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Women political empowerment and vulnerability to climate change: evidence from 169 countries

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Women political empowerment and vulnerability to climate change: evidence from 169 countries**Simplice A. Asongu, Messono O. Omang & Keyanfe T. J. Guttemberg****Abstract**

The objective of this article is to analyze the effect of the political empowerment of women on vulnerability to climate change in 169 countries for the period 1995-2017. The empirical evidence which is based on panel fixed effects regressions shows that: i) the political empowerment of women as well as its components (i.e. civil liberties of women, participation of women in civil society and participation of women in political debates) reduce vulnerability to climate change. ii) The underlying effect is most pronounced in upper middle income, Latin American, small and fragile countries. iii) Public spending on education, the effectiveness of governance and education are the real transmission channels through which vulnerability to climate change is affected by women's political empowerment. The findings are robust to alternative estimation methods such as the Tobit, dynamic fixed effects, and generalized method of moments regressions. Policy implications are discussed, *inter alia*, the need for sampled countries to encourage women's political empowerment in order to reduce risks linked to climate change.

Keywords: climate change; vulnerability; political empowerment

JEL Classification: Q50; Q54; Q58

1. Introduction

The recognition of women as major actors in environmental protection was officially recognized by the 1985 United Nations conference in Nairobi. However, women's role in addressing concerns pertaining to vulnerability to climate change (VCC) has received less scholarly attention as opposed to scientific and technological solutions (Gaard, 2015). This article enriches the literature on climate change by integrating gender into adaptive policies of developing countries. Specifically, the study examines the effect of women's political empowerment (WPE) on VCC in 169 countries around the world. To achieve this objective, two dimensions in the economic literature are taken into account: the first pertains to the determinants of climate change as substantiated by the works of Watson et al. (2013); Hansen and Stone (2015); Martin and Saikawa (2017); Raftery et al. (2017) and Sarkodie and Strezov (2019). The second is informed by the literature on "feminist political ecology" which encourages the integration of gender in adaptive policies with an emphasis on WPE. This strand of the literature is substantiated by the studies of Goebel (2004); Alber and Roehr (2006); Alaimo (2009); McCright (2010); MacGregor (2010); Nellemann et al. (2011); Ergas and York (2012); Goh (2012); Yavinsky (2012); Resurrección (2013); Israel and Sachs (2013); Nwoke and Ibe (2014); Alexander et al. (2016) ; Yadav and Lal (2017) ; Asongu et al. (2020) ; Morsy (2020) and Asongu et al. (2021).

To the best of our knowledge, no study has empirically examined the importance of WPE in resilience strategies following a climate shock. Our hypothesis postulates that WPE reduces VCC. In other words, the participation of women in political and administrative decisions improves adaptation to climate change. Thus, this article enriches both the literature on the determinants of climate change and the importance of gender in adaptive policies.

According to a Care Canada (2010) report, about two-thirds of women in the world are exposed to climate shocks. Statistics on casualties after climate-related disasters sufficiently show that women are more exposed than men. For example, the 1991 floods and cyclones in Bangladesh showed that 90% of the victims were women. In 2004, 75% of the victims of the tsunami in Aceh were females. Moreover, consistent with Gaalya (2015), 61% of the victims of Cyclone Nargis in 2008 in Myanmar were women. This result is correlated with a political under-representation of women within the bodies that drive the destiny of society. Indeed, since the 1990s, the representation of women in political decision-making bodies throughout the world has remained low.

These stylized facts corroborate the work of Aguilar (2007) who specifies that gender inequalities increase the vulnerability of women and children to climate change 14 times more than that of men. Garrd (2015) shows, moreover, that excluding women from decision-making bodies, warning and awareness of the risk of climatic change explains the high number of victims during recent natural disasters. In other words, the integration of women into political power within society can mitigate the consequences of climate shocks. However, these analyzes are limited to theoretical assertions (Ergas & York, 2012). This is consistent with the hypothesis underpinning this study that the WPE reduces VCC throughout the world. In other words, increasing women's freedoms, their participation in civil society and in political decision-making bodies promotes good adaptation to climate shocks.

The place of women in the political spectrum is increasingly important in economic literature. Sundström et al. (2017) define WPE in three dimensions. The first integrates civil liberties, the second takes into account participation in business and society. Lastly, the third is concerned with the political representation of women in decision-making bodies. WPE therefore becomes a process of increasing women's freedoms, their ability to influence political ideals and their participation in the organization of civil society.

WPE in addressing VCC is important for several reasons. A politically autonomous and responsible woman has a positive impact on socio-economic conditions and the building of institutions that govern interactions between the State and citizens (Swamy et al., 2001). Indeed, when women occupy strategic positions at the political and administrative levels, for the most part, they tend to direct the income of their activities to the maintenance of the family and in the training and sensitization of young girls against certain scourges. Dollar et al. (2001) show that the strong representation of women in parliamentary and executive institutions is negatively correlated with corruption. In other words, integrating women into public administration can ensure that public choices are adapted. For example Svaleryd (2002) asserts that countries with a high representation of women in the administration tend to increase public spending on health and education, which can improve the health conditions of the population as demonstrated by the work of Al Riyami et al. (2004). Similarly, Doepke and Tertilt (2018) report that women's social empowerment is positively associated with improvements in women's health. In other words, responsible women promote enhancement of social conditions, not least, because as documented in the extant literature, they are fundamentally motivated by social wellbeing at the microeconomic or household level on the one hand and on the other, at the macroeconomic level when given the political power to do so.

WPE in the implementation of adaptive policies linked to CC is more justified since women constitute a very vulnerable social layer. Yadav and Lal (2017) articulate that in arid zones in Asia, women are generally more affected than men following a negative shock caused by the climate. The reasons for this reality, according to the authors, are justified by the fact that women are poorer, less educated and benefit from limited access to information, institutions and decision-making bodies which affect the destiny of society (Goh, 2012). Yavinsky (2012) also demonstrates that certain degrading customs characterized by certain prohibitions or practices increase the vulnerability of women after a climate shock. Women are also the most exposed to climatic shocks because of the great responsibilities they often have with families. The work of Nwoke and Ibe (2014) underlines that natural disasters caused by climate change reduce women's ability to collect firewood and obtain drinkable water in arid areas. In Africa, the work of Aelst and Holvoet (2016) in Tanzania shows that widows and single women are generally more at risk when a climate shock occurs. They also point out that enterprising women resist better when a climate shock occurs. Cannon (2002) already pointed out that to limit the impact of climate shocks in a society, it is necessary to reduce gender inequalities through social transformations. These positions and narratives from the extant literature are suggestive of a perspective that women are vulnerable to climate change both from relative and absolute standpoints.

Based on this literature, the objective of this article is to analyze the effect of WPE on VCC in 169 countries. The contribution of this work can be assessed at three levels. First, an attempt is made to enrich the literature on "feminist political ecology" by providing empirical evidence on the importance of gender in adaptation to climate change. Second, the indicator of WPE proposed by Sundström et al. (2017) is used. This indicator is recognized for its completeness compared to the other indicators developed by Klasen (2006), Alkire et al. (2013), Liebowitz and Zwingel (2014) and Hanmer and Klugman (2016). The adopted indicator was obtained by a Bayesian estimate and was evaluated by 2,600 experts. Third, the framework of the study is not exclusively limited to analyzing the relationship between WPE and VCC because; channels through which the political empowerment of women can reduce VCC are also examined. Accordingly, the study also assesses the relevance of transmission channels such as public spending on education, education and government effectiveness as mechanisms through which vulnerability to climate change is affected by women's political empowerment.

