

Effect of financial inclusion and women empowerment on climate resilience: Evidence from sub-Saharan African households

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ABSTRACT

Inequality in financial inclusion (FI) exacerbates women's vulnerability, particularly those already affected by climate change, hindering their empowerment and limiting progress toward achieving sustainable development goals. The study analyzes the effect of FI on women's empowerment (WEP) and examines how WEP influences households' resilience to climate change in sub-Saharan Africa (SSA). Using cross-sectional data from 25,511 women-headed households in SSA, the study employs an instrumental-variables fractional probit model with country fixed effects to account for endogeneity and country-specific factors related to FI, WEP, and resilience. We find that FI significantly increase the probability of strengthening WEP, although the effects differ across dimensions. FI is negatively linked to the social dimension of WEP but positively associated with its economic and political dimensions. In turn, WEP increases the likelihood of improved household resilience to climate change and strengthens absorptive capacity, but it is negatively associated with adaptive and transformative capacities. These results are consistent when considering economic, social, and political dimensions of WEP. A nuanced assessment of the distinct dimensions of WEP is therefore essential for understanding how FI shapes resilience outcomes under climate change. These findings have important policy implications for sub-Saharan African countries in their efforts to achieve Sustainable Development Goal 13, which focuses on reducing climate-related risks. Policymakers should consider a multidimensional approach when designing strategies to address climate change in the region.

1. Introduction

The Sustainable Development Goals (SDGs) seek to promote inclusive growth and improve living standards by 2030 while ensuring equity and non-discrimination. SDG 5 specifically emphasizes gender equality in access to resources and calls for women's full participation in decision-making processes (Kpatcha et al., 2026; Monaco, 2024). Despite these commitments, substantial gender disparities in economic opportunities persist. Women account for nearly 70% of the world's poor, largely because of unequal access to education, finance, property rights, and labor markets in both developed and developing economies (Kpatcha et al., 2026; Ali, 2026; Sánchez-Páramo and Munoz-Boudet, 2018). WEP through education, literacy, skills development, and access to productive resources is

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central to reducing these inequalities (Dashti et al., 2023). Empowerment enables women to make strategic life choices and exercise greater control over economic and social outcomes (Kazembe, 2020). Economic empowerment strengthens women's capacity to manage income, assets, and risks while improving household welfare and expanding individual autonomy (Laszlo et al., 2020). However, access to economic resources remains highly uneven. In SSA, cultural norms and structural barriers continue to restrict women's participation in household and community decision-making (Aziz et al., 2022; Annan et al., 2021).

Beyond its intrinsic value, WEP contributes to poverty reduction, economic growth, and social resilience. FI is a critical channel for achieving empowerment. Access to formal financial services, including bank accounts, savings instruments, credit, and insurance, enhances women's economic agency and participation (Demirgüç-Kunt et al., 2020). Consequently, FI has become a major policy priority, particularly in developing countries (Ali, 2026; Kpatcha et al., 2026; Zelu et al., 2024; Ajwani-Ramchandani, 2017). Globally, account ownership increased from 51% in 2011 to 62% in 2014, and approximately 1.2 billion adults gained access to financial services between 2011 and 2017 (Demirgüç-Kunt et al., 2020). Nevertheless, disparities remain significant: while 94% of adults in high-income economies hold financial accounts, the corresponding figure in low-income countries is only 63% (Antunes et al., 2021). In SSA, women's FI has improved considerably over the past decade, with 49% of women holding accounts by 2021 (Zelu et al., 2024). Despite this progress, a persistent gender gap remains. Women are still less likely than men to own formal accounts and often depend on male relatives to access financial services (Dashti et al., 2023). These disparities indicate that expanding financial access alone is insufficient; policies must also address structural and socio-cultural barriers that limit women's financial autonomy.

The literature identifies several mechanisms through which FI promotes WEP. First, access to financial services increases women's bargaining power within households by giving them greater control over financial resources (Ali, 2026; Kpatcha et al., 2026; Ajwani-Ramchandani, 2017). Second, participation in formal financial systems facilitates asset accumulation (Ali and Awume, 2025) and long-term economic security. Third, access to insurance and savings instruments strengthens women's ability to manage risk and withstand economic shocks (Aker, 2022). However, discriminatory legal systems, restrictive banking practices, and entrenched gender norms continue to constrain women's financial independence in many countries (Ghosh and Vinod, 2017; Rughoobur-Seetah et al., 2022; Sahay and Cihak, 2018).

Climate change further intensifies these vulnerabilities. Environmental shocks such as droughts, floods, sea-level rise, and soil degradation disproportionately affect women, children, and low-income households, particularly in developing economies and small island states (Maja and Ayano, 2021). Because many communities in SSA depend heavily on natural resources for livelihoods, climate-related disruptions increase poverty, food insecurity, displacement, and competition over scarce resources (Moharaj and Rout, 2020). Women are especially vulnerable due to unequal access to land, education, healthcare, and information. These inequalities are often compounded by conflict, weak institutions, and social exclusion (Ali et al., 2026).

At the same time, women play a critical role in climate adaptation and resilience. Although women produce between 50 and 80% of the world's food, they own less than 10% of global land assets and are disproportionately represented among poor households (Sánchez-Páramo and Munoz-Boudet, 2018). Their contributions as caregivers, farmers, educators, and community leaders position them as essential actors in climate resilience strategies (Laszlo et al., 2020). The relationship between FI and WEP has attracted growing attention in the economic literature. Existing studies generally suggest that improved access to financial services enhances women's economic outcomes, although the extent of these effects differs across countries and institutional settings (Zelu et al., 2024; Adera and Abdisa, 2023; Arshad, 2023; Aziz et al., 2022; Pal et al., 2022). Despite this growing body of evidence, important gaps remain in SSA context. In particular, limited research has examined how FI influences the multiple dimensions of WEP and climate resilience at the household level. Most existing studies focus on narrow economic indicators, thereby overlooking the multidimensional nature of empowerment and resilience, including social, decision-making, and adaptive capacity dimensions.

Recent empirical studies provide important insights. Using data from the Ghana Living Standards Surveys, Zelu et al. (2024) found that ownership of formal financial accounts significantly enhances WEP, whereas informal financial participation has no statistically significant effect. Maruta et al. (2023) similarly concluded that FI positively affects WEP across different income groups. In Ethiopia, Adera and Abdisa (2023) employed instrumental variable and endogenous switching regression techniques and reported that improved access to financial services leads to better economic outcomes for women. Using panel data from emerging economies between 2004 and 2019, Arshad (2023) showed that FI positively influences WEP, while gender discrimination undermines it. Aziz et al. (2022), applying multilevel logistic regression models in South Asia, found that women are significantly less likely than men to own bank accounts, especially in societies where cultural and religious norms restrict female labor force participation. Similarly, Pal et al. (2022), studying rural India, demonstrated that women's earnings, participation in financial decision-making, and access to social assistance programs significantly enhance empowerment outcomes. Therefore, FI as a supportive public policy, and women's participation in economic decision-making are key determinants of WEP while strengthening household welfare and climate resilience.

From the perspectives of WEP and climate resilience, access to economic resources is critical for adapting to climate change. Timely climate information enables women to make informed agricultural decisions and reduce income losses associated with weather shocks (Barooah et al., 2022). Similarly, access to credit strengthens adaptive capacity by providing financial buffers, while market access supports stable livelihoods through fair pricing of agricultural products. FI remains an important yet understudied mechanism linking WEP and climate resilience. Existing studies largely rely on macro-level data and partial measures of WEP, FI, and climate resilience, limiting their relevance for household-level analysis in SSA. Methodological inconsistencies further weaken the reliability of policy recommendations.

Using cross-sectional data from 25,511 women-headed households in SSA, the study employs an instrumental-variables fractional probit model with country fixed effects to account for endogeneity and country-specific factors. Following Ali (2026) and Roy et al. (2019), we employ both aggregated and disaggregated indicators of households' resilience to climate change. Findings show that FI significantly increases the probability of strengthening WEP, although the effects differ across dimensions. Furthermore, WEP

increases the likelihood of improved household resilience to climate change and strengthens absorptive capacity, but it is negatively associated with adaptive and transformative capacities. These results suggest a nuanced assessment of the distinct dimensions of WEP and considering a multidimensional approach when designing strategies to address climate change in regions like SSA.

