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# Analysis of production projections and factors that correlated with rice production in Indonesia

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**ABSTRACT**

**Introduction:** Meeting rice needs is largely determined by the level of domestic rice production. However, the various dynamics that occur provide encouragement to provide an overview of the conditions for meeting food needs, namely in the form of rice, based on trends in rice production and how independent variables correlate with rice production. The aim of this research is to determine the projected rice production for 2023-2032 and determine the strength of the relationship between the dependent variable (rice production) and the independent variables in the form of harvested area, price of harvested dry grain, price of urea fertilizer and price. **Methods:** namely a quantitative descriptive method with secondary time series data from 1993-2022. Data analysis techniques for forecasting studies are by using Autoregressive Integrated Moving Average (ARIMA) analysis. Meanwhile, in the correlation analysis of rice production using the Pearson correlation. **Results:** Projections for rice commodity production in Indonesia from 2023 to 2032 using the MA1 model show a positive trend. Analysis of the relationship between the independent variable and the dependent variable, namely harvest area (X1), rice price (X2), urea fertilizer price (X3), and price of other food commodities, namely corn (X4) shows a significant positive relationship with rice production in Indonesia. **Conclusion:** Projections for rice commodity production in Indonesia from 2023 to 2032, which were analyzed using the MA 1 model, obtained data with a positive trend which states that based on past data, Indonesian rice production will continue to increase every year in line with domestic food needs.

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## INTRODUCTION

Food crop commodities experienced a growth of 10.47 percent. This was due to increased harvest areas and domestic rice production (Kementan, 2021) in line with changes in the consumption of Indonesian people by making rice the main foodstuff, a derivative product of rice plants (Ariani & Mewa, 2010). Rice is an essential agricultural commodity in solving domestic food problems because more than half of the world's population depends on this crop as a food source (Ajali *et al*, 2015). It is known that community participation in rice consumption between one island and another is similar and can even be said to be 100%. Rice is a quasi-public good that functions not only as a private good but also as a public good. Many products are produced from this commodity, so it plays a vital role in food security, economic stability, and employment (Bandumula, 2018). Thus, special attention needs to be paid to the rice sector.

The need for food increases as the population of Indonesia increases (Qoni'ah, 2022). It is known that the population of Indonesia in the last five years, from 2018 to 2022. In 2018, Indonesia's population was 264,262,600. Then, it continued to increase, namely 266,911,900 people in 2019 and 270,203,900 people in 2020 (Statistics Indonesia North Sulawesi, 2023). However, this differs from productive human resources, which is interested in the agricultural sector. Based on data released by the Central Statistics Agency of the Republic of Indonesia (BPS-RI), it is known that agriculture is a sector that is very low in demand, especially for productive workers who have higher education. In addition to the human resources problem, converting agricultural land, especially rice fields, into industry and infrastructure development adds to the complexity of developing agriculture in Indonesia (Prajanti, 2014).

Based on several problems in the agricultural sector, especially in rice commodities, and to prevent imbalances between the population explosion and the availability and sustainability of rice commodities, it is necessary to plan for rice consumption needs (Rejekiningrum, 2013). Production in physical form is the result of the work of all factors of production, namely all inputs and stakeholders. A professional producer in the farming business will maximize all existing components to achieve production efficiency. A buffer of the Indonesian State Order (farmer) will pay close attention to whether the commodity he is cultivating requires inputs because expenses greater than revenues cause losses. Government policies in the field of meeting rice needs include the grain price policy (HDG) and the price of inputs called the Highest Retail Price (HET). The policy is carried out to maximize farmers' incentives to increase productivity and efficiency to improve welfare and national food security (Retno, 2004).

Projection or forecasting has five essential stages: analyzing previous or past data. Hence, this stage is beneficial in seeing patterns that occurred in the past based on tabulated data that has been arranged in such a way before. Determining the correct analysis method, namely good forecasting results are forecasts that are not far from reality, projecting the data that has been collected with a predetermined method, and performing ARIMA analysis, which is divided into three parts, namely the autoregressive (AR) process and the moving average (MA) process. Research conducted by Rohman (2017), which discusses rice projections, says that projections of future rice consumption needs are needed to avoid food insecurity due to a lack of food supply. Companies commonly use this forecasting technique to calculate future conditions or, in other words, to predict or forecast future conditions that are still unknown. Forecasting is always trying to solve with model approaches that match the behavior of actual data and experience. This explanation is corroborated by research conducted by Aldillah (2015), which analyzes the projection of soybean commodity production, saying that the need for projection analysis is intended to determine the future picture. Increased production means increasing the company's sales distribution, but it will be problematic if it needs more product inventory to meet consumer demand (Lisnawati, 2013).