The analysis of the effect of women's empowerment on VCC within the framework of this study is carried out on 169 countries between 1995 and 2017. The indicator of VCC is

taken from the work of Chen et al. (2015). The panel data analysis leads to the following results. WPE reduces VCC across the world. Specifically, women's freedoms, participation in civil society and political affairs significantly reduce VCC. These results were subjected to a set of sensitivity tests with respect to sample size, continental origin, income bracket, level of development and country size. These results are also robust to an alternative analysis using the generalized method of moments, Tobit and dynamic panel fixed effects estimators. In addition, public spending on education, the effectiveness of governance and education are the transmission channels through which VCC is affected by WPE.

The remainder of the article is organized as follows: section 2 covers a theoretical framework by analyzing transmission channels. Section 3 presents the basic data, methodology and results. Section 4 performs sensitivity and robustness tests and Section 5 concludes.

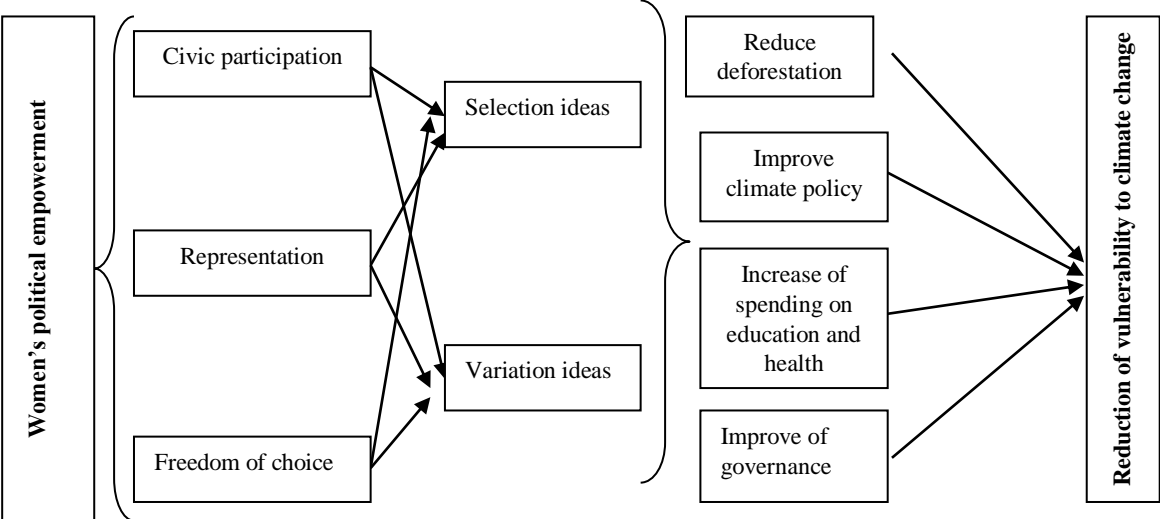
2. Conceptual framework and transmission channels

To justify the mechanisms by which WPE reduces VCC, we follow the approach of Sundström et al., (2017). This approach adopts a broad definition of WPE. It sees it as a means by which increasing women's capabilities, leads to more choice, agency and participation in decision-making in society. This understanding of empowerment encompasses both political representation, freedom of choice and the ability of all women to express ideas and preferences. The underlying choice in the corresponding analysis is not only about the difference that women can make in their daily lives as creators of change, but also in the economy as policy makers. Specifically, the concept we use has three sub-components. The first is the possibility for women to actively express their preferences and ideas through different forms of civic participation. The second is about improving women's representation in key areas of political decision-making, including the legislative and executive branches. The third is to improve women's freedom of choice in different areas, including through the strengthening of civil liberties.

We argue that the variety of new ideas introduced into society and the selection of the most effective policies for an economy are independently determined by the three subcomponents of WPE. Increasing the variety of new ideas related to economic policies, organisational processes and products, promotes innovations that can guarantee optimal organisation and ensure better results.

The main steps of our argument are illustrated in Figure 1 below. The examination of potential mechanisms linking WPE to VCC will be developed in three stages according to the three sub-components of WPE.

Figure 1: relationship between political empowerment of women and vulnerability to climate change



Source : authors' construction

2.1. Participation in women's civil society and vulnerability to climate change

Civil society mobilisation shapes political change by fostering innovation and economic growth (Weldon, 2002). According to Sundström et al. (2017), to be politically empowered, women must not only be able to freely express their political views through the protection of civil liberties, but also through the possibility to organise collectively and be represented in key spheres of political debate, such as the media and civil society. We assume that women's participation in different areas of social life reduces VCC because they facilitate both the dissemination and selection of new ideas. Indeed, when women have an effective voice, the variety and quality of information and ideas that are received by decision makers increases. Patnaik (2021) for example, highlights how the mobilisation of civil society along gender lines in Senegal is shaping policy change in relation to climate issues.

For Evans (1995), civil organisations have specialised knowledge. This means that the preferences expressed by the latter include all the parties concerned and interested. Restricting women's ability to organise and actively participate in civil society makes them more vulnerable to climate shocks. This is especially true since in this context, the relevant

feedback to decision-makers is not assured. Birnir and Waguespack (2011) state that in countries where civil society participation and information sharing between non-governmental organisations and the government is prohibited, conventional inputs and views are very limited. In the same vein, Kanter (2008) demonstrates that societies where diverse interests are represented can produce a more cooperative atmosphere. Thus, the preferences of minority groups are increasingly expressed and their interests defended. Based on this premise in the sense of gender mainstreaming organisations and societies, the inputs and contributions of diverse groups can help policy makers to carry out the two inherently difficult tasks of selecting policies with potential macroeconomic benefits and implementing them more effectively with less resistance and more cooperation from the various parties involved, including business agents (Evans, 1995).

2.2 Women's political participation (WPP) and vulnerability to climate change

In this relationship, women's political participation enhances economic, social and government readiness which in turn reduce vulnerability to climate change (Lv & Deng, 2019, Sarkodie & Strezov, 2019).

Several studies show that WPP activities preserve the environment and others argue that environmental preservation promotes adaptation to climate change (Lv & Deng, 2019). Salahodjaev and Jarilkapova (2020) for example, argue that WPP reduces deforestation. Analysing annual data from over 176 countries between 1990 and 2015, they show that the proportion of women in parliament has a significant U-shaped association with per capita forest cover. Preserving forest resources according to Chen et al. (2015) promotes social and economic adaptation which in turn reduces vulnerability to climate change. Mujeed et al (2021) also show that women's empowerment has a moderating effect on the diffusion of technology, thereby reducing greenhouse gas emissions and reducing risks from climate shocks. Mirziyoyeva and Salahodjaev (2022) find similar results for sustainability in a cross-country analysis. Increasing the share of seats held by women in parliaments is positively and significantly related to sustainable development goals. Increasing female representation in the legislature is robustly associated with reduced infant and child mortality and increased health spending in sub-Saharan Africa (Mechkova, 2020; Holland & Rammohan, 2019). Female political representation in national parliaments can also influence climate change policy outcomes by leading to the adoption of strong environmental protection policies (Mavisakalyan & Tarverdi, 2018). Thus, women's representation promotes environmental protection and the promotion of public goods as well as productivity and good governance

(Dirienzo & Das, 2019). These in turn promote economic and social readiness which finally will reduce VCC.

