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Impact of Women's Empowerment on Green Economic Growth and Vulnerability to Climate Change

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Abstract

This research paper analyzes the impact of women's empowerment (WE) on green economic growth (GEG) and vulnerability to climate change (VCC) in South Asian countries for the period 1995-2023. This article contributes to the literature on the factors that influence GEG and VCC, and the significance of gender in adaptive policy. The econometric analysis based on the Cross-sectional Autoregressive Distributed Lag (CS-ARDL) model's co-integration technique shows that (i) WE along with its components (women's civil empowerment, social empowerment, political empowerment, and economic empowerment) reduces VCC and increases GEG via breaking barriers for women through diversity and inclusivity. (ii) The effect of WE on VCC is most pronounced by the notion of gender equality in climate adaptation (iii) The effect of WE on GEG is most pronounced by women's leadership, mentoring, networking in multidisciplinary activities, and female human capital utilization through women's entrepreneurial skills. Dumitrescu-Hurlin Granger causality test and Westerlund cointegration test have been used to explore causality and long-run cointegration among modeled variables. Policy implications are formulated on how a policy agenda, both regional and global, can be developed to promote climate resilience and GEG by promoting WE in the adaptive policy and decision-making processes.

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1. INTODUCTION

The conflict between economic development, environmental conservation, and resource utilization is becoming more pronounced as global warming and resource constraints worsen (Sarkodie & Strezov, 2019). As a response to climate change and environmental degradation, the concept of "green growth" has emerged. Green growth refers to promoting economic progress while preserving the environment. In 1985, the United Nations meeting in Nairobi officially recognized women as significant players in environmental preservation. However, compared to scientific and technical solutions, women's participation in resolving climate change-related problems has received less scholarly attention(Gaard, 2015). This research aims to contribute to the literature on climate change

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by exploring the empowerment-climate-growth nexus and integrating gender into adaptive policies. It explored how much women empowerment (WE) affects Green Economic Growth (GEG) and Vulnerability to Climate Change (VCC) in South Asian countries. No prior study in the literature has empirically examined the role of WE in resilience strategies in the wake of climate change in the South Asian region.

In this paper, two hypotheses have been formulated. The first hypothesis postulates that WE reduces VCC, and the second hypothesis posits that WE increases GEG in South Asian countries. It is assumed that women's participation in civil, economic, political, and administrative decisions can improve climate change adaptation and promote GEG in these countries. WE can improve policies to reduce VCC by following ways. Firstly, women's participation in the decision-making process helps to formulate conducive climate policies(Alber & Roehr, 2007). Secondly, women, who have higher levels of education than men in terms of VCC, view climate shocks more critically (Ergas & York, 2012; McCright, 2010). Thirdly, increasing the participation rate of women in industrial enterprises promotes non-resource taxes(Asongu, Nnanna, & Acha-Anyi, 2020). Women with a strong voice, access to quality information, and innovative ideas can help decision-makers in addressing environmental issues(Emeordi, Igwe, & Madichie, 2023). Furthermore, WE can enhance GEG in two ways. Firstly, Women's empowerment increases national output by increasing their labor force participation rate and raising effective and healthy human resources in terms of the upbringing of their children. Secondly, WE can have positive impacts on social, economic, and political adaptation, ultimately leading to a decrease in VCC.

Economic development can be transformed into sustainable development by including women in parliament, administration, policy-making, and the economy as a significant factor of economic growth and as a vulnerable stakeholder in climate change(Achuo, Asongu, & S Tchamyou, 2022; Yadav & Lal, 2018). Heyland et al. (2010) report states that almost two-thirds of women worldwide are vulnerable to climatic shocks. Data on fatalities from climatic disasters indicates that women are more vulnerable than males. For example, the cyclones and floods that struck Bangladesh in 1991 revealed that 90% of the casualties were female. Women made up 75% of the Aceh tsunami victims in 2004. This outcome is directly linked to the under-representation of women within the civil, economic, and political decision-making bodies. Gender disparities make women and children 14 times more vulnerable to climate change than men (Asongu, Messono, & Guttemberg, 2022; Miller et al., 2010). In Asia's dry zones, for example, women are often more affected by negative climate shocks than men due to their lower educational and economic status, as well as limited access to knowledge, institutions, and decision-making bodies(Goh, 2012). Therefore, reducing gender inequality through social reforms is crucial in lessening the impact of climate change on communities(Cannon, 2002).

This paper makes unique contributions and presents distinct differences. First, no study has been conducted to examine the impact of WE on VCC and GEG in South Asian countries. The empirical literature on "feminist political ecology" encourages gender integration by emphasizing WE in adaptive policies(Alexander, Bolzendahl, & Jalalzai, 2016; Ergas & York, 2012; Israel & Sachs, 2013). Furthermore, the existing literature emphasizes the economic empowerment of women in developing countries (Asongu et al., 2022), but the externalities of this empowerment on climate change remain underexplored. Second, this study contributes to the literature by exploring the significance of gender in the adaptation to climate change and GEG in South Asian countries. Third, the indicator of women's empowerment proposed by Sundström, Paxton, Wang, and Lindberg (2017) and Kabeer and Natali (2013) has been used. These methods are recognized for their completeness

compared to the other indicators developed by Alkire et al. (2013) andHanmer and Klugman (2016). Fourth, a comprehensive index of WE while considering all dimensions of WE; civil, social, economic and political empowerment has been constructed. Fifth, the study has estimated the individual impact of four components of WE on VCC along with the channels through which the empowerment of women can promote VCC will also be examined.