In addition, analyzing the relationship between rice production and variables considered to be related is part of the focus of this research. Based on research conducted by Hidayanti (2021) on land area and salt production, it is necessary to conduct a relationship analysis so that the strength of the relationship can be measured, and steps can be taken to maximize production based on the strength of the relationship of each variable to production. Based on the background description, the purpose of this study is to determine the projection of rice production in 2023-2032 and to determine the level of relationship strength of the dependent variable (rice production) with independent variables in the form of harvested area, harvested dry grain price, urea fertilizer price and other food commodity prices selected as competing variables.

## METHODS

### Location, time, and object of research

The research location is Indonesia, which was chosen purposively with the consideration by researchers that Indonesia is an agricultural country with a very large rice farming area with a large population. This has implications for the need for rice as a staple food for the Indonesian people which is very high. The time of this research is in April-July 2023. The object of research is rice production in Indonesia.

### Data collection technique

The data collection technique used is the documentation technique which is a data collection technique related or relevant to research. The data collected in the projection study is data within 30 years or data from 1993-2022 so that it can be normally distributed or classified as large data, but it is still necessary to test the normality of its distribution. In the projection analysis, the data is tested stationary with the ADF (Augmented Dickey-Fuller Test) method. In the section on factors affecting harvested area and productivity, the same amount of data is collected for 30 years and will be tested for classical assumptions and multiple regression analysis.

### Data analysis technique

*Rice product projection*

Forecasting production is analyzed using ARIMA analysis as research conducted by Bangun, (2017). ARIMA is often called the Box-Jenkins time series method. ARIMA analysis is good accuracy for forecasting. This analysis is a model that completely ignores independent variables in making forecasts. It uses the past and present values of the variables in making accurate short-term forecasts. ARIMA is suitable if the observations from the time series are statistically related to each other (dependent). The analysis using the Autoregressive Integrated Moving Average (ARIMA), is divided into two parts, namely the autoregressive (AR) process and the moving average (MA) process.

a) Proses autoregressive (AR)

AR process is a process where we assume the variable has a relationship with the previous variable. In general, previous data can be distributed (distributed lag) or non-distributed (non-distributed lag) (Ekanda, 2014). So, it can be expressed in the following equation:

$$Z_t = b_0 + b_1Z_{t-1} + b_2Z_{t-2} + ......+ b_pZ_{t-p} + e_t \quad (1)$$

Description:

$Z_t$ = Time series data as the dependent variable at t-time

$Z_{t-p}$ = Time series data at a time (t-p)

$b_0$ = Constant

$b_1..b_p$ = *Autoregressive* parameter

$e_t$ = Error value at t-time period

b) Proses moving average (MA)

The MA process is a process where $Zt$ is generated from the forecast error of several previous periods (Ekanda, 2014). The MA (q) process is expressed in the following equation:

$$Z_t = b_0 + e_t - c_1e_{t-1} - c_2e_{t-2} - .... - c_qe_{t-q} \quad (2)$$

Description:

$Z_t$ = Time series data as the dependent variable at t-time

$c_{1...}\, c_q$ = *Moving average* parameter

$e_{t-q}$ = Error value at t-time period (*t-q*)

*Correlation of rice production factors*

*Correlation analysis* is a statistical method used to determine a quantity that states how strong the relationship between a variable and another variable is by not questioning whether a particular variable depends on another variable. Based on this, the relationship of rice production in Indonesia will be analyzed with related factors such as harvested area, rice prices, fertilizer prices, and other commodities in one type of commodity. The analysis used is Pearson correlation to determine whether there is a relationship between 2 independent and dependent variables on an interval or ratio scale (parametric). Correlation can produce positive (+) and negative (-) numbers. If there is a positive correlation, it means that the relationship is unidirectional. Unidirectional means that the dependent variable is greater if the independent variable is more significant. If it produces a negative number, the relationship is unidirectional. The correlation number ranges from 0-1. The following equation can be used to calculate the Pearson correlation.

$$r = \frac{\Sigma xy - \frac{(\Sigma x)(\Sigma y)}{n}}{\sqrt{(\Sigma x^2 - \frac{(\Sigma x)^2}{n})(\Sigma y^2 - \frac{(\Sigma x)^2}{n})}} \quad (3)$$

Description:

r = Correlation value

x = Independent variable (If there are more than 1 x variable, the value of each variable is adjusted)

y = Rice production variable

The strength of the correlation relationship can be assessed based on the following correlation classification table.

