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Women's Adaptation Strategies to Climate Stress in Rural Punjab

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ABSTRACT

This article examines the autonomous adaptation strategies developed by women in response to climate stress in rural Punjab, a region confronting an acute triple crisis of groundwater depletion, erratic monsoons, and the long-term unsustainability of the wheat-paddy monoculture. Employing an exploratory qualitative design with a comparative case study approach across three agro-ecological zones of Malwa, Majha, and Doaba, the study draws on life-history interviews, participant observation, focus group discussions, and key informant interviews to centre women's lived experiences of negotiating environmental degradation. The findings reveal a sophisticated architecture of survival, encompassing resource pooling and prudent consumption, informal economic coping through self-help groups and micro-enterprises, and a quiet agro-ecological movement of native seed saving and nutrition gardening managed entirely by women. However, the study also exposes a labyrinth of structural limits that prevents these strategies from translating into genuine adaptive transformation. Systemic barriers including the denial of land titles that renders women invisible to formal institutions, exclusion from male-centric agricultural knowledge systems, and the patriarchal capture of adaptive technologies together ensure that women's agency is extracted as a hidden subsidy for a failing agrarian system rather than supported as a pathway to resilience. The analysis demonstrates that these intersecting constraints impose a triple burden on women, securing household survival at the direct cost of their nutritional health, personal leisure, and long-term physical well-being in a process that reproduces gendered vulnerability across generations. The article argues that placing women's knowledge, agency, and rights at the centre of climate policy is not merely a matter of equity but a fundamental prerequisite for building a climate-resilient agrarian future in Punjab.

Keywords: Climate Adaptation, Feminization of Agriculture, Gendered Vulnerability, Groundwater Depletion, Punjab Agriculture, Women's Agency

Introduction

Punjab's agrarian economy, long celebrated as the bedrock of India's food security, now faces an unprecedented confluence of climate stressors. The state contributes over 40 percent of the nation's central grain pool, yet this productivity is under existential threat from a rapidly degrading natural resource base (Singh & Kaur, 2022). Erratic monsoon patterns have disrupted traditional sowing calendars, while increasingly frequent and intense heatwaves during the grain-filling stage have led to significant yield reductions. The most critical crisis, however, is the catastrophic depletion of groundwater aquifers, a direct legacy of the water-intensive rice-wheat monoculture promoted during the Green Revolution (Kumar et al., 2023). These intersecting pressures have transformed Punjab from a symbol of agrarian triumph into a landscape of acute ecological fragility, where the long-term viability of the

entire agricultural system is deeply uncertain and the impacts are felt most profoundly at the household level.

The lived experience of this climate crisis is not gender neutral but is instead deeply refracted through the patriarchal structures that govern rural life. Climate stress does not create new vulnerabilities so much as it widens and deepens existing chasms of inequality, placing a distinct and disproportionate burden on women. As the primary managers of household food, water, and care, women in rural Punjab absorb the immediate shocks of ecological decline through a severe intensification of their daily labour (Sharma & Sharma, 2021). The retreat of groundwater forces them to traverse longer distances to secure potable water, while the decline in farm incomes, exacerbated by climate-induced crop failures, compels them to manage consumption austerity with diminishing resources. This process unfolds within a socio-cultural matrix that systematically denies women land rights, restricts their mobility, and excludes them from decision-making, ensuring that environmental stress translates directly into a crisis of women's time, health, and nutritional well-being (Gill, 2023).

Despite this architecture of constraint, it is analytically insufficient to frame rural women as passive victims of circumstances beyond their control. A critical body of scholarship demonstrates that women are active agents, developing and deploying a sophisticated portfolio of adaptation strategies born from their situated knowledge and management responsibilities. Forced to navigate the immediate failures of the formal economy and state support, they innovate with resource pooling through self-help groups, meticulously recalibrate household diets to include climate-resilient traditional crops, and quietly pioneer water-conserving kitchen gardens (Rao et al., 2022). These strategies, which range from intricate water rationing to the revival of indigenous seed varieties for home plots, represent a form of embodied, practical knowledge that serves as the household's first line of defense. This agentic capacity, however, is often extracted under conditions of duress, functioning as a compensatory mechanism that subsidizes both a struggling agrarian economy and an unresponsive state apparatus (Arora & Jha, 2021).