2.3 Civil liberties of women and vulnerability to climate change

At this level, women's civil liberties improve the economic readiness (Dahlum et al, 2022). Improving economic readiness in the sense of Sarkodie and Strezov, (2019) empirically reduces VCC.

Women's civil liberties at this level include private and political freedoms such as freedom of expression and movement. The right to be free from forced labour and torture is also considered, as well as the rights to physical integrity and property. The current global reality according to the World Bank (2020b) shows that about half of the world's population represented by women experience sub-optimal protection of freedoms. Andrijevic et al. (2020) show that promoting gender institutionally reduces VCC and by extension, women's freedom promotes the resilience of an economy. The rule of law for women promotes female entrepreneurship which is a factor in economic and financial adjustment (Bunche & Pathak, 2015; Rink & Barros, 2021). Indeed, reforms to stimulate economic growth do not always work when women are poorly protected. Using Ghana as an example, Goldstein and Udry (2008) show that when women's land rights are less secured than those of men, total community productivity is reduced. Yet, the latter allows for increased economic adaptation. In the case of freedom of expression, media and movement, Estrin and Mickiewicz (2011) find that the violation of these principles has negative consequences on the labour market. The same diagnosis is made in the case of rural India. They argue that child malnutrition is a consequence of women's restricted movement (Imai et al. , 2014; Norgaard & York, 2005). For Knutsen (2015), technological change, which is seen as one of the main causes of economic growth, stems from the protection of civil liberties of a large part of the world's population. Based on the fact that women constitute about half of the world's population, we can conclude that stronger protection of women's civil liberties improves adaptation policies that reduce VCC. Firstly, strong participation of women in decision-making spheres is conducive to effective climate policies (Alber & Roehr 2006). Second, women are more educated than men in terms of VCC and see climate shocks as consequences of an expansive nature in the future (Brú & Cabo, 2004; McCright, 2010; Ergas & York, 2012). Third, women's economic inclusion through industrial employment has a positive effect on non-resource taxes (Asongu et al., 2021). Another argument is women's ability to reduce corruption and their ability to improve social adaptation to climate change (Swamy et al.,

2001; Clots-Figueras; 2012; Branisa et al., 2013; Sraboni et al., 2014). In conclusion, women's civil liberties improve social, economic and political adaptation which in turn reduces VCC.

3. Data and methodology

3.1 Data

The analysis of the effect of women's empowerment on VCC will be carried out in 169 countries. The study period runs from 1995 to 2017. This study period is justified by the availability of data and particularly, the expansive nature of the empowerment of women around the world over the chosen period. The list of countries included in the sample is provided in Appendix 1 while a description of the variables and corresponding sources is apparent in Appendix 4. The dataset constitutes a panel which avails the possibility of exploiting both temporal and spatial dimensions of the data. The dependent variable is VCC; it measures the propensity or predisposition of human societies to suffer the negative effects in the event of climate shocks. The data for this variable come from the Notre Dame University database on the "Global Adaptation Index 2018" previously proposed by Chen et al. (2015). This variable varies between "0 and 100". Modality 0 reflects the absence of vulnerability, while modality "100" expresses high VCC.

The independent variable of interest is represented by the index of WPE and its sub-dimensions. These variables are taken from "Varieties Democracy database of 2017 (V-Dem)". They were compiled by Sundström et al. (2017) and vary between "0 and 1". The value "0" represents the absence of empowerment and the value "1" denotes a strong empowerment of women. These indices in terms of reliability and temporal coverage have the advantage of being theoretically better founded than the existing indices. The sub-dimensions of empowerment are represented by women's civil liberties(WCL), women's participation in civil society(WPCS), and participation in political affairs.

WCL refer to their ability to make decisions in important areas of their daily lives. WPCS refers to the capacity to participate freely in public debates. Participation in political affairs is seen as the representation of women in political positions like parliament. The average of these three indicators forms the index of WPE. The low modality of these indices also reflects the fact that "men have a virtual monopoly on political questions". On the other hand, the strong modality reflects "the balance between men and women in terms of influence with decision makers".

Due to the complexity of climatic change, the study uses a set of control variables to measure adaptive capacity. These variables have been tested empirically by Sarkodie and Strekov (2019). Overall, they reduce VCC. These are: Adaptive preparation of the social framework (*SOC*) which measures the level of social inequalities in a weighted manner, the quality of the infrastructure, the educational framework and the capacity to innovate. It reflects the social conditions of a country to ensure safe and efficient economic activities. Good quality social preparation reduces VCC. It integrates the social conditions favorable to the productivity of investments and enables an efficient and equitable use of the profits recorded. It also measures the resilience of the social framework to a climate shock.

Governance readiness (*Gov*); it combines the indicators of political stability, control of corruption; the rule of law and the quality of regulation. It measures the capacity of a government to react when a climate shock occurs. We also have the preparation for an adaptation of the economic framework (*Eco*). This variable measures the various economic operations favorable to the business climate necessary for the mobilization of capital in the private sector. The composite index of these three previous control variables provides the indicator relating to an overall adaptation of the environment of a country in the face of a climate shock. All of these control variables are taken from the Notre Dame University “Global Adaptation Index (2018)” database. The descriptive statistics and correlation matrix of the variables are provided in Appendix 2 and 3, respectively.

3.2 Methodology

The empirical analysis of the effect of WPE on VCC is carried out using an econometric model motivated by the work of Sarkodie and Strekov (2019). VCC from the underlying study is a function of the adaptive preparation of the environment to which we add the WPE in the relationship below.

$$\text{Vulnerability} = f(\text{PEW, adaptataion})(1)$$

By disaggregating the effect of adaptation on VCC, we obtain Equation 2 as follows:

$$\text{VCC}_{i,t} = \varphi_k \text{WPE}_{i,t}^k + \alpha \text{Soc}_{i,t} + \beta \text{Gov}_{i,t} + \gamma \text{Eco}_{i,t} + \mu_i + \tau_t + \varepsilon_{i,t} (2)$$

where $\text{VCC}_{i,t}$ represents vulnerability to climate change in a country i for year t , with $i = 1, 2, \dots, 169$ and $t = 1995, 1996, \dots, 2017$. The independent variable of interest is the political empowerment of the woman represented by WPE. We use k ($k = 1, 2, 3, 4$) measures of the WPE, namely: women's civil liberties (WCL), women's participation in civil society (WPCS),

women's participation in political debate (WPP) and the Global Index of WPE. The control variables are represented here by economic (Eco), social (Soc) and governance (Gov) adaptation. Sarkodie and Strekov (2019) show that these different adaptation variables reduce VCC by mitigating poverty, and improving education and institutions. They also promote better quality jobs, sustainable economic growth and the reduction of inequalities. In other words, preparedness for adaptation to climate shocks improves the resilience capacity of governments. μ_i is the country-specific effect while τ_t represents the time-specific constant. They enable the control the unobservable characteristics that are invariant over time and specific to each country. $\varepsilon_{i,t}$ is the error term composed of the individual fixed effects and the time effect common to all countries. These effects are assumed not to be observed. φ_k , α , β and γ are the parameters to be estimated.

