Smog, Heatwaves, and the Feminized Face of Climate Distress: Psychological, Geographical, and Engineering Perspectives of Women's Vulnerability in Central Punjab

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In Central Punjab, Pakistan, the rising impacts of climate change, especially frequent heat waves and smog, pose extreme risks to human health. Their impact on women is not gender-neutral; in highly populated regions with socioeconomic limitations, women are disproportionately affected. This study adopts an interdisciplinary approach, incorporating psychology, geography, and environmental engineering to assess women's vulnerability to climate change. Based on a qualitative research design, in-depth interviews were conducted with women of different ages, professions, and socioeconomic statuses in the urban and semi-urban districts of Central Punjab. Thematic analysis revealed three main areas of vulnerability: psychological distress, risks associated with geography, and inadequate infrastructure. Women frequently experienced increased anxiety, helplessness, and trauma linked to long-term exposure to extreme heat and environmental pollution. Geographical mapping of participants' residences showed that women living in low-income areas faced greater exposure due to congested housing, lack of green cover, and high levels of vehicle emissions. Their susceptibility was further exacerbated by engineering-related shortcomings, such as poor ventilation, ineffective early warning systems, and unsafe transport in urban environments. These overlapping stressors collectively limited women's mobility, increased their role strain, and weakened their ability to adapt. The results highlight the urgent need for gender-sensitive, climate-resilient infrastructure and public health interventions. The integration of psychological support, inclusive urban planning, and community sensitization is essential to strengthen women's resilience to climate-related risks. This interdisciplinary perspective underscores that addressing climate distress requires closing social, spatial, and technological gaps to reduce the disproportionate burden women face from increasing environmental degradation.

Keywords: Climate Change, Women's Vulnerability, Climate Distress, Urban Geography, Environmental Engineering

Introduction:

Climate change is one of the most pressing challenges of the 21st century, with consequences that extend beyond environmental degradation to encompass human health, livelihoods, and social equity. Its effects are unevenly distributed, and vulnerable groups—particularly women—bear a disproportionate burden. In South Asia, and specifically in Central Punjab, Pakistan, rising temperatures, prolonged heat waves, and worsening air pollution have intensified risks and exacerbated gender inequality, leaving women especially vulnerable [1][2].

Pakistan is among the countries most severely affected by climate change, facing recurring floods, heat waves, and deteriorating air quality. Between 1999 and 2018, it ranked fifth worldwide among nations most frequently impacted by climate-related disasters. The catastrophic floods of 2022 displaced over 33 million people and caused agricultural losses exceeding $2.3 billion [3]. Heat waves in Pakistan have reached temperatures exceeding 46°C in some cities, and between 1997 and 2015, more than 120 such events were recorded, leading to significantly high rates of illness and mortality [4][5].

Women in Central Punjab—including major cities such as Lahore, Faisalabad, and Multan—are particularly vulnerable to climate risks due to rapid urbanization, overcrowding, and inadequate infrastructure. Their exposure is shaped not only by biological and physiological factors but also by entrenched gender roles and socio-economic disparities. Evidence suggests that a one-degree rise in temperature is associated with a 6.3% increase in domestic violence cases across South Asia [6]. The expectant females experience increased risks of miscarriages, preterm delivery, and heat-related complications[7][8]. Moreover, female residents of urban slums with low income, where there is a lack of green areas and ventilation, feel discomfort and anxiety, a sense of helplessness, and heat-related heat and smog trauma[9] [10]. These climate-related stressors also lower women's mobility, productivity, and general well-being.

Gender inequality and climate adversity are a severe intersection of vulnerability. Climate change adds to its existing inequalities in health, economic stability, and social safety by depriving women of resources, weakening access to healthcare, and diminishing their role in decision-making[11][12]. Therefore, the processing of the climate vulnerability of women cannot be dealt with on an individual basis; an interdisciplinary approach is necessary.

A combination of environmental engineering, geography, and psychology offers a comprehensive approach to studying these vulnerabilities. Engineering perspectives emphasize the need for climate-resilient, gender-sensitive infrastructure, such as accessible transportation, green urban spaces, and adequate ventilation[13]. Geographic mapping enables the identification of high-risk neighborhoods and the allocation of resources to marginalized populations[14]. Psychological insights underscore the importance of resilience-building through awareness campaigns, available mental health services, and empowerment initiatives that combat helplessness [15]. Collectively, these perspectives demonstrate that a gender-sensitive, interdisciplinary approach is essential for understanding and addressing the diverse vulnerabilities faced by women in Central Punjab.

