The impact of the Vietnam Sustainable Agriculture Transformation (VnSAT) program on the performance of Indonesian rice

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Abstract. The price of rice in the world market greatly influences prices in the domestic market, one of which is the price of rice in Vietnam, Indonesia's largest rice exporter. The increase in rice prices in Vietnam under the Vietnam Sustainable Agriculture Transformation (VnSAT) program affected the performance of Indonesian rice. This research aims to determine the impact of the VnSAT program on the Indonesian rice version. Data analysis uses simultaneous equations with the two-stage least squares (2SLS) estimation method. The research results show that the effects of the VnSAT program, through an increase in Vietnamese rice prices by 20% and 29%, are relatively small on the performance of Indonesian rice, causing domestic rice prices to decrease by 0.0015% and 0.0030%, rice supply to decrease by 0.0006% and 0.0008%, and demand for rice to increase by 0.000029% and 0.000041%. This implies that external policies from Vietnam did not influence the performance of Indonesian rice, as Indonesia is Indonesia's largest rice exporter, so Indonesia does not need to worry if there is an increase in rice prices in Vietnam.

1 Introduction

Rice is a group of cereals that contains 85% carbohydrates, vitamins, proteins and minerals [1]. The high carbohydrate content of rice makes it the food most consumed by people worldwide. The amount of rice consumption in countries on three continents, America, Europe, and Australia, tends to be smaller than that in Asia. Indonesia is one of the countries on the Asian continent that makes rice a staple food. Indonesia has the third largest rice consumption in the world after China and India. Based on statistics Indonesia 2021, Indonesia's rice consumption in 2019 was 103.74 kg/capita/year, dominated by households at 77.5 kg/capita/year, followed by hotels, restaurants and eateries at 24.37 kg/capita/year, industry at 1.75 kg/capita/year, and the services sector at 0.13 kg/capita/year.

The high rice consumption of Indonesians is not accompanied by an increase in rice production. Based on data from the USDA, Indonesia's rice production declined by 0.586% in 2011-2019. Apart from that, the availability of Indonesian rice stocks has chronic problems

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(chronic food insecurity) and periodic problems (occasional food insecurity). The crisis that occurs continuously and repeatedly results from the emergence of chronic rice stock problems. Rising food prices and limited access to food supplies have caused this crisis. Problems periodically occur due to price fluctuations, social conflicts, and natural disasters [2]. These conditions caused the Indonesian government to import rice to meet domestic needs. The government imports rice to anticipate the uneven distribution and production of domestic rice [3]. According to statistics Indonesia 2021 reports, Vietnam and Thailand are Indonesia's largest rice exporters.

Indonesia imports rice from Vietnam and Thailand because it has affordable prices. Based on USDA data, Vietnam's rice price is relatively lower than that of Thailand, so the Indonesian government imports more rice from Vietnam. BPS data shows that the most significant Indonesian rice imports in 2010-2016 came from Vietnam, with an average of 693,326.99 tons, while rice imports from Thailand amounted to 372,664.19 tons. In the following year, for the 2017-2020 period, Indonesian rice imports from Vietnam fell to 226,407.58 tons, while rice imports from Thailand amounted to 261,604 tons. In terms of price, based on USDA data, the price of 5% broken rice in 2014-2016 from Thailand (391 USD/ton) was higher than that of Vietnam (370 USD/ton). When the price of Thai rice rises, it will increase the competitiveness of Vietnamese rice in the world market, causing Vietnam's exports to increase [4]. However, in 2017-2021, the price of 5% of broken rice from Thailand was lower than Vietnam, so Thailand's rice imports in that period tended to be greater than Vietnam's. Vietnamese rice prices have increased significantly and steadily, averaging 29% [5]. Vietnam's rice prices have increased as the Vietnam Sustainable Agriculture Transformation (VnSAT) program progresses.