In order to estimate Equation 2, we adopt a sequential econometric approach depending on the difficulties encountered for each estimation technique. We start with ordinary least squares (OLS) estimates. These enable the study to use all the information available relating to the individual and temporal dimensions. Moreover, it also increases the possibility of obtaining unbiased and consistent estimators under the assumption of exogeneity of the rectifiers. On the other hand, given the fact that several economies in our sample present heterogeneities, it is difficult to claim that there is no bias in the results. Thus, this motivates the choice of a fixed effects (FE) model. The underlying removes the FE, produces unbiased estimators, but at the cost of a loss of information. An alternative to the FE estimator is to use a random effects (RE) model which produces efficient estimators in the absence of bias related to the omitted variables. One limitation of the RE model is that it is based on overly restrictive assumptions. For example, it is assumed that the individual effect is rather random and not correlated with the explanatory variables. The choice between FE and RE models is based on the Lagrange multiplier (LM) type and Hausman tests.

4. Empirical results and discussion

4.1 Baseline results

The baseline results are disclosed in two tables. Table 1 presents the effect of the global index of WPE on VCC in 6 columns. The first two columns (1 and 2) are obtained by OLS. The other 4 columns are split between the FE and the RE models. However, the Hausman test shows that the FE model is better than the RE model. Table 3 analyzes the

effect of the components of empowerment on climate change vulnerability by exclusively performing FE regressions.

Table 1: baseline model with the Global Index of Women's Empowerment

	(1)	(2)	(3)	(4)	(5)	(6)
<i>Dependent variable: vulnerability to climate change</i>						
	OLS	OLS	RE	RE	FE	FE
WPE	-0.284*** (0.006)	-0.089*** (0.007)	-0.069*** (0.003)	-0.046*** (0.003)	-0.068*** (0.003)	-0.046*** (0.003)
soc		-0.199*** (0.008)		-0.093*** (0.003)		-0.090*** (0.003)
gov		-0.061*** (0.010)		0.014*** (0.005)		0.020*** (0.005)
eco		-0.137*** (0.010)		-0.028*** (0.004)		-0.023*** (0.004)
Constant	0.725*** (0.005)	0.697*** (0.004)	0.501*** (0.007)	0.513*** (0.006)	0.501*** (0.002)	0.508*** (0.003)
Observations	3,838	3,586	3,838	3,586	3,838	3,586
Countries	169	158	169	158	169	158
R ² (adjusted)	0.423	0.649				
R ² (overall)			0.2787	0.5457		
R ² (within)					0.1506	0.3352
Wald test			671.51** *	1771.21** *		
Hausman test			0.000	0.000		
F-statistics					1543***	993***
Region fixed effects	Yes	Yes	No	No	No	No

Notes: ***, ** and * respectively indicate the significance of the coefficients at the 1%, 5% and 10% levels. Robust standard errors are in parentheses. OLS = ordinary least squares. RE = Random effects model. FE = Fixed effects model. WPE = political empowerment of women; soc = social adaptation; gov = adaptation of governance; eco = economic adaptation

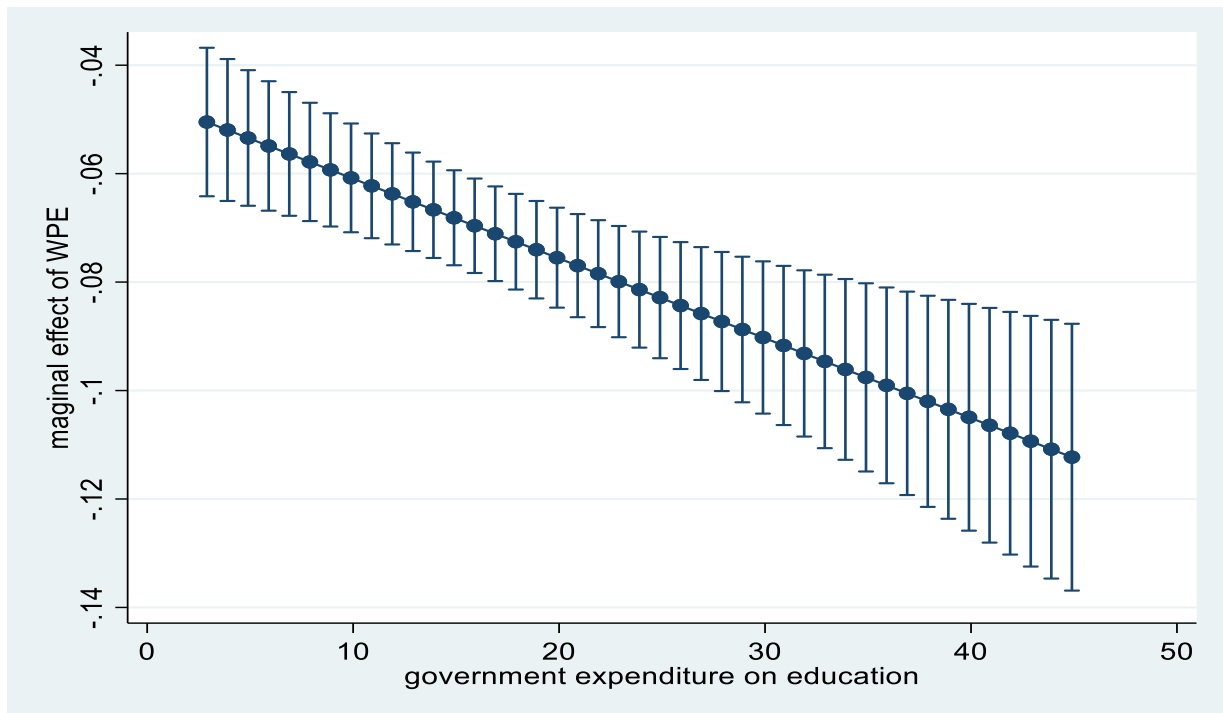
The main lesson from the results in Table 2 is that any increase in the overall index of WPE leads to a decrease in VCC around the world. Columns 1 and 2 obtained from OLS show a significant effect of the order of 1% of women's political empowerment on VCC in 169 countries. The corresponding coefficient of determination (i.e. R²) of the first specification (or Column 1) is about 42%. The integration of the control variables in Column 2 or the second specification shows the same significant effect with an R² of around 64%. Interpretation of the FE model shows that the overall index of WPE significantly reduces VCC around the world. This effect can be direct or indirect. On the direct front, part of the literature specifies that a large participation of women in decision-making spheres due to their

sensitivity to natural disasters, favors efficient policies in relation to the fight against climate change (Alber & Roehr, 2006; Gaard, 2015).

On the indirect front, the effect of WPE is through economic, social and governmental preparation for adaptation to climate change. In other words, when women are involved in political and administrative decision-making processes, they reduce corruption (Swamy et al., 2001). The reduction of the underlying corruption in turn helps to guarantee investments and profits favorable to stable growth. The stability of this growth is therefore considered as a resilience capacity of the government in the event of a climate shock (Sarkodie & Strekov, 2019). The participation of women in political life also makes it possible to increase spending on health education while reducing social inequalities (Clots-Figueras, 2012). This helps promote a viable political, economic and social framework for safe and efficient economic activities. The promotion of a secure context for economic dynamics, according to Sarkodie and Strekov (2019), ensures a strong resilience capacity of a country in the event of a climate shock. The results of the marginal effects analysis confirm these different transmission channels.

