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Environment, Population, and Economy on CO_2 Emission in Indonesia

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ABSTRACT

Recent years have seen a significant escalation in the environmental issue of climate change brought on by rising Carbon dioxide (CO_2) emission levels. Global warming and rising temperatures have the potential to cause ecological harm. The rising greenhouse gas emissions on Earth can contribute to global warming. One of the most significant factors in CO_2 output is the likelihood of disasters, which is increased by rising temperatures. The purpose of this study is to ascertain the impact of the environment (forest area), population (urbanization and motorized vehicle usage), and economy (industrialization and exports) on CO_2 emission in Indonesia from 1990 to 2021. The data was gathered from the Central Bureau of Statistics, International Energy Agency, and World Bank and is secondary data in the form of time series data. Multiple linear regression is the study methodology. The findings demonstrated that the amount of forest area, urbanization, and industrialization are negative and significant on Indonesia's CO_2 emissions. Meanwhile, Indonesia's CO_2 emissions are positively and significantly affected by the number of motorized vehicles and exports. Green and renewable energy must be used in various industries to execute policies that reduce CO_2 emissions.

Keywords: Carbon Dioxide Emission, Environment, Population, Economy
JEL Classifications: B17, O13, O15, L6

1. INTRODUCTION

The United Nations Framework Convention on Climate Change (UNFCCC, 2007 claims that climate change, which results from rising Carbon dioxide (CO_2) emissions, has recently become a significant environmental issue. Climate variability in 2007 was characterized by both natural climate variability that was seen over an extended period, as well as climate variability that was directly or indirectly attributed to human activity and led to changes in the composition of the earth's atmosphere. Global warming is ultimately to blame for this climatic change, which results from a consistent process. The chance of a calamity increases with increasing temperature. One of the necessities across various industries for consumption and production is energy.

Fossil fuels dominate Indonesia' energy consumption patterns including coal, oil, and gas (Purnomo et al. 2023). The Agency for the Assessment and Application of Technology (2018) claims that oil conditions have practically peaked. Indonesia's oil output has been falling steadily since 1991. This is because existing well productivity is decreasing, oil output is diminishing, fuel consumption will continue to rise with population expansion, and more motorbikes and vehicles will be on the road. Indonesia's final energy consumption appears to vary based on information from the Ministry of Energy and Mineral Resources. Energy consumption in Indonesia is mainly driven by industry and transportation. CO_2 emissions are the leading cause of global greenhouse gas (GHG) emissions (World Resources Institute, 2016).

The global economy is expanding quickly, as are energy use and CO_2 emissions. Widespread air pollution is a result of excessive energy usage. According to the International Energy Agency (2020), the transportation sector contributes 40–50% of all air pollution. One of the primary reasons for increased CO_2 emissions is the growth in the number of automobiles. Currently, 13.1 billion barrels of fuel oil are used by roughly 1 billion cars yearly, producing 5.4 billion tonnes of CO_2 in the process (Sang and Bekhet, 2015). Operating motor vehicles and rising energy consumption will result in increased emissions from the transportation sector.

A major worldwide issue is the increase in CO_2 emissions. Therefore, lowering CO_2 emissions must be a priority for all nations, including Indonesia, particularly in the transportation sector. The transport sector in Indonesia now consumes the most petroleum products and produces the most GHG emissions. Inaction will cause a significant rise in fuel consumption from the transportation sector that is predicted to double and will influence climate change.

