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The Effect of Foreign Tourist Visits on Carbon Dioxide Emissions in the Tourism Sector in Indonesia

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ABSTRACT

This study analyzes the impact of foreign tourist arrivals on carbon dioxide (CO_2) emissions in Indonesia's tourism sector, reflecting the increasing global concern over tourism's environmental footprint. Using time series data from 1997 to 2022 and the Ordinary Least Squares (OLS) method, the research explores the relationship between CO_2 emissions and factors such as foreign tourist arrivals, economic growth, motor vehicle numbers, and energy consumption. The findings indicate that foreign tourist arrivals significantly increase CO_2 emissions, with a coefficient of 746.57 kilotons per person. This rise is mainly due to transportation and tourism infrastructure that depend heavily on fossil fuels. Economic growth also contributes to emissions, with a 1% increase in gross domestic product resulting in an additional 64.60 kilotons of CO_2. The number of motor vehicles (9,953.66 kilotons per unit) and fossil energy use (902,884.7 kilotons per kWh) are substantial contributors as well. Conversely, the use of renewable energy and changes in population size do not significantly affect CO_2 emissions in the tourism sector. These results emphasize the urgent need for sustainable tourism management, including the adoption of renewable energy and low-carbon transportation, to mitigate environmental impacts while supporting economic growth. The study provides essential insights for policymakers to balance tourism development with environmental sustainability in Indonesia, ensuring that economic benefits do not come at the expense of environmental health.

KEYWORDS *Tourism, International Tourist Visit, Carbon Dioxide Emissions*

INTRODUCTION

The impact of tourism activities on the environment, especially carbon emissions, has become a major global concern. Increased mobility and demand for unique travel experiences have driven the growth of the tourism industry, which in

turn elevates carbon emissions in tourist destinations (McCabe, 2024). The rapid development of tourism in various countries, including Indonesia, is often not accompanied by careful planning regarding environmental sustainability, thus creating new challenges in managing its negative impacts (McKenna & Hanrahan, 2024). Intensive fossil energy consumption for transportation and accommodation remains a key factor in tourism operations and a significant contributor to CO_2 emissions (Raihan, 2024). According to the Emissions Database for Global Atmospheric Research (*EDGAR*, 2023), the average CO_2 emissions from tourism activities in Indonesia between 1970 and 2022 were around 86 tons, with the highest level recorded in 2018 at 181 tons. Tourist behaviors, such as a preference for private vehicles over public transportation, also play a role in increasing emissions (Anser et al., 2024; Zhang et al., 2024).

The conflict between the economic benefits of tourism and the need to reduce environmental impacts, especially carbon emissions, is a central issue. In 2023, the tourism sector contributed about 4% to Indonesia's GDP, which has implications for increased energy consumption and carbon emissions. Although global awareness of the importance of environmental preservation has encouraged the adoption of more sustainable strategies, including carbon emission reduction, empirical evidence on their effectiveness remains limited. This study aims to analyze the influence of the number of foreign tourists on CO_2 emissions in Indonesia's tourism sector. With limited empirical evidence, this study seeks to reveal whether there is a significant influence between the number of tourists and the level of environmental pollution caused by tourism activities in Indonesia, as a step toward the sustainability of the tourism industry.

This research provides valuable insights for policymakers, tourism stakeholders, and environmental planners by quantifying the impact of foreign tourism on CO_2 emissions in Indonesia. The findings highlight the urgent need for sustainable tourism strategies, such as promoting renewable energy adoption, improving eco-friendly transportation infrastructure, and implementing carbon reduction policies. By identifying key contributors to emissions, the study supports evidence-based decision-making to balance economic growth with environmental sustainability. Additionally, it contributes to the global discourse on sustainable tourism, offering a model for other developing nations facing similar challenges. Ultimately, this research aids in fostering environmentally responsible tourism practices that align with Indonesia's climate goals while maintaining the sector's economic benefits.

The theory of *externality* in economics refers to the impact caused by an economic activity on other parties who are not directly involved in the activity, either in the form of benefits (positive externalities) or losses (negative externalities). Katz and Rosen (1996) identified four basic characteristics of

externalities: externalities can be generated by both individuals and companies, are reciprocal, can have both negative and positive impacts, and completely zero pollution levels are undesirable because they would halt all production activities. The Environmental Kuznets Curve (*EKC*) illustrates the relationship between environmental damage and per capita income. This concept, inspired by the Kuznets curve by Simon Kuznets, hypothesizes that in the early stages, an increase in per capita income decreases environmental quality, but after a certain turning point, higher incomes improve environmental quality. Grossman and Krueger introduced this hypothesis in 1991 and tested it against SO_2 emissions in several major cities, finding that economic growth initially exacerbates environmental damage, but after a certain point, the damage decreases with further economic growth (Juwita, 2021; Liu, 2019; Hussain, 2024; Dogru, 2020; Azizurrohman, 2021)

A review of the literature shows that tourism development has a significant impact on carbon emissions. Wang et al. (2024) found that tourism positively impacts carbon emission efficiency through three main pathways. Manisha and Singh (2023) show that increased tourism revenue in Himachal Pradesh, India, increases energy consumption and carbon emissions. León-Gómez et al. (2021) emphasize the importance of sustainable tourism development to reduce negative environmental impacts. Research on Indonesia by Putri et al. (2019) examined the relationship between tourism and economic growth to CO_2 emissions in Indonesia, finding that the economic growth rate and the number of foreign tourists have a positive and significant influence on total CO_2 emissions. Meanwhile, Juliani et al. (2021) obtained different results, where the number of tourists did not contribute much to the increase in CO_2 emissions.

