The Impact of Climate Change on Grape Production in Indonesia

Ambinari Rachmi Putri[1(✉)], Abd Syakur[2], and Muhardi[2]

[1] Postgraduate of Agriculture Program, University of Tadulako, Palu, Indonesia
binambinari@gmail.com
[2] Agriculture Faculty, University of Tadulako, Palu, Indonesia

Abstract. The production of Grape of Indonesia in 2017 reached 11,734 t but in 2018 it decreased by 7.39% to 10,867 t. The decline in grape production on a national scale is influenced by the amount of production in grape's central region. One of grape's central region in Indonesia that has experienced a decline in production since 2015 is Palu City. This study aimed to identify the cause of the decline of grape's production in Palu City, from the climate change perspective. The data used are annual grape's production data (ton), annual rainfall anomaly data (mm), and El Nino- La Nina existences data for 15-year. The data was processed using a quantitative descriptive method to obtain the relationship between rainfall anomalies during El Nino, La Nina, and normal years with grape's production in Palu City. The results show that there is a very strong relationship ($r = 0.86$) and the positive direction relationship between the rainfall anomaly variable and grape's production variable in El Nino period, meaning that when there is a rainfall decreasing in that period, grape's production also decreases. After that, there is a sufficient relationship ($r = 0.50$) and the positive direction relationship between them in La Nina period, meaning that when there is a rainfall increasing in La Nina period, grape's production also increases. Finally, there is a strong relationship ($r = -0.72$) and the negative direction relationship in the normal year period, meaning that when there is a rainfall increasing during Non El Nino or La Nina period, the grape production actually decreases. This result is an indication that grapes are a comodity that is sensitive to climate change. Deficit or surplus of rainfall excessively in areas that are planted with grapes, could have an impact on decreasing grape production.

Keywords: Climate Change · El Nino · La Nina · Grape · Production

1 Introduction

The grape-producing areas in Indonesia are Bali (Buleleng), East Java (Probolinggo), and Central Sulawesi (Palu City) [1]. Palu City is suitable for grape cultivation caused by it's weather and climate characteristic. Palu City has local weather characteristics which is indicated by an unimodal pattern rainfall. This pattern existence has influenced by geographical conditions and valley topography [2] and the low rainfall throughout

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the year because Palu City is a rain shadow effect where the formation of rain clouds is influenced by orographic effect [3].

Grape production in Indonesia in 2017 reached 11,734 t and in 2018 it was 10,867 t, meaning that there was a decrease in production of 7.39% [4]. The decline in grape production on a national scale is influenced by the amount of production in the central region. The decline in grape production in Palu City has occurred since 2015. Fluctuations in grape production in Palu City occur every year. The cause of this fluctuation is not known for certain, but it is strongly suspected that the dynamics of weather and climate are the causes [5].

The growth and development of grapes is highly dependent on weather and climate. Excessively increased rain and rised temperatures are able to reduce grape production [5, 6].

Climate change is one of the causes of the erratic amount of annual rainfall and air temperature recently. In addition, climate change also affects the frequent occurrence of El Nino-La Nina [7]. El Nino-La Nina is a phenomenon of deviation from sea surface temperature in the Pacific Ocean near the central and eastern equator. ENSO is a non-periodic Global Climate System. El Nino is identified through the increase in sea surface temperature in the Equatorial Pacific waters, while La Nina is the opposite condition in the same region. El Nino can cause a decrease in sea surface temperature in Indonesian waters and La Nina tends to increase sea surface temperature in Indonesian waters [8–10]. El Nino phenomenon are generally able to reduce the number of peaks of rainfall in an area, while La Nina is able to increase the number of peaks of rainfall in an area. As happened in Amahai [11]. This has an impact on the production of various types of food crops in Indonesia. In Papua Province, soybeans are the most sensitive to this phenomenon because it has the effect of decreasing production, both in El Nino conditions (10.7%) and La Nina (11.4%). Lowland rice, though this is important to be known because grape is an important economic commodity [13]. This study will examine the impact of climate change on the commodity of grape in Indonesia, especially in Palu City. The results of this study are expected to be taken into consideration by the government in planning to reduce imported grape in Indonesia and provide information for further researchers to immediately seek adaptive steps to develop smart climate-based grapes cultivation in Indonesia.

