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RESEARCH ARTICLE

The Impact of The Use of Combine Harvester on The Income of Rice Farmer in Pemangkat District Sambas Regency

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Abstrak

Pendapatan petani tidak selalu tinggi, kadang-kadang bisa sangat rendah dan mengalami kerugian. Hal ini disebabkan oleh beberapa hal yang bisa menyebabkan menurunnya hasil panen padi yang disebabkan oleh hilangnya gabah akibat proses panen secara manual, serta tingginya biaya untuk proses produksi dan pemanenan. Tujuan dari penelitian ini adalah untuk mengevaluasi dampak penggunaan combine harvester terhadap ekonomi petani khususnya pada pendapatan petani dengan membandingkan tingkat pendapatan antara petani yang menggunakan mesin combine harvester dengan petani yang memanen secara manual di wilayah Kecamatan Pemangkat, serta menganalisis faktor-faktor yang mempengaruhi adopsi teknologi combine harvester. Studi ini dilakukan di Kecamatan Pemangkat, Kabupaten Sambas, Kalimantan Barat dengan responden berjumlah 44 orang. Variabel penelitian yaitu pendapatan, penerimaan, hasil produksi, harga jual dan biaya produksi. Penelitian ini menggunakan Uji Independent Sample T test dengan menggunakan uji normalitas data Saphiro Wilk, uji homogenitas varians Levene's test, dan uji t. Dari hasil penelitian, dapat disimpulkan bahwa pendapatan petani mengalami perbedaan yang signifikan antara petani yang menggunakan mesin combine harvester dan petani yang menggunakan panen manual. Berdasarkan hasil analisis dan observasi, penggunaan mesin combine harvester secara signifikan mengurangi biaya produksi dan pemanenan sehingga dapat meningkatkan pendapatan petani, sehingga petani sebaiknya mempertimbangkan untuk beralih menggunakan mesin untuk memanen padi yang bertujuan untuk meningkatkan pendapatan petani.

Kata Kunci: Combine Harvester; Dampak; Panen; Pendapatan Petani; Teknologi Pertanian

Abstract

Farmers' income is not always high, sometimes it can be very low and experience losses. This is due to several things that can cause a decrease in rice yields caused by the loss of grain due to the manual harvesting process, as well as the high cost of production and harvesting processes. The purpose of this study was to evaluate the impact of the use of a combine harvester on the farmer's economy, especially on the farmer's income by comparing the level of income between farmers who use a combine harvester and farmers who harvest manually in the Pemangkat District area, and analyze the factors that influence the adoption of combine harvester technology. This study was conducted in Pemangkat District, Sambas Regency, West Kalimantan with 44 respondents. The research variables were income, revenue, production yield, selling price and production costs. This study used the Independent Sample T test using the Saphiro Wilk data normality test, Levene's variance homogeneity test, and t test. From the results of the study, it can be concluded that farmers' income experienced a significant difference between farmers who used combine harvester machines and farmers who used manual harvesting. Based on the results of analysis and observations, the use of combine harvester machines significantly reduces production and harvesting costs so that it can increase farmers' income, so farmers should consider switching to using machines to harvest rice to increase farmers' income.

Keyword: Agricultural Technology; Combine Harvester; Farmers' Income; Harvest; Impact.

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1. Introduction

The ongoing era of globalization provides considerable challenges for the agricultural sector, thus encouraging farmers to improve the quality and productivity of crops. One of the strategies undertaken to achieve this goal is the use of agricultural mechanization. However, the level of adoption of combine harvester technology still needs to be improved in West Kalimantan. West Kalimantan Province has a high potential of land resources for the development of agricultural businesses, especially paddy rice. BPS data recorded that the area of paddy fields in 2023 in West Kalimantan Province was 223,244 ha with a production of 688,413 tons (BPS Kalimantan Barat, 2024). Sambas Regency is one of the centers of agricultural production in West Kalimantan, especially for the development of food crops such as paddy rice. The area of paddy fields in Sambas Regency reached 43,514 ha with a production of 171,366.17 tons (BPS Kabupaten Sambas, 2024). Sambas Regency experiences shrinking land area from year to year, this is caused by land conversion for housing, industry, and public facilities (BPS Kabupaten Sambas, 2024) recorded that the area of wetland agriculture in Sambas Regency in 2023 was 43,514 hectares, while in 2020 the area of wetland agriculture was 61,197 hectares. This shows a decrease of 17,683 hectares of wetland agriculture in just 3 years. The shrinking of paddy fields in Sambas Regency is thought to be the main factor causing the low yield of rice production and the need to increase productivity. With the narrowing of paddy fields, increasing rice production needs to focus on increasing land productivity through the use of agricultural mechanization, such as agricultural tools and machinery. Mechanization has been proven to increase rice productivity in various countries such as Cambodia (Yagura, 2020), Sri Lanka (Kahandage, et al., 2023), and China (Zhao & Wang, 2020). In addition to increasing yields per hectare, the use of alsintan also reduces production costs and increases profits for farmers (Prayuginingsih, *et al*., 2021). Agricultural mechanization, one of which is the use of combine harvester machines, is believed to not only increase harvest productivity, but also reduce crop losses, improve grain quality, and reduce operational costs (Mangunwidjaja & Sailah, 2009).

