Are Women in Agrarian Contexts Unequally Impacted by Extreme Temperatures?

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Abstract

This paper investigates how climate change reshapes women's time allocation between paid and unpaid work in rural India. Using nationally representative Time Use Survey data merged with historical district-level temperature records, we examine whether women reduce their labor supply in agriculture while intensifying domestic and care responsibilities under extreme heat. We find that high temperatures significantly reduce women's time in paid agricultural work by up to 96 minutes per day, while increasing unpaid domestic work by about 75 minutes daily — highlighting women's role as intra-household "shock absorbers." These effects are especially pronounced among women of reproductive age, lower caste groups, marginal landowners, and married women. By uncovering the hidden time trade-offs that climate shocks impose on women, this study broadens our understanding of climate-labor dynamics, demonstrating how rising temperatures exacerbate gender inequalities through unpaid labor burdens. The findings underscore the need for climate and labor policies that recognize and redistribute women's unpaid work.

JEL Classification: J16, Q54, J22, O13

1 Introduction

It is widely recognized that gender norms and social structures assign different roles, responsibilities and rights to women and men (Deshpande and Kabeer 2024). In many developing countries, women's labour outside the home is often informal or unpaid, and frequently goes unmeasured in official statistics (Hirway and Jose 2011). At the household level, women disproportionately shoulder unpaid domestic and care work — cooking, cleaning, fetching water and fuel, and caring for children or the elderly — especially in rural areas (Afridi and Mahajan 2018; Srivastava and Srivastava 2010). These burdens reinforce labour market inequalities leading women to work in lower-paid, part-time or labour-intensive roles. Such disparities in time use constrain women's productivity and economic empowerment.

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Climate change is worsening these gendered burdens. For rural women, climate variability often increases the time needed for basic household tasks. During heat waves, women are especially impacted about 60% of women in South Asia report doing more unpaid work during extreme heat and FAO (2023) reports that women's domestic workloads tend not to fall during heat spells. By contrast, men's working hours often decrease under extreme heat, reflecting a gender gap in the ability to adjust (e.g. men may reduce fieldwork while women still cook and clean). Climate shocks like drought also have gender-differentiated effects. Studies show that agricultural droughts cause a sharper drop in women's labour relative to men's. For example, Farzana Afridi (2022) find that in India women's farm workdays fall by roughly 19% more than men's during droughts. This is partly because social norms and limited mobility prevent women from migrating or taking non-farm jobs in response to crop failures. Thus, women often act as "shock absorbers": when farm income shocks occur, they may withdraw from paid farm work to meet rising domestic demands or turn to unpaid family enterprises.

Agriculture is an especially relevant context for studying these interactions. It is the largest employment sector in India, and women's involvement (often as family labour) is critical even if undercounted. Women's time in agriculture is inherently seasonal; for instance, during peak cropping periods rural Indian women can spend over five hours per day on farm activities on top of their household duties. These seasonal demands already force women to make time trade-off that affect outcomes like nutrition (Vemireddy and Pingali 2021). These constraints are exacerbated by intra-household power asymmetries: women's lack of control over productive assets (e.g., land, machinery) and social norms that rigidly assign unpaid care work limit their ability to negotiate equitable time reallocation during climate shocks (Aggarwal 1997). When temperatures disrupt agricultural productivity, households may prioritize men's paid work (due to higher perceived wages) while women absorb the resulting care and domestic burdens—a dynamic consistent with models of gender-based bargaining failure

In this paper, we examine how climate change alters women's time use in paid versus unpaid work in rural India. We ask: Does climate variability, especially extreme temperature events, change women's allocation of time between agricultural labour and domestic chores? Addressing this requires analysing women's labour supply within households. To do so, we combine data from India's recent national Time Use Survey with historical district-level weather records to analyse these effects. By exploiting variation across agricultural seasons and climate shocks, we can isolate how temperature extremes shift women's participation in paid work and unpaid care.

Our analysis on climate variability, particularly temperature extremes suggests reshaping the labour supply. The extreme heat significantly raises the effective "price" of women's time in unpaid domestic work, prompting a reallocation away from paid farm labour. In other words, women reduce their agricultural hours when heat spikes, likely to cover escalating household tasks or cope with heat risks. These effects are strongest among women of reproductive age, marginal landowners, married women, and lower-caste groups – the very segments with lower bargaining power and fewer coping options. These results align

with observations that economically disadvantaged women invest less in resilience and bear more household burdens during crises. To unpack these dynamics, we conduct subgroup analyses by wealth, land ownership, caste, marital status, and headship, and examine intrahousehold time allocation among cohabiting couples to understand decision-making shifts under climate stress. By situating our findings in demographic and labour frameworks, we contribute evidence on how environmental change shapes gendered labour supply – with implications for women's empowerment and rural development.

This paper contributes to the growing literature on the micro-level impacts of climate change by focusing on a critical yet understudied dimension: how rising temperatures affect women's time allocation between paid employment, unpaid domestic and care work, and leisure. While a robust body of work has documented the adverse effects of extreme temperatures on labour supply and productivity (Liu et al. 2023; Mahajan 2017; Somanathan 2021), cognitive development (Garg et al. 2020; Graff Zivin et al. 2018), birth outcomes (Deschênes et al. 2009), mortality risk (Banerjee and Maharaj 2020), and migration decisions (Cattaneo and Peri 2016), there is surprisingly limited evidence on the intra-household time trade-off that arise in response to climate stress — particularly for women in low-income, rural contexts.

Our findings advance the literature in three ways. First, we show that extreme heat systematically reduces women's participation in paid agricultural work while increasing their burden of unpaid domestic and care responsibilities — with net losses in leisure time, especially for women in more socially and economically vulnerable groups. Second, we document how these time reallocations vary across the agricultural calendar (Kharif and Rabi seasons), confirming that seasonality and local climatic context condition the magnitude of climate's gendered impacts. Third, by examining heterogeneity by reproductive age, caste, landholding status, wealth Quintiles, marital status, and household headship, we highlight that climate vulnerability is deeply intertwined with existing social and economic inequalities.

In doing so, this study broadens the analytical lens on climate-labour dynamics by centring unpaid work and time poverty as critical pathways through which climate shocks exacerbate gender inequality. We hope this evidence supports the development of climate adaptation and labour policies that recognize and compensate for women's role as "shock absorbers" within households — a dimension that has been largely overlooked in both the climate and labour economics literature to date.

2 Literature Review

The nexus between climate change, labour allocation, and welfare has gained significant attention due to the profound implications of rising temperatures and extreme weather events on economic activities and societal well-being.

2.1 Time use and climate change

Time pathway is critical to measure for women than men because of two reasons: first, women face severe time constraints due to competing time demands from household responsibilities and employment activities (Sharma et al. 2025) and second, understanding time patterns in climate change context is important as men and women experience and manage climate resilient strategies differently. Several studies have concluded that women disproportionately bear the burden of climate change.

A recent study by Akter (2021) highlights that while the economic costs of climate shocks are increasingly well understood, the hidden costs borne through changes in unpaid labour remain largely invisible in climate policy debates. By leveraging India's detailed Time Use Survey data — uniquely merged with historical month-district average temperature records — this paper provides some of the first systematic evidence on how climate extremes reshape the gender division of labour in rural households.

(Garg et al. 2020) examine the effects of high temperatures on children's educational outcomes in India, linking poor agricultural productivity due to hot weather with lower test scores. The study finds that temperature extremes during growing seasons substantially affect agricultural yields and subsequently reduce household resources available for education. Social protection mechanisms, like India's National Rural Employment Guarantee Act (NREGA), mitigate these adverse effects by providing income stability, showcasing the protective role of policy interventions in climate-sensitive economies.

(Graff Zivin and Neidell 2014) explore how temperature variations influence time allocation across labour and leisure in the U.S. They find that high temperatures reduce labour hours in climate-exposed sectors like agriculture and construction while prompting shifts to indoor leisure activities. These patterns emphasize the indirect welfare effects of heat-induced labour market adjustments, particularly in settings with limited adaptive capacities.

(Huang et al. 2020) provide evidence from rural China on how long-term temperature increases influence labour reallocation. A 1°C rise in mean temperature reduces farm labour by 7% while increasing off-farm work by 7.8%. This shift is gendered, with women moving from farm to off-farm labour, and men reallocating leisure time to off-farm activities. These results highlight climate-induced structural changes in rural economies, exacerbating the challenges of balancing livelihoods and social welfare in agrarian societies.

This body of work collectively highlights that climate-induced labour reallocation are not uniform but are mediated by socio-economic structures, gender norms, and institutional interventions. It becomes imperative for the gender policy to adapt strategies across diverse geographies while emphasizing policy mechanisms that enhance resilience, such as targeted social safety nets and climate-adaptive infrastructure. These efforts are critical to mitigating the adverse human capital and welfare impacts of climate variability.

3 Theoretical Framework

We consider a representative rural household with two adult members (male and female) each with a fixed time endowment (normalized to 24 hours per day). Each individual $i \in \{m, f\}$ allocates time among three categories: productive market work (h_i^p), unpaid domestic/reproductive work (h_i^r), and self-care or leisure (h_i^s). The time budgets are thus

$$h_m^p + h_m^r + h_m^s = 24, \quad h_f^p + h_f^r + h_f^s = 24.$$

These three categories map directly to the Indian Time Use Survey (ITUS) classifications: h_i^p is measured by reported hours spent in employment in agricultural activities, h_i^r by hours in domestic work and caregiving, and h_i^s by hours in sleeping, personal care, and health-related activities. Notably, the ITUS does *not* distinguish indoor versus outdoor work, so our model treats all productive and domestic work as equally exposed to ambient conditions (unlike some studies that differentiate indoor/outdoor leisure).

Production and Consumption

Market production and non-market domestic output are produced by household labour. Let w_m and w_f be the (baseline) productivity or wage rates of the male and female in market activities. We introduce temperature as an exogenous shock T that affects productivity. Specifically, total market output (which we also treat as the household's consumption good C) is

$$C \;=\; A(T)\left(w_m h_m^p + w_f h_f^p\right),$$

where $A(T)$ is a productivity factor that is *decreasing* in temperature ($A'(T) < 0$) to capture heat reducing marginal productivity of labour. Domestic or household output H (e.g. cleaned home, meals prepared, elderly and child care) is produced by unpaid time and we assume a simple linear production function:

$$H \;=\; h_m^r + h_f^r.$$

We assume full consumption sharing: the goods C and H are shared by the household members.

Preferences and Temperature Effects

The household members have preferences over consumption, home output, and leisure, and experience disutility from hot conditions during work. We adopt a collective (or weighted-utilitarian) utility function.

$$U \;=\; \alpha \ln(C) \;+\; \beta \ln(H) \;+\; \gamma_m \ln(h_m^s) \;+\; \gamma_f \ln(h_f^s) \;-\; \Phi(T)\left(h_m^p + h_f^p + h_m^r + h_f^r\right),$$

where $\alpha, \beta, \gamma_m, \gamma_f > 0$ are preference parameters. The weights γ_m, γ_f capture gender-differentiated value of self-care time. The last term introduces a temperature-dependent disutility: $\Phi(T)$ is increasing in T and multiplies the total hours spent in productive or reproductive work (hours spent in self-care are assumed not to carry this extra heat penalty). This term reflects heat stress or fatigue from labour (e.g. long hours of work or chores are more taxing when it is hot). In equilibrium, a higher T thus lowers the marginal utility of productive and domestic work relative to leisure.

Household Optimization and Intra-household Dynamics

The household maximizes U by choosing $\{h_m^p, h_m^r, h_m^s, h_f^p, h_f^r, h_f^s\}$, subject to the time constraints. The Lagrangian is

$$\mathcal{L} = \alpha \ln(C) + \beta \ln(H) + \gamma_m \ln(h_m^s) + \gamma_f \ln(h_f^s) - \Phi(T)(h_m^w + h_f^w) + \lambda_m \left(24 - \sum_j h_m^j\right) + \lambda_f \left(24 - \sum_j h_f^j\right), \tag{1}$$

where, $j \in \{p, r, s\}$: productive, reproductive, self-care. λ_m and λ_f are the lagrange multipliers for the time constraints (24 hours per day for each individual).

