**Analysis of Shallot Price Volatility at Producer Level in West Nusa Tenggara Province**

ABSTRACT

|  |
| --- |
|  West Nusa Tenggara (NTB) is a shallot producing vicinity in Indonesia, but the price of shallots fluctuates every so often. This study aims to analyze the volatility of shallot prices at the producer level. The analysis uses secondary data, namely the average monthly price of shallots from January 2019 to December 2023. The data were analyzed to identify trends using the Double Exponential Smoothing method, while the ARCH-GARCH model was employed to measure the level of price volatility. The results show that shallot production in West Nusa Tenggara has experienced a downward trend, while prices at the shallot producer level tend to increase from IDR 21,490 in January 2024 to IDR 21,510 per kilogram in December 2024. Price volatility at the producer level is classified as extremely high, based on the total *Arch* and *Garch value* of 1.3439. Price volatility at the producer level is driven by seasonal dependency, the weak bargaining position of farmers as price takers, underdeveloped farmer institutions, and inadequate post-harvest infrastructure. These results highlight the necessity for targeted policy measures to mitigate price volatility, enhance farmer organizations, and upgrade infrastructure, all of which are essential for maintaining price stability and safeguarding farmers' incomes. |

***Keywords:*** *arch-garch, shallots, double exponential smoothing****,*** *price, volatility*

# INTRODUCTION

Indonesia is known as an agricultural country (Salasa, 2021). As an agricultural country, most economic activities depend on the agricultural sector. An important sub-sector in the agricultural sector is horticulture (Klau et al, 2023). Horticulture includes vegetables, fruits, and pharmaceutical plants (Suparwata, et al, 2023). In the horticulture sub-sector, shallots (*Allium ascalonicum* *L.*) have a very strategic role as a commodity with high economic value. Domestic consumption levels continue to increase from year to year along with the increase in the number of households, while the increase in demand is not balanced with the increase in supply (Agung, 2013). The imbalance in demand and supply leads to market price instability.

Shallots as a primary commodity play a significant role in meeting household consumption needs, and shallot cultivation is the main source of livelihood for farmers (Harahap, et al, 2023). West Nusa Tenggara Province (NTB) is one of the national shallot production centers, especially in areas such as Bima, Dompu, and Sumbawa (Widia, et al, 2024). However, high production does not guarantee a stable income because farmers still face sharp price fluctuations.

Fluctuations in the price of shallots are triggered by numerous factors, including physical properties, seasonality, weather, distribution, and market structure. In an oligopsony market structure, there are few buyers and many sellers. A few collectors buy from a number of farmers in one village, while large traders control prices. Farmers in large numbers do not have bargaining power, because they do not have strong institutions (*price takers)* (Asmara, et al. 2023).

The price gap between producers and consumers indicates a disproportionate price transmission (Simorangkir, et al. 2022). When prices rise at the consumer level, profit margins do not have a direct impact on the prices received by farmers. Conversely, if prices fall to the consumer level, farmers are the most affected, because prices at the producer level will at once fall. This condition shows the weak bargaining position of farmers in the shallot market (Kiloes, et al, 2018).

In addition, limited post-harvest facilities such as *cold storage* force farmers to sell their crops as quickly as possible, because shallots are a perishable crop. As a result, during the main harvest, supplies pile up in the market and caused prices to plummet (Nurmalia, et al, 2021). The uncertainty of the minimum price from the government worsens the situation because farmers do not have a guaranteed floor price to reduce the risk of loss.

According to Irawan (2020), problems occur in the downstream sector. Seasonal and perishable horticultural production makes it difficult to manage storage and distribution. The shallot agribusiness system involves farmers as producers, traders as distributors, and consumers as the end party. Intermedia ry traders play a significant role in absorbing and distributing products, so they have an enormous influence on determining prices. With this dual role, traders often become the dominant party in the supply chain (Sukmawati, et al, 2014). Asymmetric information triggers price instability and is detrimental to farmers. Therefore, government intervention is needed through price protection, strengthening farmer institutions, and improving post-harvest infrastructure to strengthen farmers' bargaining position in the distribution system.

Based on the above background, a study was conducted with the aim of analyzing the development of production and price volatility of shallots at the manufacturer stage in West Nusa Tenggara Province.

