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IMPACT OF CLIMATE CHANGE ON FOOD PRICE IN THE AFFECTED PROVINCES OF EL NINO AND LA NINA PHENOMENON: CASE OF INDONESIA

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Abstract

Climate change has become a global issue because it has a wide impact on a country's socio-economic condition. The main factor influencing climate change in Indonesia is El Nino Southern Oscilliation (ENSO), consisting of three phases: El Nino, La Nina and Normal. ENSO plays an important role in climate variations and intensity of rainfall so that it can affect the agricultural sector, especially the food crops sub-sector which is very vulnerable to climate change. This research examines the impact of climate change on food prices i.e rice, maize and soybean using the static panel method. Cross section data focuses on the most 10 affected provinces of the ENSO phenomenon, while the time series data is used from 2011Q1 until 2016Q4. The result shows that El Nino significantly affects the increase of rice and soybean prices and the decrease of maize price. While La Nina significantly affects the increase of rice price. In general, El Nino has a bigger impact on food prices compared to La Nina.

Keywords: *Agricultural economics, climate change, food prices.*
JEL Codes: *Q11, Q26, Q31,Q34*

1. Introduction

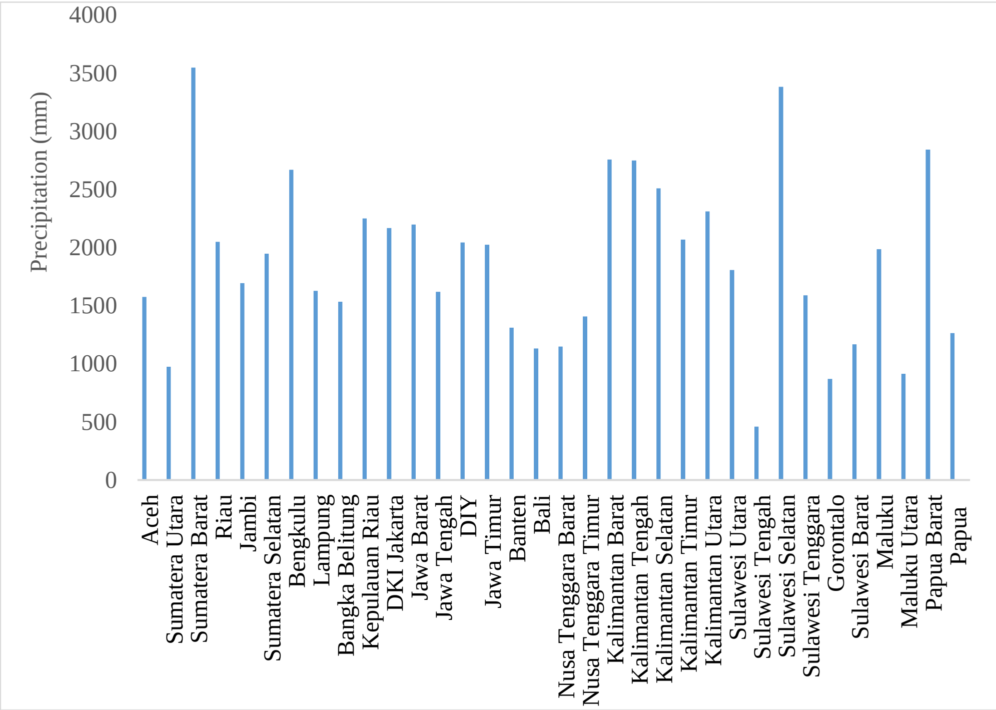
Climate change has been an interesting issue since the industrial revolution. Since then, climate change becomes a global issue. Its emergence not only affects the global climate system but also affect commodity prices and economic conditions in various country. The relationship between climate and economic performance has developed rapidly. These studies analyze the impact of ENSO on various economic conditions, both macro and micro economies. ENSO associated with macroeconomic studies generally explains a large part of the economy namely economic growth, monetary and inflation (Cashin, Mohaddes, & Raissi, 2017). While ENSO which is associated with microeconomic studies generally discusses the impact of ENSO on the production and prices of agricultural commodities (Brunner, 2000) such as; vegetable oil (Ubilava & Holt, 2013) and maize (Anderson, Seager, Baethgen, & Cane, 2017).