The figures below illustrate the marginal effects of WPE on VCC, based on education score, governance effectiveness, and public spending on education. In each of these figures, there is a statistically significant negative association between the WPE and VCC for the different values of engaged transmission channels. In other words, for every gap in public spending on education, education and effective governance, WPE reduces VCC. More specifically, from Figure 2, the marginal effect of WPE on climate change vulnerability is negative for the range of public spending on education from 2.9 to 45.

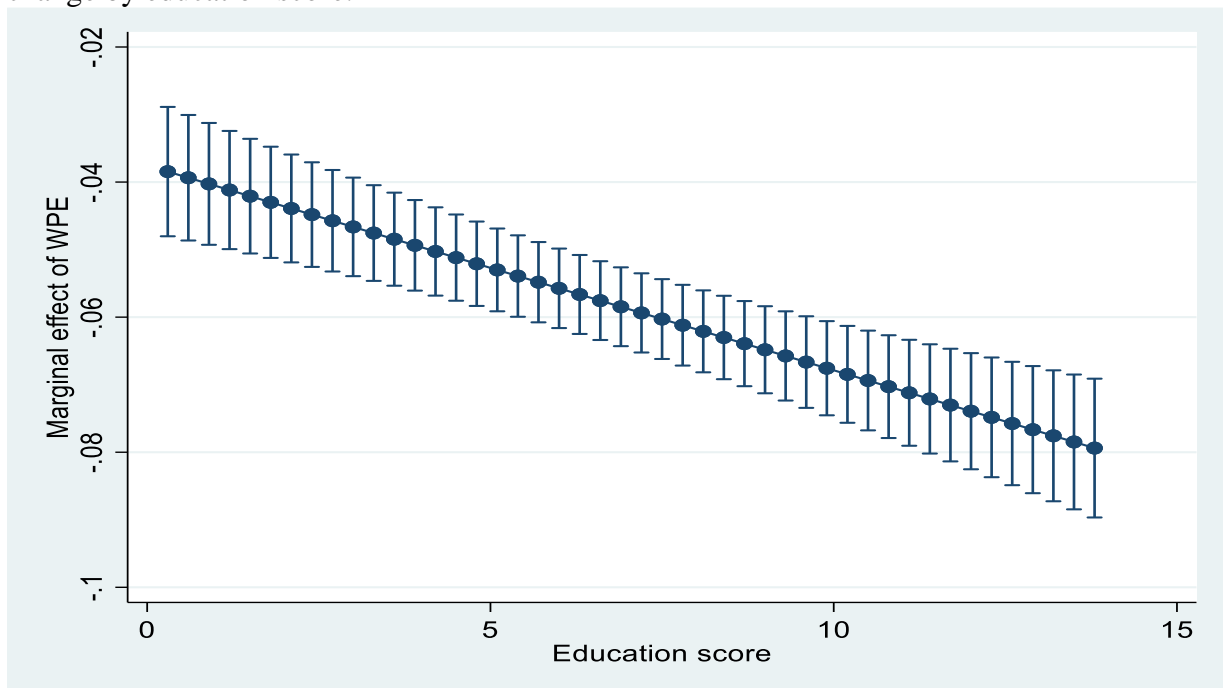
Figure 2: Marginal effects of women's political empowerment on vulnerability to climate change according to the score of public expenditure on education



Source : Authors. Note: WPE= political empowerment of women.

In Figure 3, the marginal effect of WPE on VCC is negative for education values ranging from 0.3 to 14.

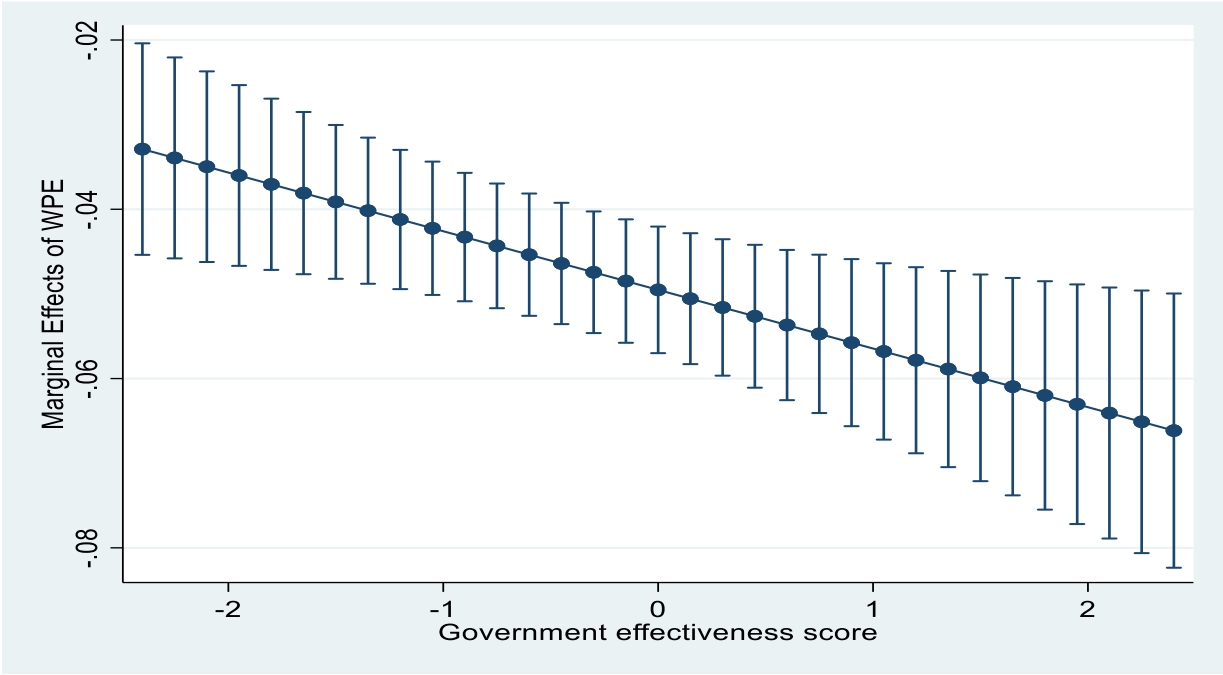
Figure 3 : Marginal effects of women's political empowerment on vulnerability to climate change by education score.



Source : Authors. Note :WPE = political empowerment of women.

In Figure 4, it is apparent there is also a negative and significant marginal effect of WPE on VCC for the range of values of -2.4 to 2.5 of government effectiveness.

Figure 4: Marginal effects of women's political empowerment on vulnerability to climate change according to governance effectiveness scores.



Source : Authors. Note: WPE= political empowerment of women.

The underlying marginal effects pertain to the first, second and third specifications of the table in Appendix 3 with confidence intervals of 95%. The decomposed effect of the WPE Index on VCC is shown in Table 2 below.

