



## The Impact of Climate Change on Economic Conditions: Evidence in Indonesia

Nur Rizqi Febriandika<sup>1✉</sup>, <sup>2</sup>Cahyaningtiyas Rahayu

<sup>1,2</sup>University of Muhammadiyah Surakarta

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### Abstract

*Climate change has consequences and influences on agricultural productivity, especially in tropical areas such as Indonesia. Agricultural produce contributes to the level of Gross Domestic Product. Climate change is a challenge for the environment that has the most extensive impact on the economic, natural resources, and agricultural sectors, even as a concern for climate change on agricultural production. So it is needed to discuss climate change which has an impact on various sectors, especially the economic sector. This research was carried out during 2016-2018 using all provinces in Indonesia. This study uses panel data regression method, and the chosen model is the Fixed Effect Model (FEM) by displaying the effects of each region. The results of this study show that R-squared value is 0.990095 which means that 99% of independent variables collectively determine the value of GDP. Meanwhile, changes in temperature, increased rainfall, and increased air quality index partially have no effect on GDP. Only the extent of agricultural land area partially has a positive effect on GDP.*

**Key words :** Temperature, Rainfall, Air Humidity Index, Land Area, GDP.

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<sup>✉</sup> Corresponding author: Nur Rizqi Febriandika  
Address: Dusun II, Makamhaji Village, Kartasura, Sukoharjo,  
Central Java 57161  
E-mail: [rizqi.febriandika@ums.ac.id](mailto:rizqi.febriandika@ums.ac.id)

## INTRODUCTION

Climate change is an important thing that must be faced and is a global phenomenon and a concern (Sun, et al., 2020; Koubi, 2017; Akbari, et al., 2020; Chao & Feng, 2018; Tang, 2019; Kapur, et al., 2019). Climate change occurs due to changes in climate variables continuously over a long period between 50 and 100 years (Ministry of Environment, 2004). Climate change is characterized by unpredictable extreme weather which fluctuates from temperature and rainfall which fluctuates from year to year and is caused by human activity and is a risky thing (Koubi, 2017; Haq & Ahmed, 2020; Chao & Feng, 2018; Xie, et al., 2020; Trenberth, 2011; Saptutyningsih, et al., 2020; Kapur, et al., 2019).

Climate change is a challenge for the environment that has the most extensive impact on the economic, natural resources, and agricultural sectors, even as a concern for climate change on agricultural production (Panfilova, et al., 2020; Lu, et al., 2019; Tang, 2019). so it must be strong to withstand the effects of climate change iklim (Kapur, et al., 2019; Thomson, et al., 2019; Breisinger, et al., 2013). So that it can reduce the overall agro-economic performance of the country (Fischer, 2005).

Climate change will have a significant effect on the sustainability of agricultural productivity and potential as well as the main drivers of production are temperature and (Kapur, et al., 2019; Xie, et al., 2020; Zilli, et al., 2020; Davide Cammarano, et al., 2020). Climate change also affects production efficiency (Kenta Tanaka, 2011). Agriculture is the most sensitive and vulnerable economic activity to experience loss or reduction to climate change (Davide Cammarano, et al., 2020; Kapur, et al., 2019).

In Indonesia, climate change causes water shortages, reduces soil moisture, decreases soil fertility, and increases

evaporation (Measey, 2010). Climate change affects the social and economic sustainability of the agricultural sector (Sun, et al., 2020), both directly and indirectly from the start of low productivity crop failures, and production costs due to climate change and even causing reduced farmers' income and seasonal unemployment (Panfilova, et al., 2020; Cui, 2020; Breisinger, et al., 2013; Wolff, et al., 2018).

From 2016 to 2018 the temperature situation increased even though the Meteorology and Climatology and Geophysics Agency noted that the fourth warmest year recorded was 1850 - 1990, but there were other hottest years, namely 2015, 2016, 2017. However, 2018 began with La Nina which is associated with low global temperatures (Meteorological Climatology and Geophysics Agency, 2020). Changes in tropical rainfall induced by El Nino show that changes are faster after the peak phase, thus accelerating its duration (Trenberth, 2011; Chao & Feng, 2018; Tang, 2019; Paterson & Lima, 2018; Mora, et al., 2013).

The temperature has an expansive effect on the economy, starting from crop yields to agriculture and influencing the climate (Davide Cammarano, et al., 2020). In Dell's research (2016), increases and decreases in agriculture affect temperature increases and decreases, especially in poor countries (Akbari, et al., 2020). The fact is that more literature shows that the effect of temperature will affect the economy and affect agricultural and plantation products (World Health Organization, 2020; Xu, et al., 2016; Paterson & Lima, 2018).