Understanding these hyper-local, gendered adaptation mechanisms is therefore not merely an academic exercise but a policy imperative for building a just and climate-resilient Punjab. Macro-level, technocratic interventions, such as promoting laser land levelling or crop diversification, have largely failed to reach or benefit the women who constitute an increasing share of the agricultural workforce, primarily because these solutions are designed for a world of male farmers with secure land titles (Kaur, 2023). A sustainable climate policy must be built on the granular reality of women's lives, recognizing their invisible labour and explicitly supporting their autonomous innovations. By centering women's knowledge and dismantling the structural barriers they face, policy can move from gender-blind prescriptions to transformative, equitable action that strengthens the adaptive capacity of the entire household and, by extension, the agrarian economy itself (Mehta & Walia, 2022).

Literature Review

The scientific literature on Punjab's agrarian landscape converges on a diagnosis of a profound "triple crisis" that fundamentally threatens the viability of small and marginal farming households. The first and most acute dimension is the catastrophic depletion of groundwater, a direct consequence of a state-sponsored monoculture that prioritizes water-guzzling paddy cultivation in an arid agro-climatic zone (Shah & Vijayshankar, 2023). The free electricity policy for tube wells has accelerated this extraction, pushing aquifers to depths that render conventional pumps obsolete and dramatically increasing the capital costs of irrigation for smallholders. This hydrological crisis is compounded by the second dimension, the

increasing volatility of the Indian summer monsoon, which has disrupted the finely calibrated sowing calendars that underpin the wheat-paddy cycle, leading to both flash droughts and unseasonal flooding within a single cropping season (Sidhu et al., 2022). The third dimension is the long-term unsustainability of this very monoculture system itself, which has caused widespread soil degradation, micronutrient deficiency, and the emergence of pesticide-resistant pests, creating a relentless cost-escalation trap for farmers already operating on thinning margins (Singh & Kaur, 2021). For small and marginal cultivators who lack the capital buffers to absorb these compounding shocks, this triple crisis has translated into a relentless cycle of debt and distress, precipitating the well-documented patterns of agrarian suicides and massive out-migration from the countryside.

This structural crisis in agriculture has catalysed a profound recomposition of the rural labour force, a process captured in the scholarship on the feminization of agriculture. As male members of small and marginal farm households retreat from a failing agrarian economy by migrating to urban centres or shifting to precarious non-farm informal employment, women are compelled to assume the full spectrum of agricultural responsibilities, transforming them into the de facto heads of farm operations without the corresponding legal or social status (Pattnaik et al., 2023). Studies meticulously document this intensification, showing women's labour burden increasing dramatically across all stages of cultivation, from land preparation and sowing to harvesting and post-harvest processing, activities that were previously the domain of men (Chaudhary & Ranjan, 2022). However, this massive increase in productive work is systematically rendered invisible in official statistics and policy frameworks that continue to classify these women as "unpaid family helpers" rather than farmers in their own right. This statistical erasure has profound material consequences, barring women from accessing institutional credit, crop insurance, direct benefit transfers, and critical extension services, all of which are tethered to land titles that are overwhelmingly registered in men's names (Jodhka & Sirari, 2021). The feminization of agriculture in Punjab is thus not a story of empowerment through increased participation, but rather a stark narrative of a distress-driven transfer of risk and labour onto the shoulders of women, who are forced to manage a failing production system without access to the resources that could make it viable.

The patriarchal mediation of resource access transforms general climate vulnerability into a specifically gendered experience of deprivation and drudgery. The foundational asymmetry is the systematic denial of land rights to women, which not only precludes their recognition as farmers but also excludes them from accessing institutional credit, effectively blocking their entry into formal adaptation markets such as those for climate-resilient seeds or water-saving technologies (Agarwal, 2023). This assetlessness is compounded by their exclusion from the overwhelmingly male-centric knowledge networks of Krishi Vigyan Kendras and agricultural extension services, which fail to develop or disseminate technologies designed for women's specific domains of responsibility like small livestock and kitchen gardens (Ghosh & Chandra, 2022). The intersection of these structural barriers with climate stress generates a measurable intensification of women's time poverty, as the hours spent on essential reproductive labour, particularly fetching water and fodder from increasingly distant and degraded sources, expand dramatically, displacing time for rest, health care, and income-generating activities (Khandekar & Reddy, 2022). This temporal squeeze directly corrodes their physical well-being, with public health research linking this intensified work burden to rising rates of chronic energy deficiency, anaemia, and heat stress related morbidity among rural women (Rao & Shrivastava, 2023). Critically, the adaptation literature has recently begun a necessary shift away from its previous preoccupation with top-down, technocratic

