PROBLEMY EKOROZWOJU/ PROBLEMS OF SUSTAINABLE DEVELOPMENT
SUBMITTED: 13.09.2024, ACCEPTED: 14.10.2024, PUBLISHED ON-LINE: 10.01.2025
2025, 20(1): 245-260
DOI: 10.35784/preko.6576

Impact of Climate Change on Women's Political Empowerment: The Sustainable Development Perspective

Wpływ zmian klimatycznych na wzmocnienie pozycji politycznej kobiet: perspektywa zrównoważonego rozwoju

Chun-Ling Ding[1], Yan Ma[2], Guo-Hua Ni[1], Chun-Ping Chang[3]*

[1]Beijing Technology and Business University, School of Economics, Beijing, China
[2]Xi'an Jiaotong University, School of Economics and Finance, Shaanxi, China
[3]Shih Chien University, Kaohsiung, Taiwan
**E-mail (Corresponding Author): cpchang@g2.usc.edu.tw*

Abstract
As the influence of climate change on human sustainable development intensifies, the issue of climate change is attracting the attention of more and more scholars, countries, international organizations. However there are few of empirical studies investigating the relationship and interaction mechanisms between climate change and women's political empowerment under the background of sustainable development. Here, using a two-way fixed-effects model, and a large balanced panel data of 132 countries from 1995 to 2023, we provide new evidence on the relationship and interaction mechanisms between climate change and women's political empowerment. We conclude that climate change has a negative impact on women's political empowerment and income inequality magnifies the effect. Subsample analysis shows the negative impact is particularly pronounced in countries with right-wing parties in power and high levels of economic development. Moreover, government efficiency, political stability and sustainable development ability slows down the impact of climate change on women's political empowerment and has a positive moderating effect. Our paper provides new insights for research in related fields.

Key words: climate change, sustainable development, women's political empowerment, income inequality, social governance
JEL codes: C33, D72, Q54

Streszczenie
W miarę jak wpływ zmian klimatycznych na zrównoważony rozwój człowieka narasta, kwestia zmian klimatycznych przyciąga uwagę coraz większej liczby naukowców, krajów i organizacji międzynarodowych. Zarazem istnieje niewiele badań empirycznych badających związek i mechanizmy interakcji między zmianami klimatycznymi a wzmocnieniem pozycji politycznej kobiet na tle zrównoważonego rozwoju. W tym artykule wykorzystując dwukierunkowy model efektów stałych i duże zbilansowane dane panelowe 132 krajów z lat 1995-2023, dostarczamy nowych dowodów na temat związku i mechanizmów interakcji między zmianami klimatycznymi a wzmocnieniem pozycji politycznej kobiet. Wnioskujemy, że zmiany klimatyczne mają negatywny wpływ na wzmocnienie pozycji politycznej kobiet, a nierówności dochodowe potęgują ten efekt. Analiza pokazuje, że negatywny wpływ jest szczególnie wyraźny w krajach, w których rządzą partie prawicowe i które mają wysoki poziom rozwoju gospodarczego. Ponadto wydajność rządu, stabilność polityczna i zdolność do zrównoważonego rozwoju spowalniają wpływ zmian klimatycznych na wzmocnienie pozycji politycznej kobiet i mają pozytywny efekt moderujący. Nasz artykuł dostarcza nowych spostrzeżeń dla badań w pokrewnych dziedzinach.

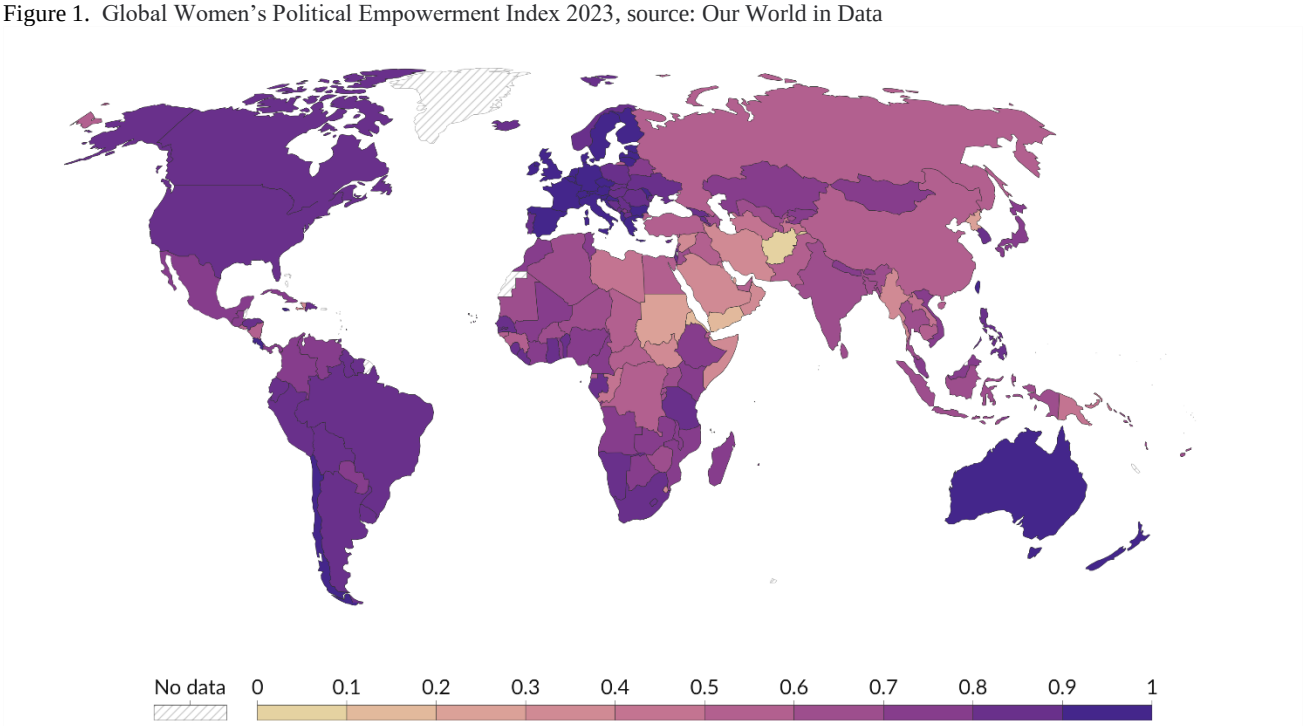
Słowa kluczowe: zmiany klimatyczne, zrównoważony rozwój, wzmocnienie pozycji politycznej kobiet, nierówności dochodowe, zarządzanie społeczne

Introduction

Climate is not only the basis and resource for human development, but also affects and limits the process of sustainable development. The global warming trend has intensified in recent years, and the average global temperature has increased by about 1.1°C per year compared to the pre-industrial average during 1850-1900 (Cevik and Jalles, 2023). Climate change has triggered heavy rainfall, floods, droughts, hurricanes and other natural disasters and extreme weather events (Stern, 2007), leading to all kinds of adverse impacts on health, food security and related property losses (IPCC, 2023). Women's economic empowerment is far more affected by climate change than men's due to differences in physiology, division of labor characteristics, and gender inequality. Climate change exacerbates gender inequality through direct or indirect factors, such as affecting women's employment opportunities and expected income. (Sorensen et al., 2018; Patel et al., 2020; Habib et al., 2022). Economic empowerment precedes political empowerment (Doepke et al., 2012). Because climate change has a direct impact on women's economic empowerment, it could also affect political empowerment (Brule, 2023). However, at a time when climate change overlaps with geopolitical tensions and crises of economic instability, there are huge differences and diversity in political systems, political parties, and levels of economic development in countries around the world, and governments continue to improve sustainable development capacity to address the climate crisis, the mechanism of climate change influence on women's political empowerment is not yet clear.

Brule (2023) showed that climate change can disrupt gendered social institutions, trigger political change, and affect women's political participation. However, he does not present an empirical analysis. Therefore, this paper aims to focus on and address the following questions: How does climate change affect women's political empowerment? Does a country's capacity for sustainable development play an important role? At the 1995 World Conference on Women, member states appealed to promote women's empowerment, put forward women's full participation in any field of society. Women's political empowerment encompasses various dimensions such as civil liberties, social participation and political participation (Sundström et al., 2017). Figure 1 shows the global state of women's political empowerment in 2023, we found that it is uneven globally. To date, no empirical studies have been conducted to explore the influence and mechanism of climate change on women's political empowerment in the context of sustainable development. We believe that this is a worthwhile research topic, and our study has practical implications in related fields.

Figure 1. Global Women's Political Empowerment Index 2023, source: Our World in Data



Notes: The figure is processed by Our World in Data. Original data are from V-Dem database. It reflects the extent to which women enjoy civil liberties, participate in civil society and participate in politics. The value ranges from 0 to 1.