The organization of this paper is outlined as follows: [Section 2](#) presents a brief literature review, and [Section 3](#) explains the methodological framework used in the study. [Section 4](#) discusses the empirical results and their implications. Lastly, [Section 5](#) provides concluding observations, explores policy implications, and proposes directions for future research.

2. Women's financial inclusion and climate resilience: A literature review

The relationship between women's FI, empowerment, and climate resilience is grounded in complementary theoretical traditions that emphasize agency, resource control, and adaptive capacity. The capability approach developed by Sen (1999) provides a foundational framework by conceptualizing development as the expansion of individuals' freedoms and capabilities to pursue valued life outcomes. Within this framework, access to financial services enhances women's economic capabilities by expanding their opportunities to make strategic decisions regarding production, consumption, and household welfare. FI therefore strengthens women's agency and their capacity to respond to economic and environmental shocks.

This perspective is reinforced by intra-household bargaining theory, which argues that control over independent financial resources increases women's bargaining power within households and enhances their participation in decision-making processes ([Doss, 2013](#); [Laszlo et al., 2020](#)). Feminist economics similarly emphasizes that ownership and control of financial assets improve women's fallback positions and shift intra-household power relations in their favor ([Nacka et al., 2025](#)). Greater financial autonomy enables women to allocate resources toward welfare-enhancing and resilience-building investments such as food security, healthcare, education, agricultural adaptation, and risk management strategies ([Ali and Awume, 2025](#); [Kpatcha et al., 2026](#)). Empirical research

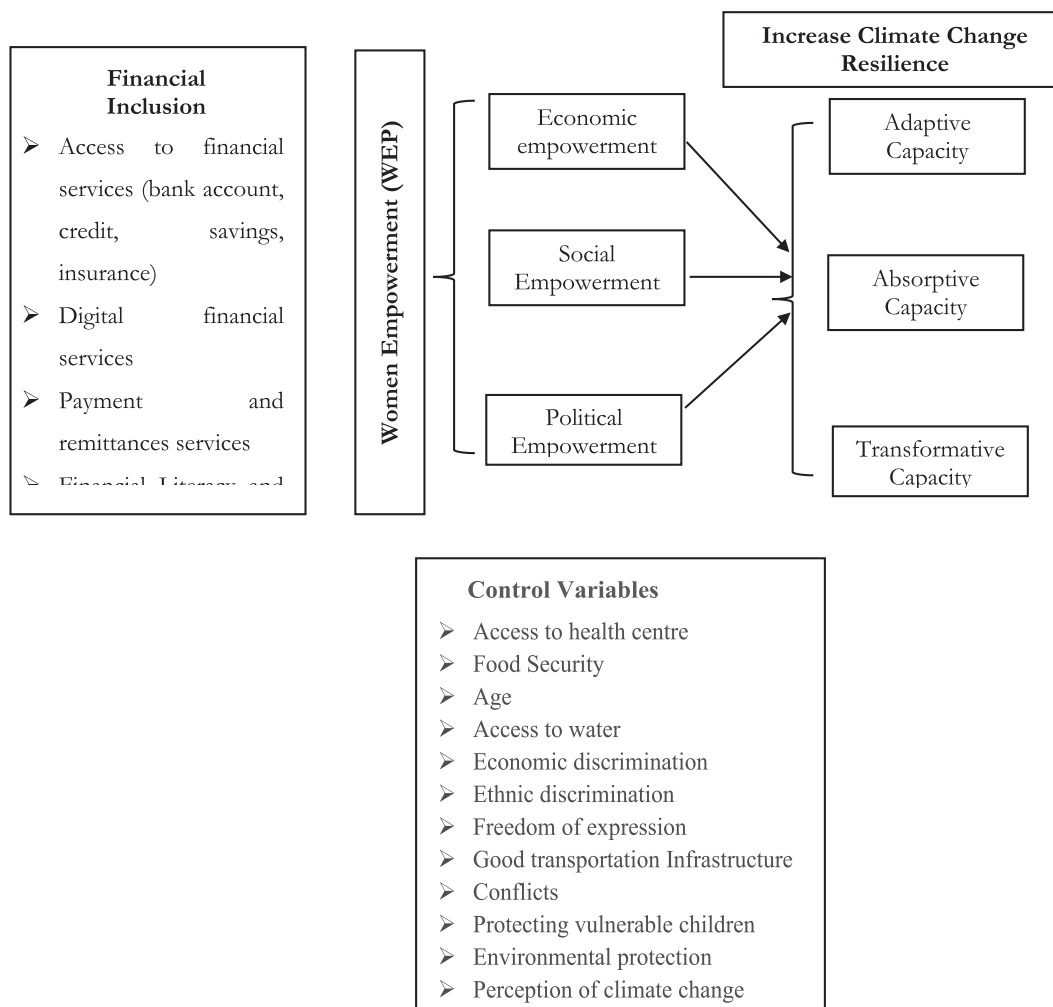


Fig. 1. Conceptual framework linking FI, WEP and climate resilience.

further suggests that women with stronger financial control tend to adopt more precautionary and long-term oriented decisions, attributes that are particularly important in climate-vulnerable contexts (Duflo, 2012).

Against this theoretical background, a growing empirical literature has examined the role of FI in advancing WEP across Africa. At the macro level, Asaloko et al. (2026), Maruta et al. (2023). Employing Principal Component Analysis to construct indicators of FI, the authors distinguish among financial access, usage, and service quality. Their findings indicate that FI significantly improves WEP, measured through the female Human Development Index. Among the three dimensions, financial access exerts the strongest effect, with impacts particularly pronounced in low- and lower-middle-income countries. These results suggest that expanding access to formal financial systems can contribute meaningfully to reducing gender disparities and promoting inclusive development.

Micro-level evidence corroborates these findings (Alom et al., 2025; Showkat et al., 2024a; Xue et al., 2024; Han et al., 2023). Using evidence from India and China, Showkat et al. (2024b) and Han et al. (2023) demonstrate the transformative role of digital finance in advancing WEP through greater financial access, autonomy, and decision-making capacity. Showkat et al. (2024a) find that digital financial services significantly improve women's financial independence in North India. Complementing this evidence, Han et al. (2023) show that digital finance enhances women's household bargaining power by facilitating entrepreneurship, labor force participation, and access to financial markets, although these effects vary across household and regional contexts. Together, these studies highlight the potential of digital finance in environments with limited physical banking infrastructure.

Beyond empowerment, recent studies increasingly examine how women's agency contributes to climate resilience and environmental sustainability. In Zimbabwe, Moyo et al. (2026) show that women play critical roles in resilience-building through resource management, involvement in decision making, and community-based adaptation practices. Nevertheless, these contributions are constrained by inadequate access to productive resources, limited financing, and exclusion from governance structures.

Macro-econometric evidence further strengthens the empowerment–resilience nexus. Using a system Generalized Method of Moments estimator for 50 African countries, Achuo et al. (2022) demonstrate that women's socioeconomic empowerment positively influences environmental sustainability. Complementing this finding, Asongu et al. (2022) show that women's political empowerment significantly reduces climate vulnerability across 169 developing countries, although the magnitude of the effect varies across regions and income groups. Finally, evidence from Cameroon indicates that improvements in women's education, healthcare access, asset ownership, and household decision-making power significantly reduce multidimensional poverty (Soh Wenda et al., 2024). Since lower poverty enhances households' adaptive capacity, these findings suggest that WEP indirectly strengthens climate resilience. FI can, therefore, constitutes an important pathway through which WEP and climate resilience can be simultaneously advanced. Fig. 1 shows the conceptual framework establishing the link among FI, WEP, and climate resilience. This framework elucidates how these elements are not isolated but deeply interconnected. From the Fig. 1, FI serves as a foundational pillar, enabling access to financial services that empower individuals and communities economically.

This economic empowerment of women is crucial as it fosters autonomy, decision-making power, and social capital, which are essential components of WEP. WEP, in turn, acts as a catalyst for enhancing climate resilience. Empowered women often lead community initiatives, adopt sustainable practices, and influence policies that mitigate climate risks. The framework's arrows indicating direct, indirect (the most underexplored link), and contextual influences underscore the dynamic feedback loops where improvements in one domain reinforce progress in others. Control Variables provide the contextual backdrop, factors such as socio-political environment, cultural norms, and economic conditions, that have direct relationship with climate resilience.