The Vietnam Sustainable Agriculture Transformation (VnSAT) program supports the implementation of the Government's Agricultural Restructuring Plan (ARP) to improve agricultural practices and value chains in the targeted areas, as well as promoting the institutional strengthening of relevant public agencies [6]. This program is implemented by the Ministry of Agriculture and Rural Development (MARD) and consists of four main components, one of which supports sustainable rice-based systems. One of the targets of this component is to achieve a harvest area of 150,000 ha with an increase in farmer profits of 20% [7–9]. The national program supported by VnSAT to accomplish the targets was through two technology packages, namely "Three Reductions, Three Gains" (3R3G) and "One Must Do, Five Reductions" (1M5R). Government support in this program takes the form of technical training courses, upgrading rice processing technology and facilities, and improving the provision of public services, mainly extension services, foundation seed production, and seed certification [7–8]. The Vietnamese government also sets production and land area targets, minimum prices during peak harvest seasons, and minimum export prices, and imposes other export requirements [10]. This has encouraged the Vietnamese government to be actively involved in rice exports. As one of the largest exporting countries in the world, Vietnam's rice exports influence global exports. World exports interact with world imports to form equilibrium prices in world markets. The world rice market is also directly related to the domestic market (Indonesia), and rice import prices impact the rice market's performance in Indonesia. Based on this background, this research aims to examine 1) the factors that influence the performance of Indonesian rice (demand, supply, and price) and 2) the impact of the VnSAT program on rice performance in Indonesia.

2 Methodology

This study uses secondary data in the form of time-series data. The research data began in 1998-2021 with the consideration that the Indonesian economy was starting to enter a stable period after being shaken by the monetary crisis of 1997. Data were obtained from the

International Rice Research Institute (IRRI), United States Department of Agriculture (USDA), Food and Agriculture Organization (FAO), World Bank, Central Bureau of Statistics (BPS), Indonesian Ministry of Agriculture, Bank Indonesia, Center for Agricultural Data and Information, and other agencies related to this research.

The data analysis method used to answer the research problem formulation was simultaneous equations. Simultaneous equations are composed of six structural equations and one identity equation. In detail, the simultaneous equations used in this research are as follows:

a) Equation of Vietnam's rice exports

$$XV = a_0 + a_1 PV + a_2 DV + a_3 QV + a_4 ERV + a_5 PW + U_1 \quad (1)$$

Expected parameter signs: $a_1, a_3, a_4, a_5 > 0$; $a_2 < 0$

b) World rice supply equation

$$SW = XV + XT + XAS + XIND + XPAK + XOTHER \quad (2)$$

c) Price equation rice world

$$PW = b_0 + b_1 SW + b_2 DW + b_3 LPW + U_2 \quad (3)$$

Expected parameter signs: $b_2, b_3 > 0$; $b_1 < 0$

d) Equation of the price of imported Indonesian rice

$$PMINA = c_0 + c_1 PW + c_2 TMINA + c_3 ERINA + U_3 \quad (4)$$

Expected parameter signs: $c_1, c_2 > 0$; $c_3 < 0$

e) Indonesian rice price equation

$$PBINA = d_0 + d_1 PMINA + d_2 DINA + d_3 SINA + d_4 LPBINA + U_4 \quad (5)$$

Expected parameter signs: $d_1, d_2, d_4 > 0$; $d_3 < 0$

f) Indonesian rice demand equation

$$DINA = e_0 + e_1 POPINA + e_2 PJINA + e_3 PBINA + e_4 GDPIK + U_5 \quad (6)$$

Expected parameter signs: $e_1, e_2, e_4 > 0$; $e_3 < 0$

g) Indonesian rice supply equation

$$SINA = f_0 + f_1 PBINA + f_2 PJINA + f_3 PUREA + f_4 APINA + U_6 \quad (7)$$

Expected parameter signs: $f_1, f_4 > 0$; $f_2, f_3 < 0$

where :

DV = Vietnam demand (ton)
QV = Vietnam rice production (ton)
ERV = Vietnam price exchange rate (VND/USD)
PV = Vietnam rice price (USD/ton)

PW = World rice price (USD/ton)
DW = World rice demand (ton)
SW = World rice supply (ton)
XV = Vietnam rice exports (ton)
XT = Thailand rice exports (ton)
XAS = United States rice exports (ton)
XIND = Indian rice exports (ton)
XPAK = Pakistani rice exports (ton)
XINA = Indonesian rice exports (ton)
XOTHER = Rice exports from other countries (ton)
PMINA = Price of Imported rice (IDR/kg)
TMINA = Rice import tariff (IDR/kg)
ERINA = Indonesian exchange rate / rupiah exchange rate (IDR/USD)
DINA = Indonesian rice demand (ton)
PUREA = Price of Urea fertiliser (IDR/kg)
APINA = Indonesian rice harvest area (ha)
SINA = Indonesian rice supply (ton)
POPINA = Indonesian population (people)
GDPIK = Indonesian GDP per capita (IDR/year)
PJINA = Indonesian corn price (IDR/kg)
PBINA = Indonesian rice price (IDR/kg)