Table 1. Interpretation of correlation coefficient

| Coefficient Interval | Level |
|---|---|
| 0.000-0.199 | Very weak |
| 0.200-0.399 | Weak |
| 0.400-0.599 | Moderately strong |
| 0.600-0.799 | Strong |
| 0.800-1.000 | Very strong |

*Source: Sugiyono (2015).*

Table 4 shows the relationship between each independent variable selected as a factor associated with rice production in Indonesia. It should be noted that the relationship can be linear or non-linear. This means that the relationship between 2 variables can be strong, but whether it is positive or negative with the significance value of the relationship degree %. A score of 0.000-0.199 is considered to have a shallow relationship. The relationship of 0.200-0.399 has a weak degree of relationship. Then 0.400-0.599 has a reasonably strong relationship between variables X and Y.

The category is strongly related if the correlation coefficient score is 0.600-0.799 for the independent and dependent variables. Furthermore, strongly related variables have a correlation coefficient score of 0.899-1.000 in the analysis results. The dependency (independence) relationship between two or more variables is one of the issues studied in probability and statistics. So far, Pearson correlation has been the most accessible and straightforward choice used to measure dependencies between variables. Theoretically, Pearson correlation assumes that variables must be normally distributed. However, data does not always have to be normally distributed (Udayani *et al.*, 2016).

## RESULTS AND DISCUSSION

### Rice production projection

Indonesia is an agrarian country, which means a country with superiority in agricultural products which is influenced by the majority of the population making a living as farmers and has other supporting factors such as sufficient natural resources both on land and water, climatic conditions that are following agricultural needs, and adequate agricultural land. Indonesia's geographical location is very strategic because it is located on the equator, one of the largest archipelagic countries, rich in natural resources, has a tropical climate, seasonal changes that are not too extreme like other countries, and become an international trade route. As an archipelago stretching from Sabang to Merauke, Indonesia has a population of around 237.6 million people with various ethnic groups that have a diversity of mindsets, religions, art knowledge, languages, local cultural traditions, and community characteristics.

ARIMA is very suitable if the observations are time series and are statistically related (dependent). The data analyzed is rice production data in Indonesia over 30 years to project production in Indonesia in 2023-2032. Temporary model identification is done by comparing the autocorrelation coefficient and partial autocorrelation coefficient distribution. If the data is not stationary, it must first be stationary with a different method. Stationarity occurs in data if there is no significant increase or decrease. The frequency of the data is around a constant average value, independent of time. Graphically, the autocorrelation of non-stationary data shows a diagonal trend from right to left as time lag increases. The number of differentiations performed to achieve stationery is denoted as d. Before conducting the analysis, the stationary test must be done using Eviews version 12 SV software, as shown in Figure 1.

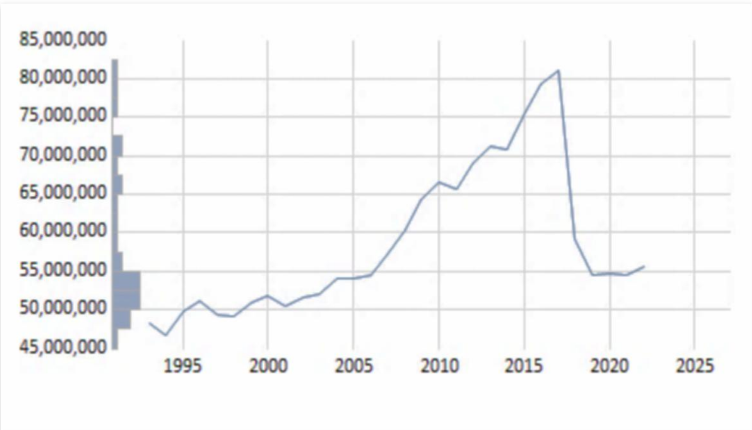


Figure 1. Graph of stationary test data for rice production in Indonesia

Based on the graph in Figure 1, it can be seen at the end of the line that there is a graph that forms an intense trough. This indicates that the data tends to be non-stationary. So, a data stationerization process is needed. If the data is not yet stationary, the data stationarity process can be done three times in the stationarity stage. The first differencing process is d=0, the second differencing process, lag-1 or order-1, is d=1, and the third differencing process, lag-2, is d=2. *Bartlett's line* is marked with a dotted model to the right and left of the center line with both autocorrelation and partial autocorrelation graphs.