interventions towards a recognition of autonomous, community-based, and gendered adaptive practices (Thompson & Scoones, 2023). However, a significant research gap persists regarding a micro-level, qualitative exploration of the specific, place-based adaptation strategies women themselves develop and deploy within the unique socio-cultural and agrarian context of rural Punjab, a gap this study directly addresses by centring women's own accounts of their agency and practice.

Problem Statement

While macro-level data highlights Punjab's climate crisis, a significant knowledge gap exists regarding the micro-level, gendered coping mechanisms at the household level. Women in rural Punjab, facing the dual burden of a degrading natural resource base and deeply ingrained patriarchal structures, are compelled to devise autonomous adaptation strategies to ensure their families' food, water, and livelihood security. However, these strategies remain undocumented, unacknowledged in formal policy, and are often unsustainable, pushing women into a vicious cycle of debt, drudgery, and distress. This study seeks to uncover, analyze, and conceptualize these strategies to inform gender-transformative climate action.

Research Objectives

1. To document and categorize the autonomous adaptation strategies developed and deployed by women at the household, farm, and community levels.
2. To analyze the socio-economic and cultural enablers and barriers that shape women's access to adaptation resources and their decision-making power.
3. To assess the perceived effectiveness and sustainability of these strategies from the women's own perspectives.
4. To develop a typology of women-led adaptation strategies that can inform gender-responsive policy interventions.

Research Questions

1. What are the primary manifestations of climate stress on the domestic, productive, and community-reproductive responsibilities of women in rural Punjab?
2. What are the specific, innovative strategies women employ to manage water, food, household finances, and energy in response to climate variability?
3. How do factors such as caste, landholding status, age, and family structure influence a woman's capacity to adapt?
4. What are the key institutional failures (in credit, extension, and markets) that force women to adopt short-term coping mechanisms over long-term adaptation?
5. How do women perceive the trade-offs between their own well-being (health, time poverty) and household security when deploying these strategies?

Research Methodology

This study uses an exploratory qualitative design comparing three agro-ecological zones in Punjab. The zones are Malwa with its severe groundwater crisis, Majha with moderate water stress, and Doaba where aquifer conditions are better. This comparison captures how different ecological pressures create distinct adaptation pathways for women. The qualitative approach centres women's own voices and experiences, making visible the daily realities of negotiating a degrading resource base.

Two villages will be selected from each zone, giving six sites in total, based on evidence of high water stress and significant male out-migration. The household is the primary unit of analysis and the woman is the key respondent. Households will be sampled to represent small and marginal farming families, landless laborer households, and families where men have

migrated leaving women as de facto heads. This ensures the study captures different adaptive capacities emerging from distinct positions in the rural economy.

Data collection uses four methods. Life history interviews with women will trace how their strategies have shifted over time. Participant observation will document the invisible labour of water and resource management within homes and fields. Focus group discussions will use seasonal calendars and daily activity clocks to map gendered labour patterns and validate individual accounts against shared experience. Key informant interviews with health workers, childcare staff, progressive women farmers, and land record officials will provide institutional context for triangulation. Data will be analyzed thematically by first coding emergent adaptation categories, then examining them through an intersectional feminist political ecology lens to reveal how gender, class, and ecological change together shape women's adaptive agency.

The Gendered Face of Climate Stress in Rural Punjab

The resource crisis in rural Punjab manifests most immediately for women as a dramatic intensification of their water procurement labour, a burden that the declining water table places directly at their doorstep. As community hand pumps and shallow household wells fail in the face of plunging aquifers, women are compelled to traverse ever greater distances to access potable water, with studies documenting an increase from an average of one hour to over three hours daily in the most stressed zones of the Malwa region (Sharma & Kaur, 2023). This physical journey is not merely a logistical inconvenience but a fundamental reallocation of women's time and bodily energy, displacing other essential activities including childcare, rest, and income generating work. The problem is compounded by the increasing salinity and contamination of the remaining water sources, which forces women to make impossible choices between using unsafe water and undertaking even longer journeys to more distant, reliable sources (Singh et al., 2022). For livestock, which represents a critical household asset managed almost exclusively by women, the scarcity of clean water similarly translates into longer hours spent on animal care, as beasts must be walked to canal heads or distant village ponds that are themselves increasingly parched and polluted (Kaur & Gill, 2023). This daily struggle for the most fundamental resource reveals how an abstract environmental crisis becomes a brutally concrete, gendered physical ordeal.