One of the indicators for detecting ENSO phases is by looking at the condition of the Sea Surface Temperature (SST). This indicator is measured by the central Pacific Ocean sea surface temperature named as ENSO 3.4 region. The ENSO phenomenon has 3 phases, namely El

Nino, normal and La Nina phases. Increasing sea surface temperature from normal conditions will cause El Nino, while decreasing Sea Surface Temperature from normal conditions will cause La Nina. The intensity of El Nino and La Nina varies depending on the anomaly that occurs at sea level. Weak El Nino occurs when sea surface temperature anomalies range from 0.5°C - 1°C, El Nino is moderate when SST anomalies range from 1.1°C - 1.5°C and El Nino category is strong when SST anomaly is more than or equal to 1.5°C for three months consecutive.

In 1992, 1998, 2010, 2015 and 2016 became the year when El Nino was in a strong category because of the anomalies of sea surface temperatures that occurred above the temperature of 1,5°C. Among these years, in 1998 and 2015 was the year when the worst El Nino phase was occurring during the last 30 years, with temperature deviations up to 2,5°C. Whereas La Nina conditions were strong in 1989, 1999, 2000, 2008 and 2011 (Climate Prediction Center, 2019).

In December 2015, across the eight districts surveyed, 40% of primary rice growers lost more than 50% of their crop in the last harvest. The drought was reported to have decreased the income of three out of five households surveyed. In 31% of households, the impact was severe (more than 30% reduction in primary income). In Kupang and Timor Tengah districts, 48% and 40% of households reported a severe impact on income (World Food Programme, 2016).



Source: (Badan Pusat Statistik, 2017)

Figure 1. The Distribution of Indonesia's Rainfall by the Province in 2015

The emerging of the El Nino phase will affect climate and weather and has the potential to reduce rainfall in an area. Figure 2 shows the distribution of Indonesian rainfall by province in 2015, where the worst El Nino is happening. In that year, interprovincial rainfall in Indonesia varied considerably. There is a region with very low rainfall which is below 1000mm per year, and there are also areas with rainfall that are quite high even reaching 3500mm. This shows that although during the El Nino phase, not all regions in Indonesia were affected by a decrease in rainfall which resulted in drought. In theory, the dry season will affect agricultural production, reduce reserves and supply, then driving up prices and then causing inflation. El Nino contributed to an increase in inflation of 3.5% -4% stemming from an increase in world real commodity prices (Brunner, 2000).

The link between climate change and the economy has been widely discussed by researchers. Since 1960, temperate countries have been converging towards high-income economies, whereas tropical countries have converged to various levels of economic income depending on economies of scale and market conditions (Masters & McMillan, 2001). The finding was previously supported by research which states that there is a correlation between the geographical location of a country, especially latitude which might affect a country's economic growth (Gallup & Sachs, 1999). Moderate temperate countries tend to have high economic growth given the industrialization of the country. Whereas a tropical country which is actually a developing country, still relies on its economy in the agricultural sector and agricultural trade itself.

The geographical location of the country will affect the country's economy, considering that this geographical location will determine the climatic conditions that are very important for agriculture. Developing countries that are generally in the southern latitudes are generally the most vulnerable to weather anomalies that have the potential to affect economic growth. There is a nonlinear dependency between the climate especially el nino with economic growth that varies between countries. El Nino which is equivalent to a deviation of 1 ° C in the sea surface temperature of the Nino 3.4 region can reduce 1-2% of economic growth per year (Smith & Ubilava, 2017).