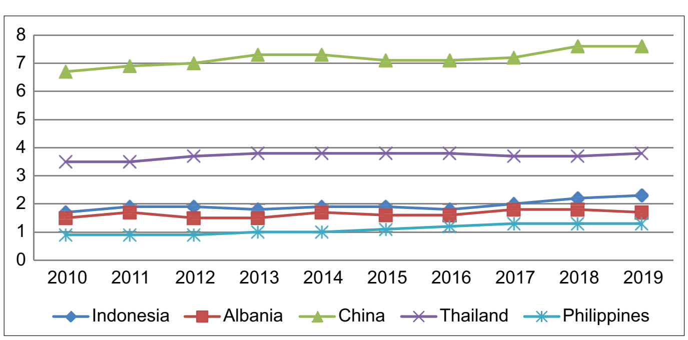
Figure 1 compares the CO_2 emissions of Indonesia and other emerging nations and demonstrates that, although being less than China and Thailand, Indonesia's CO_2 emissions can exceed those of other developing countries. Climate change is brought on by Indonesia's rising CO_2 emissions, which is a significant problem. According to the Indonesian government, climate change concerns economic growth. The CO_2 Reduction Committee of the Indonesian government emphasizes the significance of developing nations' contributions to the global community through voluntary emission reductions. Indonesia's rising GDP (measured in billion tonnes) is in sync with increasing CO_2 emissions. The approach for decreasing CO_2 emissions is to raise GDP adequately while preserving total emissions, minimizing-sing the rise in CO_2 emissions because CO_2 emissions are assessed as CO_2 emission per GDP.

Figure 2 illustrates the development of CO_2 emissions between 2010 and 2020 and their contribution to GDP. An increase in GDP coincides with an increase in CO_2 emissions. Indonesia's CO_2 emissions will rise along with its economic expansion. For some countries, especially developing countries such as Indonesia, industrialization must become a priority to build and fix economic problems (Damayanthi, 2008). The transport sector is regarded as a significant economic sector. One of the major contributors to CO_2 emissions in Indonesia is consumption by the industrial and transportation sectors. Because industrialization and manufacturing processes generate a lot of CO_2 emissions and other environmental stressors, analysis of adverse environmental consequences and quality indicators expands the scope of the nation's economic activities.

The growth of CO_2 emissions from the energy sector is depicted in Figure 3, which also demonstrates that the transport industry is one of the biggest emitters of CO_2 after power and oil producers. CO_2 emissions from the energy sector, such as industry, transportation, electricity, and oil producers, continue to increase yearly. In 2020 Indonesia's energy sector contributed 532.2 billion tons of CO_2 emissions (International Energy Agency, 2020). Improving economic growth, rapid urbanization, and rising incomes have led to a considerable increase in the demand for public transport services (Kasipillai and Chan, 2008). As people's income increases, they also use faster transportation.

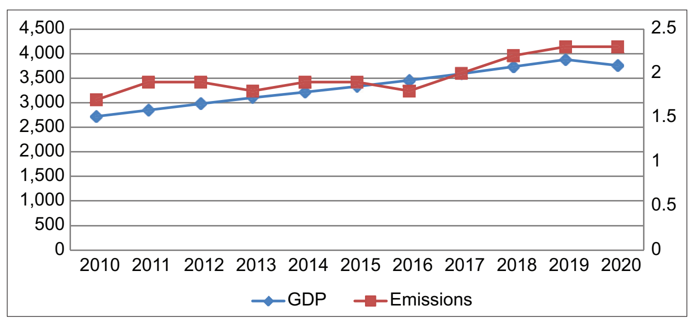
CO_2 emission reduction efforts will negatively impact economic growth as they will harm the development of the transportation sector. However, improvements in vehicle technology can prevent CO_2 emission growth and reduce CO_2 emission levels by improving fuel efficiency without affecting economic growth (Khalid, 2014). The environmental Kuznets curve, which postulates an inverse

Figure 1: Comparison of CO_2 emission between Indonesia and developing countries



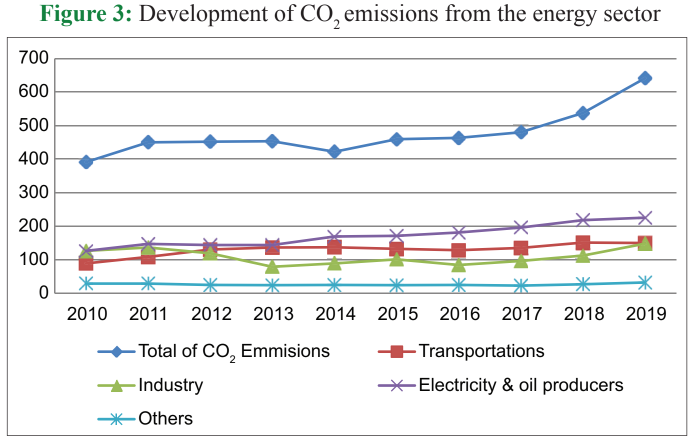
Source: World Bank (2010-2019)

Figure 2: Contribution of CO_2 emission toward gross domestic product 2010-2020



Source: World Bank (2010-2020)

Figure 3: Development of CO_2 emissions from the energy sector



Source: International Energy Agency, 2010-2019

U-shaped relationship between a country's emissions and policies with technical measures, is consistent with this hypothesis.

