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IMPACT OF CLIMATE CHANGE ON THE EXPORT OF PALM OIL, COFFEE BEANS, AND COCOA BEANS

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Abstract: Climate change is believed to impact the economy of a country. The production of food crop commodities is one of the activities that is negatively impacted by the climate change and the volume of exports. Palm oil, coffee beans, and cocoa beans are the agricultural sector's leading commodities with high competitiveness in international markets and contribute significantly to exporting countries' economies. This research aims to determine the impact of climate change (changes in the annual average temperature and total annual precipitation) on the exports of the three commodities. This study uses secondary data from various sources. The data were analyzed using panel data regression analysis. The result shows that temperature and precipitation variables have different effects on the three commodities. Temperature and precipitation variables have a significant adverse impact on coffee bean exports. In contrast, temperature and precipitation variables positively affect palm oil exports. Meanwhile, for cocoa beans, only the precipitation variable positively affects export. Adaptation action by introducing climate varietas is important to maintain future exports of those commodities.

Keywords: precipitation, panel data, leading commodities, climate change, agricultural sector's

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Abstrak: *Perubahan iklim diyakini berdampak pada perekonomian suatu negara. Produksi komoditas tanaman perkebunan berpotensi mendapat dampak negatif dari perubahan iklim sehingga mempengaruhi volume ekspor. Komoditas kelapa sawit, kopi, dan kakao merupakan komoditas unggulan sektor pertanian yang memiliki daya saing tinggi di pasar internasional dan memberikan kontribusi yang besar terhadap perekonomian negara-negara pengekspor. Penelitian ini bertujuan untuk menganalisis sdampak perubahan temperatur rata-rata tahunan dan total curah hujan tahunan terhadap ekspor ketiga komoditas tersebut. Penelitian ini menggunakan data sekunder dari 25 negara pengekspor dari tahun 1990-2019. Metode analisis yang digunakan adalah model regresi data panel. Hasil penelitian menunjukkan bahwa variabel suhu dan curah hujan memiliki pengaruh yang berbeda terhadap ekspor ketiga komoditas tersebut. Variabel suhu dan curah hujan berpengaruh signifikan negatif terhadap ekspor biji kopi, namun sebaliknya berpengaruh positif terhadap ekspor kelapa sawit. Adapun pada bijikakao, hanya variabel curah hujan yang berpengaruh positif terhadap ekspor. Aksi adaptasi dengan pengembangan varietas yang tahan perubahan iklim harus dilakukan untuk menjamin ekspor ketiga komoditas di masa yang akan datang.*

Kata kunci: *curah hujan, data panel, komoditas unggulan, perubahan iklim, sektor pertanian*

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INTRODUCTION

Based on a report issued by the Intergovernmental Panel on Climate Change (IPCC), Fifth Assessment Report (AR5) in 2014, global temperature increased by 0.85°C on average from 1880 to 2012. The same thing can also be found in a report issued by the National Oceanic and Atmospheric Administration (NOAA) in 2020; global temperature increased by 0.08°C per decade since 1880 and more than doubled by 0.18°C per decade from 1981 to 2019. On the other hand, rainfall patterns in various parts of the world are also changing with different variations in each country. These two indicators explain the phenomenon of climate change, which is believed to impact various sectors of the economy, especially in developing countries (European Parliament, 2007).

One of the sectors with the highest vulnerability level is agriculture (Paterson et al. 2015, Jones and Olken's, 2010) Countries in Africa, America, and Asia are very dependent on the agricultural sector in driving the economy through export activities to global markets (Barua and Valenzuela, 2018). But on the other hand, the current climate change phenomenon is one of the factors that can hinder developing countries' efforts to increase exports to stimulate the domestic economy. One of them is exporting palm oil commodities, coffee beans, and cocoa beans.

Based on table 1, it can be seen that from 1990 to 2019, the majority of countries with the highest export volumes were developing countries in Asia, Africa, and America, such as Indonesia, Brazil, and Ivory Coast. Indonesia and Malaysia are the two countries that control the palm oil market share globally, with a value reaching 80% of the total world trade. Meanwhile, Brazil, Viet Nam, and Colombia own more than 50% of coffee bean exports globally. Apart from these three countries, Ethiopia and Indonesia are also the largest exporters of coffee beans. Meanwhile, Ivory Coast, Ghana, and countries in the West African region have more than 70% export share for cocoa beans (FAOSTAT, 2021). The climatic conditions in most developing countries spread across the three regions support cultivating these three plants. However, climate change has affected production levels in several producing countries (European Parliament, 2007). This will ultimately affect each country's exports to the global market.