Initially, rice harvesting only used manual equipment such as sickles and *ani-ani*. Realizing that harvesting manually takes a very long time and is at risk of losing the harvested grain, the government began to adopt combine harvester machines to shorten the harvest time. The use of this combine harvester machine is one of the government's goals, because in addition to earning foreign exchange by increasing rice productivity, it also improves the welfare of the people through increased income (Gunawan, 2014). The local government of West Kalimantan, especially the Department of Agriculture Food Crops and Horticulture, has developed the agricultural sector by using agricultural tools and machinery focused on supporting rice and secondary crops. In West Kalimantan, agricultural mechanization began to be developed by the government in 1998 through the Alsintan Service Business (UPJA) program, which includes hand tractors, irrigation pumps, power threshers, rice grinders and drying machines, and every year there is an addition of alsintan, both in number and type of alsintan.

Table 1. Data on Types and Quantities of Agricultural Machinery

No	Information	Quantity (Unit)
1	4 Wheel Tractor	3
2	Hand Tractor	11
3	Water Pump	34
4	Hand Sprayer	39
5	Power Thresher	14
6	Combine Harvester	5
7	Cultivator	8
8	Rice Transplanter	3
9	Corn Sealer	5
10	3 Wheel Vehicle	3

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The availability of types and numbers of agricultural machinery in Sambas Regency is still very minimal and needs additional alsintan, as can be seen in Table 1, considering the vast amount of paddy fields in Sambas Regency 43,514 ha. One type of agricultural machinery that has a very important role in rice farming in Sambas Regency is the combine harvester. The small number of combine harvesters in Sambas Regency indicates that farmers' adoption of agricultural machinery in the form of combine harvesters is low and the development of agricultural mechanization is slow in the region. The purpose of this study is not only to determine the impact of the use of combine harvester machines in Pemangkat District, but also to analyze the factors that influence the adoption of combine harvester technology. Not only that, this research is expected to provide scientific information for the development of science, can provide and increase knowledge for both researchers and farmers, and is expected to be a contribution of thought and input for policy makers and can help solve existing problems.

Agricultural technology, particularly in the realm of Agriculture Engineering, involves the application of various technological advancements and machinery to enhance farming processes, such as soil preparation, planting, irrigation, fertilization, plant care, harvesting, and processing. The main objective of agricultural mechanization is to manage tasks that cannot be performed manually, boost human resource productivity, optimize production inputs, and improve both productivity and quality (Gunawan, 2014). A key innovation in this field is the combine harvester, a machine that efficiently replaces manual harvesting methods by combining cutting, threshing, and separating crops into seeds or grains ready for further processing. It significantly improves efficiency and productivity, reducing the time, labor, and costs typically associated with harvesting (Michael & Ojha, 2023). Production, in agricultural terms, refers to efforts aimed at increasing the utility of goods to meet specific needs, with factors such as land, labor, capital, and management playing critical roles in determining output (Hernanto, 1991). Farming revenue is calculated by multiplying the volume of production by its selling price (Soekartawi, 1995), while income refers to the financial return received by households after engaging in economic activities (Adiwilaga, 1992).

In research, comparative analysis helps identify differences between two or more variables. The independent sample t-test is commonly used to compare means between two unrelated groups, determining whether significant differences exist (Siregar, 2013). Additionally, effect sizes, such as Cohen's d, are used to assess the strength of relationships between variables, providing a clearer understanding of the impact measured (Cohen, 1988). Previous studies on the adoption of combine harvesters underscore their positive impact on farmers' efficiency, productivity, and income. For instance, Hasan *et al*. (2020) highlight that combine harvester adoption in developing countries plays a crucial role in addressing labor shortages, reducing costs, and alleviating poverty. Similarly, research by Roy *et al*. (2022) confirms that the adoption of this technology enhances livelihood security by improving efficiency and income. Studies by Muminjanov & Djanibekov (2024) and Rangga *et al*. (2024) further emphasize that the use of combine harvester services increases farm efficiency and income, especially when factors like land size and technology compatibility are favorable. In contrast, Belton *et al*. (2024) found that in rural Myanmar, combine harvester adoption did not significantly reduce labor costs or increase income. However, other studies by Rahman *et al*. (2021), Kunuti *et al*. (2020), and Zakiyah *et al*. (2022) report positive outcomes, including reduced production costs and higher incomes, advocating for government subsidies to promote adoption among smallholder farmers.