**MATERIAL AND METHODS**

1. **Research Methods**

The method used in this study is a descriptive method. The method aims to solve actual problems by collecting data, analyzing, explaining, and concluding. The unit of analysis in this study is the price of shallots per month from January 2019 to December 2023 in West Nusa Tenggara Province. The selection of research locations was carried out by purposive sampling. The data consists of quantitative and qualitative data. Quantitative data in the form of production data and shallot prices. While qualitative data in the form of information from quotes from journals or research reports that have been published or unpublished and stored in the library. Secondary data was obtained from the Central Statistics Agency (BPS), the Trade Service, the Agriculture and Plantation Service of West Nusa Tenggara Province. and other agencies.

1. **Data Analysis**
	* 1. **Trend Analysis**

Production data and prices of shallots were analyzed for trends. Trend analysis using the Double Exponential Smoothing (DES) method (Ilham, et al, 2024)*.* The software used is Microsoft Excel for trend forecasting and EViews 12 for ARCH-GARCH analysis.

DECusing two main components to analyze trend developments, namely:

1. Level

**S *t* = αY t + (1 − α) (S t−1 + T t−1)**

Information:

S t = Smoothed level at time *t*

Y t = Actual data value at time *t*

Α = Constant *smoothing* for level (value between 0 and 1)

S t−1​ = Smoothed level at time t−1

T t−1​ = Smoothed *trend at time t−1*

1. Trend

**Tt​ = β (St – St − 1) + (1−β) Tt−1**

Information:

T t  ​= Smoothed trend at time t

β = Smoothing constant for trend (value between 0 and 1)

S t = Smoothed level at time t

S t−1​ = Smoothed level at time t−1

For forecasting*,* the following formula is used:

**Ft+1 = St + Tt**

Information:

F t+k = Forecast for period t + k

S t = Smoothed level at time t*.*

* + 1. **Volatility Analysis**

Measurement This study employs an approach to measure the volatility of shallot prices using the ARCH (Autoregressive Conditional Heteroskedasticity) and GARCH (Generalized ARCH) models that can detect changes in data variability dynamically. The ARCH-GARCH model analysis has several stages that must be carried out, namely: (1) data stationarity test, (2) ARIMA modeling, (3) ARCH-LM test, (4) selection of the best model and volatility forecasting (Pipit et al, 2019). Data processing is conducted using EViews 12 software.

According to (Engle et al,2022) the criteria for volatility are as follows:

1. If α1 + β1 < 1, then price volatility is low (*low volatility)*.
2. If α1 + β1 = 1, then the price volatility that occurs is high (*high volatility)*.
3. If α1 + β1 > 1, then the price volatility that occurs is extremely high (*extremely high volatility)*.

# RESULTS AND DISCUSSION

1. **Development of Production and Price of Red Onions in West Nusa Tenggara Province.**
	* 1. **Production Development**

The development of shallot production in West Nusa Tenggara Province over the past five years (2019–2023) has shown fluctuations from year to year. The development of shallot production in 2019-2023 can be seen in Table 1.

Table 1. Presents the annual shallot production in West Nusa Tenggara Province from 2019 to 2023.

|  |  |
| --- | --- |
| **Year** | **Production (tons)** |
| 2019 | 1.882,545 |
| 2020 | 1.857,954 |
| 2021 | 2.226,197 |
| 2022 | 2.011,550 |
| 2023 | 2.126,183 |

Source: *Central Statistics Agency of West Nusa Tenggara*, 2024.

Based on Table 1, it appears that shallot production is fluctuating with a downward trend and a forecast graph of the development of shallot production in West Nusa Tenggara Province can be drawn as follows:

Figure 1. Graph of the Results of Forecasting the Production of Shallots in West Nusa Tenggara Province in 2019-2023.

Source: Processed Secondary Data, 2025.

Based on the forecast results, shallot production is predicted to decline gradually in the next year. Estimated production in 2024 is 1,759,590 tons. This decline is influenced by many factors including: climate change, extreme weather, pest attacks, limited capital, high production costs, shrinking planting area due to land conversion, and the price of shallots at harvest time (Sulistiowati et al 2021).

* + 1. **Development of Shallot Prices**

The price of shallots at the producer level directly reflects the income of farmers. (Putri et al, 2021). If the price of shallots increases, farmer income also increases. Prices at the farmer level fluctuate, namely low during harvest and increasing outside the harvest season. During the main harvest, abundant supply causes prices to fall, while in the lean season prices tend to rise because production is limited (Purwaningsi, 2008).