Significance of the Study:

This research is significant because it addresses a critical gap in the interdisciplinary literature on the gendered dimensions of climate change in Pakistan. While existing studies have examined environmental degradation, public health, and gender inequality as separate issues, limited attention has been given to how psychological, geographical, and engineering factors intersect to increase women's vulnerability during climate crises. By integrating these perspectives, this study offers a comprehensive understanding of how structural, spatial, and emotional dimensions collectively contribute to women's heightened susceptibility to climate-related risks.

The research is particularly relevant in the context of urban and semi-urban areas of Central Punjab, where rapid urbanization, inadequate infrastructure, and climate stressors—such as smog and extreme heat—exacerbate gender-specific vulnerabilities. Insights drawn from this region also hold broader applicability to other South Asian urban settings, where similar socio-environmental conditions expose women to comparable risks.

Beyond its regional focus, this study contributes to global debates on climate justice and gender equity. By emphasizing women's disproportionate burden, it highlights the need for gender-sensitive adaptation strategies that integrate infrastructure development, spatial vulnerability mapping, and psychosocial resilience-building. The findings will be valuable for policymakers, urban planners, and public health professionals in designing inclusive climate adaptation frameworks that enhance women's agency and resilience in the face of environmental change.

Objectives of the Study:

The study objectives were following:

- Recognize how long-term exposure to pollution and heatwaves affects women's psychological well-being and adaptive actions.
- Based on exposure levels, urban infrastructure, and residential settings, map and examine geographic patterns of vulnerability.
- Analyze how women's vulnerability is increased by engineering and technology deficiencies in climate-responsive urban planning and infrastructure.

Method:

Research Design:

This study adopted a qualitative research design to explore women's vulnerability to climate change–induced smog and heatwaves in Central Punjab, Pakistan. The choice of a qualitative approach was informed by the need to capture the lived experiences, perceptions, and coping strategies of women whose realities are shaped by intersecting environmental, social, and technological factors.

Unlike quantitative approaches, which tend to reduce complex realities to numerical measures, qualitative inquiry captures context, emotions, and nuanced meanings. Since climate change vulnerability is shaped by intersecting psychological, geographical, and infrastructural dimensions, a qualitative design was most suitable for illuminating these interconnections within women's everyday realities.

Participants:

Participants were women residing in urban (n=20) and semi-urban (n=10) districts of Central Punjab, including Lahore, Okara, Sahiwal, Faisalabad, and Sheikhupura. A purposive sampling strategy was employed to ensure diversity in age, socioeconomic status, marital status, and occupation. This approach enabled the inclusion of varied perspectives that reflect different levels of exposure to climate change impacts. These criteria ensured that participants represented a cross-section of women most likely to experience the psychological and structural consequences of smog and heat waves. To further reach women who were otherwise difficult to access due to mobility restrictions or cultural constraints, snowball sampling was also applied.

In total, thirty (n=30) participants were interviewed, consistent with qualitative research standards. Participants included homemakers, daily wage laborers, teachers, healthcare professionals, and university students. The majority lived in low- to middle-income neighborhoods, where infrastructural vulnerabilities were most pronounced. Data saturation was achieved by the 27th interview, when no new themes or insights emerged [16]. Three additional interviews were conducted to confirm data saturation and to ensure representation across different residential contexts. This approach provided both depth and breadth of perspectives while maintaining analytical manageability.

Data Collection:

Data were collected through semi-structured, in-depth interviews, each lasting between 45 and 70 minutes. Interviews were conducted in Urdu and Punjabi, depending on participant preference, and subsequently transcribed into English for analysis. An interview guide was developed collaboratively by psychologists, geographers, and engineers to ensure interdisciplinary coverage. The guide included open-ended questions on the following domains:

- Psychological experiences of heatwaves and smog (e.g., anxiety, helplessness, trauma, and role strain).
- Environmental exposure in daily life (e.g., housing conditions, availability of green spaces, ventilation).
- Mobility and access to safe transportation, workspaces, and health facilities.
- Perceptions of infrastructure and early warning systems for climate-related hazards.
- Adaptation and coping strategies employed by women and their households.

