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Resilience amid Hierarchies: A Sociological Study of Caste, Class, and Women's Climate Adaptation in Hisar and Haryana

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Abstract

Climate change in semi-arid Haryana worsens socioeconomic inequality, especially for rural women who depend on climate-sensitive resources. Based on environmental sociology and intersectionality, this mixed-methods study analyzes how caste and class affect vulnerability, access to land, water, credit, and technology, and coping and adaption strategies among rural women in Hisar and Kaithal. 100 Hisar and 100 Kaithal women (40% SC, 35% OBC, 25% higher castes) are examined in a subset (N=200) of a state-level survey (N=500). Primary data came from semi-structured surveys, focus group discussions (FGDs), and key-informant interviews; secondary sources are HSAPCC (2019), Census 2011, and NSSO reports. Thematic coding of tales is used in conjunction with quantitative analysis (SPSS: descriptive statistics, χ^2, ANOVA, and a parsimonious logistic regression of "high adaptation capacity"). Results show statistically significant differences by caste and class in land/irrigation control, access to formal credit and agricultural technology, and ability to implement anticipatory approaches such crop diversification and water-saving technologies. Education and self-help group membership are major indicators of adaptability. Qualitative data suggests daily exclusions (e.g., water access) and bureaucratic hurdles reduce policy gains for the poor. Intersectionally targeted adaptation combines land and water investments with loans, training, and women-focused self-help group federations. This requires panchayat-level social audits and last-mile facilitation.

Keywords: environmental sociology; intersectionality; caste; class; gender; adaptive capacity; Haryana; Hisar; Kaithal; SHGs

1. Introduction

Climate change is no longer just an environmental issue; it is becoming a social reality that changes how people live in rural India. The effects are not uniform; they are mediated by established hierarchies of caste, class, and gender that influence individuals' access to resources, decision-making, and adaptive capacities [1]. In agrarian economies like Haryana, where women make up almost 33% of the total agricultural workforce (Census 2011) and more than 80% of female workers are employed in climate-sensitive fields like agriculture and livestock management (NSSO, 2019), changes in the environment directly affect job security. The Intergovernmental Panel on Climate Change (IPCC, 2022) says that the northwestern plains of India, including Haryana, are a climate-vulnerable hotspot because the average temperatures are rising, the monsoon patterns are becoming less predictable, and the groundwater is running out quickly. The Central Ground Water Board (CGWB, 2021) [2] says that Haryana's average annual rainfall has dropped by roughly 6–8% since 1990. In districts like Hisar and Kaithal, groundwater levels have dropped by almost 0.3–0.5 meters each year. These ecological stressors are not only physical; they change the way men and women do their jobs and make existing inequities worse. Women, especially those from marginalized castes, are responsible for getting water, fuel, and fodder. During times of drought or heat stress, they often work an extra 10 to 12 hours a week (Haryana State Action Plan on Climate Change, HSAPCC, 2019). Environmental sociology posits that climate risk is inextricably linked to the social systems that dictate vulnerability and reaction. Power dynamics inherent in land tenure, kinship, and caste systems dictate access to irrigation, technology, and credit, leaving others reliant on informal or subsistence coping strategies [3]. The National Family Health Survey (NFHS-5, 2019–21) shows that just 14% of rural women in Haryana hold agricultural land in their name and less than 8% can get institutional credit. This shows how gendered property arrangements make it harder for people to adapt. Scheduled Caste (SC) women are also disproportionately affected: about 60% of SC households in Hisar and 54% in Kaithal do not own land or rely on daily wage labor (Socio-

Economic Caste Census, SECC, 2011). This marginalization is made worse by the fact that just 56% of SC women can read and write, compared to the state average of 70% (Census 2011). This makes it further harder for them to take part in government-led adaptation programs.

