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Gender-Inclusive Climate Change Adaptation Policies: An Empirical Analysis of Climate Swap Funding Impact Using Two-Step GMM Technique

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ABSTRACT

Climate change poses significant impact on human wellbeing, weakens economic stability and exacerbates social inequalities. Climate change adaptation policies mitigate this impact by considering the diverse gender-inclusive socio-demographic characteristics of the population. These policies ensure equitable and resilient outcomes to enhance the integration of gender-inclusive socio-demographic and climate change adaptation mechanisms. The objective of this research is to develop the dynamic nexus among climate change adaptation policies, gender-inclusive socio-demographic characteristics and climate swap funding. This study will be based on Ramsey-Cass-Koopmans macro-economic model incorporating gender inclusive socio-demographic characteristics of household. Considering the women empowerment a gender-inclusive socio demographic characteristic in climate change adaptation policies in the model. The panel dataset will be used to analyze the theoretical nexus in 46 developing economies for the period of 20 years from 2003-2022. Meanwhile, the study will also be empirically validated through innovative econometric approach Two Step System GMM. This technique is suitable as it investigates endogeneity factors besides gender inclusive socio-demographics that affect climate change adaptation policies. The expected outcomes resonate with the theory that gender-inclusive socio-demographic characteristic of household especially empowered women are crucial in climate change adaptation policies.

Keywords*:* Climate change adaptation policies, Women empowerment, Climate swap funding, Ramsey-Cass-Koopmans model, Two Step System GMM, Developing economies

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1. INTRODUCTION

Climate change is a contemporary issue posing significant impacts on human well-being, weakens economic stability, and worsens social inequalities. All

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such issues can be addressed by focusing on effect climate change adaptation policies(El Bilali et al., 2020; Estok, 2023; Lewis et al., 2023). These policies, compatible with socio-demographic characteristics, ensure equitable and resilient outcomes.

According to the World Meteorological Organization (WMO), the last decade was recorded as the warmest on earth. More frequent and severe extreme weather events, including droughts, floods, and heatwaves, have been noticed during this decade. These events have devastated communities globally. For instance, in 2022, Pakistan experienced record-breaking rainfall leading to extensive flooding. This affected 33 million people, caused over 1,700 deaths, and resulted in massive economic losses estimated at $30 billion. Similarly, the drought in East Africa brought food insecurity for 20 million people. It exacerbates the existing vulnerabilities and social inequalities(United Nations, 2023).

Moreover, on a planetary scale unprecedented changes have occurred due to the rising levels of greenhouse gases, including carbon dioxide, methane, and nitrous oxide. The level of sea and ocean warming reached new highs. Becoming more threatening to coastal communities and ecosystems. A global mean sea level recorded high in Antarctic as sea ice extent fall to its lowest level in 2023 (Hu and Ahmad, 2024). These environmental changes have directly and indirectly impacted badly on human livelihoods and health. Therefore, driving the population to massive migration and displacement leads to economic instability. The study's backdrop stems from the growing realization that, because of inadequate infrastructure and resources, vulnerable groups—such as women and marginalized communities—are disproportionately impacted by climate change. These gender-specific needs are frequently not considered by current climate change adaptation policies, which results in unfair and inefficient solutions (Jin et al., 2024). The gaps addressed for environment based on gender orientation and importance of gender inclusive climate change adaptation policies are addressed in Appendix (Table: A, B).

The study's importance rests in its ability to close this gap by creating a thorough framework that integrates gender-inclusive socio-demographic traits into plans for climate change adaptation. Through an emphasis on women's empowerment and other pertinent socio-demographic characteristics, this study seeks to improve the efficacy of adaption tactics, thus advancing social justice and sustainable development(Anser et al., 2020). The goals of the research are to examine the dynamic relationship that exists between funding

for climate swaps, gender-inclusive socio-demographics, and policies for adapting to climate change. The study will also use novel econometric techniques, like the Two-Step Generalized Method of Moments (GMM) technique, to empirically validate these relationships.

This study offers a novel contribution: it applies the gender-inclusive socio-demographic characteristics of the Ramsey-Cass-Koopmans macro-economic model to the examination of policies for climate change adaptation(Dombi & Dedák, 2019; Hosoya, 2014; Nævdal, 2021). In addition to offering a theoretical framework for comprehending long-term inter-temporal decisions about capital accumulation, investing, and savings, this method highlights the significance of gender inclusion in these choices. The empirical validation of the study, which was conducted over a 20-year period (2003–2022) using panel data from 46 developing economies, provides strong evidence of the effect of gender-inclusive policies on climate change adaptation. The research helps create more egalitarian, sustainable, and successful climate change adaptation policies by incorporating these ideas.

2. LITERATURE REVIEW

The relationship between gender, strategies for adapting to climate change, and financial tools like climate swap money has drawn more attention in recent research(Ahmad et al., 2024). Research indicates that to address the disproportionate effects of climate change on women and gender-diverse societies, gender-inclusive climate adaptation policies are essential. Because of pre-existing socioeconomic disparities, restricted access to resources, and lesser participation in decision-making processes, these groups frequently confront greater vulnerabilities(Ahmad et al., 2023).