Jones and Olken's (2010) research shows that warmer temperatures in developing countries harm export growth. 1°C warmer temperatures can reduce exports by 2.1% to 5.7% in developing countries, and no negative impact is found in developed countries. This is in line with what was seen by Barua and Valenzuela (2018); an increase in temperature of 1°C will significantly reduce the volume of exports from the Asian and African regions, most of which are poor and developing countries. Furthermore, Pascasio et al. (2014) research show that countries with tropical and sub-tropical climates have a worse impact than countries with colder temperatures. In a study conducted by Li et al. (2015), it was explained that warmer temperatures at the domestic level in China caused the number of exports from areas that experienced an increase in temperature to decrease while increasing annual rainfall had a positive effect on export volume from areas that experienced an increase in rainfall intensity. In addition, climate change also impacts the intensity of extreme climate events, such as prolonged dry seasons and flash floods, which occur in various countries with different consequences. As in the research conducted by Tembata and Takeuchi (2019), extreme climatic events that occurred in multiple countries in Southeast Asia resulted in a decrease in export volume by 3% to 5%.

The empirical study of the relationship between climate change and the economy, particularly exports, is interesting to re-examine, especially with the many reports issued by various agencies regarding the impact that can be caused if there are no severe steps in dealing with climate change problems. From several studies that have been conducted, there are still few that discuss the impact that climate change can have on the exports of plantation crops. Based on the formulation of the problem that has been stated, the objectives of this study are to: Analyze the export performance of the three commodities to the global market and the determinants that affect the export performance of the three commodities to the global market for the period 1990 to 2019

METHODS

This study uses data from 25 exporting countries for each commodity from 1990 to 2019. This study uses secondary data in the form of a data panel. Sources of data used in this study were obtained from various

sources. The analytical method used in this study is panel data regression analysis. Panel data regression is done by performing several stages of analysis. Panel data regression analysis uses three trial methods to select the best model. This study determined that the method used was ordinary least square (OLS) with a fixed-effect model.

The variables in the equation model are based on several previous studies (Jones and Olken, 2010; Pascasio et al. 2014; Li et al. 2015; Barua and Valenzuela, 2018), with some modifications to several variables taking into account the availability of data (Table 1). In this study, panel data regression analysis was carried out on the exports of the three commodities in the plantation sub-sector.

The empirical model used:

$$\ln Y_{ijt} = a_0 + a_1 \ln TEMP_{it} + a_2 \ln PREC_{it} + a_3 GDP_{it} + a_4 \ln PROD_{it} + a_5 \ln HRV_{it} + a_6 DElNino_{it} + e_{it}$$

Description: $\ln Y_{ijt}$ (export of commodity i (palm oil, coffee beans, and cocoa beans) to country j in year t (million tons); $\ln TEMP_{it}$ (average temperature (annual) in country i in year t); $\ln PREC_{it}$ (total rainfall (annual) in country i in year t); GDP_{it} (GDP growth value in country i in year t); $\ln PROD_{it}$ (production of commodity i in country j in year t (million tons)); $\ln HRV_{it}$ (planted area of commodity i in country j in year t (million hectares)); $DElNino_{it}$ (variable dummy phase El Nino (1 if occurs El Nino, 0 if normal)); a_0 (constant (intercept)); a_1- a_6 (predicted parameter); e_{it}(error normally distributed).

The framework of thought in this study can be seen in Figure 1. The amount of exports of exporting countries of the three commodities to the global market from 1990 to 2019 has changed. Changes in the exports of the three commodities are influenced by climate changes that can be seen through warmer temperatures and changes in rainfall in various countries. In addition, other factors affect the export of the three commodities to the global market during the study period.

Table 2. Variables and Data Sources

Variables	Description	Source
Y	Exports of the three commodities 1990-2019 (million tons)	Food and Agriculture Organization
Temperature	The average temperature in each country 1990-2019 (°C)	Climate Change Knowledge Portal
Precipitation	Total annual precipitation in each country 1990-2019 (mm)	Climate Change Knowledge Portal
GDP	Economic growth in each country 1990- 2019 (%)	World Bank
Production	Production in each country 1990-2019 (million tons)	Food and Agriculture Organization
Harvested Area	Planted area in each country 1990-2019 (million hectares)	Food and Agriculture Organization
Dummy	El Nino year (1 = year El Nino, 0 = year without El Nino)	National Oceanic and Atmospheric Administration