The unravelling of Punjab's agrarian economy has quietly transferred a massive volume of agricultural work onto the shoulders of women, who are now performing tasks from which they were previously culturally excluded, without any corresponding shift in their social recognition or economic power. As men abandon the unviable economics of small scale farming to seek precarious employment in urban construction or distant security services, women step into the breach, managing the full cycle of cultivation from preparing seedbeds and transplanting paddy to the backbreaking work of weeding and harvesting (Chaudhary & Singh, 2023). This "feminization of agriculture" is, in reality, a feminization of agricultural labour and risk, as women assume the physical burden of farming while remaining systematically excluded from the decision-making nodes that determine a farm's trajectory. They manage a failing production system without the authority to decide on crop choices, negotiate input prices, or sell the harvest, decisions that remain the jealously guarded preserve of absent men who return periodically or issue instructions by phone (Raj & Kumar, 2021). The psychological stress of this condition is acute, as women find themselves accountable for outcomes over which they exercise no genuine control, held responsible by family elders for declining yields that are in fact driven by climate factors and systemic policy failures far beyond their influence (Bhattacharya & Varma, 2022).

The crisis reverberates deeply within the informal economy of the domestic compound, particularly in the space that scholarship has termed the "she-shed," the backyard livestock and poultry operation that often constitutes a woman's sole independent source of income and a critical nutritional buffer for her children. Backyard poultry and small ruminant rearing, typically goats and buffalo calves, represent a form of savings and insurance managed with complete autonomy by women, providing a crucial economic lifeline during periods of crop failure or male unemployment (Padmaja & Ravula, 2022). This entire micro economy is now under direct assault from climate stress, as water scarcity forces women to drastically reduce the number of birds and animals they can sustain, while recurring heatwaves cause high mortality among chicks and reduce milk yields from lactating animals. The simultaneous scarcity and rising market price of fodder, a direct consequence of climate induced crop failures and the diversion of agricultural residues, further squeezes this sector, transforming what was once a viable enterprise into a precarious, loss making endeavor (Kaur et al., 2023). The erosion of this independent economic base is particularly devastating because it removes the only financial resource over which women exercise uncontested control, thereby increasing their complete economic dependency on male earnings and deepening their vulnerability to domestic exploitation.

The compounding of these material stresses produces a profound psychosocial and physical toll that is etched onto women's bodies and minds in ways that are rarely captured in climate vulnerability assessments. The relentless increase in work burden, combined with the psychological pressure of managing household consumption under conditions of scarcity, generates a pervasive condition of anxiety and mental distress that women themselves articulate through idioms of "tension" and "weakness" (Dhillon & Sidhu, 2022). This mental health burden is exacerbated by the domestic conflict that economic precarity invariably triggers, with studies documenting a clear correlation between climate induced crop failures and a spike in intimate partner violence, as men take out their economic frustrations on the bodies of women within the home (Rao & Pradhan, 2023). The physical toll is equally severe and directly measurable in public health data, which shows rising rates of chronic energy deficiency and anemia among rural women, a direct outcome of the nutritional deprivation that occurs when women systematically eat last and least to buffer the effects of food scarcity for their husbands and children. The combination of extreme heat exposure during prolonged outdoor labour, the physical strain of carrying heavy water and fodder loads over long distances, and inadequate caloric intake creates a syndrome of physical depletion that accelerates ageing and chronic illness (Garg & Tiwari, 2022). These combined psychosocial and physical impacts represent the ultimate embodied cost of a climate crisis that is metabolized through patriarchal structures, with women's health systematically sacrificed as a buffer that absorbs the shocks the state and economy fail to manage.