Interviews were conducted in participants' homes or in mutually agreed community spaces, ensuring privacy and comfort. Informed consent was obtained verbally and in writing, and participants were assured of confidentiality and the voluntary nature of participation.

Ethical Considerations:

Ethical approval was granted by the Departmental Research Ethics Committee at the Lahore College for Women University Lahore (LCWU). Participants were informed of their rights, including the right to withdraw at any stage without repercussions. Pseudonyms were used in transcripts and reporting to ensure anonymity. Particular care was taken in handling sensitive accounts of psychological distress to avoid traumatization; participants were provided with referral information for mental health support services where needed.

Data Analysis:

Data were analyzed using thematic analysis, following Braun and Clarke's six-step framework: familiarization with the data, generation of initial codes, searching for themes, reviewing themes, defining and naming themes, and producing the report. A team of three coders—a psychologist, a geographer, and an engineer—independently coded the transcripts before reaching consensus through discussion and iterative refinement. Triangulation across disciplines enhanced the credibility of findings, ensuring that psychological, geographical, and engineering dimensions of women's vulnerability were systematically captured.

NVivo software was used to organize, code, and visualize the data. Transcripts were imported into NVivo, where initial codes were generated inductively and subsequently grouped into broader categories. This process produced three overarching themes with multiple subthemes. NVivo's query and visualization tools (e.g., coding matrices and thematic charts) were instrumental in identifying cross-case patterns and generating figures that illustrated the frequency and interrelationships of themes.

To ensure trustworthiness, the study employed strategies of credibility, transferability, dependability, and confirmability. Member checking was conducted by sharing summaries of findings with five participants, strategically selected to represent diverse socio-demographic backgrounds (e.g., young/older, urban/semi-urban, middle-income/low-income). While it was not feasible to involve all 30 participants due to practical constraints of time, availability, and participant burden, these five cases served as a validity check, confirming the accuracy of interpretation and ensuring that key themes aligned with participants' intended meanings. A detailed audit trail was maintained, and peer debriefings with interdisciplinary experts were undertaken to refine interpretations further.

Results:

Table 1. Socio-demographic Characteristics of Participants (N = 30)

Variable	Categories	N	%
Age (years)	18–25	8	26.7
	26–35	12	40.0
	36–45	6	20.0
	46–55	4	13.3
Marital Status	Single	10	33.3
	Married	18	60.0
	Widowed/Divorced	2	6.7
Occupation	Homemaker	9	30.0
	Teacher	5	16.7
	Student	5	16.7
	Healthcare worker (nurse, doctor)	4	13.3
	Daily wage laborer	3	10.0
	Factory/industrial worker	2	6.7
	Other (shopkeeper's wife, clerical)	2	6.7
Residence Type	Urban	20	66.7
	Semi-urban	10	33.3
Socioeconomic Status	Low income	16	53.3
	Middle income	11	36.7
	Upper-middle income	3	10.0

Thematic analysis of interviews with 30 women in Central Punjab revealed a complex interplay of psychological, geographical, and infrastructural vulnerabilities shaping their experiences of climate distress. Three overarching themes, each with multiple subthemes, emerged: (1) Psychological Distress and Gendered Burdens, (2) Geographical Vulnerabilities and Environmental Exposures, and (3) Engineering and Infrastructure Deficiencies. To enhance authenticity and depth, illustrative verbatim excerpts from participants are integrated throughout the analysis.

Psychological Distress and Gendered Burdens:

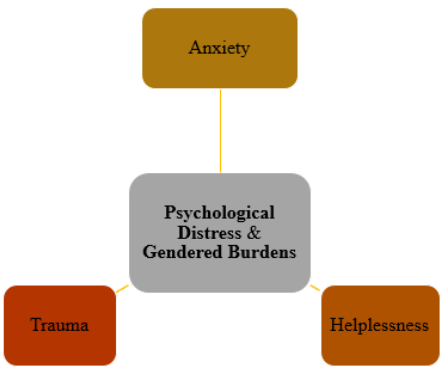


Figure 1. Psychological distress and gendered burdens experienced by women.

Figure 1 highlights heightened anxiety, emotional strain, and increased caregiving responsibilities reported by participants, illustrating how climate-related stressors disproportionately affect women's mental health. These effects were further amplified by entrenched gender roles and caregiving duties.

