of agricultural mechanization and the economic performance of farms. They found that there was a notable correlation between agricultural mechanization and increased levels of output, yields, and income derived from grains and various cash crops in China. Aryal et al. (2021) discovered that education plays a role in enhancing the adoption of farm mechanization in South Asia, particularly in the case of adopting pumps and harvesters. Their findings suggest that various socioeconomic factors, including remittances, access to credit, and household labour, exhibited significant associations with agricultural mechanization. Aspects of farm production and practices, such as farm size and cash crop cultivation, were also found to be significantly linked to agricultural mechanization. Additionally, the experience of climate change and variability, such as erratic rainfall, was significantly correlated with the utilization of mechanized tools among smallholder farmers (Mohammed et al., 2023). As of now, there has been no specific research addressing the factors influencing the adoption of agricultural mechanization in the food estate region, which constitutes marginal land in peatland areas. Therefore, to accelerate the process of agricultural modernization in Indonesia, particularly the adoption rate of agricultural technology among farmers in utilizing farming machinery, needs to be enhanced. This enhancement aims to improve productivity, production efficiency, and farmers' well-being, thus driving the development of high-quality and sustainable agriculture. Consequently, a study on the factors driving farmers to make changes through the adoption of agricultural mechanization in rice farming within the Central Kalimantan Food Estate region will provide valuable insights into efforts to increase agricultural mechanization adoption and support food security.

2. Material and Methods

This research was conducted in Pulang Pisau Regency and Kapuas Regency, Central Kalimantan Province, which were purposively selected based on the consideration that these two regencies are part of the Ministry of Agriculture's Food Estate program in 2020. The Food Estate program area covers eleven sub-districts in Kapuas Regency and five sub-districts in Pulang Pisau Regency, with a total land area of 30,000 hectares. The research was carried out from August to December 2023.

The population in this study consisted of rice farmers enrolled in the 2020 Food Estate program with the total number of farmers enrolled in the Food Estate program was 24,880 farmers. Based on the calculation using the Slovin's formula, the total sample size obtained is 394 farmers, consisting of 292 farmers in Kapuas Regency and 102 farmers in Pulang Pisau Regency. The determination of the distribution and sample size in each district was calculated proportionally based on the data of the number of farmers involved in that area.
This research utilized both primary and secondary data. Primary data were obtained through direct interviews with respondents using a structured questionnaire. Meanwhile, secondary data were collected from a literature review of relevant sources such as journals, books, and proceedings, as well as data from various institutions such as the Department of Agriculture in Kapuas and Pulang Pisau Regencies, the Provincial Department of Agriculture in Central Kalimantan, the Central Bureau of Statistics, and Agricultural Extension Office.

The analysis employed in this research is Structural Equation Modelling-Partial Least Square (SEM-PLS) using SmartPLS software. SEM-PLS analysis was utilized to determine the influence of exogenous variables on endogenous variables in this study. The endogenous variable in this study is the level of agricultural mechanization adoption, while the exogenous variables consist of farmer characteristics, socio-cultural conditions, farming characteristics, innovation characteristics, institutional conditions, and agricultural extension conditions.

3. Results and Discussion

Farmers' Characteristics

Farmers in the research area mostly fall within the age range of 35-54 years old, with an average age of 48 years. This indicates that farmers are in their productive age. According to the Bureau of Statistics, the productive age range is between 15 and 65 years old. Moving on to the educational background of farmers, the level of education among farmers remains low, with 37,06 % having completed Elementary School, followed by 29,19 % completing Junior High School, 29, 44 % completing Senior High School, and 4,31 % having attained a college degree. Education is a process of shaping an individual's character to acquire knowledge, understanding, and behaviour. A person's level of education will influence the acceptance of change. The higher the level of education attained, the more positively correlated it is with their ability to accept and implement innovations (Awotide, et al., 2016).

