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# Identifying contributing variables on rice production: case study of rural smallholder farmers

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***ABSTRACT***

*Rice is one of the staple foods of Indonesian citizens that must be fulfilled. The need for rice as a staple food will continue to increase along with the level of consumption, which will continue to increase due to rapid population growth. In meeting these needs, farmers face obstacles that can cause a decrease in production. The decline in rice production is one of the phenomena happening in Pagentan Village, Singosari Subdistrict. This study was conducted to find out what factors affect the production of rice commodities in Pagentan Village because no previous research has been conducted on the same topic at this location. The respondents of this study were 30 farmers who were members of rice farmer groups in Pagentan Village, Singosari Subdistrict. Multiple Linear Regression is the data analysis approach utilized in this study to measure five variables: production, land area, seeds, land fragmentation, and pest attack area. The findings demonstrate that the land fragmentation variable had no bearing on the decline in production at the research site. Other variables, namely land area, seeds, and the extent of pest attacks have the most significant influence on the seeds used by farmers. This study examines the problem of declining production in Pagentan Village, which has never been done before. Based on the results of the research, it is known that one of the factors that most affect the decline in production is the extent of pest attacks. So, the solution that can be given in this study is to take action to prevent and control pests, which can be done with the trap barrier system.*

***Keywords:***
*Agriculture risk, FMEA, Production decline, Regression*

## 1. Introduction

The agricultural sector is one of the sectors in Indonesia that contributes a lot to the country's economy. The results obtained from the agricultural sector are to meet the needs of the Indonesian people. Subsectors of the farming sector are widely diverse, one of which is the food crop subsector. All economic activities that result in the production of food commodities, such as rice, corn, cassava, cassava vines, sweet potatoes, peanuts, soybeans, vegetables, fruits, cereals, and other food ingredients, are included in the food crop subsector [1]. According to data from the BPS-Statistic of Malang Regency (2022), rice production in 2021 was found to produce 31.3 million tons, which became the food consumption of the population. The high level of public consumption of rice commodities causes farmers to meet the needs of the community. Lawolo et al. [2] explained that rice is one type of food crop commodity that produces rice and is a staple food whose existence is the main priority of the Indonesian people in meeting food needs. There are obstacles to meeting the food needs of the community. One obstacle farmers face in meeting the community's needs is the increasing level of rice consumption and the phenomenon of decreased rice production that has emerged in several regions in Indonesia.

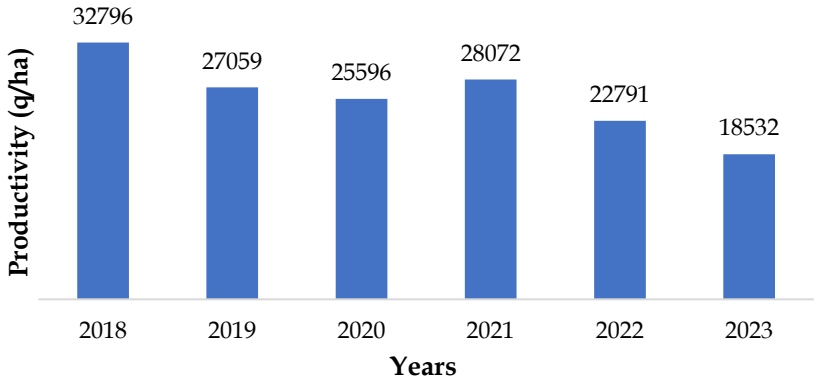


**Figure 1. Rice production of Singosari Sub-district in 2018–2024 [3–5]**

Singosari sub-district is one of the sub-districts that contributes the most rice commodities in Malang District. Singosari sub-district has excellent potential as the most significant contributor to the rice supply in Malang Regency after the Kepanjen sub-district and other sub-districts that have large areas of land. In Figure 1, there is a graph showing the level of rice production in the Singosari sub-district. The COVID-19 pandemic was the reason for the 2019 rice crop reduction, which prompted the lockdown policy to be put in place. In 2020, there was still a decline in rice production. Meanwhile, in 2021, the production of rice paddies in the Singosari sub-district began to increase. This increase was supported by an increase in land productivity in various villages in the Singosari Sub-District. However, the following years showed a decrease in rice production in 2022 and 2023. There are several potential causes for this productivity drop.