Model estimation

The results of the model identification test show that the model is declared over-identified. For this reason, the two-stage least squares (2SLS) method is the appropriate model estimation. This method can eliminate bias in simultaneous equations [11,9], is suitable for relatively small samples, and is not sensitive to modification [12,13]. The analytical tool used in this research was SAS/ETS software version 9.0.

Model simulation

Model simulations are performed for various reasons, such as model testing and evaluation, historical policy analysis, and forecasting [14]. This research used simulations for historical policy analysis or historical simulation (ex-post simulation). The policy simulation in this research aims to analyse the impact of changes in Vietnamese rice prices based on the Vietnam Sustainable Agriculture Transformation (VnSAT) program on the performance of Indonesian rice. There are two policy scenarios: 1) increasing the price of Vietnamese rice by 20% based on the target of increasing prices by the World Bank in the VnSAT project and 2) increasing the price of Vietnamese rice by 29% based on previous research by Flor et al. [5] related to increasing profits for farmers.

3 Results and discussion

3.1 Factors affecting the performance of Indonesian rice

The simultaneous equation model developed in this research has undergone several modifications to obtain a model with parameter estimates that can describe the VnSAT program's impact on Indonesian rice performance by increasing Vietnamese rice prices. The econometric model consists of seven equations: six structural equations and one identity

equation. The results of the simultaneous equation parameter testing for Indonesian rice market performance are shown in Table 1.

Table 1. Simultaneous equation parameter test results for the performance of Indonesian rice.

Equality	Variable labels	F test		Adj R2	Serial correlation test (d_w)
		F count	Prob > |F|		
XV	Vietnamese rice exports	5.44	0.0036	0.50253	1.910326
PW	World rice prices	11.83	0.0001	0.59625	1.961493
PMINA	Indonesian rice import prices	54.57	<0.0001	0.87959	1.541516
PBINA	Indonesian rice prices	13.74	<0.0001	0.69844	1.890467
DINA	Indonesian rice demand	52.67	<0.0001	0.90380	2.011274
SINA	Indonesian rice supply	14.08	<0.0001	0.70394	1.081737

Source: Analysis of secondary data, 2022

Based on Table 1, the evaluation of the F-statistical test model shows that all the equations in the model have a significance value of <0.05. This means that all exogenous variables in the model can explain the endogenous variables well. Based on the adj R^2 value, all equations in the model had relatively high values above 50%, ranging from 50.25% to 90.38%. This means that all exogenous variables in the model can explain the diversity of endogenous variables well. Based on the autocorrelation test, the Durbin-Watson statistical test results ranged between 1.081737 and 2.011274. These results clarify that the four equations do not experience serial correlation problems, and two cannot be decided. Pindyck and Rubinfeld [14] explained that the serial correlation problem only causes a reduction in the efficiency of parameter estimation and does not cause regression bias.

The performance of Indonesian rice illustrates the Indonesian rice market, which can be seen in the demand, supply, and price of rice. The results of the t-statistical test show that all exogenous variables have the direction and amount of the estimated parameter values, as expected. The results of estimating the parameters of the simultaneous equation model for Indonesian rice performance are presented in Table 2. The relationship between endogenous and exogenous variables in the concurrent equation model of Indonesian rice performance is also shown in Figure 1.

3.1.1 Indonesian rice prices

Indonesian rice prices are significantly influenced by rice demand, meaning that increasing rice demand will increase domestic rice prices. Domestic rice prices in the previous year also significantly affected domestic prices, indicating a relatively slow lead time for domestic rice prices to adjust in response to economic changes. Neither the price of rice imports in the previous year nor the rice supply significantly affected domestic rice prices. The last result of the research also states that the rice import price does not have a significant influence caused by the weak transmission of domestic rice price, so the change in rice import price is not followed by the domestic rice price change [15].