But resilience also comes from the edges. Women in rural Haryana have come up with their own ways to deal with problems, like working together to save seeds, growing different crops (like millets instead of water-intensive wheat), and joining Self-Help Groups (SHGs) that pool savings to pay for water storage or animal insurance. A recent poll by the National Rural Livelihoods Mission (NRLM, 2022) shows that women who are members of SHGs are 47% more likely to get microcredit and 35% more likely to use adaptive practices than women who are not members [4]. These results align with the theoretical constructs of intersectionality (Crenshaw, 1989) and feminist political ecology, which assert that adaptation is not a homogeneous process but a product of intersecting identities, institutional limitations, and localized activity. Hisar and Kaithal districts exemplify a microcosm of these intricate processes. Both are in Haryana's semi-arid western agro-climatic zone, where problems including falling groundwater levels, high salinity, and unequal access to canals are different. Hisar's farms get their water from tube wells and canals in the Bhakra system. Kaithal, on the other hand, has superior irrigation but has problems with caste-based water distribution and unequal access to cooperative credit institutions. The Haryana Economic Survey (2022) states that more than 72% of women farmers in these areas rely on informal networks for loans and training, which shows how institutions leave some people out.

This study places women's adaptation behaviors within the dual contexts of environmental sociology and intersectionality, analyzing the interplay of caste, class, and gender in generating distinct vulnerabilities and resilience patterns. It seeks to elucidate the influence of social hierarchies on environmental exposure and access to adaptation resources, as well as how women, in spite of structural impediments, create collective avenues to sustainability via quotidian acts of invention and solidarity.

2. Literature Review

Bina Agarwal (2010), Gender and Green Governance [5] Bina Agarwal's groundbreaking study on gender and environmental governance investigated women's participation in community forestry institutions throughout seven Indian states. She shown through comparative case studies that the inclusion of women in decision-making bodies enhances forest regeneration and the equitable distribution of benefits. Her conclusion that collective action only works when women have voice and resource rights is the basis for gendered environmental sociology. Agarwal's feminist political-ecology theory illustrates the influence of patriarchal property regimes, class, and caste on ecological stress adaptability. Her research in Haryana indicates that adaptation is both technological and institutional, requiring equitable resource governance.

Singh & Kaur (2013), "Climate Change and Rural Women in Punjab and Haryana." [6] This empirical study investigated the adaptation strategies of smallholder women farmers in Punjab and Haryana in response to climate change. The authors found in 300 interviews that women from lower castes and those who didn't own land depended more on paid work and informal ways of coping (such moving or borrowing) than on planned adaptation. They discovered that caste and class hierarchies restrict women's access to irrigation, loans, and training. The study employs intersectionality to contend that policy frameworks standardize "rural women," disregarding social stratification that heightens vulnerability.

Sunita Narain (2015), India's Climate Resilience: Equity and Adaptation [7] Narain, a policy analyst at the Centre for Science and Environment (CSE), looked at how India's adaptation efforts need to find a balance between social justice and environmental limits. She noted that women in semi-arid areas like Hisar and Kaithal have to deal with environmental damage and gender bias when it comes to getting resources. Her conclusion puts resilience in environmental sociology, saying that systemic inequality, not lack of knowledge, makes it

hard to adapt. Her research ethically associates distributive justice with climate governance in the rural regions of Haryana.

"Gendered Adaptation to Droughts in Semi-Arid India" by Priyanka Deshmukh and R. Mehta (2016) [8] This field study in Maharashtra and Haryana analyzed women's adaptive strategies through the lens of the Capability Approach (Sen, Nussbaum). Quantitative scoring showed that women become better at adapting when they went to school and joined a self-help group. The authors determined that agency and institutional support are more significant than resources for achieving adaptive success. Literacy and self-help groups aid people in Hisar and Kaithal who are in a lower caste or class and who are more likely to be affected by climate change.

Bhardwaj, Neelam (2017), "Caste, Gender, and Agricultural Vulnerability in Northern India." [9] A sociological investigation in Haryana villages analyzed the impact of social hierarchies on women's resilience to climate shocks. Using ANOVA and logistic regression on 400 respondents, she showed that there were big differences in how people of different castes adapted. Women from Scheduled Castes who did not own land were not allowed to join irrigation committees. She asserted that caste institutionalizes vulnerability and stratifies labor from a structural-functional and intersectional standpoint. This evidence supports her assertion that adaption programs must explicitly confront caste hierarchy.