Table 1. The characteristics of farmers in the research area

No	Indicators	Description	Number of Respondens	%
1.	Age	Age of farmers at the time of research		
		a. 25-34 years	37	9,39
		b. 35-44 years	104	26,4
		c. 45-54 years	143	36,29
		d. ≥ 55 years	133	27,92
2.	Formal Education	The formal education level of the farmer		
		a. Elementary School	146	37,06
		b. Junior High School	115	29,19
		c. Senior High School	116	29,44
		d. College	17	4,31
3.	Non-formal Education	Number of trainings from respondent farmers for 3 years		
		a. 1-2 times	109	27,67
		b. 3-4 times	149	37,82
		c. 5-6 times	85	21,57
		d. ≥7 times	51	12,94
4.	Farming Experience	Length of rice farming experience		

		a. ≤5 years	14	3,55
		b. 6-10 years	60	15,23
		c. 11-15 years	63	15,99
		d. >15 years	257	65,23
5.	Cosmopolitan	The intensity of respondents seeking agricultural information from outside the community during the last year		
		a. 1-2 times	127	32,23
		b. 3-4 times	162	41,12
		c. 5-6 times	74	18,78
		d. >6 times	31	7,87

Sources: Data analysis, 2023

Non-formal education is the learning process/experiential work acquired by farmers outside formal education. Approximately 37,82% of respondent farmers have only attended training sessions 3-4 times in the past three years. The limited frequency of training sessions can pose a barrier, although it is acknowledged that farmers have alternatives to obtain information through social media, particularly the internet. The use of the internet as a source of training information provides farmers with opportunities to choose training that suits their needs (Sitohang, et al., 2023).

Farmers' experience in rice farming is classified as high, with 65,23% of respondent farmers having more than 15 years of experience in rice cultivation. The length of farming experience can influence the likelihood of farmers adopting innovative agricultural technology (Paul, et al., 2017; Li, et al., 2021). Meanwhile, the cosmopolitan level represents the intensity of farmers seeking information from outside the community related to rice farming within a year. A total of 162 respondents (41,12%) stated that they seek information from outside the community 3-4 times a year. Farmers who frequently seek information about a new innovation tend to be more inclined to adopt that innovation (Barnesa, et al., 2019).

Socio-cultural Variable

Based on Table 2, the results show that the majority of respondents, 75,89%, are aware of agricultural mechanization through information from fellow farmers in their community. They adopt agricultural mechanization because many other farmers in their community are using it. Regarding the social role in society, the majority of farmers (80,96%) agree that having a position in society, farmers should set an example first for other farmers regarding the use of agricultural mechanization. In terms of culture, 62,69% respondents stated that they disagree that the use of agricultural mechanization is inherited from their families. Regarding social class in society, 79,44% respondents stated that using agricultural mechanization can reflect social class in society and have an impact on improving social status in the community, and be a role model for other farmers.

Table 2. Socio-cultural variables of respondent farmers

No	Indicators	Description	Number of Respondens	%
1.	Colleagues/ environment	Knowing agricultural mechanization from information from fellow farmers?		
		a. Strongly disagree	0	0
		b. Disagree	21	5,33
		c. Agree	299	75,89
		d. Strongly agree	74	18,78
2.	Family social	Using agricultural mechanization because many other farmers are using it?		
		a. Strongly disagree	0	0
		b. Disagree	18	4,57
		c. Agree	318	80,71

		d. Strongly agree	58	14,72
3.	Social role/status	I have a position in society so I want to use agricultural mechanization?		
		a. Strongly disagree	0	0
		b. Disagree	75	19,04
		c. Agree	319	80,96
		d. Strongly agree	0	0
4.	Culture	Accustomed to using agricultural mechanization due to family tradition?		
		a. Strongly disagree	0	0
		b. Disagree	247	62,69
		c. Agree	127	32,23
		d. Strongly agree	20	5,08
5.	Sub culture	Using agricultural mechanization because it is not contradictory to customs and religion?		
		a. Strongly disagree	0	0
		b. Disagree	0	0
		c. Agree	244	61,93
		d. Strongly agree	150	38,07
6.	Social class	Using agricultural mechanization can reflect social class		
		a. Strongly disagree	0	0
		b. Disagree	56	14,21
		c. Agree	313	79,44
		d. Strongly agree	25	6,35

Sources: Data analysis, 2023

Rice Farming Characteristic Variables

The majority of farmers, totalling 75,28 %, have a land area for rice cultivation covering 2 hectares. Some even have land areas up to 11 hectares. As for the Planting Index of rice carried out by farmers in planting rice in a year, a total of 233 respondent farmers (59,14%) planted rice once a year. This is done due to several factors, including the use of local varieties with a long growth period, requiring a harvest time of 6-7 months. Additionally, the condition of water, which sometimes floods the fields, is also a consideration for farmers in their planting decisions. Therefore, the majority of farmers only plant rice once in a year.