2 Methods

The type of data used in this study is secondary data and primary data. Secondary data in the form of grape production data and bulk anomaly data rain for 15 years, (from 2006 to 2020). Source of production data grape is BPS Palu City, while the source of rainfall anomaly data is Class II Meteorological Station Mutiara Sis Al Jufri which is generally cultivated in wetlands, decreased production by 2.9% in El Nino climate conditions and on the other hand production increased by 2.4% during La Nina events. Corn production decreased by 7.4% during El Nino and increased by 3.9% during La Nia. The sweet potato is the most tolerant of weather disturbances because it has the impact of a 2.5% increase in production in El Nino conditions [12].

The Impact of Climate Change especially in El Nino and La Nina perspective and their relation to grape commodities in Indonesia have never been studied, even

Palu (BMKG). The statistical method used to analyze secondary data from quantitative descriptive research is simple correlation because the objective is to find out whether there is a relationship between rainfall anomalies during El Nino, La Nina, and normal years with grape production in Palu City.

3 Result

This section will describe the results of Excel data analysis using a simple correlation method between grape production (tons) and rainfall anomalies (mm) in the period 2006

Table 1. Weather disturbances, Grape Production and Rain in Palu City 2006–2020

Period	Weather Disturbances	Productiom (Ton)	Rain Rate (mm)	Rain Anomaly (mm)
2006	El Nino	5	600,6	-132,2
2007	La Nina	390	948,9	216,1
2008	La Nina	2415	949,1	216,3
2009	El Nino	167	562,8	-170,0
2010	La Nina	299,9	863,8	131,0
2011	La Nina	13,1	668,9	-63,9
2012	Normal	28,4	750,5	17,7
2013	Normal	51	905,7	172,9
2014	Normal	632	705,1	-27,7
2015	El Nino	149	492,7	-240,1
2016	La Nina	87	658,1	-74,7
2017	La Nina	98	860	127,2
2018	Normal	129	584,5	-148,3
2019	El Nino	329	921,6	188,8
2020	La Nina	199	934,3	201,5
Jumlah		**4992,4**	**11406,6**	**415,3**
Rata-rata		**332,8**	**760,4**	**27,7**

Table 2. Grape Production, Rainfall and El Nino Characteristics for the Period 2006–2020

Period	Production (Ton)	Rain Anomaly (mm)	Rain Characteristic	Type of El Nino
2006	5	-132,2	BN	EL
2009	167	-170,0	BN	EK
2015	14,9	-240,1	BN	EK
2019	**329**	**188,8**	**AN**	**EL**

Table 3. Grape Production, Rainfall and La Nina Characteristics for the Period 2006–2020

Period	Production (Ton)	Rain Anomaly (mm)	Rain Characteristic	Type of El Nino
2007	390	216,1	AN	LK
2008	2415	216,3	AN	LK
2010	299,88	131,0	AN	LK
2011	**13,1**	**-63,9**	**N**	**LM**
2016	**8,7**	**-74,7**	**N**	**LL**
2017	0,3	127,2	AN	LM
2020	199	201,5	AN	LM

Table 4. Grape Production, Rainfall and Normal Year Characteristics for the Period 2006–2020

Period	Production (Ton)	Rain Anomaly (mm)	Rain Characteristic
2012	28,4	17,7	N
2013	**52,5**	**172,9**	**AN**
2014	63,2	-27,7	N
2018	**129**	**-148,3**	**BN**

to 2020 in 3 cases. The first to third cases in a row are rain during El Nino, during La Nia, and during normal years. Table 1 contains weather disturbances, the amount of grape production (tons), the amount of rain (mm), and rain anomalies (mm) in Palu City for the period 2006 to 2020.