How does climate change affect women's political empowerment? First, because women's livelihoods are more dependent on climate-sensitive jobs, climate change reduces their ability to secure resources and generate income (Sbiroli et al., 2022). Climate change makes women more vulnerable to poverty than men, which in turn affects

women's economic empowerment. Doepke et al. (2012) pointed out that from the perspective of historical evolution, economic empowerment precedes political empowerment. Economic empowerment is the right to survival and development. Women's economic empowerment is the circumstance where women gain economic benefits and negotiate influence (Cornwall and Edwards, 2010; Duflo, 2012). If climate change affects women's economic empowerment, women will face problems of survival, food and clothing, and political representation will inevitably be affected. Second, climate change may affect women's political empowerment by creating income inequality. Cevik and Jalles (2023) argued that there is a mutual influence between climate change and income inequality; increased vulnerability to climate change has led to increased income inequality in 158 countries around the world. Low-income people are more exposed to risks, such as living in areas like floodplains or arid zones, or doing manual labor outdoors, and have lower economic resilience and resistance to shocks that have more lasting negative effects on their future income, so climate change will exacerbate the gap between rich and poor (Liu, 2021). Goldin (2021) showed that the value of greedy work has risen sharply since the early 1980s as income inequality has risen. Greedy work also means that marital justice has been and continues to be abandoned in order to increase family income. When marital justice is abandoned, gender equality usually goes with it (Goldin, 2021). Income inequality further exacerbates gender inequality and may also affect women's political participation. Therefore, we believe that climate change may bring to impact on women's political empowerment, and income inequality is a mechanism.

In this paper, we develop a kind of two-way fixed-effects model, and a large balanced panel data of 132 countries from 1995 to 2023 was used in this empirical study. It innovatively incorporates income inequality as a mediating variable in the analytical framework, linking *climate economics* with *feminist political ecology* and filling the current research gap related to women's political empowerment. Following Grecequet et al. (2017), Wen et al. (2023), and Chen et al. (2023), we chose the Climate Vulnerability Index to represent climate change, which is widely used in climate change-related research. The Women's Political Empowerment Index was chosen as the dependent variable to represent the level of political empowerment.[1] The empirical results support our analysis that climate change negatively affects women's political empowerment and is mediated by income inequality. We also conducted important robustness checks to ensure reliability. These included the substitution of indicators, the addition of omitted variables, and the substitution of the estimated model and the study sample. All results were consistent with the baseline regression. The subsample analysis shows that the negative influence is particularly evident in countries with right-wing parties in power and high levels of economic development. Meanwhile, we also introduced variables such as income inequality, government efficiency, government stability and sustainable development to conduct mediation effects and moderation tests. Income inequality has magnified the impact of climate change on women's political empowerment. The results of the moderation tests show that government efficiency, political stability and sustainable development have a positive moderating effect, they could mitigate the influence of climate change on women's political empowerment.

Compared to the existing literature, our contributions are as follows. First, the existing literatures only focus on the impact on women's economic empowerment and gender mainstreaming policies related to climate change, and lack empirical research on the impact on women's political empowerment. Our study fills the gap in this area. Second, most of the existing research is related to the outcome and benefits of women's political empowerment, but only a few literature studies the factors that influence women's political empowerment. This study explores the relationship between climate change and women's political empowerment from the perspective of sustainable development, which is an addition to the existing literature. Meanwhile, this is of great significance for studying the mechanism of climate change on women's political empowerment. Third, income inequality is innovatively introduced into the analytical framework as an intermediate variable to analyze the mechanism of climate change on women's political empowerment. Climate change exacerbates the pervasive global crisis of income inequality, which disproportionately affects women. This paper connects income inequality to climate change and women's political empowerment, which sets our paper apart from previous studies.

The remainder of this paper consists of the following four parts. Section 2 reviews the literature on climate change and women's political empowerment. Section 3 provides a detailed description of the methodology and data. Section 4 presents the empirical results and causal analysis. Section 5 presents the summary and policy implications.

2. Literature review

In this section, we provide a preliminary review of the existing literature from two perspectives: the impact of climate change on women and women's political empowerment. We then point out the limitations of existing research and the value of our research.

[1] This index comes from the V-DEM dataset which is more reliable, covers a longer time period, and provides greater coverage than existing indicators.

2.1. The impact of climate change on women

On the one hand, many scholars examine the impact of climate change on women's economic and health rights. Climate change affects women's health in multiple ways, including increased exposure to climate hazards, changes in disease transmission, decreased food security, and reduced water quality (Crimmins et al., 2016). Sorensen et al. (2018) showed that women have obvious health needs, such as nutritional needs during pregnancy, and that existing gender-based health disparities may be exacerbated by climate change. Demetriades and Esplen (2008) showed that gender discrimination in the allocation of resources related to nutrition and medicines may put women at greater risk than men. According to Desai and Zhang (2021), due to vulnerability to climate change, women's health is at higher risk, especially in LMICs. Tanjeela and Rutherford (2018) showed that climate change directly affects women's household food security, water use, and livelihoods, thereby increasing women's socioeconomic vulnerability. Levy and Patz (2015) showed that climate change is a major threat to women's rights, especially for women living in rural areas of developing countries. The prevailing social norms that perpetuate traditional gender roles have the effect of hindering women's access to and control over assets, making them more vulnerable to the risks posed by climate change (Goh, 2012).

On the other hand, many scholars have studied gender mainstreaming in climate change mitigation and adaptation policies. Alston (2014) pointed out that gender mainstreaming is crucial not only to ensure the comprehensiveness of climate policies and plans, but also to ensure that women are supported and have the right to act on their own behalf. Singh et al. (2022) showed that rural women have made significant contributions to the climate change process. Glazebrook (2011) used the example of the impact of extreme weather events on subsistence farmers in Ghana to demonstrate that women can contribute to adaptation efforts.

Many of literatures on climate change and women are concerned with the disproportionate impact of climate change on women and gender mainstreaming in climate change response policies. Existing research on the impact of climate change on women's political empowerment is limited. Climate change will undoubtedly affect women's political empowerment, but the mechanisms are unclear. Our study fills this research gap.

2.2. Political empowerment of women

In the existing research literature, there are many empirical analyses from a macro perspective on the causal relationship between women's political empowerment and economic level, women's entrepreneurial environment, and natural environment. Hornset and Soysa (2022) showed that granting more rights to women is positively correlated with higher human capital. Kilolo et al. (2023) empirically analyzed that granting women more political rights has a positive impact on export diversification. Nkoa et al. (2023) showed that the use of social media has a significant positive impact on the political empowerment of African women. Goltz et al. (2015) showed that women's entrepreneurship has a positive facilitating effect on women's political empowerment.

In terms of social governance, Rios et al. (2023) found that there is a mutually reinforcing effect between women's political empowerment and improvements in the quality of government. Chattopadhyay and Duflo (2004) found that in decision-making on public issues, women can often provide different opinions due to different perspectives from men to improve the efficiency of public governance. According to Lumet et al. (2022), improving women's incomes and expanding their leadership roles helped reduce poverty. In terms of climate change, Brule (2023) showed that climate shocks can motivate women and feminist advocates to mobilize and reorient local and national policy agendas to address vulnerabilities exposed by climate shocks. Through empirical analysis of 169 countries. Asongu et al. (2022) showed that women's participation in political and administrative decision-making can increase the capacity of communities to adapt to climate change and mitigate the adverse effects of climate change. The literature on women's political empowerment mainly examines societal outcomes and benefits, but research on the factors that influence women's political empowerment is very limited. We explore the impact of climate change on women's political empowerment from the perspective of social governance, which complements the existing literature and has important implications for understanding the mechanisms through which climate change affects women's political empowerment.

We examine the impact of climate change on women's political empowerment from the perspective of social governance. Compared to the existing literature, our contributions are mainly reflected in the following aspects. Firstly, existing research has focused on the negative impact of climate change on women's health and property rights, and on gender mainstreaming in climate change mitigation and adaptation policies. There has been no empirical research on the potential link between climate change and political empowerment. Taking women's political empowerment as a research object, this paper conducts an empirical study that fills a gap in this area of research. Secondly, the majority of research has focused on the consequences and benefits of women's political empowerment, such as causal relationships with exports, human development, environment and entrepreneurship, but there are few researches on the factors that influence political empowerment. This study complements the existing literature by focusing on the impact of climate change on political empowerment from a social governance perspective. Improving the effectiveness of governance can contribute to women's political empowerment (Rios et al., 2023), and women's participation in political and administrative decision-making can improve climate

change adaptation (Asongu et al., 2022). As climate adaptation policies become the focus of attention in all countries, it is essential to explore the mechanisms of climate change on political empowerment from the lens of social governance. Thirdly, Cevik and Jalles (2023) found that increased vulnerability to climate change leads to increased global income inequality. Stockmer (2017) found that worsening income inequality has slowed the growth of women's representation. However, the link between income inequality, climate change, and women's political empowerment is not well studied. This paper innovatively introduces income inequality as an intermediate variable into the empirical model and analyzes the mechanism of climate change on women's political empowerment. Climate change exacerbates the pervasive global crisis of income inequality, which disproportionately affects women. This paper differs from previous studies by linking income inequality to climate change and women's political empowerment.