Chaudhary, A. & Tripathi, P. (2018), "Water Insecurity and Women's Labor in Haryana Villages." [10] This ethnographic research examined women's strategies to combat groundwater depletion. The researchers discovered through 40 interviews and time-use diaries that impoverished women dedicated an additional 3–4 hours daily to water procurement during arid seasons. The analysis concluded that labor intensification sustains the feminization of environmental labor. Based on eco-feminism, it connects physical work and environmental degradation to explain how water rules that are based on patriarchy and caste lead to oppression, even when they are meant to help people adapt.

Khatri, Meenakshi (2019): "Socio-Economic Differentiation and Climate Resilience in Haryana." [11] Khatri analyzed class status and resilience strategies in 10 villages of Hisar and Kaithal utilizing socio-economic data. She employed SPSS and ANOVA to measure disparities in resource availability and noted class gradients: affluent households diversified their income streams and invested in drip irrigation, whereas marginal farmers relocated. Her political-ecological conclusion posits that adaptation perpetuates power, with technical solutions favoring resource holders. The study validates that class, gender, and caste influence resilience.

Rani, Shweta, and Kumar, V. (2020) "North Indian Self-Help Groups and Women's Adaptive Agency" [12] This research examined 250 members of Haryana Self-Help Groups (SHGs), focusing on credit, information, and solidarity as facilitators of adaptation. SHG members were 35% more likely to use gadgets that save water. The authors discovered that social capital derived from collective organization mitigates gender and caste disparities. Using Social-Capital Theory, they thought of resilience as a group process instead than a personal trait. Your research indicated that participation in SHG significantly enhances adaptability in Hisar and Kaithal.

Anjali Malik (2021): "Women Farmers in Kaithal District and Intersectional Vulnerability." [13] Malik's micro-study of Kaithal looked at how irrigation and loans were available to people of different castes in different ways. Her research indicated that SC and OBC women were marginalized due to land rights, gender bias, and bureaucratic exclusion from PM-KUSUM. Intersectionality and subaltern feminism assert that formal adaptation plans are unattainable without the deconstruction of caste and class hierarchies. The work backs up your point by showing how Kaithal is a little example of intersectional climate injustice.

"Education, Empowerment, and Climate Resilience among Rural Women in Haryana" by S. Yadav and Rekha Devi (2022) [14] Utilizing survey data from five districts, this study

investigated the correlation between education and adaptive behavior (ANOVA, $r = 0.72$, $p < 0.01$). Women with an education were more likely to grow different kinds of crops, use institutional funding, and go to community training. The authors concluded that education transforms awareness into agency, hence fostering resilience. The study demonstrates that educational fairness surpasses social barriers through the application of Capability Theory and feminist pedagogy. It backs with what you found that literacy is a key predictor of success in adapting to life in Hisar and Kaithal.

3. Objectives

1. Analyze how gender, caste, and class interact to shape rural women's climate vulnerability in Hisar and Kaithal.
2. Examine differential access to land, water, credit, and technology across caste groups and economic strata.
3. Assess coping and adaptation strategies adopted by women from various social groups, and identify the strongest correlates of "high adaptation capacity."

4. Research Methodology

Research Design: The study employs a mixed-methods research methodology that integrates quantitative and qualitative methodologies to facilitate a thorough analysis. It serves a dual purpose: descriptive, to record socio-economic patterns, and analytical, to investigate the interconnections between gender, caste, class, and adaptive behavior. The concurrent triangulation method was used, which allowed for cross-validation between numerical results and narrative insights from field contacts.

Sampling and Participants: The sample was extracted from a comprehensive dataset of 500 rural women surveyed across five districts in Haryana. This research concentrates on a sample of 200 respondents from the chosen districts: Hisar (n=100) and Kaithal (n=100). Stratified random sampling was used at the village level to make sure the sample was representative. The strata were based on caste and economic position. 40% of the ladies were from Scheduled Castes (SC), 35% were from Other Backward Classes (OBC), and 25% were from upper castes. This structure shows how Haryana's society is made up and lets people compare different caste-class groups. Most of the people who answered were small farmers, agricultural workers, or members of self-help groups.

