Farmer income and farm risk of *jajar legowo* and conventional planting system

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Abstract. Indonesia's rice productivity is lower than Vietnam's. The *jajar legowo* rice planting system (*Jarwo* PLS) is a rice planting system equipped with a new technology package to raise rice productivity. On the other hand, it will increase production costs. This study aims to analyse the difference in income and risk of rice farming using *Jarwo* and conventional PLS. The research was conducted in five rice farmer groups in Karawang District, West Java Province, in November 2022. The survey method was used as the research method. Primary data were obtained from sample farmers, and the sample farmers were taken by simple random sampling. Data analysis was carried out using farm income and business risk analysis using the coefficient of variation calculation. The results showed that rice farming income with *Jarwo* PLS is higher than conventional rice planting system income due to the higher production yield and selling price of *Jarwo* PLS. The risk of rice farming with the *Jarwo* is smaller than the conventional PLS because it is fertilised and maintained better.

1 Introduction

Rice is the staple food of the Indonesian population. It is consumed by approximately 95% of the population, with an average consumption level of 24.89 kg per capita per year. Rice demand is supplied by domestic and imports. Over the last five years, harvest area, production, and productivity increased, with 2.08% per year growth in harvest area, 2.96% in production, and 0.51% in productivity [1].

West Java is Indonesia's second-largest rice production centre, contributing 16.09% of national rice production [1]. Rice production in West Java reached 12,299,701 tons with a productivity level of 5.7 tons per ha. Karawang District is one of the rice production centres in West Java; most of the land is paddy fields (almost 80% are irrigated). Paddy rice production at Karawang District is 1,087,874 tons/year, with a paddy field area of 95,018 and an average productivity of 5.98 tons per ha in 2020 [1]. The conversion of agricultural land (especially paddy fields) into industrial land and housing impacts rice production in the Karawang District. The level of land productivity in Karawang District and the level of productivity of paddy fields nationally is below the level of productivity in Vietnam, 6.07 tons per ha (the leading rice producer in ASEAN).

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The growing demand for rice requires an increase in rice production. The method to increase rice production is by intensification and extensification. According to Kusnadi [2], increasing production through extensification is increasingly challenging due to limited productive agricultural land and the conversion of land from agriculture to non-agriculture. Thus, intensifying rice farming is more suitable, especially in Java [2]. The intensification of rice farming aims to increase its productivity by optimising production inputs and the maximum output produced.

Optimal use of inputs can be done through the application of new technology. According to Binam [3], achieving maximum output and reducing production costs can be achieved by applying technology. The government has made several efforts to increase national rice production, including *Jarwo* PLS. The *Jarwo* PLS has been developed since 2013. In 2016, the government directed the increase in national rice production through *Jarwo* PLS [4].

The *Jarwo* is an engineering planting technique by placing all rows of plants on the edge of the row because of the empty rows so that plants get sunlight and air circulation better than the conventional PLS. Rice plants on the edge of the row have better growth and development than those in the middle row, so higher production is expected to be achieved.

Jarwo PLS consists of five types: type 2:1, type 3:1, type 4:1, type 5:1 and type 6:1. Based on some previous studies, the type of *Jarwo* PLS that suits the general conditions in Indonesia is *Jarwo* PLS type 2:1 [5]. This type is recommended by the Indonesian Agency for Agricultural Research and Development to be applied in our rice farming system.

The 2:1 type of *Jarwo* PLS is a planting method with two rows interspersed by one empty row where each edge row has a planting distance of half the planting distance between rows. The 2:1 type of *Jarwo* PLS can increase the population of rice plants to 213,333 clumps/ha or an increase of 33.33%. This number is higher when compared to the conventional PLS, which only has 160,000 clumps/ha.

The Jarwo PLS 2:1 has contributed to the increase in rice production. According to Amelia et al. [6], applying the 2:1 *Jarwo* PLS produces higher rice productivity than the conventional one. Despite the higher production costs, *Jarwo* PLS generates higher income. The 2:1 type of *Jarwo* PLS is equipped with superior seeds, biodecomposers, biological fertiliser, transplanter, and combine harvester. The *Jarwo* PLS emphasises using production factors such as seeds, fertilisers, pesticides, and better labour to increase farmers' rice productivity. By using these factors of production, farmers are equipped with more modern equipment, so the productivity of farmers' rice farming will be higher and more stable compared to the conventional PLS. The risk of low yields faced by farmers will be negligible.

