The Role of Women Empowerment on Environmental Sustainability: A Cross-Country Analysis

Ronia Hawash
Butler University

Eiman Aiyash
North Carolina State University

The study aims to provide insights into the impact of women's political empowerment on environmental sustainability measured using the level of carbon dioxide (CO_2) emissions. We use a panel dataset of 135 countries (30 developed and 105 developing) from 1990 to 2020. The analyses are conducted separately for developed and developing countries. We use the Women's Political Empowerment Index (WPE) constructed by the Varieties of Development Project (V-Dem). WPE has three dimensions: women's civil liberties, women's participation in civil society, and women's political participation. The dependent variable, Carbon Dioxide (CO_2) emissions, along with control variables such as GDP per capita, population levels, and renewable energy consumption, are derived from the World Development Indicators (WDI) dataset. Using fixed effects (FE) panel data analysis, our findings indicate that, in most cases, higher levels of women's political empowerment resulted in lower CO_2 emissions across both developed and developing countries.

Keywords: environmental sustainability, CO_2 emissions, women political empowerment index (WPE), women civil society participation index (WCSP), women civil liberties index (WCL), women political participation index (WPP)

INTRODUCTION

Understanding the multifaceted relationship between gender dynamics and environmental sustainability has become increasingly urgent considering the growing concerns over global climate change and its far-reaching impacts. At the core of this discussion is the influence of women's political empowerment on policy decisions concerning environmental stewardship and carbon emissions management. This paper presents a cross-country analysis to explore the implications of women's political empowerment on environmental sustainability, with a particular focus on carbon dioxide (CO_2) emissions. The study analyzes a panel dataset of 135 developed and developing countries from 1990 to 2020 to examine how variations in WPE influence a country's environmental outcomes.

The variable of interest in our study is the Women's Political Empowerment Index (WPE), constructed by the Varieties of Democracy Project (V-Dem), which captures three critical dimensions of women empowerment: women's civil liberties, women's participation in civil society, and women's political

participation. Greater political agency and representation of women are expected to foster more proactive environmental policies, potentially reducing CO_2 emissions.

Furthermore, the analysis explores the distinction between the effects of WPE in developed and developing countries. Developed nations, with their relatively robust institutional frameworks and often higher levels of gender parity, may exhibit different dynamics compared to developing countries, where gender roles and participation in public policymaking could have varying degrees of influence on environmental policy. The study uses fixed effects (FE) panel data analysis to control for unobserved fixed heterogeneity and draw more reliable inferences about the role of WPE in CO_2 emissions while controlling for GDP per capita, population levels, and renewable energy consumption.

Global warming has become a growing concern and a significant threat to humanity, making the pursuit of sustainable development increasingly urgent. Understanding women's role in mitigating environmental threats is essential. Accordingly, examining how women's political empowerment contributes to a cleaner and more sustainable environment not only contributes to the body of knowledge on gender and the environment but is also important for policy-making decisions that move the world closer to a more sustainable and cleaner environment.

LITERATURE REVIEW

Gender considerations are integral to effective climate action. The Sustainable Development Goals highlight the important intersection between women's empowerment and environmental efforts for a cleaner and more sustainable environment. Previous studies in social sciences indicate that women are generally more concerned about the environment and have higher climate change engagement than men (Givens and Jorgenson, 2011; Scannell and Gifford, 2013; Xiao and McCright, 2015). Moreover, women's roles in the household and their responsibility for their families' livelihoods, particularly in securing access to clean water and fertile cropland, suggest that they play a critical role in climate adaptation and mitigation efforts (Ergas and York, 2012). More specifically, women in developing countries are responsible for securing water, food, and fuel for cooking, which in turn requires them to travel farther with increasingly scarce resources due to climate change. Moreover, women's health is more adversely affected by environmental disasters than men's. Studies suggest that CO_2 emissions contribute to environmental conditions associated with increased maternal mortality risks (Saleem et al., 2018); living near cropland with pesticides increases the likelihood of developing breast cancer among women (Silva, et al., 2019) and disproportionately affects women in developing countries that act as subsistence labourers, and water and fuelwood collectors (Denton 2002).