In addition to seasonal factors, the prices of fertilizers, seeds, and labor also affect selling prices (Sitinjak, et al, 2022). Increasing production costs encourage farmers to raise prices to cover expenses. Extreme weather and pest attacks that cause crop failures also reduce supply and increase prices at the producer level.

Table 2 shows the price of shallots at the producer level per month in West Nusa Tenggara Province for the period 2019-2023.

Table 2. Red Onion Price Data at Producer Level in West Nusa Tenggara Province for the 2019-2023 Period

| **Period** |  |  | **Year (Rp/kg)** |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **2019** | **2020** | **2021** | **2022** | **2023** |
| January | 10,145.24 | 14,718.09 | 10,727.38 | 8,736.24 | 6,269.01 |
| February | 14,139.21 | 12,279.32 | 16,584.10 | 12,956.74 | 16,593.56 |
| March | 17,870.81 | 16,684.65 | 17,395.91 | 15,500.64 | 20,483.17 |
| April | 19,821.39 | 25,783.67 | 14,983.59 | 16,817.28 | 19,441.58 |
| May | 19,178.47 | 31,724.44 | 18,016.45 | 16,391.03 | 22,460.02 |
| June | 17,224.54 | 19,078.72 | 17,193.17 | 31,524.75 | 24,105.76 |
| July | 15,581.48 | 18,184.85 | 15,967.74 | 30,419.53 | 13,957.93 |
| August | 11,817.96 | 17,601.36 | 17,039.84 | 26,167.60 | 11,074.95 |
| September | 11,265.15 | 15,446.61 | 11,169.05 | 17,612.17 | 9,810.78 |
| October | 13,992.98 | 17,522.48 | 12,293.58 | 20,081.48 | 12,893.99 |
| November | 14,555.35 | 19,387.59 | 12,474.97 | 19,009.06 | 23,042.76 |
| December | 12,446.62 | 17,958.48 | 11,082.37 | 19,698.69 | 21,491.39 |
| **Average** | **14,838.36** | **18,631.34** | **14,832.04** | **24,345.53** | **15,331.27** |

Source: Department of Agriculture and Plantations, West Nusa Tenggara Province, 2024.

Using the data in Table 2, a graph is prepared to see the pattern to see the pattern of shallot expenses in NTB Province. The motive of this analysis is to find whether the information is trending up, trending down, seasonal, horizontal, cyclical, or stationary. The following is a data plot of Shallot price data at the producer level that was collected for the period from January 2019 to December 2023.

 Figure 2. Shallot Prices at Producer Level (2019-2023)

 Source: Processed Secondary Data (2025)

Figure 2 shows the price fluctuation pattern at the producer’s level. The price data pattern shows high fluctuation. The producer-level price data pattern reflects that farmers face high and volatile price risks throughout the year.

Based on this, a trend pattern was created using the double exponential smoothing method to analyze the data.

Figure 3. Graph of the Results of Forecasting Red Onion Prices at the Producer Level Using the *Double Exponential Smoothing Method* for the Period January 2024 - December 2024.

Source: Processed Secondary Data, 2025

Based on the forecast results on Figure 3, it is known that the shallot Producer Price Index in NTB Province is estimated to increase slowly for the next one-year period. The forecast results show that the price trend at the farmer level is predicted to increase.

* 1. **Analysis of Red Onion Price Volatility in NTB Province**

This analysis aims to measure the fluctuation of shallot prices at the producer level (Bahtiar, et al. 2022). The process includes stationarity test, deciding the best ARMA model, heteroscedasticity test, ARCH effect test, and ARCH/GARCH model formation.

* + 1. **Analysis of Red Onion Price Volatility at the Producer Level**
1. **Stationarity Test**

Stationary Test is conducted using *Augmented Dickey-Fuller* (ADF) method to ensure the data has constant meaning and variance. Data is declared stationary if the t-statistic value < critical value or *P*-value < 5% (Fadillah, et al, 2025). Table 3 presents the results of the stationary test on shallot. This study utilizes price data at the producer level.

Table 3. Stationarity Test of Red Onion Prices at LevelManufacturer

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Level** | **t-statistic** | **Prob** |
| *Augmented Dickey-Fuller test statistics* | -4.131443 | 0.097 |
| *test critical values:* | 1% | -4.121303 |   |
| 5% | -3.487845 |   |
| 10% | -3.172314 |   |

Source: Processed Secondary Data, 2025.