2. Methodology

This research was conducted in Pemangkat District, Sambas Regency, West Kalimantan. Location was selected purposively. The research was carried out from January to February 2023. The method used was the survey in rice fields with farmers who use combine harvesters and farmers who use traditional methods for harvesting. The survey method is used to obtain data from certain location in a natural way, but there is still treatment during data collection, for example through structured interviews, administering questionnaires, or test in large or small populations (Darna & Herlina, 2018). Data in this study come from

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primary sources and secondary sources. This primary data is data obtained by researchers from original sources directly (Tan, 2021). Primary data collection technique is by interviewing farmers directly to find out the input, production process, support and income. Secondary data in this study were obtained using documentation techniques, namely by collecting reports or documents from relevant agencies. The population of this research is people who own livelihood as a rice farmer in Pemangkat District, which totaled 3,158 farmers. The following is the total population of farmers in the Pemangkat District:

Tabel 2. Total Farmer Population

No.	Village Name	Number of Farmers (people)
1	Perapakan	779
2	Lonam	183
3	Harapan	148
4	Jelutung	1372
5	Pemangkat Kota	179
6	Gugah Sejahtera	53
7	Sebatuan	267
8	Penjajab	177
	Total	3.158

Determining the number of respondents using the Slovin formula. In determining the number of respondents, if the respondents are more than 100 or there are many respondents, a percentage of leeway can be taken between 10-15% or 20-25% (Arikunto, 2011). Determination of the sample respondents in this study as follows:

$$n = \frac{N}{1+N(\alpha)2}$$

Information:
n = Number of samples
N = Number of populations
α = Percentage tolerable allowance of 15%

The population contained in this study amounted to 3,158 and the percentage of leeway used in this study was 15%. Then the number of respondent samples in this study were 44 samples. The reason for choosing an error tolerance level of 15% is the limited funds, time and energy to conduct a survey with a large sample. In addition, the population of 3,158 people belongs to a medium population and has high homogeneity within the population, so a larger error tolerance level is considered to still produce representative results. Furthermore, the sample value for each village is calculated with the formulation and explained in the table below:

$$n = \frac{class\ population}{total\ population} \text{ x number of samples determined}$$

Table 3. Distribution of Farmer Samples

No.	Village	Number of Farmers (people)	Sample (people)
1	Perapakan	779	$\frac{779}{3158} \times 44 = 11$
2	Lonam	183	$\frac{183}{3158} \times 44 = 3$
3	Harapan	148	$\frac{148}{3158} \times 44 = 2$

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4	Jelutung	1372	$\frac{1372}{3158} \times 44 = 19$
5	Pemangkat Kota	179	$\frac{179}{3158} \times 44 = 2$
6	Gugah Sejahtera	53	$\frac{53}{3158} \times 44 = 1$
7	Sebatuan	267	$\frac{267}{3158} \times 44 = 4$
8	Penjajab	177	$\frac{177}{3158} \times 44 = 2$
	Total	3.158	44

The sample for this study consists of 44 individuals, divided into two groups: 22 farmers who use combine harvester machines and 22 farmers who do not. The sampling technique employed is purposive sampling, selecting individuals who meet specific criteria, including: their main occupation as a farmer, sources of capital for independent farming, ownership of land, at least 0.5 hectares of paddy rice farmland, the use of the same variety of rice seeds (Sertani), at least five years of farming experience, and the capital spent per planting season. For the farmers using combine harvesters, all machines are leased from the private sector. The variables in this study include farm income, revenue, production, selling price, and total costs. Farm income (I) is defined as the difference between revenue and costs, measured in rupiah per hectare (IDR/Ha). Revenue (TR) is calculated by multiplying the amount of production (Y) by the prevailing market price of paddy rice, expressed in rupiah per hectare (IDR/Ha). Production (Y) refers to the amount of rice produced using combine harvesters and non-users, measured in kilograms per hectare (Kg/Ha), with production in the form of milled dry grain. The selling price (Py) is determined based on the market price received by farmers, measured in rupiah per kilogram (IDR/Kg). Total costs (TC) include both fixed and variable costs. Fixed costs (FC) are ongoing costs, such as depreciation of equipment, calculated using the straight-line method, and include tools like hoes, sickles, and sprayers. Variable costs (VC) fluctuate with production levels, with larger operations incurring higher costs. The data analysis in this research first examines the costs, revenues, and income to determine the financial impact of the adoption of combine harvester technology. The effect size formula is used to calculate the magnitude of the effect, followed by a comparative analysis of the income difference between the two groups using the independent sample t-test. These methods aim to provide a clear, measurable understanding of the economic implications of adopting combine harvester technology.

$$TC = FC + VC$$

Information:
TC= total costs (IDR); FC= fixed costs (IDR); VC= variable costs (IDR)

Revenue analysis is carried out to determine the total revenue received by farmers for one rice harvest season which is determined using the formula:
TR = Y x Py
Information:
TR= total receipts (IDR), Y= rice production (Kg), Py= selling price of rice (IDR)