3. Empirical analysis methods and data

3.1. Estimation model

In this paper, we use a two-way fixed effects model to examine how climate change affects women's political empowerment. This model can reduce estimation errors caused by omitted variable bias and unobservable individual characteristics or time trends. (Yin et al., 2023; Zhao et al., 2023). Based on the above advantages, a two-way fixed effects model for panel data was constructed:

$$\mathrm{Gender_{it}} = \alpha \mathrm{Climate_{it}} + \beta \mathrm{X'_{it}} + \mu_i + \nu_t + \varepsilon_{it} \quad (1)$$

Here $Gender_{it}$ and $Climate_{it}$ represent women's political empowerment and climate change in country i in year t respectively; X'_{it} represents the control variables including level of economic development (GDP), education expenditure by government (Education), women's employment status(Employee), women's political participation (Seat), national urbanization level (Urban), national Health investment (Health), national gender structure (Population), women's entrepreneurship status (Employer); μ_i, ν_t and ε_{it} represent the capture of individual fixed effects, the capture of time fixed effects and the error term respectively; i and t represent countries and years respectively.

To investigate the mechanisms, we conduct a mediation effect analysis. Following Zhao et al. (2010), we use two-stage regression to test the effect mechanism and construct the path as shown in equations (2) and (3). Equation (3) is used to test the influence of climate change on inequality, which is chosen as the mediating variable. Equation (2) examines the influence of inequality on women's political empowerment.

$$\mathrm{Gender_{it}} = \alpha \mathrm{Climate_{it}} + \rho \mathrm{Inequality_{it}} + \beta \mathrm{X'_{it}} + \mu_i + \nu_t + \varepsilon_{it} \quad (2)$$

$$\mathrm{Inequality_{it}} = \alpha \mathrm{Climate_{it}} + \beta \mathrm{X'_{it}} + \mu_i + \nu_t + \varepsilon_{it} \quad (3)$$

Where $Inequality_{it}$ is the Gini coefficient in year t in country i.

To further explore the social governance pathways that mitigate the negative impact of climate change on women's political empowerment, we developed a moderating effects model as shown in equation (4).

$$\mathrm{Gender_{it}} = \alpha \mathrm{Climate_{it}} + \gamma M_{it} + \beta \mathrm{X'_{it}} + \mu_i + \nu_t + \varepsilon_{it} \quad (4)$$

Here, M_{it} denotes the moderating variable, including government effectiveness (Efficiency), political stability (Stability) and sustainable development (SD). If the direction of coefficient γ is the same as the baseline regression, it means that the moderating variable strengthens the original effect and, conversely, weakens the original effect (Aghion et al. 2005).

We also perform robustness tests. The PCSE estimation method is a commonly used method to correct cross-sectional correlation problems in panel data regression, it can address the simultaneous correlation, heteroscedasticity and sequence correlation problems (Beck and Katz, 1995; Zakari and Musibau, 2024). FGLS method can also modify these problems and improve the effectiveness and consistency of panel regression (Lewis and Linzer, 2005). In our study, the regression results of these estimation methods tend to be consistent. PIFE is mainly used to address endogeneity issues of available variables that vary over time and across individuals (Bai, 2009). The effects of time shocks can be multidimensional, and the same climate change shock can have different effects in different countries. PIFE better reflects reality by taking into account the multi-dimensional influence of climate change and the heterogeneity of responses to this influence across countries, thereby improving the model's goodness of fit. The model is as follows:

$$\mathrm{Gender_{it}} = \alpha \mathrm{Climate_{it}} + \beta \mathrm{X'_{it}} + \mu_i + \nu_t + \lambda_i' \mathrm{F_t} + \varepsilon_{it} \quad (5)$$

Here, $\lambda_i' F_t$ denotes the interactive fixed effect, which is the product of a multi-dimensional individual effect and a time effect ; F_t denotes co-factor, λ_i' denotes factor loading.

3.2. Variables and data description

3.2.1. Independent and dependent variables

We use the Women's Political Empowerment Index (Gender) as the primary proxy for women's rights. This index is calculated by averaging the scores of Gencl, Gencs, and Genpp. Following the practice of Asongu et al. (2022), we chose it and its sub-dimensions obtained through Bayesian estimation to measure the level of women's civil liberties (Gencl), civil society participation (Gencs) and political participation (Genpp) as dependent variables. The values of all indicators are between 0 and 1, with higher values indicating greater importance.

Following Grecequet et al. (2017) and Chen et al. (2023), we choose the climate vulnerability index from ND-GAIN as the core explanatory variable.[2] The value of the index ranges between 0 and 1, with higher values indicating higher levels of climate vulnerability. ND-GAIN data are widely used in empirical studies related to climate change (Cevik and Jalles, 2023; Wen et al., 2023). The climate vulnerability index shows a country's vulnerability to climate disruptions, which can reflect the level of influence of climate change.

3.2.2. Control variables

The protection of women's property and the prevention of violence are closely related to economic development, population, and urbanization. Doepke and Tertilt (2009) showed that women's rights are related to GDP per capita. There are examples in the American history of women's rights where the expansion of economic rights preceded their political rights. Research by Nkoa et al. (2023) found that urbanization is related to women's political empowerment. Therefore, we include the above indicators in the control variables. It is measured by GDP growth, Urban, and Population. Substantial bargaining power and guarantees of future economic sustainability are particularly important for better access to resources, so education, health is important for women's empowerment (Cornwall and Edwards, 2010; Golla et al., 2011). Therefore, we included the above indicators in our model and measured it using Education, Health, Employer and Employee. In addition, policies that better reflect women's priorities are often favored by women. They prefer policies that improve their status at home. For example, policies that improve their status in case of divorce and policies that increase their chances of entering the labor market (Duflo, 2012). We include the level of women's political participation as a control variable. All control variables are derived from the World Development Indicators dataset.

The empirical analysis uses a balanced panel data set with annual observations and covers a large set of 132 countries over the period 1995 to 2023. The description of the variables and sources is presented in Appendix Table A1, and the list of countries is presented in Table A2. The descriptive statistics of the variables after taking the natural logarithm are presented in Table 1. The value of the variable Gender is between -0.418 and -1.410; the mean deviation and the standard deviation are -0.894 and 0.208 respectively. The variable Gender is differentiated by country. Next, we focus on the variable Climate. Climate has a minimum value of -2.033 and a maximum value of -0.036. The mean and standard deviation are -0.350 and 0.320, respectively. This indicates that climate vulnerability varies across countries. In addition, some details on other control variables have been provided. For example, GDP, Population, Health, Employer, Labor, and Seat show differences across countries, while Urban and Education do not show significant differences.

Table 1. Descriptive statistics, source: authors' own computation

Variable	N	Mean	S. D.	Min	Median	Max
Climate	3828	-0.350	0.320	-2.033	-0.250	-0.036
Gender	3828	-0.894	0.208	-1.410	-0.903	-0.418
GDP	3279	1.318	0.828	-4.414	1.443	5.010
Education	2658	1.431	0.388	0.004	1.488	2.643
Employee	3695	3.819	0.855	0.571	4.185	4.596
Seat	3385	2.773	0.773	-1.102	2.907	4.155
Urban	3828	3.999	0.455	2.286	4.122	4.605
Health	2774	6.403	1.360	2.359	6.439	9.431
Population	3828	15.605	1.590	11.801	15.498	20.355
Employer	3695	0.319	0.947	-4.113	0.537	2.463

[2] We used the ND-GAIN Country Index (2024 version), but unfortunately the data was only updated to 2022, so for the accuracy of the regression results, we interpolated the data for 2023.

4. Empirical results and discussion

4.1. Baseline test

Baseline regressions were performed by adding the control variables one at a time. The regression results are shown in Table 2. All the indicators of women's political empowerment constructed above as dependent variables are in columns 1 to 9. The results show that the coefficients of the core independent variables are -0.121, -0.152, -0.437, -0.455, -0.144, -0.224, -0.174, -0.174 and -0.170, respectively, which are all significantly. The results in column 9 show that, all else equal, women's political empowerment decreases by 17.0% for every unit increase in climate vulnerability. This suggests that climate change has a negative impact on women's political empowerment. Possible reasons for this could be as follows. First, because the majority of people living in poverty are women, they tend to have fewer assets and rely more on natural resources to support their families (Bell and Braun, 2010; Ndlovu and Mjimba, 2021). The intensification of climate change and the resulting natural disasters threaten the natural resources on which women are more dependent, affect women's equal ownership, and in turn affect women's political rights to civil liberties, such as freedom of family activities (Behrman and Weitzman, 2016).