Table 2 : baseline model with the components of women empowerment

	(1)	(2)	(3)	(4)
Dependent variable: vulnerability to climate change				
<i>Estimation technique</i>	FE	FE	FE	FE
WPE	-0.046*** (0.003)			
WCL		-0.024*** (0.003)		
WPCS			-0.048*** (0.003)	
WPP				-0.021*** (0.002)
soc	-0.093*** (0.003)	-0.107*** (0.003)	-0.098*** (0.003)	-0.093*** (0.003)
gov	0.014*** (0.005)	0.016*** (0.005)	0.019*** (0.004)	0.010** (0.005)
eco	-0.028*** (0.004)	-0.025*** (0.004)	-0.024*** (0.004)	-0.020*** (0.004)
Constant	0.513*** (0.006)	0.498*** (0.003)	0.511*** (0.003)	0.496*** (0.003)
Observations	3,586	3,622	3,622	3,586
Countries	158	158	158	158
R ² (adjusted)	0.3352	0.302	0.344	0.319
R ² (within)		0.3019	0.3443	0.3187
R ² (overall)		0.5330	0.5275	0.4997
F-statistics	993.91***	958***	1002.66***	987.66***

*Note: ***, ** and * respectively indicate the significance of the coefficients at the 1% , 5% and 10% levels. Robust standard errors are in parentheses. FE = Fixed-effects model. WPE= Political empowerment of women; WCL = civil liberties of women; WPCS = participation of women in civil society; WPP = participation in political debate by women; soc = social adaptation; gov = adaptation of governance; eco = economic adaptation.*

The analysis of Table 2 shows that all three components of WPE significantly reduce VCC. Indeed, women's civil liberties (Column 2), the participation of women in civil society (Column 3) and the presence of women in political institutions (Column 4) reduce VCC by about 1%. However, it is apparent that the effect of participation in civil society debates is more pronounced than that of the other two components (Column 4). This result confirms our hypothesis which postulates that the WPE helps reduce VCC.

4.2 Sensitivity tests

Four sensitivity tests are performed on our results. Indeed, starting from the statistics of the “World Development Indicator” proposed by the World Bank in 2018, we separate high-income countries from middle-income countries and low-income countries. We also distinguish countries according to continental origin. The level of development, fragility and size of each country are also taken into account. These sensitivity tests are inspired by the work of Feindouno and Guillaumont (2019) and Guillaumont and Simonet (2011). According to these, the level of income, geographic position, level of fragility and size of a country influence its VCC. Ignoring these aspects in this work would lead to biased results. Table 3 presents the result by income bracket.

Table 3 : results by income bracket

	(1)	(2)	(3)	(4)
Income brackets	Low income countries	Lower middle-income countries	Upper middle-income countries	High income countries
Dependent variable: vulnerability to climate change				
WPE	-0.021*** (0.006)	-0.013** (0.007)	-0.042*** (0.005)	-0.019*** (0.004)
constant	0.627*** (0.005)	0.571*** (0.006)	0.483*** (0.004)	0.409*** (0.005)
Countries	24	42	42	50
R ² (adjusted)	0.205	0.541	0.542	0.357
R ² (within)	0.2046	0.5414	0.5422	0.3575
F-statistics	707.67***	271.54***	592.72***	1224.98***
Control Variables	Yes	Yes	Yes	Yes
<i>Note : ***, ** and * respectively indicate the significance of the coefficients at the 1%, 5% and 10% levels. Robust standard errors are in parentheses. The estimates were made with the Fixed Effects Model. WPE= Political Empowerment of Women</i>				

The interpretation of findings in Table 3 shows that even by distinguishing countries in terms of income levels, the negative nexus between political empowerment of women and VCC is maintained. Moreover, the magnitude of the nexus is more apparent in upper middle income countries, followed by low income countries, high income countries and lower income countries, in this order, in terms of decreasing magnitude. This result could be justified by the fact that these countries are more effective in governance. Moreover, the attendant countries could also have a comparative advantage in channels through which WPE

reduces VCC. The corresponding findings are presented in Table 4 in terms of geographical location.

Table 4: results according to geographical distribution

	(1)	(2)	(3)	(4)	(5)	(6)
	SSA	EAP	ECA	LAC	MENA	SA
Dependent variable: vulnerability to climate change						
WPE	-0.055***	-	-	-	-	-
	(0.005)	0.072***	0.044***	0.076***	0.034***	0.042***
Constant	0.582***	0.535***	0.444***	0.538***	0.472***	0.600***
	(0.005)	(0.014)	(0.005)	(0.008)	(0.006)	(0.014)
Observations	989	414	1,015	552	409	184
R ² (within)	0.112	0.376	0.412	0.606	0.417	0.775
F-statistics	499.2***	259.8***	493.1***	525.5***	823***	326.8***
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
Countries	43	18	45	24	19	8

*Note : ***, ** and * respectively indicate the significance of the coefficients at the 1%, 5% and 10% levels. Robust standard errors are in parentheses. The estimates were made with the Fixed Effects Model. WPE = Political Empowerment of Women. SSA= Sub-Saharan Africa; EAP= East Asia and the Pacific ; ECA=Europe and Central Asia; LAC= Latin America and the Caribbean; MENA= Middle East and North Africa. SA= South Asia.*

The analysis in Table 4 above shows that in sub-Saharan Africa (i.e. Column 1), WPE is significantly reduced by approximately 1%. The same effect in terms of sign of estimated coefficient is observed in East Asia and the Pacific (Column 2); in Central Europe (Column 3); in Latin America and the Caribbean (Column 4); in the Middle East and North Africa (Column 5) and South Asia (Column 6). In other words, despite the disaggregation of the sample in terms of geographic area, the negative influence of WPE on VCC withstands empirical scrutiny. However, in Asian countries (Column 2) and Latin American and the Caribbean countries (Column 4), the effect of empowering women is higher. A substantial political empowerment of women and the effectiveness of governance that characterizes these countries could justify this result. In addition, the attendant countries could also have a comparative advantage in channels through which WPE reduces VCC. Moreover, even taking into account the level of development, fragility and size of countries, the result in Table 5 below does not change the negative tendency of the main findings which further supports the validity of the tested hypothesis.

Table 5: result depending on the level of development, fragility and size of the country

	(1)	(2)	(3)	(4)	(5)	(6)
	Less developed countries	Advanced countries	Fragile countries	Non-fragile countries	Small countries	Large countries
<i>Dependent variable: vulnerability to climate change</i>						
WPE	-0.013** (0.006)	-0.050*** (0.003)	-0.009** (0.005)	-0.063*** (0.003)	-0.075*** (0.013)	-0.048*** (0.003)
Constant	0.630*** (0.004)	0.477*** (0.003)	0.592*** (0.004)	0.501*** (0.004)	0.449*** (0.014)	0.511*** (0.003)
Observations	897	2,689	598	3,011	391	3,218
R ² (within)	0.406	0.372	0.190	0.372	0.285	0.334
F-statistics	336.1***	637.3***	1728.5***	828.5***	425***	1001.1***
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
Countries	39	119	26	133	17	142

*Note : ***, ** and * respectively indicate the significance of the coefficients at the 1%, 5% and 10% levels. Robust standard errors are in parentheses. The estimates were made with the Fixed Effects Model. WPE = Political Empowerment of Women.*

The analysis of the results in Table 5 shows that advanced countries; non-fragile and small countries are the best performers when it comes to mitigating VCC through the political empowerment of women. This result is justified by the fact that these countries have better governance and better participation of women in political affairs compared to their counterparts. Moreover, the attendant countries could also have a comparative advantage in channels through which WPE reduces VCC.

