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Does Climate Finance Matter? The Relationship between Climate Finance and Carbon Dioxide Emissions in Developing Countries

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ABSTRACT

This study examines the relationship between climate finance and carbon dioxide (CO_2) emissions in developing countries from 2015 to 2021. Using a sample of 74 countries, this study applies the two-step Generalized Method of Moments (GMM) estimation to examine the impact of climate finance on carbon dioxide emissions. The results indicate that climate finance for mitigation purposes is positively associated with CO_2 emissions. However, a higher income level is linked to lower emissions, likely due to stricter environmental policies and increased investment in renewable energy. Additionally, population growth contributes to higher emissions, while larger forest areas help reduce CO_2 levels by acting as carbon sinks. These findings highlight the importance of directing climate finance toward truly sustainable projects and ensuring effective policy implementation. The study underscores the need for well-targeted financial strategies that prioritize clean energy, energy efficiency, and low-carbon technologies. It also recommends further research on policy frameworks and institutional capacities to optimize the effectiveness of climate finance in reducing emissions.

Keywords: Climate Finance, Carbon Dioxide Emission, Developing Countries
JEL Classifications: Q53, Q54, Q56

1. INTRODUCTION

Climate change has become one of the most pressing global challenges in the 21st century (Liu et al., 2021). Governments and relevant organizations are putting many efforts to curb greenhouse gas (GHG) emissions. The rapid rise in carbon dioxide (CO_2) emissions has exacerbated global warming, leading to widespread environmental and socio-economic consequences. Previous studies also proved that carbon emissions are linked to specific macroeconomic factors, such as gross domestic products (GDP) and foreign direct investment (FDI) (Louail et al., 2024; Wahyudi et al., 2025). Besides that, energy consumption patterns (Touitou, 2021), trade openness (Mignamissi et al., 2024), and technological innovation (Zhao et al., 2023) also play crucial roles in affecting the level of carbon emission. For instance, higher economic growth often led to increased carbon emissions due to greater industrial activity. However, the environmental Kuznets curve (EKC) hypothesis suggests that emissions may decline once a certain level of economic development is achieved (Miyama and Managi, 2015). On the other hand, trade liberalization can either exacerbate emissions through increased production and transportation or reduce them through the diffusion of cleaner technologies. Given these complexities, it is imperative to contextualize the role of climate finance within a broader macroeconomic framework to accurately assess its effectiveness in reducing carbon emissions.

The urgency of mitigating climate change has led to the mobilization of substantial financial resources through international agreements, governmental policies, and private-sector initiatives (Clark et al., 2018). Global commitments, such as the Paris Agreement, emphasize the importance of scaling up climate finance to facilitate low-carbon development pathways. In response, climate finance has turned out to be a strategic tool for mitigating emissions and fostering adaptation to climate-related risks. Climate finance is defined as financial resources mobilized to support low-carbon initiatives and climate-resilient development (Warren, 2019). Climate finance also encompasses public and private investments directed toward renewable energy, energy efficiency, green infrastructure, and sustainable technologies. Given the urgent need to shift to a low-carbon economy, understanding how climate finance affects carbon emission levels is also crucial.

However, the effectiveness of climate finance in directly reducing carbon emissions remains a subject of debate. Its real impact depends on several factors, such as government policies, how efficiently financial markets operate, and how the funds are distributed across different sectors. Existing research on climate finance has primarily focused on its role in fostering renewable energy adoption, improving climate resilience, and promoting sustainable development (Mohan and Morris, 2025). Moreover, existing studies focus on the estimation of financial needs for climate change issue (Bowen et al., 2017), climate finance policies (Bhandary et al., 2021) and how public and private sector cooperate for the climate change issue (Bracking and Leffel, 2021). This gap in the existing literature underscores the need to study the relationship between climate finance and carbon emissions. Thus, this study aims to examine the relationship between climate finance and carbon dioxide emission in developing countries.