Climate swap money has demonstrated potential in strengthening resilience in vulnerable areas. It is a financial instrument where debt is exchanged for promises to invest in climate adaptation projects. Research like that conducted by the OECD (2019) and the World

Bank (2018) shows that when these monies are allocated to gender-inclusive projects, they not only increase community resilience and environmental results, but also empower women. It has also been demonstrated that incorporating gender perspectives into policies related to climate adaptation increases the efficacy of these interventions. Projects that involve women in the design and implementation stages, for example, are more likely to harness local expertise and address specific risks, resulting in more sustainable outcomes(Ahmad et al., 2022; Suwandi, 2022).

The two-step Generalized Method of Moments (GMM) technique is used in empirical investigations to give reliable approaches for evaluating various financial mechanisms and policies' efficacy. Unobserved heterogeneity and possible endogeneity are two major problems in policy effect evaluations that are addressed by this method(Nosheen et al., 2021a). Notwithstanding these advantages, there are still gaps in the empirical data about the precise effects of gender-inclusive climate policies that are financed by climate swaps. This gap has begun to close with recent empirical studies that employ the two-step GMM strategy, showing that these policies, when properly funded and executed, can greatly improve adaptation outcomes(Nosheen et al., 2021b).

2.1 Research Gaps

There are still a lot of research gaps despite the growing awareness of the significance of gender-inclusive climate change adaptation plans. The empirical assessment of the effects of gender-inclusive adaptation activities funded by climate swap arrangements is one crucial area that lacks thorough investigation. Although previous research has highlighted the potential advantages of these strategies (UN Women, 2020; World Bank, 2018), there is little empirical data regarding their efficacy, especially in a range of socioeconomic and environmental circumstances. Furthermore, there is a lack of application of sophisticated econometric methods such as the two-step GMM in this field, raising concerns regarding the validity of the results that have already been discovered (Brown et al., 2020; Smith et al., 2021). Moreover, most of the research concentrates on case studies or qualitative evaluations, but large-scale quantitative analyses that can yield generalizable insights are desperately needed. Closing these inequalities can help to accomplish the goals of climate resilience and gender equality by maximizing the allocation of funding for climate adaptation.

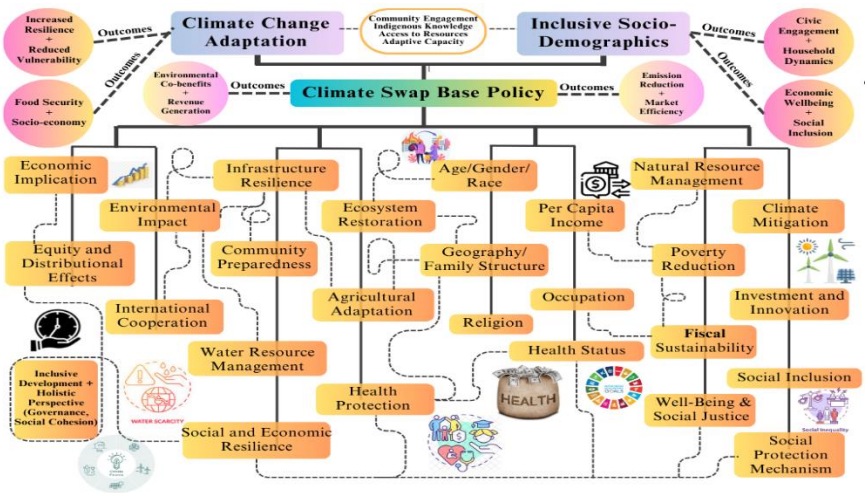
The body of research demonstrates the importance of maintaining funding for gender-inclusive adaptation programs as well as the necessity of thorough empirical evaluations to inform funding and policy choices. In addition to addressing gender disparities, this strategy increases communities' general resistance to the effects of climate change.

3. THEORETICAL MODEL

Climate change adaptation and socio demographics are studied with Ramsey-Cass-Koopmans macro-economic model. The basis of Ramsey-Cass-Koopmans model (RCK) stands distinguished in context of climate change

adaptation and socio demographics as it focuses on long-term intertemporal decision with respect to saving, investment and capital accumulation. Considering investment in adaptation activities related to climate change enhances productivity through climate resilient infrastructure and improves societies' ability to adapt to climate change impacts. Another feature of RCK is overlapping generations of individuals as climate change impact is borne by current and future generations. Ensuring sustainable policies considering the needs and interests of the future generation. Socio-demographic factors are the key player that influence individual savings and investment behavior in the RCK model. As for example, marginalized communities are most vulnerable to climate changes due to insufficient funds to financial resources and infrastructure. So adapting climate change strategies needs to specify community with their specific socio demographic characteristics are studies in RCK model (figure 1).