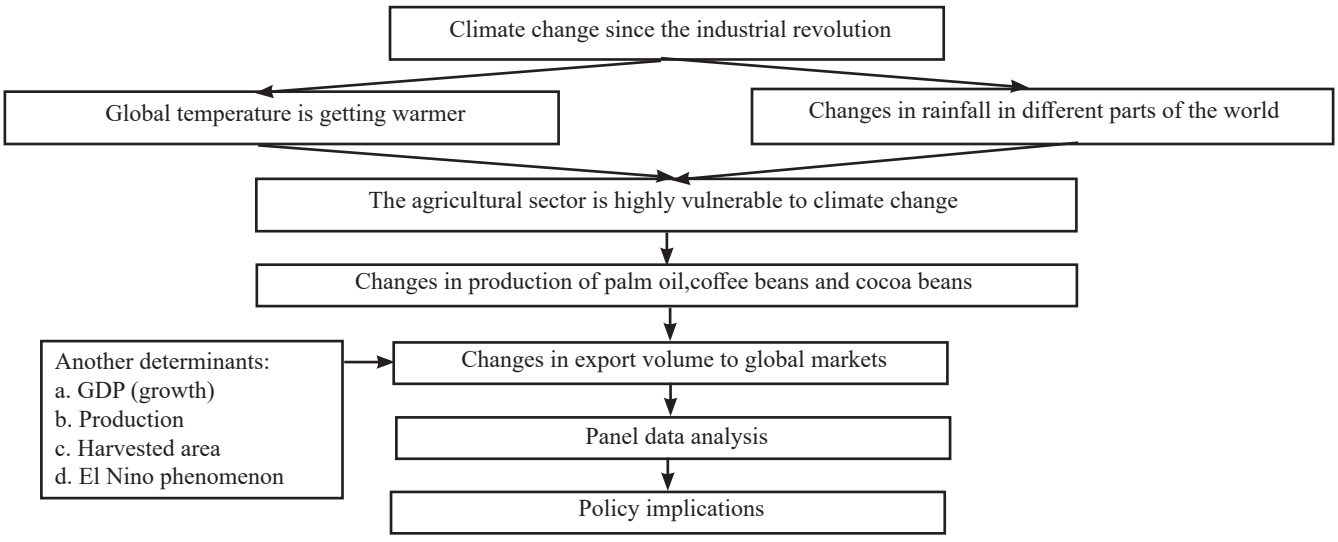

Figure 1. Research framework

RESULTS

The Export Development of the Three Exporting Countries' Commodities to the Global Market

In Figure 2. it can be seen that the total exports of palm oil to the global market had an increasing trend during the study period. In 1999, palm oil exports recorded the highest growth during the study period; palm oil exports increased from 8.8 million tons to 11.8 million tons or grew 33.78%. That year, the increase in exports was primarily due to palm oil exports from Malaysia and Indonesia to the global market. Palm oil exports from Malaysia grew 16.92%, while palm oil exports from Indonesia grew 123%. Palm oil export determine by its production, that can be influenced by climate (temperature, presipitation, rainfall) and demand from importing countries.

In 1998, overall palm oil exports experienced the most significant decline during the study period. This was caused by El Nino's phenomenon that occurred in 1997-1998, which caused palm oil production in some exporting countries to decline. During that period, overall palm oil exports fell by 14,32%. In the same period, Indonesia's palm oil exports to the global market were reduced by 50%, and this was due to the decline in domestic palm oil production of more than 600 thousand tons. The same thing happened to Malaysia. The phase El Nino that occurred had an impact on reducing palm oil production at the domestic level by 8.03%.

The phenomenon of El Nino that happened again in 2015-2016 also impacted overall palm oil exports. In El Nino's worst period since the last 20 years, overall palm oil exports fell to 5.2 million tons or grew negatively by 11.38%. During this period, palm oil exports from Indonesia and Malaysia fell by 14.1% and 10.5%, respectively. The amount of exports from Malaysia and Indonesia greatly affects the total palm oil exports to the global market because these two countries own the global palm oil market share with a value reaching 75–80% (FAOSTAT, 2021).

From 1990 to 2019, coffee bean exports from exporting countries to the global market have grown by 62.39%. El Nino's phenomenon that occurred in 1994 caused coffee bean exports to the global market to record the most significant negative growth during the study period. In that year, coffee bean exports to the global market recorded negative growth of 6,88%. In the same year, exports from Brazil fell from 871.000 tons to 720,000 tons (-17.19%), exports from Colombia fell 114,000 tons (-17.03%), exports from Indonesia recorded the most prominent negative growth (-20.38 %), and Ethiopia also experienced the same thing. Only Viet Nam recorded positive growth (40.65%) in the year. Two years later, coffee bean exports recorded immense growth during the study period. In that year, coffee bean exports to the global market increased by 600 thousand tons or grew by 17.45%. Of the five largest exporting countries to the global market, Indonesia became the country with the highest coffee bean export growth that year. Exports of coffee beans from Indonesia to the global market increased from 230,000 tons to 366,000 tons or grew 59.29% (FAOSTAT, 2021).

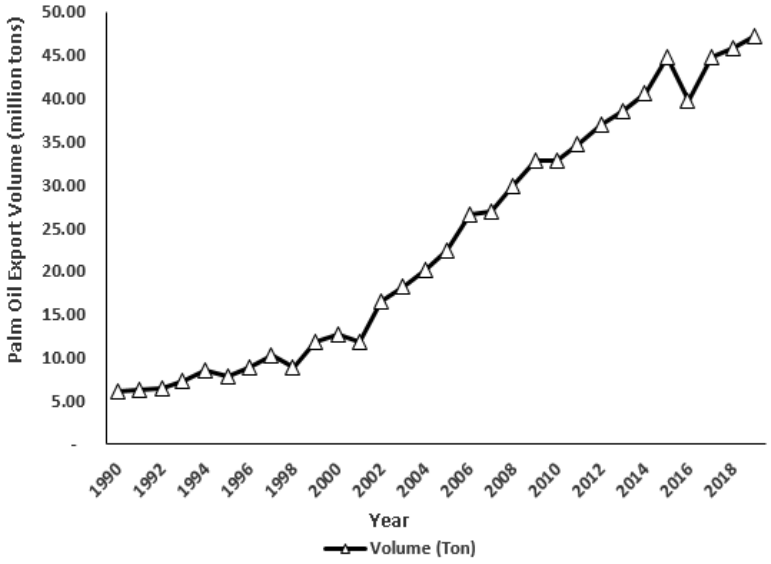

Figure 2. Total palm oil exports of exporting countries to international markets 1990-2019