CO_2, a GHG, can contribute to global warming and climate change. Both hazards will affect the ecosystem and human health and lengthen lifespans. Global warming makes The atmosphere thinner, raising the Earth's temperature. Sea levels rise due to sea expansion, glaciers melting, and perhaps accelerated melting at the North and South Poles. According to predictions, if this impact materializes, the earth's surface will gradually contract, sinking islands and bringing on massive floods everywhere (United Nations, 2022). Additionally, the ongoing rise in temperature makes it extremely warm for human habitation, making it challenging for people to do tasks outside of structures.

The expansion of forest fires, which result in crop failure and food crises, a surge in tropical illnesses, and a decline in plant and animal populations owing to difficulty adapting are further effects (United Nations, 2022). As a result, several repercussions pose a danger to future viability. From an economic perspective, this may threaten further strain state or local government spending, ultimately challenging the implementation different sustainable development programs. Exploiting natural resources, particularly those used to produce energy, is integral to modern economic activity. In the contemporary economy, business and energy are two concepts that are intimately intertwined. Energy is complicated and dynamic for the economy's residential and workplace industrial usage. Furthermore, Stern (2006) noted that energy usage or consumption is a resource for fostering economic industrialization and gaining capital for successful development in manufacturing complementary or alternative goods in the economy. The number of operating industries may cause a rise in air pollution, impacting CO_2 emissions.

In their empirical investigations on the relationship between industrialization and CO_2 emission, Al-Mulali and Ozturk (2015), Liu and Bae (2018), Arouri et al. (2012), and Ouyang and Lin (2015) discovered that there was a positive and substantial relationship between the industrialization variable and CO_2 emission. The numerous industries that are active may cause air pollution to rise, which may have an impact on CO_2 emissions. In 2019, the industrial sector contributed the most CO_2 emissions to the energy sector, at 147 million tonnes (International Energy Agency, 2019). According to Chandra (2018), industrialization in Indonesia had a detrimental and considerable impact on CO_2 emissions. According to the research of Lin et al. (2015), Nigeria's industrialization has little to no effect on CO_2 emissions. Aye and Edoja (2017) state that this demonstrates how economic growth, particularly in emerging nations, impacts the rise in CO_2 emissions. Furthermore, long-term results from the study by Farhani and Rejeb (2012) demonstrate a one-way relationship between economic growth and CO_2 emissions.

The empirical investigation by Pan et al. (2011), Kurniarahma et al. (2020), Harris et al. (2012), Houghton and Nassikas (2017), Chazdon et al. (2016), and Baccini et al. (2017) who discovered that the presence of forests has a detrimental and considerable impact on CO_2 emission. According to Kurniarahma et al.'s findings from 2020, Indonesia's CO_2 emissions are negatively and significantly impacted by the amount of forest cover. However, over the long run, the country's CO_2 emissions are not significantly affected by the varying amount of forest cover. The size of Indonesia's forests can influence how much CO_2 is emitted since more plants in enormous forests can absorb CO_2 emissions and create oxygen.

