



## **Impact of Modernized Agriculture and Trade on Carbon Emissions: The Role of Fossil Fuel and Renewable Energy Consumption Evidenced from ASEAN States**

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### **ABSTRACT**

Sustainable development goals developed to reduce the level of climate transformation and its effects, this study explores the causal association between aggregate energy consumption resources, trade liberalization, CO<sub>2</sub> emissions, and modern agriculture in selected ASEAN nations from 2000 to 2018 with the help of panel FMOLS (fully modified ordinary least square). Empirical findings have shown that the value addition level of agricultural products minimizes CO<sub>2</sub> emissions in those countries where pollution is high. And found a positive relationship between energy consumption and CO<sub>2</sub> emissions. Trade liberalization has made it possible to reduce CO<sub>2</sub> emissions in economies where environmental pollution is getting lower. While the use of fossil fuels has intensified CO<sub>2</sub> emissions, renewable energy consumption has confirmed positive effects on the pollution of the environment. While Climate-smart agriculture preferred institutions to raise income and productivity, adjusting to climate change sustainably leads to decreased greenhouse gas emissions. For example, new energy resources, renewable energy help keep the environment clean and healthy. It avoids excessive dependency on fossil fuel energy for the determinants of the agriculture sector. On the other hand, Trade policy can motivate the flow of investment opportunities and technology for a specialty in economies of scale and production. Therefore, examining strategies that encourage the agricultural sector's productivity and creating active markets for international trade in ASEAN countries will improve living standards and keep the environment clean and healthy.



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## **1. Introduction**

According to the latest studies, environmental pollution and agricultural land are damaging due to excessive fossil fuel energy use. It is identified that renewable energy technologies benefit farmers in different ways, such as wind, geothermal, hydropower, solar, and biomass (Asumadu-Sarkodie & Owusu, 2016). Social, economic, and environmental means and farming activities significantly contributed to energy consumption. However, for ensuring that the vulnerable and weak are secure from the threat of crop failure, water shortage, poverty, heat waves, food insecurity, and flood with having the guarantee of zero-emission (Bühler, Schuetze, & Junge, 2015; Rao, Gopinath, Prasad, & Singh, 2016). Therefore, this study examined the effect on CO<sub>2</sub> (carbon dioxide)

emission, inspecting the relationship among trade, aggregate, and disaggregate energy consumption and agriculture.

The energy source is the most essential and crucial factor for agriculture productivity. However, ASEAN countries have soil conservation and low productivity and face low energy (Ortas & Lal, 2013). An increase in the population and increased food production due to the rise in demand is another severe issue. However, energy scarcity is the major obstacle to attaining food security and sustainable agriculture (FAO, 2014). Without harming future generations' environment, sustainable agriculture system for hampering food security (Farooq, Wahid, Kobayashi, Fujita, & Basra, 2009). In Indonesia, fossil fuel is the contemporary practice of agriculture due to the lack of energy; on the other hand, energy generation by renewable fossil fuel. It is described that the scarcity of energy can be resolved by using clean, renewable and sustainable energy sources, which use as an instrument to eliminate climate changes and environmental changes (Asumadu-Sarkodie & Owusu, 2016).