First-order conditions (FOCs) equate adjusted marginal utilities across categories. For example, for the male:

$$\frac{\partial \mathcal{L}}{\partial h_m^p} : \frac{\alpha}{C} A(T) w_m - \Phi(T) = \lambda_m, \qquad \frac{\partial \mathcal{L}}{\partial h_m^r} : \frac{\beta}{H} - \Phi(T) = \lambda_m, \qquad \frac{\partial \mathcal{L}}{\partial h_m^s} : \frac{\gamma_m}{h_m^s} = \lambda_m.$$

Analogous conditions hold for the female with λ_f. Equating these we obtain relationships such as

$$\frac{\alpha A(T) w_m}{C} - \Phi(T) = \frac{\gamma_m}{h_m^s}, \quad \frac{\alpha A(T) w_f}{C} - \Phi(T) = \frac{\gamma_f}{h_f^s}, \quad \frac{\beta}{H} - \Phi(T) = \frac{\gamma_m}{h_m^s} = \frac{\gamma_f}{h_f^s}.$$

These conditions imply the household balances the trade-offs of allocating time between work, home production, and leisure, jointly for both members. Importantly, we assume full intra-household risk sharing: consumption is pooled and a single set of marginal utilities applies to the household. As such, if temperature shock makes one spouse less productive, the other may adjust his or her hours to partially smooth consumption, in contrast to purely individual (market-based) substitution. This cooperative allocation reflects gendered intrahousehold dynamics where men and women optimize together.

Effects of Temperature on Time Allocation

From the FOCs, temperature enters through $A(T)$ and $\Phi(T)$. Since $A'(T) < 0$ and $\Phi'(T) > 0$, a hotter day reduces effective marginal return to work and increases disutility of work. Consequently, the conditions imply both h_m^p and h_f^p fall as T rises (workers cut back hours to avoid heat fatigue). Similarly, h_m^r and h_f^r may also decline because the same disutility term applies to domestic work. With less time in work/chores,

the only remaining time is self-care, so h_m^s and h_f^s increase. In short, the model predicts $\partial h^p/\partial T < 0$, $\partial h^r/\partial T < 0$, and $\partial h^s/\partial T > 0$, consistent with reallocating time from work towards rest when it is hot (as found in other studies. Intra-household risk sharing moderates these adjustments: for example, if the male's marginal productivity shrinks more with heat than the female's, the household can compensate by shifting more productive time to the female or adjusting γ_m, γ_f shares to stabilize overall output.

Empirical Test

We relate the model variables to Indian Time Use Survey (ITUS) and observable measures. The time inputs h_i^p, h_i^r, h_i^s are directly observed as respondents' reported hours in the corresponding TUS categories (employment in agricultural work, domestic chores/care, and sleep/personal care). Total consumption C is not observed in the TUS, but in practice it is proxied by income or household expenditures (which can be controlled for or instrumented). The domestic output H is unmeasured but is proxied by a composite of household activities. The temperature T is measured using average temperature at individual's district. Since domestic chores/care work and self-care time are also affected by temperature, either through compensatory behaviour (reducing time in employment) or lack cooling equipments at home we apply the shock uniformly across all non-leisure activities. The disutility function $\Phi(T)$ is not observed, but its empirical counterpart is the reduced-form relationship between T and lower hours in work/chores.

In empirical analysis, we estimate how a degree increase in T affects reported h^p, h^r, h^s, controlling for household and individual factors. The model suggests key elasticities: e.g. $\partial h^p/\partial T$ should be negative (less work in heat) and $\partial h^s/\partial T$ positive (more sleep/rest). Gendered differences under extreme temperature responses likely reflect variation in intra-household bargaining power. For instance, if women's farm work declines more sharply than men's under heat stress (i.e., larger $\partial h^p/\partial T$ for i=f), this may signal weaker fallback options (e.g., lack of land rights) that prevent them from resisting reallocation to unpaid labour (Aggarwal 1997). Though time use survey doesn't capture factors affecting the bargaining power (Sharma et al. 2025), our stratification by land ownership, caste, and marital status provides indirect evidence of these mechanisms. The theoretical parameters like $A'(T)$ and $\Phi'(T)$ are identified through the temperature dependence of time use in the data, while $\alpha, \beta, \gamma_m, \gamma_f$ relate to the trade-offs among categories implied by the observed time allocation patterns.

4 Methodology

4.1 Data and variables

The analysis in this paper utilizes two datasets: first nationally representative Time use survey (TUS) in India, conducted in 2019[1]. A total of 138,799 households were included in the TUS19 survey, covering a population of 447,250 individuals aged six years and above. Respondents were asked to report their activities

[1] https://mospi.gov.in/publication/time-use-india-2019

over 24 hours, from 4 a.m. on the day before the survey until 4 a.m. on the day of the survey. This period was divided into 48 time slots of 30 minutes each. For each time slot, respondents could report up to three activities and designate one of them as their 'major' activity based on their subjective preference. The survey was conducted during January- December 2019 to ensure representation of population in each month.

The data collected in TUS is classified in to nine categories based on the International Classification of Activities for Time-Use Statistics (ICATUS) 2016, which draws on the International Labour Organization's (ILO) 2013 resolution . These activities include employment and related activities, production of goods for own consumption, unpaid domestic services, unpaid caregiving services, unpaid volunteer work, learning, socializing, cultural participation, and self-care.

The survey collects time use information for all the members in the household, additionally, it also collected demographics and socioeconomic information on individuals and households such as sex, education, age, occupation, and relationship to the head of the household, monthly consumption, place of residence.

The second data we use is from ICRISAT[2] on month-district average temperature data from 1999-2020 measured in degree C. We created 8 bins (coldest to hottest temperatures) based on the temperatures observed in 2019 that corresponds to the time use data and we also created standard deviation to estimate the coping effect of historical month-district temperature. We also use month-district rainfall data from 1995-2020 in 8.1 to see if our results are sensitive to the rainfall in addition to the temperature.

Our analysis focuses on the working-age population (15-85 years) yielding an analytic sample of 71,483 individuals. Our focus is to estimate the time allocation on the following activities from ITUS: employment and related activities, unpaid domestic and care giving work and self-care. Mapping our theoretical model to our data, we use employment activity for measuring impact of temperature on productive activities, unpaid domestic and care work to measure reproductive work and self-care to estimate the effect on leisure.

4.2 Empirical Framework

4.2.1 Effect of Temperature

We estimate whether men and women allocate their time differently in response to changes in extreme temperature. We study agriculture sector in Indian context for two reasons (1) extreme climate impacts both pre-production agriculture activities (sowing, irrigation, harvesting) and production of output, mainly crop failure due to floods, drought, hailstorms etc. and (2) since agriculture has largest employment share (˜50% of the labour force), climate change affects labour allocation in farm and off-farm activities which in turn has negative implication on incomes leading to reduction in human capital formation. We employ the following framework to estimate the effect of current year average temperature and historical temperature

[2]http://data.icrisat.org/dashboard/dld/src/environment.html

effect on difference in time use between women and men.

$$ActivityTime_{idm} = \beta_1 \sum_{>=0}^{<38.5} (Female_{idt} \times Tempbin_{dt}) + \beta_2 (Female_{idt} \times SD_{dt}) + \gamma X_{idt} + \lambda District_d + \epsilon_{it} \tag{2}$$

where ActivityTime$_{idm}$ is time (in minutes) spent on any given activity by an individual i, in district d, during month m. The variable Tempbin$_{idm}$ is divided into 8 bins using monthly average temperature of observed in a district 2019 to capture the real time effect of increase in temperature on time use. This allows us to capture the non-linear effects of temperature on time use. This approach complements the theoretical model's emphasis on the non-linear impact of temperature. The first interaction term $Female_{idt} \times Tempbin_{dt}$ aligns with the theoretical model's focus on gendered differences in time allocation. This interaction term allows us to capture differential responses between men and women, which is critical for testing hypotheses related to labour reallocation and compensatory behavior. The second interaction term $Female_{idt} \times SD_{dt}$ allow us to examine whether historical deviations (since 1999-2018) in temperatures has any gendered effect. We also control for time varying individual (education, age, caste, religion) and household characteristics (monthly per capita consumption (MPCE), use of technology for cooking, cleaning, lighting, washing) represented by X_{idt}, a vector of variables that may affect time spent in different activities. We also control for month and district time-invariant characteristics that may influence time spent on different activities by men and women. Since our context is agriculture specific, we restrict our sample to rural sub-population and for 15-85 years for men and women separately.

5 Descriptive Statistics

5.1 Sample Statistics

In this section, we present the descriptive analysis of TUS data in table 1 to understand the context and distribution of time use.

Table 1: Summary statistics for individuals (15-85 years) and average time spent in four major activities

	Sample Statistic	Employment activity (in min)	Unpaid Domestic (in min)	Unpaid Care (in min)	Selfcare (in min)
	%	Mean	Mean	Mean	Mean
Gender Group					
Female	29	358.132	252.45	102.25	680.21
Male	71	392.62	102.84	74.89	731.32
Working age (15-85 years)	42.76	379.67	178.19	88.65	715.39
Marital status					
1. Married	83	384	179.05	84.85	714.96
2. Widowed	8	371.68	192.79	90.27	717.86
3. Never Married	10	393.40	129.84	71.69	733.87
Education Status					
1. Illiterate	44	386.70	189.84	83.68	716.33
2. Above primary	33	387.72	171.19	84.28	716.75
3. Above secondary	18	376.29	155.23	86.62	718.96
4. Above higher Secondary	4	360.73	137.31	92.04	717.45
Wealth Index					
Quintile-1	25	387.36	178.37	87.99	726.81
Quintile-2	23	385.21	172.90	84.78	718.69
Quintile-3	22	382.50	174.83	82.54	715.78
Quintile-4	19	381.55	181.07	83.84	710.73
Quintile-5	10	381.12	181.74	77.91	701.90
Type of occupation					
Self employed	68	356.02	177.47	86.70	721.32
Casual worker	30	429.48	176.80	81.51	709.01
Caste Category					
General	22	370.54	172.22	82.20	709.50
ST	23	384.36	189.32	92.16	725.91
SC	17	401.48	175.85	84.95	717.71
OBC	39	383.25	174.83	82.82	717.07
Religion Category					
Hindu	82	383.84	178.55	85.27	717.90
Islam	6	373.71	152.96	78.48	712.13
Christian	7	373.37	185	91.70	707.61
Other	4	424.41	174.44	83.51	709.30

Source: Author's calculations from Time Use Survey (TUS 2019)

Note: The average time use reported for different activities is conditional on participation and weighted at household level.

On an average a 42.76 year old individual work in agriculture for 6.3 hours in a day, unpaid domestic work for 2.96 hours, unpaid care work for 1.15 hours and 11.91 hours in sleeping and hygiene maintenance. Since agriculture is a male dominated activity in India, our sample statistics also shows that 70% of the individuals are men. Conditional on being employed in agriculture, the time spent by men is 6.5 hours a day, slightly more compared to what women spend in agriculture. While being employed, women bear the burden of unpaid domestic and care work significantly higher than men. Interestingly, women spend 50 minutes lesser than men in sleeping and maintaining hygiene activities which shows unequal distribution of burden of time between men and women.

The education status of the individuals working in agriculture reflects that most of them are either illiterate or have education below primary level. Similarly in poverty measures, poorest and poor individuals are highly engaged in the agricultural work in the sample. The division in caste shows mostly Other backward caste (OBC) and schedule tribe (ST) are engaged in agriculture.