Anxiety and Helplessness:

"Every time the smog comes, I worry that my son will have another asthma attack. I feel helpless because I cannot stop the air we breathe." (Participant 7, 34 years, homemaker)

Role Strain:

"I have to keep the house cool, cook for the family, and still go to school for teaching. The heat makes me dizzy, but no one else will share these duties." (Participant 12, 29 years, schoolteacher)

Trauma and Persistent Stress:

"Last year, I fainted on my way to work because of the heat. Since then, I feel scared every time I have to go out in the summer." (Participant 3, 42 years, factory worker)

These findings suggest that climate stressors not only affect mental well-being but also exacerbate existing gendered burdens, leaving women with limited coping resources.

Geographical Vulnerabilities and Environmental Exposures:

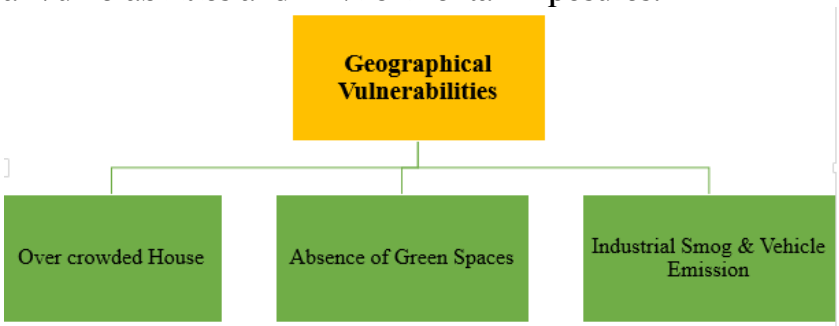


Figure 2. Geographical vulnerabilities and environmental exposures reported by participants

Figure 2 illustrates how overcrowded housing, limited green spaces, and high levels of industrial smog and vehicle emissions converge to heighten women's susceptibility to climate change impacts in Central Punjab.

Overcrowding and Housing Conditions:

"We live in a one-room house with a tiny roof. During heatwaves, the walls and roof feel like they are burning. It is like sitting inside an oven." (Participant 15, 27 years, domestic worker)

Absence of Green Spaces:

"In our area, there are no trees or parks. The air feels heavy, and there is no fresh breeze. I envy people who live in colonies with gardens." (Participant 21, 22 years, university student)

Exposure to Vehicle Emissions and Industrial Smog:

"My house is next to a busy road. When the smog comes, it mixes with the smoke from buses and trucks. My children cannot play outside, and even inside, our throats burn." (Participant 9, 38 years, nurse)

Women in low-income, densely populated areas consistently reported greater exposure to climate-related hazards and fewer adaptation options compared to those in semi-urban localities.

Engineering and Infrastructure Deficiencies:

Engineering and infrastructural deficiencies portrays that systemic shortcomings in building design, urban planning, and public systems were reported as major factors worsening women's vulnerability

Ventilation and Building Design Gaps:

"Our home has no proper windows, only small holes for air. The heat gets trapped, and it becomes suffocating inside." (Participant 2, 40 years, shopkeeper's wife)

Weak Early Warning Systems: "We never know when a heatwave or smog will start. We *just realize it when people begin* coughing, or when the heat is too much. Nobody tells us in time." (Participant 18, 30 years, daily wage laborer)

Unsafe Transportation Systems:

"I avoid going to the hospital during smog days because buses are overcrowded and unsafe. I would rather stay at home sick than risk traveling." (Participant 25, 35 years, homemaker)

The lack of gender-sensitive, climate-resilient infrastructure deepened women's sense of powerlessness and reduced their access to essential services.

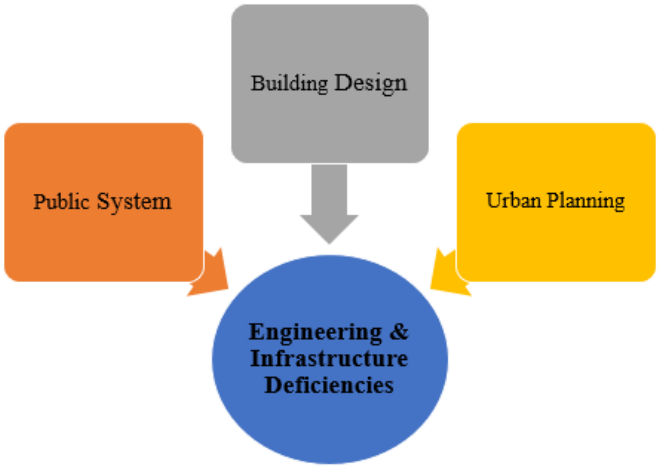


Figure. 3: Engineering and infrastructure deficiencies contributing to women's vulnerability to climate change

Integrative Insights across Disciplines

The findings demonstrate that women's climate distress is not solely a product of environmental exposure but emerges from the synergistic interaction of psychological burdens, geographical disadvantages, and infrastructural neglect. Anxiety and trauma are exacerbated by overcrowded housing, the absence of greenery, and unsafe transportation, while weak governance and inadequate engineering solutions further compound these vulnerabilities.