3. Materials and methods

3.1. Data

This study uses cross-sectional data from the ninth wave of Afrobarometer to examine the relationship between FI and WEP, and the subsequent effect of WEP on climate change resilience in SSA Afrobarometer is a pan-African research network that conducts nationally representative surveys across African countries to support research and policymaking (Afrobarometer, 2025). The surveys cover diverse themes, including governance, poverty, energy, environmental issues, democracy, health, education, and security. The analysis includes 37 sub-Saharan African countries selected based on data availability (Fig. 2).

Following FAO (2008), resilience is defined as the capacity of social, economic, and ecological systems to absorb, adapt to, and recover from shocks while maintaining essential functions and supporting long-term transformation. Drawing on households' socioeconomic characteristics, this study constructs a household resilience index (a continuous variable scaled between 0 and 1), using the FAO's Resilience Index Measurement and Analysis (RIMA) framework (FAO, 2008). The RIMA approach evaluates households' ability to withstand and recover from shocks, including food insecurity, climate variability, and economic crises, and has been widely used in the literature (Ali, 2026; Bhatia and Singh, 2019; Roy et al., 2019; Food and Agriculture Organization of the United Nations, 2008). A resilience index close to 1 indicates a high level of household resilience to climate change, whereas an index close to 0 indicates a low level of resilience capacity.

The analysis emphasizes three interrelated dimensions of resilience: absorptive, adaptive, and transformative capacities (Ali, 2026; Ospina and Rigaud, 2021). These dimensions are particularly relevant for women-headed households in SSA, whose livelihoods often depend on climate-sensitive smallholder agriculture and informal activities. Absorptive capacity enables households to cope with immediate shocks through mechanisms such as savings groups and community support, while adaptive capacity facilitates livelihood diversification and climate-smart agricultural practices. Rooted in Sen's capabilities approach, these capacities expand women's agency, autonomy, and decision-making opportunities under conditions of uncertainty (Sen, 1999).

FI is the primary independent variable in this study. In SSA, FI fosters entrepreneurship and small business development, both of

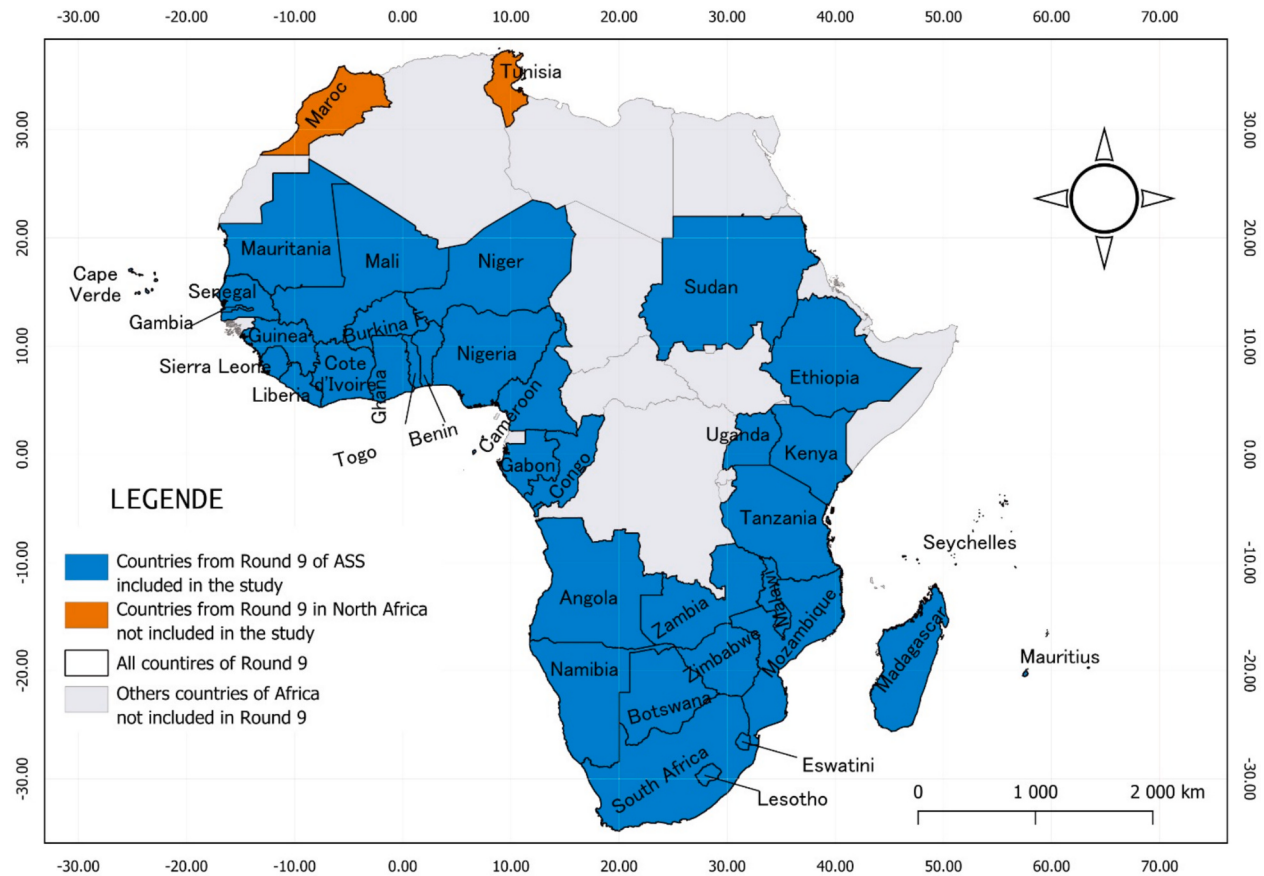


Fig. 2. Geographic coverage of the study.

which are critical for economic development. Beck et al. (2007) argue that access to financial services improves resource allocation and productivity. FI also enables women to access credit and savings, facilitating business creation, investment in education, and improvements in household welfare (Kpatcha et al., 2026; Ali, 2026; Arshad, 2023; Bhatia and Singh, 2019). Ali (2026) and Kpatcha et al. (2026) use the OECD framework to construct a FI index based on bank account ownership, mobile phone ownership, access to financial networks, and internet access (OECD, 2022). Following this established approach, the present study also adopts the OECD framework to measure FI as an index scaled between 0 and 1.

WEP has gained increasing scholarly attention because of its role in improving women's mobility and participation in decision-making (Aziz et al., 2022). Drawing on Pal et al. (2022) and Bhatia and Singh (2019), this study conceptualizes WEP through three dimensions: social, economic, and political empowerment. Social empowerment reflects women's social connectedness and status within households and communities, while economic empowerment captures women's control over resources, access to opportunities, and financial security (Pal et al., 2022). Political empowerment emphasizes women's participation in leadership, representation, education, and voting rights, all of which contribute to broader socio-economic development (Bayeh, 2016).

The data show that the FI index in SSA averages 0.7435, exceeding the global WEP index of 0.6774 (Table 1). Within the WEP dimensions, economic (0.6758) and political (0.6881) empowerment are relatively strong, whereas social empowerment remains lower (0.5857). Women's climate resilience averages 0.6753, characterized by high absorptive capacity (0.7362) but limited adaptive (0.2792) and transformative (0.4055) capacities. These findings suggest that although women in SSA can absorb climate shocks, weak adaptive and transformative capacities may constrain long-term sustainability.

3.2. Empirical strategy

Following Papke and Wooldridge (2008), we use the instrumental variable fractional probit model to analyze fractional response data. This approach addresses the limitations of the standard log-odds transformation. It also accommodates the extreme values of zero and one in the response variable. The model incorporates the “general estimation equation”. The model assumes a normal distribution and can be set as follows:

$$E(Y_{it}|X_{it}, c_i) = \Phi(X_{it}\beta_i + c_i) \quad (1)$$

where Y_{it} is the outcome variable, $0 \leq Y_{it} \leq 1$; c_i represents the unobserved establishment effect, while Φ denotes the standard normal cumulative distribution function. The marginal effects are influenced not only by the estimated β_i but also by the density function ϕ .

$$\frac{\partial E(Y_{it}|X_{it}, c_i)}{\partial X_{it}} = \beta_i \phi(X_{it}\beta_i + c_i) \quad (2)$$

Given the cumulative distribution function, the direction of the partial effects is indicated by the value of β . It is regrettably impossible to compute the partial effect from the equation due to the unseen nature of c_i . One way to compute the coefficients is to

Table 1
Descriptive statistics.