Table 2. Impact of climate change on women's political empowerment, source: authors' own computation

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Variable	Gender	Gender	Gender	Gender	Gender	Gender	Gender	Gender	Gender
Climate	-0.121*	-0.152**	-0.437***	-0.455***	-0.144**	-0.224***	-0.174***	-0.174***	-0.170***
	(-1.80)	(-2.28)	(-5.99)	(-5.99)	(-2.37)	(-3.54)	(-2.74)	(-2.76)	(-2.69)
GDP		0.000	0.003	0.003	0.000	-0.002*	0.002	0.002	0.002
		(-0.22)	(1.52)	(1.56)	(0.30)	(1.85)	(1.57)	(1.22)	(1.28)
Education			0.040***	0.041***	0.015**	0.007	0.007	0.003	0.003
			(5.84)	(5.98)	(-2.03)	(1.28)	(1.26)	(0.46)	(0.50)
Employee				-0.011	-0.020***	-0.019***	-0.031***	-0.031***	-0.032***
				(-1.22)	(-2.72)	(-2.63)	(-4.08)	(-4.10)	(-4.26)
Seat					0.096***	0.090***	0.088***	0.086***	0.085***
					(28.49)	(26.56)	(25.97)	(25.12)	(24.74)
Health						0.002	0.009	0.019***	0.018***
						(0.40)	(1.51)	(3.05)	(2.92)
Urban							0.120***	0.081***	0.082***
							(5.17)	(3.36)	(2.92)
Population								0.088***	0.091***
								(5.39)	(5.55)
Employer									0.009**
									(2.37)
Constant	0.553***	-0.560***	-0.807***	-0.782***	-0.683***	-0.695***	-1.114***	-2.378***	-2.407***
	(-9.42)	(-9.59)	(-12.20)	(-11.10)	(-12.19)	(-11.26)	(-10.96)	(-9.32)	(-9.43)
Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	3828	3279	2313	2305	2133	1860	1860	1860	1860
R-squared	0.198	0.234	0.261	0.262	0.455	0.445	0.454	0.463	0.465

Notes: *** p<0.01, ** p<0.05, and * p<0.1.

Second, climate change is associated with increased political instability. According to Dell et al. (2012), for every 1℃ increases in annual temperature, the likelihood of an unconventional change in government leadership in poor countries increases. The increase in political instability and instability challenges the role of women in political participation. At the same time, climate change leads to international instability and even the possibility of international conflict (Raleigh, 2010). In conflict, women are the weak and the victims, it is difficult for them to participate actively in politics or have less energy to participate equally in the full distribution of power.

Third, in the division of labor at home, women are often responsible for collecting food, water, fuel for cooking and heating (Liu, 2021). Extreme weather disasters, such as high temperatures, heavy rains and droughts caused by climate change, make women spend more and more time collecting food, water and fuel, and school-age girls are often involved in efforts to reduce the burden on their families. This leads to unequal treatment of girls in terms of educational resources and a decline in girls' educational attainment. Due to the declining level of education, women's participation in political decision-making is often impossible. This indirectly affects their participation in political activities and leads to the decline of women's political empowerment (Djoudi and Brockhaus, 2011).

4.2. Robust tests

Further empirical tests were conducted to verify robustness. First, variable substitutions were performed on the dependent and independent variables. Column 3 is the indicator reconstruction for the dependent variable. We use

women's civil society participation index as an indicator of women's political empowerment in equation (1) for measurement, represented by Gencs. Columns 1-2 are substitutions for independent variables, where we use two of the six life support sectors in the climate vulnerability index, food and human habitat vulnerability, as indicators of climate change in equation (1) for measurement (Cevik and Jalles, 2023), represented by Food and Habitat. As we observe in Table 3, these empirical results indicate that climate change affects women's political empowerment, which is consistent with the baseline results.

Table 3. Replace dependent and independent variables, source: authors' own computation

Variable	(1)	(2)	(3)
	Gender	Gender	Gencs
Climate			-0.212**
			(-2.26)
Food	-0.083***		
	(-2.82)		
Habitat		-0.112***	
		(-2.82)	
Control variables	Yes	Yes	Yes
Year	Yes	Yes	Yes
Country	Yes	Yes	Yes
N	1860	1860	1860
R-squared	0.465	0.465	0.145

Notes: *** p<0.01, ** p<0.05, and * p<0.1.

Second, we considered the omitted variables. Three omitted variables were introduced, namely women's labor force participation, population growth, and the size of trade. Iversen and Torben (2008) found that labor force participation has a positive impact on women's political participation. Historical statistics showed that population growth is closely related to the growth of greenhouse gas emissions (Jiang and Hardee, 2011). Global warming will bring droughts, floods, and other natural disasters, which will further increase climate vulnerability. We use population growth to measure this indicator. Expanded trade creates more employment opportunities for women, and Kim and Lee (2011) found that mobilizing women to participate in light manufacturing exports can enhance women's empowerment. We measure trade in terms of goods exports. The test results shown in Table 4 are consistent with the baseline regression.

Table 4. Endogeneity concerns – adding omitted variables, source: authors' own computation

Variable	(1)	(2)	(3)
	Gender	Gender	Gender
Climate	-0.181***	-0.198***	-0.130*
	(-2.86)	(-2.71)	(-1.79)
Labor	-0.056**	-0.051*	-0.014
	(-2.45)	(-1.92)	(-0.49)
Population Growth		-0.002	-0.001
		(-0.66)	(-0.63)
Goods			0.008*
			(1.87)
Constant	-2.192***	-2.451***	-2.842***
	(-8.14)	(-6.37)	(-7.44)
Control variables	Yes	Yes	Yes
Year	Yes	Yes	Yes
Country	Yes	Yes	Yes
N	1860	1574	1508
R-squared	0.467	0.453	0.483

Notes: *** p<0.01, ** p<0.05, and * p<0.1.

Third, three different estimation methods are used to confirm our baseline regression, such as FGLS, PCSE, and PIFE. The FGLS method proposed by Parks (1967) can effectively address the issues of heteroscedasticity and correlation by establishing a covariance matrix estimation model for error terms. Beck and Katz (1995) thought that the standard errors generated by FGLS were too small and corrected it to propose the PCSE method. The PIFE estimation method reduces the endogeneity of the model estimates by controlling for unobservable factors that vary across individuals and over time, where the interaction fixed effect is the interaction term of the time factor variable and the individual factor load, taking into account the possible dynamics of women's political empowerment. The results of the FGLS estimation are negative at the 1% level, while the result of the PCSE and PIFE

estimation are negative at the 5% level. These results, reported in column 1 to 3 of Panel A of Table 5, are consistent with the baseline regression results, demonstrating the robustness of the baseline regression results.

Table 5. Alternative analytical methods and change the sample, source: authors' own computation

Variables	(1)	(2)	(3)
	Gender	Gender	Gender
Panel A: Alternative analytical methods			
	FGLS	PCSE	PIFE
Climate	-0.170***	-0.170**	-0.118**
	(-2.81)	(-2.50)	(-2.08)
Control variables	Yes	Yes	Yes
Year	Yes	Yes	Yes
Country	Yes	Yes	Yes
N	1860	1860	1859
Prob＞chi2	0.000	0.000	0.000
Panel B: Change the sample			
	Excluding the COVID-19	Excluding financial crises	Middle 90%
Climate	-0.196***	-0.171**	-0.167***
	(-3.02)	(-2.55)	(-2.60)
Control variables	Yes	Yes	Yes
Year	Yes	Yes	Yes
Country	Yes	Yes	Yes
N	1818	1633	1679
R-squared	0.473	0.465	0.489

Notes: *** p<0.01, ** p<0.05, and * p<0.1.

Finally, our sample period is 1995-2023, which includes years affected by major events such as the financial crisis and the COVID-19 pandemic, which also affected women's political empowerment (Mittal S and Singh T, 2020; Ma, 2024). *The World's Women 2020: Trends and Data* showed that during the lockdown of the COVID-19 pandemic, many women are trapped in unsafe conditions and are highly vulnerable to violence from intimate partners. The financial crisis may cause large numbers of women to lose their jobs and may also affect women's participation in civic organizations. To avoid regression bias, these periods have been removed. Column 1 of Panel B in Table 5 removes 2020-2023, which are affected by the COVID-19 pandemic, and column 2 removes 2008, 2009, and 2010, which are affected by the financial crisis. The coefficient remains negative in all columns and is significant at the 1% or 5% level, indicating that the negative impact is not due to anomalous effects in a particular year. In addition, to mitigate the effects of outliers, all variables are winsorized at the 1st and 99th percentiles. Column 3 of Panel B in Table 5 presents a regression based on winsorized data, which indicates that there is a negative relationship between climate vulnerability and women's political empowerment.