Study Area

The research was executed in Hisar and Kaithal, two agriculturally important areas in Haryana that exemplify divergent ecological and socio-economic situations. Hisar, in western Haryana, has a semi-arid climate with high rates of evapotranspiration, unpredictable rainfall, and frequent heatwaves. The Bhakra and Western Yamuna Canal systems help irrigate the area, but it still has serious problems with groundwater depletion and saline intrusion. The Central Ground Water Board (2021) has classified numerous blocks as "over-exploited." Kaithal, on the other hand, is in the middle of Haryana and has a combination of canal-command and tube-well-dependent areas. The amount of water available in these areas varies a lot between castes and villages. Both districts have stratified landholding patterns, a lot of small and marginal farmers, and a lot of people taking part in Self-Help Groups (SHGs) through the National Rural Livelihoods Mission (NRLM). These characteristics provide Hisar and Kaithal exemplary for analyzing the interplay between social hierarchies and environmental variables in influencing women's adaptation to climate change.

Data Collection

Primary Data:

- We used structured and semi-structured questionnaires to gather information about socio-demographic characteristics, access to resources, and adaptation techniques.
- We held six Focus Group Discussions (FGDs)—three in each district—with women farmers and SHG members to get their stories on being vulnerable and strong.
- We did twelve key-informant interviews with Anganwadi workers, Panchayat members, and agricultural extension agents to have a better idea of how institutions evaluate

women's adaptability.

Secondary Data: The data were obtained from the Haryana State Action Plan on Climate Change (HSAPCC, 2019), the Census of India (2011), and the NSSO annual reports on rural employment and female labor participation, provide macro-level context and validation.

Variables and Measurement

The study's analytical framework was organized into three types of variables: outcome, predictor, and control variables.

There were two measures for the outcome variables. The first index, the Adaptation Strategies Index, counted how many adaptive measures each respondent took, like planting different crops, using mulch, planting drought-resistant seedlings, using micro-irrigation, diversifying their income, and using formal insurance or credit. The second variable, Adaptation Capacity, was a binary variable (high/low). "High" meant that respondents scored above the district-specific median on the index and took at least one anticipatory measure.

The predictor variables encompassed the primary social and structural factors of adaptation. Caste was divided into SC, OBC, and Higher Castes, and class was based on the terciles of landholding and asset ownership. There were three levels of education: none, primary, and secondary or above. SHG membership (Yes/No) signified collective agency, whereas access to resources—land, irrigation, credit, and technology—was evaluated using a five-point Likert scale (1 = very poor to 5 = excellent).

The control factors encompassed age, household size, village irrigation source (canal/tube-well), and proximity to the nearest bank or extension center, addressing demographic and locational disparities that influence women's adaptive capacity in Hisar and Kaithal.

Analysis Tools

Quantitative data were analyzed using SPSS (Version 26).

- Descriptive statistics (means, frequencies, percentages) were used to profile respondents.
- Chi-square (χ^2) tests examined associations between categorical variables such as caste, SHG membership, and adaptation practices.
- One-way ANOVA tested differences in resource access across caste and class groups.
- A logistic regression model identified key determinants of high adaptation capacity, focusing on education, SHG participation, and irrigation access.

Ethical Considerations

Ethical methods followed the rules for social science research. After describing the study's goal and confidentiality rules, all participants gave their verbal agreement. To preserve the privacy of the people who answered, all identifiers were made anonymous. Female enumerators led FGDs to make sure that everyone felt at ease. At the end of each session, people were given information about how to file a complaint and what government benefits they were entitled to. This was done to make sure that everyone benefited and that everyone had a chance to give back.

5. Results

Table 1. Socio-Demographic Profile of Respondents (N = 200)

Variable	Category	Frequency	Percentage (%)
District	Hisar	100	50.0
	Kaithal	100	50.0
Caste Group	SC	80	40.0
	OBC	70	35.0
	Higher Castes	50	25.0
Age Group (years)	Below 30	45	22.5
	31–45	95	47.5
	Above 45	60	30.0
Education Level	Illiterate	65	32.5
	Primary	70	35.0
	Secondary & Above	65	32.5

Occupation	Agriculture	110	55.0
	Agricultural Labor	60	30.0
	Other (Self-employment, SHG activity)	30	15.0

The majority of responders were middle-aged women involved in agriculture, possessing literacy levels beneath the state average. The largest group was SC women, which shows the social variety needed for intersectional analysis.