4.3 Robustness tests

Three robust tests are presented in this section. These additional robustness tests are motivated by the fact that the results presented above have certain shortcomings, notably, the estimation approach does not take into account some specificities of the outcome variable such as its limited range. First, in terms of limited range, the fact that the outcome variable is defined within the specific range of between 0 and 100 implies it is censored and hence, a double censored estimation approach such as the Tobit model is worthwhile (Asongu et al. 2020). Furthermore, our dependent variable is a continuous random variable over an interval and hence with this apparent censorship, OLS provide biased and non-convergent estimators due to the model law which is a mixture of a discrete law and a continuous law. The Tobit model is therefore appropriate to address this shortcoming. The choice of a model with limited dependent variable is justified by the fact that VCC cannot be negative.

The second robustness check pertains to employing a dynamic fixed effects estimator. This technique has the advantage of offering the possibility of addressing the long-term determinants of VCC separately from short-term adjustments. This estimator imposes the identity of all the slope coefficients and the variances of the error terms and only tolerates differences in individual effects between countries. Applying the Tobit and the dynamic fixed effects estimator leads to the results in Table 6 below.

Table 6 : results of the Tobit and the dynamic panel

	(1)	(2)	(3)	(4)
Dependent variable: vulnerability to climate change				
	FE	Tobit	Marginal Effects	DFE
WPE	-0.046*** (0.003)	-0.059*** (0.008)	-0.059*** (0.008)	-0.077*** (0.011)
D.WPE				0.004* (0.002)
EC (∅) coefficient				-0.117*** (0.007)
Constant	0.508*** (0.003)	0.650*** (0.004)		0.060*** (0.004)
Observations	3,586	3,586	3,586	3,586
R ² (adjusted)	0.335			
Countries	158			
Control variables	Yes	Yes	Yes	Yes

Note : ***, ** and * respectively indicate the significance of the coefficients at the 1%, 5% and 10% levels. Robust standard errors are in parentheses. WPE = Political Empowerment of Women. FE=Fixed Effects. DFE= Dynamic Fixed Effects. EC = Error Correction.

It is apparent from the findings in Table 6 from the Tobit estimates that a percentage change of the order of 1% in WPE leads to a marginal attenuation of VCC of 0.05 (Column 3). In the same vein, in Column 4 pertaining to the dynamic FE estimator, the established negative effect is robust to the long run incidence of the WPE in reducing VCC. These results indicate that countries around the world that promote women's empowerment are indirectly improving their resilience to climate change. The estimated average coefficient associated with the error correction term is negative, significant and situated between an interval of 0 and -1 which shows the stability of the model. In summary, the attendant findings, confirm a long-term equilibrium relationship between VCC and the group of significant determinants.

The estimated coefficients established so far have been based on estimation approaches that address only some dimensions of endogeneity such as variable omission bias and the unobserved heterogeneity. However, the concern of simultaneity or reverse causality can be taken on board with the employment of the generalized method of moments (GMM) that has been established to address such a concern (Tchamyou, 2019). As opposed to the one-step approach which only accounts for homoscedasticity, the two-step process which control for heteroscedasticity is used in the study in accordance with the corresponding literature (Blundell & Bond, 1998; Tchamyou et al. 2019). It is also important to note that the choice of this third robustness check is related to the stochastic nature of the outcome variable (i.e. past values significantly explain future values of VCC) implies that an estimation technique such the GMM (Tchamyou & Asongu, 2017) is worthwhile in order to take into account the persistent nature of the attendant outcome variable (Tchamyou, 2020). The persistence of the outcome is confirmed because the correlation between level and first lag series of the outcome variable exceeds a documented threshold of 0.800 established in the contemporary GMM-centric literature (Tchamyou, 2019, 2020). The GMM results that are presented in Table 8 below confirm the baseline findings on the negative nexus between the WPE and VCC. The model is valid because it passes the post-estimation diagnostic criteria related to: (i) the absence of instrument proliferation (i.e. the number of countries are less than the corresponding number of instruments) and (ii) failure to reject the null hypotheses of the Hansen test as well as the second order autocorrelation test in difference (Vu & Asongu, 2020).

Table 7 : estimation by the generalized method of moments

	(1)
Dependent variable: vulnerability to climate change	
GMM	
L.vulnerability to climate change	0.979*** (0.0121)
WPE	-0.023*** (0.006)
Constant	0.016* (0.009)
Control variables	Yes
Observations	359
Countries	93
AR(1)	-2.06**
AR(2)	0.12
Fisher	13680.93***
Instruments	15
Hansen test	0.159

Note : ***, ** and * respectively indicate the significance of the coefficients at the 1%, 5% and 10% levels. Robust standard errors are in parentheses. WPE= Political Empowerment of Women. GMM= Generalised Method of Moments.

5. Concluding implications and future research directions

This study has analyzed the effect of WPE on VCC around the world. To achieve the underlying objective, three dimensions of the WPE have been considered, notably: WCL, WPCS activities and women's participation in political debates. To the best of our knowledge, the empirical literature on the influence of WPE on climate change is sparse¹. The empirical evidence in the present study is based on a panel of 169 countries for the period 1995-2017.

The findings show that the WPE significantly reduces VCC. When these findings are subjected to sensitivity tests, the negative nexus withstands scrutiny on premises of income brackets, geographic location, level of development, economic size and level of fragility of countries. The findings also further withstand empirical scrutiny when assessed within the remit of further robustness checks using, Tobit, dynamic fixed effects and GMM regressions. It is also apparent from the findings that public spending on education, the effectiveness of governance and education are the transmission channels through which VCC is affected by

¹Accordingly, while the contemporary literature has substantially focused on the economic empowerment of women in developing countries (Asongu, Nnanna & Acha-Anyi, 2020; Morsy, 2020; Asongu, Adegboye & Nnanna, 2021), the role externalities of women empowerment remain spares in the literature.

WPE. This implies that the engaged socio-economic and governmental channels should be consolidated in view of empowering women politically in order to ultimately mitigate VCC and attendant unfavorable economic development externalities.

The findings in this study obviously leave for future research especially as it pertains to engaging more country-specific empirical strategies in order to provide more country-specific policy implications. Accordingly, while these findings provide insights into how regional and global policy agenda focusing on developing countries can be envisaged in view of fighting climate change and empowering the female gender, country-specific initial conditions would determine the magnitude of the proposed policy directions.

6.Declaration

Ethical approval and consent to participate: This article does not contain any studies with human participants or animals performed by the authors.

Consent to Participate: Not applicable.