Women are often underrepresented in decision-making processes related to environmental management and climate change policy. This lack of inclusion can result in policies and strategies that do not adequately address the needs and concerns of women. Several studies have examined how higher levels of women's political empowerment result in stricter regulations to preserve the environment. Given that women are more likely to be impacted by environmental sustainability and degradation, it is expected that higher female participation in public policy should enforce stricter environmental policies. Studies have shown that countries with a higher percentage of women in political participation are more likely to ratify and sign climate treaties (Norgaard and York, 2005) and have a higher preference for energy policymaking in the U.S. and Germany (Fraune, 2016). Moreover, female legislators in the U.S. House of Representatives favor stricter environmental policies compared to men (Fredriksson and Wang, 2011).

Other studies have examined the actual impact of women's political empowerment on the environment. Ergas and York (2012) use the index developed by Nugent and Shandra (2009) as a measure of women's political status. The index is based on a principal components analysis of seats in parliament held by women, number of years women have had the right to vote, and women in ministerial government. Using an Ordinary Least Squares model of over 100 countries, their study concludes that CO_2 emissions per capita are lower in nations where women have higher political status, controlling for GDP per capita, urbanization, industrialization, militarization, world-system position, foreign direct investment, the age dependency ratio, and level of democracy. Kadir Aden (2023) takes the analysis one step further by investigating the factors

that assist and empower women in politics to reduce CO_2 emissions by looking at the absence of corruption, academic freedom, regulatory quality, government effectiveness, and respect for fundamental rights as the facilitator factors of this relationship. Their analysis focuses on the Nordic and European countries for the period between 2002 and 2021. DiRienzo and Das (2019) have also examined the role of women in government in improving environmental quality by showing that women in political power usually have a pro-environmental agenda and positively impact the environment indirectly through reducing corruption.

Lv and Deng (2019) use cointegration techniques to examine the long-term and short-term effects of women's political empowerment on the environment. The study covers 72 countries during 1971 and 2012. The relationship in question is modelled using the Stochastic Impacts by Regression on Population, Affluence, and Technology (STIRPAT) model while adding women's political empowerment and the square of GDP to Equation. The study measures women's political empowerment using V-Dem Women's Political Empowerment Index, developed by Sundström et al. (2017), which comprises three indicators which are: civil liberty, civil society participation, and political participation. Holding all other variables constant, the study estimates that a one-unit increase in the index of WPE leads to a decrease in CO_2 emissions of 11.51%. The average short-term estimated coefficient of WPE is also negative but statistically insignificant in the short run. Shandra et al. (2008) argue that the higher the number of women's NGOs in a country, the lower the levels of deforestation since forest loss disproportionately impacts women in poorer rural settings who depend on natural resources for the provision of household food, income, and fuelwood. Salahodjaev and Jarilkapova (2020) reach similar results showing that nation-states with a critical mass of female legislators above 38 % should experience increases in per capita forest cover.

Our study addresses a gap in the literature, as the previous research highlights the following key issues: (1) Women's representation in parliament has been the primary proxy used in most studies, but other forms of (civil) participation remain under-explored. (2) It is important to differentiate between developed and developing countries in the analysis as the cultural role of women in the household and the society at large, and the disproportionate impact of environmental degradation and climate change differ in each setting. (3) Most existing literature focuses on environmental policies, while environmental quality itself has not been adequately addressed, highlighting the need for further research.

DATA AND METHODOLOGY

Data

This study addresses the relationship between women's political empowerment and CO_2 emissions in 135 countries, including 30 developed and 105 developing countries. The study examines the hypothesis that a higher level of women's political empowerment is associated with lower CO_2 emissions. A list of the countries studied can be found in the Appendix - Table 1. The study period is from 1990 to 2020, is determined by data availability.

