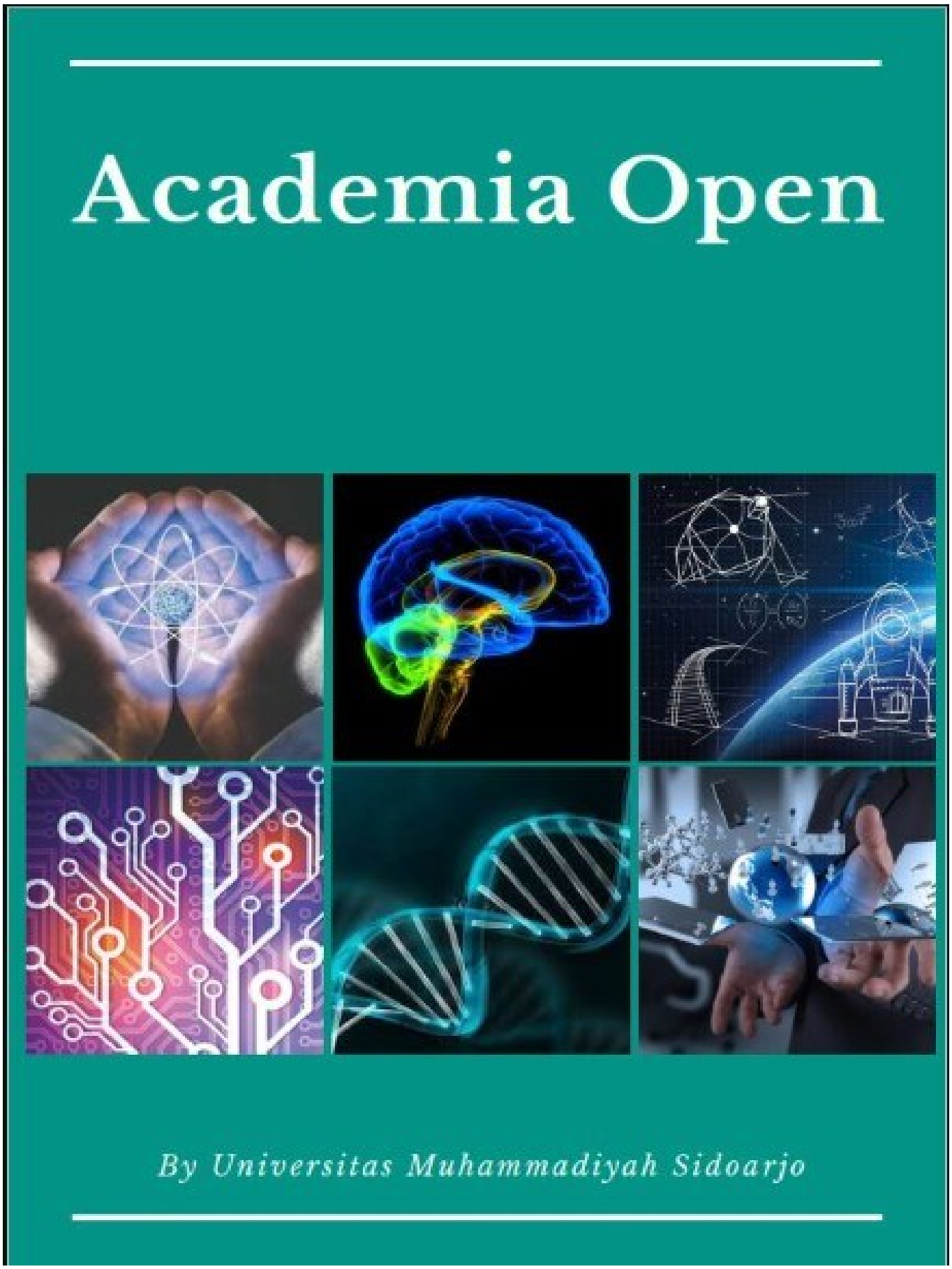
**Academia Open**

Vol. 11 No. 2 (2026): December
DOI: 10.21070/acopen.11.2026.14719

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**Academia Open**

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DOI: 10.21070/acopen.11.2026.14719