Income analysis is carried out to determine the total income received by farmers per rice harvest season, which can be determined using the formula:
Pd = TR – TC
Information:
Pd= rice farming income (IDR); TR= total receipts (IDR); T.C= total cost (IDR)

To calculate the effect size, it is necessary to calculate the standard deviation between the two samples first. The standard deviation and effect size formulas are as follows:

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Standard daviation:

$$s = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n-1}}$$

Information:
s : sample standard deviation
x_i : i-th data value
$\bar{x}$: average sample
n : number of data in the sample

Effect size:

$$\text{Cohen's d} = \frac{X_a - X_b}{Pooled\ SD}$$

$$\text{Pooled SD} = \sqrt{\frac{{S_a}^2 + {S_b}^2}{2}}$$

Information:
X_a : group average 1
X_b : group average 2
Pooled SD: combined standard deviation of the two groups
S_a, S_b : standard deviation of groups 1 and 2

A comparative analysis was conducted to determine whether there was a significant difference in the income received by rice farmers using combine harvesters and those using manual methods. Before performing an independent sample t-test, certain assumptions must be met. The data must be divided into two independent groups: farmers using combine harvesters and those using manual methods, with no participant or sample member appearing more than once. Additionally, two assumption tests must be fulfilled: the normality test and the variance homogeneity test. The normality test ensures that the distribution of dependent variable values within each group is close to a normal distribution, which can be checked using statistical tests such as Kolmogorov-Smirnov or Shapiro-Wilk, or through visual checks like histograms or Q-Q plots. If the normality assumption is not met, non-parametric tests such as the Mann-Whitney U test can be used. For the normality test, the decision rule is as follows: if the significance value is ≤ 0.05, the data is not normally distributed, while if the significance value is ≥ 0.05, the data is normally distributed (Riduwan & Warsiman, 2018). The next step is to test for variance homogeneity, which ensures that the variances of the two groups are equal or not significantly different. This can be tested using Levene's test or Bartlett's test. If this assumption is not met, Welch's t-test, which does not assume equal variances, is used. The decision rule for variance homogeneity is: if the significance value is ≤ 0.05, the variances are not equal, while if the significance value is ≥ 0.05, the variances are equal (Ghozali, 2013). Performing these tests before conducting the t-test ensures the validity of the analysis and helps avoid erroneous conclusions, such as Type I or Type II errors. Once the assumptions are met, the t-test can be performed. The null hypothesis (H0) posits that there is no difference in the average income between farmers using combine harvesters and those using manual methods, while the alternative hypothesis (H1) suggests that there is a significant difference. If the significance value (2-tailed) is ≤ 0.05, it indicates a significant difference in the average income between the two groups. If the significance value is ≥ 0.05, no significant difference is found. This analysis provides empirical evidence on the impact of using combine harvesters on farmers' income. Data will be collected from two groups of farmers—those using combine harvesters and those using manual harvesting—through surveys, and the income differences will be analyzed using an independent sample t-test to determine the statistical significance of the income disparities.

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3. Result and Discussion

3.1 Result

3.1.1 Respondent Characteristics

Table 4 displays data about respondents who are the source of information for this research. Based on the results of calculations using percentages, these respondents were dominated by farmers using combine harvesters who were aged 36-50 years, had elementary to middle school education, had 5-15 years of farming experience, had 3-4 family members, and the number of family members who helping 2 people in farming. Farmer respondents who did not use combine harvesters were dominated by farmers who were 20-35 years old, had elementary school education, had 5-15 years of farming experience, had 3-4 family members with 1 person in the family who helped with the farming process.

Tabel 4. Characteristics of Respondents in Pemangkat District

Respondent Characteristics	Number of Respondents		Percentage	
	Combine Harvester Users	Non-Combine Harvester Users	Combine Harvester User	Non-Combine Harvester Users
Age				
20-35 years old	7 people	9 people	32 %	41 %
36-50 years old	8 people	6 people	36 %	27 %
51-65 years old	7 people	7 people	32 %	32 %
Education				
No school	1 person	3 people	5%	14%
Elementary School	8 people	9 people	36%	41%
Junior High School	8 people	6 people	36%	27%
Senior High School	5 people	4 people	23%	18%
Farming Experience				
5-15 years old	14 people	15 people	64%	68%
16-25 years old	1 person	4 people	5%	18%
> 25 years old	7 people	3 people	32%	14%
Number of Family Members Who Help in the Farming Process				
1 person	5 people	11 people	23%	50%
2 persons	9 people	10 people	41%	45%
3 people	8 people	1 person	36%	5%

The majority of farmers who harvest using the manual method are young farmers aged around 20-35 years, while farmers who use a combine harvester are mostly in the age range of 36-50 years. This trend shows differences in technology preferences based on age. Unlike previous studies, younger farmers in Pemangkat are more likely to use manual methods, which may be related to the risk factor of trying new things or smaller land size. Farmers with the highest education are elementary school graduates as many as 17 people, the distribution for farmers who use and do not use combine harvester technology is equal. This means that the level of education does not really affect the farmers' decision to adopt the existing technology. A total of 10 farmers who have more than 25 years of farming experience, 7 of them prefer to use combine harvester technology. This shows that farmers with more than 25 years of experience tend to be more open to the adoption of combine harvester technology. With more family labor, the use of a combine harvester is more desirable.