The dependent variable, CO_2 represents the amount of emissions produced by burning fossil fuels and manufacturing cement. The data for CO_2 emissions is collected from the World Development Indicators Database. The index of women's political empowerment (WPE) and its sub-dimensions are used as independent variables. These variables are sourced from the "Varieties of Democracy Database of 2023 (V-Dem)" and range from 0 to 1. A value of "0" indicates the absence of empowerment, while a value of "1" indicates strong empowerment for women.

The concept of women's empowerment can be broken down into three sub-dimensions: women's civil liberties (WCL), women's civil society participation (WCSP), and participation in political affairs (WPP). WCL refers to women's ability to make important decisions in their daily lives. WCSP refers to their freedom to participate in public debates. WPP involves the representation of women in political positions such as parliament. The average score of these three indicators forms the Women's Political Empowerment (WPE) index. A low score on these indices indicates that men have a significant advantage over women in political decision-making. On the other hand, a high score reflects increased influence with decision-making, signalling greater gender parity (Asongu, Messono, & Guttemberg, 2022).

The research employed a group of control variables obtained from the World Development Indicator Database. These variables include gross domestic product per capita (GDPC), which is gross domestic product divided by midyear population, the total population (POP), and renewable energy consumption (REC), which is measured as a percentage of total final energy consumption. The descriptive statistics of these variables are provided in Table 2 of the Appendix.

Specifications for all variables used in the study is provided in Table 1.

TABLE 1
DEFINITIONS OF THE VARIABLES USED IN THE REGRESSION ANALYSIS

Variables	Description	Sources
Dependent Variable		
CO_2	CO_2 emissions (kg per 2015 US$ of GDP). Carbon dioxide emissions are those stemming from the burning of fossil fuels and the manufacture of cement. They include carbon dioxide produced during consumption of solid, liquid, and gas fuels and gas flaring.	World Development Indicators Database
Independent Variables		
GDPC	GDP per capita (constant 2015 US$). GDP per capita is gross domestic product divided by midyear population. GDP is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for the depreciation of fabricated assets or for the depletion and degradation of natural resources. Data are in constant 2015 U.S. dollars.	World Development Indicators Database
POP	Population, total.	World Development Indicators Database
REC	Renewable energy consumption (% of total final energy consumption). Renewable energy consumption is the share of renewable energy in total final energy consumption.	World Development Indicators Database
WPE	Women's Political Empowerment Index. The variable denotes the best estimate of the extent to which women enjoy civil liberties, can participate in civil society, and are represented in politics. The variable ranges from 0 to 1 (most empowered).	V-Dem
WCL	Women's Civil Liberties Index. The variable denotes the best estimate of the extent to which women are free from forced labor, have property rights and access to the justice system, and enjoy freedom of movement. The variable ranges from 0 to 1 (most liberties).	V-Dem
WPP	Women's Political Participation Index. The variable denotes the best estimate of the extent to which women are represented in the legislature and have an equal share of political power. The variable ranges from 0 to 1 (most equal).	V-Dem
WCSP	Women's Civil Society Participation Index. The variable denotes the best estimate of the extent to which women can discuss political issues, participate in civil society organizations, and be represented among journalists. The Variable ranges from 0 to 1 (most participatory).	V-Dem

METHODOLOGY

In this study, we aim to explore the effect of women's political empowerment on CO_2 emissions. Hence, the following function is developed for the study:

$$CO_2 = f\ (WPE, GDPC, POP, REC)$$

Fixed effects (FE) and random effects (RE) regression techniques are constructed to estimate the following models. The Hausman test for random effects is performed to decide what regression model to use. The test compares whether the fixed or random effect model is the most efficient. From the test results, the fixed effect model is the most efficient regression. We also construct pooled ordinary least square regression models as a robustness check for the estimation.

The developed countries model comprises 30 countries with 930 observations, while the developing countries model includes 105 countries with 3255 observations.