Low yields can reduce the income of rice farmers. Production fluctuations and income fluctuations of rice farmers illustrate the level of risk of rice farming. The wider the fluctuations in production and revenue of rice farming indicate, the riskier the farm and vice versa. According to Kadarsan [7], the risks faced by a farm can cause failure of profit or targeted income. The risks farmers face can be in the form of enterprise risk (farming) and financial risk. Enterprise risk can be defined as a risk caused by the allocation of investment to various businesses (farms) that cause differences in income from various business alternatives. Enterprise risk faced by rice farmers in Karawang District can be distinguished between the risk of rice farming with the *Jarwo* PLS and the risk of rice farming with a conventional one.

The application of *Jarwo* PLS in Karawang District is still low. Farmers only do the spacing and the use of superior seeds. At the same time, other technology components have not been applied entirely by farmers because they require costs and are technically not applicable. Farmers using *Jarwo* PLS machine tool technology have only reached about 30%, so the rice farming business has not been carried out optimally. About 70% of rice farmers in Karawang District use the conventional PLS. The conventional PLS is a conventional one that farmers have applied for a long time, while the *Jarwo* PLS is relatively new.

The difference in the planting system will cause differences in income and business risks for rice farmers between farmers who use *Jarwo* and those who use conventional PLS. Therefore, it is necessary to conduct further research on the analysis of the difference in income and risk of farming *Jarwo* and conventional PLS because the simultaneous analysis of income and risk farming in both farming systems in this location has been conducted rarely.

2 Methodology

The data used in this study are secondary and primary. Primary data was obtained from farmers, while secondary data was obtained from BPS-Statistics Indonesia and the Ministry of Agriculture. The research method is the survey method. The population in this study were farmers who applied *Jarwo* and farmers who used the conventional PLS in the Karawang District. Both groups of farmers are incorporated into farmer groups, taking farmer groups purposefully with consideration of farmer groups sampled with group members who apply *Jarwo* and conventional PLS. The farmer group has members who must use *Jarwo* PLS in Karawang District. The farmer groups are Mekar Jaya, Cipta Sari I, Maranggi Jaya, Sri Asih I, and Dewi Sri II. The total number of farmer group members applying for *Jarwo* PLS is 468. The number of farmers who apply the conventional planting system is 572 farmers, so the population of rice farmers for both planting systems is 1,040. The sample size in this study used the Slovin formula [8] as follows

$$n = \frac{N}{1+N(e)^2} \qquad (1)$$

where n is the number of farmer samples, N is the size of the farmer population, and *e* is the desired margin of error, which is no more than 10%.

Based on this calculation formula, the number of sample farmers is 91 people. The number of farmers in each group was determined based on proportional random sampling. Therefore, 41 farmers using the *Jarwo* PLS and 50 conventional farmers were obtained. The variables used in this study include variable costs, fixed costs, total costs, total production, the selling price, revenue, farm income, the standard deviation, the coefficient of variation, conventional planting system, and *Jarwo* PLS. Variable costs (VC) change with changes in production output, and variable costs include seeds, fertilisers, medicines, pesticides, and labour, measured in IDR. Fixed costs (FC) are incurred that do not depend on the output size obtained, such as the cost of tools and taxes, measured in IDR. Total costs are the sum of VC and FC, measured in IDR. Total production (TC) is the amount of paddy farmers produce in one growing season measured using units (kg/ha). The selling price (P) is the price of grain at the farm level, measured in IDR/kg. Revenue is the multiplication between TC and P, measured in IDR. Farm income is the difference between revenue and total costs, measured in IDR. The standard deviation (SD) of profit is the difference between one farmer's and all farmers' average profit. The standard deviation is calculated from the root of the variance and expressed in IDR. The coefficient of variation is the ratio of SD to average income. The conventional planting system is a planting method that has the same spacing between rows, namely 25x25 cm or, 28x28 cm, or 30x30 cm. The *Jarwo* PLS is a *Jarwo* type 2:1 with two rows of rice plants and one row of empty plants with a planting distance of 2:1.