From the explanation above, it can be concluded that:

1) Age, farming experience, and family labor contribute to the adoption of combine harvester technology.
2) The level of education is not significant in influencing technology adoption decisions.
3) Young farmers tend to use manual methods, while experienced farmers and those with more family labor tend to use combine harvesters.

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3.1.2 Cost Analysis

The costs incurred by farmers include two things, namely fixed costs and variable costs. The fixed costs in this research are the depreciation costs for equipment for lowland rice farming. The equipment used by farmers in the field is a hoe, sickle, machete, sprayer, mat, ani-ani, pump, hose, cart, and sack. Depreciation costs are calculated using the straight-line method (Suratiyah, 2006). The average depreciation costs and variable costs in this research can be seen in the following table.

Tabel 5. Recapitulation of Production Costs

Information	Average value (IDR/Ha)		
	Combine Harvester User	Non-Combine Harvester Users	Standard Deviation
	Fixed cost		
- Tool Depreciation	494,314	586,798	65,396.06
Variable Costs			
- Seed	181,818	249,293	47,712.03
- Fertilizer	782,682	779,096	2,535.68
- Pesticides	917,080	887,790	20,711.16
- Labor	1,972,573	4,871,334	2,049,734
- Equipment Rental	3,272,887	1,449,785	1,289,472
Total cost	7,037,045	8,237,298	848,707

Based on the results of the standard deviations from Table 5, the spread of equipment depreciation costs is relatively small, indicating that the differences between groups are fairly consistent. The spread of seed costs is quite low, indicating that there is not much difference between the two groups. The variation in fertilizer used is also very small, which means that both groups have almost the same expenditure. The use of pesticides has a larger variation than seeds or fertilizers, but it is still quite small, indicating a similar pattern of pesticide use. The spread of labor costs is very large, indicating that there is a significant difference between the two groups, with non-users of combine harvesters tending to have higher labor costs. The variation in equipment rental costs is also quite large, with combine harvester users having higher expenditures than non-users. The distribution of total costs shows that combine harvester users are more efficient overall than non-users. In conclusion, overall, the combine harvester user group showed lower and more stable total costs, indicating that the adoption of this technology helped improve production efficiency.

Anas & Sadat (2020) says that the use of combine harvesters provides significant benefits in improving harvesting efficiency and reducing the need for manual labor. Although the operational cost of the machine is considered quite high, the efficiency gained from using this technology makes it more economical in the long run. The same thing was expressed by (Amrullah, 2019) regarding the costs incurred in the use of combine harvesters in Banten Province is that although the use of this machine requires relatively high operational costs, such as rental and fuel costs, the benefits gained from reduced yield loss and time efficiency make it a worthy investment for farmers. Overall, the costs incurred are proportional to the increase in yield and efficiency of the harvesting process, making it an economical choice for farmers in the region.

3.1.3 Income Analysis

Farmers' income from lowland rice farming varies depending on the area of land and the amount of production costs incurred. The amount of income can be determined by calculating the amount of income obtained by farmers minus the total costs incurred. For more details, below is a recapitulation of income and total production costs related to harvest and post-harvest activities.

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Table 6. Recapitulation of Total Farmer Income

Information	Average value (IDR/Ha)		
	Combine Harvester Users	Non-Combine Harvester Users	Standard Deviation
Reception			
Total Production (Kg)	4,086	3,695	276.28
Selling Price (IDR)	5,200	5,200	-
Revenue (IDR)	21,248,533	19,212,372	1,439,783
Amount	21,248,533	19,212,372	1,439,783
Harvest Costs			
a. Variable Costs			
Seed (IDR)	181,818	249,293	47,712.03
Fertilizer (IDR)	782,682	779,096	2,535.68
Pesticides (IDR)	917,080	887,790	20,711.16
Labor (IDR)	1,972,573	4,871,334	2,049,734
Equipment Rental (IDR)	3,272,887	1,449,785	1,289,128
Amount	6,542,731	8,237,298	1,198,240
b. Fixed cost			
Depreciation of Harvesting Tools (IDR)	494,314	586,798	65,396.06
Amount	494,314	586,798	65,396.06
Total Cost (IDR)	7,037,045	8,824,096	1,263,636
Income(IDR)	14,211,488	10,388,276	2,703,419