This paper is constructed as; section 2 includes a literature review. Section 3 describes the theoretical framework of the model. Section 4 contains methodological details section 5 includes results discussions and section 6 concludes along with policy suggestions.

2. LITERATURE REVIEW

Development organizations and scholars are keenly interested in the concept of WE. The fifth of the seventeen Sustainable Development Goals was designated by the UN in 2015 as "achieving gender equality" and "empowering all women and girls"(United Nations General Assembly 2015). The impact of WE on GEG has been the subject of macroeconomic policies, theories, and green growth initiatives such as UN Women, UNIDO, and women's economic empowerment in green industry programs. Table 1 enlisted relevant economic theories that emphasize WE for adaptation and resilience to climate change (CC). Research on the effects of women's political empowerment on economic development, growth, and VCC is documented in the literature(Asongu et al., 2020; Israel & Sachs, 2013; McCright, 2010).

Table 1: Economic theories relevant to WE

Theories	Relevance	Reference
Capability Approach (Amartya Sen)	Women's access to economic opportunities, health care, and education enhances resilience, and empowered women can better address climate-related issues.	(Assaduzzaman, 2023)
Sustainable Livelihoods Framework	By improving women's ability to adapt and diversify their sources of income, women's empowerment expands their access to these resources and lessens their susceptibility to climate change (CC).	(Natarajan, Newsham, Rigg, & Suhardiman, 2022)
Feminist Economics	Women's disproportionate VCC is lessened when empowered through fair resource distribution and decision-making representation.	(Agenjo-Calderón & Gálvez-Muñoz, 2019)

Household Bargaining Models	Decisions about climate adaptation, including investing in sustainable technologies or diversifying sources of income, are more likely to be influenced by women with more negotiating power.	(Eastin, 2018)
Human Capital Theory	Women are better equipped to respond to CC by embracing creative solutions and sustainable practices when they are empowered through education and capacity-building.	(Asongu, Messono, & Guttemberg, 2022b)
Common Property Resource Management Theories	Women frequently possess unique expertise in natural resources, and their empowerment in resource management enhances community-level CC adaptation techniques.	(Khadka, 2022)
Neo-Classical Growth Theory	By encouraging creative ways for climate adaptation and advocating legislative changes, empowered women promote adaptive efficiency.	(Chitiga-Mabugu, Henseler, Maisonnave, & Mabugu, 2023)
Social Capital Theory	Empowering women increases their involvement in social networks, which are essential for CC solutions at the local level.	(Rice et al., 2023)
Environmental Kuznets Curve (EKC)	In economies, empowering women might hasten the shift to sustainable behaviors and lessen climate change susceptibility.	(Bilgili, Khan, & Awan, 2023)
Inclusive Growth Theory	Women's active participation in climate adaptation and mitigation plans is ensured by their empowerment, which promotes robust and inclusive economic systems.	(Nazir & Ali, 2020)

WE is a mechanism that improves women's capacity to make rational decisions in life and is a fundamental goal of human rights(Kabeer, 1999). Low levels of empowerment are linked to several detrimental economic and health outcomes on the well-being of women (F. Haile, 2016; Yount, Dijkerman, Zureick-Brown, & VanderEnde, 2014) and their children(Thorpe, VanderEnde, Peters, Bardin, & Yount, 2016). The inclusion of women in societal mobilization affects political transformation, economic preparedness, and climate preservation by enhancing innovation and economic growth (Dahlum, Knutsen, & Mechkova, 2022). According to (DiRienzo & Das, 2019). Furthermore, women's representation supports productivity, good governance, the development of public goods, and environmental preservation. These in turn encourage social and economic resilience, which will ultimately reduce the effects of climate change.

Andrijevic, Crespo Cuaresma, Lissner, Thomas, and Schleussner (2020) conducted a study that showed promoting gender equality in institutions can reduce VCC. When women have legal protections and are constitutionally empowered, they are more likely to engage in entrepreneurship, which can lead to positive economic and financial outcomes (Rink & Barros, 2021). Women can also contribute to increasing production and social adaptability to climate change, while simultaneously reducing corruption(Samimi & Hosseinmardi, 2011).

Gaard (2015) argues that women are often excluded from decision-making processes and the understanding of risks during natural disasters. This exclusion contributes to higher mortality rates among women. Although these studies are primarily theoretical, they support the underlying theory, which states that WE lower VCC globally. Furthermore, Yavinsky (2012) postulates that specific cultural bounds and societal odds exacerbate the vulnerability of women to climate shock. Women are also the most vulnerable to climate shocks due to their heavy familial duties, as natural catastrophes related to climatic change restrict women's ability to gather firewood and obtain drinking water in arid areas(Yadav & Lal, 2018). Van Aelst and Holvoet (2016) demonstrate that widows, single women, and entrepreneurial women are often more vulnerable to the effects of a climatic shock in Africa. WE is crucial for addressing their vulnerability to environmental degradation. An economically and politically autonomous woman positively impacts socio-economic conditions. Svaleryd (2002) explored that women's active participation in public administration guarantees the adapted policies for public choices. Similarly, women's social empowerment leads to a healthy labor force of women(Doepke & Tertilt, 2018).