4.3. Heterogeneity analysis

4.3.1. Different economic performances and political spectra

Following Wen et al. (2023), we divided the sample of countries into two groups based on income and run baseline regressions for 80 high-income and 52 low-income countries over the period 1995-2023. Table 6 shows the results. For high-income countries, the coefficient is significantly negative and for low-income countries, it is not significant. Therefore, we conclude that the impact of climate change is closely related to economic development. The possible reasons may be as follows. First, economic empowerment is a prerequisite for political empowerment. In low-income countries, the lack of economic empowerment also leads to relatively low levels of women's political empowerment. Therefore, women's political empowerment in low-income countries is less vulnerable to climate change than in high-income countries. Second, low-income countries are less able to adapt to and mitigate the effects of climate change (Cevik and Jalles, 2023).

Table 6. Heterogeneity results: Different economic performances and political spectra, source: authors' own computation

Variable	(1) High income	(2) Low income	(3) Left	(4) Right
Climate	-0.216***	0.019	-0.124	-0.278***
	(-4.10)	(0.12)	(-1.32)	(-2.86)
Control variables	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
Country	Yes	Yes	Yes	Yes
N	1211	649	388	556
R-squared	0.467	0.516	0.410	0.589

Notes: *** p<0.01, ** p<0.05, and * p<0.1. Controls include control variables, control year, and country.

Ideology is also an issue to consider. In general, right-wing parties tend to have fewer female candidates and more traditional views on women (Caul, 1999; Rule, 1981). On the contrary, left-wing parties are more concerned about women's rights (Reynolds, 1999; Studlar, 1996) and defend egalitarian principles (Lambert and Scribner, 2009). We used data from the DPI (2020) database for subsample regressions based on different ideologies. The results are shown in Table 6, where columns 3 and 4 represent left-wing and right-wing parties, respectively. For right-wing parties, the coefficient is -0.278, significant at the 1% level, but for left-wing parties, the effect is not significant. This indicates that left-wing parties are more concerned about the political empowerment of women in the context of the risks posed by climate change. This is consistent with the traditional views of left-wing parties on women's political empowerment. When climate change occurs, women's political empowerment is more affected by climate risks in right-wing parties. This is in line with our findings.

4.3.2. Different geographical locations

Climate change is a global issue, but there are also significant regional differences in climate change. Asia has the most complex climate patterns, ranging from polar to equatorial. The climate in South America is diverse, ranging from tropical rainforest to temperate climates. Europe's climate type is mainly temperate, mild and less rainy. Africa's climate is mainly tropical and dry. Women will be affected differently by climate change at different levels of climate complexity. We ran baseline regressions by dividing 132 countries into six groups based on their continents: Asia (32 countries), Europe (35 countries), Africa (34 countries), North America (11 countries), South America (16 countries), and Oceania (4 countries). The results are presented in Table 7. Due to the small number of countries in North America and Oceania, they are not representative, so they are not considered a key consideration here. For Asia, Europe and South America, the coefficients are all negative and significant. The Asian coefficient is the largest and the European coefficient is the smallest. This suggests that when climate shocks occur, the impact in Asia, Europe and South America is consistent with the complexity of climate types across the continents. Although the coefficient for Africa is also negative, the continent's relatively small climate differences, combined with limited levels of economic development, do not have a significant negative impact on women's political empowerment.

Table 7. Heterogeneity results: Different geographical locations, source: authors' own computation

Variable	(1) Asia	(2) Europe	(3) Africa	(4) North America	(5) South America	(6) Oceania
Climate	-0.94***	-0.106**	-0.018	-0.092	-0.311*	-0.462
	(-5.07)	(-2.50)	(-0.082)	(-0.49)	(-1.92)	(-0.79)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes
Country	Yes	Yes	Yes	Yes	Yes	Yes
N	448	601	410	161	200	40
R-squared	0.403	0.619	0.556	0.829	0.662	0.955

Notes: *** p<0.01, ** p<0.05, and * p<0.1. Controls include control variables, control year, and country.

4.3.3. Different time periods

Between 1995 and 2023, the world environment has changed a lot, and people are paying more and more attention to climate change and women's empowerment. In 2010, the UN General Assembly decided to establish UN-Women to promote women's empowerment; in 2015, 178 countries signed the Paris Agreement, an agreement for global action on climate change. Based on these two key points in time, we ran segmented regressions for three time periods: 1995-2010, 1995-2015, and 1995-2023, respectively, to examine how the impact of climate change on women's political empowerment changes over time. The results are presented in Table 8. The coefficients of the three time periods are -0.352, -0.209, and -0.170, respectively, all of which are significant at the 1% level. This shows that as people focus on climate change and women's empowerment, climate change has less and less impact on women's political empowerment.

Table 8. Heterogeneity results: Different time periods, source: authors' own computation

Variable	(1) 1995-2010	(2) 1995-2015	(3) 1995-2023
Climate	-0.352***	-0.209***	-0.170***
	(-3.00)	(-2.83)	（-2.69）
Control variables	Yes	Yes	Yes
Year	Yes	Yes	Yes
Country	Yes	Yes	Yes
N	907	1395	1860
R-squared	0.419	0.500	0.465

Notes: *** p<0.01, ** p<0.05, and * p<0.1. Controls include control variables, control year, and country.

4.4. Test of the mediating and moderating effects

To analyze the mechanisms by which climate change affects women's political empowerment, we introduce income inequality as a mediating variable. Cevik and Jalles (2023) showed that increasing vulnerability to climate change can lead to a worsening of income inequality. When climate change brings risks such as natural disasters, the poor are more likely to suffer from loss of assets or income because they have fewer resources, and the wealth gap will widen. In his research, Stockemer (2011) found that the growth of female representation is hampered by income inequality. The growth rate of female representation in legislatures in countries with high income inequality is 20% lower than in countries with low income inequality over the last 50 years. Based on this, we use income inequality to conduct an intermediate analysis. The Gini coefficient obtained from the Standardized World Income Inequality Database (SWIID) was used to measure the level of income inequality. The results in Table 9 indicate that there is a positive relationship between climate change and income inequality, and that income inequality has a negative impact on women's political empowerment. We came to similar conclusions with Cevik and Jalles (2023) and Stockemer (2011).

The possible reasons could be as follows. First, income inequality amplifies the risk of instability, war, and violent revolution (Nafziger and Auvinen, 2002), which may disproportionately affect women and undermine their representation. Second, countries with economic inequality have the largest gender gaps in education and health (Gonzales et al., 2015). Third, women's heavy involvement in domestic work and low-paying jobs deprives them of the resources and capacity to pursue political careers as a group (Korpi et al., 2013). In a context of income inequality, many women may lack the courage and perseverance to exercise their democratic rights, especially when it comes to running as candidates (Stockemer, 2017). In conclusion, the results show that mediation occurs when some of the effects of climate change on women's political empowerment are induced by income inequality.

Table 9. Mechanisms effects, source: authors' own computation

	(1)	(2)	(3)	(4)	(5)
Variable	Inequality	Gender	Gender	Gender	Gender
Climate	0.597***	-0.066	-0.163**	-0.117*	-0.136**
	（9.43）	（-1.07）	(-2.50)	(-1.82)	(-2.22)
Inequality		-0.042*			
		（-1.73）			
Climate*Efficiency			0.077***		
			(3.31)		
Climate*Stability				0.060***	
				(3.56)	
Climate*SD					0.094**
					(2.16)
Efficiency			0.001		
			(0.15)		
Stability				0.012***	
				(3.56)	
SD					0.056***
					(4.66)
Constant	5.160***	-2.385***	-2.297***	-2.498***	-1.663***
	（19.42）	（-8.45）	(-8.67)	(-9.61)	(-5.92)
Control variables	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes
Country	Yes	Yes	Yes	Yes	Yes
N	1653	1653	1780	1780	1756
R-squared	0.166	0.518	0.463	0.476	0.490

Notes: *** p<0.01, ** p<0.05, and * p<0.1. The results of control variables are not offered, but are available upon request.