Based on the results of the analysis of the income of paddy rice farming in Pemangkat District in Table 6., the use of Combine Harvester proved to be more efficient than the manual harvesting method. This is indicated by the higher average total production and income for Combine Harvester users, which amounted to 4,086 kg and IDR 21,248,533, respectively, compared to non-users who only reached 3,695 kg and IDR 19,212,372, respectively. In addition, Combine Harvester users had lower harvesting costs, both variable and fixed, resulting in higher net income (IDR 14,211,488 vs. IDR 10,388,276). Although there is significant variation in net income between groups, these results indicate that the Combine Harvester is a more effective and economical solution to increase farmers' productivity and profits. Based on Table 6., the production, revenue, and income per hectare of farmers are obtained. Farmers using combine harvesters have shown that harvesting using combine harvester machines can increase productivity and reduce crop losses due to damage or loss of seeds, this proves that the opinion expressed by (Lipton, 2009), Rahman *et al*., (2021), Kunuti *et al*. (2020), and (Zakiyah *et al*., 2022) are true. The differences in production results, receipts, and income are very large between farmers who use and non-users of combine harvester machines due to the following reasons:

1) The combine harvester machine is designed to harvest efficiently, so it can harvest in a shorter time than human effort. The process of harvesting rice on one hectare of land which is done for seven days with the help of three workers or two days using 10 workers if using the manual method, can be completed in only two hours using a combine harvester machine.
2) Combine harvester machines can consistently harvest crops at optimal maturity levels so that they can help maximize the quality of the harvest.
3) Harvesting machines generally have features that reduce crop losses, such as efficient grinding systems and the ability to separate seeds from stalks well. This reduces yield losses that often occur in manual harvesting. This is shown from the results in Table 5, farmers who use a combine harvester have a production yield of 391 kg more than farmers who harvest using the manual method.

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4) The use of combine harvester machines also helps overcome labor shortages and reduces the costs incurred by farmers for harvest and post-harvest labor wages. Farmers who choose to harvest manually have to spend IDR 3,856,859 for labor wages, while farmers who harvest using a combine harvester only spend IDR 2,451,754 for combine harvester machine rental. This shows that the use of a combine harvester as a harvesting machine can save IDR 1,405,105 from farmers' expenses

3.1.4 Comparative Analysis of Rice Farmers' Income

Before conducting comparative test, then first do a different data net income of farmers using combine harvester and farmers non-users combine harvesters prerequisite test in the form of normality test and homogeneity test.

1) Normality Test

Test the normality of the data using helps SPSS application with the Saphiro Wilk. Saphiro Wilk was used in this normality test because Saphiro-Wilk has a high sensitivity in detecting deviations from the normal distribution, especially in small to medium samples, which corresponds to the general conditions in the t-test (Gibbons & Chakraborti, 2014). After testing SPSS type 22 with an error rate of 5%, the results of the normality of data on the average income of farmers of users and non-users of combine harvester of paddy rice in Pemangkat District are obtained as in Table 7.

Tabel 7. Data normality

Rice Paddy Farmers	Shapiro-Wilk		
	Statistic	Df	Sig.
Combine Harvester Users	.957	22	.433
Combine Harvester Non-Users	.953	22	.356

The following table shows that the significance value of combine harvester user farmers is 0.433 and that of non-user combine harvester farmers is 0.356. Since the significance value of combine harvester users and non-users is greater than 0.05, it can be concluded that the data of both groups are normally distributed. Therefore, this data test can be continued with the homogeneity of variance test.

2) Homogeneity Test

Testing the homogeneity of variance with the F test is done to determine which t-test formula will be used for hypothesis testing, therefore it is necessary first to test the variance of the two samples of the average income of wet-rice farmers in Pemangkat District, the purpose is to see whether or not the two groups of farmers are homogeneous. Testing the homogeneity of variance of the two data using the SPSS application program type 22. After testing the equality of variance with the help of the SPSS type 22 application with an error rate of 5%, the results of the homogeneity of variance of the average income data of farmers of users and non-users of combine harvester of paddy rice in Pemangkat District are obtained in Table 8.

Table 8. Homogeneity Variance Test

Levene Statistic	df1	df2	Sig.
41.312	1	42	.000

Based on the table above shows that the significance value of the results of the income of farmers users and non-users combine harvester smaller than 0.05. So it can be concluded that the average income of the two groups of wet-rice farmers in Pemangkat District has a different variant (heterogeneous). Then testing the two populations of data on the average income of farmers users and non-users combine harvester can be continued with the Independent Sample T-test, with the provisions of the formula selection is separated variance or polled variance. But to find out the t-table is used which is the amount of dk = $n2$ -1. After tabulating and processing the data, the next step is to analyze and

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compare the average income of farmers who use and do not use the combine harvester in Pemangkat district and see how much income rice farmers get in one hectare.

