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UNRAVELING CARBON IMPACT: ASSESSING EXPORT, COMPETITIVENESS, GDP, AND POPULATION IN INDONESIA'S OIL PALM TRADE

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ABSTRAK

Studi ini menguji hubungan antara perdagangan ekspor, daya saing pasar, pertumbuhan ekonomi, dan jumlah penduduk dengan emisi karbon dalam perdagangan kelapa sawit Indonesia. Penelitian ini menggunakan data time series dari tahun 1995 sampai dengan tahun 2021 yang berasal dari data statistik. Pendekatan ekonometrika digunakan untuk menghitung dan menganalisis hubungan ini. Daya saing pasar dan praktik berkelanjutan terkait dengan emisi karbon yang lebih rendah dalam ekspor kelapa sawit. Praktik berkelanjutan dalam penggunaan lahan, pengurangan deforestasi, dan rantai pasok yang transparan sangat penting untuk memisahkan pertumbuhan perdagangan dari dampak lingkungan. Menyeimbangkan pertumbuhan ekonomi dan lingkungan sangat penting, mengingat hubungan yang terkait antara GDP dan emisi karbon. Pertumbuhan penduduk mempengaruhi permintaan terhadap kelapa sawit dan kesadaran terhadap lingkungan, mendorong upaya untuk mengurangi jejak karbon. Implikasi kebijakan meliputi kebijakan perdagangan berkelanjutan, dukungan sertifikasi, dan teknologi bersih adalah intervensi yang baik untuk diberikan. Kolaborasi antara pembuat kebijakan, pemangku kepentingan industri, dan organisasi lingkungan dapat memastikan kelangsungan hidup jangka panjang dan keberlanjutan lingkungan dalam ekspor kelapa sawit Indonesia.

Kata kunci: daya saing pasar, emisi karbon, perdagangan kelapa sawit, PDB, praktik berkelanjutan.

ABSTRACT

In Indonesia's oil palm commerce, this study investigates at the relationship between population growth, economic growth, market competitiveness, and export trade with carbon emissions. Time-series data from 1995 to 2021 collected from statistical sources is used in this study. This link is computed and analyzed using the econometric method. Lower carbon emissions in oil palm exports are correlated with sustainable practices and market competitiveness. To disentangle trade growth from environmental effect, sustainable land-use practices, deforestation reduction, and transparent supply chains are crucial. Given the erratic correlation between GDP and carbon emissions, striking a balance between economic expansion and environmental protection is imperative. Population expansion drives efforts to lower carbon footprints by influencing environmental awareness and the market for oil palm. Well-given initiatives such as clean technology, certification support, and sustainable trade policies have policy repercussions. Policymakers, industry players, and environmental groups working together can guarantee Indonesia's oil palm exports' long-term sustainability and ecological viability.

Key words: market competitiveness, carbon emissions, oil palm trade, GDP, sustainable practices.

INTRODUCTION

The Indonesian economy depends heavily on the oil palm sector, which also creates jobs and increases revenue and economic growth. Indonesia is recognized as the largest palm oil producer globally, with a substantial share of the international market. The industry's expansion and development have played a crucial role in driving economic growth and poverty reduction in the country (Mardiharini et al., 2021).

Indonesia's oil palm sector contributes significantly to its export earnings, bolstering its foreign exchange reserves and promoting economic stability (Bintariningtyas and Juwita, 2021). The export of palm oil and its byproducts, like oleochemicals and palm kernel oil, results in significant income and improves the trade balance. The Indonesian government relies heavily on this revenue to fund a range of public services and economic projects.

Moreover, the oil palm industry creates many employment opportunities, particularly in rural areas where plantations are located. It provides income for smallholder farmers, laborers, and workers engaged in various stages of production, including cultivation, harvesting, processing, and distribution. The industry's labor-intensive nature has helped alleviate poverty and improve the livelihoods of many Indonesians (Suryahadi et al., 2006).

However, the expansion of oil palm plantations and associated trade activities have raised significant concerns about their environmental impact, particularly concerning carbon emissions. Land clearing for oil palm cultivation often involves deforestation, biodiversity loss, and releasing large amounts of carbon dioxide (CO2) into the atmosphere (Vijay et al., 2016). The conversion of forested areas, especially tropical rainforests, for oil palm plantations contributes to the loss of valuable carbon sinks and the destruction of biodiversity-rich ecosystems (Koh et al., 2011).

The carbon emissions from land-use change and oil palm production processes contribute to climate change and exacerbate global warming. The release of CO2 from deforestation and the degradation of peatlands, often associated with oil palm expansion, further intensify greenhouse gas emissions (Shahputra and Zen, 2018). These emissions contribute to the global carbon footprint and undermine efforts to mitigate climate change.

As the world grapples with the challenges of climate change, it becomes increasingly important to assess the implications of trade policies and market dynamics on carbon emissions within the global oil palm sector. International trade plays a significant role in shaping the expansion and sustainability of the industry, as demand for palm oil and its derivatives continues to grow in various consumer markets worldwide (Arsyad et al., 2020).

The production and trade of oil palm products have complex environmental footprints that extend beyond national borders. The carbon emissions associated with the cultivation, processing, and transportation of palm oil can have far-reaching impacts on global climate patterns and greenhouse gas concentrations (Hassan et al., 2011). Therefore, understanding the relationship between trade policies, market dynamics, and carbon emissions is crucial for devising effective strategies to reduce the industry's environmental impact.

Trade policies, such as tariffs, quotas, and import/export regulations, influence the flow of oil palm products across borders and can affect carbon emissions. For example, trade restrictions promoting sustainable practices or mitigating deforestation may affect the industry's market dynamics and production methods (Kemper and Filho, 2021). By aligning trade policies with environmental objectives, countries can encourage sustainable production practices and reduce the carbon footprint associated with the oil palm trade.

Market dynamics, including consumer preferences, sustainability certifications, and corporate commitments, also play a pivotal role in shaping carbon emissions in the oil palm sector. Consumer awareness and demand for sustainably sourced palm oil have led to the emergence of certification schemes, such as the RSPO (Roundtable on Sustainable Palm Oil), which promotes responsible production practices and carbon emission reductions (RSPO, 2018). Similarly, corporate commitments to deforestation-free supply chains and sustainable sourcing practices can drive industry-wide efforts to mitigate carbon emissions (Jopke and Schoneveld, 2018).

Most of the impact of oil palm has been discussed and written mainly on the plantation, especially when the forest is converted into oil palm plantation, contributing to CO_2 emissions due to loss of forest cover. Research on the impacts of oil palm cultivation remains scattered and patchy (Dislich et al., 2017). The biomass of natural forest trees is converted into CO_2 emissions, including the loss of rich forest biodiversity. According to Noë et al. (2021), deforestation is the critical factor in forest Carbon emissions from 1990-2020. This study aims to expose more on how the oil palm production trade can also generate negative environmental externalities, as production for domestic trade and exports can result in CO_2 emissions, a gap for sustainable economic growth.

In economics, some discussion about the oil palm commodity contributes to economic income, including reducing poor people (Alamsyah et al., 2023). Population increases contribute to the rise in oil palm consumption, and GDP increases purchasing power. When the population rises and the GDP grows, the role of trade will increase the growth of trade activities, contributing to negative externalities (Othman, 2003). Trade competitiveness is still based on quality and price; the green product should be a priority to the competitive advantages. This study also supports a new approach in promoting the dynamic of international trade to highly consider CO_2 emission as one of the indicators for competitiveness using green commodity advantages.

This study aims to analyze the relationship between market competitiveness and carbon emissions in the global oil palm trade, explicitly focusing on Indonesia as the largest producer and exporter. Additionally, the study aims to measure Indonesia's oil palm export volume, GDP, and population to comprehensively understand the economic and demographic factors associated with the oil palm industry's carbon emissions.

Market competitiveness refers to the ability of Indonesian oil palm exports to compete in the global market based on environmental standards, efficiency, technology, innovation, and the demand for sustainable products. By examining these factors and considering the export volume, GDP, and population, this study seeks to gain insights into how market competitiveness influences carbon emissions in the oil palm industry and contributes to promoting sustainable practices and mitigating the environmental footprint of the trade.