Based on Figure 3. it can be seen that the movement of cocoa beans exports to the global market is much more volatile than the other two commodities. In 1997, cocoa bean exports recorded the highest negative growth during the study period during El Nino year. In that year, cocoa bean exports fell from 2.3 million tons to 1,8 million tons or grew negative 19.14%. This was influenced by the decline in cocoa bean exports from major exporting countries such as, Ivory Coast (-5.77%), Cameroon (-24.20%), Ghana (-45.17%), Nigeria (-17.65%), and Indonesia (-19.82%). The phenomenon of El Nino that occurred again in 2015-2016 also impacted the decline in cocoa bean exports to the global market. During this period, cocoa bean exports from countries in the African region recorded a growth of -16,30% overall. Ghana became the country with the highest negative growth record compared to other countries in that period. Cocoa bean exports from Ghana decreased to 320 thousand tons or decreased by 32.49% (FAOSTAT, 2021).

Parameter Estimation Results on Research Models
The impact of climate change on exports of palm oil commodities

In the test results, the estimation of the variable temperature has a significant effect on exports of oil palm commodities with a probability value of 0.0004 or significant at the one percent level of significance. The coefficient value of the variable temperature is 0.5884. When there is an increase in temperature of one percent, it will increase exports of palm oil commodities to the global market by 0.59% (ceteris paribus). Cadena et al. (2006) state that much warmer temperatures are the most productive conditions for palm oil. Warmer temperatures allow oil palm trees to produce more leaves, increasing oil palm fruit produced from these trees (Wen and Sidik, 2011). Still, in the same study, the authors explain that rising temperatures in oil palm producing countries can increase oil palm production from these countries as long as the temperature increase is still within reasonable limits. In addition, increasing temperatures may make the higher elevations of oil palm-producing countries, such as Indonesia and Malaysia, more suitable for oil palm cultivation (Paterson et al. 2015). Increasing oil palm plantation land in producing countries has led to domestic oil palm production.

Meanwhile, the variable precipitation has a significant positive effect on palm oil exports. Based on table 3, each increase in the variable precipitation by one percent increases palm oil exports by 0.18%. One of the most decisive factors for oil palm yields is water availability in the soil, highly dependent on rainfall. A study conducted by Fleiss et al. (2017) explained that palm oil production tends to increase when the total rainfall in producing countries increases. An increase in the production of a commodity at the domestic level is followed by the rise in exports of that commodity to the global market (Ferguson and Gars, 2017).

In terms of climatic conditions, most exporting countries have a suitable climate. The research of Paterson et al. (2015) explained that the optimum temperature level to support optimal oil palm yields is between 24°C-33°C, while the total annual rainfall is 2,500-3,000mm. However, warmer global temperatures and changing rain patterns in various countries can change these conditions. Paterson et al. (2015) state that climate change that occurs can affect the sustainability of the palm oil industry in producing countries. Therefore, adaptation is necessary for various countries to minimize the impact of climate change.

Through the Malaysian Palm Oil Board (MPOB), Malaysia has been developing varieties of clonal palm series since the early 1980s, varieties that can produce up to 30 tons of palm oil per hectares per year and has a higher resistance to pests and diseases. Malaysian palm oil production has grown an average of 4.28% per year since the early 1990s (FAOSTAT, 2021). Like Malaysia, Indonesia as the ruler of the global palm oil market is also taking adaptation steps to reduce the impact of climate change. In 2009, the Indonesian Oil Palm Research Institute (IOPRI) developed the variety, DxP 540 NG, further developing the variety DxP. This variety can produce oil palm up to 35 tons per hectare per year and has a disease incidence index value of less than 70%, making it more resistant to Ganoderma, which often attacks oil palm trees. In the future, the availability of superior varieties must be ensured that they are also available to smallholders. The ease of access for smallholders will significantly affect future oil palm production. Based on data from the United States Department of Agriculture (2021), the average growth of Indonesian palm oil production over the last ten years grew 11.74% per year, higher than 2000-2009. In the same period, Indonesia's palm oil exports to the global market averaged 22.5 million tons per year or grew 4.85% per year.

