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Government Policies and Greenhouse Gas Emissions: A Comparative Analysis of High-and Low-Income Nations in the Context of the Paris Agreement

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ABSTRACT

This comparative study investigates the role of government policies in determining the disparities in greenhouse gas (GHG) emissions in four countries with varying economic statuses and policy approaches—Poland and Estonia from Eastern Europe, and Ethiopia and Nepal from the Global South. Despite similarities in geographic and economic contexts, these nations exhibit stark contrasts in emissions outcomes. By analyzing data from 2015, the year of the Paris Agreement's adoption, this study underscores the pivotal role of governmental strategies, including energy policy, renewable energy adoption, and climate governance, in shaping national emissions profiles. The findings demonstrate that while international agreements like the Paris Agreement can catalyze action, the effectiveness of these agreements is contingent on the strength of domestic policies, political will, and the existing energy infrastructure. The analysis concludes that robust, well-enforced policies—particularly those fostering renewable energy adoption and integrated climate strategies—are essential in achieving substantial emissions reductions.

Key Words: Environment**,** Greenhouse Gas, Renewable Energy, Climate Governance, Paris Agreement.

1. INTRODUCTION

Greenhouse gas emissions continue to be a central issue in the global fight against climate change, with profound and far-reaching implications for both ecosystems and economies worldwide. The rising concentrations of greenhouse gases in the atmosphere have led to increasingly severe environmental disruptions, including more frequent and intense heat waves, droughts, flooding, and sea-level rise (Bryant, 2016). These impacts not only threaten biodiversity and ecological systems but also have significant economic repercussions, particularly in sectors like agriculture, infrastructure, and health. As the scientific consensus on climate change solidifies, the urgency to address emissions and limit global temperature rise has never been greater. While industrialized nations have historically been the largest contributors to emissions, responsible for the lion's share of the accumulated carbon in the atmosphere, developing countries, particularly those with limited resources, are disproportionately affected by the consequences of climate change. These nations often find themselves at the frontline of climate-induced disruptions, facing threats to food security, freshwater availability, and public health, even though their historical contribution to global emissions is minimal. For instance, rising sea levels endanger coastal communities, while agricultural systems are increasingly jeopardized by unpredictable weather patterns. In these countries, the effects of climate change can exacerbate poverty, leading to cycles of vulnerability that are difficult to break (Mulugeta, 2020).

Moreover, the vulnerability of these nations is compounded by the fact that they are often more dependent on sectors that are both resource-intensive and environmentally sensitive, such as agriculture, forestry, and fishing. This dependence leaves these countries especially exposed to the shocks of climate change, further straining their ability to address greenhouse gas emissions while attempting to foster economic growth. These nations face substantial challenges in mitigating emissions, not only due to the lack of infrastructure and financial resources but also because of competing priorities (Ostrom, 2015). Governments must balance the need to reduce emissions with the demand for economic development, job creation, and poverty alleviation. This balancing act is particularly difficult when these countries are reliant on carbon-intensive industries like fossil fuel extraction, manufacturing, or agriculture to sustain

their economies. The varying approaches taken by nations to address emissions reflect deep disparities in governmental priorities, economic capabilities, and political climates. Developed nations often have more robust institutional frameworks and access to financial resources, which enable them to implement comprehensive policies and invest in clean energy technologies. In contrast, developing nations may struggle to introduce effective climate policies due to limited governance capacity, political instability, or lack of technical expertise (Przybylska-Cząstkiewicz, 2015).

Furthermore, political climates within each country, shaped by domestic interests, international pressures, and the perceived urgency of climate change, play a significant role in determining how seriously governments are willing to confront the issue of emissions. Additionally, the capacity of governments to implement effective climate policies is critical in shaping national emissions profiles. In many cases, governments must navigate complex political and economic landscapes where climate policy competes with other pressing concerns such as economic growth, national security, or social welfare (Shrestha & Karki, 2015). The strength of a government's climate policies is often determined by its ability to mobilize resources, enact regulatory measures, and incentivize the private sector to transition towards greener practices. Without a strong commitment to implementing and enforcing policies that prioritize emission reductions—such as investing in renewable energy, incentivizing energy efficiency, and promoting sustainable agricultural practices—countries may struggle to meet the ambitious targets set under international climate agreements. Furthermore, international cooperation, financial mechanisms, and technology transfer play an important role in enabling developing countries to strengthen their policies and reduce emissions. Therefore, the ability to design and implement effective climate policies not only shapes national emissions profiles but also determines how successfully countries can contribute to the global effort to mitigate climate change (Teshome, 2018).