It is known that the level 1 or level 0 stationarity test of the Autocorrelation and Partial Correlation lines crosses the dotted line (Bartlett). Thus, the P-value is also more significant than the significance level of 0.05, so it can be concluded that the level (0) stationary test is not yet stationary. So, the data needs to be transformed by differentiating at the first difference level.

Correlograms of autocorrelation and partial autocorrelation at the differencing leg-1 show that almost all bars are inside the discontinuous line (Bartlett line). This shows that the data is stationary at the lag-1 differencing level stationary test. After obtaining stationary data, determine the form of the model to be used by comparing the autocorrelation coefficient or autocorrelation function (ACF) and partial autocorrelation function (PACF) of the data. The ACF and PACF plots can show the model identification of the data if the data used is stationary. The model follows an autoregressive (AR) of order p if the PACF plot is significant at all lags p and the ACF plot decreases exponentially towards zero. The shape of the ACF and PACF plots are shown in Table 5.

Table 2. ACF and PACF model assessment

| Model | ACF Pattern | PACF Pattern |
|---|---|---|
| AR (*p*) | Dies down following an exponential form. | Cut off after lag -p |
| MA (*q*) | Cut off after lag -q | Dies down following an exponential form. |
| ARMA (*p*,*q*) | Dies down after lag -(q-p) | Dies down after lag -p,q |
| ARIMA (*p*,*d*,*q*) | Cut off after lag (q-p) goes to zero with distinction | Cut off after lag (p-q) goes to zero with differentiation |

From the autocorrelation (ACF) and partial autocorrelation (PACF) plots, there is a cut-off. If the cut-off on ACF and PACF then the first possibility of p = 1 and q = 0 then the second possibility of p = 0 and q = 1. So, if combined with d, the possibility of ARIMA (p,d,q) is ARIMA (1,1,0), (0,1,1) and (1,1,1).

*Parameter Model*

ARIMA parameter estimation uses trial and error to determine the best ARIMA model. By estimating the ARIMA model (1,1,0), (0,1,1), (1,1,1) and estimating several other ARIMA models to get the best ARIMA model. The results of the analysis can be seen in Table 3. Based on the estimation that has been done, the best model selection can then be made, seen from the significant probability value or see the Residual Test value, Akaike Info Criterion (AIC), and Schwarz Criterion (SC) by looking at the smallest value.

Table 3. Analysis Result of Rice Production Forecasting Model Determination in Indonesia for 2023-2027

| Model | $R^2$ | AIC | SC |
|---|---|---|---|
| AR (1) | 0,022038 | 33,71334 | 33,85479 |
| MA (1) | 0,042483 | 33.70414 | 33,84559 |

Based on Table 3, the best model that can be used is the MA model which is the best model because it has the smallest AIC and SC values and a higher R-Square value than other models. After model selection, forecasting is carried out which is described in Figure 8 below.

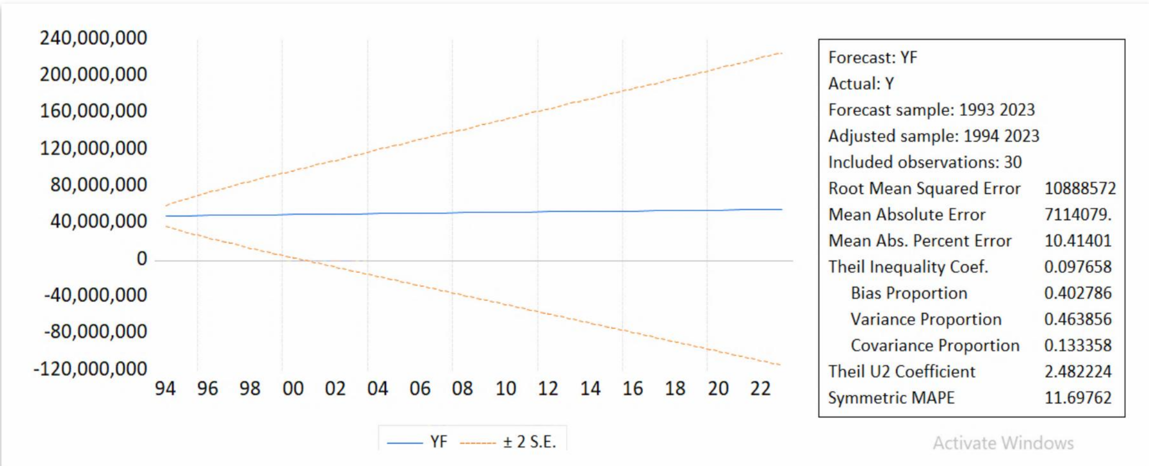


Figure 2. Forecasting analysis chart of rice production in Indonesia

Based on the forecasting graph in Figure 2, shows a positive trend which can be interpreted by the fact that the year to be forecast will tend to show an increase.