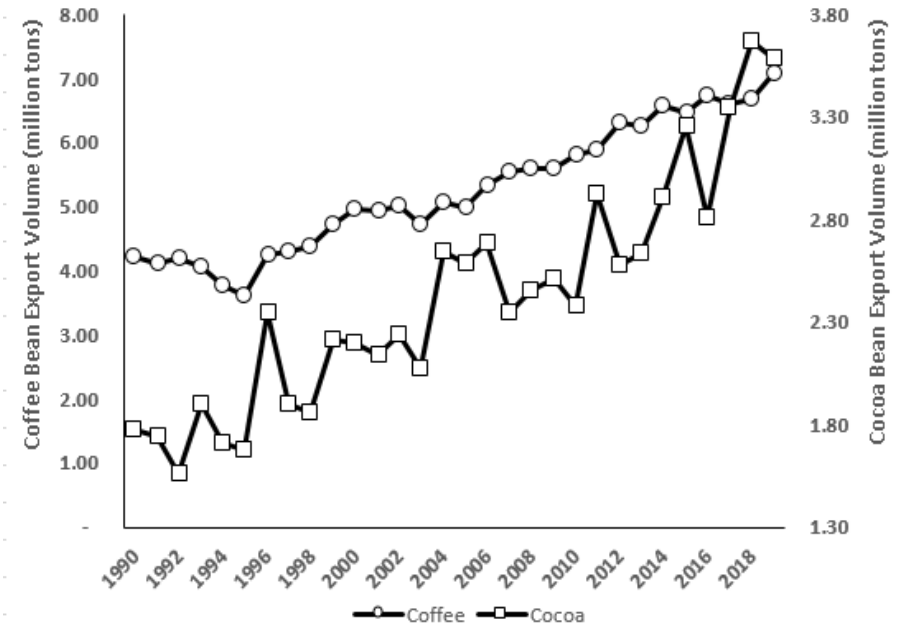

Figure 3. Total exports of coffee beans and cocoa beans from exporting countries to international markets 1990-2019

The impact of climate change on coffee bean exports

Different results were found for the coffee bean commodity. In the estimation test results, the variable temperature significantly affects the export of coffee beans to the global market with a coefficient value of -0.5603 (Table 3). This shows that when there is an increase of one percent, food will reduce exports by 0.56% (ceteris paribus). Warmer temperatures are associated with the emergence of various diseases that attack plants, as in a study conducted by Jaramillo et al. (2009), the temperature increases from year to year, followed by an increase in the population of "berry borer", the increasing population of "berry borer" has an impact on the reduced production of Colombian coffee beans. Meanwhile, the variable precipitation shows different results for the coffee bean commodity. In the estimation test results, the variable precipitation significantly affects coffee bean exports with a coefficient value of -0.1141. This shows that when there is an increase in rainfall by one percent, the export of coffee beans will be reduced by 0.12% (ceteris paribus). The research of Almeida Silva et al. (2020) explained that increased rainfall in coffee bean-producing countries was associated with a prolonged rainy season to floods which ultimately harmed coffee bean production from these countries. Koh et al. (2020) explained that the optimum temperature for optimal production results is between 18°C to 24°C, while the total rainfall is in the range of 1.200mm-1.800mm. Based on data from CCKP (2021), four of the five largest exporting countries in the world have temperature levels above the optimum temperature level, such as Brazil (25.48°C), Viet Nam (24.61°C), Colombia (24.77°C). C), and Indonesia (26.13°C). Meanwhile, 60% of exporting coffee beans have rainfall levels outside the optimum range.

Based on a report issued by the Sustainable Coffee Challenge (2019), much warmer temperatures and decreased annual rainfall over the last 20 years have reduced coffee bean production by up to 20%. One of the most affected areas is Minas Gerais, Brazil's largest coffee-producing region. Lower yields, limited knowledge about climate change, inadequate infrastructure, and difficulty in accessing capital credit for smallholders are factors that make the area highly vulnerable to climate change. Through the National Program to Strengthen Family Farming (PRONAF), the Brazilian government has provided loans to small farmers to make it easier to receive additional capital, but in reality, access to loans is too complicated (Assuncao and Souza, 2018).

Table 3. The results of an empirical model estimate using a fixed effect model

Variable	Palm Oil		Coffe Beans		Cocoa Beans	
	Coeff	Prob	Coeff	Prob	Coeff	Prob
C	-12.3206	0.0000	2.2764	0.0025	-2.4333	0.6956
InTemperature	0.5884*	0.0000	-0.5603*	0.0001	-0.5844	0.1799
InPrecipitation	0.1784*	0.0000	-0.1141*	0.0000	0.0474**	0.0345
GDP	-0.0063	0.342	0.0033*	0.0000	0.0020**	0.0129
InProduction	1.2876*	0.0000	0.8660*	0.0000	0.2026*	0.0000
In Harvested	0.4475*	0.0000	0.1206*	0.0000	0.6610*	0.0000
Dummy	-0.0163**	0.0447	0.0213*	0.0000	-0.0435*	0.0003
R-squared	0.9977		0.9793		0.9959	
Prob (F-statistic)	0.0000***		0.0000***		0.0000***	
Countries	25		25		25	
Observations	750		750		750	