RESEARCH METHOD

This study uses annual secondary data taken from various sources with the period 1997-2022. The variables used include tourism carbon emissions (metric tons of CO2) from EDGAR (2023) as a dependent variable, and independent variables in the form of the number of foreign tourist visits (soul) from BPS, economic growth (percent) from BPS, number of motor vehicles (units) from BPS, non-renewable energy use (kWh/capita) from the WorldBank, renewable energy use (kWh/capita) from the WorldBank, and population (soul) from the WorldBank.

The research model used is:

$$Y_t = \beta_0 + \beta_1 X1_t + \beta_2 X2_t + \beta_3 X3_t + \beta_4 X4_t + \beta_5 X5_t + \beta_6 X6_t + \varepsilon_t$$

Information:

- Y = Carbon emissions of the tourism sector
- β_0 = Constant
- $\beta_1, \beta_2, \beta_3, \beta_4, \beta_5, \beta_6$ = Coefficient

- X1 = Number of foreign tourist visits
- X2 = Economic growth
- X3 = Number of motor vehicles
- X4 = Use of non-renewable (fossil) energy
- X5 = Use of renewable energy
- X6 = Population
- ε = Error term

This study uses the Ordinary Least Square (OLS) method to determine the best relationship between independent variables and dependent variables. After the estimation model is developed, a classical assumption test is carried out to ensure that the linear regression model built meets the BLUE (Best Linear Unbiased Estimation) criteria.

RESULT AND DISCUSSION

Classic Assumption Test

Multicollinearity Test

The results of the multicollinearity test using the Variance Inflation Factor (VIF) showed that all variables had a Centered VIF value below 10, which means that there were no significant multicollinearity problems in the variables in the regression model.

Table 1. Multicollinearity Test Results

Variabel	Centered VIF
X1	2,83
X2	1,79
X3	1,43
X4	1,51
X5	2,87
X6	1,38

Autocorrelation Test

Based on the results of the autocorrelation test using the Breusch-Godfrey Serial Correlation LM method, the value of Prob. The Chi-Square is 0.5939 greater than the alpha 5% so it can be concluded that there are no symptoms of autocorrelation.

Normality Test

The results of the Jarque-Bera test reached 0.3868 with a probability of 0.8241 greater than alpha 5%. From these results, it can be concluded that the distribution of data used in this study has been distributed normally.

Estimated Results

Table 2. Regression Estimation Results

Variable	Coefficient	Prob.	Significance
C	-2.921,943	0,0007	***
X1	746,572	0,0274	**
X2	64,598	0,0994	*
X3	9953,659	0,0001	***
X4	902884,7	0,0000	***
X5	-5178,701	0,1061	-
X6	-902,078	0,2093	-

*Remarks: *** significant at α = 1%, ** significant at α = 5%, * significant at α = 10%*

R-Squared: 0,96398 Prob(F-Statistics): 0,0000

The R-Squared value of 96% indicates that the independent variable simultaneously has a strong effect on the dependent variable. A Prob(F-Statistics) value of 0.0000 indicates that independent variables have a simultaneous effect on dependent variables.

Discussion

The Influence of the Number of Foreign Tourist Visits

The increase in the number of foreign tourists significantly contributes to the increase in carbon dioxide emissions with a coefficient of 746.57 kilotons per person. This is due to the high carbon intensity of transportation modes, especially international flights that still rely on fossil-based jet fuel. The arrival of foreign tourists also increases the demand for tourism facilities such as hotels and restaurants, most of which still use fossil energy.

Influence of Economic Growth

Increased economic growth has a positive effect on carbon emissions with a coefficient of 64.60 kilotons per 1% growth. The economic improvement is driving higher demand for tourism facilities and infrastructure that require large energy. With the development of the economy, people's purchasing power increases, encouraging more tourist trips and other tourism activities.

The Influence of the Number of Motor Vehicles

The increase in the number of motor vehicles contributes significantly to carbon emissions with a coefficient of 9,953.66 kilotons per unit. Land transportation is the main component of tourist mobility in tourist destinations. Most motor vehicles in Indonesia still use fossil fuels, so the growth in the number of vehicles increases the carbon footprint of tourist trips.

The Influence of Fossil Energy Use

The use of fossil energy has the greatest impact on carbon emissions with a coefficient of 902,884.7 kilotons per kWh. This shows how large the contribution

of fossil energy is to emissions in the tourism sector. Tourist transportation and tourism facilities are still highly dependent on fossil energy for their operations.

Renewable Energy and Population

Despite the increase in the use of renewable energy, this is not effective enough in reducing carbon emissions in the tourism sector. Renewable energy has not been able to replace fossil fuels significantly, especially in aviation. Population also has no significant effect because emissions are more influenced by tourist activities than population growth.

CONCLUSION

This study demonstrates that foreign tourist arrivals, economic growth, the proliferation of motor vehicles, and reliance on fossil energy significantly increase carbon dioxide emissions in Indonesia's tourism sector, while renewable energy use and population size show no notable effect. Transportation for tourists—particularly international flights—emerges as a primary emissions source, and the limited adoption of renewable energy means current mitigation efforts are insufficient. To address these challenges, it is crucial for the government to prioritize the development of low-carbon transportation infrastructure and incentivize tourism facilities to transition toward renewable energy, alongside creating more environmentally friendly and sustainable tourist destinations that support continued economic growth. For future research, incorporating regional or city-level data could uncover localized emission patterns and targeted mitigation strategies, while examining behavioral factors such as tourist preferences for eco-friendly accommodations or transport would provide valuable insights for demand-side interventions. Comparative analyses with other tourism-dependent countries and the application of dynamic modeling approaches—such as system dynamics or scenario analysis—are also recommended to evaluate long-term emission trajectories and the effectiveness of various policy interventions, ultimately informing more robust sustainable tourism planning.

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