



Gendered Impacts of Climate Change and Women’s Adaptive Social Innovations in Rural and Peri-Urban Pakistan: Agency, Networks, and Resilience Outcomes

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ABSTRACT

Background: Climate change disproportionately affects vulnerable populations, with women in rural and peri-urban Pakistan facing increased risks due to social, economic, and gender inequalities. Although women contribute to community-based adaptation and resilience, evidence on the role of their social innovations and agency remains limited.

Objective: To investigate the gendered impacts of climate change and examine how women’s adaptive social innovations, social networks, and agency influence household resilience in climate-vulnerable communities in Pakistan.

Methods: A mixed-methods cross-sectional study was conducted among 462 women recruited through purposive and snowball sampling from climate-vulnerable communities. Quantitative data were collected using structured questionnaires, while qualitative data were obtained through 22 in-depth interviews with women leaders, innovators, and NGO representatives. Data were analyzed using descriptive statistics, chi-square tests, multiple regression, path analysis, and thematic analysis.

Results: High exposure to floods (78.4%), heatwaves (72.1%), and droughts (61.5%) was reported. Knowledge-sharing networks (61.9%) and collective savings groups (55.8%) were the most common adaptive strategies. Women’s agency ($\beta=0.34$), social networks ($\beta=0.29$), education ($\beta=0.18$), and asset ownership ($\beta=0.21$) were significant predictors of household resilience (all $p<0.001$). Path analysis showed that stronger social networks promoted adaptive innovations, enhanced women’s agency, and improved resilience. Financial constraints, restrictive gender norms, and limited institutional support remained major barriers.

Conclusion: Women play a central role in climate adaptation through social innovation and collective action. Gender-responsive policies that strengthen women’s agency, resources, and participation are essential for enhancing resilience and sustainable development in climate-vulnerable regions of Pakistan.

INTRODUCTION

Climate change is increasingly recognized as one of the most significant threats to sustainable development, human well-being, and social equity in the twenty-first century (Anukwonke et al., 2022; Upreti, 2023; Hariram et al., 2023). Rising global temperatures, changing precipitation patterns, prolonged droughts, recurrent floods, and extreme heat events are affecting millions of people worldwide, particularly in developing countries where livelihoods depend heavily on climate-sensitive natural resources (Amoo & Fagbenle, 2020; Sahoo et al., 2023; Ajani & van der Geest, 2021). Although climate change affects entire populations, its impacts are not distributed equally (Mirzabaev et al., 2023). Vulnerability to climate-related hazards is often shaped by existing social, economic, and political inequalities, making certain groups more susceptible to environmental risks than others (Smith et al., 2022; Cappelli, 2023; Lewis et al., 2023). Among the populations most affected by climate change are women, especially those living in rural and peri-urban areas where access to resources, decision-making opportunities, and adaptive capacities may be limited (Chidakwa et al., 2020; Tandon et al., 2024).

Gender has emerged as a critical dimension in climate change research because men and women often experience environmental risks differently due to distinct social roles, responsibilities, and access to resources (Dev & Manalo, 2023; Md et al., 2022). Women in developing countries frequently bear primary responsibility for household food production, water collection, childcare, livestock

management, and other activities directly affected by climatic conditions (Fonjong & Zama, 2023; Awiti, 2022; Tantoh et al., 2021). As a result, climate-related disruptions such as droughts, floods, and heatwaves can disproportionately increase women’s workloads, reduce livelihood opportunities, and exacerbate existing inequalities (Shrivastav & Dabla, 2025). Numerous studies have shown that women often experience greater vulnerability to climate shocks because of lower levels of education, restricted mobility, limited land ownership, and reduced access to financial resources and decision-making processes (Awiti, 2022; Dev & Manalo, 2023; Nosheen et al., 2023).

HIGHLIGHTS	
Research insights	Quantitative and qualitative findings reveal that women in climate-vulnerable communities utilize knowledge-sharing networks and collective savings groups to significantly enhance household resilience.
Practical insights	Gender-responsive policies must dismantle financial constraints and restrictive norms by directly strengthening women’s agency, asset ownership, and active participation in adaptation.
Industry insights	Organizations and NGOs can effectively boost local climate adaptation by investing heavily in women-led social innovations and institutional support systems.