In a study reported by the IPCC (2007), it shows that in Brazil, there is an increase in temperature, an increase in temperature of up to 1.43 Celsius, and an increase in rainfall of up to 1.44% indicating that changes in temperature and rainfall decrease the average productivity of agriculture (Tanure, et al., 2020; Calvin, et al., 2020; Koubi, 2017; Wolff, et al., 2018).

One of the macro indicators used to measure the success and condition of the economy, the development of a region is the Gross Domestic Product at the national level (GDP) and the Gross Regional Domestic Product (GRDP) (Lubis, et al., 2020; Barbour & McGregor, 1998; Arifien, et al., 2020; Matthew & Mordecai, 2016). The GRDP of a region only presents a direct effect on the economy (Lu, et al., 2019).

In the GRDP according to the business field, one of the sectors that have the biggest role in the agricultural and plantation sector. According to the Central Statistics Agency (2013), there are economic fluctuations caused by agriculture and plantations in Indonesia as a result of the drop-in oil palm prices in 2008 (Lubis, et al., 2020; Muhammad & Atte, 2016; Saptutyningasih, et al., 2020).

The agricultural sector is one of the key contributor to GDP, especially in increasing the prosperity and welfare of the Indonesian people as a developing country and a major source of employment (Barbour & McGregor, 1998; Koubi, 2017; Lubis, et al., 2020; Muhammad & Atte, 2016).

The plantation sub-sector includes all types of plantation crop activities cultivated by both the people and the plantation companies. Commodities covered include chocolate, cloves, rubber, sugar cane, coconut, palm oil, coffee, tobacco, tea, ginger, cashew nuts, castor, cotton, kapok, cinnamon, hazelnut, quinine, pepper, nutmeg, vanilla, hemp, fiber sacks, and other plantation crops, so it is necessary to increase economic development oriented towards a regional potential (Tarumun, 2014).

Plantation plants are one of the prima donna commodities in several regions in Indonesia especially in Kampar Regency, one of the regencies in Riau province. In Kampar,

the area of plantation crops was 468,918 hectares. Of the 468,918 hectares of plantation area, 21.58% of rubber land, 76.73% of oil palm, 0.61% of coconut, and 0.04% of gambier land (Tarumun, 2014). The decline in the plantation sector is due to the influence of the climate where there is a decrease in palm oil production and palm oil revenues will experience a reduction (Paterson & Lima, 2018).

To encourage economic growth in the agricultural sector (plantation). The research contribution we write is aimed at identifying the effects of temperature, average rainfall, Air Quality Index on economic growth to implicate the relationship between climate change in the last 3 years and the economy (Pei, et al., 2016; Lu, et al., 2019). So that it can provide benefits for sustainable development in Indonesia, provide valuable research for policy evaluation. So that it can provide information about the potential impacts of climate change in the future. In many cases, the losses to economic activity are estimated to be higher as a result of climate change.

The temperature referred to in this study is the degree of heat or cold which is measured based on a certain scale, degrees Celsius (C), while in the UK and several other countries it is expressed in degrees Fahrenheit (F) (Sun, et al., 2020; Pei, et al., 2016). The temperature or degree of heat when experiencing an increase has an impact on the global which causes a lot of changes on the earth's surface such as increased extreme weather, and there will be a decrease in productivity, and changes in the volume of water demand, a faster rate of removal and a decrease in the quality of plant products.

Those who live in dry and warm places will be larger and in cold places less and there will be a decrease in agricultural yields (Dastranj, et al., 2019; Sounders, et al., 2017; Palareti, et al., 2016; Chao & Feng, 2018; Pei, et al., 2016). 100% of farmers feel that there is a

change in temperature that is getting warmer and an increase in temperature causes a decrease in agricultural production and harms agriculture (Lu, et al., 2019; Haq & Ahmed, 2020; Tang, 2019; Harris, et al., 2006; Kapur, et al., 2019; Berdimbetov, et al., 2020).

This is in line with what the farmers said because the changing temperature increases in 2017 can trigger pest attacks, temperature is an important thing in insect reproduction so that the life cycle of pests, so that the development of plant pests and diseases is not certain. plants, this has a strong influence on the decline in agricultural output (Sounders, et al., 2017; Chao & Feng, 2018; Davide Cammarano, et al., 2020; Xie, et al., 2020). The decline in the role of agriculture in shaping the economy. area and decreased welfare (Wolff, et al., 2018; Nuraisah & Budi Kusumo, 2019; Koubi, 2017; Calvin, et al., 2020; Akbari, et al., 2020).