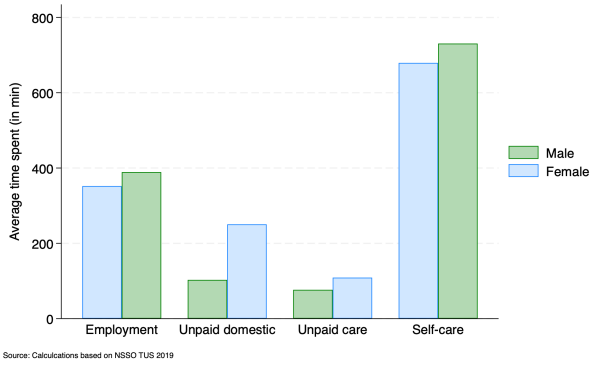


Figure 1: Gender differences in average time spent (in min) in different activities. Source: NSSO Time use (TUS) data 2019

5.2 Gender Differences in Time Use

We looked at the differences in the time use between men and women across productive and reproductive activities. Figure 1 shows that conditional on participation in activities, there are substantial differences in time use by women and men in employment in agriculture and unpaid domestic activities. These results are in line with the existing studies (Mahajan 2017).

6 Results

6.1 Gendered Effect of Temperature on Time Use

Figures 2 & 3 depicts the estimated impact of temperature variation on differences in time use between men and women for key activities—farm work, care work, housework, and leisure—during the Kharif and Rabi season. The omitted temperature category is 22.2–27.75°C, which serves as the seasonal reference point for each outcome.

Throughout the Kharif season, under cold-to-moderate cold and extreme heat conditions, women reallocate time away from farm labour more substantially than men, and absorb much of the adjustment via housework (in cold) or caregiving (across several bins), while leisure is consistently in the residual margin. The pattern is most pronounced in the coldest (11.1–16.65°C) and hottest (33.3–38.85°C) bins, where women reduce agricultural time by over two to three hours relative to men and correspondingly increase unpaid domestic and care work. These findings support the hypothesis that, under climate stress, women disproportionately bear the dual burden of sustaining household reproduction while adjusting out of physically demanding farm tasks. Although the coefficient on the 11.1–16.65°C bin (–167.7 min/day) is insignificant, it suggests that women curtail agricultural tasks by nearly three hours more than men under unusually cold conditions. This contraction is most precisely estimated under extreme heat: in the 33.3–38.85°C bin, women reduce farm work by approximately 96 minutes/day more than men. At the same time, women absorb these labour contractions by reallocating time predominantly into unpaid domestic activities and caregiving. In the 11.1–16.65°C bin, women increase the caregiving work by 75.4 min/day while reducing

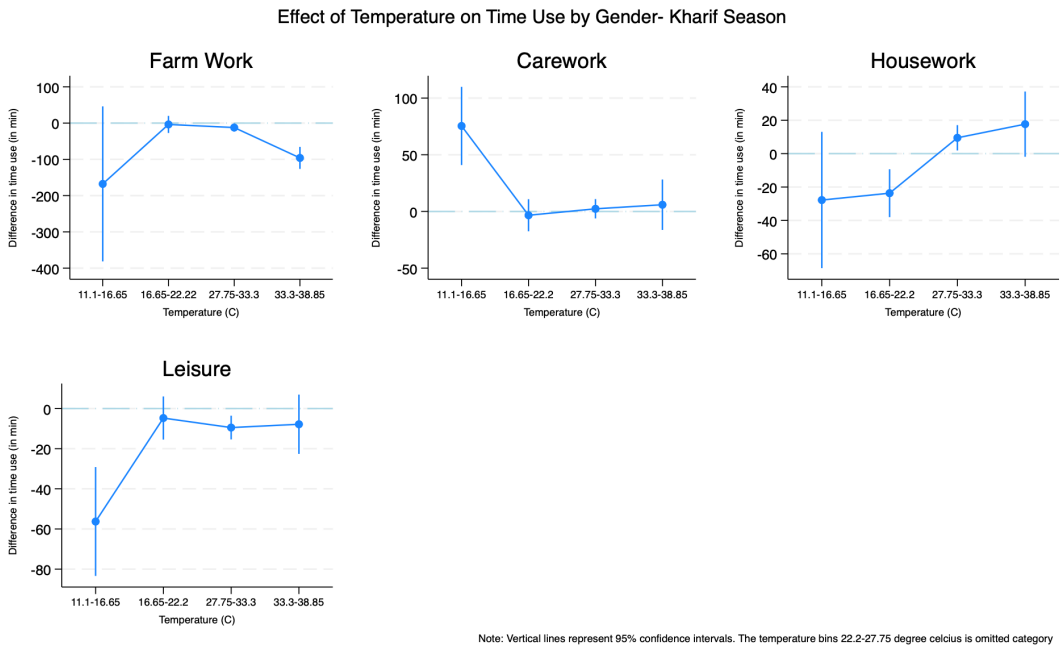


Figure 2: Gender differential in time spent in employment activities due to extreme temperature in kharif season. Source: NSSO TUS 2019 and month-district average temperature (1999-2020) using ICRISAT data. The controls are same as described in section 4.2. Kharif season is considered from June-October, rabi season from December- April

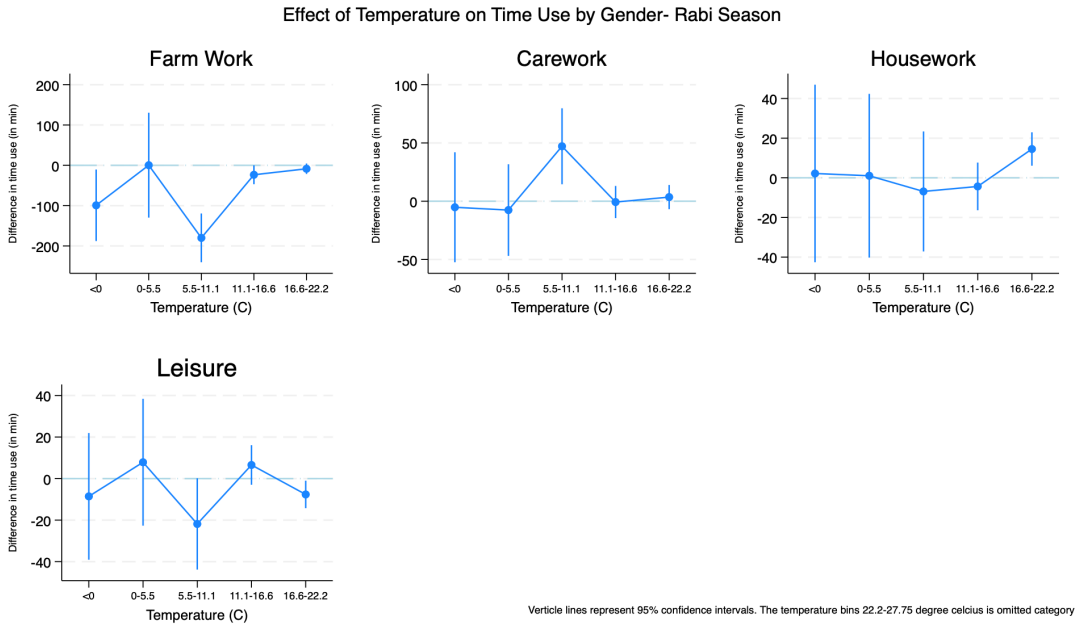


Figure 3: Gender differential in time spent in employment activities due to extreme temperature in Rabi season. Source: NSSO TUS 2019 and month-district average temperature (1999-2020) using ICRISAT data. The controls are same as described in section 4.2. Kharif season is considered from June-October, rabi season from December- April

their leisure declines by 56.3 min/day. Under extreme heat, the residual margin again falls on leisure (–7.8 min/day), accompanied by a modest uptick of 17.7 min/day in care work.

As temperatures rises, unproductive domestic and care burdens (e.g., meal preparation, water fetching) amplify, diverting time from income-generating activities to caregiving tasks, at the expense of their leisure and rest.

During rabi season, which observed freezing conditions, women curtail farm labour significantly more than men (–99.2min/day), while showing no statistically meaningful shifts in care, domestic work, or leisure. This suggests that, as cultivation becomes unfeasible, women disproportionately exit the fields but do not reallocate time to other measured activities. Whereas in near-freezing range (0-5.55°C bin), gender differences vanish (all coefficients statistically indistinguishable from zero), indicating convergence of men's and women's time use when temperatures are only moderately below the agricultural optimum. In the 5.55–11.1°C bin, women drastically cut farm work relative to men by –180.0 min/day , and simultaneously increase care work by 47.2 min/day. Housework and leisure decline modestly. This pattern signifies a pronounced compensatory shift: as cold severely restricts agricultural labour, women reallocate their freed-up hours into caregiving and sacrifice discretionary time. In temperature closer to the optimum for human activity, women's farm labour decreases by 8.5 min/day but this is not statistically significant. Notably, care work increases by 14.5 min/day, and leisure falls by –7.6 min/day. This suggests that relatively hot Rabi days spur a gendered reallocation away from leisure into caregiving roles.

Across the Rabi season, extreme cold (Bins 1 and 3) induces large farm-work reductions among women relative to men, while extreme heat (Bin 5) elicits modest shifts. The coldest optimal-agricultural-temperature bin (5.55–11.1°C) in particular engenders a clear compensatory pattern: women substitute out of farm labour by reallocating time into care work, at the expense of leisure—a reflection of intra-household risk-sharing under climate stress. In contrast, moderate deviations (Bins2 and 4) exhibit no significant gendered time reallocations, indicating that only sufficiently large temperature shocks bind agricultural labour and trigger compensatory domestic-care responses.

These findings confirm that, in winter cropping cycles, women disproportionately absorb the time-use adjustments necessitated by climatic deviations—consistent with a time-allocation model in which the household's collective utility is maintained via gender-differentiated labour reallocation

The results from main specification shows that temperature affects human capital through altering the time spent in productive and reproductive activities with gendered effects. At lower temperatures (11.1–16.65°C), women's employment time decreases further by 17 minutes per day relative to men. However, at higher temperatures (33.3–38.85°C), women's employment time increases by approximately 10.5 minutes per day compared to men. In terms of workdays, if we assume kharif cycle to be of 60 days, then women work 630 minutes or 10.5 hours more in the kharif cycle relative to men. This suggests that women increasingly take on productive roles as temperatures rise, possibly driven by economic necessity. Despite the increase in employment time, women's time spent on unpaid domestic work and care remains persistently high,

with only marginal reductions in certain temperature bins. For example, at 33.3–38.85°C, domestic work decreases by just 0.9 minutes per day, while care work increases slightly by 2.5 minutes per day. This indicates a dual burden where women must balance employment with their unpaid responsibilities.

The observed pattern—whereby women reduce farm labour more than men under temperature extremes and simultaneously increase unpaid domestic and care activities—reflects a classic compensatory response as articulated in the household time-allocation literature. In the canonical model (e.g. Becker 1965; Singh, Squire, and Strauss 1986), total available time is a fixed endowment that must be divided among market work, non-market household production, and leisure. Exogenous shocks to productivity—in this case, extreme temperatures across seasons, lower the marginal productivity of labour in farming, effectively raising the opportunity cost of continued agricultural activity.

Our findings conforms to the broad agriculture literature that establishes that in developing countries, women are disadvantageous in several aspects with respect to adaptability to climate change. Women tend to have lack of women friendly agricultural tools and technologies for land preparation, weeding and drying than men, they are less likely to interact with the information communication technology (ICT) as strategies to prevent exposure in adverse climatic conditions(**?**). Norms also play an important role in deciding the ownership of agricultural assets, livestock and division of labour on farm. As shown by (**?**), women tend to work more in non-commercial agricultural activities whereas men are responsible for commercial crops and large livestock.