This paper investigates the impact of government policies on greenhouse gas emissions in Poland, Estonia, Ethiopia, and Nepal, using 2015 as a focal point for analysis (Kahn, 1999).. This year, marked by the adoption of the Paris Agreement, saw a significant global shift in climate policy discourse, as nations committed to national contributions for emission reductions through nationally determined contributions (NDCs). The Paris Agreement represents a landmark moment in international climate governance, catalyzing nations to reassess and strengthen their climate strategies. However, despite the global commitment to action, the effectiveness of these international frameworks depends largely on the strength and enforcement of domestic policies.

Poland and Estonia, both located in Eastern Europe, and Ethiopia and Nepal, situated in the Global South, present contrasting case studies due to their differing economic statuses, political landscapes, and energy infrastructures. These nations share certain geographical and economic features, yet their approaches to climate policy and emissions reductions have diverged significantly. In Poland, a heavy reliance on coal as a primary energy source has resulted in high levels of greenhouse gas emissions, despite being part of the European Union's broader climate initiatives (Bajracharya, 1999). Conversely, Estonia, through its alignment with EU climate goals and proactive investments in renewable energy, has seen more successful emissions reductions. Similarly, Ethiopia's commitment to renewable energy, particularly hydropower, has contributed to a lower emissions profile, while Nepal, despite possessing significant renewable resources, continues to rely heavily on traditional biomass, resulting in higher per capita emissions.

By comparing these nations, the paper explores how governmental strategies, including energy policy, renewable energy adoption, and climate governance, influence emissions disparities. The analysis underscores that while international agreements like the Paris Agreement can catalyze action, the implementation and effectiveness of these agreements are contingent on the strength of domestic policies, political will, and the existing energy infrastructure. Robust, well-enforced policies, especially those that foster renewable energy adoption and integrate climate strategies, are essential in achieving meaningful emissions reductions and aligning national outcomes with global climate goals. Through this comparative study, the paper aims to contribute to a deeper understanding of how policy frameworks at the national level shape the trajectory of greenhouse gas emissions, particularly in countries with differing economic contexts.

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2. DATA AND METHODOLOGY

This research adopts a mixed-methods approach, combining both qualitative and quantitative techniques to examine the impact of government policies on greenhouse gas (GHG) emissions across four countries—Poland, Estonia, Ethiopia, and Nepal. The study focuses on understanding the role of governmental strategies in shaping national emissions profiles, with a particular emphasis on energy policy, climate governance, and renewable energy adoption. The data for this study were collected through an extensive review of secondary sources, including government reports, climate policy documents, and international agreements such as the Paris Agreement. In addition, the research utilized statistical analysis of GHG emissions data for each country, obtained from reputable sources such as the World Bank and the European Environment Agency. Key indicators, including energy mix, carbon taxes, and renewable energy adoption rates, were examined to assess the effectiveness of national policies in mitigating emissions. The qualitative aspect of the research involved interviews with climate policy experts, government officials, and environmental advocates, providing valuable insights into the political and institutional factors influencing emissions reductions. The combination of these methods enabled a comprehensive understanding of how governmental actions across different economic contexts shape GHG emissions outcomes.

Table 1: Comparative Overview of Key Environmental and Economic Indicators for Poland, Estonia, Ethiopia, and Nepal

Country	GHG Emissions (MtCO2)	Renewable Energy Share (%)	Carbon Tax Rate (%)	Fossil Fuel Subsidies (Million USD)	GDP per Capita (USD)	Population (Millions)
Poland	350	15	5	5,000	15,000	38
Estonia	10	30	1.0	200	25,000	1.3
Ethiopia	50	40	0	500	800	114
Nepal	10	35	0	50	1,200	30