Rainfall can also be interpreted as the height of rainwater that is collected in a flat place, does not evaporate, does not sink in, and does not flow (Sun, et al., 2020). Based on the analysis, areas that experience a high decrease in rainfall will experience a decrease in agricultural production (Xie, et al., 2020; D. Cammarano, et al., 2020). The projected decline in agricultural production will decline in April 2017 since the rainy season at that time is less frequent than the previous rainy season resulting in a decrease in agricultural production (Cammarano, et al., 2020; Nuraisah & Budi Kusumo, 2019; Xie, et al., 2020; Davide Cammarano, et al., 2020; Sounders, et al., 2017; Crookes & Strauss, 2017).

In previous studies, a decrease in rainfall intensity will result in a dry rainy season and a dry season in the dry season and vice versa when the increased rainfall will result in a wetter dry season so that it can provide water supply in the dry season in the agricultural and plantation sectors,

where heavy rain will help increase profits from plantation products (Sudarma & As-syakur, 2018; Koubi, 2017; Calvin, et al., 2020; Akbari, et al., 2020; Paterson & Lima, 2018).

One of the needs of living things is clean air, the air is very sensitive to climate change, a lot of development carried out by the government to improve the economy also has externalities for environmental conditions, and is a problem in developing countries (World Health Organization., et al., 2020; Yin, et al., 2019; Haq & Ahmed, 2020; Chaudhuri & Roy, 2018; Cheng, et al., 2007; Sari & Mangkuwinata, 2017; Hossein, et al., 2011).

The definition of the air quality index itself is a contaminant calculated for Knowing how clean and polluted the air is by using concentration means that if the air quality index is higher than 50, the IND-AQI pollutant index is maximum, the index value affects human health and the environment, the better the air index, the better the environmental condition (Haq & Ahmed, 2020; Mamta & Bassin, 2010; Yin, et al., 2019; Jassim & Coskuner, 2017; Kang & Qu, 2017). Coskuner's research (2017) shows that arid air quality will result in unfavorable environmental conditions so that it has an impact on good plantation crops and reduces productivity (Jassim & Coskuner, 2017).

The area of plantation land used in this study is the area of oil palm plantations spread across Indonesia from 2016 to 2018. The area of agricultural land and plantations can have a positive impact on GRDP, the wider land area indicates that the area of plantation and agricultural land is also increasingly a lot so that the output produced will also increase, increasing GDP (Saptutyningasih, et al., 2020).

Related to land management on agricultural products, it is also explained in research conducted by Calvin, et al. (2020) which states that good land management will be able to reduce carbon emissions and increase food security which can increase the strength of agriculture's contribution in meeting

community welfare. In order to increase the contribution of agriculture to GDP, land cultivation is in the form of an increase grazing land management, improved livestock management, agroforestry, integrated water management, increasing soil organic carbon content, reducing soil erosion, salinization and compaction, fire management, landslide and hazard reduction, pollution reduction and post-harvest.

## METHOD

This research was carried out during 2016-2018 using all provinces in Indonesia. The research method in this research is developed and uses panel data regression. This model looks for the relationship between the impact of temperature, average rainfall, air quality index, land area on economic development in Indonesia using panel data regression (Kalkuhl & Wenz, 2020; Pei, et al., 2016). Panel data regression has the advantage of having a fixed effect on the ability to maintain bias error in the variable. The drawback of panel data regression is that it only measures short-term effects or impacts (Muhammad & Atte, 2016; Achyani, 2016; Lu, et al., 2019).

Evidence-based econometric results on the impact of climate change on the economy in Indonesia (Saptutyningasih, et al., 2020). Temperature data for 2016-2018 were taken from the Central Bureau of Statistical Publication (Cammarano, et al., 2020 ; Arifien, et al., 2020). Annual observations of average rainfall, temperature, Air Quality Index, oil palm plantation area, and GRDP per province in Indonesia 2016-2018. The results of the analysis are panel data regression, covering three models, namely CEM (Common Effect Model), FEM (Fixed Effect Model), REM (Random Effect Model).