The price of shallots at the manufacturer stage obtained an ADF *test statistic* (0.097) < .05, meaning that the price of shallots at the producer level during the period January 2019 to December 2023 is the focus of this analysis meets the stationary requirements.

1. **Best ARMA/ARIMA Model Selection**

The ARMA/ARIMA model is selected through evaluating several combinations of orders by considering the stationarity requirements (AR and MA coefficients <1), as well as the smallest AIC, SC and HQIC values (Pipit, et al, 2019). The best model is decided based on the requirements and has significant coefficients. Some of the options evaluated include ARIMA (1.0), ARIMA (2.0), ARIMA (3.0), ARIMA (1.1), ARIMA (1.2), and ARIMA (1.3). The selected model is then used for heteroscedasticity and ARCH effect tests (Jumiati, et al, 2023). The following are the results of the selection of the best ARIMA model, as follows:

Table 4. Selection of the Best ARIMA Model for Red Onion Producer Prices at Level

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Variables** | **Model** | ***Akaike Information Criterion* (AIC)** | ***Black Criterion* (SC)** | ***Hannan-Quinn Criter* (HQIC)** |
|  | ARIMA (1.0) | 5.884615 | 5.989332 | 5.925576 |
|  | ARIMA (1.1) | 5.885802 | 6.025425 | 5.940416 |
| Price | ARIMA (1.2) | 5.905921 | 6.045544 | 5.960535 |
| manufacturer | ARIMA (1.3) | 5.907266 | 6.046889 | 5.961880 |
|  | ARIMA (2.0) | 6.214309 | 6.319026 | 6.255270 |
|  | ARIMA (3.1) | 5.923966 | 6.063589 | 5.978580 |

Source: Processed Secondary Data, 2025.

Based on Table 4 above, the best ARIMA model for shallot prices at the producer level is ARMA (1.0), which is showed by the lowest AIC, SC, and HQIC values compared to other models.

1. **Heteroscedasticity Test**

After obtaining the best ARIMA model, a heteroscedasticity test was conducted to determine whether there was an ARCH effect on the producer-level shallot price data. This test determines the feasibility of using the ARCH-GARCH model. If the probability value (*Prob F*) < .01 then there is heteroscedasticity; if > .05 then the data is homoscedastic (Ridha, et al, 2020). The test results are presented in Table 5.

Table 5. Heteroscedasticity test of ARIMA Model for Shallot Price at the Producer

|  |  |  |  |
| --- | --- | --- | --- |
| *f-statistic* | 468.9737 | *Prob. F* (3.56) | 0.0000 |
| *Obs\*R-squared* | 57.7032 | *Chi-square Prob.* (3) | 0.0000 |
| *Scaled explained SS* | 101.8385 | *Chi-square Prob.* (3) | 0.0000 |

Source: Processed Secondary Data, 2025

The test results show an F-statistic of 468.9737 with a probability of 0.0000. This indicates the presence of an ARCH effect, so the analysis can be continued with ARCH-GARCH modeling.

The best ARCH or GARCH model is selected based on previous ARIMA results with the following criteria: lowest AIC and SC values, significant coefficients, variance and residual values < 1, and no remaining ARCH effects (Dwipa, 2016). Based on these criteria, the best model is ARCH-GARCH (1,1).

Table 6. Best ARCH GARCH Model (1,1)

|  |  |  |
| --- | --- | --- |
| **variable** | **Parameter** | **ARCH GARCH best model** |
|  | *Sig* | Prob<0.0001 |
| Manufacturer Price | *Akaike information criterion* | 5.583948 |
|  | *Black criterion* | 5.760011 |
|  | *Residual* | 5.652676 |

Source: Processed Secondary Data, 2025.

1. **Analysis of Red Onion Price Volatility at Producer Level**

The volatility of shallot prices at the producer level is analyzed using the ARCH-GARCH (1,1) model. Detailed results are shown in Table 7.