The rice productivity resulting from each harvest averages between 2.1 to 3 tons/hectare (34,53%), and averages between 3,1-4 tons/hectare (32,74%). The lowest yield obtained by respondent farmers is 1 ton/hectare, while the highest reaches 6 tons/hectare. Differences in crop productivity are influenced by several factors, including different cultivation techniques, the use of different rice varieties, and differences in the use of types of agricultural mechanization.

Table 3. The farming characteristics that support mechanization adoption

No	Indicators	Description	Number of Respondens	%
1.	Farm size	Farm size for rice cultivation		
		a. ≤ 2 hectares	297	75,38
		b. 3-4 hectares	75	19,04
		c. 5-6 hectares	16	4,06

		d. > 6 hectares	6	1,52
2.	Cropping Pattern	Number of rice plants each year		
		a. 1 times/years	233	59,14
		b. 1,5 times/years	0	0
		c. 2 times/years	161	40,86
		d. >2 times/years	0	0
3.	Productivity	Rice productivity per hectare per harvest		
		a. ≤ 2 ton/hectare	62	15,74
		b. 2,1 – 3 ton/ hectare	136	34,53
		c. 3,1 – 4 ton/ hectare	129	32,74
		d. > 4 ton/ hectare	67	17,01
4.	Income from Rice Farming	Income from rice yields per hectare per season		
		a. ≤ $ 600	20	5,08
		b. $ 600 - $ 1.000	70	17,77
		c. $ 1.001 – $1.300	86	21,83
		d. > $ 1.300	218	55,32

Sources: Data analysis, 2023

Regarding the income earned by farmers from their rice farming activities, 55,32% respondents earn more than $ 1.300 from one hectare of land per harvest. In fact, during seasons of good harvest and favourable rice prices, farmers can earn up to $ 2.000/hectare/season.

Variable Characteristics of Innovation

The characteristics of innovation investigated in this study include relative advantage, compatibility, complexity, triability, and observability of the use of agricultural mechanization by rice farmers in the food estate area. Based on the research results presented in Table 4, the majority of respondents, comprising 54,82%, stated that the use of agricultural machinery is highly beneficial for their rice farming. Some of the benefits obtained by farmers after using agricultural machinery include time, energy, and cost efficiency. Regarding the compatibility of agricultural machinery with their farmland, 75,63% respondents stated that the machinery is suitable for their farmland. Meanwhile, the level of complexity of the agricultural machinery, 76,90% respondents stated that the machinery they use is easy to operate. Operating the machinery according to farmers is not too complicated, as they have been accustomed to seeing and using the machinery for a long time. However, for some newer machines like the rice transplanter and combine harvester, farmers find it somewhat difficult to modify the components if there is any damage.

The majority of respondent farmers (74,62%), totalling 294 farmers, stated that the agricultural machinery they use can be tested on relatively small plots of land. A total of 62,30% respondents said the use of agricultural machinery yields observable results. These results can be directly observed and evaluated by farmers in terms of time, cost, machine efficiency, and crop productivity after using the agricultural machinery.