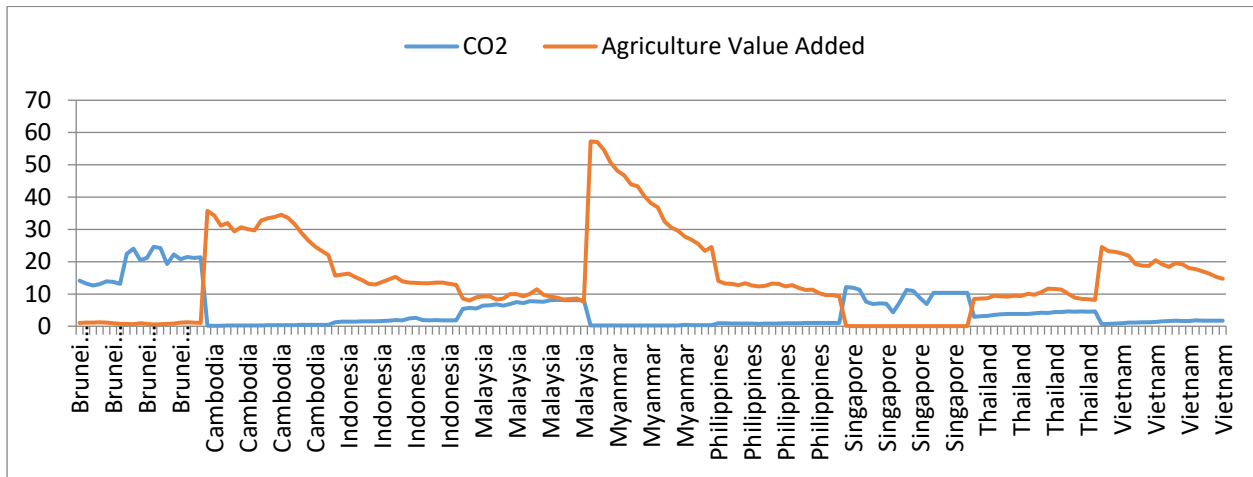
For value addition, energy is a beneficial commodity in agro-processing and crop production for the agriculture process. In agriculture, animal, human and mechanical energy is comprehensively used for crop production. There are two energy groups in the agriculture sector, i.e., direct and indirect (Todde, Murgia, Caria, & Pazzona, 2018). In crop production, such as irrigation, land preparation, harvesting, transportation & harvesting of farm produce and agriculture inputs play a vital role. On the other hand, indirect energy is based on the energy used to transport fertilizer, packing, pesticides, farm machinery, seeds, and manufacturing (Todde et al., 2018).

Renewable energy is used in the agriculture sector, which is divided into five groups such as (i) different residues of agriculture such as grain dust, hazelnut shells, and wheat straw as well as modern biofuels like biogas and bioethanol used as a source of energy, (ii) solar energy use for greenhouse cooling, heating, product drying, farm field irrigation, and lighting, (iii) in barns geothermal energy is used, aquaculture, in open fields in the greenhouse to heat the soil, soil improvement and to dry agriculture products, (iv) wind energy used for irrigating fields, grind some crops and generate electricity, (v) hydropower used for irrigation, electricity production, between farmers equitable sharing of water facilitation and the water supplies. However, in agricultural economics, the role of trade, modernized agriculture, consumption of fossil fuel and renewable energy has not been widely investigated (Bayrakçı & Koçar, 2012); other indicators are explained in Table 1.

**Table 1**  
**Average Data from 2000 to 2018 of CO2 with other Indicators**

Country	Trade	CO2	Energy Consumption	Fossil Fuel Energy	Renewable Energy	Agriculture Value Added
Cambodia	124.844	4326.47	338.255	27.4631	72.1183	30.4379
Brunei	99.6454	7236.2	7937.61	99.9979	0.014872	0.916362
Darussalam						
Myanmar	16.6956	13365.7	309.676	30.3462	76.6094	38.8088
Singapore	368.486	44858.6	5152.63	96.1414	0.55367	0.046258
Philippines	80.7242	84708.5	456.149	58.6105	30.5344	12.0261
Vietnam	152.028	120943	564.021	62.8029	41.9708	19.3467
Malaysia	169.977	197170	2641.32	96.4419	4.99212	9.07581
Thailand	127.713	265199	1661.28	80.6625	22.0388	9.53438
Indonesia	52.5348	419115	822.345	64.6912	39.8603	14.0814

According to table 1, Cambodia has the lowest carbon emission in the selected ASEAN countries with the highest agriculture value-added production, the second-highest renewable energy used, and the minimum use of fossil fuel energy. Indonesia has the highest carbon emission with the third-highest agriculture production in the selected ASEAN countries, 4th highest in fossils fuel energy use. While figure 1 shows the time trend of CO2 emission with agriculture value-added.



**Figure 1: Time trend of ASEAN Countries of CO2 emission and Agriculture value-added**

Figure 1 shows the use of carbon emission and agriculture value-added in ASEAN countries from 2000 to 2018. Buren Darraslum has the highest Co2 emissions with the lowest agriculture value added % of GDP, Cambodia and Myanmar have more excellent agriculture value-added compared to CO2 emission and with time, agriculture value-added decreasing and emission level moves to increase.