There are a number of internal and external factors that can contribute to the issue of decreasing rice output. The constraints faced in each factor will affect the decline in production. Internal factors that can affect agricultural production are in the form of land area, the use of fertilizers, pesticides, labour, and the growing season [6]. Meanwhile, limits emanating from external sources can be in the form of pests and plant diseases, climate change, and counselling obtained by farmers have a substantial influence on the drop in production [7]. Some of the impacts that can be caused by climate change can include a reduction in rice fields, changes in river and groundwater discharge, an increase in flood and drought threats, a decrease in the planting area, a decrease in productivity, and an increase in pest and disease attacks [8].

Increasing land productivity can be done by improving cultivation technology and the use of inputs in rice farming so that productivity can continue to increase [9]. This increase in productivity will affect the amount of production from the land. The amount of land utilized for food self-sufficiency will determine how much agricultural product is produced; if the area of agricultural land is shrinking, then the land productivity will be low, and vice versa. If the area used for food self-sufficiency is expanded, then land productivity will also increase [10]. Patent Village is one of the villages in the Singosari Subdistrict, where the majority of the commodity cultivated is rice. Total rice production in Pagentan Village has decreased in recent years. There are obstacles experienced by rice farmers in Pagentan Village, causing a decrease in the income earned by farmers. This will affect the capital that will be used in the cultivation of rice commodities. Based on the initial survey conducted in the field, one

of the causes of the decline in production is due to pest attacks. According to the above description, the goal of this study is to identify the production parameters that, in particular in Pagentan Village in Singosari District, have an impact on raising rice output.

## 2. Methods

The research was conducted in Pagentan Village, Singosari District, Malang Regency. This research was conducted from July to October 2023. Pagentan Village was chosen as the research location because it is a village that has experienced a decline in the production of rice commodities, which affects farmers and other parties. Data on the decrease in production was obtained when conducting initial interviews with the coordinator of the farmer group in Pagentan Village; it was found that Pagentan Village is one of the villages in the Singosari Subdistrict with pest problems that caused a decline in rice commodity production. In Pagentan village, there is one farmer group that focuses on rice commodities.

The farmer group is called the Tumapel Farmer Group. Farmers who are members of the Tumapel Farmer Group are the respondents of this study. Therefore, the researcher determined 30 farmers to be the respondents in this study. This study employed the Slovin formula to determine the number of respondents. Based on the results of calculations using the Slovin formula to determine the number of respondents with a margin of error of 10%, the number of respondents was 30 farmers who were members of the Tumapel Farmer Group. Data collection methods were carried out through interviews, questionnaires, and literature studies by accessing and analyzing previous research that had the same problem.

The data analysis used in this study is a multiple linear regression analysis with five variables that have been determined, that include independent and dependent variable. To perform multiple linear regression analysis, the following are the variables measured in this study:

### *a. Rice Production*

The production level of rice commodities is the dependent variable used in this study. The production level in this study is described in units of tons/hectare. The production level of agricultural commodities, especially rice commodities, can be influenced by various factors. These factors can come from internal factors and external factors. Internal factors that can affect production levels are land area and seeds. External factors that can affect production levels are land fragmentation and the extent of pest attacks.

### *b. Land Area*

Production levels are directly impacted by the area of land used for rice farming. The more land that is accessible, the higher the potential to raise rice production. This is because more crops can be grown, current technology can be used more effectively, and a diversity of types that are suited to the local environment may be supported. According to research by Usman et al. [11], land area positively affects the production of rice commodities.

***c. Seeds***

Quality rice seedlings are a crucial factor in determining the production level of rice commodities. Good seedlings can increase yields by ensuring that plants grow strong, are resistant to disease, and have optimal yield potential. Conversely, the use of poor-quality seedlings can reduce productivity and increase the risk of crop failure. A study by Wadu et al. [6] showed that seedlings have an effect on production and can also affect production risk. Therefore, selecting suitable seedlings is an essential first step in the effort to increase rice production effectively and sustainably.

***d. Land Fragmentation***

Land fragmentation, or the division of farmland into smaller, separate pieces, can significantly reduce production levels and affect production risk. According to Alemu et al. [12], research explained that land fragmentation is defined as a situation where a single farm or ownership consists of many spatially separated plots. Land fragmentation can affect production risk. Fragmentation of land ownership has significant implications for sustainable agricultural development and can be an obstacle to increasing productivity and sustainability of land resources.

***e. Extent of Pest Infestation***

The extent of pest infestation has a direct influence on the production level of rice commodities. The more extensive the pest attack on rice plants, the greater the possibility of crop loss. In research conducted by Hindo et al. [13], it was stated that the extent of pest attacks is one of the factors that can affect production yields. The increasing area of pest attacks will also increase the impact faced by farmers, one of which is the decrease in the level of production of farmers and the losses felt by farmers. Furthermore, these variables were analyzed using Multiple Linear Regression Analysis. The following is a data analysis method based on the research objectives:

***a. Data Preparation Stage***

The validity and reliability tests were conducted during the data preparation stage in order to determine the validity and reliability of the questionnaire items. According to Jabnabillah et al. [14], the validity test provides a foundation for making decisions. The basic principles of decision-making in the validity test are as follows: if the significance value is less than 0.05, it is correlated, and if it is more significant than 0.05, it is not.