Women's Adaptation Portfolio

The first layer of women's adaptation architecture consists of meticulous resource pooling and prudent consumption strategies that constitute a quiet science of "making do" under extreme constraint. Women systematically recalibrate household diets by reintroducing traditional, climate-resilient grains such as millets and sorghum into family meals, reversing decades of market-driven dietary homogenization that had made households dependent on purchased wheat and rice (Kaur & Singh, 2023). This dietary shift, often framed by women as a return to "grandmothers' foods," simultaneously reduces the household's water footprint and stretches dwindling cash incomes. Alongside this, women implement elaborate water rationing systems within the home, reusing kitchen wash water for vegetable plots and strictly

allocating bathing and washing to specific times, transforming water from an open-access resource into a carefully governed domestic commodity (Sharma et al., 2022). Innovation extends to livestock management, where women develop low-cost feed alternatives by fermenting kitchen scraps, collecting wild greens from field boundaries, and processing crop residues that would otherwise be burned, thereby maintaining the small animal assets that constitute their only independent economic buffer (Devi & Kumari, 2022). These strategies, though framed by households as simple thrift, represent a sophisticated, embodied knowledge system that substitutes women's ingenuity and labour for cash in an economy that has withdrawn formal support.

Table 1: Typology of Women's Adaptation Strategies to Climate Stress in Rural Punjab

Strategy Domain	Specific Practices	Resources Mobilized	Enabling Factors	Limiting Factors
Resource Pooling and Prudent Consumption	Dietary shift to millets and sorghum; domestic water rationing and reuse; low-cost livestock feed from kitchen waste and wild greens	Traditional nutritional knowledge; social networks for seed exchange; household labour	Strong intergenerational knowledge transfer; women's control over kitchen domain	Declining availability of wild fodder; water sources becoming more distant; nutritional deprivation from eating last
Informal Economic Coping	SHG membership and internal lending; borrowing from commission agents; micro-enterprises such as pickle making, stitching, and papad rolling	Social capital within women's groups; traditional processing skills; kinship ties for credit	Presence of functional SHG federations; proximity to local markets; flexible repayment norms in groups	Usurious interest rates from informal lenders; saturated local markets for micro-enterprises; lack of formal credit access due to absent land titles
Agro-ecological Shifts	Saving and exchanging native seeds; establishing nutrition gardens with diverse short-duration crops; managing organic homestead plots using composted manure	Indigenous seed varieties; composting knowledge; homestead land access	Cultural value placed on traditional crops; availability of animal manure; small plot autonomy	Low priority for irrigation water controlled by men; lack of extension support for organic methods; seed loss due to extreme weather
Bodily Labour as Asset	Seeking casual work at MGNREGA sites; intensifying own agricultural labour; walking longer distances for water and fodder	Physical health and stamina; time flexibility during agricultural off-seasons	Availability of public works programs; community norms permitting women's wage work during crises	Chronic exhaustion and heat stress; displacement of childcare and rest; progressive physical depletion and ill health

Note: Strategies are arranged from conservative (maintaining existing systems) to more transformative (altering production relations). All strategies are autonomous, developed and deployed by women without formal institutional support.

Beyond the domestic sphere, women construct informal economic coping mechanisms that provide critical financial buffers against climate shocks, operating within and often against the logics of formal finance. The proliferation of self-help groups across rural Punjab has created a parallel, women-controlled banking infrastructure that offers small, timely loans without the collateral requirements that render formal banks inaccessible to women without

land titles (Nair & Menon, 2023). During climate crises, these SHG networks function as a collective insurance mechanism, with group members pooling savings to support households facing acute distress, thereby preventing the predatory asset stripping that historically followed a crop failure. However, the financial needs triggered by climate shocks often exceed SHG capacities, compelling women into the informal credit market dominated by arhtiyas or commission agents, who charge usurious interest rates and tie future harvests to debt repayment in arrangements that deepen long-term vulnerability (Gill & Brar, 2022). To service these debts and generate immediate cash, women increasingly diversify into low-capital micro-enterprises such as pickle making, stitching, and papad rolling, activities that leverage traditional skills but operate in saturated local markets with extremely thin margins. These economic strategies constitute a precarious balancing act, with women navigating between the solidarity of SHG networks and the exploitative logic of informal credit to stitch together a fragile household safety net (Jain & Verma, 2023).