This present research explores the bond between modernized agriculture, carbon dioxide, aggregate and disaggregates energy consumption and trade openness. The environmental Kuznets curve and energy growth rely on immense literature (Bakhtyar, Kacemi, & Nawaz, 2017; Farhani & Ozturk, 2015; Özokcu & Özdemir, 2017). In this research use some macroeconomic dynamics. Moreover, energy consumption practically affects CO2 (carbon dioxide) emissions. Following the existing literature, the study uses trade liberalization in our investigation, an essential variable affecting the environment's sustainability.

Trade openness has three effects on the environment, i.e., composition effect, scale effect, and technique influence (Ling, Ahmed, Muhamad, & Shahbaz, 2015). As technical effects, trade rises, technology betters, which reduces carbon emissions. We considered the impact of scale, a rise in free trade upsurges output, and trade volume, which negatively influences the environment. Pollution incentive industries are attracted to developing countries in composition effect, consequently contributing to environmental deterioration. It shows that the composition and scale effect negatively impact, while the technique effect positively influences ecological sustainability. Trade effect depends on three dominant effects as trade openness impact on the environment is ambiguous. Usually, composition and scale harm the environmental pollution level (Fontini & Pavan, 2014; Ling et al., 2015).

The present study highlights the causal and long-term linkage between trade, agriculture, carbon emissions, and energy consumption on a panel for ASEAN nations. The present study is not similar to previous studies (Farhani & Ozturk, 2015; Muhammad Atif Nawaz, Azam, & Bhatti, 2019; Özokcu & Özdemir, 2017) in letters and spiritual sense. We investigated the long-run relationship among the model using the unit root test and, after then, used the FMOLS cointegration technique to identify the long-run relationship in the model.

These econometric techniques for unbiased statistical implications are helpful for policy formulation and significance. The paper is divided into the following sections: the literature review, which explains the link between agriculture, energy use, carbon emission, and trade in Indonesia. The methodology examines in section 3. Section 4 discusses the observed results, while section 5 provides policy recommendations and conclusions of the study.

## **2. Literature review**

The use of panel quantile, causality, and cointegration regression on macroeconomic variables and carbon emissions has increased extensively in recent studies (Chen & Huang, 2013; Ibrahim & Aziz, 2003; Sarkodie & Strezov, 2019). However, this type of investigation is limited and sporadic. The present paper donates to the scope of the current work. Meanwhile, the literature is insufficient in the study of the ASEAN region. Several studies concentrated on ASEAN regions, especially (Charfeddine & Mrabet, 2017; Jebli & Youssef, 2015; Muhammad A Nawaz & Hassan, 2016). Though these studies display an absence of consent, the difference in sample data, estimation technique, and model specification result in different findings. Most studies focused on the environmental Kuznets curve (EKC) postulate, while others concentrated on measuring environmental contamination's effect. Besides income and energy use as exogenous indicators, these studies omitted bias, considering few variables. Literature review shows that the impact of carbon dioxide (CO<sub>2</sub>) emissions on agriculture is quite topical and fresh and involves more inspection for new policymakers and insights (Tubiello et al., 2015). We use these studies to inspect the correlation between carbon emission, trade, agriculture, and energy consumption for guidance.

### **2.1 The nexus between agriculture, energy consumption, carbon emissions, and trade**

The affiliation between carbon dioxide emissions and agriculture indicates various studies' altered findings. The correlation between carbon emanations and agriculture is debated in these studies (Santiago-De la Rosa et al., 2017; Waheed, Chang, Sarwar, & Chen, 2018). The study results stated that agriculture and its services directly affect CO<sub>2</sub> emissions. Moreover, these studies' outcomes proved that agriculture actions such as pre-harvest, harvest, post-harvest actions affect emissions level. The OECD states' economies found two-way causation relation among these two variables, such as agriculture and CO<sub>2</sub> emissions (Alamdarlo, 2016). The only two research pieces discussed the causality relation among CO<sub>2</sub> production and agriculture in the case of Turkey (Dogan & Turkekul, 2016) and eastern Canada (Gagnon et al., 2016). Both studies found that there is no association between agriculture and CO<sub>2</sub> emission.