Climate variability affects the production of various plants. One crop that is quite vulnerable to the effects of climate change is rice, maize and wheat. El Nino might increase the average global soybean production by 2.1% -5.4% but decrease the average production of corn, rice and wheat by -4.5% (Lizumi, et al., 2014)

The food crop and horticultural sub-sector accounted for 34% of the GDP sector, where the agriculture sector accounted for 13.41% of Indonesia's total GDP in 2016. This second largest contributor to GDP absorbed 32% of the total workforce, which means around 38 million of Indonesia's population depends on climate conditions. It is feared that production instability due to climate change will disrupt the stability of food security, especially rice, corn and soybeans, which are the basic needs of the majority of Indonesia's population. The decline in production caused by climate change has the potential to cause an increase in food prices. If there is a continuous increase will trigger inflation, inflation will cause a decrease in purchasing power, especially the poor, thus potentially increasing poverty. If the problem occurs, a combination of food shortages and price spikes can increase riots and protest incidents in developing countries that depend on imports, causing political instability (Hendrix & Haggard, 2015).

This study aims to analyze the distribution of areas affected by climate change especially because of the ENSO phenomenon. After that an analysis of the impact of climate change on food prices in Indonesia is carried out.

2. Methodology

2.1 Provincial Rainfall Correlation and SST

To estimate the provinces in Indonesia affected by ENSO, correlation analysis was conducted. This analysis is carried out to see the relationship of rainfall in each province with SST. Considering the drought that occurs in an area is not necessarily caused by El Nino, so the analysis must be able to explain the relationship between provincial rainfall and one of the ENSO indicators, namely SST. Sea Surface Temperature Data is sourced from the National Oceanic and Atmospheric Administration (NOAA), Indonesian rainfall data is sourced from the Climate Hazards InfraRed Deposition Group with Station Data (CHRIPS) downloaded from the Earth System Research Laboratory (ERSL) web, rainfall per province from the Agency Meteorology, Climatology and Geophysics (BMKG). The analysis was carried out from 1980-2016.

Correlation analysis is used to determine the closeness of the relationship between ENSO and Indonesian rainfall. The correlation equation is defined as follows:

$$r = \frac{n\sum XY - \sum X \sum Y}{\sqrt{\{n\sum X^2 - (\sum X)^2\}\{n\sum Y^2 - (\sum Y)^2\}}} \quad (1)$$

where X is an independent variable and Y is an independent variable. The positive correlation value indicates the relationship between the two variables is directly proportional, while the negative correlation value indicates that the relationship is inversely proportional between the two variables.

The statistical t-test is carried out after the correlation coefficient results are obtained. T statistical tests function to test the significance of the correlation coefficient. This test is to find out whether the independent variables partially have a significant effect on the dependent variable. The t-statistical test is formulated as follows:

$$t = r\sqrt{\frac{n-2}{1-r^2}} \quad (2)$$

where r is the correlation coefficient and n is the number of observations

2.2 The Impact of ENSO on Food Price

The next step is to estimate the impact of ENSO on food prices in the affected provinces. The analysis used is panel data analysis. The type of data used in this study is secondary data in the form of time series data and cross section. The time series data includes quarterly data from 2011 Q1 to 2016 Q4. While the cross section data is in the 10 most affected provinces due to the existence of the ENSO phenomenon. Data is used to measure the impact of the ENSO phenomenon on consumer level prices for rice, corn and soybean commodities. Interpolation is performed on production data, where annual data is interpolated into quarterly data using the Quadratic Match Sum method. Furthermore, the production data for each observation year is reprocessed by adding the total value in the previous quarter in the second quarter to the fourth quarter. Data on consumer level prices and food crop production are sourced from the Ministry of Agriculture, the ENSO Index data is sourced from the Climate Prediction Center (CPC), and Real GDP data is sourced from the Central Statistics Agency (BPS).