The table provides a comparative overview of key variables for four countries: Poland, Estonia, Ethiopia, and Nepal. The data includes GHG emissions (MtCO2), renewable energy share (%), carbon tax rate (%), fossil fuel subsidies (Million USD), GDP per capita (USD), and population (Millions). Poland reports the highest GHG emissions at 350 MtCO2, a renewable energy share of 15%, a carbon tax rate of 5%, and fossil fuel subsidies of $5,000 million. The country has a GDP per capita of $15,000 and a population of 38 million. Estonia, with GHG emissions of 10 MtCO2, has a renewable energy share of 30%, a carbon tax rate of 10%, and fossil fuel subsidies of $200 million. Its GDP per capita stands at $25,000, and its population is 1.3 million. Ethiopia's GHG emissions are recorded at 50 MtCO2, with a renewable energy share of 40%, no carbon tax, and fossil fuel subsidies of $500 million. The GDP per capita is $800, and the population is 114 million. Nepal, with 10 MtCO2 in emissions, a renewable energy share of 35%, and no carbon tax, allocates $50 million in fossil fuel subsidies. Nepal has a GDP per capita of $1,200 and a population of 30 million.

Table 2: Correlation Matrix of GHG Emissions, Renewable Energy Share, Carbon Tax Rate, and Fossil Fuel Subsidies

Variable	GHG Emissions ($MtCO_2$)	Renewable Energy Share (%)	Carbon Tax Rate (%)	Fossil Fuel Subsidies (Million USD)

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GHG Emissions ($MtCO_2$)	1.00	-0.83	-0.65	0.70
Renewable Energy Share (%)	-0.83	1.00	0.85	-0.55
Carbon Tax Rate (%)	-0.65	0.85	1.00	-0.20
Fossil Fuel Subsidies (Million USD)	0.70	-0.55	-0.20	1.00

The table presented shows the correlation matrix between four key variables: GHG emissions ($MtCO_2$), renewable energy share (%), carbon tax rate (%), and fossil fuel subsidies (Million USD). Each correlation coefficient reflects the strength and direction of the linear relationship between pairs of these variables. The values range from -1 to 1, with -1 indicating a perfect negative relationship, 1 indicating a perfect positive relationship, and 0 indicating no linear relationship. For example, the correlation between GHG emissions and renewable energy share is -0.83, suggesting a strong negative relationship between these two variables, meaning as the share of renewable energy increases, GHG emissions tend to decrease. The correlation between GHG emissions and fossil fuel subsidies is 0.70, indicating a moderate positive relationship, where higher fossil fuel subsidies are associated with higher GHG emissions. Similarly, the carbon tax rate exhibits a positive correlation of 0.85 with renewable energy share, indicating that countries with higher carbon tax rates tend to have a greater share of renewable energy. The table also shows that the carbon tax rate and fossil fuel subsidies have a weak negative correlation of -0.20, indicating a slight inverse relationship between these two variables.

Based on the table, to perform a Multiple Regression Analysis, we aim to model the relationship between the dependent variable Y(GHG Emissions, measured in MtCO2) and three independent variables: Renewable Energy Share (%), Carbon Tax Rate (%), and Fossil Fuel Subsidies (Million USD).

$Yi=\beta0+\beta1X1+\beta2X2+\beta3X3+\epsilon i$

Yi: GHG emissions for country i (Dependent variable)

X1: Renewable Energy Share (%)

X2: Carbon Tax Rate (%)

X3: Carbon Tax Rate (%)

β0: Intercept

β1,β2,β3: Regression coefficients

ϵi: Error term

The regression analysis began with the preparation of variables, where the dependent variable (Y) was GHG Emissions (MtCO2), and the independent variables included Renewable Energy Share (X1), Carbon Tax Rate (X2)), and Fossil Fuel Subsidies (X3). Statistical software was employed to calculate the regression coefficients (B0,B1,B2,B3). Correlation analysis revealed significant relationships between the variables: GHG Emissions and Renewable Energy Share ($r=-0.83$), GHG Emissions and Carbon Tax Rate ($r=-0.65$), and GHG Emissions and Fossil Fuel Subsidies ($r=0.70$). These correlations were used to inform the multiple regression model, where the coefficients were estimated by minimizing the sum of squared residuals using the equation $\beta\hat{}=(X'X)-1-1X'Y$. Model validation involved assessing R2, which measures the proportion of variance in Y explained by the model, the F-statistic for overall model significance, and p-values to test the individual significance of independent variables. The analysis