Farhani and Shahbaz (2014) investigated the link between emission level and trade liberalization in Tunisia. This study concluded that carbon emission and trade liberalization affect each other. Some work Al-Mulali, Weng-Wai, Sheau-Ting, and Mohammed (2015); Michieka, Fletcher, and Burnett (2013); Shahbaz, Hye, Tiwari, and Leitão (2013) and Yang and Zhao (2014) explored the causality affiliation between CO<sub>2</sub> emissions and openness of trade. Different geographical locations and perspectives are used in these studies. The outcomes indicated that active trade policies have the propensity to donate to economic growth as results revealed that emission level and openness of trade are directly linked with each other. Some other studies showed a two-way association among the related variables in Vietnam, BRICS countries, and developing countries (Aziz, Mustapha, & Ismail, 2013; Zakarya, Mostefa, Abbas, & Seghir, 2015). On the other hand, these studies concluded no association between CO<sub>2</sub> emissions and trade openness (Farhani & Shahbaz, 2014; Kohler, 2013; Muhammad Atif Nawaz et al., 2021; Xiang et al., 2021).

Relationships between carbon releases and energy use have been widely studied. Using the Granger causality hypothesis, Al-Mulali et al. (2015); Farhani and Ozturk (2015), and Yang and Zhao (2014), discovered that CO<sub>2</sub> emissions and energy usage have a unidirectional link. Therefore, carbon dioxide (CO<sub>2</sub>) discharges affect energy consumption activities (Baloch et al., 2021; Pao, Yu, & Yang, 2011). Moreover, Sarkodie and Adom (2018) examined the causation affiliation among energy use and pollution discharges. The study's findings explained no negative impact on CO<sub>2</sub> emissions and economic growth decreases due to efficient energy. Lean and Smyth (2010) Moreover, Al-Mulali and Sab (2012) debated the same variables in their studies and concluded that they have a unidirectional causality relationship among energy and CO<sub>2</sub> emanations. While (Lean & Smyth, 2010) revealed that a rise in renewable energy production diminishes carbon emissions. Although a study on UAE inspects the affiliation among CO<sub>2</sub> exhibits and energy usage using the bound testing approach ARDL (autoregressive distributed lag) regression

model exposed that there is no association between these variables (Sbia, Shahbaz, & Hamdi, 2014).

### 3. Data

Description of variables are explained in table 2, this study used time series of data for 09 ASEAN<sup>1</sup> nations from 2000 to 2018. These emerging nations in the region are developing over industrialization and rapid growth. Some actions include modernization of agriculture, economic development, efficient trade, and residential energy use to renewable electricity.

**Table 2**  
**Variable description**

Variable	Definition	Unit	Source
TRD	Trade	% of GDP	WDI (World Bank, 2020)
CO2	CO2 emissions	Kilo ton per capita	WDI (World Bank, 2020)
CO2	CO2 emissions	Metric ton per capita	WDI (World Bank, 2020)
E.U.	Energy use	kg of oil equivalent per capita	WDI (World Bank, 2020)
FFE	Fossil fuel	energy	WDI (World Bank, 2020)
	consumption	% of the total	
REC	Renewable	energy	WDI (World Bank, 2020)
	consumption	% of total final energy consumption	
AVA	value-added forestry fishing, and agriculture	% of GDP	WDI (World Bank, 2020)

These six variables comprise FFE (fossil fuel energy consumption), REC (renewable energy consumption), EC (energy consumption), TRD (trade), AVA (agricultural added value), and carbon dioxide (CO2) emissions.

### 4. Methodology

The selection of econometric methods was established, which relied on the nature of data on several dynamics (kurtosis, skewness, normal distribution), cross-sectional dependence, nature of cointegration, stationarity of variables, and the number of observations. The suggested model's direct connection is explained amongst energy usage, trade, agriculture value-added, and carbon dioxide emissions.

$$CO2 = f(AVA, EC, TRD) \quad (1)$$

The linear affiliation amongst energy consumption (fossil fuel and re-newable energy), trade, agriculture value-added, and carbon of the suggested model can be stated as:

$$CO2 = f(AVA, REC, FFE, TRD) \quad (2)$$

We use the cointegration of the panel models Westerlund (2008), between the affiliation amongst the conditional distribution, the PARDL (panel Auto-Regressive Distribution Lag), and the FMOLS (fully modified ordinary least squares method) to evaluation the empirical base of the model short and long term. For short-run investigation, display of Equation 2 can be stated as:

$$CO2_{it} = \delta_0 + \delta_1 AVA_{it} + \delta_2 REC_{it} + \delta_3 FFE_{it} + \delta_4 EC_{it} + \delta_5 TRD_{it} + \epsilon_{it} \quad (3)$$