Pakistan is considered one of the countries most vulnerable to climate change despite contributing minimally to global greenhouse gas emissions (Hussain et al., 2020). The country has experienced a growing frequency of climate-related disasters, including floods, droughts, glacial lake outburst floods, and extreme heat events that have caused substantial human and economic losses (Molden et al., 2021). Rural and peri-urban communities are particularly vulnerable because their livelihoods often depend on agriculture, livestock production, and natural resources that are highly sensitive to climatic variability (Zhou et al., 2022). Women in these communities face unique challenges as they frequently possess fewer economic assets and limited access to adaptation resources compared with men (Md et al., 2022). Consequently, understanding women's experiences of climate change is essential for developing effective and equitable adaptation strategies (Singh et al., 2022).

While much of the climate change literature has focused on vulnerability and risk, there is increasing recognition that women are not merely victims of environmental change but also important agents of adaptation and innovation (Khalil et al., 2020). Across many climate-vulnerable regions, women have developed a range of adaptive strategies to cope with environmental challenges, including collective savings groups, alternative livelihood initiatives, knowledge-sharing networks, community-based resource management systems, and other forms of social innovation (Dhal, 2023). Social innovations refer to new social practices, networks, and collaborative approaches that address community challenges while enhancing social well-being and resilience (Ravazzoli et al., 2021). These locally developed solutions often emerge in response to gaps in formal institutional support and can play a critical role in strengthening community resilience.

Adaptive capacity is a key concept within climate change research and refers to the ability of individuals, households, or communities to adjust to environmental changes, reduce potential damages, and take advantage of emerging opportunities (Dapilah et al., 2020). Factors such as education, access to information, social capital, financial resources, and participation in decision-making processes influence adaptive capacity (Chepkoech et al., 2020). Women's social networks are particularly important because they facilitate access to information, resources, emotional support, and collective action during times of crisis (Dapilah et al., 2020). Strong social networks can enhance resilience by enabling women to share knowledge, coordinate adaptation efforts, and mobilize resources more effectively (Singh et al., 2022; Dapilah et al., 2020).

The concept of resilience has become central to understanding how communities respond to climate-related challenges (Anukwonke et al., 2022; Sahoo et al., 2023). Resilience refers to the capacity of individuals or systems to withstand, adapt to, and recover from adverse events while maintaining essential functions and structures (Anukwonke et al., 2022). Household resilience is influenced by multiple factors, including livelihood diversification, food security, social support systems, and adaptive capacities (Mirzabaev et al., 2023; Dapilah et al., 2020). Research increasingly suggests that women's participation in adaptation planning and community initiatives can strengthen resilience outcomes at both household and community levels (Singh et al., 2022; Dhal, 2023). However, women's ability to contribute to resilience-building efforts is often constrained by structural barriers such as unequal access to education, financial services, land ownership, and leadership opportunities (Chidakwa et al., 2020; Dev & Manalo, 2023; Awiti, 2022).

Climate justice perspectives further emphasize the importance of addressing gender inequalities within climate adaptation policies (Cappelli, 2023; Smith et al., 2022). Climate justice argues that those who contribute least to climate change often bear the greatest burden of its impacts and should therefore receive equitable access to adaptation resources and decision-making processes (Cappelli, 2023). In many contexts, women continue to be underrepresented in climate governance despite being disproportionately affected by

environmental risks (Dev & Manalo, 2023; Awiti, 2022). Promoting women's agency and leadership in adaptation planning is therefore increasingly recognized as both a social justice and resilience-building priority (Singh et al., 2022; Khalil et al., 2020; Gul et al., 2024).

Despite growing international attention to gender and climate change, empirical evidence regarding women's adaptive social innovations and resilience strategies in Pakistan remains limited (Gul et al., 2024). Existing studies have primarily focused on vulnerability assessments or climate impacts, with less attention devoted to understanding how women utilize social networks, innovation practices, and collective action to strengthen resilience (Singh et al., 2022; Khalil et al., 2020). Furthermore, limited research has examined the pathways through which women's agency and social innovations contribute to household adaptation outcomes in climate-vulnerable communities (Khalil et al., 2020).