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Academia Open

Vol. 11 No. 2 (2026): December
DOI: 10.21070/acopen.11.2026.14719

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**Academia Open**

Vol. 11 No. 2 (2026): December
DOI: 10.21070/acopen.11.2026.14719

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**Academia Open**

Vol. 11 No. 2 (2026): December
DOI: 10.21070/acopen.11.2026.14719

# Harvested Area as Main Determinant of Ngawi Rice Production

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## Abstract

**General Background** Rice is a strategic commodity for food security, and agricultural production depends on the combination of land, labor, and capital resources. **Specific Background** Ngawi Regency experienced declining rice production from 2020 to 2024 alongside land conversion, an aging farmer population, limited technological capability, and uneven agricultural machinery use. **Knowledge Gap** Existing evidence indicates that harvested area is closely associated with production, while farmer numbers and machinery may contribute weakly when labor productivity and technology utilization are suboptimal, requiring localized assessment in Ngawi. **Aims** This study examines harvested area, number of farmers, and agricultural machinery in relation to rice production in Ngawi Regency using annual secondary time-series data from 2010–2024 obtained from Statistics Indonesia and the local Food Security and Agriculture Department. Multiple linear regression was conducted using SPSS. **Results** Harvested area was positive and significant (B = 7.736; p = 0.004), while farmer numbers were negative and nonsignificant (B = −0.371; p = 0.928) and agricultural machinery was positive but nonsignificant (B = 4.525; p = 0.614). Jointly, the three factors were significant (p < 0.001), and the model explained 73.1% of production variation. **Novelty** The study jointly evaluates land, agricultural labor, and machinery as production factors using a 15-year Ngawi time series. **Implications** Sustainable production requires optimized agricultural land management, stronger farmer capability through extension services, and more effective machinery utilization to support regional and national food stability.

**Highlights:**

- Cultivated land recorded B = 7.736 and p = 0.004.
- Farmer count (p = 0.928) plus machinery (p = 0.614) remained individually nonsignificant.
- Three modeled factors jointly accounted for 73.1% of observed variance.

**Keywords:** Harvested Area, Number of Farmers, Agricultural Machinery, Rice Production

Published date: 2026-08-21

Vol. 11 No. 2 (2026): December
DOI: 10.21070/acopen.11.2026.14719

## Introduction

Indonesia is an agricultural country that has extensive agriculture and diversity abundant natural resources. The livelihood of the majority of Indonesia's population is in agricultural sector. The agricultural sector plays a very crucial role in the economy Indonesia is a country that supports food security and also the national economy [1]. Rice farming needs a lot of attention from farmers to get the best possible harvest. The reason we need to increase rice production in a sustainable way is because rice is a main food source and an important item for ensuring that people have enough to eat [2] So, rice is a very strategic commodity in supporting national food security, while farmers play an important role as the main supplier of food needs and support the Indonesian economy [3] .

Optimal agricultural production is defined as agricultural output that yields attractive results/products. Theseaspects of production complement each other, resulting in high-quality output. The size of output is largely determined by the production factors used [4] The production factors used can be clearly identified and the resulting product can also be easily identified in terms of both quality and quantity . In farming, the resulting product will be good if the production factors used are efficient, meaning that the output units produced are greater than the input units used. In other words, the results are greater than the costs incurred so that income increases [5]. Most farmers think that the amount of resources they use in farming affects how much crops they can grow. However, the best efficiency is reached when the amount of input used is matched properly to what is needed for production [6].

The Cobb-Douglas production function theory describes how different factors of production, like labor and capital, interact and affect the amount of output produced in an economy. This function makes capital and labor as production factors that influence production output [7]. This is implied in the equation Q = K x L, where Q is the output produced, K is capital, L is the labor used. In the book Principles of Economics, Alfred Marshall also stated that production is the process of creating goods by combining various factors such as land, labor, and capital which can be formulated in the production function Q = LKT Land means all natural things like farms, water, and minerals that are used to make things. While labor refers to the physical and intellectual efforts devoted by humans in the production process. In addition, capital here is not only in the form of money, but also includes machines, equipment, and infrastructure that accelerate and increase production efficiency [8]In this study, the harvested area is a representation of land availability, the number of farmers as a representation of agricultural labor, and agricultural machinery as a form of application of capital or agricultural technology in supporting the rice production process.