Developed Countries Model

$$CO_{2i,t} = \alpha_0 + \alpha_1\ WPE^k_{i,t} + \alpha_2\ GDPC_{i,t} + \alpha_3\ POP_{i,t} + \alpha_4\ REC_{i,t} + \mu_i + \tau_t + \varepsilon_{i,t}\ i = 1, 2, \ldots\ldots, 30 \text{ and } t = 1990, 1991, \ldots\ldots., 2020.$$

Developing Countries Model

$$CO_{2i,t} = \alpha_0 + \alpha_1\ WPE^k_{i,t} + \alpha_2\ GDPC_{i,t} + \alpha_3\ POP_{i,t} + \alpha_4\ REC_{i,t} + \mu_i + \tau_t + \varepsilon_{i,t}\ i = 1, 2, \ldots\ldots, 105 \text{ and } t = 1990, 1991, \ldots\ldots., 2020.$$

where CO_2 represents carbon dioxide emissions in country i for year t, the independent variable of interest is the political empowerment of women represented by WPE. We use k (k = 1, 2, 3, 4) measures of WPE, namely women's civil liberties (WCL), women's participation in civil society (WCSP), women's participation in political debate (WPP), and the global index of WPE. The control variables are represented here by GDP per capita (GDPC), total population (POP), and renewable energy consumption as a percentage of total final energy consumption (REC). $\alpha_0 - \alpha_4$ are the parameters to be estimated.

RESULTS

Baseline Results

The following section displays the outcomes obtained from the fixed effect models. Table 2 exhibits the outcomes for both developed and developing countries from the fixed effect regression analysis. The overall R^2 signifies the proportion of CO_2 emissions variance explained by the regression model. The R^2 value differs for each model. The lowest value of 6% is found in the model for developing countries, while the highest value of 30% is located in the model for developed countries.

TABLE 2
FIXED EFFECT MODEL RESULTS

	Developed Countries				Developing Countries			
	Dependent Variable: Carbon Dioxide Emissions				Dependent Variable: Carbon Dioxide Emissions			
	FE (1)	FE (2)	FE (3)	FE (4)	FE (6)	FE (7)	FE (8)	FE (9)
WPE				-1.137***				-84.251
WCL	-0.894***				-11.891			
WPP		-0.777***				-98.758***		
WCSP			0.692***				-24.161	
GDPC	-0.000***	-0.000***	-0.000***	-0.000***	-0.038***	-0.036***	-0.038***	-0.037***
POP	0.000	0.000*	0.000	0.000	-0.000	-0.000	-0.000	-0.000
REC	-0.018***	-0.017***	-0.019***	-0.017***	-0.201***	-0.203***	-0.202***	-0.203***
Cons.	1.632***	1.378***	0.218	1.735***	2067.901***	2123.515***	2074.983***	2111.78***
Obs.	930	930	930	930	3255	3255	3255	3255
R^2	0.2724	0.1479	0.2671	0.1780	0.0596	0.0755	0.0612	0.0661

*** sign at 99%, ** sign at 95%, * sign at 90%.

In columns (1) and (6), we have used women's civil liberties index (WCL) as the independent variable for developed and developing countries respectively. For developed countries, we have estimated a highly significant negative coefficient. The magnitude of the coefficient suggests that a one-unit increase in the WCL index results in a 0.89 units decrease in CO_2 emissions. This means that as more women are free from forced labor, have property rights, access to the justice system, and enjoy freedom of movement (women's most liberties), CO_2 emissions tend to decrease. However, for developing countries, we estimate a negative and insignificant coefficient, which means that women's civil rights do not impact CO_2 emissions in these countries.

In our analysis, we have considered the women's political participation index (WPP) in Columns (2) and (7) for developed and developing countries respectively. We have found a negative and significant coefficient on WPP for both developed and developing countries, which varies in magnitude between developed and developing countries. Our findings suggest that a one- unit increase in WPP is associated with a decrease of 0.78 units in CO_2 emissions for developed countries and 98.76 unit points for developing countries. This means that when women are represented in the legislature and have an equal share of political power (women most equal), CO_2 emissions decrease. This highlights the relative significance of women's participation in political power as a driving force towards preserving the environment in developing countries. This is reflected in the relatively high magnitude of the coefficient associated with WPP in the developing countries regression function.