3.1.2 Indonesian rice demand

Indonesian rice demand is significantly influenced by per capita income. This shows that increasing per capita income will increase the demand for Indonesian rice. Population and corn prices have an insignificant influence on rice demand. A positive sign for the price of corn indicates that corn is a substitute for rice. The previous year's rice price also had an insignificant effect on Indonesian rice demand. This result is in line with Nauly's research

[15], which states that income has a positive and significant effect, whereas corn and rice prices have an insignificant effect on rice demand.

Table 2. Estimation results of the simultaneous equation model of Indonesian rice performance.

Equality	Variable labels	Parameter estimate	t-value	Prob>|t|
Vietnamese rice export equation				
Intercept	Intercept	235543.1	0.04	0.9647
PV	Price of Vietnamese rice	5288.805	1.37	0.1879
DV	Demand for Vietnamese rice	-0.50839	-1.10	0.2854
QV	Production of Vietnamese rice	0.466203	1.87	0.0787*
SERV	Vietnam exchange rate changes	196.5595	1.46	0.1638
PW	World rice prices	2348.694	0.78	0.4459
World rice price equation				
Intercept	Intercept	101.8828	1.32	0.2026
SW	World rice supply	-0.00001	-1.55	0.1367
DW	World rice demand	0.000015	1.86	0.0792*
LPW	World rice price t-1	0.725975	4.88	0.0001***
Indonesian rice import price equation				
Intercept	Intercept	191.2410	1.26	0.2241
PW	World rice prices	0.495459	2.01	0.0585*
TMINA	Indonesian rice import tariffs	0.848546	5.66	<.0001***
ERINA	Indonesian exchange rate	-0.02403	-2.66	0.0156**
Indonesian rice price equation				
Intercept	Intercept	-5022.04	-0.99	0.3357
LPMINA	Indonesian rice import price t-1	0.014269	0.01	0.9941
DINA	Indonesian rice demand	0.000260	1.89	0.0749*
SSINA	Changes in Indonesian rice supply	-0.00006	-0.44	0.6638
LPBINA	Indonesian rice price t-1	0.546858	2.76	0.0130**
Indonesian rice demand equation				
Intercept	Intercept	15020050	2.75	0.0036
POPINA	Indonesian population	0.050201	1.39	0.1774
PJINA	Indonesian corn prices	86.25051	0.11	0.8334
LPBINA	Indonesian rice price t-1	-53.9597	-0.27	0.9915
GDPIK	Income per capita	1803.784	3.22	0.0047***
Indonesian rice supply equation				
Intercept	Intercept	44301886	8.07	<0.0001
LPBINA	Indonesian rice price t-1	1726.816	2.81	0.0115**
SPJINA	Changes in Indonesian corn prices	-1543.47	-0.62	0.5420
PUREA	Price of Urea fertiliser	-2776.42	-3.71	0.0016***
SAPINA	Changes in Indonesia's harvest area	3.773355	1.12	0.2793

***Significant at the 1% level; **Significant at the 5% level; *significant at the 10% level.
Source: Analysis of secondary data (2022)