Harvested area is the main production factor that affects rice production, the larger the area of land planted, the more it will affect the harvested area obtained. Harvested area is closely related to the level of production produced because the harvested area will automatically affect the level of rice production, where increasing or decreasing the harvested area will affect rice production [9]. In addition, farmers, who are key players in the agricultural sector, play a very important role in farming, from growing crops on the land to collecting the harvest. Support for providing agricultural tools and machinery is expected to help solve the big problems caused by low and high wages for agricultural labor. Using agricultural machinery in farming can make the work more efficient and effective, which helps in producing better quality crops [10].

Ngawi Regency, known as one of East Java's main rice-producing areas, is very important for helping the agricultural industry, especially in growing rice. Data from the Ngawi Regency Central Statistics Agency (BPS) shows a downward trend in rice production from 2020 to 2024. In 2020, rice production was recorded at 837773,15 tons, then decreased in 2021 to 786475,65 tons and remained relatively stable in 2022 at 785037,99 tons. Furthermore, production declined again in 2023 to 771251,37 tons and in 2024 to 765,70353 tons [11]. This situation indicates that Ngawi Regency still faces challenges in maintaining production stability, and that resource utilization in production activities has not been optimal. For example, changing land from being used for farming to being used for other purposes, the number of farmers is decreasing because the younger generation prefers to work in non-agricultural sectors, and the lack of use of agricultural machinery because many farmers still use manual methods. limited ability to operate technology, and unequal ownership of agricultural machinery among each farmer group.

Faisol Muttaqin & Suman [7], state that the area where rice is harvested is closely linked to how much rice is produced. Therefore, if we increase the area where rice is grown, it can lead to higher rice yields and help improve food security. Other research has indicated that having agricultural machines and the number of farmers involved might not greatly affect rice production if these resources are not used properly. Additionally, good soil conditions and the right technological skills are also necessary for effective production. Research by Putri & Fahira [12] also backs this up, showing that the number of farmers does not have a major impact on rice production. This is because many farmers are older adults who work less efficiently. Additionally, research by Setiyanto [13] indicates that issues like agricultural machines not matching the soil conditions, operators having limited skills, and insufficient support infrastructure lead to less effective use of agricultural machinery for boosting rice production.

Based on what has been observed before, rice farming in Ngawi Regency still has problems because the farming process is not managed very well. So, this study wants to see how the size of the land farmers harvest, the number of farmers, and the farming tools affect how much rice is produced in Ngawi Regency.

## Method

This research takes a quantitative approach and secondary data is used as the main source of analysis. The data used are time series, period 2010–2024. This information is sourced from official entities like the Ngawi District Central Statistics

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Agency and Ngawi District Food Security and Agriculture Department. The study uses a special computer program called SPSS to see how different things, like the harvested area, the number of farmers, and the use of machines, affect how much rice is grown in Ngawi District.

### 1. Multiple Linear Regression Analysis

Multiple linear regression analysis is a way to see how more than two things are connected. It helps to find out if changes in some factors are related to changes in others. According to Ghozali [14], the model for this analysis can be written like this:

$$Y = \alpha + b_1 X_1 + b_2 X_2 + b_3 X_3 + e \quad (1)$$

Information:

Y = Variable dependent (Rice Production)

α = Constant

$b_1$, $b_2$, $b_3$ = Coefficient regression

$X_1$, $X_2$, $X_3$ = Variables independent

e = Error term

### 2. Classical Assumption Test of Research Variables

Tests check if data is shaped properly and if the numbers work well together. Regression models need data that looks like a bell curve. If it doesn't, the data needs to be changed. A good regression model doesn't have confusing or repeating patterns in the data [15].

### 3. Multicollinearity Test

The multicollinearity test helps see if the things we use to predict an outcome are connected to each other. If the tolerance is more than 0.10 and the VIF is less than 10, it means these things are not too connected [14].

### 4. Normality Test

The One-Sample Kolmogorov-Smirnov test helps to see if the data follows a normal pattern. If the number it gives us is bigger than 0.05, the data is normal. If the number is smaller than 0.05, the data is not normal [16].

### 5. Heteroscedasticity Test

The heteroscedasticity test looks at whether the mistakes in a math problem change a lot for different pieces of data. In this study used Glejser test. If the chance number is more than 0.05, it means the mistakes don't change much. If the chance number is less than 0.05, it means the mistakes change a lot [14]

### 6. Autocorrelation Test

The autocorrelation test helps to see if the mistake made now is related to the mistake made earlier. The Durbin Watson test is used to check for this connection [17]. Ghozali [14] says that autocorrelation happens because each study over time is linked to the one before it. This happens because the errors are not separate from each other from one point to the next.