According to the above equation, carbon dioxide metric ton is a dependent variable, and exogenous indicators are value-added agriculture, energy consumption, fossil fuel energy, renewable energy consumption, and finally, trade liberalization.  $\delta_0$  Represents the coefficient of the equation, while  $\delta_1$  to  $\delta_5$  shows the influence on the dependent variable due to independent variables in ASEAN countries and  $\epsilon_{it}$  represents the error term based on the white noise of equation I cross-section and t is the time trend of data. Afterward examine the panel unit root and cointegration, we estimate the model by FMOLS (full modified

<sup>1</sup> Philippines, Thailand, Indonesia, Myanmar, Malaysia, Brunei Darussalam, Singapore, Vietnam, and Cambodia

ordinary least square) for the short run as well as long-run estimation's and panel FMOLS model become like this

$$CO2_{it} = \vartheta_0 + \vartheta_1 CO2_{i,t-1} + \vartheta_3 AVA_{i,t-1} + \vartheta_4 \Delta REC_{it} + \vartheta_5 FFE_{i,t-1} + \vartheta_6 EC_{i,t-1} + \vartheta_7 TRD_{i,t-1} + \epsilon_{it} \quad (4)$$

## 5. Results and Discussion

Table 3, represents the summary statics of the variables.

**Table 3**  
**Summary Statistics**

Variables	CO2	AVA	EC	FFE	REC	TRD
Mean	4.862	14.919	2209.255	68.573	32.077	132.516
Median	1.819	12.497	833.562	66.978	31.203	116.697
Maximum	24.627	57.239	9837.447	100.000	85.630	437.327
Minimum	0.163	0.025	251.275	18.621	0.014	0.167
Std. Dev.	6.005	12.818	2558.283	26.133	27.515	97.501
Skewness	1.696	1.110	1.418	-0.374	0.451	1.427
Kurtosis	5.242	4.043	3.833	1.888	2.014	4.737
Observations	171.000	171.000	171.000	171.000	171.000	171.000

According to table 3, carbon dioxide is measured by Co2 emission (mt), with the mean value is 4.86. The maximum and minimum values are 24.627, and 0.163 metric tons with the standard deviation is 6, Agriculture value-added, renewable energy use, consumption of fossil fuel, is measured by consumption of renewable energy and finally, trade (which is imports plus exports % of GDP) mean value are 14.919, 68.573, 32.077 and 132.516. Their standard deviation is 12.818, 26.133, 27.515, and 97.501, respectively.

First, we apply for numbers of unit root tests, and the results are shown in Table 4. The study uses economic variables that may have a random trend and cause instability. The first-generation unit root test was used to inspect whether variables were stationary or not. The four tests are used for unit root. These tests are (Im, Lee, & Tieslau, 2005; Levin, Lin, & Chu, 2002), PP Fisher, and ADF Fisher.

**Table 4**  
**Unit root test**

Test	Levin, Lin & Chu		I'm Pesaran & Shin	ADF - Fisher Chi-square		P.P. - Fisher Chi-square		
Variables	Statistic	Prob.	Statistic	Prob.	Statistic	Prob.	Statistic	Prob.
CO2	-2.026**	0.021	0.763	0.777	12.170	0.838	16.353	0.568
D(CO2)			-5.186***	0.000	59.308***	0.000	135.828***	0.000
EC	0.115	0.546	0.806	0.790	11.788	0.858	15.744	0.610
D(EC)	-3.875***	0.000	-2.607***	0.005	35.211***	0.009	110.785***	0.000
FFE	-1.396*	0.081	0.259	0.602	13.988	0.730	23.089	0.187
D(FFE)			-3.207***	0.001	41.549***	0.001	114.813***	0.000
REC	-0.856	0.196	0.513	0.696	15.535	0.625	25.236	0.119
D(REC)	-3.718***	0.000	-4.647***	0.000	54.578***	0.000	130.747***	0.000
TRD	-1.954**	0.025	-1.100	0.136	26.429*	0.090	26.576*	0.087
D(TRD)			-4.239***	0.000				

The number of unit root tests is applied, and the outcomes showed that some indicators are stationary at the level in some tests. Levin Lin Chu confirms that CO2, FFE, and TRD are stationary at the level and further indicates that these are at first difference stationary. So, it concluded that their mixed order of integration. So, we applied FMOLS and panel ARDL econometrics models to estimate the model.