6.2 Classification into paid and unpaid agricultural activities

To further unpack women's compensatory and adaptive behaviors under temperature stress, we stratify the sample by four principal employment categories—self-employed, unpaid family workers, wage workers, and casual labourers in table 2 and estimate gender and temperature interactions for Kharif and Rabi seasons. The omitted reference bin is 22.2–27.75°C in both panels.

Table 2: Effect of district monthly average temperature on daily time use in employment of men and women(15-85 yrs) by worker type

	Self-employed	Unpaid Family Worker	Wage Worker	Casual Worker
Panel A: Kharif season				
Female (0-male)	-54.14***	-76.25***	26.93	-25.46**
	(15.54)	(18.09)	(78.55)	(10.56)
Baseline temperature bin - 22.2-27.75° C				
Female*Temp bin (16.65-22.2°C)	3.15	-1.91	64.32	10.01
	(17.44)	(23.61)	(80.60)	(23.21)
Female*Temp bin (27.75 -33.3°C)	3.52	-28.46**	-48.93	-19.46***
	(11.21)	(12.69)	(31.79)	(6.87)
Female*Temp bin (33.3-38.85°C)	-36.74	-97.07***		-46.47*
	(26.11)	(27.71)		(27.48)
Coping effect (SD (1999-2018)	-1206.78***	33.59	-55.15	-1475.80***
	(168.00)	(156.45)	(136.86)	(309.49)
Female*SD	-5.69	2.76	-12.53	-2.31
	(3.84)	(4.15)	(19.85)	(2.78)
Observations	9350	2975	318	6392
R^2	0.37	0.41	0.73	0.35
F	9.86	5.26	3.69	7.49
Panel B: Rabi season				
Female (0-male)	-53.13***	-50.52**	34.09	-26.23**
	(16.15)	(20.51)	(37.07)	(11.12)
Baseline temperature bin - 22.2-27.75°				
Female*Temp bin (below 0°C)	-30.09	-59.41		
	(75.92)	(62.56)		
Female*Temp bin (0-5.55°C)	-148.53			
	(116.51)			
Female*Temp bin (5.55- 11.1°C)	138.91*	-77.18*		
	(83.89)	(46.67)		
Female*Temp bin (11.1-16.65°C)	23.46	-48.49**	23.27	-72.50***
	(18.37)	(23.17)	(57.52)	(24.83)
Female*Temp bin (16.65-22.2°C)	-7.68	-15.44	-53.44	-19.25**
	(11.87)	(13.19)	(32.69)	(8.80)
Coping effect (SD (1999-2018)	-456.52***	-548.08***	-22.79	-197.19
	(129.74)	(207.86)	(48.46)	(201.15)
Female*SD	-7.66*	-1.09	-13.03	-1.83
	(4.11)	(5.08)	(10.79)	(3.07)
Observations	7901	2621	276	4906
R^2	0.35	0.44	0.83	0.37
F	7.83	5.29	6.74	6.59
Individual controls	Yes	Yes	Yes	Yes
Household controls	Yes	Yes	Yes	Yes
District fixed effects	Yes	Yes	Yes	Yes

Source: Calculation based on NSSO Time use survey 2019 and month-district average temperature (1999-2020) using ICRISAT data. The estimates are conditional on participation. The controls are same as described in section 4.2. Kharif season is considered from June-October, rabi season from December- April

Across all worker types, the coefficient for female is negative for self-employed (54.1 min/day) and unpaid family work (76.3 min/day), indicating that at baseline women devote substantially fewer minutes to these employment forms than men. In contrast, wage employment shows no baseline gender gap and casual labour reveals a smaller but significant shortfall for women (25.5 min/day).

The temperature bin 27.75–33.3°C is the first to exhibit significant gender differentials in responsiveness. Here, women's employment time as unpaid family workers falls by an additional 28.5 min/day and casual labour by 19.5 min/day, whereas self-employment and wage work show no significant shifts. Under extreme heat (Temp bin: 33.3–38.85°C), the gendered contraction intensifies starkly for family workers

(97.1 min/day) and casual labourers (46.5 min/day), while women's self-employment and wage employment remain statistically unchanged.

Finally, the coping-effect interaction (SD of historical temperatures) reveals very large negative point estimates for self-employed (1206.8 min/day) and casual labourers (1475.8 min/day), suggesting that in districts accustomed to high temperature variability, women's time in these occupations drops sharply relative to men. The smaller and insignificant FemaleSD terms imply this volatility effect is not systematically different by gender beyond baseline gaps.

In Panel B for Rabi Season the baseline gender gaps persist as women work 53 min/day less in self-employment, and family work 50.5 min/ day than their male counterparts; wage workers again show no gap, and casual labourers have a modest shortfall (26.2 min/day).

Under cold temperature stress (bin 1: below 0°C and bin 2: 0–5.55°C), men's and women's work adjustments are parallel when winter temperatures are only modestly below the cropping range. However Bin 3 (5.55–11.1°C)—the coldest agriculturally relevant interval—reveals a striking female-self-employment surge of 138.9 min/day comes at a cost of reducing the unpaid family work (77.2 min/day). This pattern suggests that during early winter frosts, women reallocate away from low-return family duties into self-employment, an adaptive shift aligned with the time-allocation model's prediction of re-optimizing labour across available sectors.

In moderate cold (Bin 4: 11.1–16.65°C), women in unpaid family work reduce their hours by 48.5 min/day, while wage workers and casual labourers again show mixed or non-significant responses. The coping-effect SD interactions are large and negative for both self-employed (456.5 min/day) and family workers (548.1 min/day), echoing the Kharif findings that districts with historically variable winter temperatures amplify women's labour reductions relative to men.

7 Heterogeneity Analysis

7.1 Intra-household Analysis

Using primary or principle couple sample, we analyse how extreme temperature affects division of labour amongst agricultural households.A principal couple is typically the head of household and spouse. The findings shown in table 3 shows evidence of gendered time use responses to climatic variation. Across both Kharif and Rabi seasons, women consistently allocate significantly more time to unpaid domestic responsibilities and less to employment-related and self-care activities relative to their male counterparts.

In the Kharif season, extreme temperatures (especially 33.3–38.85°C) reduce women's employment time by approximately 76 minutes per day, while increasing their unpaid care responsibilities. Notably, colder temperature bins (11.1–16.65°C) are associated with a 59-minute rise in domestic work and a 61-minute reduction in self-care, suggesting time reallocation away from personal needs toward household care. In contrast, male time use remains largely unaffected, underscoring unequal intra-household risk-sharing.

In the Rabi season, although gendered differences persist, they appear slightly muted. Still, women's time in domestic work increases substantially under moderate temperature bins (e.g., a 17-minute rise in the 16.65–22.2°C bin), while selfcare time decreases, particularly in colder temperatures (e.g., a 42-minute drop in the 5.55–11.1°C bin).

These results align with the theoretical expectation of non-unitary household models, where bargaining power and gender roles shape time allocation responses to environmental shocks.

Table 3: Effect of district monthly average temperature on daily time use in intra-household setup

	Employment related	Unpaid domestic	Unpaid Care	Selfcare
Panel A: Kharif season				
Female (0-male)	-51.94***	173.60***	11.53	-52.03***
	(8.35)	(6.75)	(8.47)	(4.71)
Baseline temperature bin - 22.2-27.75° C				
Female*Temp bin (11.1-16.65°C)	0.00	-59.74**	95.20***	-61.38***
	(.)	(24.94)	(22.25)	(15.90)
Female*Temp bin (16.65-22.2°C)	-13.85	-25.41***	7.24	-11.84*
	(12.93)	(8.17)	(8.60)	(6.06)
Female*Temp bin (27.75 -33.3°C)	-20.33***	5.81	11.54**	-14.18***
	(5.76)	(4.33)	(5.21)	(3.24)
Female*Temp bin (33.3-38.85°C)	-75.80***	-5.30	32.00**	-9.55
	(16.18)	(12.45)	(15.27)	(8.42)
Coping effect (SD (1999-2018)	-1114.59***	-235.59*	-203.26	137.91
	(148.68)	(124.66)	(151.90)	(85.56)
Female*SD	0.01	-2.19	2.58	3.71***
	(2.07)	(1.57)	(1.99)	(1.12)
Observations	14719	11958	4145	20979
R^2	0.29	0.49	0.30	0.26
F	11.13	20.34	3.18	12.47
Panel B: Rabi season				
Female (0-male)	-48.50***	171.87***	22.47**	-47.18***
	(8.78)	(7.08)	(9.08)	(4.89)
Baseline temperature bin - 22.2-27.75°				
Female*Temp bin (below 0°C)	-34.23	-52.58*	-42.93	-17.86
	(57.80)	(29.24)	(34.32)	(17.85)
Female*Temp bin (0-5.55°C)	2.51	-19.57	12.97	-3.54
	(106.46)	(24.22)	(22.49)	(16.23)
Female*Temp bin (5.55- 11.1°C)	-44.85	9.20	10.17	-41.91***
	(36.45)	(19.31)	(23.84)	(13.09)
Female*Temp bin (11.1-16.65°C)	-5.29	-4.70	-0.62	-3.21
	(12.66)	(7.10)	(8.18)	(5.35)
Female*Temp bin (16.65-22.2°C)	-7.44	17.40***	7.79	-3.13
	(6.78)	(4.92)	(5.97)	(3.66)
Coping effect (SD (1999-2018)	-355.99***	-111.43	45.64	333.66***
	(100.22)	(118.48)	(173.62)	(104.29)
Female*SD	-4.06*	-5.11***	2.25	1.32
	(2.34)	(1.77)	(2.25)	(1.24)
Observations	12348	10631	3645	18111
R^2	0.31	0.46	0.31	0.27
F	10.00	16.64	2.96	11.65
Individual controls	Yes	Yes	Yes	Yes
Household controls	Yes	Yes	Yes	Yes
District fixed effects	Yes	Yes	Yes	Yes

Source: Calculation based on NSSO Time use survey 2019 and month-district average temperature (1999-2020) using ICRISAT data. The estimates are conditional on participation. The controls are same as described in section 4.2. Kharif season is considered from June-October, rabi season from December- April

7.2 Women's reproductive age (15-49 years)

When we restrict the sample to women and men of reproductive age (15–49) in table 4, the results qualitatively remain intact, with modest shifts in magnitude and precision. In the Kharif season, reproductive-age women still work substantially fewer minutes than their male counterparts at baseline (43.8 min/day in paid work) and spend far greater time in unpaid domestic (196.8 min/day) and care work (28.2 min/day) while leisure is lesser than men by almost one hour a day. The temperature-interaction coefficients shows similar reduction in the farm work at the 11.1–16.65°C (107 min/day) and 33.3–38.85°C bins (82 min/day), accompanied by significant increase in care work and sharp reductions in self-care.

The estimates in 11.1–16.65°C bin for the younger cohort are qualitatively similar of those in the full 15–85 years sample.

In the Rabi season, reproductive-age results are also similar as the full sample. The baseline gender gaps in paid employment (47.8 min/day) and unpaid domestic (192.9 min/day) persist, and significant farm-work contractions emerge at both subzero temperatures (113.5 min/day)and 5.55–11.1°C bin. Care work in this bin increases by 45.4 min/day, again reflecting compensatory reallocation. The coping-effect (district SD) coefficients for reproductive-age women are similarly negative and significant in paid work during both seasons, confirming that persistent temperature variability disproportionately contracts women's employment time.