### 7. Hypothesis Testing

If all the conditions needed to check a regression model have been satisfied., then a determination coefficient test is carried out, then a simultaneous test (F test) and a significance test is carried out to determine whether it is accepted or not (T test).

### 8. Coefficient of Determination Test ($R^2$)

The coefficient of determination tells us how well a model can explain changes in one variable when another variable changes. If the number is bigger, it means the model explains these changes more accurately [16]

### 9. F Test (Simultaneous)

The F-test checks if all the independent things together have a real effect on the dependent thing. According to Ghozali [16], we look at a special number called the F-statistic to see if this is true. If the p-value from the F-test is less than 5%, it means all the independent things are really affecting the dependent thing at the same time. But if the p-value is more than 5%, we can't be sure that the independent things are working together to affect the dependent thing.

ISSN 2714-7444 (online), https://acopen.umsida.ac.id, published by Universitas Muhammadiyah Sidoarjo

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**10. T-Test (Partial)**

The t-test helps figure out how much the independent variable affects the dependent variable. According to Ghozali [14] if the p-value is less than 5% or the calculated t-value is higher than the t-value from the table, it shows that the independent variable has an effect on the dependent variable on its own. If the p-value is higher than 5% or the t-value we calculate is less than the value from the t-table, then we don't have enough evidence to conclude that the independent variable has an effect on the dependent variable by itself.

# Result and Discussion

## A. Results

### 1. Multiple Linear Regression Analysis

The results of data processing using the multiple linear regression method are presented in Table 1.

**Table 1.** Result Of Multiple Linear Regression Analysis

| Variabel | Koefisien Regresi |
|---|---|
| Konstanta | -169892.796 |
| X1 = Luas Panen | 7.736 |
| X2 = Jumlah Petani | -.371 |
| X3 = Alsintan | 4.525 |

According to the findings derived from the analysis, the equation for multiple linear regression in this research is:

$$\textbf{Rice Production} = -169892{,}796 + 7{,}736\ LP + -0{,}371\ SP + 4{,}525\ AS \qquad (2)$$

Where:

a. Constant = -169892.796 means that if the harvested area, number of farmers, and agricultural machinery are zero, then the rice production variable has a value of 169892.796

b. Harvested Area ($X_1$) = 7,736, meaning that for every one hectare increase in harvested area, rice production will increase by 7,736 tons.

c. Number of Farmers ($X_2$) = -0,371, meaning that for every 1 increase in the number of farmers, rice production will increase by 0,371 tons.

d. Agricultural machinery ($X_3$) = 4,525, meaning that for every 1 unit of agricultural machinery added, rice production will increase by 4,525 tons.

### 2. Multicollinearity Test

The test results are shown in table 2.

**Table 2.** Multicollinearity Test

| Model | Collinearity Statistics | |
|---|---|---|
| | Tolerance | VIF |
| (Constant) | | |
| LUAS PANEN | .390 | 2.564 |
| JUMLAH PETANI | .593 | 1.686 |
| ALSINTAN | .107 | 1.073 |

The independent variable shows a tolerance higher than 0,100 and a VIF that is below a specific limit. So, we can say that the idea of multicollinearity is confirmed, or that there are no signs of multicollinearity.

### 3. Normality Test

The normality test in this study is shown in table 3.

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**Table 3.** Normality Test

| One-Sample Kolmogorov-Smirnov Test | | |
|---|---|---|
| | | Unstandardized Residual |
| N | | 15 |
| Normal Parameters[a,b] | Mean | .0000000 |
| | Std. Deviation | 29141.57560882 |
| Most Extreme Differences | Absolute | .120 |
| | Positive | .105 |
| | Negative | -.120 |
| Test Statistic | | .120 |
| Asymp. Sig. (2-tailed) | | .200[c,d] |

The value of the Asymp.Sig. (two-tailed) is 0.200, which is higher than 0,05. This means we can say the data follows a normal distribution since the significance level is higher than 0,05

**4. Heteroscedasticity Test**

The results of the heteroscedasticity test are presented in table 4.