3. THEORETICAL FRAMEWORK

We adopt the definitions and strategies of Kabeer (2012), and Sundström et al. (2017) to support the mechanisms by which WE affects GEG and VCC. We hypothesize that the complete relationship of WE towards GEG and VCC transmits from a combination of all four proposed aspects of WE. First, Increasing the number of women in politics enhances diversity, talent, knowledge, and experience (Sapiro, 1981). It led to the development of institutions that harmonize the interactions between citizens and the state (Swamy et., al. 2001). Dollar, Fisman, and Gatti (2001) found a negative correlation between corruption

to the powerful representation of women in parliamentary and administrative organizations. Women's political participation in national parliaments leads to the formulation of strong policies regarding education and health (Brennan, Mavisakalyan, & Tarverdi, 2020). In most cases, women who hold prominent roles in politics and administration allocate their earnings from their positions towards supporting their families and educating young girls to make them climate resilient.

Second, the promotion of civil freedom of expression and movement encourages critical communication, which enhances idea exchange and enables better decision-making(Dahlum et al., 2022). Women's social empowerment is positively linked with a healthy female labor force (Doepke & Tertilt, 2018). Such civil liberties increase the female human capital endowment, which will raise the women's bargaining power in intra-household decisions and in the market. Women get technical and skilled education that increases their opportunity cost to have more children in terms of their time allocation towards their jobs. Due to this substitution effect, women will give birth to fewer kids. This trade-off between WE and fertility rate led to effective human capital formation (a transition from the quantity to the quality of offspring). Ultimately, this phenomenon will trigger a demographic transition toward economic transition(Diebolt & Perrin, 2013). Empowered women create a virtuous cycle, starting with gender equality, low fertility rates, increased life expectancy, eradicated child stunting, and skilled human capital, leading to economic growth. Third, enabling women to voice their perspectives through civil society and media empowers policy-makers to choose more effective adaptation policies(Evans, 1995; Weldon, 2002). Women's active participation in public administration guarantees the adapted policies for public choices(Cabaleiro-Casal & Buch-Gómez, 2020). For instance, such countries tend to increase their public expenditures on education and health which leads to a healthy future workforce. Thus, women's representation promotes public goods along with productivity and good governance (DiRienzo & Das, 2019).

Fourth, the participation of women in economic activities will increase the labor force of the economy and hence economic growth (Folasade & Olarewaju, 2019). Transforming women into human capital enhances factor accumulation(Mulligan & Sala-i-Martin, 2002). Women's economic empowerment is a process that enhances women's ability to make strategic life choices(Kabeer & Natali, 2013) and is an essential objective of human rights. Low participation rate in economic activities have significant negative impacts on the well-being of women (S. Haile, Emmanuel, & Dzathor, 2016; Jones et al., 2019; Mabsout, 2011) and their children (Chakraborty & Anderson, 2011; Pratley, 2016; Thorpe et al., 2016) due to associated economic and health outcomes. The presented "business case" for WE has the potential to nudge hesitant leaders to empower women, even if for instrumental reasons. All of these factors suggest that the empowerment of women can enhance GEG and reduce VCC.

Details of all components of WE are described in Table A10 in the Appendix. WE can have a positive and significant impact on climate change and environmental preservation by altering society's choices and priorities in important ways(Duflo, 2012). Women have a very vulnerable social layer concerning climatic change, hence the inclusion of WE in the administration and execution of adaptive policies for environmental resilience is more justified. Expanding women's liberties, their involvement in civil society, and their participation in decision-making promotes climate shock adaptation (Sundström et al., 2017).

4. MODEL SPECIFICATION AND METHODOLOGY

a. Model Specification

We analyzed the relationship WE with VCC and GEG of South Asian countries, using various econometric techniques. We employ the CSARDL developed by (Pesaran, Shin, & Smith, 2001) to analyze the short- and long-term relationships. We have estimated following three empirical models.

$$VCC_{it} = \beta_0 + \beta_1 WE_{it} + \beta_2 ECOR_{it} + \beta_3 GOVRit + \beta_4 SOCR_{it} + \beta_5 HDI_{it} + \rho_{it} \quad (1)$$

$$VCC_{it} = \beta_0 + \beta_1 ECOR_{it} + \beta_2 GOVRit + \beta_3 SOCR_{it} + \beta_4 WCE_{it} + \beta_5 WPE_{it} + \beta_6 WEEit + \beta_7 WSE_{it} + \beta_8 HDI_{it} + \rho_{it} \quad (2)$$

$$GEG_{it} = \alpha_0 + \alpha_1 K_{it} + \alpha_2 FR_{it} + \alpha_3 T_{it} + \alpha_4 WE_{it} + \alpha_5 HDI_{it} + \alpha_6 GOVR_{it} + \alpha_7 SOCR_{it} + \varepsilon_{it} \quad (3)$$

Where VCC is the vulnerability to climate change for country i over a period; it measures how vulnerable societies are to climate shocks. K is gross fixed capital formation, FR is the fertility rate, T is total trade, a measure of trade openness, WE is women's empowerment index. We developed the WE Index by combining V-Dem's political representation, civil liberties, and involvement in civil society indices with a fourth indicator of women's economic empowerment. We use the PCA Method to develop a comprehensive WE index based on all four indicators of empowerment. A detail of all the indicators measured in each sub-index is given in Table A2 in Appendix. HDI is human capital development index. SOCR, GOVR and ECOR variables indicate social, governmental and economic resilience of the society, simultaneously. We use these variables as the indicators to measure adaptive capacity of a society as mentioned by Sarkodie and Strekov (2019) in the literature. WCE, WEE, WSE and WPE are women's civil empowerment, women's economic empowerment, women's social empowerment and women's political empowerment, respectively.