The analysis used in this research is income analysis and farm risk analysis. According to Sukirno [10], farm income is the difference between total revenue (TR) and total cost (TC); mathematically, the formula for farm income:

$$\pi = TR - TC \qquad (2)$$

where π is farm income (IDR), TR is the total revenue of rice farming (IDR), and TC is the total cost of rice farming (IDR).

To evaluate the impact of *Jarwo* PLS on farmers' income can be done by comparing farmers' income with *Jarwo* PLS with farmers' income with conventional cropping system. The difference in both incomes was tested using an independent sample t-student test. Both population samples are large, each population sample is normally distributed, and the standard deviation (σ1= σ2) is not known then the t-student formulation is

$$t_{count}=\frac{(x-y)}{Sp\sqrt{\frac{1}{n_x}+\frac{1}{n_y}}} \quad (3)$$

$$Sp^2=\frac{(n_x-1)Sx^2+(n_y-1)Sy^2}{n_x+n_y-2} \quad (4)$$

where:

x = average income of farmers with *Jarwo* PLS
y = average income of farmers with conventional PLS
S_x^2 = variance of farmer income with *Jarwo* PLS
S_y^2 = variance of farmers income with conventional PLS
n_1 = sample size of farmers with *Jarwo* PLS
n_2 = sample size of farmer with conventional PLS

Before testing the independent sample t-student test, the null hypothesis is determined: H_0: x = y, there is no difference in income between the *Jarwo* and the conventional PLS. H_1: x ≠ y, income differs between *Jarwo* and the conventional PLS. The decision rule of the t-Student test uses a two-tail test, the distribution at α/2 with degrees of freedom (d_f = n-2), where α = 0.05, so the t-Student test decision: If $t_{count} > t_{table}$ at the significant level α, then reject H_0; If $t_{count} < t_{table}$ at the significant level α, then accept H_0. The decision of the t-test results can also be determined based on the P value; if the P value > 0.05 means accept H_0, and if the P value < 0.05 means reject H_0.

The next step is to analyse farm risk using the standard deviation of profit. The size of the variation or standard deviation is often used to measure the risk of a farm [7]. The narrow/width of the standard deviation can describe the high and low risk of a farm. In statistical science, the scattering of observations of profit data around the expected average value is used to measure variance or standard deviation. According to Man [10], the variance formula is

$$V^2=\frac{\sum_{i=1}^{n}(E1-E)^2}{(n-1)} \quad (5)$$

Standard deviation is obtained by rounding the variance value. According to Hasanah et al. [11], the standard deviation (SD) of profit is

$$V=\frac{\sqrt{\sum_{i=1}^{n}(E1-E)^2}}{(n-1)}=\sqrt{V^2} \quad (6)$$

A more relevant measure of risk is to consider the standard deviation and the mean value (profit), known as the coefficient of variation (CV). The CV is the ratio between the SD and the mean value. The coefficient of variation is often used to indicate a business's risk level.

The coefficient of variation can describe the risk faced by farmers per IDR of funds invested; the coefficient of variation formula:

$$CV = \frac{v}{E} \quad (7)$$

where V is the standard deviation of rice farmer profit, and E is the average profit of rice farmers

Hasanah et al. [11] used the size of the CV and the lower limit of profit, L to measure the risk of profit/loss of rice farming. If CV ≤ 0.5 and the value of L ≥ 0, entrepreneurs will make a profit or break even, and if the value of CV > 0.5 and L < 0, entrepreneurs are likely to make a loss.

3 Results and discussion

The analysis of farm income of *Jarwo* and conventional PLS discusses the components: costs, production yields, revenue, and income in detail. Table 1 shows that average cost of farming the *Jarwo* (IDR 15,458,429 per ha) is greater than that of a conventional PLS (IDR 12,797,526 per ha). The higher production cost of the *Jarwo* PLS is due to the use of inputs, especially labour and more machine rent. The *Jarwo* PLS uses more agricultural machinery (tractors, combine harvesters, and transplanters), while the conventional PLS only uses tractors.