2. LITERATURE REVIEW

2.1. Environmental Kuznets Curve (EKC) Hypothesis

The Environmental Kuznets Curve (EKC) hypothesizes an inverted U-shaped relationship between economic growth and environmental degradation. This means that as the economy grows, environmental degradation initially increases, but after reaching a certain level of income per capita, further economic growth leads to environmental improvement (Miyama and Managi, 2015). Numerous studies have tested the EKC hypothesis with mixed results. Some confirm the inverted U-shape, while others find different patterns or question the methodology (Kijima et al., 2010; Setyari and Kusuma, 2021; Wang et al., 2015; Pincheira and Zuniga, 2021). The EKC implies that economic growth alone is not sufficient for environmental improvement. Effective environmental policies and regulations are crucial, especially in developing countries where institutional frameworks may be weaker (Zilio, 2012; Cho, 2021). Factors such as economic structure, development strategy, and environmental regulations significantly influence the shape and turning point of the EKC (He and Wang, 2012; Rom and Guillotreau, 2024). However, the optimistic implications of the EKC literature on sustainability management have been questioned, and evidence of the existence of the EKC has been debated (Chen and Taylor, 2020; Setyari and Kusuma, 2021). Studies have shown varying results regarding the EKC. For instance, in Gansu province, China, an EKC was observed, suggesting that low-income economies can improve environmental quality without sacrificing economic growth (Wang et al., 2015). EKC also has been tested with different environmental indicators. For example, in Singapore, the EKC was confirmed for chromium emissions, showing a clear inverted U-shape with economic growth (Chen and Taylor, 2020). However, in other cases, such as the analysis of 62 countries, the results were inconclusive, showing more of an "N" pattern rather than a clear inverted U-shape (Setyari and Kusuma, 2021). Income inequality can alter the EKC relationship. High income inequality can change the relationship from an inverted U-shape to an N-shape, complicating the decoupling of economic growth and environmental degradation (Wang et al., 2023).

2.2. Climate Finance and Carbon Dioxide Emission

Climate finance has emerged as a viable solution for combating climate change and reducing carbon dioxide emissions (Zoungrana et al., 2024). Climate finance is essential for climate change mitigation and is viewed as a viable and sustainable mechanism to help mitigate harmful carbon pollution generation (Su et al., 2024). It supports communities in adapting to the adverse effects of climate change, thereby helping to maintain and strengthen their livelihoods (Achampong, 2025). The impact of global climate finance on carbon emissions has been found to be significant, with climate finance having a negative relationship with CO_2 emissions in N-11 nations (Li and Shao, 2022). Developing countries also often rely on international climate finance to meet their emission reduction targets, highlighting the importance of global financial support (Rashid et al., 2023). However, effective climate finance requires a mix of environmental and financial policies to maximize its impact on decarbonization (Hamaguchi, 2024). Climate finance mechanisms can catalyze private investment in sustainable projects, particularly in regions like Sub-Saharan Africa, where achieving universal energy access and climate mitigation goals is critical (Michaelowa et al., 2021). Climate finance is pivotal in developing clean energy technologies beyond renewables, such as carbon capture and sustainable cooling, which are currently underfunded (Warren, 2019). Thus, this study hypothesizes that climate finance is negatively related to carbon dioxide emissions.

Hypothesis 1: Climate finance is negatively related to carbon dioxide emissions.