Table 5 Pedroni (1999) test indicates that we accept the alternative hypothesis and reject the null hypothesis, which confirmed that there exists cointegration in the model Pedroni (1999), further estimate the model by FMOLS (fully modified OLS). In the estimated FMOLS model, the coefficient value-added of agriculture is statistically significant at the level of 5% and positively associated. The results show that a 1% rise in value-added agriculture boosts carbon dioxide emissions by 0.17%. For every 1% increase in metric tons of energy consumption, carbon dioxide emissions grow by 7.303% of metric tons. Similarly, a 1% rise in the energy of fossil fuel results in 0.4070% boosts in carbon emissions, an increase of 1% in renewable consumption of energy results in a 0.448% reduction in

emissions levels and an increase of one percent in trade liberalization reduce CO<sub>2</sub> emissions by 0.020%.

**Table 5**  
**Panel Cointegration and FMOL Results**

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Pedroni PP			-7.73588	0.000
Pedroni ADF			-2.58072	0.004
AVA	0.178**	0.072	2.473	0.015
EC	7.303***	0.666	10.972	0.000
FFE	0.470***	0.055	8.584	0.000
REC	-0.448***	0.045	-10.027	0.000
TRD	-0.020***	0.004	-5.388	0.000
Model Diagnostics				
R-square				0.832161
Adj. R-square				0.827885
S.E. of regression				2.510778

Note: \*\*\*,\*\* and \* show 1%, 5% and 10% level of significance respectively.

The study using FMOLS methods to compare outcomes with existing studies Levin et al. (2002) pointed out that for each rise of 1% in value-added agriculture, carbon emissions per capita increased by 0.17%. For each 1% upsurge in nonrenewable energy per capita, CO<sub>2</sub> (carbon dioxide) emissions increase carbon emission in ASEAN nations by 0.470%. Asumadu-Sarkodie and Owusu (2017) exposed that, for every 1% rise in the machinery of agriculture, carbon dioxide emissions increase by 0.09%. Asumadu-Sarkodie and Owusu (2017) study show an increase in total energy production in the long run and combustible remaining upsurge 307.9 kt CO<sub>2</sub> emissions. The indication from (Asumadu-Sarkodie & Owusu, 2016), taking Nigeria as an example, shows that carbon emissions boost 3% for every 1% surge in non-renewable energy consumption.

Renewable energy raises energy use and decreases the level of carbon dioxide production. Regarding the impact of energy consumption, the rise in renewable energy consumption has minimized the CO<sub>2</sub> level of emissions. Besides, renewable energy has a major optimistic impression on CO<sub>2</sub> emissions compared to other drivers. These results are related to (Al-Mulali et al., 2015; Chien, Kamran, et al., 2021; Jebli, Youssef, & Ozturk, 2016). Therefore, an inverse correlation between CO<sub>2</sub> discharges and renewable energy consumption was detected (Bölük & Mert, 2014; Farhani & Shahbaz, 2014; Muhammad Atif Nawaz et al., 2019).

Non-renewable & Renewable energy has an optimistic impression of CO<sub>2</sub> discharges from ASEAN countries. This also explains why using renewable energy can help improve the environment. Because existing technologies agree that renewable energy decreases carbon productions, such as nations use additional renewable energy, they emit less carbon dioxide. This study's results are reliable with the findings as (Al-Mulali et al., 2015; Chien, Sadiq, et al., 2021; López-Menéndez, Pérez, & Moreno, 2014). On the other hand, it stands in stark contrast to (Bölük & Mert, 2014).

Concerning nonrenewable energy consumption, NREC causes severe degradation of the environment. Associated with non-renewable energy, the elasticity of CO<sub>2</sub> emissions means that the rise in NREC of 1% reduces the level of emissions by 0.470%. Summarizing the impact of energy, this study discovers that the increase in renewable resources in the energy structure reduces the emissions of CO<sub>2</sub>. In the form of energy, a rise in non-renewable means leads to pollution in ASEAN countries.