The average seed use in the *Jarwo* was more significant (20.2 kg/ha) than in the conventional PLS (18.3 kg/ha). Farmers with the *Jarwo* PLS use seeds of new superior varieties of *Inpari* and *Ciherang* purchased from agricultural stores. The use of these superior seeds can increase production yields. Farmers use their seeds from the previous harvest in a conventional PLS. Many farmers still use their seeds because certified seeds are expensive. The average price of new superior varieties (certified seeds) seeds is IDR 15,000 per kg, while seeds obtained from fellow farmers are worth IDR 5,000–7,000 per kg. Rice seed varieties widely used by farmers in the conventional PLS are the *Ciherang*, *Mekongga*, and *Situbagendit* varieties.

Table 1. Total costs of *Jarwo* and conventional PLS.

Input	*Jajar legowo* (per ha)		Conventional (per ha)	
	Quantity	Value (IDR)	Quantity	Value (IDR)
Variable cost				
Seed (kg)	20.2	323,230	18.3	273,304
Urea (kg)	197.8	359,626	205.9	399,415
NPK (kg)	143.9	345,420	142.3	350,200
SP-36 (kg)	98.9	213,821	105.4	243,613
Organic fertiliser (kg)	234.7	325,233	253.4	266,488
Pesticide (lt)	7.3	1,514,018	8.0	1,562,880
Labour (Mh)	77.7	9,910,785	63.3	7,564,938
Fixed cost				
Equipment depreciation		290,220		289,533
Land tax (IDR)		139,100		135,416
Irrigation (IDR)		642,000		625,000
Farm machine rental		2,500,000		1,856,000
Total cost (IDR)		15,458,429		12,797,526

Fertilisers used by farmers are chemical fertilisers and organic fertilisers. The use of chemical fertilisers in the *Jarwo* PLS includes Urea 197.8 kg, NPK Phonska 143.9 kg, SP-36 98.9 kg, and organic fertiliser 234.7 kg/ha, while in the conventional PLS includes Urea 205.9 kg, NPK Phonska 142.3 kg, SP-36 105.4 kg, and organic fertiliser 253.4 kg/ha. The recommended fertiliser dose in rice farming is 200 kg/ha urea, 300 kg/ha NPK Phonska, 100 kg/ha SP36, and 500–1000 kg/ha organic fertiliser. *Jarwo* and conventional PLS farmers use fertiliser near the recommended dosage.

In the use of pesticides in farming, the *Jarwo* is 7.3 litres/ha, and the conventional PLS is 8.0 litres/ha. The conventional PLS uses more pesticides, indicating that pests, and diseases invade the plants more often.

The following farming cost is labour cost, which has the most significant percentage in rice farming cost. The labour used in the *Jarwo* PLS was 77.7 person-days per ha, while the conventional planting system used 63.3. The amount of work in the *Jarwo* PLS is due to the greater use of inputs (seeds) and plant maintenance in farming activities.

Another cost is the cost of renting agricultural machinery. Renting agricultural machinery in the *Jarwo* is IDR 2,675,000 per planting season, while the conventional PLS rents agricultural machinery worth IDR 1,856,000. The *Jarwo* PLS uses a higher cost of agricultural machinery because the *Jarwo* PLS uses more agrarian machinery, such as tractors for land cultivation, transplanters for transplanting, and combine harvesters as a tool for harvesting rice. Transplanters and combine harvesters are only used by some farmers (30%) due to cost and technical reasons that cannot be used. In contrast, farmers who use conventional PLS only rent tractor engines.

The rice production of farmers using the *Jarwo* (6,928 kg per ha) is greater than that of farmers applying the conventional PLS (5,967 kg per ha). The difference in production of the two planting systems is 961 kg/ha. The high production of the *Jarwo* PLS is mainly due to the use of more seeds and the use of superior varieties. According to Arnanda et al. [12], using superior seed positively and significantly affects rice production in the Kuala Kampar Sub-district, Pelalawan District. According to Amelia et al. [6], the 2:1 *Jarwo* PLS production amounted to 6,485 kg/ha, while the PLS produced 5,573 kg/ha [6]. Triatmoko et al. [13] mentioned that the productivity of the *Jarwo* PLS is 7–15% more than the conventional planting system.

Average revenue is the multiplication of average rice production with the average selling price. The selling price of paddy grain in *Jarwo* and conventional PLS is IDR 5,302 and 4,920 per kg, respectively. The average revenue of farmers using the *Jarwo* (IDR 37,156,074 per ha) is greater than that of the conventional PLS (IDR 28,379,807 per ha). This is because the *Jarwo* PLS has higher production yields and selling prices.