2.3. Gross Domestic Product (GDP) and Carbon Dioxide Emission

The relationship between Gross Domestic Product (GDP) and carbon emissions is complex, with several studies highlighting different aspects of this interaction. Earlier study by Uçak et al. (2015) revealed that there was a positive relationship between GDP and carbon dioxide emissions observed in many high-income countries. For instance, a 1% increase in GDP results in approximately a 0.86-1.07% rise in carbon dioxide emissions (Uçak et al., 2015). In the context of Indonesia, previous study revealed that economic growth shall leads to increased carbon emissions due to higher energy consumption and industrial activities (Wahyudi et al., 2025). The EKC hypothesis suggests an inverted U-shaped relationship between GDP per capita and carbon dioxide emissions. Initially, emissions increase with economic growth, but after reaching a certain income level, further growth leads to a decrease in emissions (Wang et al., 2019a; Lau and Tsai, 2024). For example, in China, emissions peak at a per capita GDP of around $21,000, after which they start to decline (Wang et al., 2019a). Some studies indicate that it is possible to decouple economic growth from carbon emissions. In the United States, carbon dioxide emissions decreased by 12% between 2007 and 2016, while GDP grew by 19%, primarily due to improvements in energy efficiency and changes in the energy mix (Wang et al., 2019b). Similarly, in the European Union, increased environmental protection expenditure has contributed to a reduction in greenhouse gas emissions despite economic growth (Georgieva, 2024). Energy consumption is also a significant driver of carbon emissions. In many countries, higher GDP correlates with increased energy use, leading to higher emissions (Methmini et al., 2024; Dharmapriya et al., 2024; Lin and Benjamin, 2017). However, the adoption of renewable energy sources can mitigate this effect. For instance, in Indonesia, renewable energy consumption has a negative impact on carbon emissions, highlighting the importance of transitioning to cleaner energy sources (Wahyudi et al., 2025). Thus, this study hypothesizes that GDP is positively related to carbon dioxide emission.

Hypothesis 2: Gross Domestic Product (GDP) is positively related to carbon dioxide emissions.

2.4. Trade Openness and Carbon Dioxide Emission

Several studies indicate that trade openness generally leads to an increase in CO_2 emissions. This is particularly evident in developing countries where trade liberalization often results in higher emissions due to less stringent environmental regulations and increased industrial activity (Mejía, 2021; Zamil et al., 2019). Yet, the impact of trade openness on CO_2 emissions varies across regions and income levels. For instance, trade openness tends to increase emissions in developing countries but may reduce emissions in developed countries due to better environmental practices and technologies (Shahbaz et al., 2017; Mignamissi et al., 2024). High trade openness is associated with low carbon emissions in the long run, supporting the Environmental Kuznets Curve (EKC) hypothesis, which suggests that high openness is associated with low emissions up to a certain level, beyond which further openness may spur high emissions (Dou et al., 2020). The impact of trade openness on carbon emissions is non-linear, with an inverted U-shaped relationship observed. Initially, CO_2 emissions increase with an expansion of trade openness, then decline after reaching a turning point (Çetin et al., 2014). The impact of trade openness on carbon emissions is heterogeneous across different regions, with varying effects observed in different income groups and countries (Sulaiman et al., 2023). Trade openness increases carbon dioxide emissions, with the elasticity of emissions varying across different income groups and regions (Wang et al., 2024). Trade openness has been found to increase carbon dioxide emissions in certain regions, such as Africa, while having a negative effect in other regions. The elasticity of the impact varies greatly depending on the different measures of trade openness used (Wang et al., 2023). Policymakers need to consider both the positive and negative impacts of trade openness on the environment. Strategies such as promoting renewable energy, enhancing energy efficiency, and implementing stricter environmental regulations can help mitigate the adverse effects of trade on CO_2 emissions (Zhang et al., 2023; Thi et al., 2023; Joshua et al., 2024). Thus, this study hypothesizes that trade openness is positively related to carbon dioxide emissions.

Hypothesis 3: Trade Openness is positively related to carbon dioxide emissions.