Urbanization tends to lead to a rise in CO_2 emissions, according to Seto et al. (2014), Creutzig et al. (2015), Zhou et al. (2010), Martinez-Zarzoso and Maruotti (2011), Gu et al. (2011), and Liu et al. (2011). This study has implications for government programs that aim to mitigate the effects of rising urbanization and CO_2 emissions. Urbanization is a phenomenon that results from an imbalance in how development is distributed between urban and rural regions. More individuals dwell in urban areas when the per capita income is more significant (Todaro and Smith, 2009). Urbanization can raise CO_2 emissions because a significant number of people relocating to urban regions will increase population density, which will lead to more activities like burning, which can increase CO_2 emissions, being carried out. The empirical study by Keirstead and McMahon (2010) demonstrates that urbanization has a favorable and considerable impact on CO_2 emissions. According to a survey by Rehaghana (2020), who also discovered that urbanization impacts CO_2 emissions, urbanization typically cannot be halted since it is one of the elements of economic growth that causes the urbanization phenomenon to continue. These findings, however, contradict an empirical research by Fan et al. (2006), one of whose conclusions is that as per capita wealth grows, people would become more interested in science and technology, hence lowering CO_2 emissions and optimizing energy usage.

Along with the increase in car ownership, CO_2 emissions from the transportation sector are also on the rise. To significantly reduce CO_2 emissions, it is typically necessary to adopt cleaner vehicle technologies, such as electric or alternative fuel vehicles, as well as to improve fuel efficiency and build sustainable transportation infrastructure (Gossling and Choi, 2015; Zhang et al., 2017; Al-Mulali, 2015; and Zhang and Geng, 2014). Transportation, as noted by Hickman and Bannister (2007), is the primary application for carbon-based fuels and promotes rising CO_2 emissions. Additionally, increased economic openness is causing CO_2 emissions to rise. Research by Haug and Ucal (2019) In contrast, declining exports have been shown to lower per capita CO_2 emissions (Ozturk and Caravci, 2013; Chen et al., 2021; Haug and Ucal, 2019). Mahmood et al.'s research from 2020 revealed that exports had an impact on CO_2 emissions in North Africa. The results of a study by Musri et al. in 2022 showed that the export variable positively and significantly impacts CO_2 emissions in Indonesia. This is because the more goods that are exported, the more CO_2 emissions there will be because the exported goods will turn into consumer goods, and producing consumer goods can increase CO_2 emissions.

The setting for this investigation is the high levels of CO_2 emissions and the negligent treatment of environmental harm issues that might lead to ozone layer depletion. The results of prior research on the elements that influence CO_2 emission are still contradictory or inconsistent. While few time series data are available for study at the Indonesian level, research on CO_2 in Indonesia mainly concentrates on the regional level. This research was conducted to close such gaps. More research is needed to understand the factors influencing CO_2 emissions in Indonesia.

2. LITERATURE REVIEW

A forest is where trees grow. Trees are a natural unit of life, and the state designates the living environment in a forest. Legal entities and forestry department organizations define forestry law as a collection of rules about operations and their management that are written and unwritten. According to Law No. 5 of 1967, "forest areas" are specific regions the Minister has decided should be kept as permanent forests. The larger the forest area, the more plants can generate oxygen and absorb CO_2 emissions. According to studies by Kurniarahma et al. (2020), Waheed et al. (2018), Harris et al. (2012), Houghton and Nassikas (2017), Chazdon et al. (2016), and Baccini et al. (2017), the amount of forest has a sizable detrimental impact on CO_2 emission.

Urbanization is the movement of people from villages to cities, and those who do urbanization are called urbanites. Urbanization begins with the unequal distribution of development between urban and rural areas. The higher the income per capita, the more people live in urban areas (Todaro and Smith, 2009). The higher the level of urbanization, the higher the level of CO_2 emissions because the large number of people moving to urban areas can increase the density in a room. With a dense population, more activities will be carried out, such as burning, which can increase CO_2 emissions. In line with research conducted by Wang et al. (2012), Kurniarahma et al. (2020), and Zi et al. (2016) showed that urbanization has a positive and significant effect on CO_2 emissions.

Motorized vehicles are all vehicles propelled by mechanical devices in engines other than rail vehicles (RI Law No. 22 of 2009). The more the number of motorized vehicles, the more pollution will be produced from the residual combustion of vehicle exhaust gases, in line with research conducted by Isnaeni (2019), Wang et al. (2011), Chen and Lei (2017), found that there is a positive and significant effect of the number of motorized vehicles on CO_2 emissions. Hickman and Banister (2007) explained that transportation primarily uses carbon-based fuels and encourages increased CO_2 emissions. Along with the growth in the number of vehicles, CO_2 emissions from the transportation sector are also growing. Therefore, significant reductions in CO_2 emissions usually involve adopting cleaner vehicle technologies, such as electric vehicles or alternative-fueled vehicles, as well as increasing fuel efficiency and sustainable transportation infrastructure (Gossling and Choi, 2015; Zhang et al., 2017).