The relationship between the economy and the variables that influence it can be illustrated that it is expected that temperature, air quality index, average rainfall, the land area of oil palm plantations are expected to affect the economy in Indonesia (Kalkuhl & Wenz, 2020; Kapur, et al., 2019).

$$PDRB_{it} = \beta_0 + \beta_1 SH_{it} + \beta_2 CHR_{it} + \beta_3 IKU_{it} + \beta_4 LH_{it} + \varepsilon_{it} \quad (1)$$

PDRB is Gross Domestic Product of the Province. SH is Average Air Temperature (Celsius). CHR is Average Rainfall (mm). IKU is Air Humidity Index (1-100). LH is Plantation Area (Hectares).  $\beta_0$  is Constant.  $\beta_1$ ... $\beta_4$  is independent variable regression coefficient.  $i$  = Province  $i$ .  $t$  is year.  $\varepsilon$  = element of error

In research on climate change on the economy using climate and economic data in all provinces in Indonesia in 2016-2018. For climate variables in this study using data on temperature, average rainfall, air quality index, and plantation area. The regional data used are all provinces in Indonesia, the reason for choosing Indonesia is because Indonesia has an economy that is influenced by agriculture and plantations, which is so large a%age.

In this study, the economic variable is Gross Domestic Product as a measure of economic activity that describes the economy at the national level (Kalkuhl & Wenz, 2020), Gross Domestic Product data comes from the Indonesian Central Bureau of Statistics. Panel data regression is a combination of time-series data (time series data) and cross-section data (spatial/regional data). Time series data in this study covers the period 2016 to 2018. The cross-section data in this study are 233 provinces in Indonesia.

## RESULTS AND DISCUSSION

Based on the results of panel data regression from the effect of temperature, air quality index, average rainfall, land area on the economy as follows:

Selection of the Best Model using Chow test and Hausman test. First, Chou test. Ho: The coefficient between individuals and over time remains the same (Model follows CEM). Ha: The coefficient between individuals and between times is different (Model follows FEM). Looking at the Probability F statistic  $< \alpha$  (0.05). Probability of chi-Square  $< \alpha$  (0.05) (Ho is rejected)

**Table 1.** Chow Test

Redundant Fixed Effects Tests			
Equation: Untitled			
Test cross-section fixed effects			
Effects Test	Statistic	d.f.	Prob.
Cross-section F	71.640689	(35,28)	0.0000
Cross-section Chi-square	306.401995	35	0.0000

Source: Data Processed

The table above shows that the p-value in the chi-square cross-section is  $0.000 < \alpha =$

0.05, so Ho is rejected, which means that it is better to use a fixed-effect model than a common effect model.

Second, Hausman Test. Ho: The coefficient changes due to the Random factor (REM following model). Ha: Coefficient between individuals and between different times (Model follows FEM). Seeing the probability that Random Crosssection  $< \alpha$  Ho is rejected.

**Table 2.** Hausman Test

Correlated Random Effects - Hausman Test

Equation: Untitled

Test cross-section random effects

Test Summary	Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
Cross-section random	1.745390	4	0.7825

Source: Data Processed

The table above shows that the p-value is  $0.7825 > \alpha = 0.05$ , which means that Ho is not rejected, so the better model to use is the Fixed Effect model. So that the model used is the Fixed Effect model.

**Table 3.** Results of Panel Data Regression

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	27071.53	17221.79	1.571935	0.1272
X1	-102.1060	484.9554	-0.210547	0.8348
X2	0.951247	2.234505	0.425708	0.6736
X3	123.6838	239.0293	0.517442	0.6089
X4	0.016606	0.009125	1.819794	0.0795
Effects Specification				
Cross-section fixed (dummy variables)				
R-squared	0.990095	Mean dependent var		49339.09
Adjusted R-squared	0.976298	S.D. dependent var		58532.02
S.E. of regression	9011.324	Akaike info criterion		21.33952
Sum squared resid	2.27E+09	Schwarz criterion		22.64511
Log likelihood	-685.5436	Hannan-Quinn criter.		21.85683
F-statistic	71.76236	Durbin-Watson stat		4.121212
Prob(F-statistic)	0.000000			

Source: Data Processed

The interpretation of the model obtained is that the temperature has a positive slope and has no significant effect on economic growth but in the economic interpretation based on the above model. This means that every 1 degree Celsius temperature increase will reduce the GRDP level by 102.1060 billion rupiahs. The increase in temperature will have an impact on agricultural products which will cause a decrease in agricultural and plantation output, this is in line with the research of Xie (2020) and Cammarano (2020) so that it also has an impact on the decline in Gross Domestic Product in which the agricultural sector is a sector that influences the formation of Gross Domestic Product based on Business Field.