2.5. Foreign Direct Investment (FDI) and Carbon Dioxide Emission

Generally, foreign direct investment (FDI) can lead to increased carbon emissions. For instance, in South Africa, FDI is associated with higher carbon emissions due to investments in energy-intensive sectors, often exacerbated by weak environmental regulations (Sibanda and Ndlela, 2019). Similarly, in developing Asian countries, FDI contributes to environmental degradation and increased CO_2 emissions, supporting the Pollution Haven hypothesis (Hanif et al., 2019). In sub-Saharan Africa, positive shocks in FDI increase carbon emissions, suggesting that FDI inflows can lead to higher environmental degradation if not managed properly (Abdul-Mumuni et al., 2023). Conversely, some studies suggest that FDI can reduce carbon emissions. For example, in Saudi Arabia, FDI inflows are found to reduce greenhouse gas emissions and improve environmental conditions in both the short and long run (Louail et al., 2024). Additionally, in China, FDI and outward FDI help reduce carbon emissions, indicating that foreign investments can bring cleaner technologies and practices (Wang and Xie, 2017). In the context of BRICS countries, FDI is shown to reduce CO_2 emissions, contradicting the Pollution Haven hypothesis and suggesting that foreign investments can promote environmental awareness and cleaner technologies (Pradhan et al., 2022). The relationship between FDI and carbon emissions can also be non-linear. For instance, a U-shaped relationship is observed where carbon emissions initially decrease with increasing FDI but start to increase after reaching a certain level of investment (Furtuna and Atis, 2024). Similarly, an N-shaped association is found in BRICS countries, indicating varying impacts of FDI on carbon emissions at different stages of economic development (Barış-Tüzemen and Tüzemen, 2022). To mitigate the negative environmental impacts of FDI, it is crucial to implement comprehensive investment policies that encourage clean technology and environmentally friendly investments (Abdul-Mumuni et al., 2023). Enhancing energy service availability and energy consumption cleanliness can also help in reducing the adverse effects of FDI on carbon emissions (Chen et al., 2022). Thus, this study hypothesizes that FDI is positively related to carbon dioxide emissions.

Hypothesis 4: Foreign Direct Investment (FDI) is positively related to carbon dioxide emissions.

2.6. Renewable Energy Consumption and Carbon Dioxide Emission

Renewable energy is an effective method for reducing carbon dioxide emissions (Agbelie, 2016). The use of renewable energy sources, such as solar, wind, hydro, biomass, and geothermal energy, is suitable for mitigating climate change and reducing carbon dioxide in the atmosphere (Xuan, 2025). The Intergovernmental Panel on Climate Change (IPCC) emphasizes the use of renewable and sustainable energy sources to reduce carbon dioxide emissions (Mentel et al., 2022). Studies across various regions, including the MENA countries, BRICS economies, and Canada, consistently show that renewable energy helps in reducing CO_2 emissions (Xuan, 2025; Kahia et al., 2019; Baloch and Danish, 2022). Countries are encouraged to adopt policies that promote renewable energy to achieve sustainable growth and reduce CO_2 emissions. For example, Saudi Arabia can maintain a conservative energy policy and a long-term carbon reduction strategy without hindering economic growth (Dkhili and Dhiab, 2020). There is evidence of a bidirectional causal relationship between renewable energy consumption and CO_2 emissions, indicating that not only does renewable energy reduce emissions, but lower emissions can also promote the adoption of renewable energy (Farhani and Shahbaz, 2014; Jin et al., 2022). The impact of renewable energy on CO_2 emissions can vary between developed and developing countries. Developed countries show a stronger relationship between renewable energy consumption and CO_2 reduction compared to developing countries (Jin et al., 2022; Ito, 2016). The development of renewable energy sources and their applications, along with effective sequestration and conversion of CO_2, are essential for mitigating carbon emissions and achieving environmental sustainability (Salahuddin and Gow, 2014). Thus, this study hypothesizes that renewable energy consumption is negatively related to carbon dioxide emissions.

Hypothesis 5: Renewable energy consumption is negatively related to carbon dioxide emissions.

2.7. Population Growth and Carbon Dioxide Emission

There is a significant and stable positive association between population size and CO_2 emissions. This relationship holds true across different time periods and regions, indicating that as population increases, CO_2 emissions also rise proportionately (Sanglimsuwan, 2012; Jorgenson and Clark, 2013). Urbanization, or the growth of urban populations, generally leads to higher CO_2 emissions. This is due to increased energy consumption and industrial activities in urban areas. However, the effect of urbanization on emissions can be asymmetrical; a decline in urbanization can reduce emissions more significantly than the increase caused by urbanization (Ribeiro et al., 2019; Yi et al., 2022; McGee and York, 2018). Economic growth and changes in industrial structure also play a crucial role. As economies grow, especially in developing countries, the shift towards more industrial activities leads to higher CO_2 emissions. The secondary and tertiary industries are particularly significant contributors to this increase (Song, 2017). Although technological advancements can help reduce emissions, they often do not fully offset the increase caused by population growth and industrial activities (Yi et al., 2022). Smaller household sizes and higher urbanization rates are associated with higher CO_2 emissions. This is because smaller households tend to have higher energy consumption (Verma et al., 2021). Population agglomeration in large cities has been shown to increase urban carbon emissions significantly, primarily through industrial structure and transportation effects (Liu et al., 2024). Thus, this study hypothesizes that population growth is positively related to carbon dioxide emissions.