The detailed definition/description, data sources, descriptive statistics, and correlation analysis of the variables are provided in Table A1 (see appendix). We used balanced panel data from 1995 to 2023 for the South Asian countries, namely Pakistan, India, Bangladesh, Sri Lanka, Bhutan, and Nepal. Data on Afghanistan and Maldives was not available for many variables.

b. Measurement of Green Economic Growth

Green Economic Growth (GEG) refers to a sustainable form of growth that is achieved by ensuring the efficient utilization of renewable resources while taking into account the negative impact of greenhouse gases, overuse of natural resources, and other harmful externalities. The calculation of GEG is as follows:

$$GEG = GDP + NRP + CDD + PED \quad (4)$$

Where GEG is green economic growth; GDP is gross domestic product; NRP is used for natural resource depletion, CDD is used for carbon dioxide damage, PED, is used for Particulate emissions damage.

c. Preliminary tests

i. Cross-Sectional Dependence Tests

In order to decide the nature of the empirical relationship of the panel data, we first conducted cross-sectional dependence (CD) tests developed by Breusch-Pagan LM, Pesaran Scaled LM, and Pesaran (2015), to check CD in residuals and in variables. CD problem might arise due to cross-country similarity in the population, region, and political or socio-economic inducement. Therefore, we conduct CD dependence tests to test the cross-dependence among panel cross-sections. This test also helps to determine whether

we should use first-generation estimation techniques or second-generation estimation techniques.

ii. Slope Homogeneity Test

The methodology to determine if the slope coefficients of the cointegration equation are homogenous was established by Swamy (1970). Swamy's slope homogeneity test was enhanced by Pesaran and Yamagata (2008). This test checks the slope homogeneity/heterogeneity in the panel analysis. If the sample countries are heterogeneous; hence we should use heterogeneous panel methodologies.

iii. Second Generation Unit Root Test

We employ Pesaran's second-generation unit root tests to check for stationarity in the presence of cross-sectional dependence. First-generation unit root tests (Levin, Lin, & Chu, 2002) do not take into account cross-sectional dependence. So, we employ second-generation unit root tests to check the stationarity level of variables. Thus, the cross-sectional augmented Dickey-Fuller (CADF) test by Im, Pesaran, and Shin (2003) and the cross-sectional augmented IPS (CIPS) test by Pesaran (2007) have been employed.

iv. Westerlund Test for Panel Cointegration

To estimate the cointegration between dependent and independent variables over a range of cross-section units and throughout time, we have applied the Westerlund Test for Panel Cointegration (Westerlund, 2007). This test takes into account the special features of the panel data, such as CD and slope homogeneity issues.

v. Demitrus Hurlin Causality Test

To examine if there is any causal relationship between variables, we have used the Dumitrescu and Hurlin (2012) method. One of the primary challenges with panel data models is the specification of heterogeneity while conducting the causality test. To address this issue, Dumitrescu and Hurlin (2012) assumed that all coefficients could differ between cross-sections to account for the heterogeneity across cross-sections.

vi. Cross-Sectional Augmented Autoregressive Distributed Lag (CSARDL)

The results of CS dependence and unit root tests proposed to apply the cross-sectional augmented-autoregressive distributed lags (CS-ARDL) approach for our model.

$$\Delta Y_{it} = \emptyset_i + \gamma_i (Y_{it-1} - \alpha_i X_{it-1} - \delta_{1i}\bar{Y}_{t-1} - \delta_{2i}\bar{X}_{t-1}) + \sum_{k=1}^{p-1} \partial_{ij}\Delta Y_{it-k} + \sum_{k=0}^{q-1} \tau_{ij}\Delta X_{it-k} + \vartheta_{1i}\Delta\bar{Y}_t + \vartheta_{2i}\Delta\bar{X}_t + \varepsilon_{it} \quad (5)$$

In the above equation, Y_{it} represents the dependent variable, while $\emptyset_i$ represents the intercept. α_i denotes the slope coefficients of independent variables as well as lagged dependent variables. X_{it} is a vector of independent variables. δ_i denotes the error correction term (ECM) indicating an adjustment of short-run disequilibrium towards long-run equilibrium after an economic shock. Y_{t-1} and X_{t-1} provide a proxy for the unobserved factor in the long run, while ΔYt and ΔXt provide a proxy for the unobserved factor in the short run in Equation (8).

5. Empirical Results and Discussion

a. Result Discussion of Pre-Estimation Test

The findings of Cross-sectional dependency tests are statistically significant at 1%, which confirms the presence of the cross-dependence problem in all models. This implies that South Asian countries rely on one another. The estimates of the Slope homogeneity test of Pesaran and Yamagata (2008) reveal that the slope coefficients are heterogeneous at a 1% level of significance. Second-generation unit root tests of CIPS results show that all variables are integrated at the first difference, I(1). However, the results of CADF are quite

different and indicate that only SOCR and GOVR are integrated at I(0) while all other variables are stationary at first difference. Results of the Westerlund test for panel cointegration confirm that all panel variables are co-integrated in the long run at a 1 percent level of significance. The results of the Durmitrescu- Hurlin test state bidirectional causality exists among K and GEG; WE and GEG; SOCR and GEG; WE and HDI; while FR and T cause GEG; WE, ECOR, and GOVR causes VCC. WE also cause SOCR and SOCR cause ECOR and GOVR. (See details of all test statistics in Appendix A).