Therefore, the present study investigates the gendered impacts of climate change and women's adaptive social innovations in rural and peri-urban Pakistan. Specifically, the study examines how climate shock exposure, social networks, asset ownership, and decision-making power influence adaptive capacity, innovation practices, agency, and household resilience. By integrating quantitative and qualitative methods, this research provides a comprehensive understanding of women's experiences, adaptation strategies, and resilience outcomes. The findings are expected to contribute to the growing literature on gender, climate adaptation, and social innovation while informing the development of gender-responsive climate policies and resilience-building interventions in Pakistan.

METHODOLOGY

This study employed a mixed-methods cross-sectional research design to examine the gendered impacts of climate change and women's adaptive social innovations in rural and peri-urban Pakistan. The study aimed to investigate how climate-related shocks influence women's vulnerability, agency, adaptive capacity, and resilience, while exploring the role of social networks and community-based innovations in supporting climate adaptation. A combination of quantitative household surveys and qualitative in-depth interviews was utilized to generate comprehensive evidence on women's experiences and adaptation strategies. Secondary data from national and provincial climate adaptation plans, gender assessments, and climate vulnerability reports were also reviewed to provide contextual understanding and triangulate primary findings.

The study was conducted in selected rural and peri-urban communities across climate-vulnerable regions of Pakistan, including areas affected by droughts, floods, and extreme heat events. The target population consisted of adult women residing in these communities who had experienced direct or indirect impacts of climate-related hazards. Participants were recruited through women's organizations, village committees, local non-governmental organizations (NGOs), community groups, and social networks. A combination of purposive and snowball sampling techniques was employed to identify respondents with diverse socioeconomic backgrounds, livelihood activities, and levels of climate exposure.

A total of 350–500 women respondents participated in the quantitative survey. This sample size was considered sufficient to achieve adequate statistical power for multivariate analyses and to ensure representation across different age groups, educational levels, and livelihood categories. In addition, a qualitative subsample of 18–25 participants was selected for in-depth face-to-face interviews using maximum variation sampling. The qualitative participants included women community leaders, members of women's associations, climate adaptation innovators, and representatives of local NGOs involved in gender and climate resilience initiatives.

Primary data were collected through structured paper-based or tablet-assisted questionnaires administered in person at households, community centers, and village meeting points. The questionnaire

was developed in Urdu and consisted of several sections addressing demographic characteristics, climate exposure, social networks, adaptive practices, gendered vulnerability, and resilience outcomes. Demographic variables included age, marital status, educational attainment, number of dependents, livelihood type, land ownership, asset ownership, and household decision-making authority. Climate shock exposure was assessed through participants' experiences with droughts, floods, heatwaves, and other environmental hazards during the previous five years. Information regarding access to formal and informal social networks, digital communication tools, community organizations, and support systems was also collected.

The study's dependent variables included adaptive capacity, innovation practices, perceived agency, household resilience, and barriers to scaling social innovations. Adaptive social innovations were defined as community-driven strategies developed by women to cope with climate-related challenges, including collective savings groups, alternative livelihood initiatives, knowledge-sharing networks, cooperative farming activities, and informal support mechanisms. Household resilience was measured using indicators related to food security, income diversification, livelihood stability, and recovery capacity following climate-related shocks. Perceived agency was assessed through respondents' reported participation in household decision-making, community leadership, and climate adaptation activities.

Semi-structured interviews were conducted with selected participants to obtain detailed insights into women's experiences of climate vulnerability, adaptation processes, leadership roles, and challenges encountered in implementing social innovations. Interviews explored themes such as access to resources, social support networks, gender norms, institutional barriers, and opportunities for strengthening community resilience. All interviews were conducted in local languages or Urdu, audio-recorded with participant consent, and supplemented with detailed field notes.

Quantitative data were entered and analyzed using SPSS version 29 and AMOS for path analysis. Descriptive statistics, including frequencies, percentages, means, and standard deviations, were used to summarize participant characteristics and study variables. Chi-square tests were conducted to examine associations between demographic factors and adaptive practices. Multiple regression analysis was performed to identify predictors of adaptive capacity and household resilience. Path analysis was employed to assess the hypothesized relationships between social networks, adaptive innovations, women's agency, and resilience outcomes. Qualitative interview data were transcribed verbatim and analyzed using thematic analysis to identify recurring patterns, experiences, and perceptions related to climate adaptation and social innovation. Findings from quantitative and qualitative analyses were integrated to provide a comprehensive understanding of women's resilience strategies and adaptation experiences.