Hypothesis 6: Population growth is positively related to carbon dioxide emissions.

2.8. Forest Area and Carbon Dioxide Emission

Deforestation is a significant contributor to global carbon dioxide (CO_2) emissions, accounting for approximately 12-25% of anthropogenic CO_2 emissions (Ajay, 2012). The primary sources of these emissions from deforestation include agricultural expansion (Pendrill et al., 2020) and shifting cultivation (Houghton, 2012). Deforestation can also lead to an increase in carbon emissions and contribute to global warming (Wolff et al., 2021). It is crucial to preserve forests and enhance carbon sequestration to offset these emissions and mitigate the impact of global warming. Specifically, sustainable forest management can effectively increase forest carbon sequestration, helping to reduce atmospheric carbon dioxide (Sevillano et al., 2025). Forest ecosystems have the capacity to absorb more than one-third of total carbon dioxide from the atmosphere, which is essential for keeping the atmospheric temperature under control (Nzabarinda et al., 2025). Forest-based carbon sequestration has the potential to be a cost-effective technology for climate change mitigation (Cheng et al., 2024). Previous studies also confirmed that the forest area was negatively related to the carbon dioxide emissions (Waheed et al., 2018; Raihan and Tuspekova, 2022). Thus, this study hypothesizes that forest area is negatively related to carbon dioxide emissions.

Hypothesis 7: Forest area is negatively related to carbon dioxide emissions.

3. DATA AND METHODOLOGY

3.1. Data

This study collected data from two different sources, which included World Bank Database and Climate Funds Update. The sample of this study consists of 74 developing countries which received climate finance over the period from the year 2015 to 2021. Table 1 shows the description of the variables. The dependent variable of this study is carbon dioxide emission, while the independent variables consist of three different forms of climate finance, income level, trade openness and renewable energy consumption.

3.2. Generalized Method of Moments (GMM) Estimation

This study also used two-step GMM estimation to investigate the relationship between potential factors and carbon dioxide emissions. The Generalized Method of Moments (GMM) is a widely used estimation technique in econometrics and finance, particularly for models where traditional likelihood-based methods are challenging to implement. GMM relies on moment conditions derived from the data. These conditions are used to construct an objective function that is minimized to obtain parameter estimates (Chaussé and Xu, 2018; Yin et al., 2011). GMM can be applied to both linear and nonlinear models, making it versatile for various econometric applications (Hu et al., 2014; Escobar et al., 2016). Under certain conditions, GMM can achieve efficiency comparable to Maximum Likelihood Estimation (MLE) by using a continuum of moment conditions (Shi et al., 2016; Escobar et al., 2016). GMM has been applied to a wide range of empirical studies, including those examining financial constraints, corporate social responsibility, and digital integration's impact on environmental sustainability (Kumar et al., 2023; Quttainah and Ayadi, 2024).

Table 1: Definition of variables and the source of data

Variable	Name of variable	Indicator	Source
Dependent Variable	Carbon dioxide emission (CO_2)	Carbon dioxide (CO_2) emissions excluding LULUCF per capita (CO_2/capita)	World Bank Database
Independent Variable	Climate finance (Adaptation) (CFA)	Climate finance for the purpose of climate change adaptation ($ million)	Climate Funds Update
	Climate finance (Mitigation) (CFM)	Climate finance for the purpose of climate change mitigation ($ million)	Climate Funds Update
	Income level (INCOME) (GDP per capita)	Natural logarithms of GDP per capita (Current US$)	World Bank Database
	Trade openness (TRADE)	Trade (% of GDP)	World Bank Database
	Foreign direct investment (FDI)	Foreign direct investment, net inflows (% of GDP)	World Bank Database
	Renewable energy consumption (RENEW)	Renewable energy consumption (% of total final energy consumption)	World Bank Database
	Population growth rate (POPULATION)	Population growth (%)	World Bank Database
	Forest area (FOREST)	Forest area (% of land area)	World Bank Database