This study employs an econometric model to examine the relationship between market competitiveness, trade volume, economic factors (such as Gross Domestic Product - GDP), and carbon emissions. The findings will provide insights into pathways for promoting sustainable practices and reducing carbon emissions associated with the oil palm sector.

The first objective of this study is to analyze the relationship between market competitiveness and carbon emissions in the oil palm trade from Indonesia to various export markets. The second is to assess the impact of trade volume on carbon emissions in the Indonesian oil palm sector and identify strategies to decouple trade growth from environmental impact. Thirtly is to examine the relationship between GDP and carbon emissions in the oil palm trade, exploring the mixed pattern and potential for adopting cleaner technologies. Fourthly, to investigate the influence of population dynamics on oil palm product demand and carbon emissions, considering the balance between population growth and sustainability efforts. Fifthly, to provide policy recommendations for promoting sustainable practices, certification schemes, and environmental standards in Indonesia's oil palm trade to reduce carbon emissions and ensure long-term industry viability.

The outcomes of this study will be of great significance for policymakers, industry stakeholders, and environmental organizations seeking to address the environmental challenges associated with the global oil palm trade. By identifying the key drivers of market competitiveness and their impact on carbon emissions, this research will provide valuable insights and recommendations for promoting sustainable practices, reducing carbon footprints, and ensuring the long-term viability of the global oil palm sector.

THEORETICAL REVIEW

Market Competitiveness and Carbon Emissions

Several studies have extensively investigated the relationship between market competitiveness and carbon emissions in various industries to seek a deeper understanding and insights into the complex relationship and interactions between economic activities, such as those in the oil palm industry, and environmental sustainability goals. These studies recognize the importance of understanding how market competitiveness influences carbon emissions, as it can provide insights into the effectiveness of policies and strategies to reduce environmental impact.

A few studies have examined the relationship between market competitiveness and carbon emissions in the context of the oil palm industry. For instance, research has explored the impact of market competitiveness on carbon emissions in the production and trade of oil palm products in countries like Malaysia, Indonesia, and Thailand (Ma et al., 2021). Market dynamics, competition, and trade policies play a significant role in shaping carbon emissions within the oil palm sector.

Market competitiveness affects carbon emissions through multiple channels. For instance, increased competition in the global market can lead to efficiency improvements, technological advancements, and innovation, reducing carbon emissions (OECD, 2015). On the other hand, fierce competition may also result in a race to the bottom, where producers prioritize cost reduction (OECD, 2015) and neglect environmental considerations, leading to higher carbon print (Santoso, 2017).

Factors such as trade volume, economic growth, population, and environmental standards can further influence the relationship between market competitiveness and carbon emissions in the oil palm trade. Higher trade volumes and economic growth can drive increased production and trade activities, potentially leading to higher carbon emissions if not accompanied by sustainable practices (Brenton and Chemutai, 2021). Additionally, population growth and changes in consumer preferences for sustainable products can influence the demand for palm oil and affect the industry's environmental performance (Dauda et al., 2021).

Econometric analyses and modeling techniques have been employed to understand better and quantify the relationship between market competitiveness and carbon emissions. These approaches allow researchers to examine the complex interactions between market dynamics, trade patterns, economic variables, and carbon emissions (Zhen and Friere, 2023). Such studies contribute to the knowledge surrounding the oil palm industry's environmental impact and provide insights into potential pathways for reducing carbon emissions.

There was a relationship between market competitiveness and carbon emissions in various industries, involving multiple variables and intricate mechanisms that need to be understood and analyzed. It was indicated that higher market competitiveness is often associated with increased carbon emissions due to intensified production and trade activities. The pressure to gain a competitive edge may lead to a focus on cost reduction and neglect of environmental considerations, resulting in higher emissions.

The reporting of greenhouse gas emissions by companies worldwide is on the rise. This upward trend entails a significant increase in the potential opportunity cost for companies that disclose incorrect information regarding their emissions. As more companies participate in disclosing their greenhouse gas emissions, the importance of accurate and reliable data becomes paramount, as any inaccuracies could result in substantial costs for these companies (Lee and Lee, 2022).

From a different perspective, greater market competitiveness can drive firms to adopt cleaner technologies and practices, reducing carbon emissions. However, more than domestic market development is needed for export competitiveness, as technological catch-up requires firm-level advantages provided by accessing lead markets (United Nations, 2023). In this view, staying competitive motivates companies to improve efficiency, invest in innovation, and implement sustainable measures to reduce environmental impact. Market competitiveness can catalyze positive change and contribute to sustainable practices in the industry.

The relationship between market competitiveness and carbon emissions is complex. It is essential to consider various factors such as industry characteristics, regulatory frameworks, technological capabilities, and the availability of sustainable alternatives. The context-specific nature of the oil palm trade further highlights the need for further investigation into the specific dynamics of this industry.

Economic Growth and Carbon Emissions

The relationship between economic growth and carbon emissions has garnered significant attention in research. The Environmental Kuznets Curve (EKC) has attractted significant attention and motivated numerous studies. The EKC suggests an inverted U-shaped relationship between income and CO2 emissions. Environmental degradation occurs in the early stages of development, but as economic development progresses, CO2 emissions decrease (Grossman and Helpman, 1991). The EKC hypothesis suggests an inverted U-shaped relationship between income levels and environmental degradation. According to this hypothesis, as a nation's income initially rises, environmental degradation intensifies, but beyond a certain income threshold, economic development leads to improved environmental quality.

Although some studies provided some evidence supporting the EKC hypothesis, recent research has produced mixed findings, underscoring the need for context-specific analysis. For instance, Iskandar (2019) conducted a study in Indonesia and found a positive association between economic growth and carbon emissions. The carbon emissions increase as these nations experience economic expansion.

Population and Carbon Emissions

Population size is crucial in determining carbon emissions as it directly impacts energy consumption and industrial activities. The larger the population, the higher the energy demand, increasing carbon emissions. Research conducted by Mohammadi and Burhan (2020) has provided evidence of a positive correlation between population growth and carbon emissions, highlighting the role of population dynamics in environmental impact.

However, it is essential to consider additional factors that can influence the relationship between population and carbon emissions. Studies such as Ribeiro et al. (2019) have suggested that population density and urbanization significantly shape this relationship. Higher population density and increased urbanization can lead to more efficient energy use, improved infrastructure, and enhanced waste management systems, potentially mitigating carbon emissions. These findings underscore the importance of considering not only the population size but also the context of urbanization and population distribution when assessing the carbon impact of Indonesia's oil palm trade.

Environmental Standards and Sustainable Practices

Adopting environmental standards and sustainable practices within the oil palm trade is recognized as a critical approach to reducing carbon emissions. Prior research by Heilmayr et al. (2020) emphasized the importance of implementing stringent environmental regulations and certification schemes to promote sustainable practices in the oil palm industry. These measures aim to ensure responsible production, minimize deforestation, and limit the carbon footprint associated with oil palm cultivation and processing.

While studies by Ariyanto et al. (2020) highlighted the role of technological innovation and efficiency improvements in mitigating the environmental impact of oil palm production. Introducing advanced technologies and implementing more efficient practices can help reduce resource consumption, optimize production processes, and minimize carbon emissions throughout the supply chain. These innovations encompass precision agriculture, waste management, and renewable energy utilization.

RESEARCH METHOD

This study compiles comprehensive trade data on the amount of Indonesian oil palm goods exported to international markets. A comprehensive understanding of Indonesian oil palm products' trade dynamics and patterns, particularly in export volume, can be obtained by collecting the necessary data. The data collected will serve as the foundation for analyzing the relationship between market competitiveness, carbon emissions, and other relevant factors in the oil palm trade. This research will provide valuable insights into the environmental sustainability of Indonesia's oil palm exports, along with identifying potential pathways to reduce carbon emissions and promote sustainable practices in the global oil palm trade.

Data in this study encompasses trade activities between Indonesia and various countries worldwide, providing insights into trade volumes and product classifications. This study utilizes time-series data covering the period from 1995 to 2021. The data included CO_2 emissions, Export Volume, Market Competitiveness, GDP, and Population, all obtained from reliable sources such as the World Bank, Comtrade, and the Observatory of Economic Complexity (OEC). These sources offer reliable and up-to-date information on international trade statistics. By analyzing this trade data, a comprehensive examination of the relationship between market competitiveness and carbon emissions in the oil palm sector will shed light on the industry's environmental impact.