Figure 1: Comprehensive overview of gender inclusive climate change adaptation and climate finance



Maximizing the utility of identical consumer in the context of intertemporal optimization[2] problem:

[2] $u(c,T)$: Utility function where *c* shows the consumption of the identical consumer (per capita consumption) and *T* shows the time.
$e^{(n-\rho)^t}$: Exponential discount factor, *n* shows the population growth rate and ρ shows discount rate.
$\int_0^\infty$; Shows integrating over time from *t=0* to *t=∞*
$u(c,T)e^{(n-\rho)^t}$; The objective is to maximize the integral utility of identical consumer with respect to the time. As it conveys the meaning of finding the consumption path over time that maximizes the discounted

$max \int_0^{\infty} u(c,T)e^{(n-\rho)^t}dt$ (1)

Subject to:

$\dot{K} = F(K,L,T) - cL - \delta(T)K$ (2)

$\dot{L} = n(T)L, \qquad L_0 = 1$ (3)

Assuming that climate change is time independent and exogenous indicator T . the greater the value of T indicates larger the impact of climate changes. Four level meet the criteria where climate changes affects the optimization conditions, (i) health impact (ii) longevity of capital impact (iii) market impact and (iv) non-market impact

$\dot{c} = -\frac{u_c}{u_{cc}}(fk - \delta - \rho)$

The steady state condition $\dot{k} = \dot{c} = 0$ implies $fk = \delta + \rho$ and $c = f - \delta k - nk$.

Dealing with the Dynamics of Capital Accumulation

Taking into account the impact of climate changes on the physical stock of capital. Keeping saving rate exogenous in order to isolate the capital accumulation effect. Assuming that economic agents will not change their saving behavior in response to the climate change. Thus saving rate will be constant function of output.

$\bar{s} = 1 - {}^{c}/_{f}$ Multiplying f both sides we get $\bar{s}f = 1 - c$

$\bar{s}f = (\delta + n)k$

$\frac{\partial k}{\partial T} = \frac{k(\delta_T + n_T) - \bar{s}f_T}{\bar{s}f_k - \delta - n}$

Dealing with the Dynamics of Savings

Taking s^G gross savings per capita equals deduction of consumption from the savings.

$s^G = f - c = (\delta + n)k$

Differentiating the gross savings s^G with respect to climate change T

The individual (saver) is not willing to set a aside extra money to compensate for the unwanted and negative effects of climate change.

Magnitude of Dynamic Effect

Few required changes have been made that suit our objective. However, the basic model we have followed is DICE (Dynamic Integrated Climate Economy) model. To distinguish between saving and capital effect, the model we have followed is applicable in two different modes. These models are associated with growth models.

utility. The discount factor indicates the individual consumer's time preferences for future consumption.

3.1 Empirical Methodology

The empirical methodology of gender inclusive climate change adaptation policies are based on on the proportion of female-headed households. As we know that Female-headed households might have different savings behavior due to various socio-economic factors. The formula for women adjusted saving behavior as recommended by RCK model in section 3.

$$Adjusted\ Gross\ Savings\ (Women) = Gross\ Savings * \left(\frac{Female\ Headed\ Household}{100}\right)$$

Such formula helps us to find the gender based decision in household consumption and savings pattern. Therefore such proxy is suitable to determine the RCK parameter leading toward the gender inclusive climate change adaptation policies. Table 1 gives an overview of RCK model comparison with other macro-economic and development economic models.

Table 1: Similarities and Differences to Incorporate Climate Change polices among various Economic Models

	Solow Swan Growth Concepts	Ramsey Cass Koopmans Growth Concepts	Mankiw-Romer-Weil Growth Concepts	DICE Model
Similarities	Long term growth	Long term growth	Long term growth	Long term growth with specific emphasis on the interaction between economic growth and climate change
	Capital accumulation, labor and technological progress basic	Intertemporal utility maximization by households	Capital accumulation, labor and technological progress basic determinant of growth	Economic growth theory along with environmental considerations

	determinant of growth			
Differences	Constant returns to scale in production	Incorporates intertemporal optimization and consumption smoothing	idea of endogenous technological progress	Explicitly models the effects of greenhouse gas emissions, climate policies, and climate damages on economic growth
	Does not include endogenous factors such as savings decisions or technological progress	representative agent making consumption and saving decisions	human capital accumulation as a key determinant of growth	Focuses on policy analysis related to climate change mitigation and adaptation strategies, which is not a primary focus of the other growth models

Variable	Definition	Proxy of the variables	Sources
Economic Growth	Economic growth is inclusive and equitable, ensuring mutual benefits of development shared by all segments of society. It includes vulnerable populations disproportionately affected by climate change.	1. GDP per capita 2. Sustainable economic	WDI
Climate Finance/Debt Swap Funding	Outstanding debt is restructured or cancelled in favor of domestic resources invested by the indebted country for environment-oriented purposes. (These resources are portrayed as climate change adaptation policies, however they complement the infrastructure as climate change adaptation policies).	1Debt for nature swaps (SDGs 13).	OECD
Physical Stock of Capital	The physical stock of capital represents critical infrastructure investments needed to enhance resilience and provide social protection against climate change impacts. Such investments are essential for promoting sustainable development and ensuring the well-being of populations in developing economies vulnerable to climate change.	Gross fixed capital formation (% GDP)	WDI
Human capital	Capacity-building investments needed to strengthen workforce skills, education, and healthcare systems to enhance resilience and social protection against climate change impacts. Such investments are essential for promoting inclusive growth, reducing vulnerability, and ensuring sustainable development in developing economies facing climate risks.	Human capital index based on years of schooling	Penn World Table
Climate Adaptation Policy	Climate adaptation policy entails implementing initiatives and investments to safeguard vulnerable communities, improve social protection mechanisms, and ensure access to essential services in the face of climate-related risks	Index of Health, education and environment using KMO methodology	WDI