Table 9. Data on t-test Results

Independent Samples Test						
t-test for Equality of Means						
		T	Df	Sig. (2-tailed)	95% Confidence Interval of the Difference	
					Lower	Upper
Income	Equal variances assumed	13.193	42	.000	7889827.370	10739542.90
	Equal variances not assumed	13.193	22.270	.000	7851462.906	10777907.37

After testing using the t test, then to find out how much effect is caused using the effect size formula. The results are as follows:

$$\text{Pooled SD} = \sqrt{\frac{731{,}812^2 + 3{,}188{,}351^2}{2}}$$

$$= \sqrt{\frac{535{,}548{,}803{,}244 + 10{,}165{,}582{,}099{,}201}{2}}$$

$$= 2{,}313{,}128.93$$

$$\text{Cohen's d} = \frac{18{,}327{,}039 - 12{,}016{,}914}{2{,}313{,}128.93}$$

$$= 2{,}73$$

Test results using the t-test for Equality of Means show a significant difference between the income of Combine Harvester users and non-users. The t-value of 13,193 with 42 degrees of freedom (df) and a significance value (p-value) of 0.000 (<0.05) indicates that there is a highly statistically significant difference in average income. The 95% confidence interval for the difference in average income is between 7,889,827.37 and 10,739,542.90, indicating that the range of the difference is quite large. To measure the effect size of the difference, Cohen's d was used, which yielded a value of 2.73. This value indicates a very large effect according to the general interpretation of Cohen's d (d > 0.8). This means that the use of a Combine Harvester has a very significant impact on increasing farmers' income. In conclusion, the data shows that the use of a Combine Harvester not only significantly increases income, but also has a large effect in a practical context. Based on the analysis that has been done, it can be seen that the positive impact of using a combine harvester machine is as follows:

1) Streamline the production process
   The combine harvester combines the three main operations of harvesting, threshing, and cleaning in one machine. This not only speeds up the harvesting process, but also reduces the number of steps required to complete the work, resulting in a shorter time required for harvesting. reduces the amount of labor costs used for the rice harvesting process.
2) Labor reduction
   The use of this machine significantly reduces the need for manual labor. The rice harvesting process, which usually takes two days with 10 workers for one hectare, can be completed in just two hours with three people operating the machine. This reduction in labor also has an impact on the costs incurred for labor wages. With the use of a combine harvester machine, no labor costs are incurred for the harvesting process, only the cost of renting the equipment including the workers who will operate it. Although the combine harvester machine has a positive impact on the income of rice farmers, it has a

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labor impact on labor workers. With the use of combine harvester machines, employment opportunities for farm laborers are also reduced, especially female laborers who are usually involved in the harvesting process.

3) Increased crop yield
   The grain produced tends to be cleaner and of higher quality compared to manual harvesting which is often contaminated by dirt or crop residues. Yield loss during harvesting can also be reduced. In this study, the yield loss rate when using this machine can be reduced to 9%.
4) Economic impact
   Although there is an initial cost to rent a combine harvester, the reduction in labor costs and increased efficiency results in significant savings for farmers. For example, the expenditure on labor costs for farmers who are not combine harvester users is IDR 4,871,334, but the cost incurred by farmers who are combine harvester users is only IDR 1,972,573.

Some of the positive impacts found on farmers using combine harvesters in Pemangkat Subdistrict are in line with the findings of the study from Fatimah, *et al*., (2023) which shows that the use of a combine harvester not only reduces harvesting time, but also significantly reduces harvesting costs. With this tool, the harvesting process is faster than the manual method, and the use of labor is reduced, resulting in higher efficiency. (Fauzan & Desrial, 2023) in a study conducted in Kampung Inovasi, Subang, West Java, also showed that the effective field capacity (EFC) of the combine harvester was much higher compared to the manual method. In addition to speeding up the harvesting process, this tool also reduces yield losses, making it more efficient in terms of time and cost compared to scythes and other manual tools. Based on the findings in this study, it can be concluded that the use of combine harvesters has a positive impact on farmers, especially in the income section. In order to increase the efficiency and productivity of rice farming, farmers are advised to adopt combine harvester technology. Because in this study and several previous studies, this machine is proven to be able to speed up the harvesting process up to five times compared to the manual method, while reducing labor costs and yield losses. Higher field efficiency and a significant reduction in harvesting costs can increase farmers' income and speed up land preparation for the next planting season. Although the combine harvester provides many positive impacts, combine harvesters also have a negative impact on employment and damage to soil structure. The use of these machines reduces the need for manual labor, which can result in reduced employment for farm laborers. In some cases, this can lead to social problems, especially in areas with high unemployment. The weight of combine harvesters can cause soil compaction, which reduces soil porosity and affects crop growth in the following planting season. This can impact the long-term productivity of the farm. Not only that, this machine has limitations to be widely adopted. For example, in Pemangkat District, farmers have several obstacles in using a combine harvester, namely the high cost of renting a combine harvester, road access to rice fields in villages that are inadequate for combine harvester machines to pass through, and some rice fields near rivers do not have bridges that are suitable for combine harvester machines to pass through. These barriers greatly affect the level of farmer adoption.