The econometric model employed in this study aims to analyze the relationship between the dependent variable, the carbon emissions associated with oil palm exports from Indonesia to the global market, and several independent variables. These independent variables include the trade volume, representing the quantity of oil palm in Indonesia's export trade. Additionally, market competitiveness is measured by Indonesia’s export share to the world’s market. The GDP variable reflects Indonesia's economy's overall economic activity and size. The econometric model equation used in this analysis incorporates population size as a factor influencing carbon emissions:

$$\text{Carbon Emissions} = \beta0 + \beta1 * \text{ExportVolume} + \beta2 * \text{Market Competitiveness} + \beta3 * \text{GDP} + \beta4 * \text{Population} + \varepsilon$$

In this equation, $\beta0$ represents the intercept, while $\beta1$, $\beta2$, $\beta3$, and $\beta4$ are the coefficients associated with each independent variable. The ε term denotes the error term capturing any unexplained factors influencing carbon emissions.

This study conducts several tests and procedures to examine the relationship between variables: carbon emissions, export volume, market competitiveness, GDP, and population. The stationarity test, specifically the Augmented Dickey-Fuller (ADF) test, is employed to assess the presence of a unit root and determine the long-run relationship among the variables in the time series data. Furthermore, the Johansen Cointegration Test is utilized to examine the consistency of the estimated equation.

The presence of serial correlation in the time-series data is evaluated using the Breusch-Godfrey Serial Correlation L.M. Test. Additionally, the Breusch-Pagan-Godfrey Test is employed to investigate heteroskedasticity. Once the data prerequisites are tested and accepted, the estimated equation for carbon emissions is derived using the ordinary least squares (OLS) method. This estimation allowed us to assess the contributions of Export Volume, Market Competitiveness, GDP, and Population to CO2 emissions.

The econometric tests and estimation of the long-run equations are performed using the EViews Software, a powerful and widely recognized tool in econometrics that offers advanced analysis capabilities and precise modeling techniques. These procedures ensured the robustness and validity of the analysis, enabling us to examine the relationships and draw meaningful conclusions regarding the factors influencing carbon emissions in the context of this study.

By employing this econometric model, the study aims to gain insights into the complex relationship between these variables and carbon emissions, providing valuable information for understanding and addressing the environmental impact of Indonesia's oil palm exports.

A descriptive analysis will be performed in the data analysis phase to gain insights into the variables. This analysis will examine the collected data's distribution, trends, and summary statistics. By conducting a descriptive analysis, we aim to understand the characteristics and patterns of the variables in the study.

The econometric analysis will estimate the independent variables' coefficients (β values) using a technique such as ordinary least squares (OLS) regression. This estimation process will enable the assessment of the statistical significance and magnitude of the coefficients. By examining these coefficients, we can gain insights into the relationships between carbon emissions and the trade variables, providing a deeper understanding of how trade volume, market competitiveness, GDP, and population influence carbon emissions in the oil palm trade.

The estimated coefficients and their statistical significance for the independent variables will be analyzed and interpreted during the interpretation and discussion of the results. Specifically, the impact of market competitiveness, trade volume, GDP, and population on carbon emissions in Indonesia's oil palm exports will be assessed. By examining these relationships, valuable insights can be gained regarding how market competitiveness influences carbon emissions and the role of other variables in shaping carbon emissions within the oil palm sector. The discussion will focus on the implications of the findings, highlighting the importance of market competitiveness in addressing carbon emissions and considering the broader context of sustainability in the oil palm industry.

ANALYSIS AND DISCUSSION

Carbon Emissions and Export Dynamics

The data provided in Figure 1 includes information on CO_2 emissions (in kilo tons), oil palm exports (in hundred tons), GDP (in U.S. dollars), and the population (in thousands) of Indonesia for the years 1995 to 2021.

The trend analysis of CO_2 emissions reveals a consistent overall increase over the years, although with inevitable fluctuations. The trend analysis of CO_2 emissions reveals a consistent overall increase over the years, although with inevitable fluctuations. Between 1995 and 2021, the recorded CO_2 emissions in Indonesia exhibited a notable rise, climbing from 223,680 kilograms to 670,435 kilograms. This figure demonstrates substantial growth in carbon emissions during the analyzed period.

The oil palm export trends reveal a consistent upward pattern, although some fluctuations occurred in specific years. The export volume of oil palm products from Indonesia experienced a significant increase from 1,576,423 tons in 1995 to 26,950,382 tons in 2021. This substantial export growth indicates a rising global demand for oil palm products.

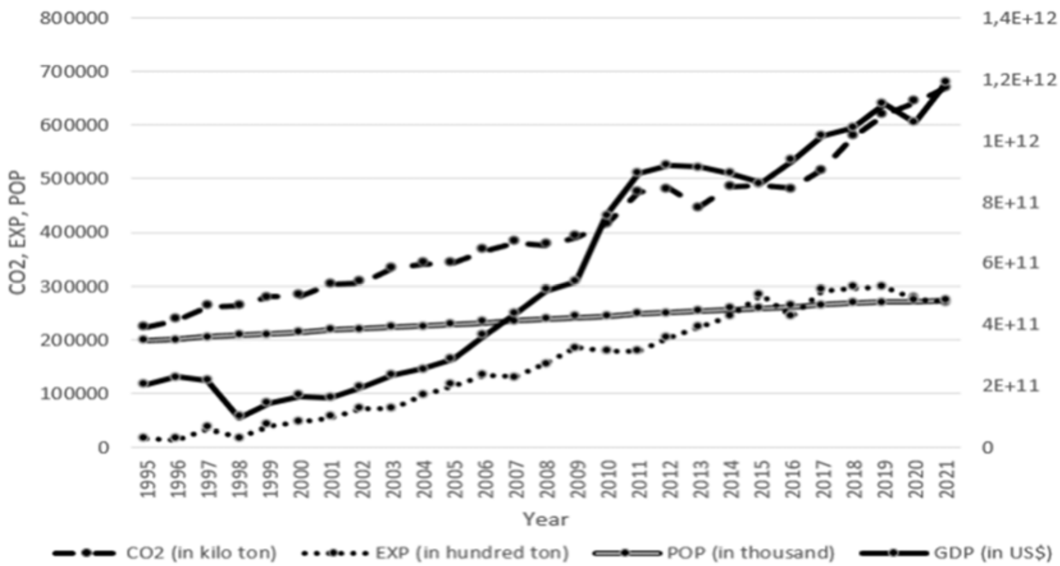

Figure 1

Trends in CO2 Emissions, Oil Palm Exports, Population, and GDP of Indonesia

Source: Data obtained from statistical sources and processed

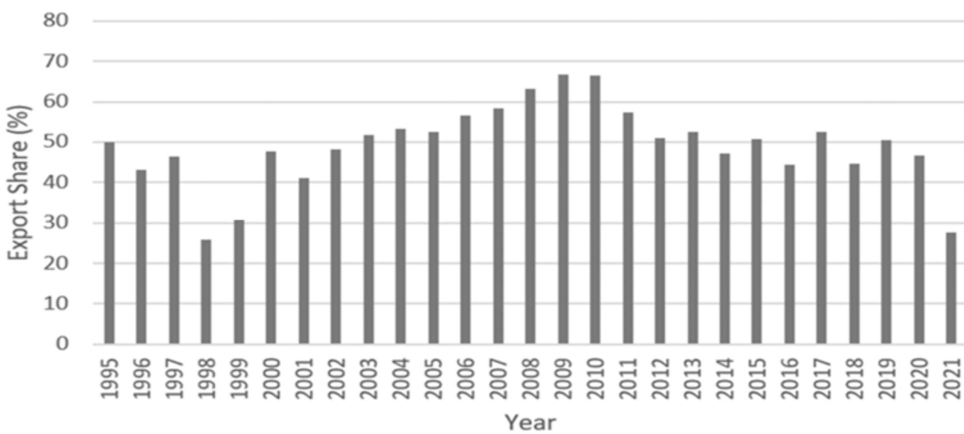

Figure 2

Trends in Eksport Share of Indonesia to the World Market

Source: Data obtained from statistical sources and processed

The GDP of Indonesia demonstrates a generally upward trend, indicating economic growth over the years. The GDP increased from 202.13 billion U.S. dollars in 1995 to 1.18 trillion U.S. dollars in 2021. This consistent growth reflects the country's expanding economy and development.