Conceptually, industrialization can be understood as a transitional state of socio-economic conditions from pre-industrial conditions with low incomes to industrialization with higher income trends. The more industrialization, the higher the CO_2 emission level because high industrialization can increase air pollution, which can affect CO_2 emissions. In line with the research of Wang et al. (2012), Zhao and Yang (2013) Al-Mulali and Ozturk (2015), Liu and Bae (2018), Arouri et al. (2022), and Ouyang and Lin (2015) in their research on the effect of industrialization on CO_2 emissions found that there was a positive and significant effect on industrialization variables on CO_2 emissions.

Export is the release of goods from the customs area to be transported abroad under applicable regulations, including customs regulations. The higher the level of exports, the more CO_2 emissions will be produced because the exported goods will become consumer goods, and the exporting country will become a producer of these consumer goods. Producing consumer goods can increase CO_2 emissions. In line with research conducted by Mahmoood et al. (2020) found that exports have a positive and significant effect on CO_2 emissions. In an empirical study by Haug and Ucal (2019), reduced exports reduce per capita CO_2 emissions (Ozturk and Caravci, 2013; Chen et al., 2021; and Haug and Ucal, 2019). Research conducted by Mahmood et al. (2020) found that exports affected CO_2 emissions in North Africa.

3. RESEARCH METHODS

This study falls under the category of quantitative research. This study used time series data from 1990 to 2021 in Indonesia as secondary data. The data sources are the World Bank, the International Energy Agency, and the Central Bureau of Statistics. The operational definition of CO_2 emissions is a gas created by burning fossil fuels and builds up in the atmosphere (tonnes per person). A forest area is a forest region that has become overrun with trees of all types, both functional and useless (hectare); Moving from rural areas to cities with a population (soul) is known as urbanization; The total number of motorized vehicles includes all occupants' (units') vehicles; Industrialization is measured by the quantity of both large and small businesses; The entire dollar amount of all products exported is known as an export. Techniques for multiple linear regression data analysis. The stationary and cointegration tests come first before doing multiple linear regression. The multiple linear regression equation is mathematically expressed by:

$$Et = a + \beta_1 FA_{1t} + \beta_2 U_{2t} + \beta_3 NMV_{3t} + \beta_4 I_{4t} + \beta_5 E_{5t} + e$$

Information:
E = CO_2 Emission
a = constant
FA = Forest Area
U = Urbanization
NMV = Number of Motorized Vehicles
P = Population
I = Industrialization
E = Export
t = Time Series
e = term error
The regression results must be the Best Linear Unbiased Estimator (BLUE), which must pass the classic assumption test, including

normality, multicollinearity, heteroscedasticity, and autocorrelation (Wooldridge, 2010).

4. RESULTS AND DISCUSSION

The values are the same for different delays, and it doesn't matter when the measurement starts. Therefore, stationary tests determine if the data's mean, variance, and autocovariance are constant throughout time. This study employed the unit root test as stationary (Wooldridge, 2010). To ascertain if the data is static, the statistical ADF value is contrasted with the critical ADF value. The data is stationary if the ADF value exceeds the crucial value and non-stationary if the ADF value is less than the critical value.

Only data I (Industrialization) is stationary, while the other data are not stationary at the 1%, 5%, and 10% confidence levels, according to Table 1. Therefore, a stationary test utilizing the first difference must be performed on further data. Table 2 below shows the outcomes of data processing utilizing the first difference.

It is essential to do a static test on the second difference since Table 2 demonstrates that the variable data on Forest Area and Urbanization are not fixed at the 1%, 5%, and 10% confidence levels in the stationary test data on the first difference. The results of processing using the second difference can be seen in Table 3.

Table 3 shows that all data is at a 1% confidence level in the second difference stationary test. 5% and 10% are stationary.