Variables	Nature	Observations	Mean	Std. dev	Min	Max
Women Empowerment	Continuous	25,511	0.6774	0.2211	0	1
i. Women social empowerment	Continuous	25,511	0.5857	0.1841	0	1
ii. Women economic empowerment	Continuous	25,511	0.6758	0.3273	0	1
iii. Women political empowerment	Continuous	25,511	0.6881	0.2757	0	1
Climate change resilience	Continuous	25,511	0.6753	0.2109	0	1
i. Adaptation capacity	Continuous	25,511	0.2792	0.2399	0	1
ii. Absorption capacity	Continuous	25,511	0.7362	0.2952	0	1
iii. Transformation capacity	Continuous	25,511	0.4055	0.1862	0	1
Financial inclusion	Continuous	25,511	0.7435	0.2307	0	1
Controle variables			Mean			
Age	Continuous	25,511	39.16	15.49	18	112
Area of residence	Binary	25,511	0.4537	0.4978	0	1
Education: Secondary above	Binary	25,511	0.5703	0.4950	0	1
Access to water	Binary	25,511	0.5601	0.4963	0	1
Access to health center	Binary	25,511	0.3006	0.4585	0	1
Price instability	Binary	25,511	0.8648	0.3418	0	1
Economic discrimination	Binary	25,511	0.8077	0.3940	0	1
Ethnic Discrimination	Binary	25,511	0.3749	0.4841	0	1
Conflicts	Binary	25,511	0.2500	0.4330	0	1
Access to electricity	Binary	25,511	0.6682	0.4708	0	1
Owning TV	Binary	25,511	0.6431	0.4790	0	1
Protecting vulnerable children	Binary	25,511	0.4586	0.4982	0	1
Environmental protection	Binary	25,511	0.4167	0.4930	0	1
Perception of climate change impact on countries	Binary	25,511	0.5931	0.4912	0	1
Good transport infrastructure	Binary	25,511	0.4219	0.4938	0	1
Full time job status	Binary	25,511	0.2559	0.4364	0	1
Freedom of expression	Binary	25,511	0.2788	0.4484	0	1

simulate the distribution of c_i , given strictly exogenous covariates X_{it} , then average the individual partial effects (Papke and Wooldridge, 2008). It follows:

$$E_c[\beta_i \varnothing(X_{it}\beta_i + c_i)] = \beta_i E_c[\varnothing(X_{it}\beta_i + c_i)] \quad (3)$$

In contrast to c , these average partial effects rely on β and $\mathbf{X}$ (Papke and Wooldridge, 2008).

$$E(Y_{it}|X_{it}, c_i) = \varnothing(X_{it}\beta_i + c_i) \quad (4)$$

with $t = 1, \dots, T$ and $X_i = (x_{i1}, \dots, x_{iT})$

In the light of this study, the instrumental variable fractional probit regression is adopted to achieve the two objectives since the dependent variables (WEP and climate change resilience indices) are continuous and proportion bounded between 0 and 1. This fractional probit regression is employed with an instrumental variable to address the issue of endogeneity. In eq. 5, the study assesses the effect of FI on WEP. This associated fractional probit model is specified as follows:

$$E(WEP_i|FI_i, X_i) = \varphi(\beta_0 + \beta_i FI_i + X_i \beta) + \lambda_j + \varepsilon_i \quad (5)$$

where WEP_i is the women empowerment represented by index, social, economic or political empowerment, FI_i is the financial in-

Table 2
effect of financial inclusion on women empowerment.

Variables	(1)	(2)	(3)	(4)
	Women Empowerment	Dimensions of women empowerment		
		Social Dimension	Economic Dimension	Political Dimension
Financial inclusion	0.2994*** (0.031)	-0.0609*** (0.024)	0.2705*** (0.047)	0.3389*** (0.040)
Access to health Centre	0.0256*** (0.008)	0.0215*** (0.006)	0.0371*** (0.013)	0.0209* (0.011)
Food security	0.0147* (0.008)	0.0344*** (0.006)	0.0249* (0.013)	0.0100 (0.011)
lnAge	0.2462 (0.169)	-0.3325*** (0.127)	0.0019 (0.255)	0.4202* (0.220)
lnAge_Square	-0.0260 (0.023)	0.0541*** (0.018)	0.0126 (0.035)	-0.0525* (0.030)
Access to water	0.0064 (0.008)	0.0448*** (0.006)	0.0267** (0.012)	-0.0064 (0.011)
Economic discrimination	0.0296*** (0.010)	-0.0458*** (0.008)	-0.0620*** (0.015)	0.0922*** (0.013)
Ethnic discrimination	-0.0200** (0.008)	-0.0863*** (0.006)	-0.0806*** (0.013)	0.0195* (0.011)
Freedom of expression	0.0175** (0.008)	-0.0096 (0.006)	0.0056 (0.013)	0.0277** (0.011)
Good transport infrastructure	0.0101 (0.009)	0.0403*** (0.007)	0.0314** (0.013)	-0.0019 (0.011)
Conflicts	-0.0232** (0.010)	-0.0837*** (0.007)	-0.0305** (0.014)	-0.0223* (0.013)
Protecting vulnerable children	0.0772*** (0.009)	0.0885*** (0.007)	0.1375*** (0.013)	0.0430*** (0.011)
Environmental protection	0.0229*** (0.009)	0.0260*** (0.007)	0.0456*** (0.013)	0.0087 (0.011)
Perception of climate change impact	-0.0787*** (0.008)	-0.0490*** (0.006)	-0.0558*** (0.012)	-0.1037*** (0.010)
Region (Southern Africa = 0)				
1. West Africa	0.3698*** (0.037)	0.1140*** (0.027)	0.3112*** (0.054)	0.4386*** (0.047)
2. Eastern Africa	0.1047*** (0.032)	0.0470* (0.024)	-0.2430*** (0.046)	0.3838*** (0.041)
3. Central Africa	0.1284*** (0.036)	0.0399 (0.028)	-0.1332*** (0.051)	0.3330*** (0.047)
Constant	-0.4066 (0.303)	0.6923*** (0.228)	0.1697 (0.457)	-0.8223** (0.394)
athrho2_1	-0.0399*** (0.006)	0.0126*** (0.005)	-0.0458*** (0.010)	-0.0380*** (0.008)
lnsigma2	-1.7743*** (0.005)	-1.7743*** (0.005)	-1.7743*** (0.005)	-1.7743*** (0.005)
Observations	25,511	25,511	25,511	25,511
Wald chi2	3601***	4285***	4739***	1352***
Wald test of exogeneity: chi2(1)	38.68***	6.80***	22.90***	21.02***
Country fixed-effect	Yes	Yes	Yes	Yes

Robust standard errors in parentheses; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

clusion, φ is the predicted value of WEP_i which remains between 0 and 1, β_0 is the constant, β_i is the coefficient of FI, $X_i\beta$ represents the effects of the explanatory variables and ε_i is the error term. The parameter λ_j represents the fixed effect for country (j) accounting for variations in WEP influenced by country-specific factors. Differences in economic size and political influence across countries can have distinct impacts on WEP, and this fixed-effect term ensures these country-level disparities are appropriately controlled for in the analysis. FI may be endogenous in estimating its effect on WEP, as empowered women may be more likely to use financial services, while unobserved socioeconomic or cultural factors may affect both outcomes (Kpacha et al., 2026). To address this issue, the study uses instrumental variables linked to FI: area of residence, access to electricity, full-time employment, educational attainment, and television ownership. These factors influence access to financial infrastructure, digital finance, financial literacy, stable income channels, and exposure to financial information, making them strong predictors of participation in formal financial systems. The second objective which examines the effect of WEP on climate change resilience is stated in the model in eq. 6.