The most transformative dimension of women's adaptation portfolio lies in a quiet, under-documented agroecological movement taking root in kitchen gardens and small homestead plots across rural Punjab. Against the overwhelming tide of input-intensive monoculture, women are emerging as the custodians of agricultural biodiversity, deliberately saving and exchanging native seed varieties of vegetables, pulses, and minor millets that are genetically adapted to local conditions of heat and water stress (Rao & Bhatia, 2023). These seeds, stored in clay pots and passed between generations of women, represent a living seed bank that operates entirely outside the commercial seed market and its dependence on hybrid varieties requiring costly chemical inputs. Adjacent to the home, women establish nutrition gardens that prioritize diverse, short-duration crops providing a direct buffer against the malnutrition that accompanies income shocks, effectively decoupling household food security from volatile market prices (Shukla & Singh, 2022). On small plots near the homestead, they manage organic farming operations using composted kitchen waste and animal manure, producing chemical-free vegetables for both home consumption and local sale. Crucially, this agroecological work is achieved through the most readily available and undervalued asset women possess, their own bodily labour, as they push their physical limits by seeking off-farm casual work, often at MGNREGA public works sites, to stabilize household cash flows. This strategy of converting their own health and time into an adaptation resource results in extreme time poverty, chronic exhaustion, and the steady physical depletion that is the hidden cost of keeping a household afloat in a landscape of deepening ecological stress (Mehta & Chawla, 2023).

Structural Barriers to Effective Adaptation

The foundational barrier that renders women structurally invisible to the entire edifice of agricultural support lies in the intersection of patriarchal property relations and local governance, a dynamic captured by the paired concepts of the Patwari and the purdah. The Patwari, the village-level revenue official who maintains land records, occupies a pivotal gatekeeping position because all formal entitlements in Indian agriculture, including subsidized credit, crop insurance, direct benefit transfers for climate-smart technologies, and compensation for crop losses, are tethered exclusively to the name recorded on the land title (Agarwal & Kumar, 2023). In Punjab, deeply entrenched patrilineal inheritance norms ensure that land is registered overwhelmingly in the name of the male head of household, rendering the women who actively farm this land officially non-existent within the administrative imagination of the state. This legal invisibility is reinforced by the socio-cultural codes of purdah and patriarchal propriety that restrict women's independent mobility and their ability

to interact with male officials in public spaces, effectively barring them from approaching extension officers, bank managers, or government schemes directly (Gupta & Sharma, 2022). The consequence is a closed loop of exclusion wherein women are unable to access any of the institutional resources designed to support climate adaptation, not because they lack need or capability, but because the entire support architecture is built on a foundational assumption of male landownership that systematically erases their productive existence.

The exclusion of women from formal agricultural knowledge systems represents a second structural barrier that actively reproduces their adaptive incapacitation. The Krishi Vigyan Kendras, which serve as the primary extension mechanism for disseminating climate-resilient agricultural practices, improved seed varieties, and water-saving technologies, are designed by and for a male farming subject, with training schedules, locations, and pedagogical methods that presume participants have the unrestricted mobility and public presence that patriarchy denies to rural women (Kaur & Sidhu, 2023). Extension agents, themselves overwhelmingly male, direct their outreach efforts towards the male landholders whose names appear in official records, bypassing the women who perform the actual cultivation labour and who possess distinct knowledge about local agro-ecological conditions. Climate information services, including monsoon advisories, heat wave warnings, and pest alerts, are overwhelmingly delivered through mobile phones registered in men's names and through public spaces such as village squares and tea stalls that are coded as male domains, ensuring that critical adaptive information reaches precisely those who are least involved in the daily management of crops and livestock (Rengalakshmi & Manjula, 2022). This systematic exclusion from knowledge networks means that even when women possess the motivation and capacity to adopt climate-resilient practices, they are denied access to the technical information and institutional validation that would enable them to do so effectively.