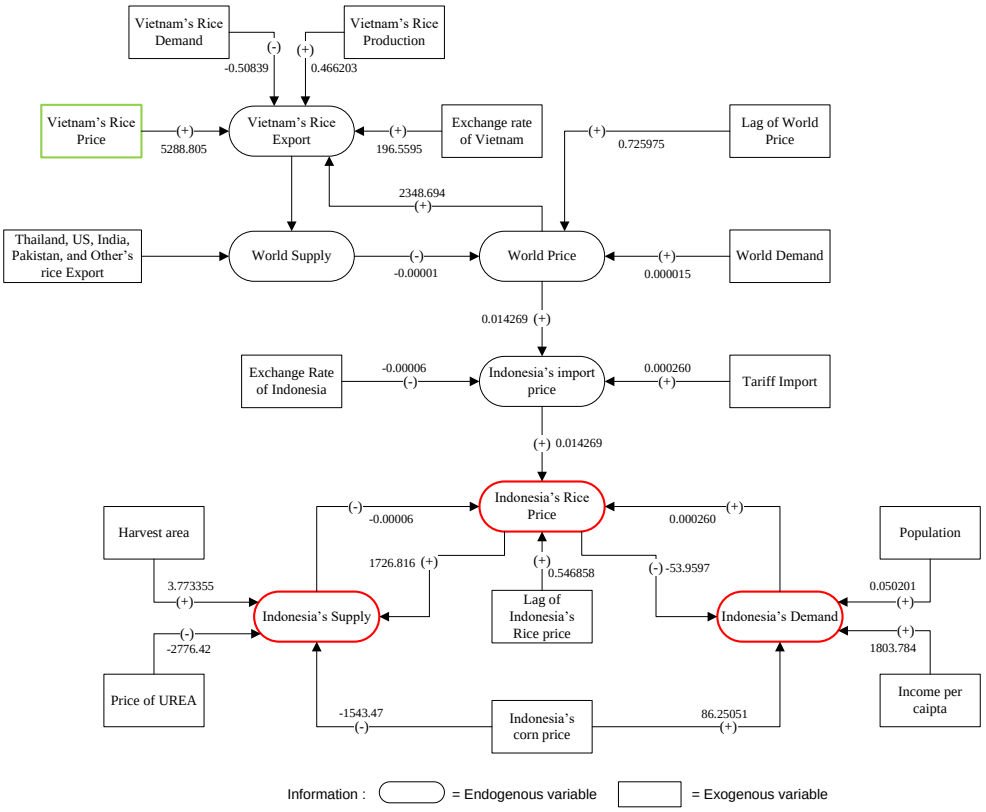

Fig. 1. Flowchart of the relationship between endogenous and exogenous variables of Indonesian rice performance.

3.1.3 Indonesian rice supply

Domestic rice prices significantly influenced Indonesia's rice supply in the previous year. This means that an increase in domestic rice prices in the previous year will increase rice supply. Fertiliser prices have a significant influence on rice supply. This shows that an increase in fertiliser prices will reduce rice supply. The increase in fertiliser prices is a disincentive for farmers, which causes them to minimise the use of inputs for farming. Meanwhile, changes in corn prices and harvested area did not significantly affect Indonesia's rice supply.

3.2 The impact of the Vietnam Sustainable Agriculture Transformation (VnSAT) program on the performance in Indonesian rice

3.2.1 Simultaneous equation model validation

The model validation consisted of the root mean square percentage error (RMSPE), bias proportion (UM), variance proportion (US), and covariance proportion (UC). The validation results of the simultaneous equation model for Indonesian rice performance are presented in Table 3.

Table 3. Validation of the simultaneous equation model of Indonesian rice performance.

Variable	RMSPE	*Proportion of inequality*			UM+US+UC	U-theils
		UM	US	UC		
XV	25.1258	0.35	0.09	0.56	1.00	0.0858
SW	3.3243	0.35	0.01	0.64	1.00	0.0154
PW	72.1946	0.86	0.00	0.14	1.00	0.2428
PMINA	29.5139	0.65	0.05	0.30	1.00	0.0975
PBINA	2.3773	0.00	0.11	0.89	1.00	0.0781
DINA	2.6378	0.00	0.02	0.98	1.00	0.0134
SINA	7.9294	0.00	0.11	0.89	1.00	0.0387

Source: Analysis of secondary data (2022)

Table 3 shows that five equations in the model had an RMSPE value of ≤30%, and one equation had an RMSPE value of > 30%. All equations in the model have ideal values, meeting the criterion value UM+US+UC = 1. In addition, the U-Theil value has an average of 0.0817 or below 0.1, which means that the value meets the criteria close to 0.00. The model validation results indicate that the model simulation follows its actual data properly and has good predictions for historical simulations

3.2.2 The model simulation on the increasing Vietnamese rice price

The simulation of changes in Vietnamese rice prices includes two policy scenarios: increasing rice prices in the Vietnam Sustainable Agriculture Transformation (VnSAT) program by 20% and increasing rice prices by 29% [5]. Model simulations were carried out to determine the impact of increasing prices on the performance of Indonesian rice. The historical simulation results for the impact of increasing Vietnamese rice prices in the VnSAT program are shown in Table 4.

Table 4. Historical simulation results of the impact of increasing Vietnamese rice prices on Indonesian rice performance.