**Table 4.** Heteroscedastisity Test

| Model | t | Sig. |
|---|---|---|
| (Constant) | -.263 | .797 |
| LUAS PANEN | .844 | .417 |
| JUMLAH PETANI | -.050 | .961 |
| ALSINTAN | -.806 | .438 |

The independent variable has a significance value that is higher than 0,05. This means we can say there are no signs of heteroscedasticity, or in other words, the requirements for the heteroscedasticity test have been satisfied.

**5. Autocorrelation Test**

The autocorrelation test results for the research model are shown in table 5.

**Table 5.** Autocorrelation Test

| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate | Durbin-Watson |
|---|---|---|---|---|---|
| 1 | .888[a] | .789 | .731 | 32876.13117 | 1.919 |

According to the findings from the Durbin–Watson autocorrelation test, the DW value came out to be 1,919. This value falls between DU (1,7501) and 4-DU (2,2499), which means it satisfies the condition of DU < DW < 4-DU. Therefore, we can say that the regression model does not show signs of autocorrelation, which means it is appropriate for use in research analysis.

**6. Coefficient of Determination Test**

The coefficient of determination values obtained are shown in table 6.

**Table 6.** Test Coefficient Determination

| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate |
|---|---|---|---|---|
| 1 | .888[a] | .789 | .731 | 32876.13117 |

The Adjusted R Square value is 0,731, which indicates that the combined effect of Harvested Area, Number of Farmers, and Agricultural Machinery accounts for 73,1% of the Rice Production Variable. The other 26,9% is affected by different factors that are not included in this study.

**7. F Test (Simultaneous)**

The results of the simultaneous test (F test) in this study are presented in the following table 7.

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**Table 7.** F-Test Simultaneus

| Model | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Regression | 44460283071.667 | 3 | 14820094357.222 | 13.712 | .000[b] |
| Residual | 11889240005.505 | 11 | 1080840000.500 | | |
| Total | 56349523077.172 | 14 | | | |

The significance value obtained is 0.000 (<0,05), It can be inferred that the factors of harvested land, quantity of farmers, and farming equipment collectively have a substantial impact on the variable concerning rice production.

**8. T-Test (Partial)**

The results of the partial test (t-test) are presented in table 8.

**Table 8.** T-Test (Partial)

| | | Unstandardized Coefficients | | Standardized Coefficients | | |
|---|---|---|---|---|---|---|
| | | B | Std. Error | Beta | t | Sig. |
| 1 | (Constant) | -169892.796 | 690894.296 | | -.246 | .810 |
| | Luas Panen | 7.736 | 2.143 | .801 | 3.610 | .004 |
| | Jumlah Petani | -.371 | 4.021 | -.017 | -.092 | .928 |
| | Alsintan | 4.525 | 8.727 | .103 | .518 | .614 |

The results of the regression indicate that the amount of area harvested positively and significantly influences rice output (B = 7,736, Sig. 0,04), indicating that an increase in harvested area leads to an increase in rice production.Meanwhile, fertilizer subsidies (B = -0,371) and agricultural machinery assistance (B = 4,525) have a positive but insignificant effect because their significance values are 0,928 and 0,614 (> 0,05), respectively.

## B. Discussion

**1. The Effect of Harvest Area on Rice Production in Ngawi Regency**

The analysis results indicate that the area harvested has a coefficient of 7,736 and a significance value of 0,004, which is less than 0,05. We can say that the area we harvest has a good and important impact on rice production. As a result, any growth in the area where rice is grown will lead to a large rise in rice production. Usually, the bigger the area that is harvested, the greater the amount of crops produced. This shows that the area where rice is grown is one of the key factors that affects how much rice is produced, so using the land in the best way is very important.

In farming, how much food is made depends on things like land, workers, and tools. The land used to grow rice is called the harvested area. If more land is used to grow rice, then more rice can be produced. But if less land is used, then farming doesn't go as smoothly and less rice is made [18]. Furthermore, the larger the harvested area, the more optimal the use of production inputs, thereby increasing overall rice production.

This corresponds with the findings of Faisol Muttaqin & Suman [7] that the extent of cultivated land positively influences rice output. Production rises in direct relation to the size of the land. Similar research by Sahta Valentina Banurea et al [19] shows If more land is available, then rice production will also go up. However, the amount of land that can be used still depends on technical factors like the quality of things used in farming, such as seeds, fertilizers, and irrigation, as well as how farmers manage their land. So, expanding farmland should go along with making farming more efficient, using technologies that are good for the environment, to get the best possible crop production.