Table 2. Illustrative Summary of Themes

Theme	Subthemes	Key Illustrative Findings
Psychological Distress and Gendered Burdens	Anxiety & helplessness, role strain, trauma	Fear for children's health, double responsibility during heatwaves, fainting episodes, persistent stress
Geographical Vulnerabilities and Environmental Exposures	Overcrowding, lack of greenery, exposure to emissions	Tin-roofed homes trap heat, absence of trees worsens heat stress, unsafe neighborhoods with high pollution
Engineering and Infrastructure Deficiencies	Poor building design, weak early warning, unsafe transport	Poor ventilation increases heat exposure, lack of climate alerts, restricted mobility due to unsafe public transport

Summary:

The results highlight that women's experiences of smog and heatwaves in Central Punjab are marked by a synergistic interaction of psychological strain, environmental deprivation, and infrastructural neglect. Direct narratives illustrate the gendered dimension of climate distress, where caregiving responsibilities, unsafe neighborhoods, and poorly designed infrastructure magnify suffering. The findings call for gender-responsive climate adaptation

strategies, such as inclusive urban planning, affordable climate-resilient housing, and accessible early warning systems.

Table 3. Frequency of Themes and Subthemes Identified in Participants' Narratives (N = 30)

Main Theme	Subthemes	Number of Participants (n)	Percentage (%)
1.Psychological Distress and Gendered Burdens	Anxiety and helplessness	22	73.3
	Role strain (domestic + occupational)	18	60.0
	Trauma and persistent stress	12	40.0
2.Geographical Vulnerabilities and Environmental Exposures	Overcrowding and poor housing	20	66.7
	Absence of green spaces	15	50.0
	Exposure to vehicle emissions/industrial smog	19	63.3
3.Engineering and Infrastructure Deficiencies	Poor ventilation and building design	17	56.7
	Weak early warning systems	14	46.7
	Unsafe and unreliable transportation	16	53.3

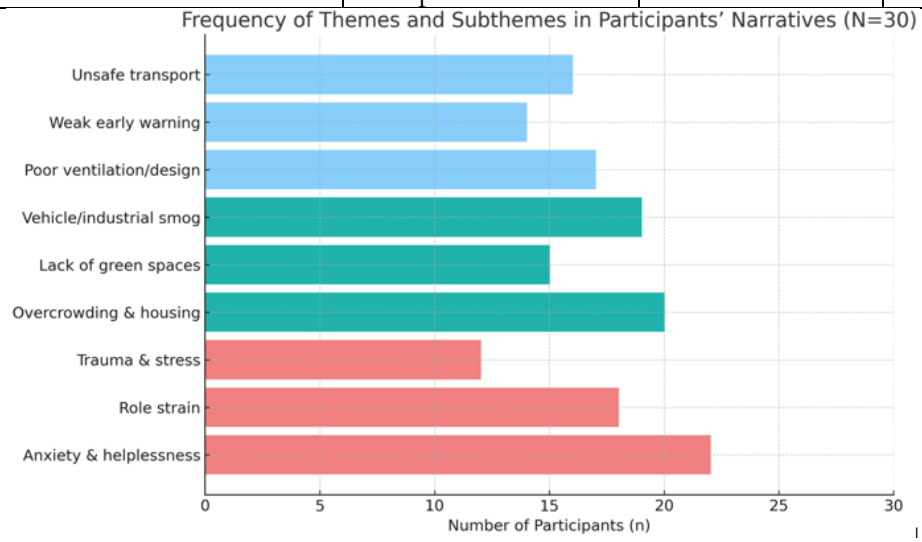


Figure 4. Bar chart displaying frequency of major themes (psychological distress, geographical risks, and infrastructural deficiencies) among study participants.