Gender based RCK Savings Parameter	The concept of savings can be represented as Gross savings represented by the difference between disposable income and consumption. The decision is based on female headed household patterns.	Percentage of GDP	WDI
Endogenous Growth Parameter	It consists of growth rate of population and depreciation rate measured as depreciation parameter.	The value obtained by summing up (population growth rate and average depreciation of capital stock)	WDI, Penn World table
Trade Openness	The extent to which developing economies engage in global trade partnerships and integrate into the international market.	Trade percentage of GDP	WDI

Table 2: An overview of the many terms, definitions, proxies, and sources used to evaluate the efficacy of policies for adapting to climate change and their influence on sustainable development is given in this table. GDP per capita and sustainable economic indicators are used to measure economic growth, with a focus on including disadvantaged groups (WDI). Investments geared toward the environment are financed by climate financing, especially through debt-for-nature swaps (OECD). The Human Capital Index serves as a stand-in for human capital, which is concentrated on healthcare, workforce skills, and education (Penn World Table). An index of environmental, health, and education indicators is used to evaluate climate adaptation policies (WDI). The savings habits of families headed by women are used to examine gender-based savings as a percentage of GDP (WDI). The gross fixed capital formation, which is a measure of the physical stock of capital, emphasizes the essential infrastructure investments required for resilience (WDI). The trade percentage of GDP (WDI) is used to measure trade openness, while the endogenous growth parameter (WDI, Penn World Table) incorporates population growth and depreciation rates. When taken as a whole, these factors provide a thorough framework for assessing the complex effects of climate change and the efficiency of adaptation measures in promoting equitable and sustainable growth.

3. RESULTS AND DISCUSSION

Table 3 offers descriptive statistics for important factors that are considered when evaluating how well policies for adapting to climate change affect sustainable development. For every variable, there are 920 observations in the data. GDP per capita indicates economic growth with a mean of 3.78 and high variability (standard deviation of 5.69), showing a range of growth experiences from -20.72 to 7.42 in the sample. The mean value for debt swap/climate financing is 3.18, indicating a moderate level of investment, with a range of 1.00 to 5.00. The physical capital stock, which is a necessary component of resilience, ranges from 4.62 to 59.41% of GDP on average. With a mean of 10.54, the growth parameter—population growth rate plus depreciation—highlights the dynamics of the economy and demographics. With a mean of 4.64 and values ranging from -15.23 to 18.42, trade openness—a measure of participation in international markets—indicates varying degrees of trade integration within the sample. The mean index score for human capital is 2.23, which represents differences in the education and skill levels of the workforce. A mean score of 8.75 for climate adaptation strategies indicates that they are

being implemented widely. In contrast, the gender-based RCK savings metric exhibits significant variability, from 0.32 to 39.32 for an average of 8.34. Figure 2 shows the trends of the various variables.