Table 4. The variables of agricultural mechanization innovation characteristics that support farmers' adoption

No	Indicators	Description	Number of Respondens	%
1.	Relatif advantage	The use of agricultural machinery can provide benefits.		
		a. Very unprofitable	0	0
		b. Not profitable	0	0

		c. Profitable	178	45,18
		d. Very profitable	216	54,82
2.	Compatibilities	The compatibilities and suitability of machinery with agricultural land		
		a. Not compatible	1	0,25
		b. Less compatible	29	7,36
		c. Compatible	298	75,63
		d. Very compatible	66	16,75
3.	Complexities	The level of complexity of the machinery used		
		a. Very complicated	2	0,51
		b. Complicated	27	6,85
		c. Easy	303	76,9
		d. Very easy	62	15,74
4.	Triabilitas	Agricultural machinery can be tried in narrow areas		
		a. Absolutely impossible	0	0
		b. Can not	0	0
		c. Can	294	74,62
		d. Very possible	100	25,38
5.	Observabilities	The results of the use of machinery can be observed		
		a. Absolutely can't	0	0
		b. Can not	0	0
		c. Can	249	63,2
		d. Very possible	145	36.80

Sources: Data analysis, 2023

Institutional Condition Variables

The institutional conditions within the research area encompass various farmer institutions playing roles in the agricultural and agribusiness processes. This includes a variety of existing institutions, the level of farmer participation in groups, their degree of involvement, and farmers' perspectives on the benefits derived from their membership in these groups. The majority of farmer respondents 73,86%, indicated the existence of Farmer Groups (FG), Farmer Group Associations (FGA), Women Farmer Groups (WFG), and Agricultural Machinery Service Units (AMSU). A total of 67,01% respondents stated their involvement in these group activities. One of the primary objectives of farmer involvement is to access subsidized fertilizers. Farmers eligible for subsidized fertilizers are those engaged as members of farmer groups. Regarding the level of active participation, 86,80% respondents declared active involvement in group activities.

Table 5. Institutional variables of rice farmers in the food estate area

No	Indicators	Description	Number of Respondens	%
1.	The types of institutions	The types of farmer groups available in your area		
		a. FG	0	0
		b. FG and FGA	0	0
		c. FG, FGA, and WFG	103	26,14
		d. FG, FGA, WFG, and AMSU	291	73,86

2.	The involvement in the group	Involvement in group activities.		
		a. Not involved	0	0
		b. Rarely involved	23	5,84
		c. Involved	264	67,01
		d. Always involved	107	27,15
3.	Level of activity in the group	The farmers' level of activity within the group		
		a. Not active	1	0,25
		b. Less active	16	4,06
		c. Active	342	86,8
		d. Very active	35	8,89
4.	Attendance level in group activities	Attendance level at group activities		
		a. Never attends	0	0
		b. Rarely attends	11	2,79
		c. Attend	310	78,68
		d. Always attends	73	18,53
5.	Group benefits	The benefits of having groups		
		a. Not beneficial	0	0
		b. Somewhat beneficial	5	1,27
		c. Beneficial	152	38,58
		d. Very beneficial	237	60,15

Sources: Data analysis, 2023

Respondents' attendance levels in each meeting/group activity indicated that farmers attended every group activity, with 78,68% respondents confirming attendance. Routine group activities are usually conducted before planting or approaching harvest seasons. These activities involve group meetings to discuss preparations for the upcoming planting season. As many as 60,15% of respondents stated that the existence of groups could provide benefits for farmers. Through these groups, farmers can find solutions to their problems, utilize machinery managed by the group, and optimize the group's role as a learning platform, cooperative venue, and business platform (Elsiana, et al., 2018).

Agricultural Extension Condition Variables

The perception regarding the alignment of the materials delivered by extension officers, according to 84,77% respondents, they are already suitable for the needs of farmers. The materials provided by the extension officers are tailored to the specific conditions and circumstances of the area. Meanwhile, the level of application of the extension materials delivered by the extension officers, as reported by 83,50% respondents, indicates that the materials are being applied by farmers. Some of the extension materials applied by farmers include the use of new superior rice varieties, balanced fertilization, and the use of agricultural machinery.

The frequency or visits of agricultural extension officers to their assigned areas vary depending on each extension officer and the visited locations. A total of 67,26% respondents, state that extension officers visit their areas more than four times during a planting season. However, some respondents mentioned that extension officers only visit farmers twice during each season. The frequency of extension officers' visits to their assigned areas depends on the situation and conditions in the field.