Indonesia's population has continuously increased over the years while at a decreasing rate. The population rose from 198,140,162 in 1995 to 273,753,191 in 2021. While the population growth rate has slowed down, Indonesia's population remains on an upward trajectory.

The export share of Indonesia's oil palm fluctuated from 1995 to 2021 (See Figure 2). It started at 49.9 percent in 1995 and experienced variations over the years. The export share reached its lowest point in 1998, dropping to 25.8 percent. However, it gradually increased in subsequent years, peaking at 66.7 percent in 2009. From 2010 to 2021, the export share fluctuated from 27.6 percent to 66.7 percent.

Table 1
Unit Root Tests

Statistic/Diagnostic	CO2	EXP	SHARE	GDP	POP
	1st difference with Intercept	Level with Intercept	1st difference with Intercept	1st difference with Intercept	Level with None
ADF test statistic (t-Statistic)	-4.441142	-6.793971	-5.476012	-3.853861	-2.470840
Prob	0.0019**	0.0000**	0.0002**	0.0074**	0.0160**
Test Critical value					
1% Level	-3.724070	-3.724070	-3. 724070	-3.724070	-2.669359
5% Level	-2.986225	-2.986225	-2.986225	-2.986225	-1.956406
10% Level	-2.632604	-2.632604	-2.632604	-2.632604	-1.608495

Source: Processed statistical data.

Table 2
Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value
None *	0.861156	90.08889	47.85613
At most 1 *	0.672388	42.70314	29.79707
At most 2 *	0.458900	15.92091	15.49471
At most 3	0.048028	1.181277	3.841466

Trace test indicates 3 cointegrating eqn(s) at the 0.05 level
**** denotes rejection of the hypothesis at the 0.05 level***
*****MacKinnon-Haug-Michelis (1999) p-values***
Source: Processed statistical data.

From 1995 to 2021, Indonesia's CO2 emissions totaled approximately 406,746 kilotons. The country's oil palm exports averaged around 154,315 hundred tons during the same period. The average GDP stood at approximately 5.78136 trillion U.S. dollars, while the population-averaged 237,638 thousand. Notably, the export share for Indonesia's oil palm, on average, accounted for approximately 48.6 percent of the total during the entire period.

The time-series data are tested to investigate the presence of a unit root of the variables with the Augmented Dickey-Fuller (ADF) tests of EViews Statistical Data Processing. The null hypothesis of the time series data is the presence of a unit root, and the alternative hypothesis is stationarity. The result of the ADF and P.P. unit root test is shown in Table 1. It shows that variables are stationary at the first difference for all variables, and the variables are then ready for the cointegration test.

The cointegration test aims to examine the possible correlation between several time-series data. The null hypothesis of the time-series data was a no-cointegration equation against the alternative of a cointegration equation. The Johansen Cointegration Test shows the rejection of a null hypothesis of no-cointegration and accepts a cointegration equation at the 0.05 level of variables with lags of interval in first differences. The results of the cointegration test are shown in Table 2.

The autocorrelation test for this research used the Breusch-Godfrey Serial Correlation L.M. Test. For Canada, the Breusch-Godfrey Serial Correlation L.M. Test with the result of Prob. Chi-Square 0.41 > 0.05, or more than α of 5 percent. It indicated the acceptance of Ho, so there is no autocorrelation. The normality test using Jaque-Berra Probability of 0.59 >0.05, or more than α of 5 percent, so the data distribution is normal. The Heteroskedasticity Test Breusch- Pagan-Godfrey results in a Probability of Chi-Square (4) 0.46 > 0.05, or more than α of 5 percent, so there is no heteroskedasticity.

They have proven that there was no autocorrelation, data was normally distributed, and there was no heteroskedasticity. The estimated equations with the OLS method and the coefficient of the equation are shown in Table 3.

The estimated equation of the EKC for each country is as follows:

LNCO21 = 764.8583-49.58118*LNEXP011+ 1.199275*LNEXP011_2 - 0.246443*LNSHARE1_2+3.18E-22*GDP1_2 - 12.69536*LNPOP

Relationship between Market Competitiveness and Carbon Emissions

The study analysis is expected to reveal a negative relationship between market competitiveness and carbon emissions in the oil palm trade. Within sustainable practices, higher market competitiveness, driven by factors such as adherence to environmental standards, technological advancements, and demand for sustainable products, is likely to be associated with lower carbon emissions.

Based on the estimated coefficients in Table 3, the results show a negative relationship between market competitiveness (LNSHARE1_2) and carbon emissions in the oil palm trade between Indonesia and the world market. The coefficient of LNSHARE1_2 is statistically significant (p = 0.0630); it shows a negative sign, indicating that higher market competitiveness is associated with potentially lower carbon emissions.

Some studies also mentioned that higher market competitiveness is associated with potentially lower carbon emissions in various industries (OECD, 2021). This relationship is based on the assumption that greater market competitiveness often drives the adoption of sustainable practices, efficient technologies, and adherence to environmental standards, resulting in reduced carbon emissions per unit of production.

Some Studies have also indicated a positive relationship between the market competitiveness of Indonesian oil palm exports and lower carbon emissions because heightened market competitiveness often drives the adoption of sustainable practices, efficient technologies, and adherence to environmenttal standards, leading to reduced carbon emissions per unit of oil palm production (Leimona et al., 2015).

Companies with greater market competitiveness are more likely to invest in sustainnable practices, such as zero-burning policies, responsible land management, and innovative technologies that optimize resource use and minimize emissions. Market-driven demand for sustainably sourced products also incentivizes companies to implement responsible sourcing, traceability, and certification schemes throughout their supply chains, further reducing carbon emissions (Grabs, 2023).

According to Raitzer et al. (2015), market competitiveness can incentivize firms to embrace cleaner technologies and reduce carbon emissions. The transition to a low-carbon economy and the resulting cost reduction depends on technological advancements and access to advanced low-carbon energy solutions. Carbon capture and storage play a pivotal role in emission reduction among these technologies.

The study suggests that there may be a relationship between market competitiveness and carbon emissions. The regression model's overall fit is relatively strong, with an R-squared value of 0.894541, indicating that the independent variables explain approximately 89.5 percent of the variation in carbon emissions.

Table 3
The estimated coefficient of variables

Dependent Variable: LNCO21
Method: Least Squares

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNEXP011	-49.58118	19.95348	-2.484839	0.0679
LNEXP011_2	1.199275	0.484177	2.476932	0.0684
LNSHARE1_2	-0.246443	0.096444	-2.555283	0.0630
GDP1_2	3.18E-22	8.94E-23	3.551262	0.0238
LNPOP	-12.69536	4.990068	-2.544125	0.0637
C	764.8583	292.7114	2.613011	0.0592

R-squared	0.894541	Mean dependent var	9.317288
Adjusted R-squared	0.762718	S.D. dependent var	1.143787
S.E. of regression	0.557157	Akaike info criterion	1.951771
Sum squared resid	1.241697	Schwarz criterion	2.133322
Log likelihood	-3.758853	Hannan-Quinn criteria.	1.752610
F-statistic	6.785904	Durbin-Watson stat	0.001967
Prob(F-statistic)	0.043628		

Source: Processed statistical data.

These findings emphasize the significance of promoting sustainable practices and certification schemes, such as the Roundtable on Sustainable Palm Oil (RSPO), to reduce the oil palm industry's environmental footprint effectively. Implementing stringent environmental regulations and certification schemes has been highlighted as a crucial step in promoting sustainability within the sector (Amundsen and Osmundsen, 2020).

Certification schemes like the RSPO set criteria for sustainable palm oil production, which include environmental considerations, social responsibility, and economic viability. Adhering to these standards encourages the adoption of sustainable practices, such as minimizing deforestation, protecting biodiversity, and reducing carbon emissions throughout the oil palm value chain (Kamaruddin et al., 2018).