Based on the calculation of the correlation value between production (tons) and rainfall anomaly (mm) during the El Nino period in the 2006–2020 period, the result of r is 0.862775976, which means that the correlation is very strong. A positive value for r indicates a unidirectional correlation between rainfall and production anomalies. Table 2 shows that there were outliers in 2019, namely even though El Nino occurred in 2019, the amount of rainfall that year actually increased to above normal. This is indicated by the rainfall anomaly value of 188.8 mm and the nature of the rain AN (Above Normal). The El Nino weather disturbance that occurred in 2019 was a Weak El Nino. This shows that when a weak El Nino hit Indonesia in 2019, the local weather system in Palu was stronger than this weak El Nino (EL), so the impact of decreasing rainfall did not occur in Palu City (Appendix 8). From Table 2, it can also be seen that the El Nino weather disturbance which has an impact on a significant decrease in rainfall in Palu City so that the annual rainfall is below normal (BN), generally is El Nino with a strong intensity (EK).

Furthermore, in La Nina period, based on the calculation of the correlation value between production and rainfall anomalies during the La Nina period in the 2006–2020 period, the result of r is 0.495034577 which means a sufficient correlation. A positive

value for r indicates a unidirectional correlation between rainfall and production anomalies. Outliers also occurred during this period. Table 3 shows that the 2011 Moderate La Nina (LM) and the 2016 Weak La Nina (LL) caused a decrease in rainfall of -63.9 mm and -74.7 mm, respectively. This negative sign means that the rainfall in La Nina 2011 and La Nina 2016 did not increase and actually decreased. However, this decrease is still included in the normal category because the nature of the rain in 2011 and 2016 was still within the normal threshold (N). From Table 3 it can also be seen that the La Nina weather disturbances that have an impact on a significant increase in rainfall in Palu City so that the nature of the rain becomes above normal (AN), generally are La Nina with Moderate (LM) and Strong (LK) intensity.

Based on the calculation of the correlation value between production and rainfall anomalies in a normal year during the 2006–2020 period, the result of r is - 0.717503822 which means a strong correlation. A negative value for r indicates a non-unidirectional correlation between rainfall and production anomalies. This means that when rainfall increases in a normal year, there is a decrease in grape production, while when rainfall decreases in a normal year, there is an increase in grape production. Outliers that occurred in normal years occurred in 2013 and 2018. This can be seen from the nature of the rain which is classified as Upper Normal (AN) and below normal (BN). This outlier occurred due to other weather disturbances such as tropical cyclones, so that although these years were classified as undisturbed by El Nino and La Nina weather disturbances, the presence of other weather disturbances made the rainfall value higher in 2013 and lower in 2018. (Appendix 8).

Rainfall anomaly data from Tables 2, 3, and 4 are evidence that Palu City has 'Local' weather characteristics. This is indicated by not every El Nino period causing negative anomalies or a significant decrease in rainfall, and not all La Nina periods causing positive anomalies or significant increases in rainfall, because sometimes the 'local' weather system that Palu City has is stronger. compared to the intensity of El Nino and La Nina weather disturbances that hit.

4 Conclusion

Successively there is a very strong, moderate, and strong relationship between rainfall anomalies during El Nino, La Nina, and normal years weather disturbances on grape production in Palu City. These mean that when there is a rainfall decreasing in El Nino, grape's production also decreases; when there is a rainfall increasing in La Nina period, grape's production also increases; when there is a rainfall increasing during Non El Nino or La Nina period, the grape production actually decreases. This result is an indication that grapes are a comodity that is sensitive to climate change. Deficit or surplus of rainfall excessively in areas that are planted with grapes, could have an impact on decreasing grape production.

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