The level of suitability of extension methods refers to the approach extension officers use to select methods for delivering extension materials. A total of 348 respondents (88,32%) stated that the method of material delivery employed by extension officers met the expectations of farmers. Some common methods used by extension

officers to deliver extension materials include individual visits and group meetings. Meanwhile, the distance from farmers' residences to agricultural extension offices varies. About 44,92% of respondents live within a distance of ≤ 5 km, 28,68% reside within the range of 6-10 km, and 17,01% are located > 15 km away. The nearest distance to agricultural extension offices is 0,4 km, while the farthest reaches up to 48 km. Farmers who regularly attend training sessions at Agricultural Extension Office (AEO), even though it is located quite far, they tend to have a positive perception of agricultural innovation. This finding is consistent with the study conducted by Kariyasa & Yovita (2013), which showed that the distance between farmers' locations and sources of information, such as agricultural extension offices, can influence innovation adoption and impact the economic benefits derived from these innovations.

Table 6. The variables of agricultural extension conditions in the research location

No	Indicators	Description	Number of Respondens	%
1.	Level of suitability of extension materials to farmers' needs	The suitability of the materials presented by the extension officer to the farmers' needs		
		a. Not suitable	0	0
		b. Less suitable	9	2,28
		c. Suitable	334	84,77
		d. Very suitable	51	12,94
2.	The level of application of extension materials.	The extension materials provided by the extension worker are applied by the farmers.		
		a. Not applied	0	0
		b. Applied less	19	4,82
		c. Applied	329	83,5
		d. Always applied	46	11,68
3.	Frequency of visits by agricultural extension officers to farmers' locations	The frequency of visits made by extension officers to farmer groups during each planting season.		
		a. 1 time	0	0
		b. 2 times	19	4,82
		c. 3 times	110	27,92
		d. ≥ 4 times	265	67,26
4.	The level of suitability of extension methods	The suitability of the extension methods chosen by agricultural extension agents		
		a. Not suitable	0	0
		b. Less suitable	9	2,28
		c. Suitable	348	88,32
		d. Very suitable	37	9,4
5.	The distance between the Agricultural Extension Office (AEO) and farmers' locations	Distance between AEO and farmers' locations		
		a. >15 km	67	17,01
		b. 11 - 15 km	37	9,39
		c. 6 – 10 km	113	28,68

	d. ≤ 5 km	177	44,92

Sources: Data analysis, 2023

In measuring the variable of agricultural mechanization adoption, categories are assigned to farmers regarding the extent of the adoption process used, consisting of 5 stages, namely: 1) awareness stage; 2) interest stage; 3) evaluation stage; 4) trial stage; and 5) adoption stage.

Table 7. Variable stage of adoption of agricultural mechanization

No	Indicators	Description	Number of Respondens	%
1.	Awareness	Do you know the benefits of using agricultural machinery?		
		a. Don't know	0	0
		b. Not sure	14	3,55
		c. Know	328	83,25
		d. Really know	52	13,2
2.	Intertest	Are you interested in using agricultural machinery?		
		a. Not interested	0	0
		b. Less interested	4	1,02
		c. Interested	250	63,45
		d. Very interested	140	35,53
3.	Evaluation	Does the use of agricultural mechanization provide added value compared to before using agricultural machinery?		
		a. Does not provide added value	0	0
		b. Provides less added value	2	0,51
		c. Provides added value	226	57,36
		d. Always provides added value	166	42,13
4.	Trial	Have you tried using agricultural machinery on your own land?		
		a. Never tried	0	0
		b. Occasionally tried	16	4,06
		c. Tried	232	58,88
		d. Always tried	146	37,06
5.	Adoption	Do you implement agricultural mechanization in rice cultivation?		
		a. Not implemented	1	0,25
		b. Less implemented	20	5,08
		c. Implemented	290	73,6
		d. Always implemented	83	21,07

Sources: Data analysis, 2023

The majority, 73,60% of farmers, use agricultural mechanization in their rice cultivation. The agricultural machines most commonly used by farmers are hand tractors (96,19%), power thresher (68,53%), combine harvesters (31,47%), four-wheeled tractors (17,77%), and rice transplanter machine (2,28%). For land preparation until ready for planting, farmers prefer using hand tractors over four-wheel tractors. This is because some paddy fields cannot be ploughed with four-wheel tractors due to deep mud. During planting, farmers prefer manual planting with female labour compared to using rice transplanter. According to farmers, manual labour is more

practical than using a rice transplanter. There are many requirements that farmers must fulfil when using a rice transplanter, including adjusting the depth of the mud and requiring special seedbeds, which farmers find more complex and difficult.