The model used in this study consisted of 3 models that were differentiated based on the commodities studied, namely rice prices, corn prices and soybean prices. The difference in the effect of the El Nino, normal and La Nina phases on prices is represented by the use of dummy variables. The model specifications in this study are formulated as follows:

$$LnPriceR_{it} = \alpha_0 + \alpha_1 LnProdR_{it} + \alpha_2 LnPrecip_{it} + \alpha_3 DElNino_{it} + \alpha_4 DLaNina_{it} + \alpha_5 LnPDRBRiil_{it} + \varepsilon_{it} \quad (3)$$

$$LnPriceM_{it} = \beta_0 + \beta_1 LnProdM_{it} + \beta_2 LnPrecip_{it} + \beta_3 DElNino_{it} + \beta_4 DLaNina_{it} + \beta_5 LnPDRBRiil_{it} + \varepsilon_{it} \quad (4)$$

$$LnPriceS_{it} = \gamma_0 + \gamma_1 LnProdS_{it} + \gamma_2 LnPrecip_{it} + \gamma_3 DElNino_{it} + \gamma_4 DLaNina_{it} + \gamma_5 LnPDRBRiil_{it} + \varepsilon_{it} \quad (5)$$

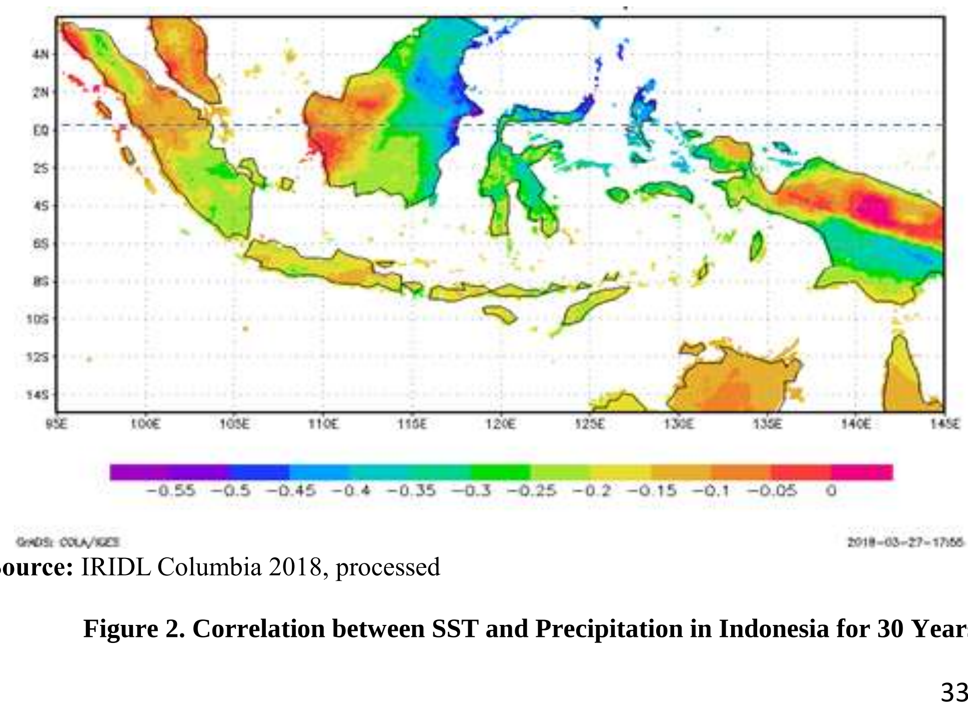
where $LnPriceR,M,S_{it}$ are natural logarithm of food price consumer level, $LnProdR,M,S_{it}$ are natural logarithm of food production (rice, maize and soybean), $LnPrecip_{it}$ are natural logarithm of precipitation, $DElNino_{it}$ are dummy El Nino, $LaNina_{it}$ are dummy La Nina and $LnPDRBRiil_{it}$ are gross regional domestic income.

3. Result and Discussion

3.1 Provinces Affected by ENSO

Climate can differ from one region to another. In theory, there are several factors that influence the distribution of climate in each region. These factors can be in the form of latitude, elevation, topography, water bodies, atmospheric circulation and vegetation. The interaction between climate factors and SST plays a role in receiving rainfall in each region. The diverse characteristics of the Indonesian region produce varied climate and rainfall patterns. Low rainfall in an area is not necessarily caused by El Nino, as well as heavy rains that occur in an area not necessarily caused by La Nina. Therefore it is important to look at the correlation between SST anomalies with rainfall in an area to ascertain how much the relationship between the two.