By championing sustainable practices, the oil palm sector can mitigate its impact on carbon emissions and contribute to more environmentally sustainable trade. Encouraging industry-wide adoption of certification schemes and promoting sustainable practices are essential to achieving a more sustainable and responsible oil palm industry.

Influence of Trade Volume on Carbon Emissions

Based on the estimated coefficient in Table 3, the results suggest a positive relationship between export trade volume (LNEXP011_2) and carbon emissions in the oil palm trade between Indonesia and the world market.

The coefficient of LNEXP011_2 (trade volume of oil palm between Indonesia and the world market) was found to be statistically significant (p = 0.0684), indicating a positive association with carbon emissions. This result aligns with previous studies that have observed higher trade volumes contributing to increased carbon emissions in the agricultural and global trade sectors (Foong et al., 2022).

The positive relationship between trade volumes and carbon emissions emphasizes the importance of considering the environmental impact of trade activities and implementing sustainable practices to mitigate carbon emissions throughout the oil palm supply chain.

This positive relationship can be attributed to the potential consequences of increased production levels, which may lead to expanded land use for oil palm plantations, contributing to land-use change, deforestation, and increased emissions from transportation activities.

The analysis is expected to demonstrate a positive relationship between trade volume and carbon emissions, indicating that the associated carbon emissions increase as trade volumes increase. This finding highlights the urgency of implementing strategies to decouple trade growth from environmental impact within the oil palm sector. It emphasizes the importance of adopting sustainable land-use practices, promoting responsible sourcing, and reducing deforestation to mitigate the carbon intensity of the industry. By addressing these challenges, stakeholders can work towards a more sustainable and environmentally friendly oil palm trade.

The significant coefficient of LNEXP011_2 (trade volume of oil palm between Indonesia and the world market) highlights the importance of adopting sustainable land-use practices, promoting responsible sourcing, and reducing deforestation to mitigate the carbon intensity of the industry. Research studies have consistently emphasized the need for sustainable practices in the oil palm sector to address environmental challenges.

For example, a study by Shahputra and Zen (2018) found that unsustainable land-use practices, such as forest conversion for oil palm plantations, contribute significantly to carbon emissions and deforestation. The industry can reduce its environmental impact by adopting sustainable land-use practices, such as zero-deforestation commitments and protecting high-carbon stock areas (Austin et al., 2021).

Furthermore, responsible sourcing initiatives, such as the Roundtable on Sustainable Palm Oil (RSPO), have been developed to promote sustainable production and trade of palm oil. These initiatives encourage adopting best management practices, including reducing.

Greenhouse gas emissions and protecting biodiversity (Ayompe et al., 2021). By supporting responsible sourcing and certification schemes, stakeholders can contribute to reducing carbon intensity in the oil palm trade.

Role of GDP in Carbon Emissions

The estimated coefficient for GDP (GDP1_2) in Table 3 suggests a statistically significant relationship with carbon emissions in the oil palm trade between Indonesia and the global market ($p = 0.0238$). This finding indicates that GDP significantly influences carbon emissions in this context. The statistically significant relationship between GDP and carbon emissions in the oil palm trade underscores the importance of considering economic factors in addressing environmental sustainability and reducing carbon footprints. The significant relationship between GDP and carbon emissions in the oil palm trade highlights the importance of considering economic factors in addressing environmental sustainability and reducing carbon footprints.

The finding that GDP significantly influences carbon emissions in this context aligns with previous research examining the relationship between economic growth and carbon emissions. Several studies have found evidence of a positive relationship between GDP and carbon emissions, suggesting that higher levels of economic activity and consumption contribute to increased carbon emissions. For instance, Mitić et al. (2023) examined the relationship between CO_2 emissions, economic growth, energy availability, and employment in South-Eastern European countries. The findings reveal short-term bidirectional causality between CO2 emissions and employment, as well as available energy and employment. Unidirectional causality is observed from available energy and employment to GDP.

However, it is essential to consider that various factors can influence the relationship between GDP and carbon emissions and vary across contexts. Gu (2022) explored the impact of the sharing economy on urban carbon emissions in China. Findings indicate that personal credit information services, digital finance, and technological innovation contribute to reducing carbon emissions. Spatial spillover effects also play a role. Policy recommendations are provided for promoting the collaborative economy and reducing urban carbon emissions.

The relationship between GDP and carbon emissions may vary. While a higher GDP often indicates increased economic activity and consumption, which can contribute to higher carbon emissions, it is also possible that economic growth is accompanied by the adoption of cleaner technologies and sustainability measures, leading to reduced carbon intensity.

The relationship between GDP and carbon emissions can exhibit positive and mixed patterns, depending on various factors. A higher GDP is often associated with increased economic activity and consumption, which can lead to higher carbon emissions. This positive relationship between GDP and carbon emissions has been observed in several studies.

For example, Afolayan et al. (2019) found a positive relationship between GDP and carbon emissions in developing countryes. The study suggests that as these countries experience economic growth, carbon emissions tend to increase due to greater energy consumption and industrial activities.

However, it is also important to note that economic growth can be accompanied by adopting cleaner technologies and sustainability measures, reducing carbon intensity. This mixed relationship between GDP and carbon emissions has been highlighted in recent research.

For instance, Dinda (2004) proposed the Environmental Kuznets Curve (EKC) hypothesis, which suggests an inverted U-shaped relationship between income levels and environmental pressure. The theory posits that environmental pressure increases as a country's income rises, but economic development leads to improved environmental quality beyond a certain threshold.

Shen et al. (2023) also analyzed the decoupling between carbon emissions and economic growth in China's major regions from 1997 to 2019. Results show varying degrees of decoupling, with better outcomes in the eastern and western regions. Renewable energy reduces carbon intensity, especially in the western region. Findings highlight the importance of stable economic growth and increased clean energy consumption for achieving carbon neutrality in China.

Overall, the relationship between GDP and carbon emissions is complex and context-specific, influenced by economic development, policy measures, and technological advancements.

The relationship between GDP and carbon emissions can be complex. On the one hand, higher GDP often correlates with increased economic activity and consumption, which can contribute to higher carbon emissions. However, economic growth can also lead to adopting cleaner technologies and sustainability measures, potentially reducing carbon intensity. Therefore, the relationship between GDP and carbon emissions in the oil palm trade may exhibit a mixed pattern, with positive and negative factors influencing carbon emissions.

The relationship between GDP and carbon emissions in the oil palm trade context can exhibit a mixed pattern, as economic growth can positively and negatively influence carbon emissions. Studies have shown that higher GDP levels are associated with increased energy consumption and industrial activities, contributing to higher carbon emissions. For example, a study by Radmehr (2021) explored the relationships between economic growth, carbon emissions, and renewable energy consumption in European Union (E.U.) countries. Positive spatial correlations are observed, with economic growth showing a stronger correlation. Bidirectional links exist between economic growth and carbon emissions, growth, and renewable energy consumption. The study emphasizes the importance of targeted policies to achieve the E.U.'s sustainability and economic development goals.

However, it is essential to note that economic growth can also drive the adoption of cleaner technologies and sustainability measures, which can mitigate carbon emissions. As countries develop and become more aware of environmental concerns, there is a growing emphasis on sustainable practices and environmental regulations—the implementation of cleaner technologies and efficiency improvements that reduce the carbon intensity of economic activities. For example, China's actions are crucial for global carbon emission reduction. Our study found that many Chinese provinces have successfully decoupled economic growth from production, consumption, and income-based emissions. Emission intensity is a key driver for mitigation, while per capita GDP and population size present challenges. Recommendations include technological improvements, consumption structure adjustments, allocation changes, and increased investment in cleaner production. Policy adjustments such as taxes, subsidies, and loans are also advised (Li et al., 2022).

The relationship between Indonesia's GDP and carbon emissions in the oil palm trade may exhibit a mixed pattern, following the Environmental Kuznets Curve (EKC) hypothesis. Initially, as Indonesia's GDP increases, carbon emissions may rise due to more significant economic activity. However, beyond a certain threshold, higher income levels may incentivize the adoption of cleaner technologies and sustainability measures, leading to a decline in carbon emissions. The analysis could shed light on the stage of development at which Indonesia's oil palm trade lies along this curve, providing insights into the potential sustainability implications and the role of GDP in shaping carbon emissions within the industry.