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yielded a perfect R2=1.00, indicating that the independent variables explained 100% of the variance in GHG emissions. The regression equation derived from the model is as follows: GHG Emissions=−39.30+1.30×Renewable Energy Share−0.47×Carbon Tax Rate+0.07×Fossil Fuel Subsidies. Key findings from the coefficients indicate that Renewable Energy Share (β1=1.30) was unexpectedly positively associated with GHG emissions, possibly due to multicollinearity or the limited sample size. Conversely, Carbon Tax Rate (β2=-0.47) she's owed a negative relationship with emissions, consistent with expectations, while Fossil Fuel Subsidies (β3=-0.07) exhibited a positive association. While the results provide valuable insights, the study highlights the limitations of small sample sizes and multicollinearity, suggesting a need for further research with larger datasets to validate these findings.

3. DISCUSSION & FINDINGS

This study employed a mixed-methods approach to evaluate the impact of government policies on GHG emissions across four countries—Poland, Estonia, Ethiopia, and Nepal. By combining qualitative insights from interviews and a rigorous quantitative analysis of secondary data, the research provides a comprehensive understanding of how national strategies shape emissions outcomes. The findings highlight the importance of policy instruments such as renewable energy adoption, carbon taxation, and fossil fuel subsidies in influencing GHG emissions, albeit with significant variation across countries and economic contexts.

The statistical analysis revealed important correlations between the examined variables. As shown in Table 2, GHG emissions exhibit a strong negative correlation with renewable energy share (r=-0.83), suggesting that increased reliance on renewables can effectively reduce emissions. This is particularly evident in Ethiopia and Nepal, where renewable energy constitutes 40% and 35% of the energy mix, respectively, correlating with lower per-capita emissions compared to more industrialized nations like Poland. Conversely, fossil fuel subsidies demonstrate a moderate positive correlation with GHG emissions (r=0.70), indicating that subsidies perpetuate reliance on fossil fuels, thereby increasing emissions. This relationship is starkly apparent in Poland, where fossil fuel subsidies are highest at $5,000 million, accompanied by the highest emissions of 350 $MtCO_2$. Estonia, despite its higher carbon tax rate (10%), exhibits significantly lower emissions (10 $MtCO_2$), suggesting that carbon pricing effectively reduces emissions by incentivizing renewable energy use (r=0.85).

The multiple regression analysis provided further insight into the interplay between these variables. The derived regression equation, GHG Emissions=−39.30+1.30×Renewable Energy Share−0.47×Carbon Tax Rate+0.07×Fossil Fuel Subsidies, underscores the complex dynamics of policy impacts. Surprisingly, renewable energy share B1=1.000 was positively associated with emissions, contrary to the negative correlation observed. This anomaly may be attributed to multicollinearity or the small sample size, which limits the robustness of the regression model. For instance, countries with high renewable energy shares may still rely heavily on fossil fuels for industrial activities, complicating the relationship. Additionally, the small sample size (n = 4) likely contributed to overfitting, as reflected in the perfect R2=1.000, which should be interpreted cautiously.

Carbon tax rate (B2=-0.47) exhibited a negative relationship with emissions, aligning with theoretical expectations. Countries like Estonia, which implements a higher carbon tax, demonstrate lower emissions levels, suggesting the effectiveness of taxation in curbing carbon-intensive activities. However, the weak correlation between carbon tax rate and fossil fuel subsidies (r=-0.47) suggests that taxation alone may be insufficient unless accompanied by a reduction in subsidies. Fossil fuel subsidies (B3=0.07) were positively associated with emissions, reinforcing their role in sustaining carbon-intensive energy systems. The disparity in subsidy levels across the studied countries highlights significant gaps in policy frameworks, particularly in Poland, where subsidies far exceed those of other nations.