The next stage is the classic assumption test which includes the normality test, multicollinearity, heteroscedasticity, and autocorrelation. The normality test determines whether the data is normally distributed. The normality test in this study used the Kolmogorov-Smirnov non-parametric statistical test. The Kolmogorov-Smirnov significance value of 0.073 is > 0.05. so that the data is normally distributed. The multicollinearity test determines whether a research regression model correlates with the independent (free) variables. If the VIF value < 10.00, the regression model has no multicollinearity.

Table 4 shows the VIF value of the forest area, urbanization, number of motorized vehicles, industrialization, and export. If the VIF value is < 10, it can be stated that there is no multicollinearity problem. The heteroscedasticity test tests whether variance differences exist from one observation to another in the regression model. This heteroscedasticity test uses the Glejser test method. If the significance value (sig) between the independent variables and the absolute residual > 0.05, there is no heteroscedasticity problem. Conversely, if the significance value (sig) < 0.05, it can be concluded that there is a heteroscedasticity problem.

Table 5 shows the significance value of the forest area variable, urbanization, number of motorized vehicles. There is no

Table 1: Stationary test: Level

No.	Variable	Test critical values: Level			t-Statistics	Prob.*
		1%	5%	10%		
1.	CO_2	−3.72407	−2.98623	−2.6326	1.700692	0.9993
2.	FA	−3.67017	−2.96397	−2.62101	−0.890066	0.7774
3.	U	−3.67017	−2.96397	−2.62101	−1.956118	0.3036
4.	NMV	−3.66166	−2.96041	−2.61916	1.350446	0.9983
5.	I	−3.670170*	−2.963972*	−2.621007*	−3.897410	0.9023
6.	E	−3.66166	−2.96041	−2.61916	−0.110084	0.9397

*Stationary. Source: Results of data processing e-views 10

Table 2: Stationary test: First difference

No.	Variable	Test critical values: First difference			t-Statistics	Prob.*
		1%	5%	10%		
1.	CO_2	−3.67932*	−2.96777*	−2.62299*	−5.818288	0.0000
2.	FA	−3.67017	−2.96397	−2.62101	−2.453652	0.1365
3.	U	−3.6 7017	−2.96397	−2.62101	−2.242123	0.1965
4.	NMV	−3.67017*	−2.96397*	−2.62101*	−3.681981	0.0097
5.	I	−3.699871*	−2.976263*	−2.627420*	−4.569487	0.0012
6.	E	−3.67017*	−2.96397*	−2.62101*	−3.965789	0.0048

*Stationary. Source: Results of data processing e-views 10

Table 3: Stationary test: Second difference

No	Variable	Test critical values: Second difference			t-Statistics	Prob.*
		1%	5%	10%		
1	CO_2	−3.73785*	−2.99188*	−2.63554*	−4.464191	0.0019
2	FA	−3.67932*	−2.96777*	−2.62299*	−7.223487	0.0000
3	U	−3.67932*	−2.96777*	−2.62299*	−5.001478	0.0004
4	NMV	−3.68919*	−2.97185*	−2.62512*	−5.993373	0.0000
5	I	−3.689194*	−2.971853*	−2.625121*	−6.407372	0.0000
6	E	−3.68919*	−2.97185*	−2.62512*	−6.16124	0.0000

*Stationary. Source: Results of data processing Eviews 10 heteroscedasticity issue when industrialization and exports are both over 0.05. The autocorrelation test is used to test whether there is a correlation between the confounding errors for period t and the errors for the linear regression model's 1st (previous) period. It is known that the number of samples (n) = 32; $\alpha = 5\%$; the number of variables (k) = 6. Meanwhile, from the DW table, the value of dL is 1.0409, and dU is 1.9093. so that 4 - dL values of 2.9591 and 4 - dU 2.0907 can be obtained. Thus, it can be concluded that there is no negative or positive autocorrelation.

Multiple linear regression analysis was used to measure the effect of forest area, urbanization, number of motorized vehicles, industrialization, and exports on CO_2 emissions. The following Table 6 shows a summary of the multiple linear regression outputs.