Table 2: Long-Run Estimates of CS-ARDL

Models	**Model 1**	**Model 2**	**Model 3**
Independent Variables	**VCC**	**VCC**	**GEG**
ECM	-.9430*** (.1332068)		-.9732*** (.1562436)
WE	-.0449*** (.008034)		.06891** (.0352056)
WCE		-.0552** (.028019)	
WSE		.0363** (.0191252)	
WPE		-.017411** (.0057586)	
WEE		-.06829** (.03906)	
ECOR	-.1024** (.0417475)	-.0268** (.0128359)	
GOVR	.01752 (.098047)	.3342* (.250501)	.7215*** (.2538736)
SOCR	.4923*** (.1729974)	.0491451** (.02348877)	.3094 (1.305487)
K			.3398 (.4944058)
HDI	-.4881** (.2137361)		.2637* (.1422056)
FR			.4914** (.2420285)
T			.00124 (.001333)

Where, *, **, *** indicate significance levels of 1, 5, and 10%, respectively. Standard errors are in parenthesis.

The findings of the CS-ARDL estimation in Table 2 show that all indicators are detrimental to VCC in South Asia in the long run. Furthermore, empirical results show that the WE index reduces VCC by 3% in South Asian countries. The individual impact of various components of WE on VCC shows that the magnitude of the effect of women's economic

empowerment is large. While the magnitude of the impact of women's political empowerment is only 1 percent. This low influence of women in politics justified the VCC of South Asian countries. Overall negative effect of WE on VCC can be viewed by both direct and indirect dimensions of WE. On the direct front, women's sensitivity to natural crises makes them more likely to participate in decision-making, which helps shape effective policies to control negative climate change(Alber & Roehr, 2007; Gaard, 2015). While WE has an indirect impact in preparing the political, social, and economic spheres for climate change adaptation. Moreover, Swamy et al. 2001 examine that corruption is decreased when women participate in administrative and political decision-making processes. Consequently, this contributes to ensuring investments and profits that result in steady growth. As a result, the government's ability to withstand a climatic shock is considered as dependent on the stability of this steady growth (Sarkodie and Strekov 2019). The error correction term of all three models is negative and significant indicating the stability of the models in the long run. These results conclude socio-economic and governmental channels should be strengthened to empower women, which can ultimately help to reduce VCC and its negative economic impacts.

The empirical findings of model 3 show that all variables have a positive association with GEG in the long run. A 1% increase in education will lead to a 26% increase in GEG. The coefficient of WE indicates that a 1 % increase in WE leads to a 7 % increase in GEG. WE improve GEG in two ways. Firstly, WE enhance GEG by increasing labor force participation and the entrepreneurial skills of women. Furthermore, WE promote economic development by raising effective and healthy human resources in terms of the upbringing of their children. Secondly, WE enhance social, economic, financial, political, and environmental adaptation, which in turn increases GEG. Development leads to WE and WE in turn stimulates development by starting a virtuous circle (Duflo, 2022). Women increased spending on health education and reduced social inequalities when they had access to policy-making decisions and resources (Clots-Figueras 2012). The negative and significant value of the ECM term shows the speed of adjustment is 97% from the short run to the long run and confirms the stability of the model. For short-run results of the models see appendix.

6. CONCLUSION

This study examines how GEG can be promoted and VCC can be reduced in South Asian economies. Six South Asian nations were selected as a sample size for the period of 1995 to 2023 for this purpose. The study controlled the problem of heterogeneity and cross-sectional dependency (CD) by using second-generation co-integration estimation techniques. Empirical findings of the CS-ARDL model confirm the positive association of WE with GEG and the negative impact of WE on VCC. Westerlund Cointegration test confirms the cointegration among the modeled variables. Furthermore, the Dumitrescu-Hurlin Granger causality test has been used to explore causality among modeled variables. The findings indicate that bidirectional causality exists among WE and GEG while unidirectional causality exists from WE to VCC.

The study aimed to test two hypotheses in the South Asian region. The first hypothesis examined the effect of WE on VCC, while the second hypothesis explored the impact of WE on GEG. Four aspects of the WE have been considered, namely: women's civil liberty, women's civil society participation, economic participation of women, and women's involvement in political discourse. These four sub-components of WE act independently to introduce new ideas into society and select effective economic and environmental

policies. The empirical literature has no study on how WE affect climate change and GEG in the South Asian region. The results demonstrate that the WE considerably lowers VCC and promotes GEG. The results also show that HDI, the resilience of government, society, and economy are the transmission channels by which WE affects VCC and GEG.

Based on the findings, the study proposes several policy suggestions, elaborated in Table 3, along with the proposed interventions through which these suggestions can be implemented to achieve the specific objective. However, the effectiveness of the proposed policies may vary depending on the initial conditions specific to each country.

Table 3: Proposed Policy Recommendations and Implementation Steps

Policy Recommendations	**Interventions/Implementation Steps**
Access to quality education and training is essential for WE and GEG.	To achieve this, we need to eliminate financial barriers and ensure that there are no school-related costs. We also need to build and upgrade schools, provide transportation support, create safe school environments, implement security measures for travel, and develop a gender-sensitive curriculum and teaching materials. Additionally, community outreach programs and parental involvement can help to improve access to education for girls. Non-formal education programs, adult literacy programs, health and well-being support, digital literacy programs, connectivity initiatives, vocational training programs, and financial literacy education are also essential components of a comprehensive education system for women.
Comprehensive Mechanisms for Monitoring and Evaluation should be designed to track and assess the progress and effectiveness of educational policies on women's empowerment.	• Create a strong monitoring and evaluation mechanism that can track the enrollment, retention, and academic performance of girls, and to identify and address any barriers to their education. • Conduct periodic reviews of education policies to ensure that they are still relevant and effective, and to adjust based on changing needs and circumstances.
Women should have easy access to Financial and Economic resources to get economic empowerment	• Provide women access to savings programs, microfinance, and credit to help them pursue entrepreneurship in climate-resilient sectors. • Create legislation that supports women's involvement in sustainable and green companies, empowering them economically and lowering their susceptibility to the effects of climate change.
Women should have constitutionally Legal protections and Property Rights	• Legal administration of the laws protecting women's rights, particularly those related to land and property, so they can take part in natural resource management and sustainable agriculture. This guarantees that women have protected access to and control over the resources essential for resilience and climate adaptation.