The Cronbach Alpha technique was used to measure the reliability test in this investigation. When a variable's Cronbach's alpha (α) value is more excellent than 60% (0.60), it is considered trustworthy; if it is less than 60% (0.60), it is considered unreliable. This is the outcome of the reliability test in the Cronbach Alpha technique.

***b. Multiple Linear Regression Analysis Model***

The following is a linear regression analysis model adjusted to the variables that will be used in this study.

$$Y = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \varepsilon \quad (1)$$

Description:

| | | | |
|---|---|---|---|
| Y | = Rice Production | $X_2$ | = Seeds |
| a | = Constant | $X_3$ | = Land Fragmentation |
| $\beta$ | = Regression Koefisien | $X_4$ | = Extent of Pest Infestation |
| $X_1$ | = Land Area | $\varepsilon$ | = error |

***c. Classic Assumption Test***

The normality, multicollinearity, and heteroscedasticity tests make up the traditional assumption test used in this investigation. In this work, the classical assumption test aims to guarantee that the regression equation obtained has impartial, consistent, and accurate estimation. The normality, multicollinearity, and heteroscedasticity tests make up the traditional assumption test used in this investigation. The multicollinearity test yield results based on the assessment of tolerance, variance inflation factor (VIF) values, and the degree of correlation between the independent variables. According to Setiawati [15], If a regression model's tolerance number is at least 0.10 and its VIF value is no more than 10, it is considered multicollinearity-free.

According to Ayuwardani et al. [16], the purpose of the Glejser test is to establish a correlation between each study variable and the absolute value of the residuals. Decision-making is based on the heteroscedasticity test, just like it is with other classical assumptions. The regression model does not have the same residual variance from one observation to the next if the Glejser test findings indicate that the independent variable's significance value is higher than 0.05 [17].

***d. Multiple Linear Regression Analysis***

***Test Coefficient of Determination ($R^2$)***

A regression is considered good if $R^2$ is equal to or greater than 1. This indicates a good degree of fit between the independent and dependent variables. In contrast, poor regression quality (lower level of confidence) is indicated by a regression's $R^2$ value growing smaller or farther from 1.

***Simultaneous Test (F Test)***

This test is designed to determine how concurrently or jointly acting independent variables affect the dependent variable. At the 5% test stage, the independent variables in this study have no simultaneous effect on the dependent variable if the probability value (F-sig) ≥ (0.05). This is the decision-making probability threshold. At the 5% test stage, the independent variables simultaneously affect the dependent variable if the probability value (F-sig) < (0.05).

***Partial Test (t-Test)***

The degree to which each independent variable influences the dependent variable is determined using the t-test. Basic T-test decision-making guidelines state that the independent variable partially influences the dependent variable if the probability (t-sig) < (0.05) and partially does not affect the dependent variable if the probability (t-sig) ≥ (0.05) [18].

## 3. Results and Discussion

### *3.1. Validity and Reliability Test Result*

The following Table (Table 1) is the results of the validity test conducted to determine the level of closeness between variables.

**Table 1. Validity test result**

| Numb. | Variable | *Sig.* | Description |
|---|---|---|---|
| 1. | Production | 0.000 | Valid |
| 2. | Land Area | 0.000 | Valid |
| 3. | Seedlings | 0.000 | Valid |
| 4. | Land Fragmentation | 0.000 | Valid |
| 5. | Extent of Pest Infestation | 0.000 | Valid |

Every variable employed in this study is valid based on the outcomes of the analysis mentioned above. The reason for this is that all variables have a significance value of 0.000. If the significance value is less than 0.00, the instrument on the questionnaire can be determined to be correlated or valid, in line with the previously described grounds for decision-making. The reliability test was carried out to see whether a measurement tool or procedure is consistent and dependable in yielding identical or comparable findings when repeated under the same circumstances. The results are listed in Table 2.

**Table 2. Reliability test result**

| Cronbach's Alpha | Number of Variables | Description |
|---|---|---|
| 0.848 | 5 | Reliable |

Based on the results of the analysis carried out on the reliability test, the reliability value obtained is 0.848. The reliability test is conducted to measure how well the multiple linear regression model used in this study can explain the variation of the dependent variable (Y). The value obtained of 0.848 indicates that about 84.8% of the variation of the dependent variable, namely the production level, can be explained by the independent variables, namely land area, number of seeds, land fragmentation, and the extent of pest attack. The higher the value of the reliability test, the better the linear regression model will be in explaining the data being observed.