4.1. Effect of Forest Area on CO_2 Emission in Indonesia

Between 1990 and 2021, the amount of forest considerably impacts CO_2 emissions. According to this, Indonesia's forests have a greater capacity to absorb CO_2 emissions and create oxygen the more land they cover. This study supports the findings of Kurniarahma et al. (2020), according to which the amount of forest has a negative and considerable impact on CO_2 emissions. The amount of forest you have will affect how much CO_2 you emit. These findings also align with Pant's (2009) research, which discovered a negative and enormous impact of forest acreage on CO_2 emissions. An empirical investigation by Harris et al. (2012), Houghton and Nassikas (2017), Chazdon et al. (2016), and Baccini et al. (2017) discovered that the forest area variable had a favorable and substantial impact on CO_2 emission. The findings also demonstrate that any increase in forest area will decrease CO_2 emissions because more plants that can absorb CO_2 emissions and create oxygen will grow as the forest area increases. This must be maintained to slow the deforestation rate that is still occurring, where the forestry industry plays a significant role in lowering CO_2 emission levels. The Indonesian state will benefit from the forest area's protection. Indonesia must develop with a green viewpoint and protect its forests to preserve reasonable CO_2 emissions.

Table 4: Multicollinearity test

No.	Variable	Collinearity statistics
		VIF
1.	Forest area	1.079
2.	Urbanization	1.819
3.	Number of motorized vehicles	3.700
4.	Industrialization	1.032
5.	Export	4.807

Source: SPSS 25 data processed. VIF: Variance inflation factor

Table 5: Heteroscedasticity test

No.	Variable	Sig.
1.	Forest area	0.496
2.	Urbanization	0.380
3.	Number of motorized vehicles	0.114
4.	Industrialization	0.314
5.	Export	0.763

Source: Output SPSS 25

4.2. The Influence of Urbanization on CO_2 Emission in Indonesia

Between 1990 and 2021, urbanization negatively and significantly impacts CO_2 emissions in Indonesia. Indonesia is rapidly urbanizing, which indicates that the country is still developing. Excessive fossil fuel use and CO_2 emissions frequently bring on environmental harm from increased growth. However, Indonesia's regions are not all in the same state of development. When per capita income hits higher levels, urbanization can harm carbon emissions. People will use science and technology to maximize energy consumption and lower CO_2 emissions (Fan et al., 2006). Contrary to Seto et al.'s (2014) literature review, Creutzig et al. (2015), Zhou et al. (2010), Maruotti and Martinez-Zarzoso (2011), Gu et al. (2011), and Liu et al. (2011) findings, urbanization tends to increase CO_2 emissions. According to an empirical study by Wang et al. (2012), urbanization significantly and favorably affects CO_2 emissions. According to research by Wang et al. (2017), urbanization had a favorable impact on CO_2 emissions in the Western part of China but a negative impact in the Central region. Zi et al. (2016) and Kurniarahma et al. (2020) revealed that urbanization positively and considerably impacts CO_2 emissions. This occurs due to the rapid population shift from rural to urban regions, which can increase population density. So more activities, such as burning, which might raise CO_2 output, will be done due to a dense population.

4.3. Effect of the Number of Motorized Vehicles on CO_2 Emission in Indonesia

In Indonesia, between 1990 and 2021, the number of motorized vehicles will positively and considerably impact CO_2 emissions. This is because more exhaust gas from combustion leftovers will be produced owing to the increasing number of automobiles being operated. As a result, these cars emit a lot of pollution, which may cause Indonesia's CO_2 emissions to rise. The findings of this study are consistent with Isnaeni's research (2019), which discovered that CO_2 emissions are significantly and positively impacted by the number of motorized vehicles on the road. Transportation, as noted by Hickman and Bannister (2007), is the primary application

Table 6: Multiple linear regression test

No.	Variable	Coefficient	t-statistics	t table	P-value
1.	Constanta	784.376	10064	1.708	0.000
2.	Forest area	−23.037	−4.632	1.708	0.009
3.	Urbanization	−4069	−2.844	1.708	0.000
4.	Number of motorized vehicles	0.006107	6.936	1.708	0.040
5.	Industrialization	−43.685	−2.166	1.708	0.003
6	Export	0.001658	3.286	1.708	0.000