The bar graph (Figure 4) illustrates the frequency of major themes and subthemes emerging from participants' narratives. Psychological distress was most frequently expressed in terms of anxiety and helplessness (73.3%)**,** followed by role strain (60%) and trauma-related stress (40%)**.** Geographical vulnerabilities were also highly salient, with overcrowding and poor housing (66.7%) and exposure to vehicular and industrial smog (63.3%) emerging as common experiences. Engineering and infrastructural deficiencies, particularly poor ventilation and unsafe transport, were reported by over half of participants, highlighting the role of systemic neglect in shaping women's climate vulnerability.

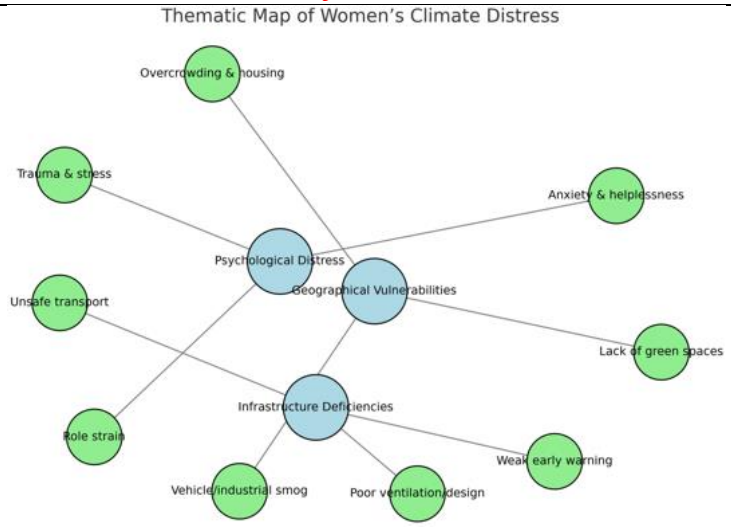


Figure 5. Thematic map illustrating the relationship between main themes and subthemes derived from NVivo coding.

The thematic map (Figure 5) conceptually organizes the findings, demonstrating how the three overarching domains—Psychological Distress, Geographical Vulnerabilities, and Infrastructure Deficiencies—interconnect to form a holistic picture of women's climate distress in Central Punjab. The diagram visually reinforces that no single factor operates in isolation; rather, intersecting stressors across mental health, spatial environment, and engineering design collectively intensify women's exposure and reduce their resilience.

Discussions:

The theme analysis indicated that the climate change has a significant impact on the mental health of women in South Punjab, Pakistan. Globally, including in Pakistan, climate change is changing ecosystems and destroying the lives of millions of people. Increasing temperatures, unpredictable rainfalls, season change, and worsening natural disasters endanger food and water infrastructure, ruin infrastructure, and lead to economical instability [17]. The Findings indicated three themes (1) Psychological Distress and Gendered Burdens, (2) Geographical Vulnerabilities and Environmental Exposures, and (3) Engineering and Infrastructure Deficiencies.

Empirical evidence has been given to these assertions in the past studies. Studies in various countries have always shown that stressors involved in climate change may exacerbate mental problems, especially in vulnerable populations who reside in the rural setting. Climate change worsens the social and economic inequalities that already exist because women usually have less resources and the capacity to address climate-related risks [17].

To illustrate, elevated temperatures and their impacts have been associated with a greater degree of psychological distress and heat-related illnesses, which affect the general psychological well-being[18]. In the same way, PTSD, anxiety, and depression have been linked to extreme weather events like floods and storms in the affected communities [19][20].

The second and the third themes are also consistent with the previous research. The stress created by climate is overly experienced by women in rural and agricultural settings. This exposes them to the effects of climate particularly in the areas of their service as carers, food providers and pillars of the community. Direct threats to food security include droughts and crop failure, which only further burden women to take care of their families in more challenging conditions.

Water deficiency means that women have to travel long distances to buy the simplest needs, and natural calamities often upset the family and community structures, which contributes to the worsening of mental pain. Such experiences can raise anxiety, depression,

and trauma in women within such communities, in an attempt to release essential activities amidst mounting climatic issues[21][22]. The effect of climate change has been disastrous on the agricultural, water resources and economic stability in general since a considerable part of the population in Pakistan depends on agriculture directly to make a living. The agricultural reliance of Pakistan implies that any fluctuation in climate stability may lead to the food shortages, economic losses, and the rise of social tensions on a massive scale[23][24].