Table 4: Effect of district monthly average temperature on daily time use in of men and women in reproductive age (15-49 yrs)

	Employment related	Unpaid domestic	Unpaid Care	Selfcare
Panel A: Kharif season				
Female (0-male)	-43.83***	196.82***	28.16***	-58.73***
	(9.25)	(7.82)	(8.24)	(5.06)
Baseline temperature bin - 22.2-27.75° C				
Female*Temp bin (11.1-16.65°C)	-107.06	-43.08	74.07***	-50.00***
	(103.04)	(33.73)	(21.17)	(17.91)
Female*Temp bin (16.65-22.2°C)	9.29	-33.86***	11.00	-13.78**
	(13.31)	(9.22)	(8.24)	(6.29)
Female*Temp bin (27.75 -33.3°C)	-19.25***	3.47	8.92*	-11.83***
	(6.26)	(4.93)	(5.15)	(3.37)
Female*Temp bin (33.3-38.85°C)	-82.38***	7.95	30.34**	-19.25**
	(17.03)	(14.37)	(15.26)	(8.59)
Coping effect (SD (1999-2018)	-973.69***	-235.68	-195.11	-61.09
	(162.60)	(157.55)	(171.11)	(95.54)
Female*SD	-3.22	-2.95	0.79	3.71***
	(2.28)	(1.82)	(1.94)	(1.20)
Observations	13053	10130	4294	18276
R^2	0.29	0.51	0.31	0.26
F	9.86	18.66	3.56	11.01
Panel B: Rabi season				
Female (0-male)	-47.80***	192.93***	31.55***	-55.79***
	(9.96)	(8.43)	(10.17)	(5.39)
Baseline temperature bin - 22.2-27.75°				
Female*Temp bin (below 0°C)	-113.53*	-20.82	-34.65	-47.41**
	(64.76)	(32.01)	(28.25)	(19.28)
Female*Temp bin (0-5.55°C)	-62.40	2.03	-11.11	-13.21
	(140.16)	(33.30)	(32.93)	(22.05)
Female*Temp bin (5.55- 11.1°C)	-38.78	-0.67	45.42*	-44.66***
	(38.03)	(25.80)	(24.26)	(14.82)
Female*Temp bin (11.1-16.65°C)	-18.61	-8.62	-4.74	-6.32
	(13.59)	(7.92)	(9.02)	(5.51)
Female*Temp bin (16.65-22.2°C)	-12.30*	15.76***	7.21	0.70
	(7.20)	(5.46)	(6.43)	(3.76)
Coping effect (SD (1999-2018)	-379.42***	-100.54	87.43	397.51***
	(102.25)	(128.39)	(188.03)	(104.91)
Female*SD	-3.20	-4.93**	2.46	1.41
	(2.59)	(2.08)	(2.55)	(1.34)
Observations	10783	8881	3779	15480
R^2	0.32	0.49	0.30	0.27
F	9.19	15.66	2.96	10.36
Individual controls	Yes	Yes	Yes	Yes
Household controls	Yes	Yes	Yes	Yes
District fixed effects	Yes	Yes	Yes	Yes

Source: Source: Calculation based on NSSO Time use survey 2019 and month-district average temperature (1999-2020) using ICRISAT data. The estimates are conditional on participation. The controls are same as described in section 4.2. Kharif season is considered from June-October, rabi season from December- April

7.3 Caste

In India, caste category remains a critical socio-economic determinant in India, shaping access to resources, labour roles and occupational segregation. Caste reflects status of the households and it has been observed that marginalized castes (SC, ST) often inhabit areas more prone to climatic stress (e.g., drought-prone regions) and has less resources for climate reliance. They face systemic barriers to adaptation, including limited access to education, land, and financial resources. Due to this segregation, individuals from SC,

ST and OBCs social groups are exposed and vulnerable to the climate change. These structural inequities amplify their vulnerability to climate shocks, as reflected in disproportionate impacts on employment and unpaid labour. A study by Shah et al. (2024) reflects that majority of heat exposed occupations are carried by SC and ST population in India and these groups spend 50% of their time in outdoor activities.

At a descriptive level, our results from table 1 also shows extensive participation of marginalized caste groups (Schedule Caste, Schedule Tribes and Other Backward Caste) in agriculture compared to the dominated caste (General) as per Indian caste hierarchical system. As discussed in literature, predominantly outdoor activities are performed by marginalized caste groups due to occupational segregation and labour market discrimination (Munshi 2019; **?**).

In table 5 we show the differences in time use by different caste groups under extreme temperature across Kharif and Rabi season. In panel A and B, the baseline difference between men and women's time use is more pronounced in General category than marginalized caste group which shows necessity of marginalized caste group's women to work in agriculture. A reason for this difference in time use in employment activities amongst caste category could also be the gender norms. Time spent by women in upper caste groups in employment activities is generally considered as low status job compared to women in marginalized groups have more relaxed gender norms (Eswaran et al. 2013).

In panel A specifically, we find that time difference in women and men in agriculture widens in extremely hotter temperatures (Temp bin: 33.3–38.85°C) causing reduction in women's time use by 103 min/day and an equivalent increase in the unpaid care work due to reduction in productive time use. Women in ST and OBC groups also substantially reduce their time spent in productive work but did not significantly alter their time use in reproductive activities. Most stark result is observed for women in SC group where working hours between men and women are indistinguishable under extreme heat. Several studies in the rural context in India confirms these findings that schedule caste (or schedule tribes where they are present) are the mainstay in female labour force (Swaminathan 2020).

In panel-2, in extremely colder temperature (below 0°C) self-care time suffers significant reductions, particularly among General and ST women, who sacrifice personal well-being to manage increased household responsibilities and reduced employment opportunities. When temperature increases in Rabi season and become closer to optimum, women in ST groups reduces their time in employment and increase almost same time in unpaid domestic work (40 min/day). Whereas, women in SC group compensate an increased time spent in agriculture by reducing their unpaid domestic work in near to optimum temperature.

Table 5: Time use for working aged individuals in households(15-85 yrs)by caste

	Employment Activity				Unpaid Domestic Work				Unpaid Care Work				Selfcare			
	Gen	SC	ST	OBC	Gen	SC	ST	OBC	Gen	SC	ST	OBC	Gen	SC	ST	OBC
Panel A: Kharif season																
Female	-71.98***	-31.27*	-40.13**	-53.73***	168.18***	175.24***	188.34***	177.07***	20.25	30.61	8.65	20.71*	-43.07***	-30.48***	-73.63***	-50.84***
	(17.04)	(17.85)	(17.19)	(11.42)	(13.31)	(17.26)	(15.00)	(9.73)	(14.29)	(19.14)	(19.42)	(11.10)	(8.32)	(9.70)	(9.66)	(6.86)
Baseline temperature bin - 22.2-27.75° C																
Female*Temp bin (11.1-16.65°C)		-122.40			57.80	-46.08*				51.54**		18.90	3.28	-40.61***	-237.05**	-73.37
		(89.58)			(115.19)	(25.41)				(21.04)		(79.76)	(72.56)	(13.89)	(106.33)	(63.30)
Female*Temp bin (16.65-22.2°C)	-60.06**	25.87*	-62.52	-17.31	-50.91**	-22.17**	-42.19	-40.20*	9.27	-6.41	-109.65	9.65	-1.93	-16.73***	-0.24	16.79
	(26.13)	(14.05)	(48.53)	(26.53)	(19.88)	(9.78)	(51.83)	(24.34)	(19.07)	(9.66)	(86.82)	(44.88)	(11.29)	(6.47)	(25.08)	(17.45)
Female*Temp bin (27.75 -33.3°C)	-18.80	-21.07*	-20.39*	-25.36***	-2.17	20.04**	-5.06	1.60	35.33***	-2.83	-3.60	17.38**	9.81	-13.76**	-4.73	-11.27**
	(12.67)	(10.88)	(11.72)	(7.94)	(10.36)	(8.88)	(10.20)	(6.58)	(11.41)	(9.74)	(12.99)	(7.06)	(6.79)	(5.47)	(6.77)	(4.81)
Female*Temp bin (33.3-38.85°C)	-103.39***	25.32	-127.50***	-96.22***	-32.78	19.67	-22.08	2.45	110.80**	29.71	-4.61	14.60	49.45***	3.69	-1.52	11.57
	(35.34)	(27.47)	(43.74)	(22.28)	(35.04)	(25.19)	(35.39)	(19.54)	(45.03)	(28.54)	(38.87)	(21.96)	(18.17)	(13.26)	(23.37)	(11.94)
Coping effect (SD (1999-2018)	-996.49***	97.64	-215.52*	-2.99	-314.67**	-71.31	-16.35	6.90	-122.14	-1.14	-266.61**	-19.34	-24.92	-84.60	5.15	
	(23.72)	(167.69)	(173.71)	(116.21)	(38.61)	(146.89)	(166.47)	(102.22)	(22.89)	(186.93)	(228.48)	(129.96)	(20.31)	(94.84)	(112.84)	(78.53)
Female*SD	0.07	-1.59	-3.43	0.66	2.84	-6.38	-4.40	-2.53	-2.10	2.51	6.57	0.61	1.89	-1.04	7.27***	2.34
	(4.69)	(4.21)	(4.28)	(2.83)	(3.47)	(3.94)	(3.44)	(2.26)	(3.75)	(4.47)	(4.67)	(2.61)	(2.18)	(2.22)	(2.29)	(1.62)
Observation	4471	3917	3382	7481	2989	3979	2496	5433	958	1703	814	1903	6007	6704	4514	10118
R^2	0.40	0.45	0.39	0.31	0.56	0.48	0.53	0.49	0.43	0.41	0.50	0.35	0.33	0.39	0.33	0.27
F	7.55	9.69	4.93	7.17	9.42	11.14	6.17	11.31	2.10	4.31	1.94	2.43	6.93	11.96	4.70	7.66
Panel B: Rabi Season																
Female (0-male)	-120.99***	5.94	-20.21	-43.58***	210.62***	163.76***	167.21***	170.40***	15.50	-17.03	26.25	14.26	-52.90***	-49.06***	-33.70***	-51.88***
	(17.22)	(21.98)	(18.90)	(11.66)	(14.97)	(19.50)	(15.97)	(10.37)	(24.00)	(22.85)	(22.34)	(12.83)	(9.64)	(11.24)	(11.14)	(6.71)
Baseline temperature bin - 22.2-27.75°																
Female*Temp bin (below 0°C)	-37.89	0.00	-54.65	0.00	-29.94	0.00	0.00	28.89	-39.68		14.17	85.69	-50.28***	0.00	-75.73*	-67.93
	(49.86)	(.)	(112.30)	(.)	(30.81)	(.)	(.)	(98.20)	(40.49)		(67.18)	(86.20)	(18.78)	(.)	(41.94)	(80.58)
Female*Temp bin (0-5.55°C)	-55.61	0.00	13.05	0.00	-87.10**	-13.65	113.84	-44.81	-23.83	-11.73	-49.18	-0.91	-19.82	-29.72	-10.92	64.33*
	(121.75)	(.)	(177.65)	(.)	(40.43)	(46.42)	(74.97)	(50.11)	(50.10)	(43.89)	(59.75)	(40.80)	(24.86)	(27.90)	(43.22)	(34.49)
Female*Temp bin (5.55-11.1°C)	-39.82		-134.90	-103.01**	-53.19*	46.80	75.78	9.65	56.34	-25.06	10.49	-30.48	-34.81**	-24.43	-5.29	-11.29
	(42.67)		(141.51)	(47.92)	(28.06)	(32.62)	(70.37)	(102.89)	(39.48)	(60.62)	(53.45)	(87.00)	(17.61)	(26.86)	(31.24)	(29.10)
Female*Temp bin (11.1-16.65°C)	-125.54***	33.24**	-12.41	-60.32***	-15.45	-24.46**	-4.57	18.18	-36.66	7.30	-15.61	-25.79*	22.27*	10.18	12.30	-25.28***
	(46.97)	(16.60)	(28.49)	(18.95)	(19.56)	(10.59)	(18.29)	(12.71)	(32.11)	(12.87)	(23.80)	(13.52)	(13.49)	(6.82)	(12.85)	(8.90)
Female*Temp bin (16.65-22.2°C)	2.20	1.45	-41.67**	-10.60	-12.28	20.66**	40.89***	8.70	26.00	9.20	-15.22	-18.84**	-0.81	-4.24	7.93	-1.38
	(14.85)	(10.39)	(16.40)	(9.61)	(12.45)	(8.36)	(12.56)	(7.76)	(21.11)	(10.12)	(19.24)	(8.98)	(8.46)	(5.20)	(9.22)	(5.41)
Coping effect (SD 1999-2018)	-14.06	84.19	0.04	-78.89***	-429.46***	-57.18	-9.98	-51.75***	-5.42	-86.68	37.76	21.87	-120.79**	403.23***	33.18**	4.22
	(15.78)	(237.55)	(26.71)	(23.44)	(117.63)	(125.33)	(19.58)	(19.44)	(127.76)	(195.88)	(24.46)	(18.32)	(57.28)	(93.73)	(15.17)	(10.64)
Female *SD	9.23*	-14.71***	-9.75**	-3.48	-9.67**	-3.07	-4.62	-5.50**	4.37	14.67***	1.88	6.17*	3.80	0.20	-2.01	3.04*
	(5.02)	(5.42)	(4.92)	(3.18)	(4.12)	(4.77)	(3.93)	(2.59)	(6.71)	(5.57)	(5.85)	(3.23)	(2.67)	(2.70)	(2.78)	(1.73)
Observation	3426	3461	2639	6409	2562	3442	2153	4930	898	1289	790	1763	5005	5621	3736	8949
R^2	0.41	0.43	0.47	0.32	0.54	0.49	0.55	0.45	0.34	0.40	0.41	0.33	0.37	0.35	0.40	0.29
F	5.91	9.69	5.49	6.84	7.11	11.01	5.97	8.86	1.36	3.55	1.43	1.94	6.57	9.37	5.47	7.63