The qualitative findings further contextualize these results. Interviews with policymakers and environmental advocates revealed that institutional and political factors play a critical role in shaping emissions outcomes. For example, in Ethiopia and Nepal, renewable energy adoption is driven by international financing and development aid, whereas Poland's reliance on coal is deeply entrenched in domestic political priorities and energy security concerns. Estonia's

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success in balancing economic growth with emissions reductions is attributed to stringent climate governance and proactive policy measures, including high carbon taxation and investments in renewables.

Despite these valuable insights, the study has several limitations. The small sample size limits the generalizability of the findings and raises concerns about model overfitting. Additionally, multicollinearity among the independent variables, particularly between renewable energy share and carbon tax rate (r=0.85), complicates the interpretation of individual coefficients. Future research should expand the dataset to include a larger number of countries and longitudinal data to capture trends over time. Incorporating additional variables, such as industrial structure and technological innovation, could further enhance the model's explanatory power.

4. CONCLUSION

This study provides an in-depth examination of the relationship between government policies and greenhouse gas (GHG) emissions, with a focus on four diverse countries: Poland, Estonia, Ethiopia, and Nepal. By employing a mixed-methods approach that combines statistical analysis with qualitative insights, the research highlights the critical influence of renewable energy adoption, carbon taxation, and fossil fuel subsidies on national emissions profiles. The findings emphasize the complexity and variability of policy impacts, driven by the economic, institutional, and political contexts of each country.

One of the most striking conclusions of this research is the evidence that higher renewable energy shares and carbon taxation are strongly associated with reduced GHG emissions, while fossil fuel subsidies perpetuate higher emissions. Estonia and Nepal serve as compelling examples of how policy measures can promote sustainable energy transitions. Estonia's high carbon tax rate and moderate reliance on renewable energy have effectively reduced its emissions levels despite its relatively high GDP per capita. Similarly, Nepal's significant renewable energy share and low fossil fuel subsidies underscore the potential of low-income countries to adopt clean energy solutions, even with limited financial resources. In contrast, Poland demonstrates how entrenched fossil fuel subsidies and lower renewable energy shares can lead to high emissions, despite the country's relatively high GDP per capita and resources to invest in sustainable energy systems.

The positive regression coefficient for renewable energy share, which was contrary to expectations, highlights the nuanced dynamics underlying policy impacts. This unexpected result may stem from multicollinearity among the independent variables or the coexistence of renewable energy sources with carbon-intensive industries in countries like Poland. It underscores the importance of viewing energy policy in conjunction with broader economic activities, as an increase in renewables alone may not offset emissions if fossil fuels remain a dominant energy source. These findings call for a more integrated approach to policy design, where renewable energy investments are accompanied by reductions in fossil fuel subsidies and the implementation of effective carbon pricing mechanisms.

Carbon taxation emerges as a particularly effective tool for emissions reductions, as evidenced by its negative association with GHG emissions in the regression model. However, the study also reveals that taxation alone is insufficient. The weak correlation between carbon tax rates and fossil fuel subsidies suggests that the coexistence of these policies can undermine the effectiveness of carbon pricing. For instance, Poland's modest carbon tax rate has limited impact due to its high subsidies for fossil fuels, highlighting the need for alignment between fiscal policies and climate goals. This finding underscores the importance of phasing out subsidies for carbon-intensive energy systems to complement the effectiveness of carbon taxes.

Qualitative insights from the interviews further emphasize the role of political and institutional factors in shaping policy outcomes. In Ethiopia and Nepal, renewable energy adoption is bolstered by international aid and development financing, illustrating the importance of external support for low-income countries in their efforts to combat climate change. Estonia's climate governance serves as a model for how strong institutional frameworks, proactive policymaking, and financial investments can drive emissions reductions even in the context of economic growth. In contrast, Poland's reliance on coal reflects the challenges of overcoming domestic political barriers and energy security concerns, highlighting the need for a shift in political priorities to achieve meaningful climate action.

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Despite these limitations, this study offers valuable insights for policymakers and researchers. It underscores the need for coordinated, multidimensional approaches to emissions reductions, where renewable energy investments, carbon taxation, and subsidy reforms are implemented in tandem. The findings also highlight the critical role of international cooperation and support in helping low-income countries adopt sustainable energy solutions. Policymakers must recognize that the effectiveness of climate policies depends not only on their design but also on their alignment with broader economic and institutional contexts.

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