In Columns (3) and (8), we have included the women's civil society participation index (WCSP) as an independent variable for developed and developing countries respectively. Our analysis shows that, surprisingly, there is a positive and highly significant coefficient between WCSP and CO_2 emissions. This means that a one-unit increase in WCSP results in a 0.70 unit increase in CO_2 emissions in developed countries. The coefficient suggests that as women are able to engage in political discussion, participate in civil society organizations and are represented among journalists (women most experienced), CO_2 emissions increase in developed countries. However, in the case of developing countries, we found the opposite to be true. The coefficient was negative and insignificant, which means that women's civil society participation does not impact CO_2 emissions. This could suggest that civil society activism does not always translate to policy implementation.

Finally, In Columns (4) and (9) for developed and developing countries respectively, we have used the composite index, i.e., the Women's Political Empowerment Index (WPE), as our independent variable of interest. For developed nations, we have observed a negative and highly significant coefficient, which indicates that a one-unit increase in WPE (meaning women are more empowered) leads to a 1.14 unit decrease in CO_2 emissions. This suggests that when women enjoy civil liberties, can participate in civil society, and have representation in politics, there is a substantial reduction in CO_2 emissions. However, for developing countries, we have found a negative and insignificant coefficient, which implies that not all dimensions of women empowerment have a significant impact on CO_2 emission, but rather some of the women empowerment dimensions are more important than others. Clearly, women's political participation is the most significant and important factor impacting CO_2 emissions in developing countries. On the other hand, women's political participation and their civil liberties are equally important for developed countries.

Robustness Check Results

In this section, we assess the reliability of our primary findings by conducting Pooled OLS analysis. Our aim is to compare the results of our primary analysis with the Pooled OLS results. The estimation outcomes presented in Table 3 indicate that although there are some similarities between our primary findings and the Pooled OLS results in terms of the direction and statistical significance, there are also some differences.

TABLE 3
POOLED OLS MODEL RESULTS

	Developed Countries				Developing Countries			
	Dependent Variable: Carbon Dioxide Emissions				Dependent Variable: Carbon Dioxide Emissions			
	OLS (1)	OLS (2)	OLS (3)	OLS (4)	OLS (6)	OLS (7)	OLS (8)	OLS (9)
WPE				-0.065				-214.70***
WCL	-1.404***				-192.39***			
WPP		0.106				-271.21***		
WCSP			0.488***				-311.78***	
GDPC	-0.000***	-0.000***	-0.000***	-0.000***	-0.024***	-0.024***	-0.024***	-0.023***
POP	-0.000	-0.000*	-0.000	-0.000*	0.000***	0.000***	0.000***	0.000***
REC	-0.004***	-0.004***	-0.005***	-0.004***	-0.792***	-0.784***	-0.792***	-0.787***
Cons.	1.986***	0.642***	0.311***	0.79***	2772.41***	2836.64***	2849.27***	2782.14***
Obs.	930	930	930	930	3255	3255	3255	3255
R^2	0.4448	0.4105	0.4172	0.4100	0.4103	0.4128	0.4124	0.4100

*** sign at 99%, ** sign at 95%, * sign at 90%.

DISCUSSION AND POLICY IMPLICATIONS

Our study highlights a significant negative association between women's political empowerment and CO_2 emissions, which supports our hypothesis. These results are in line with the theoretical framework that suggests involving women's preferences in decision-making can lead to lower CO_2 emissions.

It has been proven through various studies that the presence of women in government can positively impact the environment in two ways. Firstly, by advocating for pro-environmental policies and secondly, by reducing corruption levels. Research has shown that when women hold more political power, instances of corruption tend to decrease, which leads to better environmental outcomes. These findings further support earlier studies suggesting that increased female representation in government can significantly improve environment conditions (DiRienzo & Das, 2019). Studies have also shown that countries with higher levels of women's political participation exhibit lower corruption levels (Swamy, Knack, Lee, & Azfar, 2001), and allocate higher public spending to education (Clots- Figueras, 2012; Halim, Yount, Cunningham, & Pande, 2016) and health (Bhalotra & Clots- Figueras, 2014).