Source: Author's calculation based on NSSO Time use survey 2019

Source: Calculation based on NSSO Time use survey 2019 and month-district average temperature (1999-2020) using ICRISAT data. The estimates are conditional on participation. The controls are same as described in section 4.2. Kharif season is considered from June-October, rabi season from December- April

7.4 Consumption Quintile

Since there is a heterogeneity in response to climate change along the lines of levels of income or wealth, we stratified the sample into different quintiles. These quintiles are based on per capita consumption show different levels of coping behavior through trade-off in the time use between productive, reproductive and leisure activities by women and men. Due to data limitations, we do not observe actual agricultural investments or asset holding, we use these quintiles to unpack the financial ability of households to cope against the climate change through investment in the improved agricultural technological resources and inputs to mitigate the climate risk and necessity of households to work or get exposed to the extreme temperatures.

Our quintile-stratified analysis by consumption quintile from figure 4 and 5 reveals that lower- and upper-middle-income households (consumption quintiles 1, 2, and 4) exhibit the canonical compensatory behavior predicted by time-allocation theory: as temperatures deviate from their seasonal norms, women in these strata significantly reduce farm labour, while men's agricultural hours remain comparatively inelastic. In contrast, middle-income (quintile 3) and wealthiest (quintile 5) households demonstrate a striking resilience to heat-driven labour reallocation. Specifically, quintile 3 households maintain gender-neutral farm-work participation across all temperature bins, and quintile 5 households show significant female labour withdrawal only under the coldest conditions, but no systematic responses to extreme heat.

This heterogeneity suggests that only households at particular junctures of the consumption distribution possess both the substitution effect (to safeguard subsistence) and income effect (to forgo agricultural earnings) required to reassign women's labour in response to climatic stress. The poorest households face acute livelihood constraints under extreme heat, compelling women to curtail arduous crop work, whereas the middle quintile appears to leverage alternative income sources or intra-household support networks that buffer gendered labour shifts (**?**). Meanwhile, the wealthiest can absorb cold-weather shocks without invoking further female labour reductions, likely due to greater asset holdings (cooling appliances such as cooler and fans or labour saving agricultural assets) and diversified revenue streams (such as livestock).

These findings underscore the imperative for tailored adaptation strategies. Policy interventions—such as labour-saving agricultural technologies and heat-resilient crop varieties—should target lower-income agrarian households, where women's labour is most vulnerable to climate extremes. Simultaneously, enhancing non-farm income opportunities for middle-strata families can reinforce their latent resilience, preventing gendered welfare losses as climate variability intensifies.

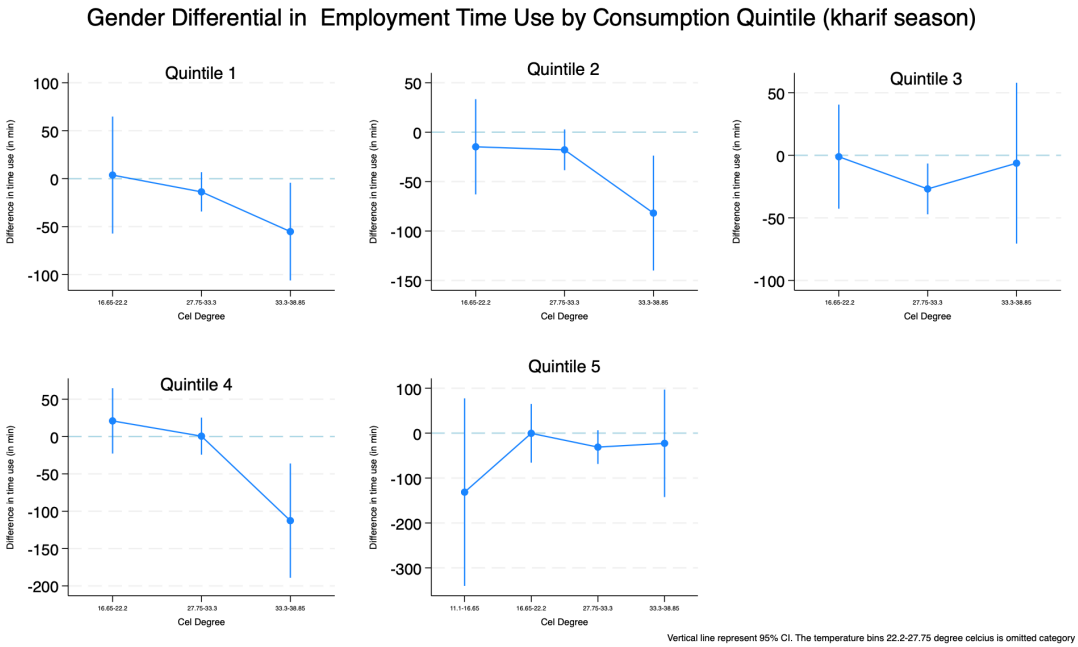


Figure 4: Quintile Wise Gender differential in time spent in employment activities in kharif season. Source: Calculation based on NSSO Time use survey 2019 and month-district average temperature (1999-2020) using ICRISAT data. The estimates are conditional on participation. The controls are same as described in section 4.2. Kharif season is considered from June-October.

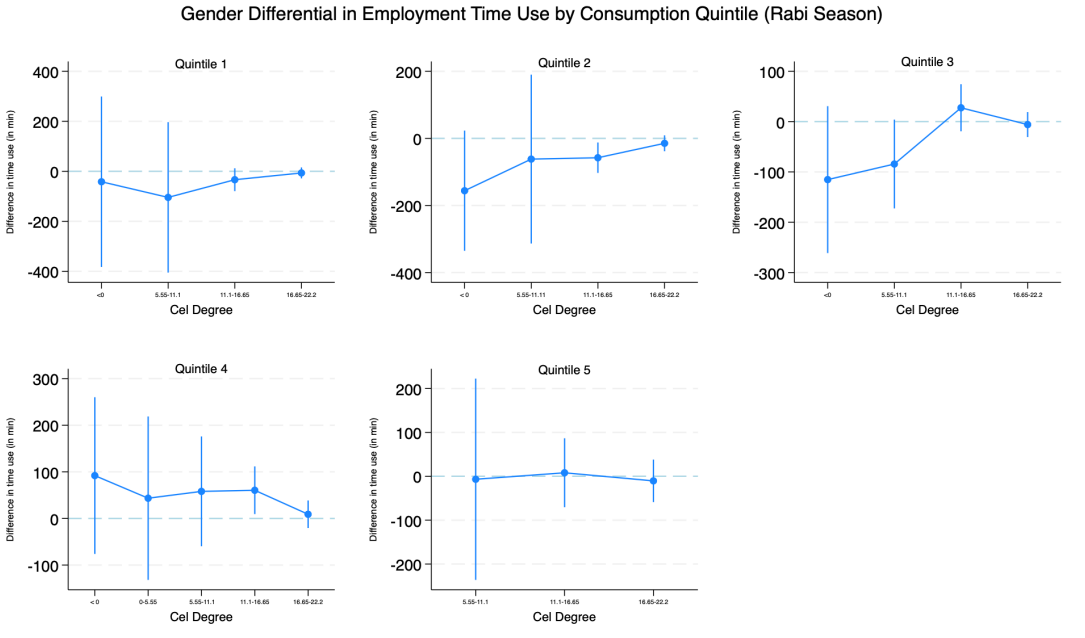


Figure 5: Quintile Wise Gender differential in time spent in employment activities in kharif season. Source: Calculation based on NSSO Time use survey 2019 and month-district average temperature (1999-2020) using ICRISAT data. The estimates are conditional on participation. The controls are same as described in section 4.2. Rabi season from December- April

7.5 Land ownership

The land ownership or tenure security has an important role to play in defining farmers efforts in developing resilience to climate change. Several studies (Alemayehu and Bewket 2017; Murken and Gornott 2022)

identifies land ownership as an important instrument in shaping farmer's ability to withstand climate change as it allows them to invest in improved farming practices (Abid et al. 2019) instead of traditional practices in the event of climate shock and it provides financial protection especially to the vulnerable socio-economic groups in case of climate adversities. Though we don't have a measure of how much land does women and men own separately in the time use survey, we ran our analysis across land ownership categories of the household as a joint unit. Our heterogeneity analysis in figure 6 and 7 shows the estimates of time use in productive activities during Kharif and Rabi season that varies across different land ownership categories. Within the categories of land ownership, the results highlights significant gendered differences (Batool et al. 2018). These results underscore how land ownership mediates the interplay between gender roles and economic opportunities.

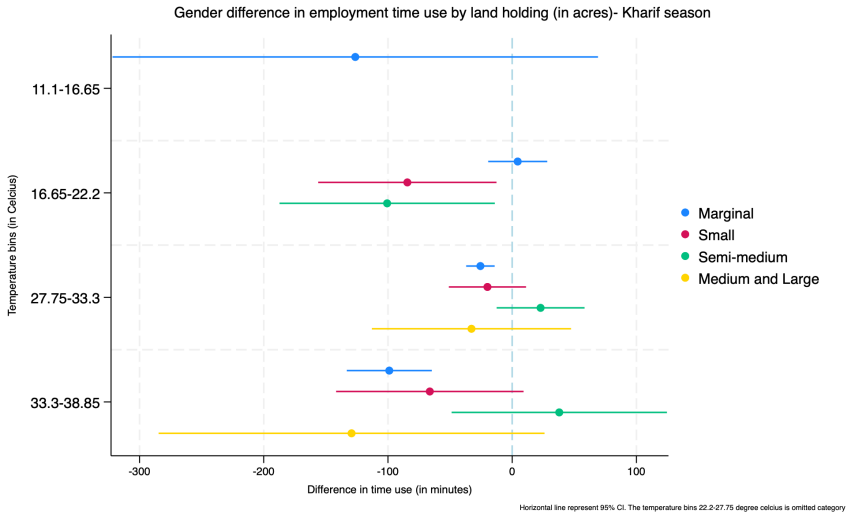


Figure 6: Source: Calculation based on NSSO Time use survey 2019 and month-district average temperature (1999-2020) using ICRISAT data. The estimates are conditional on participation. The controls are same as described in section 4.2. Kharif season is considered from June-October

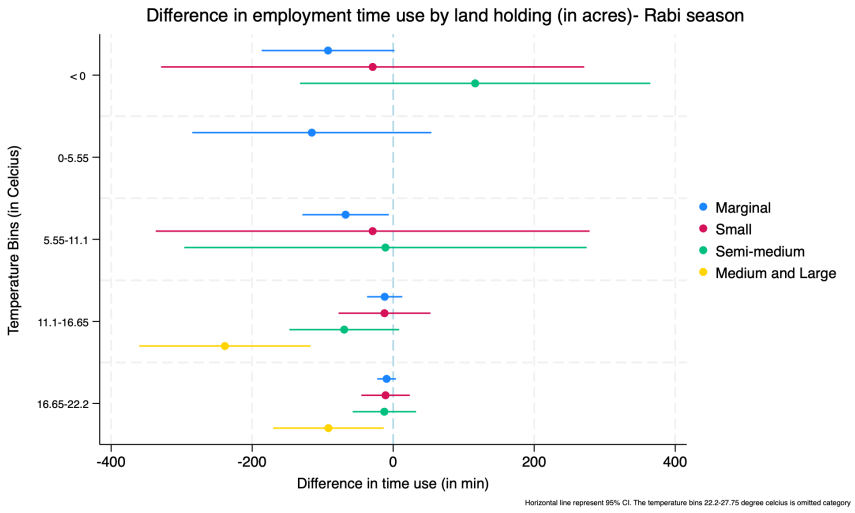


Figure 7: Source: Calculation based on NSSO Time use survey 2019 and month-district average temperature (1999-2020) using ICRISAT data. The estimates are conditional on participation. The controls are same as described in section 4.2. Rabi season from December- April

7.6 Headship of Households

The results on household headship in table 6 shows important gendered dynamics in how time use responds to climatic stress, depending on whether the household is headed by a female or a male.