$$E(CR_i|WEP_i, X_i) = \varphi (\beta_0 + \beta_i WEP_i + X_i\beta) + \delta_j + \varepsilon_i \quad (6)$$

where CR_i is the climate resilience index, φ is the predicted value of CR_i which remains between 0 and 1, β_0 is the constant, β_i is the coefficient of FI, $X_i\beta$ represents the effects of the explanatory variables and ε_i is the error term. The parameter δ_j captures the fixed effect for country (j) accounting for variations in climate change resilience influenced by country-specific factors. This fixed-effect term ensures these country-level disparities are appropriately controlled for in the analysis. Based on Eqs. 5 and 6, and following Adera and Abdisa (2023) and Zelu et al. (2024), we estimate the effect of WEP on household resilience to climate change using instrumental variables approach since WEP may be endogenous. To address this issue, the study uses instrumental variables linked to WEP notably: area of residence, access to electricity, full-time employment, water access. Area of residence, full-time employment, and access to water are expected to shape women's empowerment. Urban residence often improves access to education, markets, infrastructure, information, and decision-making opportunities. Full-time employment strengthens women's economic independence, bargaining power, and control over resources. Improved water access reduces time spent collecting water, enabling greater participation in productive and household activities.

4. Results and discussions

4.1. Financial inclusion: A pathway to empowering women

Table 2 reports the instrumental variable fractional probit estimates of the effect of FI on WEP and its social, economic, and political dimensions. The Wald tests of exogeneity are statistically significant across all specifications, confirming the presence of endogeneity in FI and justifying the use of the IV approach. Country fixed effects are included in all models to account for unobserved heterogeneity across countries. The estimates indicate that FI is positively and significantly associated with overall WEP. The coefficient reported in column (1) suggests that women with greater access to and use of formal financial services exhibit higher levels of empowerment. This result is consistent with Jose and Younas (2023) and related studies that document a positive relationship between financial access and women's economic autonomy, bargaining position, and participation in household and community activities. Access to savings, credit, insurance, and digital payment systems is often associated with greater participation in income-generating activities and improved management of household resources, which may strengthen women's agency and decision-making capacity.

The disaggregated results reveal substantial heterogeneity across dimensions of empowerment. Financial inclusion is positively associated with economic empowerment (column 3) and political empowerment (column 4), while the coefficient for the social dimension is negative and statistically significant (column 2). The largest coefficient is observed for political empowerment, where the estimate of 0.3389 indicates a strong positive association between FI and women's participation in political and civic activities.

This pattern is consistent with the view that access to financial resources may be linked to greater participation in community organizations, leadership activities, and public decision-making processes (Xue et al., 2024). Similarly, the positive coefficient for economic empowerment suggests that financially included women are more likely to participate in productive activities and exercise greater control over economic resources. This finding aligns with evidence in the literature showing that financial access is associated with entrepreneurship, asset accumulation, and improved capacity to manage income fluctuations (Asaloko et al., 2026, Alom et al., 2025 Showkat et al., 2024b; Han et al., 2023). By contrast, the negative association between financial inclusion and social empowerment suggests that improvements in financial access do not necessarily correspond to immediate gains in social dimensions of empowerment. One possible interpretation is that social norms, gender roles, and cultural constraints continue to shape women's social participation even when access to financial services expands. This result may also indicate that the social dimension of empowerment responds more slowly to changes in economic opportunities and therefore may depend on complementary institutional and social interventions. Several control variables are also significantly associated with WEP outcomes.

Access to health centers is positively associated with overall empowerment and most sub-dimensions, highlighting the relevance of healthcare access for women's welfare and participation. Food security is positively associated with overall, social, and economic empowerment, although its relationship with political empowerment is not statistically significant. In contrast, conflict and perceived climate change impacts are negatively associated with empowerment across most specifications, suggesting that insecurity and environmental stress are correlated with weaker empowerment outcomes. The coefficients on the regional indicators reveal notable regional variation relative to Southern Africa. Women in West Africa exhibit higher levels of overall, economic, and political empowerment. Eastern and Central Africa are also positively associated with political empowerment, although both regions display lower economic empowerment relative to Southern Africa.

Overall, the findings suggest that FI is strongly associated with WEP in SSA, particularly in the economic and political dimensions. At the same time, the negative coefficient for social empowerment indicates that financial access alone may not be sufficient to address persistent social and cultural barriers affecting women's status and participation. These results point to the importance of combining FI policies with broader institutional, educational, and gender-focused interventions to support more balanced empowerment outcomes across dimensions.

4.2. Transformative potential of women's empowerment in climate resilience frameworks

This section examines the effect of WEP on climate change resilience in SSA using an instrumental variable fractional probit model. The Wald tests of exogeneity are statistically significant across all specifications, confirming the appropriateness of treating WEP as endogenous. The significant Wald chi-square statistics further indicate the overall goodness-of-fit of the models. The results in Table 3 show that WEP exerts a statistically significant influence on climate resilience outcomes, although the direction and magnitude differ across resilience dimensions. In column (1), WEP is positively associated with overall climate change resilience at the 1% significance level. This finding suggests that greater empowerment of women enhances households' and communities' ability to withstand and respond to climate-related shocks. The result is consistent with previous studies emphasizing that women's access to education, productive resources, financial services, and decision-making processes strengthens resilience and improves adaptation outcomes (Agarwal, 2010; Meinzen-Dick et al., 2019).

However, the estimated effects across the three resilience dimensions reveal important heterogeneity. In column (2), WEP is

Table 3
Effect of women empowerment on climate change resilience.

Variables	(1)	(2)	(3)	(4)
	Climate change Resilience	Dimensions of Climate change Resilience		
		Adaptive Capacity	Absorption Capacity	Transformation Capacity
Women empowerment	3.2328*** (0.141)	-4.4334*** (0.167)	4.8009*** (0.028)	-4.7146*** (0.050)
LnAge	-0.1011** (0.039)	-0.0063 (0.299)	-0.2418 (0.310)	0.6588** (0.284)
lnAge_Square	0.0145*** (0.005)	0.0244 (0.042)	0.0242 (0.043)	-0.0763* (0.039)
Price instability	0.0034 (0.002)	-0.0709*** (0.022)	0.0107 (0.019)	-0.0120 (0.019)
Economic discrimination	-0.0144*** (0.003)	0.0065 (0.021)	-0.0639*** (0.017)	0.0620*** (0.017)
Ethnic discrimination	-0.0080*** (0.002)	-0.0755*** (0.015)	0.0381*** (0.014)	-0.0343** (0.014)
Freedom of expression	-0.0047** (0.002)	0.0362*** (0.013)	-0.0282** (0.014)	0.0292** (0.014)
Conflicts	-0.0059** (0.002)	-0.0852*** (0.018)	0.0370** (0.017)	-0.0469*** (0.017)
Owning TV	-0.0101** (0.004)	0.0411 (0.025)	-0.0861*** (0.023)	0.0851*** (0.018)
Protecting vulnerable children	0.0059 (0.005)	0.1607*** (0.014)	-0.1335*** (0.015)	0.1417*** (0.014)
Environmental protection	0.0007 (0.002)	0.0616*** (0.015)	-0.0308** (0.015)	0.0434*** (0.015)
Good transport infrastructure	0.0042** (0.002)	0.0558*** (0.014)	-0.0349** (0.014)	0.0215 (0.015)
Region (Southern Africa = 0)				
1.West Africa	-0.0478** (0.023)	0.5258*** (0.076)	-0.6816*** (0.062)	0.6604*** (0.062)
2.Eastern Africa	-0.0619*** (0.012)	0.0813 (0.076)	-0.2726*** (0.060)	0.2722*** (0.058)
3.Central Africa	-0.0539*** (0.013)	0.0727 (0.082)	-0.3071*** (0.064)	0.2745*** (0.065)
Constant	-1.4418*** (0.081)	2.2995*** (0.500)	-2.2484*** (0.556)	1.4237*** (0.513)
athrho2_1	-0.0652** (0.031)	1.5626*** (0.218)	-2.9740*** (0.373)	2.3043*** (0.225)
lnsigma2	-1.5735*** (0.004)	-1.5734*** (0.004)	-1.5731*** (0.004)	-1.5734*** (0.004)
Observations	25,511	25,511	25,511	25,511
Wald chi2	93516**	20214***	47991***	21546***
Wald test of exogeneity: chi2(1)	4.53**	51.60***	63.56***	104.78***
Country Fixed-effect	Yes	Yes	Yes	Yes