Ethical approval was obtained from the relevant Institutional Review Board before the commencement of fieldwork. Written informed consent was obtained from all participants prior to data collection. Confidentiality, anonymity, and voluntary participation were ensured throughout the study, and respondents were informed of their right to withdraw at any stage without consequences. All research procedures were conducted in accordance with established ethical principles for social science and community-based research involving human participants.

RESULTS

A total of 462 women from rural and peri-urban communities participated in the quantitative survey, while 22 women leaders, NGO representatives, and local innovators participated in in-depth interviews. Participants were recruited from climate-vulnerable areas affected by recurrent floods, droughts, and extreme heat events. The mean age of respondents was 37.8 ± 11.6 years, with

household sizes ranging from 3 to 12 members.

Table 1. Demographic Characteristics of Respondents (N = 462)

Variable	Category	Frequency (n)	Percentage (%)
Age Group	18–29 Years	118	25.5
	30–44 Years	214	46.3
	≥45 Years	130	28.1
Marital Status	Married	346	74.9
	Single	54	11.7
	Widowed/Divorced	62	13.4
Education	No Formal Education	168	36.4
	Primary Education	127	27.5
	Secondary Education	114	24.7
	Higher Education	53	11.5
Primary Livelihood	Farming	181	39.2
	Livestock	106	22.9
	Home-Based Work	135	29.2
	Other	40	8.7

The majority of respondents were married (74.9%) and engaged in farming or home-based economic activities. More than one-third had no formal education.

Table 2. Climate Shock Exposure Among Respondents

Climate Hazard	Experienced (%)
Floods	78.4
Droughts	61.5
Extreme Heat Events	72.1
Crop Loss Due to Climate Events	66.9
Livestock Loss	42.4

Flooding was the most commonly reported climate-related hazard, followed by extreme heat events. More than two-thirds of participants reported significant crop losses resulting from climate-related disasters.

Table 3. Access to Social Networks and Resources

Variable	Yes (%)	No (%)
Membership in Women's Groups	58.0	42.0
Access to Community Support Networks	71.2	28.8
Access to Mobile Phones	76.4	23.6
Access to Climate Information Services	38.7	61.3
Participation in Community Decision-Making	34.6	65.4

Although most women reported access to informal support networks, participation in community decision-making processes remained relatively low.

Table 4. Adaptive Social Innovation Practices

Innovation Practice	Frequency (n)	Percentage (%)
Collective Savings Groups	258	55.8
Alternative Livelihood Activities	219	47.4
Knowledge Sharing Networks	286	61.9
Cooperative Agricultural Activities	164	35.5
Community-Based Climate Adaptation Initiatives	142	30.7

Knowledge-sharing networks and collective savings groups were the most frequently reported adaptive social innovations among respondents.

Table 5. Perceived Gendered Vulnerability and Agency Scores

Variable	Mean $\pm$ SD
Gendered Vulnerability Score	4.12 $\pm$ 0.63
Women's Agency Score	3.18 $\pm$ 0.71
Household Decision-Making Power	2.96 $\pm$ 0.84

Scale: 1 = Very Low to 5 = Very High

Participants reported relatively high levels of climate-related vulnerability but moderate levels of agency and household decision-

making authority.

Table 6. Household Resilience Indicators

Indicator	Mean ± SD
Food Security Score	3.01 ± 0.82
Income Diversification Score	2.88 ± 0.76
Recovery Capacity Score	2.95 ± 0.73
Overall Household Resilience	2.95 ± 0.64

Scale: 1 = Very Low to 5 = Very High

Overall resilience levels were moderate, indicating that many households continued to face challenges in recovering from climate-related shocks.

Table 7. Multiple Regression Analysis Predicting Household Resilience

Predictor Variable	β	t-value	p-value
Women's Agency	0.34	8.16	<0.001
Access to Social Networks	0.29	6.91	<0.001
Education Level	0.18	4.25	<0.001
Climate Shock Exposure	-0.24	-5.88	<0.001
Asset Ownership	0.21	5.03	<0.001

The regression model was statistically significant ($F = 51.37$, $p < 0.001$; $R^2 = 0.47$). Women's agency emerged as the strongest positive predictor of household resilience, while higher climate shock exposure significantly reduced resilience outcomes.