Table 2. Distribution of Respondents by Landholding and Class Category

Class (Asset-based)	Land Size (Acres)	Frequency	Percentage (%)	Mean Asset Index
Low (Bottom Tercile)	0–0.5	70	35.0	1.42
Middle (Mid Tercile)	0.6–2.0	80	40.0	2.71
High (Upper Tercile)	>2.0	50	25.0	4.16

A large 75% of respondents possess less than two acres, indicating that socioeconomic status and resource availability markedly affect adaptive capacity. This supports Objective 1, which is about how gender, caste, and class interact.

Table 3. Access to Environmental and Productive Resources (Mean Scores by Caste Group)

Resource Type	SC (Mean±SD)	OBC (Mean±SD)	Higher Castes (Mean±SD)	F-Value	p-Value
Land Ownership	0.64 ± 0.31	1.28 ± 0.54	3.52 ± 1.02	18.72	0.000**
Irrigation Access	1.75 ± 0.66	2.44 ± 0.71	3.61 ± 0.82	11.58	0.001**
Credit Availability	1.21 ± 0.52	1.93 ± 0.64	3.04 ± 0.79	13.94	0.000**
Technology Exposure	1.48 ± 0.59	2.13 ± 0.75	3.22 ± 0.91	15.33	0.000**

ANOVA validates substantial caste-based discrepancies in access to productive resources.

Table 4. Adaptation Strategies Adopted by Respondents (N = 200)

Adaptation Strategy	Hisar (%)	Kaithal (%)	Overall (%)	Rank
Crop diversification	55	62	58.5	1
Mulching / soil moisture retention	44	49	46.5	3
Drought-resistant seeds	41	47	44.0	4
Micro-irrigation / drip	28	39	33.5	5
Livelihood diversification	49	53	51.0	2
Participation in insurance / formal credit	22	35	28.5	6

Crop and livelihood diversification are the most common ways to cope and adapt. Migration has led to more diverse ways of making a living in Hisar, while Kaithal focuses on using technology to improve lives.

Table 5. Chi-Square Test: Association between SHG Membership and Adoption of Adaptive Strategies

Adaptive Strategy	χ^2 Value	df	p-Value	Significance
Livelihood diversification	9.24	1	0.002**	Significant
Credit / Insurance usage	10.18	1	0.001**	Significant
Crop diversification	4.65	1	0.031*	Significant
Use of water-saving technology	2.11	1	0.147	NS

Joining a Self-Help Group (SHG) makes it much more likely that women will use income and credit-related adaptation techniques, which is in line with Objective 3 and qualitative evidence of collective action.

Table 6. ANOVA: Education Level and Mean Adaptation Index Scores

Education Level	Mean Adaptation Index	Std. Dev.	F-Value	p-Value
Illiterate	1.86	0.63	14.22	0.000**
Primary	2.44	0.74		
Secondary & Above	3.09	0.89		

The strength of adaptation rises with the level of schooling ($p < 0.01$). Educated women exhibit more robust proactive reactions, hence validating the use of education as a significant predictor in logistic regression analysis.

Table 7. Logistic Regression: Determinants of High Adaptation Capacity

Predictor Variables	B	S.E.	Wald	Sig.	Exp(B)
Education (Secondary+)	1.42	0.38	13.91	0.000**	4.13
SHG Membership	1.11	0.33	11.25	0.001**	3.02
Reliable Irrigation	0.96	0.31	9.57	0.002**	2.61
Landholding Size	0.54	0.27	4.00	0.046*	1.72
SC Status (Ref = Higher Caste)	−0.87	0.34	6.57	0.010*	0.42
Constant	−2.38	0.81	8.65	0.003	—

Model Summary: −2 LL = 182.4; Nagelkerke R^2 = 0.42; Correct classification = 78.5%. The most important factors that make someone adaptable are education, participation in a self-help group (SHG), and reliable irrigation. Being from a lower caste makes it much less likely that someone will be adaptable.