	• Ensuring that women have equitable access to and control over land resources by addressing gender inequities in land ownership.
Women should have access to healthcare and reproductive rights.	• Ensure women's access to healthcare facilities, particularly in rural areas, to address health concerns including waterborne illnesses and difficulties with maternal health that are made worse by climate change. • Encourage family planning and reproductive rights while acknowledging the link between environmental sustainability and population dynamics.
Encourage the use of sustainable and climate-smart farming methods to increase the adaptability of female farmers to climate change.	• Launch women-led agricultural cooperatives to assist women in implementing climate-smart farming methods. These cooperatives should offer markets, financial assistance, training, and resource access. • Incorporate traditional knowledge and practices held by women into agricultural programs, to increase community resilience to climate change. • Provide women farmers with training in agroecology, sustainable farming, and climate-resilient crop management.
Develop a national climate action plan that recognizes the special vulnerabilities and strengths of women in the context of climate change.	• Conduct gender-specific climate vulnerability assessments to determine the particular difficulties experienced by women. • Establish gender-responsive goals and metrics for climate resilience and mitigation. • Budgetary resources should be equitably distributed for gender-inclusive projects.
Enable women to take an active part in the sustainable management of water resources, taking into account their important role in water-related activities.	• Promote women to participate in committees and decision-making bodies for water governance. • Provide training in sustainable water usage techniques, water conservation and rainwater harvesting. • Through the protection of land and property rights, ensure women's control over and access to water resources.
Every country should develop a Gender-Responsive Disaster Management system.	• Develop and implement gender-responsive disaster management plans, recognizing the distinct vulnerabilities and capacities of women in the face of climate-related disasters. • Ensure that evacuation and relief programs are designed to address the specific needs of women, including

	healthcare, sanitation, security, and protection from gender-based violence. • Establish women-led community response teams and provide training in disaster management.
Conduct awareness campaigns to endorse women's rights and gender equality in relation to climate change.	• Integrate climate change education into school curricula, emphasizing its gender dimensions. • Women's leadership abilities can be strengthened via training and capacity-building initiatives. They will empower women to actively engage in decision-making at all levels.
International Collaboration should be encouraged globally due to increase the environmental resilience.	• Collaborate with neighboring countries, and national and international organizations to share resources and best practices that promote women's empowerment and climate resilience. • Participate in regional initiatives that focus on the gender-climate nexus, promoting knowledge exchange and joint projects, accessing funding, technical expertise, and capacity-building support.
Gender-Responsive Climate Action Plan should be launched for climate resilience.	• Establish a gender-disaggregated database to track the impacts of climate change on women and the effectiveness of gender-responsive policies. • Set gender-responsive targets and indicators for climate resilience and mitigation initiatives. • Promote partnerships between academic institutions, research organizations, and civil society to enhance knowledge-sharing and collaboration.
Address the intersection of climate change and women's health by ensuring access to climate-resilient healthcare services.	• Integrate climate-sensitive healthcare into national health policies, considering the impact of changing climate patterns on health. • Provide education and training for women on climate-resilient health practices and disease prevention.
Initiate education and awareness campaigns to highlight the importance of women's roles in climate action.	• Promote the understanding of climate change, its impacts, and the opportunities for women to contribute to solutions. • Support studies that highlight the contributions of women and the gendered impacts of climate-related initiatives.

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APPENDIX

Table A1: Description, Measurement of Variables and Data Sources

Variables (Symbol)	**Variable Description**	**Measurements**	**Source**
Green Economic Growth (GEG)	GDP minus	Index = 1 denotes maximum productivity, 0 denotes no productivity	Author's own calculation

Human Development Index (HDI)	HDI encompasses a long, healthy life, education, and good living standards.	Index = 1 denotes maximum development, 0 denotes no development	Human Development Reports (2018)
Women's Empowerment Index (WE)	We is the process of increasing the abilities, agency, participation in social decision-making, and economic participation of women.	Index = 1 denotes fully empowered, 0 denotes no empowerment	PCA Method (Author's own calculation)
Vulnerability to climate change (VCC)	It denoted varying levels of Human societies' vulnerability to negative impacts resulting from climate shocks, ranging from 0 to 100.	Index = 1 denotes fully empowered, 0 denotes no empowerment	Global Adaptation Index (2018)
Social Resilience	It is a question of social inequalities, in particular the quality of infrastructure, the educational framework and the ability to innovate	Index = 1 denotes fully empowered, 0 denotes no empowerment	Global Adaptation Index (2018)
Governmental Resilience	It combines the indicators of political stability. Control of corruption; the rule of law and the quality of regulation	Index = 1 denotes fully empowered, 0 denotes no empowerment	Global Adaptation Index (2018)
Economic Resilience	Measures the various economic operations favorable to the business climate necessary for the mobilization of capital in the private sector	Index = 1 denotes fully empowered, 0 denotes no empowerment	Global Adaptation Index (2018)

Gross fixed capital formation (K)	It includes land improvements, plant and equipment purchases, construction of buildings, railways, and roads.	Data are in constant 2015 prices, expressed in U.S. dollars.	World Development Indicators
Fertility rate (FR)	Total number of kids a woman would have if she followed age-specific fertility rates until the end of her childbearing years.	total (births per woman)	World Development Indicators
Trade Openness (T)	It refers to the total value of both exports and imports of goods and services.	Trade (% of GDP)	World Development Indicators

Table A2: Test of Homogeneity and Cross-Sectional Dependence of Model 1
Where, *, **, *** indicates significance level of 1, 5 and 10%, correspondingly. Standard errors are in parenthesis.