### *3.2. Classic Assumption Test Result*

#### *3.2.1. Normality Test*

Finding out whether variables are regularly distributed is done using the normality test. In this study, the Kolmogorov-Smirnov test was used to determine the normalcy.

Through consideration of the significance threshold, the test employs unstandardized values. Data that are regularly distributed will have significance values higher than 0.05. A significant value of 0.200 is determined by applying Kolmogorov Smirnov normalcy test results. This indicates that, with a significance value of greater than 0.05, the normalcy test performed using the Kolmogorov-Smirnov test satisfies the predefined parameters. A normality test can also be performed using the Normal PP Plot in addition to the Kolmogorov-Smirnov test. The following is a plot of the residual distribution results:

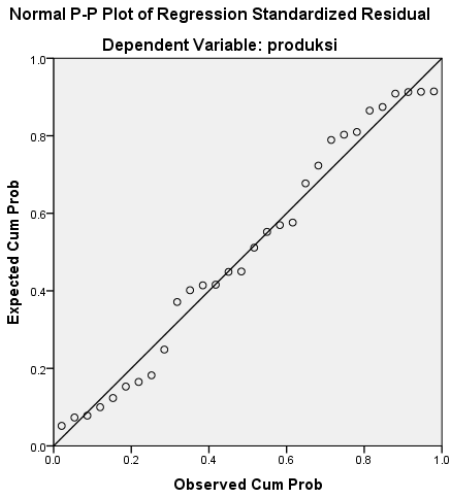


**Figure 2. Normality test result with normal PP plot**

The preceding image shows that the data is typically dispersed if it is scattered near the line. The data cannot be considered regularly distributed if it deviates significantly from the line. The figure shows that the data given to respondents in this survey is quite near the line depicted in the figure. Thus, this study's residual values have a normal distribution.

### *3.3. Multicollinearity Test*

The following are the results obtained from the Multicollinearity test conducted:

**Table 3. Multicollinearity test result**

| Numb. | Independent Variable | VIF | 1/VIF |
|---|---|---|---|
| 1. | Land Area ($X_1$) | 5.553 | 0.180 |
| 2. | Seeds ($X_2$) | 9.699 | 0.103 |
| 3. | Land Fragmentation ($X_3$) | 2.324 | 0.430 |
| 4. | Extent of Pest Infestation ($X_4$) | 3.250 | 0.308 |

As can be seen in the Table 3, every variable in this study has a VIF value less than 10. Therefore, the regression model for any of the study's variables, including land area, seeds, land fragmentation, and the severity of pest infestations, does not show multicollinearity.

### *3.4. Heteroscedasticity Test*

The findings of the heteroscedasticity test applied to the variables of land area, seeds, land fragmentation, and insect attack area are as shown in Table 4.

**Table 4. Heteroscedasticity Test**

| Numb. | Independent Variable | *Sig.* |
|---|---|---|
| 1. | Land Area ($X_1$) | 0.478 |
| 2. | Seeds ($X_2$) | 0.118 |
| 3. | Land Fragmentation ($X_3$) | 0.153 |
| 4. | Extent of Pest Infestation ($X_4$) | 0.775 |

The Glejser Test can be used to determine whether there is an inequality in variance between residual observations in the regression model. If the test result is more significant than 0.05, the Glejser test value shows that there is no heteroscedasticity in the regression model. The factors of land area, seedlings, land fragmentation, and pest attack area were found to have a significant value larger than 0.05, as indicated by Table 4. In summary, the study's regression model does not exhibit indications of heteroscedasticity.

### *3.5. Simultaneous Test Result (F Test)*

To ascertain if the independent variables have a simultaneous impact on Pagentan Village's rice commodity production, a simultaneous test analysis is carried out. Independent variables are considered to have simultaneous effects if the significance threshold is less than 0.05. The F-test value is 0.000 according to the outcomes of the simultaneous test that was performed. It is demonstrated that the F-test value is 0.000 <0.05. Therefore, it can be said that the amount of pest infestations, land fragmentation, seeds, and land area all have an impact on rice production in Pagentan Village, Singosari District, at the same time.

### *3.6. Partial Test Result (t-Test)*

The purpose of this study's partial test is to determine whether the independent variable has a partial impact on the dependent variable. The findings of the t-test from the study are listed in Table 5.