The results of the correlation above are the distribution of the areas most affected by the ENSO phenomenon. Correlation values ranged from -0.55 to 0. The greater the correlation value indicates the stronger the relationship between SST and rainfall in the region. The results obtained are mostly negative, which means that SST and Indonesian rainfall have an opposite relationship. The increase in SST in the Pacific Ocean will reduce Indonesia's rainfall so that it can be ascertained that areas with blue to purple distribution (correlation values between -0.55 to -0.35) if they experience droughts or floods, El Nino or La Nina have a big contribution as the main factor.



Source: IRIDL Columbia 2018, processed

Figure 2. Correlation between SST and Precipitation in Indonesia for 30 Years

Table 1. T test result

Province	t calculate	Province	t calculate
Gorontalo	-2.3743	Nusa Tenggara Timur	-1.0930
Maluku Utara	-2.1972	Bengkulu	-1.0383
Kalimantan Utara	-2.0703	Nusa Tenggara Barat	-1.0051
Sulawesi Utara	-1.830	Jawa Tengah	-1.0014
Sulawesi Tengah	-1.7927	Papua Barat	-0.9961
Kalimantan Selatan	-1.7888	Jawa Barat	-0.9911
Kalimantan Timur	-1.7729	Banten	-0.9516
Sulawesi Tenggara	-1.5394	DIY	-0.9103
Sulawesi Selatan	-1.5391	DKI Jakarta	-0.9041
Bali	-1.5179	Sumatera Utara	-0.8982
Sulawesi Barat	-1.4811	Jawa Timur	-0.8657
Maluku	-1.2478	Kepulauan Riau	-0.8370
Lampung	-1.2208	Kalimantan Barat	-0.7420
Kalimantan Tengah	-1.2020	NAD	-0.6868
Sumatera Selatan	-1.1786	Riau	-0.6867
Bangka Belitung	-1.1345	Sumatera Barat	-0.6804
Papua	-1.0976	Jambi	-0.6741

SST Correlation Analysis and rainfall can be narrowed to produce more specific correlation results. Specifications are carried out at the provincial level by cutting the correlation between SST and Indonesian rainfall with the latitude and longitude of each province, so that the correlation value reflects the SST correlation and rainfall in the province. Correlation numbers are then sorted by the largest value (negative fixed sign). The results of SST correlation and rainfall per province can be seen in the Figure 4.

The results of the SST correlation and rainfall per province can be seen in1 Figure 3. The results of these correlations have been sorted by the largest value (negative sign) which means they have been sorted by the province most affected by the ENSO phenomenon. After obtaining the results of the correlation per province, a t-statistical test was conducted to test the significance of the correlation coefficient. This test was conducted to know whether SST has a significant effect on the rainfall of each province. The t-statistic test used uses a real level of 10%. The results of t-statistics testing can be seen in the Table 1.

The H_0 t-statistic test is $r = 0$ which means that SST does not affect rainfall in the province. Whereas H_1 or the goal hypothesis is $r < 0$ which means that SST significantly influences rainfall in the province. The number of observations in the t-table used is t (0.1; 28) where the t-table value is 1.3125. The next step is to compare the value of the results of the t calculate with t-Table. If the absolute value of t calculate is greater than the absolute value of t-table, then accept H_1, which means SST has a significant effect on rainfall in the province. Meanwhile, if the absolute value of t calculate is smaller than the absolute value of t-table, then accept H0, which means SST has no significant effect on rainfall in the province.

Source: IRDL Columbia, processed

Figure 4. Correlation between SST and Rainfall by Province in Indonesia during 1980-2016