Description: Significant at level 1% (*); Significant at level 5% (**); Significant at level 10% (***)

In addition, the development of coffee seed varieties that are more resistant to climate change has also been developed in Brazil. However, this variety is still limited to plantations managed by the private sector, while 70% of coffee plantations in Brazil are run by small farmers who produce 40%-50% of national production. Based on data obtained from FAOSTAT (2021), coffee bean production in Brazil has tended to decline in the last 20 years. In the 2010-2019 period, Brazil's average coffee bean production growth was 3.12%, down from the 2000-2009 period of 6.21%. The decline in coffee bean production caused Brazil's coffee bean exports to the global market to decline in the same period. During the last ten years, the average export growth of coffee beans decreased from 3.83% to 3.65%. This finding is in line with the research results by Jones and Olken (2010), commodity exports in the agricultural sector are very vulnerable to climate change.

The impact of climate change on the export of cocoa beans

In the estimation test results, the variable precipitation significantly affects exports of cocoa beans with a probability value of 0.0000 or significant at one percent level. The coefficient value of the variable precipitation is 0.0474, and when there is an increase in precipitation of one percent, it will increase the export of cocoa beans to the global market by 0.047% (ceteris paribus). Koissy et al. (2020), in their research, explains that the increased annual rainfall in cocoa bean producing countries has a positive impact on production, this is in line with research conducted by Ofori-Boateng (2014), which states that increased rainfall in cocoa bean producing countries in the West African region has a positive impact on the production of cocoa beans at the domestic level. This is because most cocoa bean plantations in West Africa have not been equipped with a qualified irrigation system. They are very dependent on sufficient rainfall throughout the year. The same study explains that the optimum temperature to support good production results is between 1,100mm to 3,000mm without being accompanied by a dry season of more than three months and rainfall of 100mm per month. Increased cocoa bean production in producing countries has a positive effect on the volume of cocoa bean exports from that country to the global market (Wardhany and Adzim, 2018)

Around 70% of the world's cocoa is grown in West Africa, most of the plantation land is run by small farmers who have less than two hectares of land and are highly vulnerable to climate change. The Government of Ghana, since 2013 through The Ghana Cocoa Board (COCOBOD), has planted 50 million cocoa seeds that were then distributed to small farmers and provided free fertilizer to encourage crop yield growth. In Coulibaly and Erbao's (2019) study, fertilizers in the right amount significantly affect cocoa bean yields. In addition, the application of shade management can also minimize the impact of climate change. Most cocoa plantations in the Ivory Coast (13% of total agricultural land) are planted with banana trees. Taller and broadleaf banana trees can protect cocoa trees from excessive sun exposure to support the early stages of growth of cocoa trees, and it has even been proven that cocoa bean production has increased by more than 50% even during a prolonged period of the dry season. This program is supported and funded directly by the Cocoa Coffee Council with the

2QC Sustainability Program (FAO, 2018). In addition, the use of hybrid varieties of cocoa beans is also an adaptation to minimize the impact of climate change. Such as the variety CCN-51, which cocoa farmers in Ecuador mostly use. A report from the United States Department of Agriculture in 2010 stated that 36% of cocoa bean production in Ecuador uses the variety CCN-51. This variety has higher productivity so that it produces more cocoa beans, besides that, this variety is also more resistant to diseases or pests and current climatic conditions. The average production of cocoa beans in Ecuador over the last ten years is 185,000 tons, with an average growth of 12.09% per year. In the same period, cocoa bean export growth increased from 8.48% to 9.07% (FAOSTAT, 2021)

The impact of GDP on the exports of the three commodities

In the test results, the estimated variable *GDP* significantly affects exports of coffee beans and cocoa beans with a coefficient value of 0.0033 and 0.0020. This shows that a GDP growth of one percent will increase the export of coffee beans by 0.0033% (ceteris paribus). Meanwhile, every one percent increase invariable GDP will increase cocoa bean exports successively by 0.0020% percent (ceteris paribus). This finding is supported by previous research that an increase in GDP can encourage an increase in output and a reduction in costs that can promote an increase in exports (Barua and Valenzuela, 2018).

The impact of production on the exports of the three commodities

In the test results, the estimation of the production variable has a significant effect on the exports of the three commodities at a significant level of one percent, with a coefficient value of 1.2876 for oil palm commodities, 0.8660 for coffee and 0.2026 for cocoa beans. This shows that when the production of the three commodities at the domestic level increases by one percent, it will increase exports to the global market by 1.29%, 0.87%, and 0.20% (ceteris paribus). This increase occurred because exporting countries could export more with the increase in production of the three commodities. This finding is supported by research by Ferguson and Gars (2017), which states that increased production in the agricultural sector in exporting countries is followed by an increase in the volume of exports from exporting countries to the global market.