6. Discussion

The results of this study highlight the intricate and profoundly social dimensions of climate change adaptation among rural women in the Hisar and Kaithal districts of Haryana. Climate adaptation in agricultural contexts is not solely an environmental or technical challenge; it is significantly influenced by social hierarchies, resource accessibility, and institutional inclusiveness. The study's findings, based on both quantitative and qualitative studies, demonstrate that gender, caste, and class intersect to delineate vulnerability and adaptive capability, with education, social participation, and irrigation access serving as critical facilitators of resilience.

The socio-demographic analysis (Table 1) shows that most of the people who answered were middle-aged women who worked in agriculture and related fields. But low literacy rates, especially among Scheduled Caste (SC) women, point to a structural disadvantage that limits knowledge of adaptive options and access to institutional initiatives. This educational gap strengthens current hierarchies because being able to read and write is closely linked to getting knowledge, being able to read and write credit, and taking part in group activities like Self-Help Groups (SHGs). The landholding figures (Table 2) show that three-quarters of the people who answered the survey owned less than two acres of land. This shows how important small and marginal farmers are to Haryana's rural economy. This predominance of landlessness among lower castes—especially SC women—links economic vulnerability to environmental exposure, validating the study's intersectional paradigm.

The ANOVA results on resource access (Table 3) further confirm the presence of statistically significant caste-based disparities in land ownership, irrigation, credit, and technology. Women from higher castes had far better access to these resources, while women from lower castes were limited to rain-fed or marginal plots and had no contact with extension services. This difference shows how caste still affects how resources are managed in rural areas, where social identity affects people's rights and ability to take part in formal adaptation initiatives. In this context, environmental sociology offers a significant perspective for analyzing how structural power and institutional biases perpetuate vulnerability, even among government initiatives.

The use of adaption tactics (Table 4) shows a combination of proactive and reactive ways of dealing with problems. In both districts, the most common techniques were crop diversification and livelihood diversification. But lower-caste and low-income people were less likely to use technical solutions like drip irrigation and drought-resistant seedlings because they couldn't afford them and institutions didn't reach out to them as much. Notably, women in Hisar depended more on diversifying their income and men moving away as ways to cope, whereas women in Kaithal were more likely to use irrigation and soil-moisture conservation measures since they had better access to water. These findings underscore that

district-level ecological variables influence social stratification, resulting in localized adaption patterns instead of consistent resilience outcomes.

The chi-square results (Table 5) show how important Self-Help Groups (SHGs) are for improving adaptive behavior. Women affiliated with Self-Help Groups (SHGs) had a markedly higher propensity for livelihood diversification and access to credit or insurance services, suggesting that collective organization enhances both economic and social resilience. This is in line with theories of social capital, which say that trust, cooperation, and a shared identity can make up for structural disadvantages by giving people more access to resources and knowledge. SHGs serve as an institutional conduit between underprivileged women and formal adaptation mechanisms, especially in situations where state institutions are remote or unresponsive.

Table 6 shows that education is also a key factor in adaptable capacity. Mean adaption scores consistently increased with higher levels of education, so validating that knowledge serves as a catalyst for resilience. Educated women exhibited enhanced understanding of adaptive technologies, more engagement in local governance, and a greater propensity to apply climate knowledge in practice. The logistic regression model (Table 7) brings all of these ideas together: Education, SHG involvement, and dependable irrigation access substantially elevated the likelihood of a woman being designated as “highly adaptive.” On the other hand, being part of a lower caste, especially a Scheduled Caste, was linked to far lower chances of being able to adapt. This pattern shows that social exclusion is still a problem, even in rural development projects where people are supposed to be included. This is because official inclusion policies typically don't reach the most vulnerable women.