Impact of Population on Carbon Emissions

The relationship between population and carbon emissions may also vary. A larger population can increase demand for oil palm products, potentially driving higher production levels and associated carbon emissions. However, population growth can also coincide with increased awareness of sustainability issues, leading to more significant efforts to reduce carbon emissions and promote sustainable practices.

The relationship between population and carbon emissions in the oil palm trade context can exhibit a mixed pattern influenced by various factors. On the one hand, a larger population can drive higher demand for oil palm products, leading to increased production levels and potentially higher carbon emissions. Studies have shown that population growth is associated with increased energy consumption and industrial activities, which can contribute to higher carbon emissions. For example, According to Birdsall (1992), population growth has a dual impact on greenhouse gas emissions. Firstly, as the population increases, the energy demand also rises, resulting in higher greenhouse gas emissions. Secondly, rapid population growth leads to deforestation and changes in land use practices, further contributing to increased greenhouse gas emissions.

However, it is important to note that population growth can also coincide with increased awareness of sustainability issues and efforts to reduce carbon emissions. As populations grow, there is greater recognition of the need for sustainable practices and environmental conservation that lead to implementing policies and initiatives to reduce carbon emissions and promote sustainable production methods.

Shunfa et al. (2022) examined the relationship between urban spatial structure and carbon emissions. The findings highlight the need for research on urban agglomerations and indicators for urban form. Three-dimensional indicators are crucial for policy-making. Complex and fragmented urban structures are associated with higher carbon emissions. A comprehensive framework is proposed to analyze this relationship as a bridge between human and natural ecosystems in urban planning.

With a p-value of 0.0637, the relationship between population (LNPOP) and carbon emissions in the oil palm trade in this study may be considered statistically significant. A larger population can increase demand for oil palm products, potentially driving higher production levels and associated carbon emissions. However, population growth can also coincide with increased awareness of sustainability issues, leading to greater efforts to reduce carbon emissions and promote sustainable practices. With a p-value of 0.0637, the relationship between population (LNPOP) and carbon emissions in the oil palm trade suggests a potential statistical significance, indicating that population size may play a role in influencing carbon emissions.

The relationship between population and carbon emissions in the context of the oil palm trade shows exciting dynamics. The p-value of 0.0637 suggests a potential statistical significance, indicating that population (LNPOP) may play a role in influencing carbon emissions. A larger population can indeed lead to increased demand for oil palm products, which may drive higher production levels and, in turn, contribute to elevated carbon emissions. Several studies have examined the link between population growth and carbon emissions in different contexts.

Raihan et al. (2022) examined the relationship between economic growth, forested area, oil palm cultivation, and carbon emissions in Malaysia. The findings reveal that economic growth positively contributes to carbon emissions, while deforestation has a negative impact, particularly from oil palm cultivation. Implementing policies and mechanisms like afforestation, forest conservation, and emission reduction can help reduce carbon emissions while sustaining economic growth and addressing the environmental challenges of oil palm cultivation in Malaysia.

However, it is essential to note that population growth can also be associated with increased awareness of sustainability issues and efforts to reduce carbon emissions. As populations grow, there is often a greater recognition of the need for sustainable practices and environmental conservation, addressing policies and initiatives to reduce carbon emissions and promote sustainable production methods. According to Qi (2012), geographical location plays a significant role in carbon emissions in urban areas, with daily commuting being a major contributor. As urban populations continue to grow due to migration, natural growth, aging, increased car ownership, and expanding living areas, household carbon emissions are expected to rise in the next decade.

The relationship between population and carbon emissions in the oil palm trade is complex and influenced by various factors, including the awareness of sustainability issues, policy interventions, and population density. It is crucial to consider these factors when analyzing the impact of population on carbon emissions in the oil palm industry. While a larger population may drive higher carbon emissions through increased demand, population growth can coincide with greater efforts to mitigate carbon emissions and promote sustainable practices.

The analysis may reveal a complex relationship between Indonesia's population and carbon emissions in the oil palm trade. With a larger population, there may be increased demand for oil palm products, which could drive higher production levels and increase carbon emissions. However, it is also possible that population growth is accompanied by a heightened environmental consciousness, leading to a greater emphasis on sustainable practices and the adoption of cleaner technologies to mitigate carbon footprints within the industry.

Examining consumption patterns and their impact on carbon emissions in Indonesia's oil palm sector can provide valuable insights into the interplay between population dynamics and environmental sustainability. Understanding how consumption patterns influence carbon emissions is crucial for developing effective strategies to mitigate the environmental impact of the oil palm trade.

A study by Liu et al. (2023) studied China's CO_2 emissions from agricultural land use during 1995-2020. It identifies key factors driving emissions and highlights the potential for adequate control. The findings suggest reducing fertilizer and agricultural diesel use, improving film utilization, and optimizing agricultural structure. The decoupling between CO_2 emissions and economic growth strengthens over time. The agricultural economic level is a significant factor driving emissions, while emission intensity, agricultural structure, and labor force contribute to emission reduction. The study proposes recommendations for sustainable agricultural land use in China.

According to Lenzen et al. (2018), tourism's carbon footprint has grown rapidly, accounting for 8 percent of global emissions. High-income countries contribute the most. It exceeds decarbonization efforts, making it a significant source of greenhouse gas emissions. Addressing carbon footprint, emissions, population, consumption, and sustainability is crucial in mitigating its impact.

Policy Implications

The analysis and discussion highlight the importance of Indonesian government policies in promoting sustainability within the oil palm sector. Formulating and implementing sustainable trade policies are crucial for mitigating the industry's environmental impact and promoting responsible practices. Several studies provide insights into the role of government policies in driving sustainability in the oil palm sector.

Government policies are essential in promoting sustainable palm oil production in Malaysia and Indonesia. The introduction of ISPO and MSPO as mandatory certifications alongside RSPO reflects an effort to address the concerns raised by firms regarding the burdensome requirements and perceived bias of RSPO, thereby promoting sustainable palm oil production and addressing the interests of producing countries (Junior et al., 2014).

It is crucial to formulate and implement sustainable trade policies that incentivize the adoption of certification schemes, encourage sustainable land management practices, and promote clean technologies. Additionally, the Indonesian government implemented the Indonesian Sustainable Palm Oil (ISPO) certification to address sustainability issues in the palm oil industry. However, the study reveals challenges in governance, including conflicting regulations and institutional power. The paper emphasizes the need to strengthen ISPO governance at the regional and local levels to enhance credibility and sustainability in Indonesian palm oil (Putri et al., 2022).

These policies can significantly reduce carbon emissions associated with the oil palm trade and promote environmentally responsible practices throughout the supply chain. Furthermore, by prioritizing sustainnability in trade policies, Indonesia can contribute to a more environmentally sustainable and socially responsible oil palm industry. The argument aligns with the global push for sustainable development and responsible production practices. The United Nations Sustainable Development Goals, particularly Goal (SDG) 12 on responsible consumption and production, emphasize promoting sustainable practices in industries such as oil palm. SDG 12 aims to decouple economic growth from unsustainable resource use and emissions, improve waste management, and promote responsible consumption and production. The 10-Year Framework of Programmes on Sustainable Consumption and Production is instrumental in achieving these goals, emphasizing efficient resource use, waste reduction, and companies' adoption of sustainable practices (Chan et al., 2018).

By prioritizing sustainability in trade policies, Indonesia can contribute to a more environmentally sustainable and socially responsible oil palm industry. By implementing and enforcing supportive policies, Indonesia can create a regulatory framework that encourages sustainable practices, reduces carbon emissions, and promotes the overall sustainability of the oil palm industry. These policies should address various aspects, including land management, certification schemes, technological innovation, and supply chain transparency, to achieve a more sustainable and environmentally responsible oil palm sector.

CONCLUSION AND SUGGESTION

In order to promote sustainable practices and offer insights into environmental sustainability, this study examines Indonesia's oil palm trade policies and their effect on carbon emissions. Lower carbon emissions in Indonesia's oil palm exports are linked to higher market competitiveness, which is driven by environmental standards and consumer demand for sustainable products. This highlights the significance of certification programs and sustainable practices.