Meanwhile, we introduced three new variables to test the potential moderating effects. First, we introduced a variable called Government efficiency (hereafter, Efficiency). The empirical results in column 3 of Table 9 showed that effective government mitigated the impact of climate change on women's political empowerment. For example, the United Nations Development Programme has conducted several SDG demonstration projects, mainly in poor areas of developing countries. Most of these areas are in areas prone to natural disasters, and extreme events such as rainstorms, floods and droughts brought about by climate change are frequent. Poverty is particularly pronounced among women. With the pilot of Sustainable Development Goals demonstration projects, the local government developed policies and actively implemented construction projects in water conservation, transportation, electricity, and cultural tourism. According to project data, the per capita income of poor areas has increased significantly, and the political participation rate of women has also increased significantly. It can be seen that government efficiency is an important mechanism for women's political empowerment through climate change.

The possible reasons are as follows. First, when sudden climate shocks such as floods, storms, and other natural disasters occur, effective governments tend to perform well (Ma et al.,2023). The loss of life and property caused by climate shocks will be reduced, the impact on women will be reduced, and women's political empowerment will be protected accordingly. Second, government efficiency means that the government has a strong ability to handle national affairs and may have formulated a series of measures, such as rational protection and utilization of resources, infrastructure construction, law and regulation formulation, adaptive agriculture and agricultural management, energy conservation and emission reduction. An effective government also means a stronger ability to deal with climate change, which will have far less impact on women's political empowerment.

In addition to government efficiency, we introduced the variable Stability to test whether political stability affects the impact of climate change on women's political empowerment. Higher values of this variable indicate greater political stability and lower likelihood of political unrest and terrorism. The results shown in column 4 of Table 9 indicate that political stability slows down the impact of climate change on women's political empowerment. Political stability as an important institutional variable, relevant research shows that there is a positive and significant impact of institutional variables on women's political rights (Nkoa et al., 2023). Ten (2014) showed that peace and stability allowed the number of women politicians to increase. Drury and Peksen (2014) found that international economic sanctions can have a significant impact on the stability of the targeted country, which may worsen women's political rights. We find similar results. When extreme weather events can cause social unrest, political instability, and panic, a country's political stability means that social and political order is good, regime change remains dynamic, orderly, and continuous, there is no violence or terrorism, and women's political representation is less affected. We therefore believe that political stability slows down the impact of climate change on political empowerment.

Finally, we introduced a variable called Sustainable Development (hereafter SD), which was obtained from the Sustainable Development Index dataset (Hickel, 2020). SD is a powerful indicator of a country's ability to develop sustainably. It is the ratio of a country's development index (including the three dimensions of education, life expectancy, and income) to its ecological impact index (including the two dimensions of CO_2 emissions and material footprint). A larger SD index means that a high level of social performance can be achieved with a low level of ecological impact. The empirical results in column 5 of Table 9 show that a country's capacity for sustainable development mitigates the impact of climate change on women's political empowerment. Sustainable development goals include good health, quality education, and other goals. Women's health status directly affects their ability to participate in political and social activities, and improving women's education levels helps them gain more rights and opportunities in politics and society. As a country's capacity for sustainable development increases, so does women's participation and influence in the economy, which helps increase their status and power in political decision-making. When climate shocks occur, a country's strong capacity for sustainable development can effectively reduce the impact of climate change on women's political empowerment.

5. Conclusion and policy recomendations

In recent years, women's political empowerment has been increasingly affected by climate change, but the mechanisms are unclear. We explore this impact from the social governance perspective, which fills the research gap and has important practical value. First, we developed an empirical research model by using panel data of 132 countries from 1995 to 2023 as the initial data. The baseline regression shows that climate change has a negative impact on women's political empowerment. Second, we conducted important robustness checks to ensure reliability. These included the substitution of indicators, the addition of omitted variables, the substitution of the estimated model, and the substitution of the study sample. All results were consistent with the baseline regression. Third, we examined heterogeneity in this paper. We compared high-income and low-income countries and found that climate change significantly affects women's political empowerment in high-income countries. We compared the influence of different ideologies and found that climate change has a significant influence in right-wing governments. We compared the effects across continents and found that the impact of climate change on women's political empowerment in Asia, Europe, and South America is significant, and the magnitude of the impact is consistent with the complexity of climate patterns across continents. We also considered how things have changed over time, and we found that as people put more emphasis on climate change, women's empowerment, climate change has less and less impact on women's political empowerment. Fourth, we analyzed not only the direct influence of climate change, but also the indirect influence of climate change. The results of the analysis show that income inequality has magnified the impact of climate change on women's political empowerment. The result of moderation tests shows that government efficiency, political stability and sustainable development have a positive moderating effect, they could mitigate the influence of climate change on women's political empowerment.

According to the empirical result of this study, we suggest several policy implications. First, governments should reduce income inequality between different groups, especially between genders, which can help mitigate the effects of climate change. We find that income inequality acts as an intermediary. Governments can prevent this mechanism by reducing income inequality in the following ways. The first is to take measures to increase women's

participation in the labor market and strengthen vocational training for women. The second is to take measures to strengthen men's participation and responsibility in domestic affairs, change the traditional concept of gender, reduce inequality in working hours caused by family responsibilities, and then reduce gender income inequality. The third is to use redistribution tools and means to adjust household income inequality, narrow the income gap between different classes, and reduce the Gini coefficient.

Second, in the sub-sample test, we provide policy recommendations for governments of different countries. For high-income countries, climate change has a significant impact on women's political empowerment. Women in low-income countries have relatively low levels of political empowerment and are less vulnerable to climate change. Low-income countries should improve women's economic status and provide women with opportunities for economic independence and development, such as providing low-interest or interest-free loans for women to start their own businesses. More fundamentally, equal educational opportunities and social environments are critical. Improving the level of women's economic empowerment is conducive to promoting a country's economic development, which in turn improves the level of political empowerment. Political empowerment can fully realize women's dominant role in climate adaptation and mitigation and promote sustainable development. In addition, we recommend that the right-wing government continue to focus on the unique capabilities and perspectives of women and promote their participation in the response to climate change.

Third, the government should improve the effectiveness of social governance, such as improving government efficiency and maintaining political stability, enhance sustainable development capacity, which will help promote women's political empowerment. We find that government efficiency and sustainable development slows down the impact of climate change on women's political empowerment and has a positive moderating effect. Therefore, the government should formulate and implement gender-responsive employment and education policies to promote women's political empowerment. In addition, governments should actively participate in environmental governance and promote green transformation to enhance sustainable development capacity and thus mitigate the impact of climate change.

References

1. AGHION P., BLOOM N., BLUNDELL R., GRIFFITH R., HOWITT P., 2005, Competition and innovation: an inverted-u relationship, *Quarterly Journal of Economics* 120(2): 701-728, https://doi.org/10.1093/qje/120.2.701.
2. ALSTON M., 2014, Gender mainstreaming and climate change, *Womens Studies International Forum* 47: 287-294, https://doi.org/10.1016/j.wsif.2013.01.016.
3. ASONGU S.A., MESSONO O.O., GUTTEMBERG K.T.J., 2022, Women political empowerment and vulnerability to climate change: evidence from 169 countries, *Climatic Change* 174(3-4), https://doi.org/10.1007/s10584-022-03451-7.
4. BAI J.S., 2009, Panel data models with interactive fixed effects, *Econometrica* 77(4): 1229-1279, https://doi.org/10.3982/ECTA6135.
5. BECK N., KATZ J.N., 1995, What to do (and not to do) with time-series cross-section data, *American Political Science Review* 89(3), 634-647, https://doi.org/10.2307/2082979.
6. BEHRMAN J.A., WEITZMAN A., 2016, Effects of the 2010 Haiti earthquake on women's reproductive health, *Studies in Family Planning* 47(1): 3-17, https://doi.org/10.1111/j.1728-4465.2016.00045.x.
7. BELL S.E., BRAUN Y.A., 2010, Coal, identity, and the gendering of environmental justice activism in central Appalachia, *Gender & Society* 24(6): 794-813, https://doi.org/10.1177/0891243210387277.
8. BRULE R., 2023, Climate shocks and gendered political transformation: how crises alter women's political representation, *Politics & Gender* 19(3): 928-934, https://doi.org/10.1017/S1743923X22000393.
9. CAUL M., 1999, Women's representation in parliament - the role of political parties, *Party Politics* 5(1): 79-98, https://doi.org/10.1177/1354068899005001005.
10. CEVIK S., JALLES J.T., 2023, For whom the bell tolls: climate change and income inequality, *Energy Policy* 174, https://doi.org/10.1016/j.enpol.2023.113475.
11. CHATTOPADHYAY R., DUFLO E., 2004, Women as policy makers: evidence from a randomized policy experiment in India, *Econometrica* 72(5): 1409-1443, https://doi.org/10.1111/j.1468-0262.2004.00539.x.
12. CHEN C., NOBEL I., HELLMANN J., MURILLO M., COFFEE J., HAWLA N., 2023, *University of Notre Dame-Global Adaptation Index*, Country Index Technical Report.
13. CHEN X., ZHAO X., CHANG C.P., 2023, The shocks of natural disasters on NPLs: global evidence, *Economic Systems* 47(1), https://doi.org/10.1016/j.ecosys.2022.101050.
14. CORNWALL A., EDWARDS J., 2010, Introduction: negotiating empowerment, *Ids Bulletin-Institute of Development Studies* 41(2): 1-9, https://doi.org/10.1111/j.1759-5436.2010.00117.x.
15. CRIMMINS A., BALBUS J., GAMBLE J.L., BEARD C.B., BELL J.E., DODGEN D., EISEN R.J., FANN N., HAWKINS M.D., HERRING S.C., JANTARASAMI L., MILLS D.M., SAHA S., SAROFIM M.C., TRTANJ J., ZISKA L. ,2016, *The impacts of climate change on human health in the United States: a scientific assessment*, U.S. Global Change Research Program, https://doi.org/10.7930/J0R49NQX.
16. DELL M., JONES B.F., OLKEN B.A., 2012, Temperature shocks and economic growth: evidence from the last half century, *American Economic Journal-Macroeconomics* 4(3): 66-95, https://doi.org/10.1257/mac.4.3.66.
17. DEMETRIADES J., ESPLEN E., 2008, The gender dimensions of poverty and climate change adaptation, *Ids Bulletin-Institute of Development Studies* 39(4): 24, https://doi.org/10.1111/j.1759-5436.2008.tb00473.x.
18. DESAI Z., ZHANG Y., 2021, Climate change and women's health: a scoping review, *Geohealth* 5(9), https://doi.org/10.1029/2021GH000386.