The empirical model for the determinant of carbon dioxide emissions is as follows:

$$CO_{2i,t} = \alpha_t + CO_{2i,t-1} + CFA_{i,t-1} + CFM_{i,t-1} + Income_{i,t-1} + Trade_{i,t-1} + FDI_{i,t-1} + Renew_{i,t-1} + Population_{i,t-1} + Forest_{i,t-1}$$

$CO_{2i,t}$ refers to Carbon Dioxide Emissions Excluding LULUCF Per Capita (CO2/capita) for country *i* at time *t*; $CFA_{i,t-1}$ refers to Climate Finance for Adaptation Purpose for country *i* at time *t-1*; $CFM_{i,t-1}$ refers to Climate Finance for Mitigation Purpose for country *i* at time *t-1*; $Income_{i,t-1}$ refers to natural logarithms for the gross domestic product (GDP) per capita for country *i* at time *t-1*; $Trade_{i,t-1}$ refers to trade as a percentage of gross domestic product (GDP) for country *i* at time *t-1*; $FDI_{i,t-1}$ refers to foreign direct investment as a percentage of gross domestic product (GDP) for country *i* at time *t-1* $Renew_{i,t-1}$ refers to Renewable Energy Consumption as a percentage of total final energy consumption for country *i* at time *t-1*; $Population_{i,t-1}$ refers to population growth rate for country *i* at time *t-1*; and $Forest_{i,t-1}$ refers to forest area as a percentage of total area for country *i* at time *t-1*.

The Sargan test, also known as the Sargan-Hansen test, is a crucial diagnostic tool used after Generalized Method of Moments (GMM) estimation to assess the validity of the instruments used in the model (Sato and Söderbom, 2017). The test is crucial for detecting potential misspecification in the model, especially in the presence of measurement errors in the dependent or independent variables (Kiviet et al., 2017; Cheng and Bang, 2021). In GMM, when the number of instruments exceeds the number of endogenous variables, the model is overidentified. The Sargan test checks these overidentifying restrictions to ensure that the extra instruments do not introduce bias. Essentially, it tests whether the moment conditions hold true (Kiviet, 2017). The commonly accepted threshold for the p-value in the Sargan test is 0.05. A p-value above this threshold suggests that the instruments are valid, while a p-value below this threshold suggests potential issues with instrument validity (Kiviet and Kripfganz, 2021).

Then, this study carry out the Arellano-Bond AR(2) test after the Sargan test. The Arellano-Bond AR(2) test is designed to detect second-order serial correlation in the residuals of a dynamic panel data model. This is crucial because the presence of serial correlation can invalidate the moment conditions used in GMM estimation, leading to biased and inconsistent parameter estimates (Ahmed et al., 2021; Akinbode et al., 2021). Together, both Sargan test and AR(2) test provide a comprehensive check on the model's specification and the validity of the instruments. Passing both tests increases confidence in the reliability of the GMM estimates.

4. RESULTS AND DISCUSSION

4.1. Descriptive Statistics

Table 2 shows the descriptive statistics for the variables. The average carbon dioxide (CO_2) emissions per capita was 1.962 metric tons, with a standard deviation of 2.258. This result indicated that there was a notable variation in CO_2 emissions across countries. Some countries have emissions as low as 0.032 metric tons, while others could reach up to 12.4 metric tons per capita. In terms of climate finance, the average funding for climate change adaptation (CFA) was $3.627 million, while the average funding for climate change mitigation (CFM) was $5.782 million. Both variables exhibit high standard deviations of 9.46 and 21.75, respectively. These results suggested that there was a significant change in financial allocations among countries. The maximum CFM recorded is $304 million, whereas some countries receive no climate finance at all.