Pakistan engineering and infrastructure vulnerabilities, as per the topics of study, are insufficient ventilation and the design of buildings, poor early warning systems, and dangerous and insecure transportation. These results are also in line with the previous studies[15]. Flooding and heavy rainfall occur frequently which adversely affects infrastructure, agriculture and human livelihood of the country. Climate change touches upon numerous social spheres and European honor, such as social justice, health, food security, or displacement[25].

Conclusion:

The analysis reveals a growing number of mental health challenges, reduced mobility, and additional household and caregiving responsibilities imposed on women as a result of extreme weather events. Psychological suffering is further intensified by structural weaknesses, including ineffective early warning mechanisms, low levels of public awareness, and poor household ventilation. Geographic mapping of participants' residences showed that women in low-income metropolitan areas face greater exposure to heat and smog due to high population density, lack of tree cover, and elevated vehicle emissions. Findings underscore the urgent need for gender-sensitive, climate-resilient infrastructure in both low-income housing and urban transportation systems, as supported by engineering research. Overall, the interplay of psychological stressors, geographic deprivation, and infrastructural neglect significantly increases women's vulnerability to climate change in Central Punjab. Addressing these challenges requires a gender-responsive and comprehensive approach that integrates insights from psychology, geography, and engineering. To strengthen women's resilience, this study recommends inclusive city planning, gender-sensitive public health initiatives, and targeted awareness campaigns.

Policy Implications:

The results highlight the significance of policy interventions that integrate the areas of climate change adaptation and mental health care within the rural population. The primary focus of the initiatives should be the enhancement of the social support system, community unity, and provision of resources as well as the consideration of cultural norms. Mental health treatments that are gender sensitive, community resilience programs and climate adaptation plans need to be put in place and implemented. The policymakers need to collaborate across sectors to offer holistic practices that mitigate stressors associated with climate, enhance psychological health, and empower rural women. The infrastructure, health, education, and livelihood opportunities funded by the government are essential to create resilience and long-term growth of climate-prone communities that would eventually have benefits to the rural population.

Future Implications:

Policy Integration:

The results underscore the urgent need for gender-responsive climate policies in Pakistan. Urban planning must incorporate climate-resilient housing, ventilation systems, and green belts, particularly in low-income neighborhoods where women's exposure is highest.

Health and Well-being:

Mental health professionals should be integrated into climate adaptation frameworks, as women's anxiety, role strain, and trauma indicate an under-addressed psychological dimension of climate vulnerability. Establishing community-based counseling services and climate-health awareness campaigns may mitigate distress.

Technological and Engineering Innovations:

Affordable climate-smart housing materials, improved ventilation designs, and gender-sensitive transport solutions should be prioritized by engineers and policymakers to enhance women's resilience.

Community Preparedness:

Developing accessible early warning systems in local languages, utilizing mobile phones, mosques, and community centers, could empower women with timely information to protect themselves and their families during smog and heatwave episodes.

Limitations:

Although this study provides valuable interdisciplinary insights, several limitations should be noted:

Sample Size and Scope:

The study was limited to 30 participants from select urban and semi-urban districts of Central Punjab. Findings may not be generalizable to rural populations or other provinces of Pakistan.

Qualitative Focus:

While thematic analysis provides depth, the absence of quantitative measures restricts the ability to statistically generalize findings across wider populations.

Self-Report Bias:

Data were based on self-reported experiences, which may be influenced by recall bias or social desirability.

Disciplinary Representation:

Although interdisciplinary in design, geographical and engineering insights were derived indirectly from participants' accounts rather than direct technical assessments of infrastructure.

Suggestions for Future Research and Practice:

Mixed-Method Approaches:

Future studies should adopt mixed-method designs, combining qualitative narratives with quantitative surveys or spatial mapping to provide a more comprehensive analysis.

Rural Women's Vulnerability:

Expanding research to rural communities, where women face unique climate-related challenges (e.g., water scarcity, agricultural labor), would broaden applicability.

Longitudinal Studies:

Following participants over multiple climate events could capture evolving adaptation strategies and long-term psychological impacts.

Participatory Action Research:

Engaging women as co-researchers in designing interventions may ensure culturally appropriate, gender-sensitive, and sustainable solutions.

Policy-Oriented Collaborations:

Collaboration between psychologists, urban planners, engineers, and public health specialists is essential for translating research into effective climate adaptation policies**:**

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