**Table 5. Partial test result**

| Numb. | Independent Variable | *Sig.* | Description |
|---|---|---|---|
| 1. | Land Area ($X_1$) | 0.020 | Significant |
| 2. | Seeds ($X_2$) | 0.000 | Significant |
| 3. | Land Fragmentation ($X_3$) | 0.070 | Not Significant |
| 4. | Extent of Pest Infestation ($X_4$) | 0.002 | Significant |

Based on the data in Table 5, in the significance table, it can be seen that the variables of land area, seeds, and pest attack area are significant because they have a significance value of less than 0.05. Meanwhile, the land fragmentation variable is insignificant because the significance value of the variable is more than 0.05. It can be

concluded that, when viewed from the significance value, the variables of land area, seeds, and area of pest attack each have a partial influence on rice production in Pagentan Village.

### *3.7. The Effect of Production Factors on Production Levels Based on the Multiple Regression Analysis*

The following are the results of the regression analysis conducted on production factors in the form of land area, seeds, and fragmentation, and the extent of pest attack on production yields at the research location.

**Table 6. Multiple linear regression analysis results**

| Numb. | Variable | Coefficient |
|---|---|---|
| 1. | Constant | -2.237 |
| 2. | Land Area ($X_1$) | 0.015 |
| 3. | Seeds ($X_2$) | 0.995 |
| 5. | Area of Pest Attack ($X_4$) | -0.093 |

Source: Primary Data, 2023

The regression equation found in this study is as follows, which is based on the multiple linear regression test findings in the Table 6.

$$Y = -2.237 + 0.015X_1 + 0.995X_2 – 0.093X_4 + e$$

The constant's regression coefficient value is -2.237, as the equation above demonstrates. This indicates that there will be a -2.237 drop in the output of rice commodities if the independent variable is assumed to be absent or equal to 0. Farmers' land area has a regression coefficient value of $\beta1 = 0.015$. This demonstrates that the amount of land that Pagentan Village farmers own has a favourable correlation with rice production. Based on the data obtained during the interviews, most of the farmers have rented land from other people. With an average land area of 0.5 hectare–1 hectare. This indicates that rice production will rise by 0.015 for every 1% increase in land area. The amount of land used by the farmer affects the production yields that are produced. According to the study that was done by Usman et al. [11], land area and higher output are positively correlated. It can be inferred from farmer interviews that other factors may have an impact on the marginal impact of land area on production yields. According to Matulessy et al. [19], the area of rice fields that are plotted and limited by bunds will affect the harvest area on the land, which will have an impact on production yields. The quantity of production will rise if the land held by large farmers has any bearing on it. This is so because the production process relies heavily on land area, which in turn influences the amount of income that farmers receive [11].

The regression coefficient value ($\beta2$) for the number of seeds used that farmers set is 0.995. This demonstrates the beneficial correlation between rice production and the quantity of seeds planted by Pagentan Village farmers. The seeds obtained by farmers are seeds planted by farmers themselves through nurseries. Most farmers do not trust the seedlings purchased from input suppliers due to the experience of farmers who received many damaged seedlings from input suppliers. So, farmers choose to do

their breeding. Table 6 shows that any use of the number of seeds by 1% will have an impact on increasing rice production by 0.995. The present investigation's findings are consistent with those of a study by Zarliani [20], which indicates that the use of seeds can influence the productivity of paddy rice in the research area. The number of seeds will determine how much yield the farmer will get.

Regarding the degree of pest attack that farmers experience, the regression coefficient value of β4 is -0.093. This indicates that there is a negative correlation between rice yields and the severity of pest attacks faced by farmers in Pagentan Village. Based on these results, it shows that rice production will decrease by -0.093 for every 1% increase in the extent of pest attacks. This is consistent with research by Nurhijjah et al. [21], which demonstrates a negative correlation between production yields and the degree of insect infestation. Thus, it may be said that the analysis's findings indicate that farmers' output will decrease in direct proportion to the extent of a pest infestation.

## 4. Conclusion

Land area, seeds, and land fragmentation are recognized to correlate positively with production outcomes based on research findings. Its potential to expand production exists there, provided it can be used to its fullest. Meanwhile, there is a negative correlation between crop yield and pest attack area variables. We can conclude that farmers need to make an effort to lessen the severity of insect attacks on their property. Farmers also feel that there still needs to be more information that really helps with the obstacles faced. Based on the results of the analysis obtained, researchers can provide solutions to both farmers and responsible farmer groups, namely by optimizing the use of the land area, selecting the right seeds, taking preventive action and pest control, planning and risk management, and implementing education or training by farmer groups.

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