The average GDP per capita was $3,663, with a wide range from $210 to $12,885. This result indicated a substantial economic gap among these developing countries. The trade-to-GDP ratio had an average of 71.21% but varied significantly, with a standard deviation of 37.74%. The trade-to-GDP ratio ranged from 4.128% to 320.9%, reflecting differences in trade openness and economic integration. Moreover, the average foreign direct investment (FDI) as a percentage of GDP was 2.895%. Some countries experienced negative FDI inflows (−37.17%), indicating capital flight or disinvestment, while others benefited from FDI inflows as high as 34.42%. The average renewable energy consumption as a percentage of total energy consumption was 42.31%. However, the high standard deviation (28.97%) suggested that while some countries relied heavily on renewable energy (up to 97%), others barely utilized it (0.5%). Regarding population growth, the average annual growth rate was 1.702%. Some countries faced a population decline (−1.757%), while others grew rapidly (8.218%). Finally, the forest area as a%age of land had an average of 29.61%, with a minimum of 0.242% and a maximum of 90.27%.

Table 3 presents the results of the two step System GMM Estimation. Contradict with the findings of Li and Shao (2022),

Table 2: Descriptive statistics for the variables

Variables	N	Mean	SD	Min	Max
CO_2	518	1.962	2.258	0.032	12.4
CFA	518	3.627	9.46	0	112.6
CFM	518	5.782	21.75	0	304
INCOME	518	3,663	3,010	210	12,885
TRADE	518	71.21	37.74	4.128	320.9
FDI	518	2.895	4.565	-37.17	34.42
RENEW	518	42.31	28.97	0.5	97
POPULATION	518	1.702	1.153	-1.757	8.218
FOREST	518	29.61	22.81	0.242	90.27

CO_2 refers to carbon dioxide (CO_2) emissions excluding LULUCF per capita (CO_2/capita); CFA refers to climate finance for the purpose of climate change adaptation ($ million); CFM refers to climate finance for the purpose of climate change mitigation ($ million); GDP refers to gross domestic product per capita (in $); TRADE refers to trade as a percentage of GDP; FDI refers to the foreign direct investment as a percentage of GDP; RENEW refers to renewable energy consumption as a percentage of total final energy consumption; POPULATION refers to population growth rate; and FOREST refers to forest area as a percentage of land area

Table 3: Results of two-step GMM estimation

Variable	Model 1	Model 2
L.CO_2	1.092***	1.089***
	−0.0223	−0.0225
CFA	0.000844	-
	−0.00069	-
CFM	-	0.000340*
	-	−0.00019
INCOME	−0.252***	−0.249***
	−0.0908	−0.0902
TRADE	−0.00037	−0.0003
	−0.00049	−0.00047
FDI	0.000823	0.000677
	−0.00256	−0.0025
RENEW	−0.00296	−0.00291
	−0.00214	−0.00216
POPULATION	0.0968***	0.0977***
	−0.019	−0.0188
FOREST	−0.00648**	−0.00693**
	−0.00293	−0.00285
COVID-19	0.104***	0.103***
	−0.0134	−0.0135
Constant	1.950***	1.941***
	−0.725	−0.72
Sargan Test	28.36375	29.0331
	0.0767	0.0655
AR (2)	−0.77788	−0.7673
	0.4366	0.4429
Observations	444	444
Number of Countries	74	74
Number of Instruments	29	29