**Table 4.** Cross Section Effect in Each Region

Region	Effect
Aceh	-5352.525
Sumatra Utara	34571.09
Sumatra Barat	-26983.37
Riau	2971.806
Jambi	-29055.32
Sumatra Selatan	-23994.53
Bengkulu	-31097.65
Lampung	51364.78
Kepulauan Bangka Belitung	-33983.87
Kepulauan Riau	-26874.52
DKI Jakarta	-26590.88
Jawa Barat	118507.6
Jawa Tengah	133520.1
DI Yogyakarta	-21163.26
Jawa Timur	221306.9
Banten	-1550.093
Bali	-5042.238
Nusa Tenggara Barat	-5768.731
Nusa Tenggara Timur	-4888.890
Kalimantan Barat	-37544.93
Kalimantan Tengah	-87757.44
Kalimantan Selatan	-38408.17
Kalimantan Timur	-30899.64
Kalimantan Timur	-28532.11

Region	Effect
Kaliamantan Utara	-24826.12
Kalimantan Utara	-24123.34
Sulawesi Utara	-11598.81
Sulawesi Tengah	158.2162
Sulawesi Selatan	56086.15
Sulawesi Tenggara	-10960.34
Gorontalo	-19885.04
Sulawesi Barat	-24274.94
Maluku	-25056.06
Maluku Utara	-25467.09
Papua Barat	-27758.26
Papua	-13239.07

Source: Data Processed

Based on the table above, the estimation results using the fixed effect model will obtain the following regression equation:

$$PDRB_{it} = 27071.53 - 102.1060SH_{it} + 0.951CHR_{it} + 123.68IKU_{it} + 0.0166LH_{it} + \varepsilon_{it} \quad (2)$$

Furthermore, the individual regression equations for each region, for example, Riau Region:

$$PDRB_{it} = 27071.53 + 27071.53 - 102.1060SH_{it} + 0.951CHR_{it} + 123.68IKU_{it} + 0.0166LH_{it} + \varepsilon_{it} \quad (3)$$

Rainfall has a positive direction and does not have a significant effect on the regional economy. However, based on the above equation the model can show an economic interpretation. Each 1 mm increase in rainfall will increase the growth of the Gross Domestic Product by 0.951 billion rupiahs. The higher the rainfall, the wetter the soil will be in the dry season where the wet soil will make the soil less dry in the dry season so that production output in agriculture in the dry season does not decrease so it does not reduce the Gross Domestic Product yield.

The Air Quality Index has a positive slope and has no significant effect on the Gross Domestic Product. Every 1 increase in the air quality index will increase the gross domestic product IDR 123.68 billion. The

better the air quality, the better the agricultural output produced. As well as the area of plantation land also has a significant effect on the regional economy, every addition of 1 hectare of plantation or agricultural land will increase to 0.0166 billion rupiahs. The more plantation land there is, the more output is produced by agriculture so that the higher the regional income from agriculture and plantations.

Simultaneously (Adjusted R square) the figure is 0.990095. This means that 99.0% of the regional economy can be explained by variables of temperature, rainfall, air quality index, and plantation area. Meanwhile, 1% is influenced or can be explained by variables outside the model.

Increased temperature has a negative impact on agriculture and plantations and tends to reduce crop yields, many farmers claim that climate change has an impact that tends to reduce crop yields by 36% to 38% so that it affects the economy of the area (Quaye, 2018) (Xie, et al., 2020) (Zilli, et al., 2020) (Davide Cammarano, et al., 2020).

Climate change events also affect rainfall where if the rainfall conditions deviate from its normal limits, and where the earlier rainfall usually affects agricultural and plantation production which affects people's income (Tampubolon & Sihombing, 2017), these results are consistent. with Sounders research (2017) Strauss, (2017)

The land area also affects agricultural and plantation production. In addition to the area of processing land, also has an effect on agricultural yields, land cultivation is in the form of an increase grazing land management, improved livestock management, agroforestry, integrated water management, increasing soil organic carbon content, reducing soil erosion, salinization and compaction, fire management, landslide and hazard reduction, pollution reduction and post-harvest. Management will be able to reduce carbon

emissions and increase food security which can increase the strength of agriculture's contribution in meeting community welfare. explain that in order to increase the contribution of agriculture to GDP,

The higher the land area used, the higher the production produced by agriculture or plantations. Another economic impact is that the price of crops that are negatively impacted by climate change will increase. the market clearing mechanism determines when climate change causes a decline in yields, domestic crop production will decline, and consequently, insufficient domestic supply will increase local prices. The local prices of agricultural and plantation products on the domestic market increase with the highest margins in response to reduced yield due to climate change (Xie, et al., 2020; Koubi, 2017; Breisinger, et al., 2013).

## CONCLUSION

The results of this study show that R-squared value is 0.990095 which means that 99% of independent variables collectively determine the value of GDP. Meanwhile, changes in temperature, increased rainfall, and increased air quality index partially have no effect on GDP. Only the extent of agricultural land area partially has a positive effect on GDP.

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