Table A3: Descriptive Statistics of Model 1

Test For Slope Homogeneity			
Swamy test statistic	**Model 1**	**Model 2**	**Model 3**
$\tilde{\Delta}$	6.230*** (0.000)	7.130*** (0.000)	4.520*** (0.000)
$\tilde{\Delta}$adj	7.826*** (0.000)	8.586*** (0.000)	6.658*** (0.000)
Cross-Sectional Dependence			
Tests	**F. Statistics**		**Probability**
Breusch-Pagan LM	73.52708*** (0.000)	89.256*** (0.000)	105.0103*** (0.000)
Pesaran Scaled LM	9.590088*** (0.000)	62.5684 (0.000)	15.33812*** (0.000)
Pesaran CD	1.084818*** (0.000)	1.5689*** (0.000)	0.405256*** (0.000)

	LNVCC	WE	ECOR	GOVR	HDI2	SOCR
Mean	0.654585	0.013061	0.444079	0.402587	0.579540	0.242608
Median	0.643903	0.009446	0.412836	0.401746	0.581000	0.242093
Maximum	0.525484	2.064526	0.831469	0.657601	0.786000	0.324915
Minimum	0.786535	2.491113	0.170012	0.238487	0.417000	0.157198
Std. Dev.	0.061735	1.011885	0.149627	0.104883	0.092398	0.039274
Skewness	0.390297	0.478061	1.018611	0.651662	0.392714	0.162828

Kurtosis	2.504102	3.225809	3.956374	2.715540	2.448667	2.630128
Jarque-Bera	6.200510	6.997416	36.72069	12.90188	6.676267	1.760710
Probability	0.045038	0.030236	0.000000	0.001579	0.035503	0.414636
Variables	CORRELATION ANALYSIS					
LNVCC	1					
WE	-0.49	1				
ECOR	0.24	-0.14	1			
GOVR	-0.32	0.43	-0.14	1		
HDI2	-0.65	0.68	-0.25	0.46	1	
SOCR	-0.36	0.19	-0.05	-0.15	0.46	1

Table A4: Descriptive Statistics of Model 3

	LNGEG	LNK2	HDI2	FR	WE	T	GOVI
Mean	24.8583	23.4695	0.579540	2.90324	-0.01306	50.9077	0.4025
Median	25.2083	23.7604	0.581000	2.53550	0.009446	45.7053	0.4017
Maximum	28.7048	27.6777	0.786000	5.89400	2.064526	116.549	0.6576
Minimum	20.0156	18.6658	0.417000	1.37300	-2.49111	21.4599	0.2384
Std. Dev.	2.23924	2.07558	0.092398	0.99815	1.011885	23.4980	0.1048
Skewness	-0.4466	-0.0463	0.392714	0.95804	-0.4780	1.04381	0.6516
Kurtosis	2.532799	2.499572	2.448667	3.211787	3.225809	3.269631	2.7155
Jarque-Bera	7.36833	1.87783	6.676267	26.9428	6.997416	32.1240	12.901
Probability	0.025118	0.391051	0.035503	0.000001	0.030236	0.000000	0.0015
Variables	CORRELATION ANALYSIS						
LNGEG	1						
LNK2	0.75	1					
HDI2	-0.09	-0.06	1				
FR	0.08	0.00015	-0.76	1			
WE	-0.32	-0.24	0.68	-0.77	1		
T	-0.74	-0.70	0.37	-0.34	0.38	1	
GOVR	-0.58	-0.49	0.46	-0.41	0.43	0.78	1
SOCR	0.59	0.63	0.46	-0.44	0.19	-0.37	-0.15

Table A5 Second Generation Unit Root Test

Where, *, **, *** indicates significance level of 1, 5 and 10%, correspondingly. Standard errors are in parenthesis.

Variables	**CIPS**		CADF	
	Level	**1st Diff.**	**Level**	**1st Diff.**
FR	-1.395	-2.712***	-1.574	-2.365**
HCD	-0.954	-3.414***	-1.113	2.610***
K	-0.973	-3.047***	-1.064	-2.797***
EDU	-1.410	-4.108***	-1.320	2.610***
LNGEG	-1.865	-3.565***	-2.275*	2.610***
VCC	-1.803	-4.762***		
T	-1.573	-4.732***	-1.892	-2.364**
WE	-1.985	-4.732***	-2.044	-2.422**
ECOR	-2.053	-4.037***	-1.888	-3.004***
GOVR	-2.199	-4.295***	-2.429**	
SOCR	-2.051	-4.261***	-2.480**	
WCE	-2.549	-5.521***	-1.549	-4.521***
WSE	-1.984	-5.419***	-2.984**	
WPE	-2.356	-3.526***	-1.356	-2.526**
WEE	-1.343	-4.127***	-1.433	-3.127**