The analysis indicates a favorable correlation between trade volume and carbon emissions, emphasizing the necessity to separate trade expansion from environmenttal consequences by implementing sustainable land-use practices, reducing deforestation, and establishing transparent supply chains. The correlation between GDP and carbon emissions shows a varied trend, first rising and maybe decreasing as cleaner technologies are implemented, highlighting the importance of balancing economic expansion and the environment.

Population expansion affects the market for oil palm products and carbon emissions, but it also promotes environmental awareness and initiatives to reduce carbon footprints. Policy implications involve creating trade regulations that promote certification systems, sustainable land management, and clean technology to decrease carbon emissions and guarantee the industry's long-term sustainability.

This research emphasizes the need for a comprehensive approach to address carbon emissions in Indonesia's oil palm trade policies. By prioritizing market competitiveness and sustainable practices, policymakers, industry stakeholders, and environmental organizations can collaborate to promote sustainable development, reduce carbon footprints, and ensure the environmental sustainability of Indonesia's oil palm exports.

Addressing carbon emissions in Indonesia's oil palm trade requires a concerted effort from policymakers, industry stakeholders, and environmental organizations to foster market competitiveness, adopt sustainable practices, and ensure the long-term environmental sustainability of the industry.

REFERENCES

Afolayan, O. T., H. Okodua, H. Oaikhenan, and O. Matthew. 2019. Carbon Emissions, Human Capital Investment and Economic Development in Nigeria. *International Journal of Energy Economics and Policy* 10(2): 427–437. http://dx.doi.org/10.32479/ijeep.8476.

Alamsyah, Z., A. Mara, N. F. Rayesa, E. Hamid, M. Yanita, G. Fauzia, and D. M. T. Napitupulu. 2023. Oil Palm Contribution to SDGs Achievement: a Case Study in Main Oil Palm Producing Provinces in Indonesia. *E3S Web of Conferences* 373(04030). https://doi.org/10.1051/e3sconf/202337304030.

Amundsen, V. S. and T. C. Osmundsen. 2020. Becoming Certified, Becoming Sustainable? Improvements from Aquaculture Certification Schemes as Experienced by Those Certified. *Marine Policy* 119 (104097): 1-8. https://doi.org/10.1016/j.marpol.2020.104097.

Ariyanto, A., Y. Syaukat, S. Hartoyo, and B. M. Sinaga. 2020. Technology Adoption and Technical Efficiency of Oil Palm Smallholder Plantation in Riau and West Kalimantan. *Jurnal Manajemen & Agribisnis* 17(3): 239-253. https://doi.org/10.17358/jma.17.3.239.

Arsyad, M., A. Amiruddin, Suharno, and S. Jahroh. 2020. Competitiveness of Palm Oil Products in International Trade: An Analysis between Indonesia and Malaysia. *Caraka Tani: Journal of Sustainable Agriculture* 35(2): 157-167. https://doi.org/10.20961/carakatani.v35i2.41091.

Austin, K. G., R. Heilmayr, J. J. Benedict, D. N. Burns, M. Eggen, H. Grantham, A. Greenbury, J. K. Hill, C. N. Jenkins, M. S. Luskin, T. Manurung, L. V. Rasmussen, G. Rosoman, B. Rudorff, M. Satar, C. Smith, and K. M. Carlson. 2021. Mapping and Monitoring Zero- Deforestation Commitments. *BioScience* 71(10): 1079-1090. https://doi.org/10.1093/biosci/biab082.

Ayompe, L. M., M. Schaafsma, and B. N. Egoh. 2021. Towards Sustainable Palm Oil Production: The Positive and Negative Impacts on Ecosystem Services and Human Wellbeing. *Journal of Cleaner Production* 278(123914): 1-11. https://doi.org/10.1016/j.jclepro.2020.123914.

Bintariningtyas, S. and A. H. Juwita. 2021. Perkebunan Kelapa Sawit dalam Pengentasan Kemiskinan di Provinsi Kalimantan Tengah. *Forum Ekonomi* 23(2): 199-205. https://doi.org/10.30872/jfor.v23i2.9389.

Birdsall, N. 1992. Another Look at Population and Global Warming. *Working Paper*. World Bank. Washington, DC.

Brenton, P. and V. Chemutai. 2021. *The Trade and Climate Change Nexus: The Urgency and Opportunities for Developing Countries*. The World Bank. Washington, DC.

Chan, S., N. Weitz, A. Persson, and C. Trimmer. 2018. SDG 12: Responsible Consumption and Production. *A Review of Research Needs. Technical Annex to the Formas report Forskning för Agenda 2030: Översikt av forskningsbehov och vägar framåt*. Stockholm Environment Institute. Stockholm.

Dauda, S. A., S. F. Sidique, T. Y. Sheng, and M. Djama. 2021. Consumer Preference for Certified Sustainable Palm Oil with Environmental Sustainability Attributes: A Choice Experiment Approach. *Estudios de Economia Aplicada* 39(4): 1-13. https://doi.org/10.25115/eea.v39i4.4570.

Dinda, S. 2004. Environmental Kuznets Curve Hypothesis: A Survey. *Ecological Economics* 49(4): 431–455. https://doi.org/10.1016/j.ecolecon.2004.02.011.

Dislich, C., A. C. Keyel, J. Salecker, Y. Kisel, K. M. Meyer, M. Auliya, A. D. Barnes, M. D. Corre, K. Darras, H. Faust, B. Hess, S. Klasen, A. Knohl, H. Kreft, A. Meijide, F. Nurdiansyah, F. Otten, G. Pe'er, S. Steinebach, S. Tarigan, M. H. To ̈lle, T. Tscharntke, and K. Wiegand. 2017. A Review of the Ecosystem Functions in Oil Palm Plantations, using Forests as A Reference System. *Biological Review* 92: 1539–1569. https://doi.org/10.1111/brv.12295.

Foong, A., P. Pradhan, O. Frör, and J. P. Kropp. 2022. Adjusting Agricultural Emissions for Trade Matters for Climate Change Mitigation. *Nature Communications* 13(3024): 1-10. https://doi.org/10.1038/s41467-022-30607-x.

Grabs, J. 2023. A Theory of Credible Cross-Temporal Corporate Commitments as Goal-Based Private Sustainability Governance. *Business Strategy and the Environment* 32(8): 5146-5160. https://doi.org/10.1002/bse.3423.

Grossman, G. M. and E. Helpman. 1991. Trade, Knowledge Spillovers, and Growth. *European Economic Review* 35(2-3): 517-526. https://doi.org/10.1016/0014-2921(91)90153-A.

Gu, J. 2022. Sharing Economy, Technological Innovation and Carbon Emissions: Evidence from Chinese Cities. *Journal of Innovation & Knowledge* 7(3): 1002282. https://doi.org/10.1016/j.jik.2022.100228.

Hassan, M. N. A., P. Jaramillo, and W. M. Griffin. 2011. Life Cycle GHG Emissions from Malaysian Oil Palm Bioenergy Development: The Impact on Transportation Sector's Energy Security. *Energy*

Policy 39(5): 2615–2625. https://doi.org/10.1016/j.enpol.2011.02.030.

Heilmayr, R., K. M. Carlson, and J. J. Benedict. 2020. Deforestation Spillovers from Oil Palm Sustainability Certification. *Environmental Research Letters* 15(7): 1–15. https://doi.org/10.1088/1748-9326/ab7f0c.

Iskandar, A. 2019. Economic Growth and CO_2 Emissions in Indonesia: Investigating the Environmental Kuznets Curve Hypothesis Existence. *Jurnal Badan Pendidikan dan Pelatihan Keuangan (Jurnal BPKK)* 12(1): 42-52. https://doi.org/10.48108/jurnalbppk.v12i1.369.

Jopke, P. and G. C. Schoneveld. 2018. Corporate Commitments to Zero Deforestation: An Evaluation of Externality Problems and Implementation Gaps. *Occasional Paper 181*. Center for International Forestry Research. Bogor.

Junior, R. M., P. J. Best, and J. Cotter. 2014. Sustainability Reporting and Assurance: A Historical Analysis on a Worldwide Phenomenon. *Journal of Business Ethics* 120(1): 1–11. https://doi.org/10.1007/s10551-013-1637-y.