The R/C ratio can illustrate the level of profit achieved by a farm. The R/C ratios of *Jarwo* and conventional PLS are 2.36 and 2.24, respectively, meaning both businesses are profitable. Listiani et al. [14] revealed that the R/C farming ratio in the Mlongo Sub-district of Jepara District was 2.19.

Table 2. Rice farming income of both planting systems.

Description	*Jarwo*	Conventional
Production (kg)	6,928	5,967
Total cost (IDR/ha)	15,458,429	12,797,526
Revenue (IDR/ha)	37,156,074	28,379,807
Income (IDR/ha)	21,285,570	16,575,807

The difference between average revenue and average costs generates average income. The average income of rice farming with the *Jarwo* PLS is IDR 21,285,570 per ha, while the conventional planting system income is IDR 16,575,807 per ha (Table 2). Listiani et al. [14] revealed that conventional rice farming income per ha in the Mlongo Sub-district of Jepara District amounted to 17,848,850 per ha. The income of the *Jarwo* PLS in the research location is greater than the farm income with the conventional planting system. The difference reaches IDR 4,709,763 per ha, showing that the *Jarwo* PLS is more profitable for farmers.

Amelia et al. [6] mentioned a difference of IDR 1,788,062 per ha per growing season between the income received by *Jarwo* and conventional PLS farmers in Aceh Besar District. Likewise, a study result by Triatmoko [13] indicated a difference of IDR 8,404,816 per ha between the income of *Jarwo* and conventional rice farming in Tanah Laut District.

The average income of farmers using the *Jarwo* is IDR 21,285,570 per ha, while the average income using the conventional PLS is IDR 16,575,807 per ha. It can be seen that the two cropping systems have different amounts of income, so a statistical test was conducted using the t-student test to analyse the difference.

The t-student test results showed a statistically significant difference between the income of the *Jarwo* and conventional PLS with a t-count (t_{count} = 9.34). At the same time, the t-table value is (t_{table}= 1.98). It means that the *Jarwo* PLS gives more income to farmers due to the higher production yield and selling price of output.

Table 3. Output of t-student test.

Variable	t_{count}	t_{table} (α=5%)	d_f n-2	P-value	Sig. P-value
Income	9.34	1.98	89	0.024	0.000
Conclusion: $t_{count} > t_{table}$					

The scattering of income data around the farmer's average income (profit) is a standard deviation. Business risk assessment is measured by the value of deviations that occur [15]. Several risk measures include coefficient of variation, variance, and standard deviation. The calculation results show that the standard deviation of farm income of *Jarwo* and conventional PLS are 2,787,211 and 2,411,407, respectively. The standard deviation results show that the *Jarwo* PLS has a more significant standard deviation.

The ratio of standard deviation and the average income (profit), known as the coefficient of variation (CV), is more relevant to measure farming risk. The CV describes the risk farmers face per rupiah of funds invested. The CVs of *Jarwo* and conventional PLS are 0.135 and 0.145, respectively, meaning that every unit of profit will bear the risk of loss of 0.135 and 0.145, respectively. Suharyanto [16] found that the coefficient of variation of paddy rice production in Bali Province was 0.13.

The coefficient of variation of *Jarwo* PLS has a lower value than the conventional one. Thus, *Jarwo* farming has a lower risk than conventional PLS due to the high and stable production of *Jarwo* PLS. The higher and more stable income of *Jarwo* PLS is because the farm is fertilised and maintained better so that fewer pests and plant diseases attack it, giving a higher selling price of grain.

4 Conclusions

The rice farming income of the *Jarwo* is higher than the rice farming income of the conventional PLS. Thus, the *Jarwo* is more profitable because paddy grain yield and selling price are higher than the conventional PLS. The risk of farming rice with the *Jarwo* is lower than the risk of farming rice with a conventional planting system because farming rice with the *Jarwo* PLS is fertilised and maintained better so that less attacked by pests and plant diseases and higher selling price of paddy grain. Rice farmers in Karawang District should be encouraged to implement the *Jarwo* PLS to increase productivity and rice farmers' income.

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