In total energy consumption, the proportion of fossil fuels had a severe negative influence on ASEAN acceptance of renewable power technologies; this is the so-called lobbying effect. It supports the results of Pfeiffer and Mulder (2013); Sovacool (2009); Sun et al. (2021) and Sovacool (2009) also found that the lobbying effect of old-style energy sources prevented renewable energy factors. Similarly, Pfeiffer and Mulder (2013), considered that the high production of fossil fuels seems to interrupt renewable energy. This study findings also showed that the fossil fuel industry has a meaningful impression of stopping from implementing renewable technologies. This is understandable given that it is

one of the world's biggest fossil fuel producers, and the industry provides considerable government revenue and exchange rates. Because of this, players in the fossil fuel industry work to undermine measures to promote renewable energy technologies.

Recent business openings provide a good overview of different countries' contributions and regions to environmental improvement (Dogan & Turkekul, 2016). According to the literature, this study shows that increasing trade liberalization has reduced ASEAN's carbon emissions. More specifically, it has a high significance, and an increase in trade openness can diminish long-term CO<sub>2</sub> emissions by 0.01%. As mentioned in the introduction, the environment is impacted by trade in three ways. This study's outcomes specify that the net impact of trade openings on the environment reduces environmental degradation, as the technology and the composition effects dominate the effect of stairs. This makes sense, especially in the last few decades, where developed countries have completed significant progress in discovering different technologies. The ASEAN group looks to advantage from technology disseminated due to trade. By focusing more on the effects of synthesis, we can draw some interesting conclusions. For example, dirty and energy-intensive industries operating in ASEAN economies favor transferring to develop & underdeveloped countries because they use lower environmental standards than ASEAN. The latter situation generally states to the pollution paradise postulate. This condition shows that developed economies are aware that pollution of the environment can lead to the transfer of dirty factories and their operation in countries with less environmental compliance and regulation (Cole, 2004; Zhuang et al., 2021). In conclusion, the entire ASEAN may produce and export energy-saving, dirty import goods, and environmentally-friendly goods. While the level of general pollution in the world remains the same, pollution seems to change from one place to another. It is a reality that ASEAN benefits from free trade and standard countries with harsh environmental conditions.

## **6. Conclusion**

The study studied the affiliation amongst disaggregate and aggregate energy consumption (fossil fuel and renewable), trade openness, agriculture, and its influence on the environment degradation of ASEAN nations from 2000 to 2018. FMOLS econometric technique is employed to examine the impact of value-added in agriculture on CO<sub>2</sub> emissions. Although trade liberalization and energy consumption originate from enhancing environmental pollution. The empirical investigation outcome confirmed that agriculture value-added reduces carbon dioxide emissions with a higher pollution level in ASEAN economies. Furthermore, it affirms that total energy consumption boosts the level of carbon emission in the ASEAN region. Conversely, carbon dioxide emissions reduction due to trade openness and minimizes environmental pollution. Whereas the rise in energy consumption of fossil fuel is found to boost CO<sub>2</sub> emissions, renewable energy use decreases the pollution of the atmosphere in ASEAN nations. However, nonrenewable energy is the primary source of energy use in ASEAN countries, which minimizes the carbon emission level while in the presence of sound economic development and helps the total energy production in the ASEAN countries. Furthermore, it captures the new technologies that boost the energy efficiency that helps maintain the carbon emission level and keep the environment neat and clean.

In place of a concern policy suggestion, agricultural segment improvements for ASEAN countries need to emphasize sustainable agriculture production then smart climate. This method can benefit upsurge income and productivity, adjust to climate modification compassion, and decrease greenhouse gas emissions. This method can contribute to the agricultural stakeholders reducing emissions and raising their productivity. Trade openness tends to subsidize economic growth significantly; well-organized regional trade strategies can decrease carbon emissions in nations thru higher than lower environmental degradation.

According to this, endorse the administrations of ASEAN economies to recommend the guidelines that can increase the agriculture sector's production and generate a well-organized marketplace for global trade. Such strategies can inspire the movements of the investment opportunities besides technology aimed at specialism towards economies of scale and production. However, ASEAN's nations donate less to ecological worsening than established countries. Financial assistance joined through the supports of technology must



be improved toward adjusting with altering climatic circumstances. Improved disaster administration organizations by developing equipping and infrastructure will benefit ASEAN nation's agriculture sector. An unusual consideration must be specified towards implementing advanced energy technologies, like renewable energy, a decrease of dependence on fossil fuel aimed at agricultural determinations that donates to the increasing stages of atmospheric carbon emissions.

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