In both Kharif and Rabi seasons, female-headed households exhibit significantly higher time allocations to unpaid domestic work, while simultaneously showing lower or stagnant employment time, especially under temperature extremes. For example, during the Kharif season, women in female-headed households spend on average 112 minutes more in unpaid domestic work relative to men, while their employment time shows no significant difference. Notably, under colder Kharif temperatures (11.1–16.65°C), they increase domestic work by 69 minutes and reduce selfcare by 80 minutes, suggesting a shift from personal well-being to household responsibilities under thermal stress.

In the Rabi season, a similar burden persists. Female heads spend 131 minutes more in unpaid domestic work and exhibit lower selfcare, while experiencing marginal or non-significant changes in employment. The interaction with extreme cold (e.g., below 0°C or 0–5.55°C) again indicates time loss in selfcare and inconsistent patterns in care work, with some evidence of increased care during certain bins.

These findings suggest that female-headed households absorb climatic shocks primarily through non-market labour and self-sacrifice, consistent with compensatory intra-household dynamics posited in household production theory. The absence of a male partner may intensify women's responsibility for maintaining household functioning under environmental stress, translating into time reallocations away from self-maintenance and toward unpaid labour. This pattern reflects both constrained labour choices and a gendered response to household vulnerability.

Overall, the results point to the compounded disadvantage faced by women in female-headed households, who not only lack male support but also assume disproportionate caregiving and domestic responsibilities in response to climate stressors.

Table 6: Effect of monthly average temperature on daily time use of men and women(15-85 yrs) by Household Headship

	Employment related	Unpaid domestic	Unpaid Care	Selfcare
Panel A: Kharif season				
Female head of household(0-male)	-8.32	112.40***	0.14	-18.02**
	(15.66)	(9.00)	(14.62)	(8.59)
Baseline temperature bin - 22.2-27.75° C				
Female head *Temp bin (11.1-16.65°C)	0.00	69.21*	59.68	-80.66**
	(.)	(39.16)	(46.83)	(35.10)
Female head *Temp bin (16.65-22.2°C)	-60.31**	-21.34*	10.25	-8.84
	(24.91)	(12.47)	(17.64)	(11.30)
Female head*Temp bin (27.75 -33.3°C)	-20.28*	4.47	13.74	-4.41
	(11.40)	(6.35)	(10.14)	(6.35)
Female head*Temp bin (33.3-38.85°C)	-5.59	-26.04	11.04	3.64
	(33.54)	(18.33)	(32.62)	(17.01)
Coping effect (SD (1999-2018)	-1081.14***	-112.53	-6.25	146.80
	(160.60)	(122.95)	(156.56)	(96.45)
Female head*SD	-4.22	3.02	3.64	-0.34
	(3.99)	(2.10)	(3.27)	(2.03)
Observations	11454	6889	2805	15755
R^2	0.31	0.37	0.34	0.22
F	9.12	7.18	2.55	7.77
Individual controls	Yes	Yes	Yes	Yes
Household controls	Yes	Yes	Yes	Yes
District fixed effects	Yes	Yes	Yes	Yes
Panel B: Rabi Season				
Female head of household(0-male)	-23.24	131.44***	25.79*	-22.17***
	(15.54)	(9.40)	(15.12)	(8.55)
Baseline temperature bin - 22.2-27.75°				
Female head*Temp bin (below 0°C)	-2.01	-11.64	164.06**	-26.10
	(138.91)	(36.87)	(68.78)	(28.63)
Female head*Temp bin (0-5.55°C)	-189.52*	29.12	-16.28	41.09
23.36				
	(150.17)	(25.26)	(31.06)	(22.33)
Female head*Temp bin (5.55-11.1°C)	28.02	3.97	-33.82	-53.43**
	(138.62)	(28.22)	(44.29)	(25.35)
Female head*Temp bin (11.1-16.65°C)	0.60	-0.78	-21.40	3.65
	(23.53)	(10.60)	(16.18)	(10.16)
Female head*Temp bin (16.65-22.2°C)	14.72	4.88	-0.55	5.36
	(13.85)	(7.79)	(11.77)	(7.46)
Coping effect (SD 1999-2018)	-462.73***	-48.34	-64.19	375.87**
	(128.52)	(164.01)	(160.47)	(147.55)
Female head *SD	-9.81**	-3.28	-0.75	-1.99
	(4.32)	(2.39)	(3.66)	(2.22)
Observations	9643	6283	2496	13619
R^2	0.32	0.35	0.33	0.24
F	8.20	5.98	2.16	7.58
Individual controls	Yes	Yes	Yes	Yes
Household controls	Yes	Yes	Yes	Yes
District fixed effects	Yes	Yes	Yes	Yes

Source: Calculation based on NSSO Time use survey 2019 and month-district average temperature (1999-2020) using ICRISAT data. The estimates are conditional on participation. The controls are same as described in section 4.2. Kharif season is considered from June-October, rabi season from December- April

7.7 Marital status

The table 7 illustrates the gendered and unequal impacts of climate change on time use across employment activities, unpaid domestic work, unpaid care work, and self-care, disaggregated by marital status and

agricultural seasons (Kharif and Rabi). Disaggregating the impact of extreme temperatures on time use by marital status yields important insights into the intra-gender heterogeneity of climate vulnerability. Women's time allocation patterns across employment, domestic labour, care work, and self-care activities differ markedly based on their marital status, reflecting variations in household responsibilities, economic dependency, and bargaining power (Afridi and Mahajan 2018).

In the Kharif season, married women emerge as the most adversely affected group in terms of employment time. Compared to their male counterparts, married women lose approximately 59 minutes per day in employment—significantly more than unmarried or widowed women, whose employment differentials are either statistically insignificant or moderately large. Moreover, the interaction of extreme heat (bin 8: 33.3–38.85°C) with gender reveals that married women experience substantial reductions in paid work (103 minutes/day), suggesting that caregiving and domestic expectations during this season crowd out economic activity. At the same time, married women's unpaid domestic work increases significantly across all temperatures, with the strongest negative coping response observed under cold stress (e.g., 64.99 minutes/day in employment and +77.07 minutes in care work for temp bin 4), reinforcing their dual burden during environmental extremes.

Widowed women also exhibit declines in employment at high temperatures, but unlike married women, their reductions in housework and care are more muted, possibly reflecting smaller household sizes and reduced dependent care obligations. Unmarried women, however, demonstrate relatively limited responsiveness to temperature fluctuations across all activity types. Their labour supply appears more stable, likely due to lower familial caregiving demands or stronger attachment to labour markets independent of household roles.

In the Rabi season, a broadly similar structure of vulnerability persists. Married women again experience a consistent decline in employment time with rising temperatures, particularly in moderate-to-hot bins (e.g., 13.9 minutes in bin 5). Their unpaid domestic work increases significantly under both moderate and extreme temperatures, suggesting role intensification in reproductive domains. Interestingly, unmarried women show the sharpest decline in employment at very low temperatures (e.g., 190 minutes in bin 2), suggesting that in the absence of household support systems, unmarried women may be more exposed to climate-related disruptions.

Care work responses are also revealing: in both seasons, married women increase time spent on caregiving under cold stress, while widowed women—possibly due to fewer dependent care obligations—show minimal adjustment. Self-care time (often representing rest, hygiene, and sleep) decreases for married women at high temperatures, indicating crowding out of personal well-being when reproductive responsibilities mount.

Taken together, the results underscore that marital status is a powerful axis of intra-gender inequality in climate vulnerability. Theoretically, this aligns with household time allocation models where marital status conditions both time endowments and role expectations. Married women are embedded in relational household structures that compel them to adjust time more acutely in response to external shocks, reinforcing

asymmetric exposure to climate burdens. By contrast, widowed and unmarried women retain somewhat greater autonomy in adjusting time allocations, albeit still subject to economic and social constraints.

Table 7: IPW on TU for working aged individuals in households(15-85 yrs)by marital status