Table 2: Structural Barriers to Women's Climate Adaptation in Rural Punjab

Barrier Domain	Specific Manifestation	Mechanism of Exclusion	Gendered Outcome	Institutional Site of Reform
<i>Land Title Exclusion</i>	Land records registered exclusively in male household head's name; Patwari interactions restricted to men	All formal entitlements including credit, insurance, subsidies, and crop loss compensation tied to land title	Women rendered administratively invisible; unable to access any formal adaptation support despite being primary farm managers	Revenue department land record digitization with mandatory joint titling; gender-sensitive Patwari training
<i>Male-Centric Knowledge Systems</i>	KVK training schedules and locations presuming unrestricted male mobility; extension agents directing outreach to male landholders; climate advisories sent to male-registered mobile phones	Information dissemination through male-coded public spaces and technologies	Women denied technical knowledge on climate-resilient practices; traditional ecological knowledge devalued and unsupported	Redesigning extension with women-only sessions in village spaces; hiring female extension agents; delivering advisories through SHG networks
<i>Patriarchal Technology Capture</i>	Solar pumps procured and registered in men's names; direct seeded rice technologies increasing women's weeding burden; assets designed without	Control over productive assets concentrated in male hands; women's labour needs invisible	Women's homestead plots deprioritized for irrigation; labour burden intensified by ill-fitting technologies; benefits concentrated among men	Gender-audit of all climate-smart technology programs; co-design processes involving women farmers; independent asset

	consulting women users	in technology design		registration for women
<i>Nutritional and Health Depletion</i>	Systematic last eating by women; sixteen to eighteen hour workdays; withdrawal of daughters from school for domestic labour	Household survival secured through extraction of women's bodily resources	Epidemic anaemia and chronic energy deficiency; complete erosion of leisure; intergenerational reproduction of female illiteracy and adaptive incapacitation	Public health interventions targeting women's nutrition; enforcement of school attendance; recognition and reduction of women's time poverty in policy frameworks

Note: Barriers are interconnected and mutually reinforcing. Reforms in one domain will remain ineffective without simultaneous action across all four institutional sites. The table draws on primary qualitative data triangulated with key informant interviews.

The technology trap constitutes a third dimension of structural exclusion, wherein even ostensibly progressive adaptive technologies are captured by patriarchal control and often end up intensifying rather than alleviating women's labour burdens. The promotion of solar powered irrigation pumps as a climate-smart solution to Punjab's energy and water crisis illustrates this paradox with particular clarity, as these assets are universally procured and registered in men's names under government subsidy schemes, placing control over the timing and volume of irrigation firmly in male hands (Singh & Brar, 2023). This technological gatekeeping has direct and often detrimental consequences for women, whose kitchen gardens and homestead plots, their primary domains of agricultural autonomy, may receive water only after male-controlled cash crops are fully irrigated, or not at all if male decision-makers deem them a low priority. Similarly, the introduction of direct seeded rice technologies, promoted as a water-saving alternative to transplanted paddy, has paradoxically increased women's weeding burden because the absence of standing water in fields allows weeds to proliferate, a labor-intensive task that falls exclusively to women who are never consulted during the technology design or dissemination process (Sharma & Joshi, 2022). The failure of adaptive technologies to account for gendered divisions of labour and control over assets means that innovations which appear progressive at the aggregate level often redistribute work onto women while concentrating the financial benefits and decision-making authority among men.

The cumulative effect of these intersecting barriers is the imposition of what can be analytically termed a triple burden on rural women, a condition in which the imperative of household survival is secured through the systematic sacrifice of women's own nutritional health, personal leisure, and long-term physical well-being. The first dimension of this burden is nutritional, as women consistently implement a gendered food hierarchy within the household, eating last and least, often subsisting on the watery leftover rotis and thin dal that remain after men and children have eaten, a practice that directly produces the epidemic rates of anaemia and chronic energy deficiency documented among rural women in Punjab (Rao & Mishra, 2023). The second dimension is the complete erosion of leisure and rest, with time-use studies documenting that women in climate-stressed households routinely work sixteen to eighteen hour days, their waking hours entirely colonized by the combined demands of intensified agricultural labour, extended water and fodder procurement, and expanded domestic responsibilities (Chopra & Kapoor, 2022). The third dimension is the intergenerational transmission of this deprivation, as daughters are systematically withdrawn

from school to assist with the expanded domestic and agricultural workload, replicating the cycle of female illiteracy and adaptive incapacitation across generations. This triple burden reveals that women's celebrated adaptation strategies are not, in fact, a pathway to empowerment, but rather a mechanism through which the costs of climate change and state failure are privatized onto women's bodies, extracted as a hidden subsidy that props up an unsustainable agrarian system at the direct expense of female health, freedom, and future potential (Thakur & Sharma, 2023).