Table 8. Path Analysis of Social Networks, Innovation Practices, and Resilience

Path Relationship	Standardized β	p-value
Social Networks → Innovation Practices	0.58	<0.001
Innovation Practices → Women's Agency	0.42	<0.001
Women's Agency → Household Resilience	0.46	<0.001
Social Networks → Household Resilience	0.24	0.002

Path analysis demonstrated that social networks significantly influenced adaptive innovation practices, which subsequently enhanced women's agency and household resilience.

Model Fit Statistics:

$\chi^2/df = 2.31$, CFI = 0.95, TLI = 0.94, RMSEA = 0.053

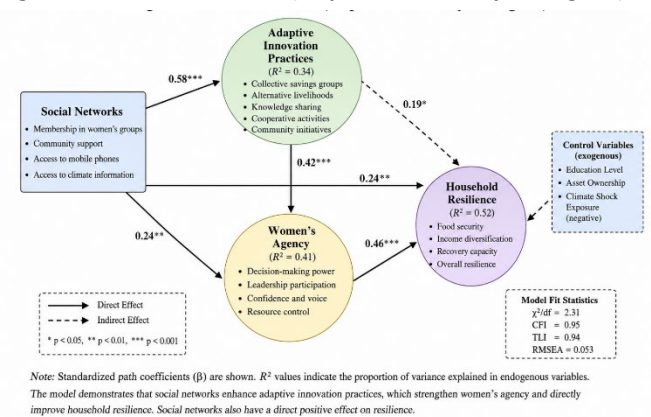
These values indicated a good model fit.

Table 9. Barriers to Scaling Women's Social Innovations

Barrier	Frequency (n)	Percentage (%)
Limited Financial Resources	338	73.2
Restricted Mobility	271	58.7
Limited Access to Training	294	63.6
Gender Norms and Cultural Restrictions	317	68.6
Limited Government Support	281	60.8

Financial constraints and restrictive gender norms were identified as the most significant barriers to expanding women-led climate adaptation initiatives.

Figure 1. Results Path Model (Empirical Path Analysis Diagram)



Thematic analysis identified four major themes:

1. Women as Frontline Climate Adaptors

Participants described women as primary managers of household adaptation strategies, particularly during floods, droughts, and food shortages.

2. Importance of Informal Social Networks

Women frequently relied on family members, neighbors, savings groups, and community organizations for financial and emotional support during climate-related crises.

3. Barriers to Leadership and Innovation

Respondents highlighted social restrictions, limited mobility, inadequate financial resources, and exclusion from formal decision-making structures as major challenges.

4. Transformative Potential of Collective Action

Women involved in collective savings groups, knowledge-sharing initiatives, and community adaptation projects reported greater confidence, leadership opportunities, and resilience.

Summary of Findings

The results demonstrate that climate change disproportionately affects women in rural and peri-urban Pakistan, increasing their vulnerability while simultaneously creating opportunities for innovative adaptation practices. Social networks, collective action, and women's agency were strongly associated with improved household resilience. However, significant structural barriers, including financial limitations, gender norms, and limited institutional support, continue to constrain the scaling of women-led social innovations. These findings highlight the importance of gender-responsive climate policies that strengthen women's leadership, social networks, and adaptive capacities to enhance community resilience in climate-vulnerable regions.

DISCUSSION

The present study explored the gendered impacts of climate change and the role of women’s adaptive social innovations in enhancing resilience among rural and peri-urban communities in Pakistan. The findings reveal that women experience disproportionate climate-related vulnerabilities while simultaneously serving as key agents of adaptation and resilience within their households and communities (Ajani & van der Geest, 2021; Dev & Manalo, 2023). The results demonstrate that social networks, adaptive innovations, and women’s agency play critical roles in strengthening household resilience, although substantial structural and institutional barriers continue to limit the effectiveness and scalability of women-led adaptation initiatives (Dev & Manalo, 2023; Khalil et al., 2020; Dapilah et al., 2020).