Variable	Unit	Basic values	Simulation	
			S1	S2
XV	ton	5611510	6.3342	7.6010
SW	ton	29994358	1.1850	1.4220
PW	USD/ton	628	-1.8949	-2.2771
PMINA	USD/ton	774.1	-0.7622	-0.9172
PBINA	IDR/kg	6662.9	-0.0015	-0.0030
DINA	ton	31493223	0.000029	0.000035
SINA	ton	48089523	-0.0006	-0.0007

Note: S1 = simulated price increase of 20%; S2 = simulated price increase of 29%.
Source: Analysis of secondary data (2022)

Table 4 shows the simulation results of an increase in the price of Vietnamese rice, which increases the amount of rice exports made by Vietnam. Increasing the quantity of Vietnam's exports will increase the world's rice supply, which has implications for reducing world rice prices. Changes in rice prices in exporting countries will influence rice prices in the international market [16]. Furthermore, the decreasing price of rice in the world market will reduce the price of rice imports in importing countries, including Indonesia. Low imported rice prices will influence the decline in domestic rice prices. Prices in the world market

influence price dynamics in the domestic market [9,17]. The price of rice in the international market will reduce the price of imported and domestic rice. A decrease in domestic rice prices will cause the supply of rice to decrease and public demand for rice to increase. Nauly [15] explains that farmers' relatively lower incomes caused a reduced rice supply, so they switched to cultivating other commodities. In addition, a decrease in domestic rice prices benefits consumers, thereby increasing the demand for rice in the domestic market [18].

A simulation of a 20% increase in the price of Vietnamese rice (S1) based on the World Bank's target in the VnSAT program caused Vietnam's rice exports to increase by 6.3342%, which was then followed by an increase in world rice supply of 1.1850%. The increase in Vietnam's rice exports decreased rice prices in the world market by 1.8949%. The decline in rice prices in the world market was transmitted to domestic rice prices through rice import prices by 0.0015%. The decline in domestic rice prices resulted in a decrease in rice supply by 0.0006% and an increase in demand by 0.000029%.

The simulated increase in Vietnam's rice price by 29% (S2) directly impacted Vietnam's rice exports, which increased by 9.1845%, followed by an increase in world rice supply of 1.7183%. The increase in world rice supply has implications for world prices, which have decreased by 2.7548%. The decline in world rice prices was transmitted to domestic rice prices by 0.0030% through imported rice prices. The decline in domestic rice prices caused a decrease in rice supply by 0.0008% and an increase in rice demand by 0.000041%.

The simulation results for both S1 and S2 show that increasing the price of Vietnamese rice through the VnSAT program has a small impact. This is due to the indirect influence of the increase in Vietnamese rice prices on the performance of Indonesian rice. The impact of Vietnam's rice exports due to the increase in rice prices on world rice supply is relatively small, and then interacts with world rice demand, thus forming world rice prices which are also relatively small, between 1.8949% and 2.2771%. Changes in rice prices in the world market are then transmitted to rice import prices and domestic (Indonesian) prices, which are getting smaller. Domestic rice prices change following rice price conditions in the international market [19–21]. Relatively small changes in domestic rice prices affect relatively small changes in supply and demand. Apart from that, another factor is also caused by the relatively small market share of Vietnamese rice exports to Indonesia, which causes relatively small changes in the performance of Indonesian rice. This is proven by FAO data regarding Vietnam's rice export market share to Indonesia in 2017-2021, which was only 3.62%.

4 Conclusions and policy recommendations

4.1 Conclusions

Factors that influence the performance of Indonesian rice include 1) rice demand is significantly influenced by per capita income, 2) rice supply is significantly influenced by the previous year's rice price and the price of urea fertiliser, and 3) domestic rice prices are influenced by demand and the previous year's rice price. The Vietnam Sustainable Agriculture Transformation (VnSAT) program, through a simulation of increasing Vietnamese rice prices by 20% and 29%, has a relatively small impact on the performance of Indonesian rice, which is reducing domestic rice prices by 0.0015% and 0.0030%, reducing rice supply by 0.0006% and 0.0008%, and increasing demand for rice by 0.000029% and 0.000041%.

4.2 Policy recommendations

The proposed policy recommendations based on the analysis results include the following: (1) The simulation results of an increase in Vietnamese rice prices have a relatively small impact on the performance of Indonesian rice. This implies that the performance of Indonesian rice was not influenced by external policies from Vietnam, Indonesia's largest exporter. Hence, Indonesia does not need to worry about the increase in rice prices in Vietnam. (2) The Indonesian government still needs to maintain rice supply through programs to increase rice productivity, such as increasing irrigation areas and using certified seeds. It aims to increase domestic rice production to reduce Indonesian rice imports.

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