Table A6 Short-Run Estimates of CS-ARDL

Models	**Model 1**	**Model 2**	**Model 3**
Dependent Variables	**VCC**	**VCC**	**GEG**
WE	**-.0317** (.00792)**		.0759** (.0380523)
WCE		-.0561** (.029109)	
WSE		.0263** (.023252)	
WPE		-.018211** (.0062586)	
WEE		-.05829** (.038606)	
ECOR	**-.0722** (.0242489)**	-.0218** (.0136359)	
GOVR	**-.00341 (.0806176)**	.3012* (.265012)	.7171** (.3129197)
SOCR	**-.5049** (.220772)**	.0401451** (.02448877)	.2391979 (1.037157)
K			.0136* (.1578626)

HDI	**-.4176*** (.1529601)**		.6484** (.1332056)
FR			.4190* (.2278578)
T			.0012434 (.0015261)

Where, *, **, *** indicates significance level of 1, 5 and 10%, correspondingly. Standard errors are in parenthesis.

Table A7 Pairwise Dumitrescu Hurlin Panel Causality Tests of Model 1

Where, *, **, *** indicates significance level of 1, 5 and 10%, correspondingly. Standard errors are in parenthesis.

Pairwise Dumitrescu Hurlin Panel Causality Tests of Model 1				
Null Hypothesis:	W-Stat.	Zbar-Stat.	Prob.	Direction of Causality
WE → VCC	3.88693	1.69893*	0.0893	Homogeneous Bi-directional causality among WE and VCC
	3.10132	0.90773	0.3640	
ECOR →VCC	5.78296	3.60844***	0.0003	Homogeneous uni-directional causality among ECOR and VCC
	2.07600	-0.12489	0.9006	
GOVR →VCC	4.40913	2.22484**	0.0261	Homogeneous uni-directional causality among GOVR and VCC
	3.73658	1.54751	0.1217	
HDI ←→VCC	6.92464	4.75824***	0.0000	Homogeneous bi-directional causality among HDI and VCC
	6.74385	4.57617***	0.0000	
WE → SOCR	3.21953	1.02678	0.3045	Homogeneous uni-causality among WE and SOCR
	6.20292	4.03139***	0.0000	
ECOR →GOVR	1.98821	-0.21330	0.8311	Homogeneous uni-causality among ECOR and GOVR
	3.89464	1.70669*	0.0879	
SOCR →ECOR	3.90171	1.71381*	0.0866	Homogeneous uni-causality among SOCR and ECOR
	0.89476	-1.31452	0.1887	
HDI ←→GOVR	4.40635	2.22204**	0.0263	Homogeneous bi-causality among HDI and GOVR
	6.41880	4.24881***	0.0000	
SOCR →GOVR	4.46593	2.28205**	0.0225	Homogeneous uni-causality among SOCR and GOVR
	2.09132	-0.10946	0.9128	

Table A8 Pairwise Dumitrescu Hurlin Panel Causality Tests of Model 3

Where, *, **, *** indicates significance level of 1, 5 and 10%, correspondingly. Standard errors are in parenthesis.

Table A9 Westerlund Test for Panel Co-integration

Pairwise Dumitrescu Hurlin Panel Causality Tests of Model 2				
Null Hypothesis:	W-Stat.	Zbar-Stat.	Prob.	Direction of Causality
LNGEG ⟷ LNK	4.18092	1.99501**	0.0460	Homogeneous bi-directional causality among
	4.21646	2.03081**	0.0423	LNGEG and LNK
LNGEG ⟷ HDI	6.68794	4.51986***	0.0000	Homogeneous bi-directional causality among
	4.95485	2.77444***	0.0000	LNGEG and HDI
FR → LNGEG	7.70856	5.54773***	0.0000	Homogeneous uni-directional causality
	3.05001	0.85606	0.3920	among FR and LNGEG
WE ⟷ LNGEG	3.63025	1.44042**	0.0497	Homogenous bi-directional causality among
	5.27614	3.09802***	0.0019	WE and LNGEG
WE ⟷ HDI	6.74385	4.57617***	0.0000	Homogeneous bi-directional causality among
	6.92464	4.75824***	0.0000	WE and GTFP
T → LNGEG	5.24512	3.06678***	0.0022	Homogeneous uni-directional causality
	2.13447	-0.06600	0.9474	among T and LNGEG
LNGEG ⟷ SOCR	4.28897	2.10383**	0.0354	Homogeneous bi-causality among LNGEG
	17.1937	15.1003***	0.0000	and SOCR

Statistics	**Model 1**	**Model 2**	**Model 3**
Variance ratio	-2.3412*** (-2.5482)	-1.4322*** (-1.6722)	-1.8521*** (-2.1542)

Where, *, **, *** indicates significance level of 1, 5 and 10%, correspondingly. Standard errors are in parenthesis.

Table A10: Components and Indicators of Women Empowerment Index

Indicators	**Definition**	**Data Source**
Women's Social Empowerment Index	Women's access to justice, liberty from enforced labor, domestic mobility, and right to own property	Varieties of Democracy Database (2023)
Women's Civil Empowerment Index	Engagement in organizations of civil society, representation among journalists, and freedom of open discussion of political topics.	Varieties of Democracy Database (2023)
Women's Political Empowerment Index	women are equally represented in the legislative bodies and have	Varieties of Democracy Database (2023)

	a fair share of power allocation in all aspects.	
Women's Economic Empowerment	Participate in the labor force by providing their skills and services for the production of goods and services within a specified period.	International Labor Organization (ILO)