Table 7. Red Onion Price Volatility Equation at Producer Level

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Variables** | **Coefficient****α and β** | **Prob value** | **Equality** | **Volatility****(α + β)** |
| Manufacturer | α = 0.165741 | 0.0263 | σ2CPt = 0.443887 +0.165741 𝜀 2 CPt-1 +1.178164 𝜎 2 CPt-1 | 1.343905 |
|  | β = 1.178164 | 0.0000 |
|  |  |  |

Source: Processed Secondary Data, 2025

Information:

𝜎2CPt-1= Conditional varianceof *the squared residual* price at the producer level in period t.

𝜀2CPt-1 = *squared residual* price at producer level in period t-1

α = ARCH coefficient

β = GARCH Coefficient

Based on Table 7, volatility is obtained from the volatility value is derived from the sum of the coefficients α and β. The total value of 1.343905 shows that the level of price instability for shallots at the producer level is a key indicator in this analysis is classified as very high (*extremely high volatility)*. This condition reflects that the price of shallots in West Nusa Tenggara Province is very volatile and risky, so special attention is needed in managing its production and distribution.

In contrast, price volatility at the producer level is much higher. Large and unstable price fluctuations create uncertainty for farmers, increase the risk of loss and reduce interest in continuing production in the long term (Ramadhani, 2025). This condition is closely related to the oligopsony market structure, where only a few buyers decide prices. Farmers have no bargaining power and only act as price takers(Sukirno, 2021).

High volatility at the producer level is influenced by external factors such as planting seasons, climate, and extreme weather. During peak harvests, excess supply puts sharp pressure on prices. Conversely, during times of drought, prices spike due to limited supply. Risks also increase due to natural disasters and pest attacks (Ellis, 1988). The absence of a basic price policy from the government exacerbates this uncertainty.

Internal factors also amplify volatility, such as limited post-harvest facilities. Shallots are perishable, and without cold storage, farmers are forced to sell their crops all at once, causing price pressure. Weak institutions and limited access to market information make it impossible for farmers to hold onto goods or delay sales.

Thus, high volatility at the producer level in NTB is caused by the dominance of buyers (wholesalers) but many farmers, external factors such as climate and season, and internal weaknesses of farmers. Cross-season distribution strategies, post-harvest facility improvements, and policies that strengthen farmers' positions in the supply chain are needed.

# CONCLUSION AND SUGGESTIONS

Based on the results of the research and discussion that have been described, it can be concluded that the production of shallots tends to decrease from year to year. In 2024 it was 1,759,590 tons. The Producer Price Index (IHP) of shallots in the period from January to December 2024 is predicted to increase gradually. The price in January 2024 is predicted to be IDR **21,498** increased to IDR 21.510 in December 2024. Price volatility at the producer level is extremely high (*ARCH* + *GARCH* = 1.343905). **To prevent price instability at the producer level, a price regulation is needed that protects farmers from price shocks, because low shallot prices are detrimental to farmers and hinder efforts to increase shallot production in West Nusa Tenggara Province. Farmers need to set planting schedules and delay selling times to prevent oversupply during the harvest season and a** cross-season distribution strategy, improved post-harvest facilities, and policies that strengthen farmers' positions in the supply chain are needed.

# CONSENT

The research entitled *“Analysis of Shallot Price Volatility at Producer Level in West Nusa Tenggara Province”* is entirely based on secondary data obtained from official agencies such as the Central Bureau of Statistics (BPS) and relevant local institutions. As the study does not involve direct human participation or personal data, obtaining informed consent was not required.

# ETHICAL APPROVAL

The study titled *“Analysis of Shallot Price Volatility at Producer Level in West Nusa Tenggara Province”* is entirely based on secondary data obtained from official institutions such as the Central Bureau of Statistics (BPS) and relevant government agencies. As the research did not involve any human or animal subjects, ethical approval was not required.

**COMPETING INTERESTS DISCLAIMER:**

Authors have declared that they have no known competing financial interests OR non-financial interests OR personal relationships that could have appeared to influence the work reported in this paper.

Disclaimer (Artificial intelligence)

The authors declare that generative artificial intelligence technologies, such as Large Language Models, were utilized during the writing and/or editing process of this manuscript. Detailed information regarding the technology used—including its name, version, model, source, and examples of input prompts—is provided below:

Details of AI Usage:

* Technology Used: ChatGPT, GPT-4o model (OpenAI)
* Purpose of Use: To enhance language structure, perform academic paraphrasing, and refine grammar

Example Prompts: For instance, “Please clarify this sentence,” or “Rewrite this abstract in an academic style,” and similar requests

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