Figure 2: Trends of GDP, Climate Finance and Capital Stock

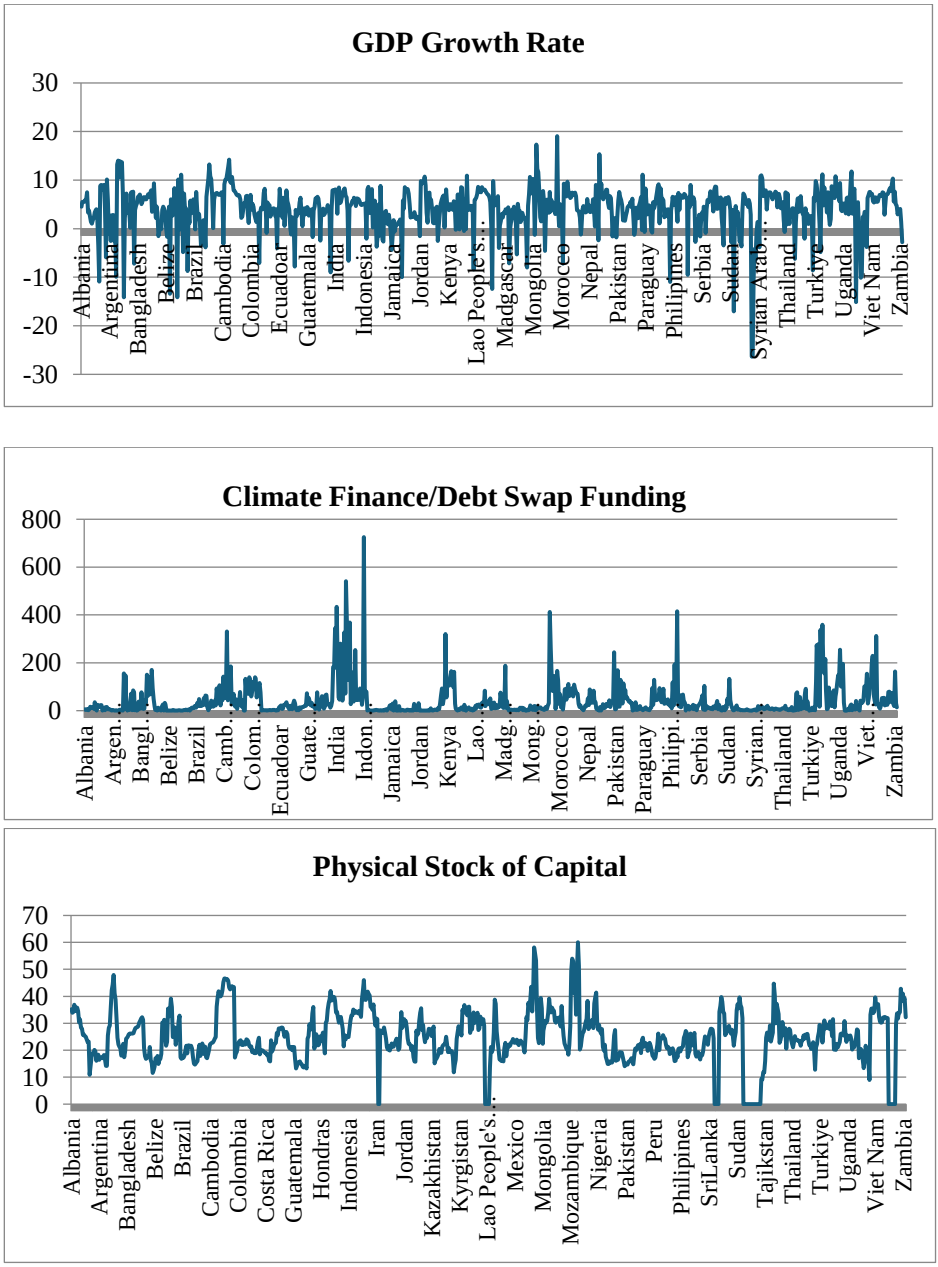


Table 3: Descriptive Statistics: RCK Savings rate and Climate Finance and Climate Adaptation Policies

Variable	Observations	Mean	Std. Dev.	Min.	Max.
		Full Sample			
Economic growth	920	3.78	5.69	-20.7	7.42
Climate Financing	920	3.18	1.42	1.00	5.00
Physical Stock of capital	920	28.45	3.73	4.62	59.41
Human capital	920	2.23	1.99	2.54	3.83
Climate Adaptation Policies	920	8.75	0.59	7.17	10.38
Gender based RCK Saving Parameter	920	8.34	6.29	0.32	39.32
Growth Parameter$(n+g+\delta)$	920	10.54	2.58	4.84	16.77
Trade Openness	920	4.64	2.75	-15.2	18.42

Table 4: Correlation Matrix: RCK Savings rate and Climate Finance and Climate Adaptation Policies

Matrix	Economic growth	Climate Finance/ Debt Swap Funding	Physical Stock of capital	Human capital	Climate Adaptation Policies	Gender based RCK Saving Parameter	Growth Parameter *(n+g+ʊ)*	Trade Openness
Full sample								
Economic growth	1							
Climate Finance/Debt Swap Funding	0.326***	1						
Physical Stock of capital	0.229*	0.169**	1					
Human capital	0.436***	0.615***	0.041	1				
Climate Adaptation Policies	0.259**	0.265***	0.059	0.167**	1			
Gender based RCK Saving Parameter	0.267***	0.1737*	0.271***	0.042	0.151**	1		
Growth Parameter*(n+g+ʊ)*	0.180*	0.534***	0.194***	0.009	0.776***	0.139**	1	
Trade Openness	0.327***	0.079	0.228***	0.129**	0.1789**	0.256***	0.130	1

Table 4 depicts the links between important variables pertaining to policies for adapting to climate change and economic growth are displayed in the correlation matrix for the entire sample. All the variables show a positive association with economic growth, with trade openness (0.327***) and human capital (0.436***) having the strongest correlations. There are noteworthy positive relationships between debt swap funding and climate finance/growth (0.326***), human capital (0.615***), and the growth parameter (0.534***). The physical capital stock has a favorable correlation with both trade openness (0.228***) and economic growth (0.2295*). Economic growth (0.436***) and climate finance (0.615***) have a substantial correlation with human capital. Policies aimed at addressing climate change have moderately positive associations with several variables, most notably the growth parameter (0.776***). Climate funding (0.535***) and strategies for climate adaptation (0.776***) are highly correlated with the growth parameter. Trade openness has a positive correlation with both the physical stock of capital (0.228***) and economic growth (0.327***). The interdependence of different adaptation policies, human and physical capital, climate finance, and economic growth. A substantial positive association has been observed between the gender-based RCK savings parameter and the physical stock of capital (0.271***), economic growth (0.267***), and climate adaptation strategies (0.151**). Table 5 Economic growth has a moderately favorable impact on Model 1 (Fixed Effect), as indicated by its coefficient of 0.2316, which is significant at the 10% level. Physical capital and human capital both show considerable positive benefits with coefficients of 0.237 (1% level) and 0.296 (5% level), respectively. Climate finance/debt swap funding indicates a large positive influence (0.451, significant at the 5% level). While the growth parameter exhibits a modest positive effect (0.0346, 10% level), the gender-based RCK saving parameter also considerably positively effects growth (0.124, 1% level). In this paradigm, trade openness is not significant. The model explains 15% of the variability in economic growth, according to the R-squared value of 0.15. The coefficient of economic growth in Model 2 (Random Effect) is smaller (0.115, 5% threshold). Funding for debt swaps and climate change continues to be positively substantial (0.275, 1% level). While the gender-based RCK saving parameter (0.1527, 1% level) and human capital (0.1996, 10% level) demonstrate significant positive impacts, the physical stock of capital is not significant. Additionally, the growth parameter (0.0513, 10% level) is still significant. Trade openness is still not very important. At 0.14, the R-squared value is marginally less. Endogeneity is indicated by the Durbin-Wu-Hausman test, indicating that the fixed effects model may be a better fit.