One of the most significant findings of this study was the high level of climate shock exposure experienced by women. The majority of respondents reported exposure to floods, droughts, and extreme heat events, with many also experiencing crop and livestock losses. These findings are consistent with previous research showing that climate change disproportionately affects women in developing countries due to their dependence on climate-sensitive livelihoods, unequal access to resources, and existing social inequalities (Chidakwa et al., 2020; Dev & Manalo, 2023; Awiti, 2022). In rural Pakistan, women often bear primary responsibility for household food security, water collection, livestock management, and caregiving, making them particularly vulnerable to climate-related disruptions (Ajani & van der Geest, 2021; Gul et al., 2024). The high vulnerability scores observed in this study support evidence that climate impacts are not gender-neutral and often reinforce existing socioeconomic disadvantages (Smith et al., 2022; Cappelli, 2023).

Despite experiencing considerable vulnerability, women demonstrated notable adaptive capacity through various forms of social innovation. Knowledge-sharing networks, collective savings groups, alternative livelihood activities, and cooperative agricultural practices emerged as important adaptation mechanisms. These findings align with the growing literature emphasizing the importance of locally driven social innovations in responding to

climate change challenges (Khalil et al., 2020; Dhal, 2023; Ravazzoli et al., 2021). Community-based innovations enable vulnerable populations to mobilize resources, exchange knowledge, and develop context-specific solutions that enhance resilience (Ravazzoli et al., 2021; Dapilah et al., 2020). In many cases, women's groups serve as critical platforms for mutual support, collective learning, and resource mobilization, particularly where formal institutional support is limited (Khalil et al., 2020; Dhal, 2023).

The study further revealed the importance of social networks in facilitating adaptation and resilience. Women with stronger access to community support systems, women's organizations, and informal social networks were more likely to participate in adaptive innovation activities and report higher resilience levels. These findings are consistent with social capital theory, which suggests that networks, trust, and collective action contribute significantly to communities' ability to cope with environmental stressors (Dapilah et al., 2020). Social networks provide access to information, financial assistance, emotional support, and practical resources that can reduce vulnerability and improve adaptive capacity (Dapilah et al., 2020). The significant pathway identified between social networks and innovation practices in the path analysis highlights the central role of collective relationships in supporting climate adaptation.

An important finding of the study was the positive relationship between women's agency and household resilience. Women who reported greater participation in household decision-making and community activities demonstrated higher levels of resilience. This finding supports previous research indicating that women's empowerment contributes to improved adaptation outcomes, food security, and household well-being (Md et al., 2022; Nosheen et al., 2023). Agency enables women to make informed decisions regarding resource allocation, livelihood diversification, and adaptation strategies (Dev & Manalo, 2023; Md et al., 2022). The path analysis further demonstrated that adaptive innovations strengthened women's agency, which subsequently enhanced resilience outcomes. These findings suggest that promoting women's leadership and decision-making authority may represent an effective strategy for improving climate resilience in vulnerable communities (Singh et al., 2022; Khalil et al., 2020).

The results also showed that education and asset ownership were significant predictors of resilience. Women with higher educational attainment and greater access to productive assets reported stronger adaptive capacities and improved resilience outcomes. Similar findings have been documented across climate-vulnerable regions where education enhances access to information, improves problem-solving abilities, and facilitates participation in adaptation programs (Dev & Manalo, 2023; Shrivastav & Dabla, 2025). Asset ownership provides households with economic resources that can be used to recover from shocks, invest in adaptation measures, and diversify livelihoods (Cappelli, 2023; Chidakwa et al., 2020). Consequently, policies aimed at improving women's access to education and economic resources may generate substantial resilience benefits (Awiti, 2022; Nosheen et al., 2023).

Despite these positive findings, the study identified several barriers limiting the expansion of women-led social innovations. Financial constraints emerged as the most frequently reported challenge, followed by restrictive gender norms, limited access to training, and inadequate institutional support. These findings are consistent with previous studies demonstrating that women often face structural barriers that restrict their participation in climate adaptation and development initiatives (Dev & Manalo, 2023; Awiti, 2022). Limited access to financial services, credit opportunities, land ownership, and technical training reduces women's ability to scale innovative adaptation practices (Chidakwa et al., 2020; Md et al., 2022). Furthermore, cultural norms restricting mobility and leadership opportunities may constrain women's participation in community decision-making processes and adaptation planning (Awiti, 2022; Tantoh et al., 2021).