Meanwhile, for harvesting, farmers whose fields can be accessed by combine harvesters will use this equipment for harvesting. However, if their fields are difficult for combine harvesters to navigate, they will use a power thresher machine to thresh their harvested rice.

Table 8. Types and number of farmers adopting agricultural mechanization.

No	Types of Agricultural Machinery	Number of Farmer Adopters	(%)	Rank
1.	Hand tractor	379	96,19	1
2.	Four Whell tractor	70	17,77	4
3.	Rice transplanter	9	2,28	5
4.	Power thresher	270	68,53	2
5.	Combine harvester	124	31,47	3

Sources: Data analysis, 2023

Evaluation of Measurement Models

The analysis used in this study is Structural Equation Modelling-Partial Least Square (SEM-PLS) using SmartPLS software. SEM-PLS analysis is employed to determine the influence of exogenous variables on the endogenous variable in this research. To assess the validity and reliability of a model, the measurement model (outer model) is evaluated. A model is considered valid if the outer loading values and the Average Variance Extracted (AVE) are >0.5, while the model is considered reliable if it has a composite reliability value >0.7 (Solimun, 2020).

The results of data processing from SEM PLS show that all variables have AVE greater than 0.50. and the value of CR and CA values above 0.7, thus considered reliable. Furthermore, the detailed values of each variable processed using SEM PLS analysis can be visualized in Figure 1.