**2. The Influence of the Number of Farmers on Rice Production in Ngawi Regency**

The findings from the analysis indicate that the quantity of farmers has a coefficient of -0,371 and a significance level of 0,004. This indicates that an increase in the number of farmers is not always followed by an increase in rice production. This condition may occur because the majority of the agricultural workforce in Ngawi Regency is dominated by elderly farmers, so that the ability to manage farm businesses and implement agricultural innovations is still relatively limited.

The number of farmers is a proxy for the labour in the rice farming sector, as farmers are the primary actors directly involved in rice farming activities, from land preparation, planting, land maintenance, to the harvesting process. The insignificant results reinforce the hypothesis that the agricultural sector in Indonesia still faces challenges in "managerial efficiency" and digital literacy. The use of information technology and the internet has been shown to be positively correlated with productivity, but access is still dominated by young, highly educated farmers [20]. This suggests a lack of succession, with educated young workers tending to migrate to non-agricultural sectors, while those who remain in rural areas may not yet be optimally applying their knowledge to land management [21].

This is in line with research by Putri & Fahira [12] which shows that the labor variable has a negative but insignificant effect, because the majority of farmers are older and have low productivity. Similar research by Ardhianti & Moninthofa Ariyani [22] which states that the influence of farmer age on the labor force significantly impacts rice production, because older farmers' age causes farming skills, such as working and thinking, to take longer.

### 3. The Impact of Agricultural Machinery on Rice Production in Ngawi Regency

The analysis results show that farm equipment possesses a coefficient of 4.525, and it carries a significance value of 0,928, which is greater than 0,05. This suggests that farm equipment has a beneficial yet statistically insignificant impact on the production of rice. The addition of agricultural tools and machinery does tend to increase production, but the effect is not yet clearly visible. This could be because agricultural machinery utilization in the field is not optimal, both in terms of use by farmers and its distribution. As a result, the contribution of agricultural machinery to increasing rice production is still not optimal.

Agricultural machinery and agricultural input subsidies are important government programs, but implementation in the field still faces challenges. This assistance will only be effective if it is distributed appropriately, used according to technical needs, and supported by intensive extension assistance. Therefore, the results of this study serve as an important assessment that increasing rice production depends not only on the provision of physical inputs, but also on management, mentoring, and active farmer participation in maximizing the use of this assistance [23]

This is in line with the research results of Sopian et al., [24] which shows that increasing the agricultural subsidy budget is not always directly proportional to increased rice productivity, and in some cases even has a negative correlation because the distribution of aid is not well-targeted and creates market distortions. Similar research by Fuady et al., [25] also states that even though equipment and agricultural input assistance are available, many farmers still experience obstacles in accessing and utilizing them effectively due to a lack of training, operators, and supporting infrastructure.

## Conclusion

Based on the research results, it shows that harvested area, number of farmers, and agricultural machinery simultaneously influence rice production. However, partially, The cultivated land has a beneficial and considerable impact on rice yield, this indicates that increasing harvested area can increase rice production yields. Meanwhile, the number of farmers has an adverse and negligible impact on the production of rice, which indicates that an increase in the number of farmers is not necessarily followed by an increase in variables if not supported by optimal labor productivity. Then, agricultural machinery also oes not have a major impact on rice output, so it is essential to make effective use of agricultural advancements to achieve substantial crop yields.

This indicates that production factors such as harvested area, number of farmers, and technology play a crucial role in supporting rice production in Ngawi Regency. Therefore, it is necessary to optimize agricultural land management, improve the quality of farmer resources, such as through agricultural extension services, and increase the effective use of agricultural machinery to support sustainable rice production. These initiatives are essential for upholding both regional and national food stability, since rice is a vital food product that significantly contributes to fulfilling community requirements.

## Acknowledgement

The author would like to thank the Ngawi Regency Food Security and Agriculture Service and the Ngawi Regency Central Statistics Agency for providing the necessary data and information to successfully conduct and complete this research. Also thanks to supervisor for her guidance, direction, and input throughout the research process and the completion of this article. These contributions were invaluable in completing this article.

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