19. DJOUDI H., BROCKHAUS M., 2011, Is adaptation to climate change gender neutral? Lessons from communities dependent on livestock and forests in northern Mali, *International Forestry Review* 13(2): 123-135, https://doi.org/10.1505/146554811797406606.
20. DOEPKE M., TERTILT M., VOENA A., 2012, The economics and politics of women's rights, *Annual Review of Economics*, 4(1): 339-372, https://doi.org/10.1146/annurev-economics-061109-080201.
21. DOEPKE M., TERTILT M., 2009, Women's liberation: what's in it for men? *Quarterly Journal of Economics* 124(4): 1541-1591, https://doi.org/10.1162/qjec.2009.124.4.1541.
22. DRURY A.C., PEKSEN D., 2014, Women and economic statecraft: the negative impact international economic sanctions visit on women, *European Journal of International Relations* 20(2): 463-490, https://doi.org/10.1177/1354066112448200.
23. DUFLO E., 2012, Women empowerment and economic development, *Journal of Economic Literature* 50(4): 1051-1079, https://doi.org/10.1257/jel.50.4.1051.
24. GOH, A.H.X., 2012, *A Literature Review of the Gender-differentiated Impacts of Climate Change on Women's and Men's Assets and Well-being in Developing Countries*, CAPRi Working Paper.
25. GLAZEBROOK T., 2011, Women and climate change: a case-study from northeast Ghana, *Hypatia-a Journal of Feminist Philosophy* 26(4): 762-782, https://doi.org/10.1111/j.1527-2001.2011.01212.x.
26. GOLTZ S., BUCHE M.W., PATHAK S., 2015, Political empowerment, rule of law, and women's entry into entrepreneurship, *Journal of Small Business Management* 53(3): 605-626, https://doi.org/10.1111/jsbm.12177.
27. GOLDIN C., 2021, *Career and family: women's century-long journey toward equity*, Princeton University Press, Princeton, USA.
28. GOLLA A. M., MALHOTRA A., NANDA P., MEHRA R., KES A., JACOBS K., NAMY S. ,2011, *Understanding and Measuring Women's Economic Empowerment*. International Center for Research on Women.
29. GONZALES C., JAIN-CHANDRA S., KOCHHAR K., NEWIAK M., ZEINULLAYEV T. ,2015, Catalyst for change: empowering women and tackling income inequality, *IMF Staff Discussion Notes* 15(20): 1, https://doi.org/10.5089/9781513533384.006.
30. GRECEQUET M., DEWAARD J., HELLMANN J.J., ABEL G.J., 2017, Climate vulnerability and human migration in global perspective, *Sustainability* 9(5): 720, https://doi.org/10.3390/su9050720.
31. HORNSET N., SOYSA I.D., 2022, Does empowering women in politics boost human development? An empirical analysis, 1960-2018, *Journal of Human Development and Capabilities* 23(2): 291-318, https://doi.org/10.1080/19452829.2021.1953450.
32. HABIB N., ALAUDDIN M. CRAMB R., 2022, What defines livelihood vulnerability to climate change in rain-fed, rural regions? A qualitative study of men's and women's vulnerability to climate change in Pakistan's Punjab. *Cogent Social Sciences* 8(1):2054152, https://doi.org/10.1080/23311886.2022.2054152.
33. HICKEL, J., 2020, The sustainable development index: measuring the ecological efficiency of human development in the anthropocene. *Ecological Economics* 167: 106331, https://doi.org/10.1016/j.ecolecon.2019.05.011.
34. IPCC, 2023, Summary for Policymakers, *Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*, eds Core Writing Team, Lee H., Romero J., IPCC, Geneva, Switzerland: 1-34.
35. IVERSEN T., ROSENBLUTH F., 2008, Work and power: the connection between female labor force participation and female political representation, *Annual Review of Political Science* 11(1): 479-495, https://doi.org/10.1146/annurev.polisci.11.053106.151342.
36. JIANG L., HARDEE K., 2011, How do recent population trends matter to climate change? *Population Research and Policy Review* 30(2): 287-312, https://doi.org/10.1007/s11113-010-9189-7.
37. KILOLO J.M., BAH M.M., MASTAKI J.N., 2023, Does women empowerment foster export diversification? Evidence from a sample of developing countries, *Journal of International Trade & Economic Development* 32(8): 1215-1248, https://doi.org/10.1080/09638199.2023.2255908.
38. KIM E.M., LEE J.E., 2011, Gender empowerment in south Korean development: lessons for foreign aid, *International Studies Review* 12(1): 55-72, https://doi.org/10.1163/2667078X-01201003.
39. KORPI W., FERRARINI T., ENGLUND S., 2013, Women's opportunities under different family policy constellations: gender, class, and inequality tradeoffs in western countries re-examined, *Social Politics* 20(1): 1-40, https://doi.org/10.1093/sp/jxs028.
40. LAMBERT P.A., SCRIBNER D.L., 2009, A politics of difference versus a politics of equality do constitutions matter? *Comparative Politics* 41(3): 337, https://doi.org/10.5129/001041509X12911362972313.
41. LEVY B.S., PATZ J.A., 2015, Climate change, human rights, and social justice, *Annals of Global Health* 81(3): 310-322, https://doi.org/10.1016/j.aogh.2015.08.008.
42. LEWIS J.B., LINZER D.A., 2005, Estimating regression models in which the dependent variable is based on estimates, *Political Analysis* 13(4): 345-364, https://doi.org/10.1093/pan/mpi026.
43. LIU X.N., 2021, *Climate Change and Income Inequality: Empirical Analysis Based on Cross-Country Panel Data*, Liao Ning University.
44. LIU L., 2021, Progress and implications of integrating gender considerations in the process of addressing climate change. *Progress in climate change research* 17(5), 548-558.
45. LUMET K., GITAU R., OWUOR G., 2022, The influence of women's empowerment on poverty reduction: a case of smallholder sugarcane farmers in western Kenya, *African Journal of Agricultural and Resource Economics-Afjare* 17(3): 255-271, https://doi.org/10.53936/afjare.2022.17(3).17.
46. MA Y., FENG G., CHANG C., 2023, From traditional innovation to green innovation: how an occurrence of natural disasters influences sustainable development? *Sustainable Development* 32(3), 2779-2796, https://doi.org/10.1002/sd.2802.