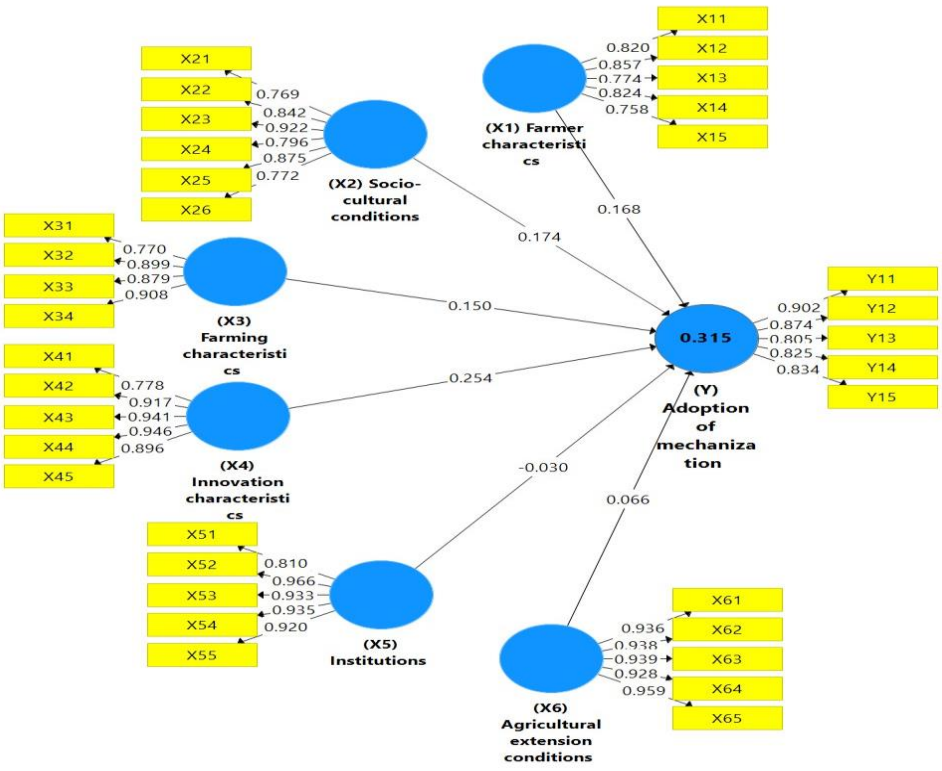

Figure 1. Outer model

The Influence of Exogenous Variables on Endogenous Variables

The structural model (inner model) is evaluated using the coefficients of determination (R^2) and path coefficients or t-values. Structural model testing involves the bootstrapping procedure to obtain R^2 values and coefficients of the influence of exogenous variables on endogenous variables. This study uses a significance level (α) of 0.05 or 5%.

The exogenous variables used in this study include farmer characteristics (X1), socio-cultural factors (X2), farming characteristics (X3), innovation characteristics (X4), institutions (X5), and agricultural extension conditions (X6). Meanwhile, the endogenous variable is the adoption of mechanization (Y). The influence between variables can be considered significant if the P-value is less than the predetermined significance level ($P < 0.05$). The results of the direct influence of exogenous variables on endogenous variables are presented in Table 9.

For the endogenous variable of agricultural mechanization adoption (Y), the data show that variables X1, X2, X3, and X4 have P-values < 0.05, indicating a positive and significant influence on Y at the significance level (α) of 0.05. Meanwhile, variables X5 and X6 have P-values > 0.05, indicating no significant influence on variable Y. This indicates that farmer characteristics, socio-cultural factors, farming characteristics, and innovation characteristics have a positive influence on the level of adoption of agricultural mechanization. However, institutional and agricultural extension condition variables do not have a significant influence on the adoption of agricultural mechanization.

Table 9. Direct influence of exogenous variables on endogenous

No	The influence between variables		Original Sampel (O)	Standard Deviation (STDEV)	T Statistics	T Table	P Values	Significancy
1.	Farmer characteristics	Adoption	0.162	0.063	2.580	1.962	0.010	Significant
2.	Socio-cultural	Adoption	0.175	0.062	2.808		0.005	Significant
3.	Farming characteristics	Adoption	0.151	0.050	3.021		0.003	Significant
4.	Innovation characteristics	Adoption	0.261	0.059	4.442		0.000	Significant
5.	Institutional	Adoption	-0.045	0.074	0.614		**0.539**	Nonsignificant
6.	Agricultural extension	Adoption	0.073	0.073	1.000		**0.318**	Nonsignificant

Sources: Data analysis, 2023

Based on the test results through bootstrapping procedures, it is shown that exogenous variables, namely farmer characteristics, socio-cultural conditions, farming characteristics, and innovation characteristics, have t-statistic values > t-table at a significance level of 5%. This can be interpreted that farmer characteristics, socio-cultural conditions, farming characteristics, and innovation characteristics influence the level of adoption of agricultural mechanization. Meanwhile, the variables of institutional conditions and agricultural extension conditions have t-statistic values < t-table. This can be interpreted that the current institutional conditions and agricultural extension conditions do not affect the adoption of agricultural mechanization in rice farming.

Farmer characteristics have a positive and significant influence on the level of farmers' adoption of agricultural mechanization. Older age and longer experience in conventional rice cultivation facilitate the entry of new innovations, especially in the use of agricultural mechanization (Anto, 2020). Additionally, a higher level of formal education makes it easier to analyze and accept new innovations, including the adoption of agricultural mechanization. This is supported by a study conducted by Ma, et al (2023), which indicates that the adoption of agricultural mechanization is positively influenced by age and education level.

In embracing new innovations, farmers generally consider family, social norms, culture, and the social environment as factors influencing their decisions. This is because the acceptance of innovation is perceived to have an impact on various aspects, both at the family and social levels as a whole. According to Herbig (1998), the existing cultural conditions are determinants of the diffusion of an innovative technology. Culture influences attitudes and intentions towards technology and innovation, which have been proven to affect decisions to adopt technology (Eseonu, and Egbue, 2014). If agricultural mechanization is not in conflict with norms or traditions within the social system, it will be more easily accepted by farmers. This is also supported by the research of Curry, et al. (2021), which found that socio-cultural factors can hinder the adoption of new technology.