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Appendix 1: Lists of countries by region

SSA		EAP	ECA		LAC	MENA	NA	SA
Angola	Mali	Australia	Albania	Latvia	Argentina	Algeria	Canada	Afghanistan
Benin	Mauritania	Myanmar	Armenia	Lithuania	Barbados	Bahrain	USA	Bangladesh
Botswana	Mauritius	Cambodia	Austria	Luxembourg	Bolivia	Djibouti		Bhutan
Burkina Faso	Mozambique	China	Azerbaijan	Macedonia	Brazil	Egypt		India
Burundi	Namibia	Fiji	Belarus	Moldova	Chile	Iran		Maldives
Cameroon	Niger	Indonesia	Belgium	Montenegro	Colombia	Iraq		Nepal
Central African Republic	Nigeria	Japan	Bosnia and Herzegovina	Netherlands	Costa Rica	Israel		Pakistan
Chad	Republic of the Congo	Laos	Bulgaria	Norway	Cuba	Jordan		Sri Lanka
Comoros	Rwanda	Malaysia	Croatia	Poland	Dominican Republic	Kuwait		
Democratic Republic of the Congo	Sao Tome and Principe	Mongolia	Cyprus	Portugal	Ecuador	Lebanon		
Equatorial Guinea	Senegal	New Zealand	Czech Republic	Romania	El Salvador	Libya		
Eritrea	Seychelles	Papua New Guinea	Denmark	Russia	Guatemala	Malta		
Ethiopia	Sierra Leone	Philippines	Estonia	Serbia	Guyana	Morocco		
Gabon	Somalia	Singapore	Finland	Slovakia	Haiti	Oman		
Ghana	South Africa	Solomon Islands	France	Slovenia	Honduras	Qatar		
Guinea	Sudan	South Korea	Georgia	Spain	Jamaica	Saudi Arabia		
Guinea-Bissau	Swaziland	Thailand	Germany	Sweden	Mexico	Syria		
Ivory Coast	Tanzania	Timor-Leste	Greece	Switzerland	Nicaragua	Tunisia		
Kenya	The Gambia	Vanuatu	Hungary	Tajikistan	Panama	United		

Lesotho	Togo	Vietnam	Iceland	Turkey	Paraguay	ArabEmirates	
Liberia	Uganda		Ireland	Turkmenistan	Peru	Yemen	
Madagascar	Zambia		Italy	Ukraine	Suriname		
Malawi	Zimbabwe		Kazakhstan	United Kingdom	Trinidad and Tobago		
			Kyrgyzstan	Uzbekistan	Uruguay		
					Venezuela		

Notes : SSA= Sub-Saharan Africa ; EAP= East Asia and the Pacific ; ECA=Europe and Central Asia; LAC=Latin America and the Caribbean; MENA= Middle East and North Africa. NA= North America , SA= South Asia.

Appendix 2 :descriptive statistics

Variables	Obs	Mean	S.D	Min	Max
Vulnerability to climate change	3887	0.451	0.098	0.26	0.709
Political empowerment of women	3884	0.723	0.191	0.055	0.975
Civil liberties of women	3921	0.677	0.246	0.002	0.985
Participation in women's civil society	3921	0.696	0.206	0.016	0.975
Women's political participation	3884	0.808	0.214	0.066	1
Preparation for global adaptation	3933	0.388	0.155	0.001	0.802
Preparation for social adaptation	3818	0.307	0.16	0.08	0.814
Preparation for adaptation of governance	3864	0.484	0.184	0.001	0.906
Preparation for economic adaptation	3749	0.384	0.174	0	0.827
Dummy on regions	3933	2.93	1.639	1	7
Dummy on the income bracket	3933	2.696	1.066	1	4
Dummy on the level of development	3933	0.257	0.437	0	1
Dummy on the size of the country	3933	0.187	0.39	0	1
Dummy on the country's level of fragility	3933	0.175	0.38	0	1
Dummy on the islands	3933	0.123	0.328	0	1

Source : Authors; note: Obs : Observations. S.D : Standard Deviation. Min : Minimum. Max : Maximum.

Appendix 3 : Correlation matrix

	(1) VCC	WPE	WCL	WPCS	WPP	soc	gov	eco	adg
VCC	1								
WPE	-0.528 (0.000)	1							
WCL	-0.526 (0.000)	0.902 (0.000)	1						
WPCS	-0.504 (0.000)	0.919 (0.000)	0.845 (0.000)	1					
WPP	-0.328 (0.000)	0.808 (0.000)	0.536 (0.000)	0.614 (0.000)	1				
soc	-0.667 (0.000)	0.518 (0.000)	0.514 (0.000)	0.477 (0.000)	0.367 (0.000)	1			
gov	-0.665 (0.000)	0.636 (0.000)	0.685 (0.000)	0.583 (0.000)	0.370 (0.000)	0.653 (0.000)	1		
eco	-0.690 (0.000)	0.492 (0.000)	0.523 (0.000)	0.459 (0.000)	0.277 (0.000)	0.635 (0.000)	0.818 (0.000)	1	
adg	-0.745 (0.000)	0.617 (0.000)	0.647 (0.000)	0.569 (0.000)	0.379 (0.000)	0.839 (0.000)	0.928 (0.000)	0.916 (0.000)	1
<i>N</i>	3933								

VCC= vulnerability to climate change. WPE = political empowerment of women; WCL = civil liberties of women; WPCS = participation of women in civil society; WPP = participation in political debate by women soc = social adaptation; gov = adaptation of governance; eco = economic adaptation; adg = global adaptation.

Appendix 3 : Channels of transmission of the Global Women's Empowerment Index

	(1)	(2)	(4)
Dependent variable: vulnerability to climate change			
Estimation technique	FE	FE	FE
WPE	-0.046*** (0.008)	-0.038*** (0.005)	-0.050*** (0.004)
Public expenditure on education	0.001*** (0.000)		
WPE_x Public expenditure on education	-0.001*** (0.000)		
Education		0.002*** (0.000)	
WPE_x Education		-0.003*** (0.001)	
Government effectiveness			0.004* (0.002)
WPE_x Government effectiveness			-0.007*** (0.003)
Global adaptation	-0.118*** (0.008)	-0.104*** (0.006)	-0.128*** (0.008)
Constant	0.528*** (0.006)	0.511*** (0.004)	0.533*** (0.004)
Observations	2,045	2,952	2,055
Countries	158	144	166
R ² (adjusted)	0.263	0.256	0.246
R ² (within)	0.514	0.557	0.557
R ² (overall)	0.600	0.557	0.565
F-statistics	595.92***	959.24***	750.74***

Note : ***, ** and * respectively indicate the significance of the coefficients at the 1%, 5% and 10% levels. Robust standard errors are in parentheses. The estimates were made with the Fixed Effects Model. WPE = Political Empowerment of Women. FE : Fixed Effects.

Appendix 4 : description of variables

Variables	Description	Sources
Dependent Variable		
Vulnerability to climate change	It is about the propensity or predisposition of human societies to suffer the negative effects in the event of climatic shocks. This variable varies between "0 and 100".	<i>Global Adaptation Index (2018)</i>
Independent Variables		
Political empowerment of women	Women's Political Empowerment Index. It represents the average of the indices of civil liberty of women. participation in civil society of women and political participation of women.	V-Dem (2018)
Civil liberties of women	Percentage of women making decisions in important areas of their daily life.	V-Dem (2018)
Participation in women's civil society	Percentage of women participate freely in public debate.	V-Dem (2018)
Participation in women's civil society	Percentage of women freely participate in public debate.	V-Dem (2018)
Preparation for global adaptation	The composite index of social adjustment readiness. governance and economic.	<i>Global Adaptation Index (2018)</i>
Preparation for social adaptation	It is a question of social inequalities, in particular the quality of infrastructure, the educational framework and the ability to innovate.	<i>Global Adaptation Index (2018)</i>
Preparation for adaptation of governance	It combines the indicators of political stability. Control of corruption; the rule of law and the quality of regulation.	<i>Global Adaptation Index (2018)</i>
Preparation for economic adaptation	Measures the various economic operations favorable to the business climate necessary for the mobilization of capital in the private sector.	<i>Global Adaptation Index (2018)</i>

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