Table 5: RCK Savings rate and Climate Finance and Climate Adaptation Policies (Full Sample): Fixed Effects/Random Effects: Dependent Variable (Inclusive economic growth index)

Variables	Model 1	Model 2
	Fixed Effect	Random Effect
Economic growth	0.232*	0.115**
	(0.1158)	(0.036)
Climate Finance/Debt Swap Funding	0.451**	0.275***
	(0.203)	(0.079)
Physical Stock of capital	0.237***	0.120
	(0.059)	0.066
Human capital	0.296**	0.199*
	(0.099)	(0.075)
Gender based RCK Saving Parameter	0.124***	0.153***
	(0.032)	(0.038)
Growth Parameter$(n+g+\delta)$	0.0346*	0.0513*
	(0.016)	(0.021)
Trade Openness	0.0042	0.0041
	(0.003)	(0.004)
Constant	3.008***	2.967***
	(0.754)	(0.703)
Observations	920	920
R-squared	0.15	0.14
Durbin Wu Hausman (DWH) Test	23.57	48.97
No of countries	42	42

Notes: Robust standard errors are in parentheses. *, ** and *** denote significance at the 10, 5 and 1% levels, respectively.

Table 6: Impact of RCK savings rate and Climate finance on Climate Adaptation Policies (Full Sample); Dependent Variable (Climate Adaptation Policies).

Variables	Model 1	Model 2	Model 3	Model 4	Model 5
Economic growth	-0.2374	-0.2279	-0.2121	-0.2619	-0.2254
	(0.1187)*	(0.0897)**	(0.0754)**	(0.1636)	(0.11270)*
Climate Finance/Debt Swap Funding	0.0043	0.0039	0.0041	0.0038	0.0037
	(0.00100)	(0.0015)**	(0.0014)*	(0.0019)*	(0.0009)***
Physical Stock of capital	0.11034	0.1073	0.1078	0.1029	0.1084
	(0.0735)	(0.0422)*	(0.0383)**	(0.0343)***	(0.0542)*
Human capital	1.027	1.2161	0.9382	1.0002	1.1052
	(0.5135)*	(0.7896)	(0.3338)**	(0.6251)	(0.3696)**
Gender based RCK Saving Parameter	0.0494	0.0158	0.0523	0.0854	0.0392
	(0.0123)***	(0.0044)***	(0.0090)***	(0.0185)***	(0.0122)***
Growth Parameter$(n+g+\mho)$	-0.0231	-0.0417	-0.0611	-0.0291	-0.0638
	(0.0235)	(0.0198)	(0.0160)***	(0.0182)	(0.0581)
Trade Openness	0.1264	0.1897	0.1934	0.1328	0.1554
	(0.0632)*	(0.0746)**	(0.0688)**	(0.0664)*	(0.0777)*
GDP growth(-1)	0.6663	0.62765	0.6832	0.6812	0.5978
	(0.3331)*	(0.2471)***	(0.2431)***	(0.3406)*	(0.2989)*
Constant	1.2482	1.3942	1.3734	1.7991	1.3211
	(0.4710)**	(0.5488)**	(0.4887)**	(0.6919)**	(0.5977)**
Observations	920	920	920	920	920
Number of Groups	42	42	42	42	42
F /Wald test	(5.76)	(7.16)	(3.76)	(4.34)	(2.52)

The study uses the two-step SYSGMM approach, which considers it appropriate to control endogeneity and is suitable for cross-country differences(Jiang & Khan, 2023; Sinha & Vodwal, 2022). The two-step SYS-GMM is more efficient than first-difference estimators. This study employs a two-step SYS-GMM to produce asymptotically efficient values when the problem of heteroscedasticity is heavily embedded. The pre-SYS-GMM test Fixed Effects and random effects are given in Table 6.

The table displays the findings from five econometric models, each of which used a different collection of variables to analyze key aspects impacting economic growth. Economic growth is significantly correlated at different levels (10% to 5%) and negatively correlated across all models, with coefficients ranging from -0.2374 to -0.2121. Economic growth is constantly positively and significantly impacted by debt swap funding and climate finance, with coefficients between 0.0037 and 0.0043 that are significant at the 1% to 5% levels.

In all models, the physical capital stock shows a positive correlation with economic growth, with coefficients ranging from 0.1029 to 0.11034, most of which are significant. In most models, human capital has a substantial positive influence (though not always a large one), with coefficients hovering around 1.0. All models show that the gender-based RCK saving parameter has a positive and significant effect on economic development; coefficients range from 0.0158 to 0.0854, all of which are significant at the 1% level. With the exception of Model 3, where it is significant at the 1% level, the growth parameter exhibits a negative but generally non-significant impact on economic growth. In the majority of models, trade openness has a large and positive impact, with coefficients ranging from 0.1264 to 0.1934. With coefficients averaging 0.66, the delayed GDP growth variable is positively significant in all models, suggesting persistence in economic growth tendencies.