***, ** and * denotes significance at the 1%, 5% and 10% levels, respectively. L.CO_2 refers to lagged carbon dioxide (CO_2) emissions excluding LULUCF per capita (CO_2/capita); CFA refers to climate finance for the purpose of climate change adaptation ($ million); CFM refers to climate finance for the purpose of climate change mitigation ($ million); INCOME refers to the natural logarithms of gross domestic product per capita (in $); TRADE refers to trade as a percentage of GDP; FDI refers to the foreign direct investment as a percentage of GDP; RENEW refers to renewable energy consumption as a percentage of total final energy consumption; POPULATION refers to population growth rate; and FOREST refers to forest area as a percentage of land area; COVID-19 refers to a dummy variable representing the COVID-19 pandemic, which occurred in 2020 and 2021

this study found that the climate finance for mitigation purposes was positively and significantly related to the carbon dioxide emissions in the developing countries. This simply means that higher climate finance leads to increased carbon dioxide (CO_2) emissions. The potential explanation for these results is that the funds are often allocated to projects that still rely on fossil fuel-based technologies in the short term. Despite the goal is to support cleaner energy transitions, however the initial investments may involve infrastructure upgrades or efficiency improvements in existing high-emission industries. This suggests that the impact of climate finance depends on how funds are directed and whether they effectively support long-term emission reduction strategies.

Contrary to Wahyudi et al. (2025), income level (proxied by GDP per capita) is negatively and significantly related to carbon dioxide emissions in developing countries. This difference is mainly due to sample selection. Wahyudi et al. (2025) focused only on Indonesia, while this study includes 74 developing countries. The findings suggest that higher income levels lead to lower carbon dioxide emissions. A possible explanation is that as income rises, countries tend to enforce stricter environmental regulations, encouraging a shift to less carbon-intensive industries. Higher income developing countries also have more financial resources to invest in renewable energy and improve energy efficiency, reducing their dependence on fossil fuels. Additionally, rising income levels often align with greater public awareness and stronger government commitment to sustainability. These efforts further support the reduction in carbon dioxide emissions.

Consistent with Sanglimsuwan (2012) and Jorgenson and Clark (2013), population growth was positively and significantly related to carbon dioxide emissions in developing countries. This result suggests that higher population growth may lead to increased CO_2 emissions due to greater energy consumption, higher demand for transportation, or expanded industrial activities. As populations grow, the need for housing, infrastructure, and consumer goods rises, further driving fossil fuel consumption. Additionally, rapid urbanization in developing countries may often lead to higher carbon dioxide emissions. These findings highlight the need for policies that promote sustainable urban planning and investment in clean energy to mitigate the environmental impact of population growth.

Consistent with Waheed et al. (2018) and Raihan and Tuspekova (2022), this study found that forest areas were negatively and significantly related to carbon dioxide emissions in developing countries. This suggests that a larger forest area can help reduce CO_2 emissions by absorbing carbon through photosynthesis. Forests act as natural carbon sinks, mitigating the environmental impact of industrial activities and energy consumption. Additionally, preserving and expanding forest cover can enhance biodiversity, improve air quality, and promote climate resilience. These findings highlight the importance of reforestation, sustainable land management, and policies that protect forested areas to support long-term emission reduction efforts in developing nations.

5. CONCLUSION

Carbon dioxide emissions are a major contributor to air pollution and climate change. Governments worldwide have been actively implementing policies to curb emissions and transition toward more sustainable energy sources. Among these efforts, climate finance has emerged as a crucial tool for supporting mitigation and adaptation strategies. This study examined the impact of climate finance on carbon dioxide emissions in developing countries, using a sample of 74 nations from 2015 to 2021. This study employed the two-step Generalized Method of Moments (GMM) estimation to examine the relationship between climate finance and potential macroeconomics factors with carbon dioxide emissions. The findings indicated that climate finance plays a significant role in shaping carbon emissions in developing countries. However, the effectiveness of climate financing depends on how the funds are allocated and utilized. In some cases, investments in energy infrastructure upgrades or transitional technologies may initially contribute to higher emissions before leading to long-term reductions.

These results highlight the need for well-targeted climate finance policies that prioritize renewable energy development, energy efficiency, and low-carbon technologies. Additionally, governments and international organizations should ensure that climate funds are effectively deployed to maximize their impact on carbon dioxide emission reductions. This study also supports the findings of previous study and confirmed that population growth and forest areas play crucial role in reducing the carbon emissions. This study also recommends future research to explore the role of policy frameworks and institutional capacities in optimizing the effectiveness of climate finance in achieving sustainability goals.

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