Robust standard errors in parentheses; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

negatively associated with adaptive capacity and statistically significant at the 1% level. This result implies that, despite improvements in overall resilience, empowered women may still face constraints in engaging effectively in long-term adaptation planning and adjustment strategies. In many SSA contexts, women continue to shoulder disproportionate responsibilities related to household management, caregiving, and income generation, which can limit the time and resources available for sustained adaptive investments (Koomson, 2024). Moreover, persistent institutional barriers, including unequal land rights, limited access to credit, and sociocultural restrictions, may reduce the extent to which empowerment translates into stronger adaptive capacity (Nosheen et al., 2023). By contrast, column (3) indicates that WEP has a positive and statistically significant effect on absorptive capacity. This suggests that empowered women are better able to support short-term coping mechanisms and immediate responses to climate shocks. Women's participation in community networks and informal support systems may strengthen households' ability to absorb and manage climate-related risks. This finding corroborates evidence showing that women often play a central role in mobilizing social capital, preserving indigenous knowledge, and coordinating household-level risk management strategies during environmental crises (Khadka and Schuett, 2024).

The estimates in column (4) further show that WEP is negatively and significantly associated with transformative capacity. This result indicates that empowerment at the household or individual level may not necessarily translate into broader structural transformation. Deeply entrenched political, economic, and institutional inequalities across many SSA countries may continue to constrain women's ability to influence systemic changes required for long-term climate resilience. Although women may gain greater agency in household decision-making, their participation in formal governance structures and climate policy processes often remains limited. Consequently, structural transformation toward climate-resilient systems may require broader institutional reforms beyond individual empowerment interventions alone.

Among the control variables, economic discrimination, ethnic discrimination, and conflicts generally reduce overall climate resilience, highlighting the importance of social cohesion and inclusive institutions in resilience-building processes. Similarly, regional differences remain substantial, with West, Eastern, and Central Africa displaying significantly different resilience patterns relative to Southern Africa. Overall, the findings underscore the multidimensional relationship between WEP and climate resilience in SSA. While empowerment strengthens overall resilience and absorptive capacity, its negative association with adaptive and transformative capacities suggests that empowerment alone is insufficient to overcome structural constraints. Policies aimed at enhancing climate resilience should therefore complement WEP initiatives with institutional reforms that expand women's access to land, finance, education, and political participation. Strengthening gender-responsive governance frameworks and reducing structural inequalities will be essential for translating WEP into sustained and comprehensive climate resilience outcomes.

4.3. Strengthening climate change resilience through women's economic empowerment

Table A1 reports estimate from the instrumental variable fractional probit model with country fixed effects examining the association between women's economic empowerment and climate change resilience and its dimensions. The results indicate that women's economic empowerment is significantly associated with overall climate resilience and with the different resilience dimensions considered in the analysis. The statistically significant Wald tests of exogeneity further support the appropriateness of the instrumental variable specification. Column (1) shows a positive and statistically significant association between women's economic empowerment and overall climate change resilience. The estimated coefficient suggests that higher levels of women's economic empowerment are correlated with stronger resilience outcomes. This finding is consistent with earlier studies arguing that women's participation in labor markets, entrepreneurship, and access to productive resources are linked with greater investment in climate-resilient livelihood strategies (Denton, 2002). Economically empowered women may have greater opportunities to diversify household income sources, adopt sustainable production practices, and improve household preparedness for climate-related shocks.

The disaggregated results reveal heterogeneous associations across the dimensions of resilience. In Column (2), women's economic empowerment is negatively associated with adaptive capacity, while the coefficient remains statistically significant at the 1% level. This pattern may reflect differences in how adaptive capacity is measured relative to other resilience dimensions, suggesting that economically empowered women may prioritize short-term absorptive responses or longer-term structural adjustments over incremental adaptation measures. The result highlights the multidimensional nature of resilience and indicates that the relationship between women's economic empowerment and adaptation processes is not uniform across resilience indicators.

Column (3) indicates a positive and statistically significant association between women's economic empowerment and absorptive capacity. This result suggests that households or communities characterized by higher levels of women's economic empowerment tend to exhibit stronger capacities to absorb and cope with climate-related shocks. The finding aligns with evidence showing that women's access to economic resources can strengthen risk management strategies, savings behavior, and household coping mechanisms during periods of environmental and economic stress (Nosheen et al., 2023). By contrast, Column (4) reports a negative and statistically significant relationship between women's economic empowerment and transformative capacity. Although this result differs from some expectations in the literature, it may suggest that structural and institutional transformations associated with climate resilience are influenced by broader contextual constraints beyond women's economic participation alone. Transformative capacity often depends on institutional reforms, infrastructure development, and governance arrangements that may not respond uniformly to changes in individual-level economic empowerment. Nevertheless, the statistical significance of the coefficient indicates that women's economic empowerment remains closely related to broader resilience transformation processes.

Several control variables also exhibit significant associations with resilience outcomes. Conflicts are negatively associated with adaptive and transformative capacity, underscoring the disruptive effects of instability on resilience-building efforts. Variables related to social protection and public goods provision, including environmental protection and transport infrastructure, are significantly

associated with specific resilience dimensions, suggesting the importance of institutional and infrastructural conditions in shaping resilience outcomes. Regional differences are also evident. Compared with Southern Africa, households in West, Eastern, and Central Africa display significantly different resilience profiles across the various dimensions, indicating substantial regional heterogeneity in climate resilience dynamics. These results suggest that women's economic empowerment is closely associated with climate change resilience, although the direction and magnitude of the relationship vary across resilience dimensions. These findings reinforce the importance of incorporating gender-responsive economic strategies into climate resilience frameworks while recognizing the multi-dimensional and context-specific nature of resilience processes.

4.4. Strengthening climate change resilience through women's social empowerment

Table A2 reports the estimates from the instrumental variable fractional probit model with country fixed effects examining the association between women's social empowerment and climate change resilience. The Wald tests of exogeneity are statistically significant across all specifications, supporting the relevance of the instrumental variable approach. The results further indicate substantial heterogeneity across the different dimensions of resilience.

The estimates in Column (1) show that women's social empowerment is positively and significantly associated with overall climate change resilience. This finding suggests that greater participation of women in social networks, collective organizations, and community engagement is correlated with stronger resilience outcomes. The result is consistent with studies emphasizing the importance of women's participation in collective action, local governance, and community-based adaptation processes for strengthening resilience to environmental shocks (Agarwal, 2009; Khadka and Schuett, 2024). However, the disaggregated results reveal contrasting relationships across resilience dimensions. In Column (2), women's social empowerment is negatively associated with adaptive capacity. This pattern may indicate that socially empowered women are concentrated in contexts where immediate climate-related pressures constrain longer-term adaptive investments and planning. It may also reflect the uneven distribution of adaptive resources and institutional support across communities. Similar tensions between social participation and adaptive constraints have been discussed in the climate adaptation literature, particularly in settings characterized by limited infrastructure and resource scarcity (Nosheen et al., 2023).

By contrast, Column (3) indicates a strong positive association between women's social empowerment and absorptive capacity. This result suggests that socially empowered women are more likely to contribute to household and community mechanisms that facilitate coping with climate-related shocks and stresses. Participation in social networks and community organizations may enhance information sharing, mutual support systems, and collective responses during periods of environmental or economic disruption. These findings align with prior research highlighting the role of women's social capital in strengthening household and community resilience (UN Women, 2022). In Column (4), women's social empowerment is negatively associated with transformative capacity. This result may reflect structural and institutional barriers that limit the translation of women's social participation into broader systemic transformation. Although women's engagement in social spheres may strengthen coping mechanisms and localized resilience, entrenched inequalities in access to assets, political influence, and institutional representation may constrain transformative change. Previous studies similarly note that meaningful transformation often requires broader institutional reforms that extend beyond participation alone (Arora-Jonsson, 2011; UN Women, 2022).