The impact of the planted area on the export of the three commodities

The variable of plantation area has a positive effect on exports of the three commodities with coefficients of 0.4475 (oil palm), 0.1206 (coffee beans), and 0.6610 (cocoa beans). This means that every one percent increase in the area of agricultural land in a country will increase exports of the three commodities respectively by 0.45%, 0.12%, and 0.66%. In other words, the wider the plantation area of the three commodities in a country, the greater the production yield, and its exports can increase. These results follow Hakiki and Asnawi's (2019) research that land area has a positive and significant influence on exports. In addition, the rejuvenation of low-yielding plantations is one of the policies taken by local authorities to increase land productivity with the main objective of increasing exports of these commodities.

The impact of the phenomenon *El Nino* on the exports of the three commodities

The variable dummy El Nino has a significant and negative effect on the exports of the three commodities. The coefficient values for the variable El Nino dummy are -0.0163 (palm oil), -0.0213 (coffee beans), and -0.0435 (cocoa beans), which means that exports of the three commodities during El Nino are smaller than exports when there is no El Nino with a difference of 0.0163% to 0.0435% for the three commodities (ceteris paribus). During the last two decades, the phenomenon El Nino that occurred in the period 2009 and 2015 negatively impacted the yields of various agricultural commodities, including oil palm, coffee beans, and cocoa beans. This is in line with the findings in Silva et al. (2020) study, which states that coffee bean yields in Brazil experience a more significant decline when there is a phenomenon El Nino, such as in 2009. El Nino years are associated with much warmer temperatures and lower coffee bean production. Apart from the much warmer temperatures, reduced water reserves are also the cause of coffee bean production in years which is El Nino much smaller. During an El Nino year, the average monthly rainfall in Brazil's largest coffee bean-producing areas decreased. If referring to data from FAOSTAT (2021), coffee bean production in Brazil in 2009 decreased by 12.76%. Still, Brazil's coffee bean exports to the global market also recorded negative growth in the same period.

The negative impact of El Nino's phenomenon in the last two decades can also be found in cocoa beans. The research of Hutchins et al. (2015) stated that in El Nino, the temperature in cocoa bean-producing countries became warmer. Warmer temperatures cause a decrease in soil moisture levels and a decrease in soil fertility in Ghana, making cocoa bean trees more susceptible to pests and diseases that cause the death of cocoa trees, which in turn causes the level of cocoa bean production at the domestic level to decline. During El Nino's phase, the long dry season and decreased rainfall in Ivory Coast caused crop yields to experience a more significant decline than in years without El Nino (Ouedraogo et al. 2018). From 2015 to 2016, cocoa bean production in Ivory Coast decreased by 10%. This caused exports to fall to 230 thousand tons (FAOSTAT, 2021). Meanwhile, the El Nino phenomenon that occurred in 1997 also impacted reducing palm oil production at the domestic level in Malaysia (Azlan et al. 2016). During that period, palm oil production fell to 700 thousand tons. The same thing was experienced by Indonesia, which ultimately caused palm oil exports in that period to fall by 14.32% overall (FAOSTAT, 2021).

CONCLUSIONS AND RECOMENDATIONS

Conclusions

The analysis results indicate that climate change that occurs has a different impact on each commodity. Through proper adaptation, palm oil exports to the global market are still growing, as with cocoa bean exports. Meanwhile, coffee bean exports declined because coffee beans were more vulnerable to climate change. Changes in temperature levels increase exports of palm oil commodities and reduce exports of coffee beans from exporting countries. Meanwhile, the amount of rainfall increases exports of palm oil and cocoa beans while reducing exports of coffee beans to the global market. This study shows that production and export volume of palm oil, coffee and cocoa are influenced by climate change. Adaptation actions to climate change by developing varieties that are resistant to changes in temperature and precipitation must be taken to maintain export targets in the future.

Recommendations

For further research, the authors suggest using monthly data if it is available in the future to see the impact in more detail. In addition to further research, other climatic variables such as duration of sunshine, humidity, and wind speed can be added if data is available for each country. In addition, it can add technology-level variables to see the adaptations that have been made in each country in the face of climate change that occurs.

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REFERENCES

[CCKP] Climate Change Knowledge Portal for Development Practitioners and Policy Makers. 2021. https://climatechangeknowledgeportal.worldbank.org. [28 Nov 2021].

[FAOSTAT] Food and Agriculture Organization of the United Nations. 2021. https://www.fao.org. [28 Nov 2021].

[NOAA] National Oceanic and Atmospheric Administration. 2021. https://www.noaa.gov. [28 Nov 2021].

[USDA] United States Department of Agriculture. 2021. https://www.usda.gov. [28 Nov 2021].

Almeida Silva, K., de Souza Rolim, G., Borges Valeriano, T.T. and da Silva Cabral de Moraes, J.R., 2020. Influence of El Niño and La Niña on coffee yield in the main coffee-producing regions of Brazil. *Theoretical and Applied Climatology* (*139)*:1019–1029.https://doi.org/10.1007/s00704-019-03039-9

Assuncao JJ, Souza ZP. 2018. The Fragmented Rules of Brazilian Rural Credit. *Climate Policy Initiative*.