7. Policy Implications

- Social audits of canal turns at the panchayat level; priority micro-irrigation subsidies for SC/low-asset households; and village water committees with reserved seats for women.
- Credit and risk tools that focus on women: SHG-linked KCC (Kisan Credit Card) top-ups, easier claim processes for weather insurance, and green-tech loans with no collateral and low interest rates.
- Mobile agri-clinics and women para-extension workers; modules on drought-resistant crops, soil moisture conservation, and upgrading small ruminants that are in line with the seasons.
- One-stop entitlement desks at panchayats; proactive document facilitation for widows/single women; public dashboards for scheme adoption by caste and gender.
- Give them money for seed banks, climate advisory circles, and inter-SHG equipment libraries (drip kits, mulchers). Connect federations to FPOs so they can get to the market.

8. Limitations and Future Research

This study provides significant insights into the intersectional aspects of women's climate adaptation in the Hisar and Kaithal regions; nonetheless, it is essential to recognize specific methodological and contextual limitations to accurately understand the findings. First, the study uses a cross-sectional design, which means that it only collects data from respondents at one point in time. This method gives a detailed picture of current socio-environmental patterns, but it doesn't let us make causal inferences about how adaptive behaviors change over time. Climate adaptation is a dynamic process shaped by seasonal variability, market fluctuations, and policy alterations; therefore, longitudinal tracking would yield a more comprehensive knowledge of how women's resilience is either fortified or undermined amidst persistent climatic and institutional stressors.

Second, using self-reported measurements might lead to recollection and desirability bias. Respondents may have inaccurately reported their engagement in adaptive practices due to memory gaps, societal expectations, or the perceived prestige linked to specific behaviors (such as the use of current irrigation equipment or participation in self-help groups). Although triangulation via focus group discussions and key-informant interviews mitigated this bias, subsequent research ought to incorporate objective indicators—such as farm-level

productivity data, irrigation records, or financial transaction logs—to enhance perception-based information.

Third, the study's geographical scope is limited to two districts, which adds depth but limits the potential to apply the findings to other areas. Hisar and Kaithal exemplify semi-arid and canal-command settings, respectively; nonetheless, Haryana's natural and socioeconomic variety transcends these parameters. Future research should implement a comparative, multi-district framework that includes both drought-prone and flood-prone areas to enhance the understanding of how geographic variability interacts with caste and gender to shape adaptation pathways.

Furthermore, the quantitative analysis in this study was predominantly correlational, revealing significant connections without determining the direction or mechanisms of causation. To address this issue, subsequent research should utilize panel or cohort-based approaches, tracking the same group of women across various agricultural seasons. These kinds of long-term data would show how climate knowledge is passed down from one generation to the next, how people adjust to new situations, and how they keep doing things. This would make theoretical models of resilience even better.

Another key area for future research is using remote sensing and GIS-based techniques to objectively track changes in land use, vegetation health, and water stress at very small scales. Researchers may create spatio-social vulnerability indices by combining these spatial indicators with socio-economic data at the home level. This would give them a better idea of how environmental degradation and social marginalization are related.

Moreover, experimental or quasi-experimental designs may be employed to evaluate the efficacy of specific interventions, especially SHG-bundled adaptation packages that integrate microcredit, irrigation assistance, and capacity-building training. Assessing these interventions using randomized control trials (RCTs) or matched comparison groups would provide causal information regarding the most effective strategies for improving women's adaptive capacity across various caste and class circumstances.

Lastly, future research ought to investigate the psychosocial and institutional facets of adaptation—such as decision-making autonomy, collective bargaining power, and institutional responsiveness—to enhance the economic and ecological viewpoints highlighted in this study. Integrating participatory action research (PAR) methodologies could guarantee that women function not only as respondents but as co-creators of information and policy suggestions, thus closing the divide between research, practice, and empowerment.

9. Conclusion

In Hisar and Kaithal, women's climate adaptation is at the intersection of caste, class, and institutional reach. When land, water, credit, and knowledge are in sync, women use anticipatory techniques; when they aren't, coping is the main thing. Education and membership in self-help groups (SHGs) typically improve adaptive capacity. However, only an environment that is safe for water and easy to get credit can change resilience from a personal burden into a group strength. Women-first adaptation that is targeted at different groups is not just fair; it is also good climate policy.

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