	Employment Activity			Unpaid Domestic Work			Unpaid Care Work			Selfcare		
	Unmarried	Married	Widowed	Unmarried	Married	Widowed	Unmarried	Married	Widowed	Unmarried	Married	Widowed
Panel A: Kharif season												
Female	12.85	-58.78***	-57.97*	119.39***	193.82***	110.25***	873.10	13.51*	-40.52	19.61	-58.00***	-35.47*
	(45.72)	(8.35)	(30.33)	(33.85)	(6.78)	(25.94)	(574.42)	(7.59)	(79.41)	(22.94)	(4.63)	(19.27)
Baseline temperature bin - 22.2-27.75° C												
Female*Temp bin (11.1-16.65°C)	-193.53	0.00	0.00	0.00	-64.99**	19.74	0.00	77.07***	0.00	34.14	-53.52***	-21.76
	(136.83)	(.)	(.)	(.)	(25.25)	(77.19)	(.)	(19.13)	(.)	(77.99)	(15.44)	(63.75)
Female*Temp bin (16.65-22.2°C)	37.07	-17.71	-17.18	-20.24	-36.40***	0.93	0.00	4.56	-150.20	-6.37	-13.42**	4.24
	(32.91)	(12.97)	(47.18)	(26.40)	(8.22)	(28.95)	(.)	(7.65)	(94.97)	(17.55)	(5.96)	(23.74)
Female*Temp bin (27.75 -33.3°C)	-18.88	-21.39***	4.82	37.59*	6.56	-19.74	218.64**	11.02**	-34.64	31.65**	-15.64***	-1.31
	(28.28)	(5.82)	(20.49)	(19.66)	(4.37)	(17.06)	(87.55)	(4.76)	(52.14)	(13.16)	(3.20)	(12.48)
Female*Temp bin (33.3-38.85°C)	27.85	-102.83***	28.19	40.61	6.66	-89.19	414.70*	24.51*	-221.13	-53.73*	-10.26	34.77
	(57.00)	(16.23)	(70.06)	(49.73)	(12.69)	(62.11)	(201.21)	(14.36)	(166.11)	(27.72)	(8.24)	(41.35)
Coping effect (SD (1999-2018)	-967.79**	-1085.58***	-440.75*	-260.93	-310.23**	269.12	344.06	-176.63	-240.56	10.26	98.95	6.75
	(430.19)	(152.62)	(248.90)	(506.70)	(150.36)	(419.06)	(302.03)	(148.22)	(409.36)	(240.73)	(89.32)	(387.39)
Female*SD	-7.13	0.28	9.73	-3.13	-4.52***	-4.47	-231.42	3.39*	32.28	-9.66*	3.89***	3.27
	(10.83)	(2.07)	(7.20)	(7.73)	(1.58)	(5.86)	(140.66)	(1.79)	(22.31)	(5.23)	(1.10)	(4.29)
Observation	1955	15948	1193	1158	12187	1396	112	4948	282	2678	22632	1821
R^2	0.41	0.30	0.52	0.49	0.51	0.50	0.96	0.28	0.82	0.37	0.26	0.40
F	2.73	12.15	2.47	2.06	23.00	2.49	2.17	3.56	1.38	2.78	13.62	2.04
Panel B: Rabi Season												
Female (0-male)	72.56	-51.83***	-3.59	43.13	184.99***	111.35***	-376.73	22.73**	18.85	-29.16	-54.33***	-58.10***
	(50.59)	(8.91)	(32.66)	(42.07)	(7.24)	(25.23)	(235.23)	(9.07)	(64.38)	(25.02)	(4.93)	(18.65)
Baseline temperature bin - 22.2-27.75°												
Female*Temp bin (below 0°C)	0.00	-60.29	-29.30	0.00	-29.24	-24.35		-37.41	0.00	-30.13	-27.76*	62.35
	(.)	(47.85)	(152.58)	(.)	(27.03)	(89.25)		(26.24)	(.)	(122.79)	(16.56)	(65.04)
Female*Temp bin (0-5.55°C)	-189.52*	0.00	-175.16	0.00	0.00	-43.27*	120.92		-18.33	0.00	0.00	-14.07
68.26												
	(.)	(124.09)	(.)	(.)	(24.02)	(79.90)		(22.83)	(.)	(.)	(16.45)	(68.35)
Female*Temp bin (5.55-11.1°C)	0.00	-52.38*	-384.04**	0.00	7.10	-136.88	0.00	49.20**	0.00	0.00	-31.79**	-18.32
	(.)	(31.82)	(180.10)	(.)	(19.51)	(106.35)	(.)	(20.30)	(.)	(.)	(12.41)	(54.78)
Female*Temp bin (11.1-16.65°C)	64.51	-16.16	9.03	-56.04*	-2.08	-2.97	0.00	-5.53	89.01	9.51	-7.24	-0.22
	(43.58)	(12.95)	(47.48)	(29.12)	(7.20)	(27.20)	(.)	(8.30)	(79.72)	(18.30)	(5.32)	(20.33)
Female*Temp bin (16.65-22.2°C)	30.95	-13.89**	22.28	54.34**	18.07***	-12.69	-63.04	5.46	44.58	10.18	-6.78*	9.55
	(27.41)	(6.76)	(26.36)	(21.26)	(4.93)	(20.41)	(127.58)	(5.98)	(48.28)	(13.24)	(3.62)	(15.05)
Coping effect (SD 1999-2018)	-360.96***	31.38	62.94	-135.19	107.20	-59.55	66.42	0.85	376.39	352.48***	-36.01	
	(252.96)	(98.51)	(73.26)	(427.45)	(118.57)	(111.28)	(72.90)	(184.02)	(33.23)	(314.20)	(103.70)	(50.31)
Female *SD	-29.04**	-3.12	-8.91	6.74	-5.53***	-4.00	99.00	4.02*	4.13	0.17	2.15*	3.44
	(12.17)	(2.35)	(9.03)	(9.85)	(1.80)	(6.49)	(69.46)	(2.28)	(14.41)	(5.77)	(1.24)	(4.68)
Observations	1507	13238	1044	963	10701	1265	113	4319	281	2189	19280	1617
R^2	0.47	0.31	0.55	0.53	0.49	0.47	0.98	0.28	0.78	0.39	0.27	0.45
F	2.59	10.94	2.30	2.00	18.91	1.95	6.13	3.13	1.17	2.45	12.41	2.24

Source: Calculation based on NSSO Time use survey 2019 and month-district average temperature (1999-2020) using ICRISAT data. The estimates are conditional on participation. The controls are same as described in section 4.2. Kharif season is considered from June-October, rabi season from December- April

8 Robustness Checks

8.1 Sensitivity to Rainfall

Time use in different productive and reproductive activities can also be impacted by the rainfall in addition to the temperature especially when we are studying the agricultural context in India which is heavily dependent on the monsoon for sowing. To address this potential sensitivity to the rainfall shocks, we control for the standard deviation in rainfall for the period 1995-2020 to rule out any additional impact or coping strategy in productive or reproductive activities against climate change.

Our results remain qualitatively similar to the main results shown in 6.1. The direction and magnitude of the change in time use is shown in table 8.

Table 8: Sensitivity analysis using monthly rainfall standard deviation on daily time use of men and women(15-85 yrs)

	Employment related	Unpaid domestic	Unpaid Care	Selfcare
Panel A: Kharif season				
Female (0-male)	96.64***	152.52***	15.41	-62.06***
	(21.03)	(12.54)	(13.79)	(9.84)
Baseline temperature bin - 22.2-27.75° C				
Female *Temp bin (11.1-16.65°C)	0.00	-17.81	64.40***	-56.22***
	(.)	(23.10)	(18.63)	(14.90)
Female *Temp bin (16.65-22.2°C)	-31.88**	-25.38***	-2.15	-6.96
	(14.13)	(8.10)	(7.89)	(6.17)
Female *Temp bin (27.75 -33.3°C)	8.14	6.93	-4.49	-9.57**
	(9.78)	(5.52)	(6.30)	(4.63)
Female *Temp bin (33.3-38.85°C)	-50.74**	19.82	-14.30	8.71
	(20.43)	(12.58)	(15.70)	(9.69)
Coping effect Temp(SD (1999-2018)	0.64	4.06**	3.70*	-2.86**
	(2.19)	(1.86)	(1.99)	(1.13)
Female *Temp SD	-27.45***	1.19	4.76*	3.35*
	(4.36)	(2.56)	(2.88)	(2.01)
Rainfall SD	-0.17***	0.01	-0.01	0.03
	(0.04)	(0.03)	(0.03)	(0.02)
Observations	9251	7780	3136	14543
R^2	0.13	0.40	0.18	0.12
F	12.77	49.63	6.52	19.31
Individual controls	Yes	Yes	Yes	Yes
Household controls	Yes	Yes	Yes	Yes
District fixed effects	Yes	Yes	Yes	Yes
Panel B: Rabi Season				
Female (0-male)	81.33***	146.18***	22.05	-55.07***
	(21.12)	(12.40)	(16.18)	(10.05)
Baseline temperature bin - 22.2-27.75°				
Female *Temp bin (below 0°C)	-59.19	81.06**	18.45	-6.48
	(50.53)	(40.34)	(47.37)	(26.52)
Female *Temp bin (0-5.55°C)	-5.28	48.12*	-23.62	-22.42
	(86.29)	(28.57)	(27.03)	(20.69)
Female*Temp bin (5.55-11.1°C)	-106.46***	-12.10	52.68***	-32.93***
	(32.94)	(16.25)	(18.99)	(12.13)
Female*Temp bin (11.1-16.65°C)	-14.76	3.59	-2.36	-6.02
	(13.53)	(6.82)	(8.34)	(5.52)
Female *Temp bin (16.65-22.2°C)	-14.20	27.79***	8.85	-19.72***
	(9.23)	(5.44)	(7.33)	(4.47)
Coping effect Temp (SD 1999-2018)	10.09***	-0.25	-0.96	-5.32***
	(2.29)	(1.89)	(2.26)	(1.20)
Female *SD- temp	-25.16***	-0.65	2.89	3.00
	(4.32)	(2.51)	(3.17)	(2.00)
Rainfall SD	-0.32***	-0.03	-0.06	0.04*
	(0.04)	(0.03)	(0.04)	(0.02)
Observations	8382	7643	2853	13549
R^2	0.13	0.39	0.16	0.12
F	12.04	45.98	4.93	17.68
Individual controls	Yes	Yes	Yes	Yes
Household controls	Yes	Yes	Yes	Yes
District fixed effects	Yes	Yes	Yes	Yes

Source: Calculation based on NSSO Time use survey 2019 and month-district average temperature (1999-2020) using ICRISAT data. The estimates are conditional on participation. The controls are same as described in section 4.2. Kharif season is considered from June-October, rabi season from December- April. The rainfall data for the study period is available for a sub-sample of 20 major states in India.

8.2 Impact on other outdoor activities- collection of natural resources

In order to collect firewood, water and other household consumption material, women covers miles and collect these materials for household consumption. These materials are for own consumption of the household (which are otherwise purchased from the market) but has to be collected outside of the home.

Table 9: IPW on TU for working aged individuals in households(15-85 yrs)by outdoor

	Production for self consumption		Socialization	
	Kharif	Rabi	Kharif	Rabi
Baseline temperature bin - 22.2-27.75° C				
Female*Temp bin (11.1-16.65°C)	43.70**	1.18	-9.41	-4.44
	(20.87)	(9.45)	(15.63)	(5.83)
Female*Temp bin (16.65-22.2°C)	49.73***	-4.44	28.33***	-1.65
	(10.12)	(7.62)	(6.10)	(3.95)
Female*Temp bin (27.75 -33.3°C)	-6.84		7.42**	
	(6.83)		(3.25)	
Female*Temp bin (33.3-38.85°C)	-10.28		19.68**	
	(15.15)		(8.24)	
Coping effect (SD (1999-2018)	958.92***	450.89***	40.26	-48.51
	(233.41)	(170.62)	(88.27)	(116.10)
Female*SD	3.40	1.78	-3.73***	0.44
	(2.33)	(2.69)	(1.12)	(1.35)
Observation	11094	9952	26119	21910
R^2	0.43	0.43	0.21	0.21
F	15.58	13.95	11.73	10.10

Source: Calculation based on NSSO Time use survey 2019 and month-district average temperature (1999-2020) using ICRISAT data. The estimates are conditional on participation. The controls are same as described in section 4.2. Kharif season is considered from June-October, rabi season from December- April

9 Conclusion & Policy Implications

Under temperature shocks, optimal reallocation dictates households to reduce their opportunity cost of working in less productive sector. Our empirical evidence shows that women, who typically hold greater responsibility for reproductive tasks and possess more elastic time budgets (due in part to gendered norms around labour division), absorb the bulk of this reallocation.

We show that women lose up to 56 minutes of leisure daily during climate extremes, reallocating this time toward unpaid domestic responsibilities. Yet most State Heat Action Plans (SHAPs) in India fail to consider time poverty or unpaid work as a dimension of climate vulnerability. States should embed gender-disaggregated time-use indicators within SHAPs to identify where and when women's time burdens intensify. Our district-level evidence suggests that targeted community cooling centers, especially near water collection points, could reduce time spent walking long distances under heat stress. Mobile health units for maternal care during heatwaves, as well as behavioral nudges to redistribute domestic chores within households, can further alleviate these pressures.

Additionally, Programs like the Mahila Kisan Sashaktikaran Pariyojana (MKSP) should prioritize SC/ST women for agroecology training and access to community climate adaptation resources. Additionally, local governments could pilot caste-sensitive shaded workspaces or heat shelters, in partnership with Panchayats, to protect SC/ST labourers who often work in the most heat-exposed informal sectors. Finally, our finding reinforces the argument that asset ownership strengthens women's fallback position within households. State governments should therefore scale up joint land titling initiatives for women farmers. Additionally, time-saving and labour-saving technologies — such as solar-powered weeders and portable irrigation — can directly reduce exposure to heat and the time cost of essential tasks. Extension programs delivered via Krishi Vigyan Kendras should be tailored to women, providing training on climate-resilient crops (e.g., millets) and efficient irrigation practices. These measures would help mitigate the steep time trade-off we document for the most vulnerable women.

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