*2. Results of 2023-2032 production projections*

After forecasting with a graph, the trend of rice production in Indonesia in 1993-2032 can be seen from the forecasting results using the MA (1) model. The results of the projection analysis can be seen in the following table.

Table 4. Results of 2023-2032 production projections

| Num. | Year | Projection results (ton GKG) |
|---|---|---|
| 1. | 2023 | 55.649.747 |
| 2. | 2024 | 55.900.429 |
| 3. | 2025 | 56.151.109 |
| 4. | 2026 | 56.401.789 |
| 5. | 2027 | 56.652.470 |
| 6. | 2028 | 56.903.151 |
| 7. | 2029 | 57.153.832 |
| 8. | 2030 | 57.404.513 |
| 9. | 2031 | 57.655.194 |
| 10. | 2032 | 57.905.875 |
| | Average | 56.777.811 |

Based on Table 4, the results of production projections from 2023 to 2032 continue to increase. By the end of 2023, it is predicted that rice production in Indonesia will be 55,649,747 tons of MDG. In 2024 it was 55,900,429 tons of MDG. Meanwhile in 2025, 2026, 2027, and 2028 respectively 56,151,109 tons of MDG, 56,401,789 tons of MDG, 56,652,470 tons of MDG, and 56,903,151 tons of MDG. Then it continued to increase over time, namely in 2029 it reached 57,153,832 tons of GKG, and in 2030 it was 57,404,194 tons of GKG. Furthermore, in 2031 and 2032, 57,655,194 tons of MDG and 57,905,875 tons of MDG respectively. Thus, the average rice production from 2023-2032 is 56,777,811 tons of MDG.

This is based on past conditions from 1993 to 2022 which show a good graph. The selection of the MA model at the first difference level produces future data that is expected to match the existing reality. This certainly does not make agricultural commodity stakeholders complacent about the possibility of X that could occur. Improvement of the agricultural system from upstream to downstream must continue to be massive so that Indonesia can be food sovereignty. The following graph shows the condition of rice production in Indonesia.