To use a combine harvester, farmers who have rice fields that are blocked by rivers have to spend a lot of money just to build a large bridge so that the combine harvester can pass. With the additional costs incurred, it means that the net income that will be received by farmers is also reduced. Some of the barriers found in this study also have similarities with previous research. Research conducted by (Rizal & Wulandari, 2022) indicates that high rental costs are a significant barrier for farmers, limiting the accessibility of this technology. Poor road conditions to farmland can hinder the movement of machines to enter the land to be harvested and also make farmers not use combine harvester machines (Prasetyo, *et al*., 2023). Therefore, there is a need for government intervention in improving road infrastructure to farmland, such as building adequate bridges or repairing roads so that combine harvester machines can pass (Rahman, *et al*., 2021). Previously, the government of Sambas Regency has made various efforts to support the adoption of combine harvester technology, namely providing equipment assistance to farmer groups by providing combine harvester machines, providing training and counseling to improve farmers' skills in utilizing technology, providing infrastructure support such as farm roads and irrigation systems,

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and holding cooperation with the ministry of agriculture to ensure that farmers get access to the latest technology and support needed in agricultural production. However, the efforts made by the Sambas Regency government have only been realized in a few sub-districts such as Semparuk, Jawai Selatan, and Tebas. With the support of the local government, farmers in these three sub-districts have started using combine harvesters as part of agricultural modernization (BBPP Ketindan, 2024).

3.2 Discussion

The results of this study show that the use of combine harvesters has a positive impact on farmers' income, with a significant difference observed between farmers who use combine harvesters and those who still use manual harvesting methods. The normality and homogeneity of variance tests showed that the income data of the farmers were normally distributed, which allowed for the use of the t-test to compare the incomes of the two groups. The t-test confirmed a significant difference in income between farmers using combine harvesters and those using manual methods. Several factors contribute to this income disparity, including lower production costs for farmers using combine harvesters. Farmers who use combine harvesters only incur costs for renting the machine and paying for the operator, whereas those using manual methods face higher labor costs and spend more time harvesting. This finding is consistent with Amrullah (2019), who stated that the use of combine harvesters reduces crop loss and improves time efficiency, ultimately increasing farmers' income. Additionally, this study aligns with Anas & Sadat (2020), who found that the use of harvesting machines improves efficiency and productivity for farmers. In terms of production, farmers using combine harvesters experienced higher yields due to the more efficient harvesting process and reduced crop loss. This finding supports Fatimah *et al*. (2023), who noted that the use of combine harvesters helps reduce harvest losses and improve the quality of harvested crops, leading to higher output at lower costs. Furthermore, research by Rahman *et al*. (2021) also revealed that combine harvesters improve productivity and reduce operational costs, which directly impacts farmers' income.

However, despite the many benefits of using combine harvesters, there are challenges that need to be addressed to expand their use. Some of the barriers identified in this study include the relatively high rental costs of the machines and limited access to roads that can accommodate the machinery in rural areas. This is consistent with the research by Prasetyo *et al*. (2023), which found that poor road infrastructure can hinder the adoption of modern agricultural technologies in rural areas. Therefore, additional support from the government, such as subsidies for machine rentals or improvements in infrastructure, is necessary to enable smallholder farmers to access this technology and benefit from it. Overall, this study demonstrates that combine harvester technology has a significant positive impact on farmers' income. The use of this technology proves to be more efficient in terms of cost and time, as well as reducing harvest losses, which ultimately increases farmers' income. As a recommendation, the government should intensify support for the adoption of this technology through extension services, subsidies, and infrastructure improvements to ensure that the benefits of this technology can be enjoyed by all farmers, particularly smallholder farmers in rural areas.

4. Conclusion

From the discussion above, it can be concluded that the use of combine harvester machines in rice harvesting in Pemangkat District has a positive impact on both increasing production and improving farmers' income. The significant difference in income per hectare between farmers who use combine harvesters and those who do not is primarily due to differences in production costs, crop yields, and revenues. Farmers who use combine harvesters incur lower costs as they only need to rent the machine for harvesting. In contrast, farmers who do not use combine harvesters must bear the cost of labor for harvesting, transportation, and thresher machines. Additionally, farmers using combine harvester machines experience larger harvests and smaller yield losses, which contribute to increased income.

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To raise public awareness of the importance of adopting this technology, the government can take several steps. These include providing counseling and field demonstrations to showcase the benefits of combine harvesters, offering subsidies for purchasing, fueling, or maintaining the machines, providing training on machine operation and maintenance, encouraging the formation of farmer groups for collective machine rental, and improving road infrastructure to facilitate the transportation of machinery to farms. However, this research has certain limitations, particularly in data collection and limited access to combine harvesters. It is recommended that future studies use more diverse and comprehensive data collection methods, such as in-depth interviews and direct observations, to enhance the findings. Additionally, collaboration with relevant stakeholders, such as the government or agribusiness service providers, is crucial to improving farmers' access to combine harvesters. This collaboration is expected to provide valuable insights and practical solutions for advancing agricultural mechanization in the future.

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