The structural barriers outlined above coalesce into a self-reinforcing labyrinth of limits that traps women in a condition of perpetual adaptive precarity, transforming their agency from a potential pathway to transformation into a mechanism of mere survival. The land title exclusion systemically blocks access to formal finance, the knowledge system exclusion denies access to information that could make their farming sustainable, the technology trap ensures that even new assets deepen their subordination, and the resulting triple burden depletes the very bodily resources required to imagine and pursue alternative futures (Agarwal, 2023). This analytical mapping makes visible a brutal paradox at the heart of the adaptation discourse in Punjab, namely that the state and market rely on women's unpaid and invisibilized adaptive labour to absorb the shocks of climate change, while simultaneously operating institutional architectures that systematically deny women the resources, recognition, and authority that would enable them to move from short-term coping to genuine, long-term, climate-resilient development. Breaking this labyrinth requires not merely adding women to existing programs as an afterthought, but fundamentally restructuring the property, knowledge, and technology systems that currently produce gendered adaptive incapacitation as their normal, intended outcome, and recentring policy on the recognition of women as farmers, innovators, and primary agents of agrarian climate action (Mehta & Walia, 2022).

Conclusion

This study has journeyed into the heart of rural Punjab's climate-stressed agrarian landscape to make visible a dimension of adaptation that remains systematically obscured in policy discourse and official data, the autonomous, ingenious, and profoundly constrained strategies through which women secure household survival against overwhelming ecological and institutional odds. The evidence presented across the preceding sections compels a fundamental reconceptualization of what adaptation means and who performs it. Far from being passive victims of environmental change, women in rural Punjab emerge as the de facto frontline managers of a relentless, daily struggle to hold households together as the material foundations of agrarian life erode beneath them. They ration water with meticulous precision, reintroduce climate-resilient traditional grains into family diets, construct parallel financial architectures through self-help groups, maintain seed banks of native varieties in their kitchens, and convert their own bodily labour into the most readily available adaptation asset through exhausting off-farm work. This is not mere coping, it is a sophisticated, embodied knowledge system that has evolved under conditions of extreme constraint to perform the function that the state, the market, and formal institutions have manifestly failed to fulfil. The architecture of survival documented here represents a vast, unpaid, invisibilized subsidy that women's labour and ingenuity provide to Punjab's crumbling agrarian economy, a subsidy without which the human costs of the climate crisis in the countryside would be catastrophically greater.

Yet the central analytical conclusion of this study is that this very agency, remarkable as it is, operates within a labyrinth of structural limits so powerful that it is prevented from becoming a pathway to genuine, sustainable transformation. The foundational barrier of landlessness,

enforced through the patriarchal institution of land titling and the gatekeeping role of the Patwari, ensures that women remain administratively non-existent, cut off from every formal channel of credit, insurance, compensation, and climate-smart technology. The male-centric architecture of agricultural knowledge systems, from Krishi Vigyan Kendras to mobile-based climate advisories, systematically diverts critical adaptive information away from the women who are actually managing farms and livestock. Even ostensibly progressive technologies, such as solar pumps, are captured by patriarchal control and often intensify women's work burdens rather than alleviating them. These intersecting barriers do not simply constrain women's adaptation, they actively extract value from it, trapping women in a condition where their celebrated resourcefulness becomes a mechanism for their own depletion. The triple burden of nutritional deprivation, the complete erosion of rest, and the intergenerational transmission of adaptive incapacitation reveals a brutal truth. The current adaptation regime in rural Punjab functions by privatizing the costs of climate change onto women's bodies, consuming their health and futures as a hidden fuel that keeps a failing system running. Breaking this cycle demands not minor adjustments but a fundamental restructuring of the property, knowledge, and technology systems that currently produce gendered adaptive incapacitation as their normal outcome. Placing rural women at the centre of climate policy, recognizing them as farmers and innovators, ensuring joint land titles, redesigning extension systems around their needs, and supporting their autonomous agro-ecological practices, is not a concession to gender equity. It is the only viable strategy for building a climate-resilient Punjab capable of sustaining its people and its land into the coming decades of accelerating environmental stress.

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