4. CONCLUSION

The study concludes that several important discoveries are highlighted by the study's use of five econometric models to analyze the factors driving economic growth. Economic growth consistently exhibits a negative connection across all models, indicating the possibility of underlying structural or external variables negatively affecting growth. However, funding for debt swaps and climate change emerges as major, consistent positive drivers of economic growth across models(Benhamed et al., 2023; Petrović, 2023; Zhao & Liu, 2023). This suggests that certain financial tools designed to combat climate change can significantly influence the promotion of economic

expansion. Both the human and physical capital stocks show strong positive returns, highlighting the role that infrastructure and skill development play in promoting economic growth and resilience. favorable effect, highlighting the contribution of gender-inclusive finance policies to economic expansion.

Furthermore, although the impact of trade openness on economic growth differs among models, the analysis shows that it generally has a favorable effect. The significance of the delayed GDP growth variable emphasizes the tenacity of growth trends and suggests that past economic performance can impact future growth paths. The growth parameter's negative coefficients indicate possible limits associated with population growth and capital depreciation, notwithstanding the variables' typically favorable effects. These constraints may require additional research. All things considered, the results point to the necessity of a multimodal strategy that includes trade integration, gender-inclusive policies, climate finance, and the development of human and physical capital. Policymakers seeking to strike a compromise between aims for gender parity, climate adaption, and economic development may find great assistance in these observations.

4.1 Policy Implication

The results of the study highlight how crucial it is to incorporate gender-inclusive strategies into policies for adapting to climate change in order to promote sustainable economic growth. Financial mechanisms that expressly target gender-responsive initiatives, such as debt swap funding and climate finance, should be prioritized by policymakers as they have been found to considerably boost economic growth and resilience. These benefits can be further amplified by making investments in human capital and physical infrastructure, with a focus on empowering women via skill development and education. Policies that encourage gender-based savings and financial inclusion are particularly crucial because they guarantee that women and other marginalized groups are better prepared to handle the risks associated with climate change in addition to contributing to economic stability (Ahmad et al., 2024).

4.3 Future Insight

Further investigations exploring the precise processes via which policies promoting gender-inclusive climate adaptation spur economic growth are warranted. This involves investigating how women's empowerment and financial inclusion can promote more resilient and sustainable economies both directly and indirectly. Insights into the long-term effects of these policies and recommendations for best practices for incorporating gender issues into more comprehensive economic and environmental initiatives may be obtained via longitudinal studies. It will also guarantee that policy recommendations are

both locally and globally relevant if research is broadened to encompass a wider range of socioeconomic and geographic contexts. Designing more focused and efficient initiatives that not only reduce climate threats but also advance gender equity and inclusive development would be made easier with the help of such thoroughassessments.

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Appendix

Table A: Gender Data for Climate Action: COP28 and Beyond

Section	Key Points
Introduction	Gender equality is a priority in COP28 to ensure women's equal participation and promote gender-responsive climate action.
Definition of Gender Data	Gender data captures information on the different lived experiences of women, men, and gender-diverse people, including data disaggregated by sex or gender, and data reflecting gender issues.
Definition of Gender-Responsive Climate Action	Gender-responsive climate action actively promotes gender equality by recognizing gender differences, ensuring equitable participation in decision-making, and distributing benefits equitably.
Importance of Gender Data in Climate Action	Gender data helps highlight the unique impacts of climate change on women, girls, and gender-diverse people and informs the design and monitoring of gender-responsive climate policies.
Challenges in Gender Data Collection	Efforts to collect and use gender data have been slow, with a lack of high-quality, regularly collected, and internationally comparable gender data.
COP28 Gender Data Priorities	Enhanced collection and use of gender data is crucial for advancing gender-responsive climate action at global, regional, and national levels, especially in the context of the Paris Agreement.
First Global Stock take	The first Global Stock take highlights the need for stronger outcomes emphasizing gender equality and social inclusion, and encourages the use of gender data in national climate actions.
Global Goal on Adaptation	Negotiations for the Global Goal on Adaptation should include gender targets and indicators, supported by the collection and use of gender data.
Strengthening Gender Data Beyond COP28	Parties should invest in gender data systems, enhance gender data collection and use in UNFCCC processes, and track participation of women, girls, and gender-diverse people in climate decision-making.

Table B: Mapping Gender Data Gaps in the Environment and Climate Change

Category	Information	Detail in Hand	Facts and Figures
Introduction	Gender data is crucial for understanding the impacts of climate change on women, girls, and gender-diverse people.	Women, girls, and gender-diverse people often have less access to and control over environmental resources. For example, in many regions, women are more likely to face health risks and food insecurity due to climate change (World Economic Forum) (UN Women).	**Investment in Gender-Responsive Climate Action**: Only 3% of climate finance goes to gender-responsive projects (UN Women) (UN Women).
Gender Data Definition	Gender data includes information on the different lived experiences of women, men, and gender-diverse people.	This data is both quantitative and qualitative, with collection methods accounting for stereotypes and social norms. Recent reports highlight the need for improved data to understand the intersection of gender and climate change impacts. (UN Women).	**Proportion of Women in Climate Decision-Making**: Women make up 38% of the delegates at COP28 (World Economic Forum) (UN Women).
Gender Data in Environmental Commitments	International commitments recognize the link between environment, climate change, and gender equality but lack targeted measures for gender	Only 20 out of 114 SDG indicators with an environmental focus require gender-specific and/or sex-disaggregated reporting (UNFCCC) (UN Women).	**Access to Clean Energy**: Only 20% of women in low-income countries have access to clean cooking solutions (UN Women).