Farmers who practice multiple rice planting cycles within a year are more likely to use agricultural mechanization compared to those who adopt a single rice planting cycle annually. Additionally, the extent of land ownership also influences the use of agricultural mechanization, as the larger the land area for rice cultivation, the higher the farmers' inclination to employ agricultural mechanization. This is due to the efficiency in terms of cost, labour, and time for the rice cultivation process from land preparation to harvesting. Consistent with the research conducted by Ma, et al. (2023), which found that the adoption of agricultural mechanization is influenced by the extent of land ownership. Furthermore, the increase in productivity after adopting agricultural mechanization also influences farmers to adopt the sustainable use of agricultural mechanization on their farmland.

The latent variable of innovation characteristics consists of five indicators: relative advantage, compatibility, complexity, trialability, and observability. Farmers who adopt agricultural mechanization will initially examine, assess, and analyse several comparative advantages of the specific type of agricultural machinery. This includes the suitability of the machinery with their farmland, the benefits obtained, the level of complexity, and the direct observable improvement in yield. If farmers provide positive evaluations of the characteristics of agricultural machinery, they are more likely to continue adopting the use of agricultural machinery on their farmland. This is consistent with research conducted by Gandasari. et al. (2020), which demonstrates that innovation attributes significantly influence farmers in adopting agricultural mechanization technology.

Meanwhile, the latent variables of institutional conditions and agricultural extension services do not influence the adoption of agricultural mechanization. Active participation in farmer groups does not necessarily promote the use of agricultural mechanization on their farms. The majority of farmers participate in groups mainly as a requirement to receive subsidized fertilizer from the government. Regarding whether farmers use agricultural machinery or not, farmer groups play a limited role in encouraging farmers to adopt agricultural mechanization. Therefore, the function of the group becomes active only when there are government programs in place. Similar findings were also shown in a study conducted by Elsiana (2018), which indicated that there was no significant influence between group functions and the level of member autonomy. Hence, there is a need to enhance the dynamics of farmer group functions as platforms for learning, collaboration, production units, and business endeavours.

Farmers obtain information about agricultural mechanization not only from agricultural extension officers but also through the sophistication of technology. They access information from the internet, such as Facebook, YouTube, or WhatsApp, from fellow farmers who have already adopted agricultural mechanization. Moreover, the distance from farmers' residences to the Agricultural Extension Office (AEO) can be considerable, sometimes up to 40 km. This distance often poses a challenge for both extension officers and farmers to meet and interact directly to discuss information related to agricultural mechanization. Inadequate road infrastructure requires farmers to travel by boat to reach the Agricultural Extension Office, which can take approximately one hour. According to Latif (2022), there is a significant relationship between the role of extension officers and farmers' perceptions of performance with the improvement of farmers' agricultural productivity. While the role of extension officers as facilitators is generally effective, it has not been optimized in practice.

4. Conclusion

Based on the results of identification and observation in the field, various types of agricultural mechanization innovations are used by rice farmers in the Central Kalimantan food estate area. Sequentially, the types of agricultural machinery most adopted by rice farmers in the Central Kalimantan food estate area are hand tractors, combine harvesters, power threshers, and four-wheeled tractors. The factors influencing the adoption of

agricultural mechanization by rice farmers in the Central Kalimantan food estate area include farmers' characteristics, socio-cultural factors, farming characteristics, and innovation characteristics, while institutional conditions and agricultural extension conditions do not affect the adoption of agricultural mechanization.
Therefore, to increase the adoption of agricultural mechanization in the food estate area, efforts are needed to enhance farmer involvement in the agricultural mechanization adoption process through strengthened empowerment of farmers in agricultural mechanization activities. Also, a holistic approach should be considered in planning and implementing agricultural mechanization programs, integrating the factors influencing agricultural mechanization adoption by incorporating local characteristics, both cultural and land suitability, in the development of mechanization innovations. Thus, the types of agricultural mechanization to be developed will be in line with the needs of farmers and the cultivation land, which often constitutes marginal land.

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