After comparing the t-table and t-count values, 11 provinces were obtained where SST significantly affected the rainfall in each province. The 11 provinces are Gorontalo, Maluku Utara, Kalimantan Utara, Sulawesi Utara, Sulawesi Tengah, Kalimantan Selatan, Kalimantan Timur, Sulawesi Tenggara, Sulawesi Selatan, Bali and Sulawesi Barat. Kalimantan Utara Province is a division province of Kalimantan Timur province which was officially approved in October 2012. The limitation of the time series data for the Kalimantan Utara province makes this province not included in the cross section data. So based on the results of the t-test, 10 provinces were obtained with SST correlations and significant rainfall at 10 percent level. The 10 provinces were the provinces most affected by the ENSO phenomenon which was then used as the basis for selecting cross section data in subsequent analyses. The provinces most affected by the ENSO phenomenon are Gorontalo, Maluku Utara, Sulawesi Utara, Sulawesi Tengah, Kalimantan Selatan, Kalimantan Timur, Sulawesi Tenggara, Sulawesi Selatan, Bali and Sulawesi Barat. Geographically, provinces that have significant rainfall are influenced by SST, located close to one another and located around the equator.

3.2 The Impact of ENSO on Food Price

Some tests need to be done to determine the best approach between Pooled Least Square

(PLS), Fixed Effect Model (FEM) and Random Effect Model (REM). The Chow test is used to determine the best model between using the FEM or PLS approach and the Hausman Test to determine between FEM or REM.

Table 2. Chow Test and Hausman Test Result

Best Model Test	Probability Chi-Square		
	Rice Price	Maize Price	Soybean Price
Chow test	0.0000*	0.0000*	0.0000*
Hausman test	0.0000*	0.0103**	0.0000*
Decision	FEM	FEM	FEM

Note: *: Significant at 1% level. **: Significant at the 10% level

The Chi-Square probability on Chow Test value for all models is equal to 0.0000 is smaller than the 5% significance level, which means that the FEM approach is better than the PLS approach. Whereas based on the Hausman test the Chi-Square probability of all models is smaller than the 5% significance level, which means the FEM approach is better than the REM approach. Therefore the next estimate uses the Fixed effect Model approach.

The classic Assessment Test must be carried out so that the estimator meets the criteria of Best, Linear, Unlimited, Estimator (BLUE), which includes a normality test, a multicollinearity test, a heteroscedasticity test, and an autocorrelation test.

3.2.1 Normality Test

Table 3. Normality Test Results

	Rice	Maize	Soybean
Prob(*Jarque Berra)*	0.7999	0.0409	0.0688

The normality test results of the rice and soybean models indicate that the Jarque Berra probability value is greater than the 5% significant level, which means that the residual model is spread normally. Whereas in the corn model, the Jarque Berra probability value is 0.0409, which means that the model residuals are not normally distributed. However, this study uses a large number of samples (240 observations), so according to (Gujarati, 2004) the assumption of normality is not too important in large amounts of data.

3.2.2 Multicollinearity Test

The results of the multicollinearity test showed the correlation value between the analyzed variables did not exceed the absolute sign 0.8 for the four models, so it can be concluded that there was no violation of the classical assumptions of multicollinearity.

3.2.3 Heteroscedasticity Test and Autocorrelation Test

All four models have been freed from the problem of heteroscedasticity because the value of Sum Squared Residual Weighted Statistics <Sum Squared Residual Unweighted Statistics. The results of the autocorrelation test are seen from the Durbin Watson Statistics (DW) value where in all four models there are autocorrelation problems. However, the model already uses GLS (Generalized Least Square) weighting cross section weights so that the problem of heteroscedasticity and autocorrelation can be overcome.

4. Estimated Results

Table 4. Estimation Results of Rice, Maize and Soybean Prices using the Fixed Effect Model

Variabel	Rice		Maize		Soybean	
	Koef	Prob	Koef	Prob	Koef	Prob
LnProd	-0.0255*	0.0006	-0.0328*	0.0110	-0.0185*	0.0011
LnPrecip	0.0066*	0.0405	0.0053	0.2619	-0.0013	0.8402
Dummy El Nino	0.0367*	0.0032	-0.0370**	0.0575	0.0680*	0.0000
Dummy La Nina	0.0149*	0.0293	-0.0048	0.7294	-0.0051	0.7237
LnPDRBRiil	0.6465*	0.0000	0.5034*	0.0000	0.8574*	0.0000
C	-1.4627	0.0071	0.6447	0.1640	-4.8260	0.0000
R^2	0.9332		0.6408		0.8522	