Source: SPSS data processed

for carbon-based fuels and promotes rising CO_2 emissions. According to Chen and Lei's 2017 empirical investigation, the variable number of motorized vehicles positively and substantially impacted CO_2 emissions. This result is consistent with that of Nurdjanah (2014), who discovered that motorized vehicles account for 60–70% of air pollution, with motorbikes and passenger cars being the main contributors. The usage of private automobiles is more common among Indonesians than that of public transit. In Indonesia, using private automobiles may increase the number of motorized vehicles and the use of fuel oil as a fuel source. This may result in more combustion leftovers being released, increasing CO_2 emissions. The unequal distribution of public transit is to blame for this development. Only select regions may be reached via public transport.

4.4. The Effect of Industrialization on CO_2 Emissions in Indonesia

Between 1990 and 2021, industrialization in Indonesia negatively and significantly impacts Cimpactedsions. The findings of this study contradict the theory that industrialization significantly and favorably affects CO_2 emissions. Increased operating expenditures are to blame for this because of rising energy prices. To save expenses and maintain their competitiveness, businesses are becoming more efficient. It is possible to significantly lower emission levels and the intensity of emissions from the industrialization sector by using energy more efficiently in the industrial sector. The findings of this study are consistent with those of Lin et al. (2015), who discovered that industrialization significantly and negatively impacted CO_2 emissions in Nigeria. Chandra (2018) investigation found that industrialization had a detrimental impact on CO_2 emissions. This outcome diverges from Al-Mulali and Ozturk's (2015), Bae and Liu (2018), Arouri et al. (2012), Lin and Ouyang (2015), Wang et al. (2012) and Zhao and Yang (2013) which stated Industrialization has a favorable and significant impact on CO_2 emissions. Environmental effects of industrial expansion are present. Impacts, including air pollution and ecological degradation. The activities of industrial production equipment that discharge their smoke waste through factory chimneys, which throughout the manufacturing process, engage in more combustion activities, cause air pollution.

4.5. Effect of Exports on CO_2 Emission in Indonesia

Exports positively and significantly affected CO_2 emissions in Indonesia from 1990 to 2021. This is because more goods are exported, CO_2 emissions will also increase because exported goods will become consumer goods, and exporting countries become producers of these consumer goods by producing consumer goods can increase CO_2 emissions. An empirical study by Haug and Ucal (2019) where in the long term. reduced exports can reduce per capita CO_2 emissions (Ozturk and Caravci, 2013; Chen et al., 2021; and Haug and Ucal, 2019). The empirical study of Mahmood et al. (2020) found that exports affected CO_2 emissions in North Africa. The findings of Musri et al. (2022) explain that there is a positive and significant effect of the export variable on CO_2 emissions in Indonesia because the more goods exported, the CO_2 emissions will increase because the exported goods will become consumer goods, and the exporting country becomes a producer of these consumer goods by producing consumer goods can increase CO_2 emissions. This finding is not in line with Alfarisy et al. (2023), who found a negative effect of the export variable on CO_2 emissions. This impact means that increased product sales can reduce CO_2 emissions. Exports can have a negative effect on CO_2 emissions due to several things, such as manufacturing companies in Indonesia only exporting goods to environmentally conscious customers, such as European Union countries.

5. CONCLUSIONS

Recently, CO_2 emission levels have emerged as a severe environmental issue. Global warming and rising temperatures have the potential to cause environmental harm. The rising GHG emissions on Earth can contribute to global warming. A calamity is more likely as the temperature rises. It is one of the crucial factors in CO_2 emission.

The study's findings display the woodland area. CO_2 emissions in Indonesia are negatively impacted by urbanization and industry. Meanwhile, Indonesia's CO_2 emissions are positively and significantly affected by the number of motorized vehicles and exports. (1) Efforts are required to stop ongoing deforestation and conserve forest areas, according to this study. (2) To prevent a rise in the demand for housing and transit, which might increase CO_2 emissions, the government must also manage urbanization. (3) The government must plan and implement green and renewable energy, particularly in electricity production. Update legislation against industrialization's externalities and enhance public transit.

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