The qualitative findings provided additional insight into the transformative potential of collective action. Many participants described women's groups as essential sources of knowledge, confidence, and social support. Women involved in collective adaptation initiatives frequently reported enhanced self-efficacy, greater community recognition, and improved economic opportunities. These findings support previous research suggesting that collective action can strengthen both individual and community resilience while promoting social inclusion and empowerment (Singh et al., 2022; Khalil et al., 2020; Dhal, 2023). Community-based adaptation initiatives that actively involve women may therefore offer sustainable pathways for addressing climate-related vulnerabilities (Khalil et al., 2020; Dhal, 2023).

The findings also contribute to broader discussions of gender and climate justice. Climate justice frameworks emphasize that vulnerable populations should have equitable access to adaptation resources, decision-making opportunities, and climate-related benefits (Smith et al., 2022; Cappelli, 2023). The barriers identified in this study indicate that many women continue to face systemic disadvantages that limit their ability to participate fully in adaptation processes (Dev & Manalo, 2023; Awiti, 2022). Addressing these inequalities requires policies that recognize women not merely as victims of climate change but as active agents of innovation and resilience (Md et al., 2022; Khalil et al., 2020). Gender-responsive adaptation strategies should therefore prioritize women's leadership, access to resources, and participation in climate governance (Awiti, 2022; Nosheen et al., 2023).

This study makes an important contribution to the literature by providing empirical evidence on the relationships among climate exposure, social networks, adaptive innovations, women's agency, and resilience in Pakistan. While much of the existing research has focused primarily on vulnerability, the present findings highlight the significant adaptive capacities that women possess and the critical role of social innovation in fostering resilience (Dev & Manalo, 2023; Khalil et al., 2020). The mixed-methods approach further enhances understanding by combining statistical evidence with detailed accounts of women's lived experiences.

Overall, the findings underscore the need for climate adaptation policies that strengthen women's social networks, support community-led innovations, expand access to financial and educational resources, and promote women's participation in decision-making processes (Nosheen et al., 2023; Khalil et al., 2020; Dapilah et al., 2020). Investments in women-centered adaptation initiatives have the potential to improve household resilience, reduce vulnerability, and contribute to sustainable development outcomes (Nosheen et al., 2023). As climate risks continue to intensify across Pakistan, recognizing and supporting women's adaptive capacities will be essential for building resilient and equitable communities (Ajani & van der Geest, 2021; Hussain et al., 2020).

CONCLUSION

This study highlights the disproportionate impact of climate change on women in rural and peri-urban Pakistan while demonstrating their vital role in strengthening community resilience through adaptive social innovations. Women's agency, social networks, education, and asset ownership significantly enhanced household resilience despite repeated climate-related shocks. Community initiatives, including knowledge-sharing and collective savings groups, supported adaptation and recovery, although financial constraints, restrictive gender norms, limited training, and inadequate institutional support remained key barriers. Strengthening women's access to resources, participation in decision-making, and climate adaptation programs is essential for improving resilience. Gender-responsive policies that empower women as leaders in climate adaptation can promote climate justice, sustainable development, and long-term resilience in vulnerable communities across Pakistan.

Ethical Considerations

The study adhered to relevant ethical principles. Informed consent was obtained from all participants, participation was voluntary, and confidentiality and anonymity were maintained throughout the study.

Data Availability

Available from corresponding author on request.

Author Contributions

Sehar Anees: Study conception and design, data collection, statistical analysis, interpretation of findings, and drafting and writing of the manuscript.

Muhammad Saleem Mohsin: Methodological development, data interpretation, critical revision of the manuscript, and final approval of the version to be published.

All authors accept responsibility for the integrity and accuracy of the research and its findings.

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Conflict of Interest

The authors declare no conflict of interest.

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Artificial Intelligence (AI) Disclosure

The authors disclose that Grammarly was used for language editing, proofreading, and improving the clarity of the manuscript. Gemini AI was used to assist in generating images included in the manuscript. AI tools were not used to generate, analyze, interpret, or fabricate the research data or findings. The authors reviewed and verified all AI-assisted content and accept full responsibility for the accuracy, originality, integrity, and final content of the manuscript.

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