Kamaruddin, H., H. A. Wahab, and H. M. Anuar. 2018. Legal and Non-Legal Agricultural Practices: Toward A Sustainable Future in Malaysia's Palm Oil Industry. *Indonesia Law Review* 3: 316-327. https://dx.doi.org/10.15742/ilrev.v8n3.512.

Kemper, K. and M. de M. E. Filho. 2021. *Designing Fiscal Instruments for Sustainable Forests*. World Bank Group.

Koh, L. P., J. M., S. C. Liew, and J. Ghazoul. 2011. Remotely Sensed Evidence of Tropical Peatland Conversion to Oil Palm. *Biological Sciences* 108(12): 5127-5132. https://doi.org/10.1073/pnas.1018776108.

Lee, H. and J. Lee. 2022. Industry Competition, Corporate Governance, and Voluntary Disclosure of Greenhouse Gas Emissions Information: Evidence from South Korea. *International Journal of Environmental Research and Public Health* 19(23): 1–15. https://doi.org/10.3390/ijerph192316272.

Leimona, B., S. Amaruzaman, B. Arifin, F. Yasmin, F. Hasan, H. Agusta, P. Sprang, S. Jaffee, and J. Frias. 2015. *Indonesia's Green Agriculture's Strategies and Policies: Closing the Gap between Aspirations and Application*. The World Agroforestry Center. Kenya.

Lenzen, M., Y. Sun, F. Faturay, Y. Ting, A. Geschke, and A. Malik. 2018. The Carbon Footprint of Global Tourism. *Nature Climate Change* 8: 522–528. https://doi.org/10.1038/s41558-018-0141-x.

Li, J., G. Huang, Y. Li, L. Liu, and B. Zheng. 2022. Decoupling Degrees of China's Economic Growth from Three-Perspective Carbon Emissions. *Journal of Cleaner Production* 368(133209). https://doi.org/10.1016/j.jclepro.2022.133209.

Liu, S., J. Jia, H. Huang, D. Chen, Y. Zhong, and Y. Zhou. 2023. China's CO2 Emissions: A Thorough Analysis of Spatiotemporal Characteristics and Sustainable Policy from the Agricultural Land-Use Perspective during 1995–2020. Land 12(6): 1–20. https://doi.org/10.3390/land12061220.

Ma, J., T. Fujino, Y. Lim, W. Niyommaneerat, and O. Chavalparit. 2021. Greenhouse Gas Emission from Palm Oil Industry in Thailand and its Countermeasures. *International Journal of Earth & Environmental Sciences* 6(184): 1-10. https://doi.org/10.15344/2456-351X/2021/184.

Mardiharini, M., D. H. Azahari, R. M. Chaidirsyah, and K. Obaideen. 2021. The Palm Oil Industry is Moving towards the Achievement of Sustainable Development Goals (SDGs). *IOP Conf. Series: Earth and Environmental Science* 892: 012068. DOI 10.1088/1755-1315/892/1/012068.

Mitić, P., A. Fedajev, M. Radulescu, and A. Rehman. 2023. The Relationship Between CO_2 Emissions, Economic Growth, Available Energy, and Employment in SEE Countries. *Environmental Science and Pollution Research* 30: 16140–

16155. https://doi.org/10.1007/s11356-022-23356-3.

Mohammadi, A. and A. A. Burhan. 2020. Impact of Population and Economic Growth on CO2 Emission (Case of Afghanistan). *Journal of Emerging Technologies and Innovative Research* 7(10): 368-378.

Noë, J. L., K. H. Erb, S. Matej, A. Magerl, M. Bhan, and S. Gingrich. 2021. Altered Growth Conditions More Than Reforestation Counteracted Forest Biomass Carbon Emissions 1990–2020. *Nature Communications* 12(1), 6057. https://doi.org/10.1038/s41467-021-26398-2.

OECD. 2015. *Monitoring the Transition to A Low-Carbon Economy: A Strategic Approach to Local Development*. OECD.

OECD. 2021. *Financial Markets and Climate Transition: Opportunities, Challenges, and Policy Implication*. OECD. Paris.

Othman, J. 2003. Linking Agricultural Trade, Land Demand, and Environmental Externalities: Case of Oil Palm in South East Asia. *ASEAN Economic Bulletin* 20(3): 244–255. https://muse.jhu.edu/article/387670.

Putri, E. I. K., A. H. Dharmawan, O. Hospes, B. E. Yulian, R. Amalia, D. I. Mardiyaningsih, R. A. Kinseng, F. Tonny, E. P. Pramudya, F. Rahmadian, and D. Y. Suradiredja. 2022. The Oil Palm Governance: Challenges of Sustainability Policy in Indonesia. *Sustainability* 14(3): 1-20. https://doi.org/10.3390/su14031820.

Qi, Y. 2012. *Annual review of Law-Carbpn Development in China (2011-2012)*. Social Sciences Academic Press. China.

Radmehr, R., S. R. Henneberry, and S. Shayanmehr. 2021. Renewable Energy Consumption, CO_2 Emissions, and Economic Growth Nexus: A Simultaneity Spatial Modeling Analysis of E.U. Countries. *Structural Change and Economic Dynamics* 57: 13-27. https://doi.org/10.1016/j.strueco.2021.01.006.

Raihan, A., R. A. Begum, M. Nizam, M. Said, and J. J. Pereira. 2022. Dynamic Impacts of Energy Use, Agricultural Land Expansion, and Deforestation on CO2 Emissions in Malaysia. *Environmental and Ecological Statistics* 29(3): 477-507. https://doi.org/10.1007/s10651-022-00532-9.

Raitzer, D. A., F. Bosello, M. Tavoni, C. Orecchia, G. Marangoni, and J. N. G. Samson. 2015. *Southeast Asia and the Economics of Global Climate Stabilization*. Asian Development Bank. Manila.

Ribeiro, H. V., D. Rybski, and J. P. Kropp. 2019. Effects of Changing Population or Density on Urban Carbon Dioxide Emissions. *Nature Communications* 10(3204): 1-9. https://doi.org/10.1038/s41467-019-11184-y.

RSPO. 2018. *Principle and Criteria for the Production of Sustainable Palm Oil*. Roundtable on Sustainable Palm Oil. Kuala Lumpur.

Santoso, A. D. 2017. Jejak Karbon Individu Pegawai di Instansi Pemerintah: Studi Kasus Pegawai Pemerintahan di Kawasan Puspiptek, Tangerang Selatan. *Jurnal Teknologi Lingkungan* 18(2): 233-240. https://doi.org/10.29122/jtl.v18i2.2242

Shahputra, M. A. and Z. Zen. 2008. Positive and Negative Impacts of Oil Palm Expansion in Indonesia and the Prospect to Achieve Sustainable Palm Oil. *IOP Conf. Series: Earth and Environmental Science* 122: 012008. DOI 10.1088/1755-1315/122/1/012008.

Shen, T., R. Hu, P. Hu, and Z. Tao. 2023. Decoupling between Economic Growth and Carbon Emissions: Based on Four Major Regions in China. *International Journal of Environmental Research and Public Health* 20(1496): 1–18. https://doi.org/10.3390/ijerph20021496.

Shunfa, H., E. C. Hui, and L. Yaoyu. 2022. Relationship Between Urban Spatial Structure and Carbon Emissions: A Literature Review. *Ecological Indicators* 144(109456). https://doi.org/10.1016/j.ecolind.2022.109456.

Suryahadi, A., D. Suryadarma, and S. Sumarto. 2006. Economic Growth and Poverty Reduction in Indonesia: The Effect of Location and Sectoral Components of Growth. *SMERU Working Paper*.

United Nations. 2023. *Technology and Innovation Report 2023: Opening Green Windows-Technological Opportunities for a Low-Carbon World*. United Nations. New York.

Vijay, V., S. L. Pimm, C. N. Jenkins, and S. J. Smith. 2016. The Impacts of Oil Palm on Recent Deforestation and Biodiversity Loss. *PLoS ONE* 11(7): e0159668. https://doi.org/10.1371/journal.pone.0159668.

Zhen, N. and C. Freire. 2023. The Interlinks Between the Economic Complexity and Carbon Footprint. *United Nations Conference on Trade and Development.*