Azlan HA, Tui L, Yaw S, Sudharsan S, Rosman R, Izwanizam A, Palaniappan. 2016. Impact of el nino on palm oil production. *The Planter* 92 (1008): 789-806. https://doi.org/10.56333/tp.2016.013

Barua S, Valenzuela E. 2018. Climate Change Impact on Global Agricultural Trade Patterns: Evidence from the Past 50 Years. *Proceedings of the*

6th International Conference on Sustainable Development 2018, November.

Cadena MC et al. 2006. Relationship between the 1997/98 el nino and 1999/2001 la nina events and oil palm tree production in Tumaco, Southwestern Colombia. *Advances in Geoscience* 6: 195-199. https://doi.org/10.5194/adgeo-6-195-2006

Coulibaly KS, Erbao C. 2019. An empirical analysis of the determinants of cococa production in Cote d'Ivoire. *Economic Structures 8, 5 (2019).* https://doi.org/10.1186/s40008-019-0135-5

European Parlement (Policy Department Economic and Scientific Policy). 2007. Climate Change Impact on Developing Countries – EU Accountability.

Ferguson MS, Gars J. 2017. Measuring the Impact of Agricultural Production Shocks on International Trade Flows.

Fleiss, S., Hill, J.K., McClean, C., Lucey, J.M. and Reynolds, G., 2017. Potential impacts of climate change on oil palm cultivation. *A science-for-policy paper by the SEnSOR Programme*:1-17.

Intergovernmental Panel on Climate Change. 2014. IPCC Fifth Assessment Report (AR 5).

Jaramillo J, Chabi-Olaye A, Kamonjo C, Jaramillo A, Vega FE, Poehling HM, Borgemeister C. 2009. Thermal tolerance of the coffee berry borer Hypothenemus hampei: predictions of climate change impact on a tropical insect pest. *PloS one*, *4*(8): 64-87. https://doi.org/10.1371/journal.pone.0006487

Hakiki IS, Asnawi. 2019. Pengaruh luas lahan, produksi, harga kakao internasional terhadap ekspor kakao Indonesia. *Jurnal Ekonomi Pertanian Unimal* 2(1): 48–64. https://doi.org/10.29103/jepu.v2i1.1794

Hutchins A, Tamargo A, Bailey C, Kim Y. 2015. Assessment of climate change impacts on cocoa production and approaches to adaptation and mitigation: a contextual view of Ghana and Costa Rica. In *International Development Studies* (24). World Cocoa Foundation.

Koh I, Garrett R, Janetos A, Mueller ND. 2020. Climate risks to Brazilian coffee production. *Environmental Research Letters 15*(10): 104-115. https://doi.org/10.1088/1748-9326/aba471

Koissy, Auriol VY, Fofana FN. 2020. Climate change and cocoa production in cote d'ivoire: should we worry?. *Journal of Economics and Business* 2: 965-979. *https://doi.org/10.31014/aior.1992.03.02.253*

Jones BF, Olken BA. 2010. Climate shocks and exports. *American Economic Review* 100(2): 454–459. https://doi.org/10.1257/aer.100.2.454

Li C, Xiang X, Gu H. 2015. Climate shocks and international trade: Evidence from China. *Economics Letters* 135: 55–57. https://doi.org/10.1016/j.econlet.2015.07.032

NOAA (*National Centers for Environmental Information*). 2020. State of the Climate: Global Climate Report for Annual 2020.

Ofori-Boateng K, Insah B. 2014. The impact of climate change on cocoa production in West Africa. *International Journal of Climate Change Strategies and Management* 6(3): 296-314. https://doi.org/10.1108/IJCCSM-01-2013-0007

Ouedraogo M, Partey TS, Doumbia S. 2018. *Climate Smart Agriculture in Cote d'Ivoire.* Food and Agriculture Organization of the United Nations.

Paterson RM et al. 2015. Future climate effects on suitability for growth of oil palms in Malaysia and Indonesia. *Scientific Reports* 5: 14457. https://doi.org/10.1038/srep14457

Pascasio MC, Takahashi S, Kotani K. 2014. Effects of climate shocks on Philippine international trade. *Economics & Management Series* EMS-2014-07: 1–37.

Sustainable Coffee Challenge. 2019. Coffee Production in the Face of Climate Change: Brazil.

Tembata K, Takeuchi K. 2019. Floods and exports: an empirical study on natural disaster shocks in Southeast Asia. *Economics of Disasters and Climate Change* 3(1): 39-60. https://doi.org/10.1007/s41885-018-0033-6

Wardhany M, Adzim F. 2018. Determinant of cocoa export in Indonesia. *Economics Development Analysis Journal* 7(3): 286-293. https://doi.org/10.15294/edaj.v7i3.25262

Wen PP, Sidik JM. 2011. Impacts of rainfall, temperature, and recent el nino on fisheries and agricultural products in the West Coast of Sabah (2000-2010). *Borneo Science* 28: 73–85.