	data collection.		
Gender Data Gaps	Key findings include lack of individual-level data, absence of standardized data collection methods, and insufficient disaggregation by age, race, etc.	Most environmental data is collected at the household level, which does not allow for intra-household gender differences. Data on gender-based violence in environmental contexts is especially lacking (World Economic Forum) (UN Women).	**Disaster Mortality**: Women are 14 times more likely than men to die during a disaster (UN Women).
Land Ownership and Security	Limited data on women's land ownership and security, collected mainly through national agricultural surveys and international databases.	Definitions of 'ownership' and 'secure rights' are difficult to operationalize for data collection. Recent efforts are focusing on better data collection methods (UNFCCC) (UN Women).	**Climate Displacement**: 80% of people displaced by climate change are women and girls (UN Women).
Natural Resource Management	Data on women's roles in natural resource management is often collected through national censuses and agricultural surveys.	Data on women's employment in natural resource sectors varies widely between countries, limiting comparability (UN Women) (UN Women).	**Gender-Based Climate Funding**: Approximately 0.01% of global climate finance is explicitly targeted towards gender equality (UN Women) (UN Women).

Water, Sanitation, and Hygiene	Household-level data on WASH is commonly collected but lacks individual-level analysis.	59% of countries produce data on safe drinking water access; 60% on safe sanitation and hygiene services. Women often bear the burden of securing water in areas affected by climate change (UN Women) (UN Women).	**Proportion of Women in Agriculture**: Women represent 43% of the agricultural labor force in developing countries, yet they have less access to resources and services compared to men (UN Women).
Clean Energy	Data on women's access to clean energy and employment in the clean energy sector is scarce.	Sex-disaggregated data on clean energy employment is especially hard to find. Efforts are being made to include more gender-specific data in this sector (UNFCCC) (UN Women).	**Access to Safe Water**: 70% of women in rural areas of developing countries do not have access to safely managed drinking water (UN Women).
Environmental Decision-Making	Tracking women's participation in environmental decision-making processes is essential for promoting gender-responsive policies.	The UNFCCC regularly reports on the gender and age composition of COP delegations and constituted bodies (UNFCCC) (UN Women).	**Impact on Health**: 60% of preventable maternal deaths occur in humanitarian settings and fragile contexts exacerbated by climate change (World Economic Forum).
Disaster Risk Management	Gender data is lacking in disaster risk management, despite acknowledgment of gender aspects in international frameworks.	The Sendai Framework indicators recommend but do not require disaggregation by sex, age, and disability (World Economic Forum) (UN Women).	**Representation in Climate Negotiations**: Women constituted 33% of the heads of delegations at the latest UN climate conference (UN Women).

Disaster-Related Mortality and Morbidity	Near-total absence of sex-disaggregated data on disaster-related mortality and morbidity.	Only 11 out of 85 countries disaggregated disaster-related mortality data by sex (UN Women).	**Climate-Related School Dropout Rates**: In climate-affected areas, school dropout rates for girls increase by 12% compared to non-affected areas (UN Women).
Climate Migration and	More data is needed on the gender dynamics of climate-induced migration and displacement.	UNHCR's 2022 Global Trends Report provides sex and age disaggregated data for 76% of refugees and displaced persons (UN Women).	**Employment in Clean Energy Sector**: Women hold 32% of jobs in the renewable energy sector globally (UN Women).
Sexual and Reproductive Health and	Linkages between climate change and sexual and reproductive health are recognized but not well measured.	Studies link climate change impacts with disruptions in sexual and reproductive health services, increasing risks of maternal and child health issues (World Economic Forum) (UN Women).	**Women's Land Ownership**: Only 13% of agricultural landholders worldwide are women (UN Women).
Gender-Based Violence	Awareness of the link between climate change and gender-based violence is growing but data remains insufficient.	Gender-based violence in environmental contexts includes control over land access and participation in climate justice movements (UN Women) (UN Women).	**Climate-Induced Food Insecurity**: By 2050, climate change is projected to increase the number of food-insecure women and girls by 132 million globally (UN Women) (UN Women).
Unpaid Care Work	Climate change impacts unpaid care work, increasing the time required for resource collection and care activities.	Extreme weather events increase unpaid care work for women and girls, such as time spent on resource collection (World Economic Forum) (UN Women).	**Gender-Based Violence in Climate Contexts**: In areas affected by climate change, incidents of gender-based violence can increase by up to 30% during and after disasters (UN Women).

Efforts to Improve Gender Data	Key efforts include development of gender-environment indicators, national and international data collection initiatives, and partnerships for local data collection.	Gender and Environment Statistics by IUCN and UNEP propose 19 gender-environment indicators (UNFCCC) (UN Women).	**Women's Participation in Disaster Risk Reduction**: Only 15% of countries have policies in place to ensure women's participation in disaster risk reduction planning and decision-making (World Economic Forum) (UN Women).

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