The control variables also provide important insights. Age exhibits a nonlinear association with resilience outcomes, suggesting that resilience dynamics vary across the life cycle. Price instability, ethnic discrimination, and conflict are negatively associated with adaptive and transformative dimensions of resilience, highlighting the importance of stable socioeconomic and institutional environments. Ownership of a television, often used as a proxy for access to information, is positively associated with overall resilience and absorptive capacity, while environmental protection and transport infrastructure display mixed relationships across resilience dimensions. Regional differences are also evident, with households in West, Eastern, and Central Africa exhibiting resilience patterns distinct from those observed in Southern Africa. Overall, the findings indicate that women's social empowerment is strongly associated with overall resilience and absorptive capacity, while its relationship with adaptive and transformative capacities appears more complex and context dependent. The results underscore the importance of considering the multidimensional nature of climate resilience and the institutional conditions under which women's social participation translates into broader resilience outcomes.

4.5. Women's political empowerment as a catalyst for climate change resilience

The results reported in Table A3 indicate a statistically significant association between women's political empowerment and multiple dimensions of climate resilience. In column (1), women's political empowerment is positively associated with overall climate resilience. This finding is consistent with studies suggesting that greater female representation in political and decision-making processes is often linked to stronger environmental governance and broader support for climate-related initiatives (McKinney and Fulkerson, 2015; Ergas and York, 2012). The positive coefficient may reflect the tendency for women's participation in governance structures to coincide with increased attention to community welfare, social inclusion, and environmental sustainability.

In contrast, column (2) shows a negative and statistically significant association between women's political empowerment and adaptive capacity at 1% level. This result suggests that higher levels of women's political empowerment are correlated with lower adaptive capacity within the sample. Probably, political inclusion alone may not be sufficient to strengthen adaptive responses where institutional constraints, limited administrative capacity, or inadequate implementation mechanisms persist (Prodip, 2021; Phuong et al., 2018). The finding may also indicate that the benefits of political empowerment are uneven across different dimensions of resilience, particularly where adaptation requires substantial financial, technical, and institutional support. Column (3) indicates a

positive and highly significant relationship between women's political empowerment and absorptive capacity. This association suggests that politically empowered women may contribute to strengthening the ability of households and communities to withstand and manage climate-related shocks. Previous research has emphasized that women leaders frequently support policies related to food security, social protection, disaster preparedness, and community-based risk management, all of which are closely associated with absorptive resilience capacities (Khadka and Schuett, 2024; UN Women, 2022).

By contrast, the coefficient reported in column (4) reveals a negative and statistically significant association between women's political empowerment and transformative capacity. This finding suggests that greater political empowerment among women does not necessarily coincide with higher levels of long-term structural transformation in climate resilience. The result may reflect persistent institutional rigidities, unequal access to strategic resources, or the limited integration of women's political participation into broader structural reforms. Similar observations in the literature note that although women's political representation may improve inclusiveness in governance, this does not automatically translate into transformative institutional change without complementary policy support and enabling governance conditions (MacGregor, 2010; UN Women, 2022).

The control variables further highlight the multidimensional nature of climate resilience. Overall, the findings underscore that women's political empowerment is closely associated with climate resilience outcomes, although the direction and magnitude of these relationships differ across resilience dimensions. The findings indicate that political inclusion is more closely associated with shock absorption and overall resilience than with adaptive or transformative capacities, which depend on wider institutional and structural conditions. Governments should promote women's engagement in microclimate decision-making through gender quotas, leadership training, and institutional reforms. However, political participation alone is insufficient; it must be reinforced by access to funding, decision-making authority, and climate adaptation resources. Therefore, strengthening climate resilience requires integrating women's political empowerment with robust institutional support.

5. Conclusion and policy insights

Climate change impacts every aspect of human life, regardless of geographical location, making it a central issue in both global and regional policy discourses. A growing concern within these discussions is how FI and WEP can serve as effective pathways for climate-vulnerable societies to develop resilience. However, while these topics are frequently explored in open discourse, there is a paucity of rigorous scientific studies examining their empirical relationship with climate resilience. Using data from the 9th Afrobarometer survey, this study fills this gap through looking at the effects of FI and WEP on climate resilience of 25,511 women-headed households in sub-Saharan African nations using an instrumental variable fractional probit regression model applied to country fixed-effect to control for country-effect heterogeneity in FI, WEP and resilience. Political, social, and economic facets of WEP are taken into consideration as the research concentrates on both aggregated and disaggregated components of climate resilience.

The empirical evidence demonstrates that FI significantly increase the likelihood of strengthening WEP, although the effects differ across dimensions. FI is negatively linked to the social dimension of WEP but positively associated with its economic and political dimensions. Access to financial resources reduces women's economic dependence on traditional structures, enabling them to participate in leadership roles and empowerment programs. SSA governments and financial institutions should design integrated policies that not only provide financial access but also link these services to leadership training, civic education, and gender empowerment initiatives. Such holistic approaches can amplify the role of women in climate resilience efforts by addressing the financial and structural barriers that limit their participation.

Furthermore, the findings show that WEP strengthens households' absorptive capacity of resilience, but remains insufficient to improve adaptive and transformative capacities in SSA. This gap reflects persistent structural constraints: women may participate in local decision-making yet still lack secure land tenure, affordable credit, climate information, and access to agricultural extension services needed for long-term adaptation. Policy responses should therefore move beyond generic gender commitments toward targeted institutional reforms. Governments should prioritize joint land titling programs, gender-sensitive agricultural credit schemes, and subsidized climate insurance for women farmers, particularly in drought-prone regions including SSA. Expanding women's access to extension services and climate-smart technologies through local cooperatives and digital platforms would also strengthen adaptive capacity at relatively low implementation cost.

The results further suggest that political empowerment can enhance community preparedness and climate governance. SSA countries should therefore establish minimum representation quotas for women in local climate adaptation committees and disaster-risk management bodies, supported by dedicated budget allocations and leadership training. While this study provides important evidence, it relies on Afrobarometer cross-sectional data, limiting causal inference and analysis of changes over time; thus, findings should be interpreted cautiously. In addition, self-reported household responses may reflect perception, recall, or reporting biases. Future research should incorporate longitudinal data and qualitative approaches for stronger evidence.

CRedit authorship contribution statement

Essossinam Ali: Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Formal analysis, Data curation, Conceptualization. **Pius Gamette:** Writing – original draft, Validation. **Francis Tawiah Anaisie:** Writing – review & editing, Writing – original draft, Validation.

Consent for publication

The authors of this manuscript consents to its publication.

Ethics approval and consent to participate

Ethical approval was sought from the Ethics and Research Committee of the Afrobarometer and all respondents consented to participate in this study.

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Appendix A. Appendix

Table A1
Strengthening climate change resilience through women's economic empowerment.

Variables	(1)	(2)	(3)	(4)
	Climate change Resilience	Dimensions of Climate change Resilience		
		Adaptative Capacity	Absorption Capacity	Transformation Capacity
Economic Women Empowerment	2.1036*** (0.266)	−3.1258*** (0.124)	3.3373*** (0.017)	−3.2945*** (0.031)
lnAge	0.2244* (0.133)	−0.3762 (0.301)	0.2134 (0.306)	0.1796 (0.284)
lnAge_Square	−0.0314* (0.018)	0.0753* (0.043)	−0.0401 (0.042)	−0.0092 (0.039)
Price instability	0.0410*** (0.011)	−0.1171*** (0.022)	0.0684*** (0.019)	−0.0685*** (0.019)
Economic discrimination	0.0666*** (0.009)	−0.0998*** (0.020)	0.0579*** (0.016)	−0.0576*** (0.016)
Ethnic discrimination	0.0281*** (0.011)	−0.1242*** (0.015)	0.0952*** (0.014)	−0.0912*** (0.014)
Freedom of expression	0.0109* (0.007)	0.0130 (0.014)	−0.0043 (0.014)	0.0057 (0.014)
Conflicts	−0.0092 (0.008)	−0.0754*** (0.019)	0.0329** (0.017)	−0.0417** (0.017)
Owning TV	0.0173 (0.011)	0.0111 (0.027)	−0.0436* (0.023)	0.0476*** (0.018)
Protecting vulnerable children	−0.0080 (0.016)	0.1742*** (0.014)	−0.1507*** (0.015)	0.1584*** (0.015)
Environmental protection	−0.0058 (0.008)	0.0683*** (0.015)	−0.0416*** (0.015)	0.0529*** (0.015)
Good transport infrastructure	−0.0016 (0.008)	0.0590*** (0.015)	−0.0410*** (0.015)	0.0294** (0.015)
Region (Southern Africa = 0)				
1.West Africa	0.1759*** (0.048)	0.2502*** (0.070)	−0.3618*** (0.058)	0.3514*** (0.058)
2.Eastern Africa	0.3016*** (0.028)	−0.3791*** (0.069)	0.2498*** (0.058)	−0.2388*** (0.056)
3.Central Africa	0.2368*** (0.028)	−0.2883*** (0.077)	0.1124* (0.062)	−0.1331** (0.062)
Constant	−1.5961*** (0.283)	2.4953*** (0.506)	−2.5035*** (0.549)	1.7455*** (0.514)
athrho2_1	−0.2360** (0.093)	1.7089*** (0.292)	−3.0268*** (0.391)	2.4507*** (0.267)
lnsigma2	−1.2099*** (0.004)	−1.2097*** (0.004)	−1.2095*** (0.004)	−1.2096*** (0.004)
Observations	25,511	25,511	25,511	25,511