As women's political empowerment is expected to play a crucial role in reducing emissions and promoting sustainable development policies, they tend to be limited in their participation in government and subject to discrimination in the political field especially in the developing countries. This is due to sociocultural barriers and inadequate training for women in political organizations. Women are underrepresented in all aspects of the political process, which limits their ability to express opposition or discontent towards environmental pollution, especially in developing countries. Accordingly, improving the social status of women is necessary and creating incentives for higher participation of women in the political and policymaking sectors are crucial steps towards sustainability. One effective method for increasing the number of women in politics is to establish public policies that incentivize young women to pursue political careers. Additionally, educational policies that inform and encourage school-aged girls to be more engaged in the political life.

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APPENDIX

TABLE 1
LISTS OF COUNTIES BY REGION

Developed Countries				
Australia	Austria	Belgium	Bulgaria	Canada
Cyprus	Czechia	Denmark	Finland	France
Germany	Greece	Hungary	Ireland	Italy
Japan	Luxembourg	Malta	Netherlands	New Zealand
Norway	Poland	Portugal	Romania	Slovak Republic
Spain	Sweden	Switzerland	United Kingdom	United States
Developing Countries				
Albania	Algeria	Angola	Argentina	Armenia
Azerbaijan	Bahrain	Bangladesh	Barbados	Belarus
Benin	Bhutan	Bolivia	Botswana	Brazil
Burkina Faso	Burundi	Cameroon	Central African Republic	Chad
Chile	China	Colombia	Comoros	Congo, Rep.
Costa Rica	Cote d'Ivoire	Cuba	Dominican Republic	Ecuador
Egypt, Arab Rep.	El Salvador	Equatorial Guinea	Eswatini	Ethiopia
Gabon	Gambia	Georgia	Ghana	Guatemala
Guinea	Guinea-Bissau	Guyana	Haiti	Honduras
India	Indonesia	Iran, Islamic Rep.	Iraq	Jamaica
Jordan	Kazakhstan	Kenya	Kuwait	Kyrgyz Republic
Lebanon	Lesotho	Madagascar	Malawi	Malaysia
Mali	Mauritania	Mauritius	Mexico	Mongolia
Morocco	Mozambique	Namibia	Nepal	Nicaragua
Niger	North Macedonia	Pakistan	Panama	Papua New Guinea
Paraguay	Peru	Philippines	Russian Federation	Rwanda
Senegal	Singapore	Solomon Islands	South Africa	Sri Lanka
Sudan	Syrian Arab Republic	Tajikistan	Tanzania	Thailand
Togo	Trinidad and Tobago	Tunisia	Türkiye	Turkmenistan
Uganda	Ukraine	United Arab Emirates	Uruguay	Uzbekistan
Vanuatu	Vietnam	Yemen, Rep.	Zambia	Zimbabwe

TABLE 2
DESCRIPTIVE STATISTICS

	Developed Countries (Obs. 930)				Developing Countries (Obs. 3255)			
Var.	Mean	S.D.	Min	Max	Mean	S.D.	Min	Max
CO2	0.3760628	0.3111111	0.0478721	1.941272	1626.148	938.2538	1	3251
GDPC	34754.55	21130.87	3540.316	112417.9	4670.634	7615.411	190.3332	64592.61
POP	32400000	56600000	354170	332000000	48100000	170000000	150882	1410000000
REC	14.57806	13.43417	0	61.37	1196.821	789.7731	1	2578
WPE	0.9018204	0.0506974	0.691	0.965	0.648565	0.1673944	0.131	0.948
WCL	0.9310118	0.0465984	0.721	0.983	0.6166802	0.2022161	0.014	0.955
WPP	0.9306172	0.0850033	0.569	1	0.7087008	0.2267263	0.066	1
WCSP	0.8642882	0.0608222	0.626	0.938	0.6218602	0.1871979	0.057	0.936

Var., variables; Obs., observations; S.D., standard Deviation; Min, minimum; Max, maximum.