Note: *: Significant at 1% level. **: Significant at the 10% level

Based on the model estimation, all variables significantly influence the rice price model at the real level of 1%. An increase in rice production by 1% will reduce rice prices by 0.0255%. The precipitation coefficient value of 0.0066 shows that when there is an increase in rainfall of 1 percent, it will increase the price of rice by 0.0066%. This happens because the increase in rainfall has the potential to be accompanied by an increase in the intensity of disturbance in plant pests that disturbs plant growth so that rice production decreases and prices are pushed up. The price of rice when the El Nino occurs is greater than the price of rice when there is no El Nino occurring with a price difference of 0.0367%. The emergence of the El Nino phase causes rainfall to be below normal or even to the point of drought which will certainly affect rice production and reduce rice supply in the market. The price of rice when La Nina occurred was greater than the price of rice when La Nina did not occur with a price difference of 0.0149%.

Corn production has a significant effect on corn prices where an increase in corn production by 1% will reduce the price of corn commodity consumer level by 0.0328%. The price of corn at the time of El Nino is lower than the price of corn when there is no El Nino with a difference of 0.037%. These results contradict the research hypothesis that when El Nino occurs it will increase food prices. The argument to support the difference between the hypothesis and the results of the study is that corn plants do not need much water in their growth period so that the presence of El Nino actually supports the flowering season thereby increasing corn production (Anderson, Seager, Baethgen, & Cane, 2017).

Soybean production has a significant effect on soybean prices where when an increase in soybean production by 1% will reduce the price of soybean commodity consumer level by 0.0185%. El Nino dummy variable has a significant and positive effect on soybean price dependent. The price of soybean when El Nino occurred was higher than when El Nino did not occur with a difference in soybean price difference of 0.068%. This is consistent with research that found that soybean production in Maluku at the time of El Nino decreased (Santoso, 2016).

GRDP variables in all models significantly affect the price of rice, corn and soybeans. Real GDP of expenditure reflects the economic conditions and welfare of a region. One of the improvements in welfare is marked by an increase in output and an increase in purchasing power. Increased demand due to increased purchasing power will increase the price of goods. Therefore, the increased Real GRDP will increase the price of rice, corn and soybeans.

The results obtained indicate that El Nino has a significant effect on increasing rice and soybean prices as well as decreasing corn prices. While La Nina has a significant effect on increasing rice prices. In general El Nino has a greater impact on food prices than La Nina.

5. Conclusion

This study analyzes the impact of climate change, especially ENSO, on food prices in Indonesia. El Nino and La Nina affect climatic conditions in all regions of Indonesia with varying intensities. Areas that are close to the equator or the equator generally have a stronger correlation between Sea Surface Temperature (SST) and Precipitation than areas that are not close to the equator.

The ENSO phenomenon, both the El Nino phase and the La Nina phase both have an influence on food prices and horticulture, but with different magnitudes depending on the commodity. The El Nino phase affects the increase in the price of rice and soybean and lowers the price of corn. The La Nina phase affects increasing rice prices and does not affect soybean and corn prices. Based on the results of the analysis it can be concluded that rice is the commodity most sensitive to climate change because both the El Nino phase and the La Nina phase are both able to influence an increase in rice prices. In general, the El Nino phase has a greater impact on price changes than the El Nino phase.

Special attention is needed to the Indonesian region which is near the equator where the region is potentially more affected by climate change. The synergy between government institutions is needed to deal with climate change, especially to cope with regional inflation due to agricultural production shocks. More optimal outreach of the Agricultural Insurance Program as a farmer guarantee in case of crop failure, especially in areas affected by ENSO.

Suggestions that can be recommended in this study are the need for strong synergy between the government and farmers in anticipating and dealing with climate change. The government through integrated policies and programs should focus on anticipating climate change and also improve food quality through the discovery of superior seeds that are resistant to climate change, especially for rice plants that are most affected by climate change among other food crops. If food production is in a stable condition, supply shocks can be avoided so that the risk of rising prices or inflation can be minimized and can bring Indonesia to an optimal level of economic growth.

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