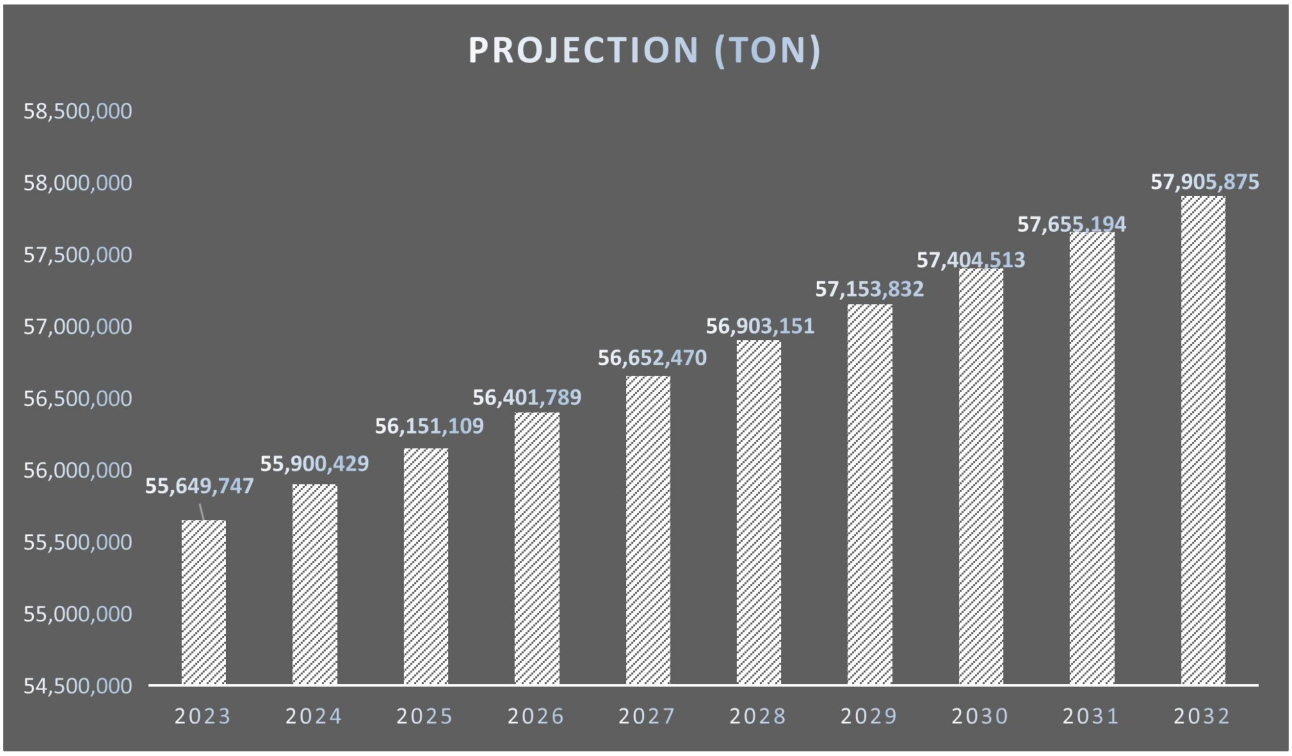


Figure 3. Projection chart of rice commodity in 2023-2032

The results of this study are supported by research conducted by Fatah and Sulistyaningsih (2022) with the same graph showing a positive value. In addition, this research is also supported by Nurman & Nusrang (2022) who analyzed forecasting on rice commodities with the scale of Maros Regency, South Sulawesi Province in 2019-2028 and the graph of rice production has increased every year. Forecasting on rice commodities with an area of one country was conducted by Rahma (2010) and the ARIMA model showed significant results but with a shorter time scale. In addition, it is also supported by research conducted by Sibuea *et al.* (2014).

**Factors that correlate with rice production in Indonesia**

The testing process is also intended to determine the strength of the relationship so that based on the Pearson correlation analysis technique of rice production with the variables that have been selected, the following analysis results are obtained.

Table 5. Pearson correlation analysis results of variable X to Y

| Variable | Pearson correlation value |
|---|---|
| $X^1$, $Y^1$ | 0.8927 |
| $X^2$, $Y^2$ | 0.6652 |
| $X^3$, $Y^3$ | 0.6290 |
| $X^4$, $Y^4$ | 0.6668 |

Table 5 shows the relationship between the independent variable (independent variable) and the dependent variable (dependent variable), which is based on Table 5 classification of the correlation coefficient that the variable harvest area (X1) is strongly and positively related to rice production with a value of r = 0.8927 so classified in the classification of a powerful relationship that is unidirectional. The unidirectional relationship is that the harvest area is strongly related to 89.27% of rice production in Indonesia. The rice (X2) variable price is positively and strongly related to rice production in Indonesia with a value of r = 0.6652, so the relationship is positive at 66.52%. Then, variable X3, namely the price of urea fertilizer, is also strongly related to rice production in Indonesia, with a value of r = 0.6290 or positive by 62.90%. Furthermore, the variable price of other food commodities, namely corn (X4), is strongly related to rice production with a value of r = 0.6685, so the relationship is positive by 66.85%. The relationship of production variables on rice commodities in Indonesia can still be known through other variables. So, this research can still be developed through other research schemes later. This research is supported by previous research by Liana *et al.* (2022), which states that there is a relationship between fertilizer costs, production, and land area. Research conducted by Bahruddin (2020) explains a strong relationship between the variables included and the rice production variable.

## CONCLUSIONS

Projections of rice commodity production in Indonesia from 2023 to 2032 analyzed using the MA 1 model obtained data with a positive trend which states that based on past data, Indonesian rice production will continue to increase every year in line with the needs of domestic food fulfillment. It is expected that this will also continue to occur in productive forces that will contribute to the farming sector directly.

Analysis of factors associated with rice paddy production shows that the variable area is very strongly related to rice paddy production. The variable price of harvested dry rice, the price of urea fertilizer, and the price of food commodities in the form of corn together are strongly related to the variable rice production. Based on the study of projections and correlations, it can be seen that rice production will continue to increase and there is a relationship between the condition of the variables that are part of the input, namely the area of harvested area, the price of harvested dry grain at the farm level, the price of urea fertilizer and other food commodities, namely corn. So, it will be a common concern that to increase the amount of production it is necessary to maximize the variables associated with the rice production process in Indonesia.

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