47. MA Y., FENG, G., YIN, Z., CHANG C., 2024, ESG disclosures, green innovation, and greenwashing: All for sustainable development? *Sustainable Development*, Online Version of Record before inclusion in an issue, https://doi.org/10.1002/sd.3210.
48. MITTAL S., SINGH T., 2020, Gender-based violence during covid-19 pandemic: a mini-review, *Frontiers in Global Womens Health* 1, https://doi.org/10.3389/fgwh.2020.00004.
49. NAFZIGER E.W., AUVINEN J., 2002, Economic development, inequality, war, and state violence, *World Development* 30(2): 153-163, https://doi.org/10.1016/S0305-750X(01)00108-5.
50. NDLOVU T., MJIMBA V., 2021, Drought risk-reduction and gender dynamics in communal cattle farming in southern Zimbabwe, *International Journal of Disaster Risk Reduction* 58, https://doi.org/10.1016/j.ijdrr.2021.102203.
51. NKOA B.E.O., BEYENE B.O., SIMB J.F.N.N., ELOUNDOU G.N., 2023, Does social media improve women's political empowerment in Africa? *Telecommunications Policy* 47(9), https://doi.org/10.1016/j.telpol.2023.102624.
52. PATEL S.K., AGRAWAL G., MATHEW B., PATEL S., MOHANTY B., SINGH A., 2020, Climate change and women in south Asia: a review and future policy implications, *World Journal of Science Technology and Sustainable Development* 17(2): 145-166, https://doi.org/10.1108/WJSTSD-10-2018-0059.
53. PARKS R.W., 1967, Efficient Estimation of a System of Regression Equations When Disturbances are Both Serially and Contemporaneously Correlated, *Journal of the American Statistical Association* 62 (318): 500-509, https://doi.org/10.1080/01621459.1967.10482923.
54. RALEIGH C., 2010, Political marginalization, climate change, and conflict in African Sahel States, *International Studies Review* 12(1): 69-86, https://doi.org/10.1111/j.1468-2486.2009.00913.x.
55. REYNOLDS A., 1999, Women in the legislatures and executives of the world - knocking at the highest glass ceiling, *World Politics* 51(4): 547, https://doi.org/10.1017/S0043887100009254.
56. RIOS V., BELTRAN-ESTEVE M., GIANMOENA L., PEIRO-PALOMINO J., PICAZO-TADEO A.J., 2023, Quality of government and women's political empowerment: evidence from European regions, *Papers in Regional Science* 102(6): 1067-1096, https://doi.org/10.1111/pirs.12761.
57. RULE W., 1981, Why Women Don't Run: The Critical Factors in Women's Legislative Recruitment, *Western Political Quarterly*. 34 (1): 60-77, https://doi.org/10.1177/106591298103400106.
58. SBIROLI E., GEYNISMAN-TAN J., SOOD N., MAINES B.A., JUNN J.H., SORENSEN C., 2022, Climate change and women's health in the United States: impacts and opportunities, *The Journal of Climate Change and Health* 8, https://doi.org/10.1016/j.joclim.2022.100169.
59. SINGH P., TABE T., MARTIN T., 2022, The role of women in community resilience to climate change: a case study of an indigenous Fijian community, *Womens Studies International Forum* 90, https://doi.org/10.1016/j.wsif.2021.102550.
60. SORENSEN C., SAUNIK S., SEHGAL M., TEWARY A., GOVINDAN M., LEMERY J., BALBUS J., 2018, Climate change and women's health: impacts and opportunities in India, *Geohealth* 2(10): 283-297, https://doi.org/10.1029/2018GH000163.
61. STERN, N., 2007, *The Economics of Climate Change: The Stern Review*, Cambridge University Press, Cambridge, UK.
62. STOCKEMER D., 2017, Income inequality and women's descriptive representation, *International Journal of Comparative Sociology* 58(1): 33-54, https://doi.org/10.1177/0020715217692019.
63. STOCKEMER D., 2011, Women's parliamentary representation in Africa: the impact of democracy and corruption on the number of female deputies in national parliaments, *Political Studies* 59(3): 693-712, https://doi.org/10.1111/j.1467-9248.2011.00897.x.
64. SUNDSTRÖM A., PAXTON P., WANG Y., LINDBERG S.I., 2017, Women's political empowerment: a new global index, 1900–2012, *World Development* 94: 321-335, https://doi.org/10.1016/j.worlddev.2017.01.016.
65. STUDLAR M.D.T., 1996, The contagion of women candidates in single-member district and proportional representation electoral systems: Canada and Norway, *Journal of Politics*, 58(3): 707-733, https://doi.org/10.2307/2960439.
66. TANJEELA M., RUTHERFORD S., 2018, The influence of gender relations on women's involvement and experience in climate change adaptation programs in Bangladesh, *Sage Open* 8(4), https://doi.org/10.1177/2158244018812620.
67. TEN S., 2014, *Cambodia: women's legislative representation 1993-2013*, Dissertations & Theses – Gradworks.
68. WEN J., ZHANG S., CHANG C.P., ANUGRAH D.F., AFFANDI Y., 2023, Does climate vulnerability promote green investment under energy supply restriction?, *Energy Economics* 124, https://doi.org/10.1016/j.eneco.2023.106790.
69. YIN H.T., CHANG C.P., ANUGRAH D.F., GUNADI I., 2023, Gender equality and central bank independence, *Economic Analysis and Policy* 78: 661-672, https://doi.org/10.1016/j.eap.2023.04.006.
70. ZAKARI A., OLUWASEYI MUSIBAU H., 2024, Sustainable economic development in OECD countries: does energy security matter? *Sustainable Development* 32(1): 1337-1353, https://doi.org/10.1002/sd.2668.
71. ZHAO X., LYNCH J.G., CHEN Q., 2010, Reconsidering baron and Kenny: myths and truths about mediation analysis, *Journal of Consumer Research* 37(2): 197-206, https://doi.org/10.1086/651257.
72. ZHAO X.X., WEN J., ZOU X., WANG Q.J., CHANG C.P., 2023, Strategies for the sustainable development of China in the post-epidemic era, *Sustainable Development* 31(1): 426-438, https://doi.org/10.1002/sd.2401.

Appendix

Table A1. Variable definitions and sources, source: authors' own work

Variable	Definition	Source
Gender	Women political empowerment index	Variety of Democracy Dataset
Climate	Climate vulnerability index	ND-GAIN Dataset
GDP	GDP growth (annual %)	WDI
Education	Government expenditure on education, total (% of GDP)	WDI
Employee	Wage and salaried workers, female (% of female employment)	WDI
Seat	Proportion of seats held by women in national parliaments (%)	WDI
Urban	Urban population (% of total population)	WDI
Health	Current health expenditure per capital	WDI
Population	Population, female	WDI
Employer	Employers, female (% of female employment)	WDI
Gencs	Women civil society participation index	Variety of Democracy Dataset
Food	One of the vulnerabilities of a country by considering life-supporting sectors	ND-GAIN Dataset
Habitat	One of the vulnerabilities of a country by considering life-supporting sectors	ND-GAIN Dataset
Labor	Labor force, female (% of total labor force)	WDI
Population Growth	Population growth (annual %)	WDI
Goods	Goods exports (BoP, current US $)	WDI
Efficiency	Government Effectiveness: Percentile Rank	WGI
Stability	Political Stability and Absence of Violence/Terrorism: Percentile Rank	WGI
SD	Development Index /Ecological Impact Index	SD INDEX Dataset
Inequality	Gini coefficient	SWIID

Table A2: List of countries, source: authors' own work

Asia:					
Azerbaijan	Bahrain	Bangladesh	Cambodia	China	Cyprus
India	Indonesia	Iran	Iraq	Israel	Japan
Jordan	Kazakhstan	Kyrgyzstan	Laos	Lebanon	Malaysia
Nepal	Pakistan	Philippines	Singapore	South Korea	Sri Lanka
Syria	Tajikistan	Thailand	Turkey	United Arab Emirates	Uzbekistan
Vietnam	Yemen				
Europe:					
Albania	Austria	Belgium	Bulgaria	Belarus	Switzerland
Czechia	Germany	Denmark	Spain	Estonia	Finland
France	United Kingdom	Greece	Hungary	Ireland	Iceland
Italy	Lithuania	Luxembourg	Latvia	Moldova	Malta
Mongolia	Netherlands	Norway	Poland	Portugal	Romania
Russia	Serbia	Slovenia	Sweden	Ukraine	
Africa:					
Angola	Benin	Botswana	Cameroon	Djibouti	Algeria
Egypt	Eritrea	Ethiopia	Gabon	Ghana	Guinea-Bissau
Equatorial Guinea	Kenya	Libya	Morocco	Madagascar	Mozambique
Mauritania	Mauritius	Namibia	Niger	Nigeria	Rwanda
Sudan	Senegal	Sierra Leone	Eswatini	Togo	Tunisia
Tanzania	South Africa	Zambia	Zimbabwe		
North America:					
Armenia	Canada	Costa Rica	Cuba	Dominican Republic	Georgia
Honduras	Haiti	Jamaica	Mexico	USA	
South America:					
Argentina	Bolivia	Brazil	Chile	Colombia	Ecuador
Guatemala	Guyana	Nicaragua	Panama	Peru	El Salvador
Suriname	Trinidad and Tobago	Uruguay	Venezuela		
Oceania:					
Australia	Fiji	New Zealand	Papua New Guinea		