(continued on next page)

Table A1 (continued)

Variables	(1)	(2)	(3)	(4)
	Climate change Resilience	Dimensions of Climate change Resilience		
		Adaptative Capacity	Absorption Capacity	Transformation Capacity
Wald chi2	7696**	23297***	71549***	28819***
Wald test of exogeneity: chi2(1)	6.44**	34.34***	59.93***	84.43***
Country Fixed-effect	Yes	Yes	Yes	Yes

Robust standard errors in parentheses; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table A2

Empowering women for climate resilience: analyzing social impacts.

Variables	(1)	(2)	(3)	(4)
	Climate change Resilience	Dimensions of Climate change Resilience		
		Adaptative Capacity	Absorption Capacity	Transformation Capacity
Social Women Empowerment	1.1961*** (0.330)	-1.0436** (0.431)	5.6542*** (0.074)	-2.9764*** (0.266)
lnAge	0.4063** (0.171)	-1.3494*** (0.195)	1.4756*** (0.304)	0.1696 (0.192)
lnAge_Square	-0.0525** (0.024)	0.2213*** (0.027)	-0.2161*** (0.042)	0.0004 (0.027)
Price instability	-0.0166 (0.012)	-0.1450*** (0.015)	-0.0544*** (0.020)	0.0123 (0.013)
Economic discrimination	0.0498*** (0.011)	-0.1543*** (0.012)	0.1111*** (0.017)	-0.0719*** (0.012)
Ethnic discrimination	0.0099 (0.014)	-0.1374*** (0.017)	0.2009*** (0.015)	-0.0964*** (0.013)
Freedom of expression	0.0183** (0.008)	0.0177* (0.009)	0.0216 (0.014)	-0.0092 (0.009)
Conflicts	0.0122 (0.015)	-0.1593*** (0.017)	0.1926*** (0.017)	-0.1455*** (0.013)
Owning TV	0.0764*** (0.008)	-0.2030*** (0.010)	0.1422*** (0.025)	-0.2086*** (0.011)
Protecting vulnerable children	0.0442*** (0.016)	0.1191*** (0.018)	-0.1969*** (0.016)	0.1354*** (0.013)
Environmental protection	0.0104 (0.009)	0.0804*** (0.010)	-0.0493*** (0.015)	0.0678*** (0.010)
Good transport infrastructure	0.0029 (0.010)	0.0777*** (0.012)	-0.1021*** (0.015)	0.0003 (0.011)
Region (Southern Africa = 0)				
1.West Africa	0.3536*** (0.041)	-0.2580*** (0.044)	-0.1870*** (0.062)	-0.0062 (0.043)
2.Eastern Africa	0.1255*** (0.034)	-0.4926*** (0.038)	-0.0257 (0.060)	-0.1009*** (0.037)
3.Central Africa	0.1405*** (0.037)	-0.5299*** (0.039)	-0.0579 (0.065)	-0.1296*** (0.042)
Constant	-1.2217*** (0.387)	2.5350*** (0.454)	-5.6148*** (0.535)	1.1801*** (0.406)
athrho2_1	-0.1872*** (0.059)	0.1971*** (0.076)	-2.0676*** (0.186)	0.5680*** (0.062)
lnsigma2	-1.7682*** (0.004)	-1.7681*** (0.004)	-1.7669*** (0.004)	-1.7681*** (0.004)
Observations	25,511	25,511	25,511	25,511
Wald chi2	3771**	9372***	32400***	3361***
Wald test of exogeneity: chi2(1)	10.16***	6.66***	123.55***	85.02***
Country Fixed-effect	Yes	Yes	Yes	Yes

Robust standard errors in parentheses; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table A3

Women's political empowerment as a catalyst for climate resilience.

Variables	(1)	(2)	(3)	(4)
	Climate change Resilience	Dimensions of Climate change Resilience		
		Adaptative Capacity	Absorption Capacity	Transformation Capacity
Political Women Empowerment	3.1753*** (0.462)	-3.5831*** (0.084)	3.7092*** (0.017)	-3.6784*** (0.028)
lnAge	-0.3647*	0.2898	-0.4857	0.7511***

(continued on next page)

Table A3 (continued)

Variables	(1)	(2)	(3)	(4)
	Climate change Resilience	Dimensions of Climate change Resilience		
		Adaptative Capacity	Absorption Capacity	Transformation Capacity
	(0.199)	(0.303)	(0.305)	(0.286)
lnAge_Square	0.0525** (0.027)	−0.0255 (0.043)	0.0630 (0.042)	−0.0960** (0.040)
Price instability	−0.0439*** (0.013)	−0.0013 (0.024)	−0.0437** (0.020)	0.0422** (0.020)
Economic discrimination	−0.0933*** (0.022)	0.0920*** (0.022)	−0.1341*** (0.017)	0.1322*** (0.017)
Ethnic discrimination	−0.0498*** (0.008)	−0.0072 (0.016)	−0.0222 (0.014)	0.0240* (0.014)
Freedom of expression	−0.0176* (0.010)	0.0408*** (0.014)	−0.0349** (0.014)	0.0356** (0.014)
Conflicts	−0.0019 (0.012)	−0.0634*** (0.019)	0.0282* (0.017)	−0.0351** (0.017)
Owning TV	−0.0261 (0.022)	0.0478** (0.024)	−0.0804*** (0.022)	0.0779*** (0.018)
Protecting vulnerable children	0.0277 (0.019)	0.0874*** (0.015)	−0.0633*** (0.015)	0.0697*** (0.014)
Environmental protection	0.0111 (0.010)	0.0321** (0.016)	−0.0091 (0.015)	0.0177 (0.015)
Good transport infrastructure	0.0101 (0.010)	0.0325** (0.015)	−0.0163 (0.014)	0.0076 (0.015)
Region (Southern Africa = 0)				
1.West Africa	−0.1990 (0.124)	0.5474*** (0.072)	−0.6440*** (0.062)	0.6315*** (0.062)
2.Eastern Africa	−0.4034*** (0.095)	0.4434*** (0.079)	−0.5869*** (0.059)	0.5828*** (0.058)
3.Central Africa	−0.3206*** (0.087)	0.3515*** (0.084)	−0.5197*** (0.064)	0.4964*** (0.064)
Constant	−0.7947** (0.311)	1.1525** (0.520)	−0.9976* (0.549)	0.4876 (0.515)
athrho2_1	−0.5207** (0.210)	1.9283*** (0.296)	−3.4579*** (0.549)	2.7051*** (0.332)
lnsigma2	−1.3124*** (0.004)	−1.3124*** (0.004)	−1.3122*** (0.004)	−1.3124*** (0.004)
Observations	25,511	25,511	25,511	25,511
Wald chi2	8670***	30961***	54949***	34528***
Wald test of exogeneity: chi2(1)	6.12**	42.44***	39.70***	66.23***
Country Fixed-effect	Yes	Yes	Yes	Yes

Robust standard errors in parentheses; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Data availability

Data will be made available on request.

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