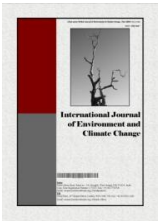

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Farmers' Perception of Climate Change and Livelihood Vulnerability in Rainfed Regions of India: A Gender-environment Perspective

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Authors' contributions

This work was carried out in collaboration between both authors. Author SS designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript, while author AS managed the literature searches. Both authors read and approved the final manuscript.

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ABSTRACT

This study has attempted to investigate the nature and magnitude of livelihood vulnerability in the Bundelkhand region, India. A multistage sampling technique has been used to select study sites and collect farm-level data of 200 households using a well-structured and pre-tested schedule. The findings revealed that female-headed households are relatively more exposed to changing climate than are the male headed households. Due to the lack of basic amenities and common-pool resources, the livelihood vulnerability score was highest for female-headed households. Therefore, to improve the livelihood security of vulnerable households' measures like identifying vulnerable groups, providing innovative, practical and easy to use methods to visualize the extent and dimensions of livelihood vulnerability are imminent. The framework used to analyze and identify specific interventions would help in building livelihood resilience for the most vulnerable people within a community.

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Keywords: Indicator approach; vulnerability; rainfed agriculture; livelihood security; gender perspective.

1. INTRODUCTION

Climate change increasingly recognized as a hurdle to achieving sustainable development goals, has largely begun influencing the lives and livelihoods of people around the world [1]. As the reality of climate change becomes accepted in the scientific community, it is critical to understand its impact on the ground, particularly for a community dependent on agriculture and natural resources [2]. Climate change poses numerous risks to agricultural communities, yet farmers may be able to reduce some of these risks by adapting their cropping practices to better suit changes in climate. However, not all farmers respond to climate change in the same way [3]. The vulnerability is a concept often employed in the context of climate change to identify risks and develop policy and adaptation measures that address current and projected impacts [1]. However, it was situated in a broader social context, driven by factors such as land tenure and access, livelihood diversification, and employment, which single out historically backward, discriminated, highly exposed section of the society, i.e., women.

1.1 Socio-ecological Vulnerability: A Gender Perspective

Women are highly vulnerable with the least resource accessibility, tenure rights, low literacy, and the least freedom to participate in mainstream adaptation strategies. The following points highlight gender vulnerability; (i) women are more disadvantaged, such as tend to farm in smaller plots, work shorter hours, or limit farming to cash crops [4], (ii) extreme climate events in disaster-prone agrarian communities appear to subject women to forced migration, increased discrimination, and loss of customary rights to land, resource poverty, and food insecurity, and (iii) migration represented one of the most important adaptation strategies for men, while women, migration strategy more as a cause of vulnerability than an adaptive capacity. Male activities have added to the workload of women. For example, when a man migrates to search for new employment opportunities, this added an additional layer of vulnerability in the highly sensitive system, i.e., agriculture. Further, lack of power to influence the decision at the household and community levels as well as limited market opportunities for women are additional factors made women vulnerable.

Women in agriculture will remain largely neglected by information and service providers [5], unless their differing needs, access to, and control over resources are consider at policy and project design stage. For example, in a region with highly inequitable gender division of labour, the workload of women can increase by climate change [6]. Women often play an important role in natural resource-based livelihood activities that fall within the sphere of reproduction, such as the collection of fuel wood and water. Also, ecological changes, such as salinity intrusion or changes in groundwater availability can force women to travel longer distances [2].

Gender division of labour is important for vulnerability is that women and men often have separate control over different income sources [7]. If climate change undermines a particular livelihood activity, this may differently influence man or women individual's income. This impacts women in backward regions in particular, as the personal income they can control is often more limited than that of men. During food crises, which follow natural disasters, women often forgo an adequate diet to ensure that children and other family members remain well fed. Economic stress brought about by climate change and associated natural disasters have shown to increase cases of violence against women [8]. This includes an increase in the trafficking of girls, as well as an increase in violence and harassment of women, brought about by increased competition for resources both within the households, and between households.

With the above background, this study evaluates gender- environment perspective of climate change in agriculture. This study tries to answer some key questions (i) do female-headed households perceive highly that climate change adversely affects their livelihoods than that of male, and (ii) does the least adaptive capacity of female makes more vulnerable to climate change. The major strength of this study is; how within a region to understand women differential perceived and affected to climate change. This study also provides insightful information on how differential livelihood vulnerability, which distributed between and within a community.

2. METHODS AND MATERIALS

2.1 Study Area

The present study was undertaken in the Bundelkhand region of Uttar Pradesh in India. Uttar Pradesh is the key state and plays a vital role in India's food and nutritional security by contributing 17.83% of the country's total food grain output in 2016-17 (GoI, 2018). Geographically, Uttar Pradesh is divided into four economic regions, viz., Western, Central, Eastern, and Bundelkhand. This study was undertaken in two districts of Bundelkhand region, viz. Jalaun and Jhansi due to the preponderance of droughts in the region (Fig. 1). Compared to any other region of Uttar Pradesh, Bundelkhand is historically more vulnerable to climate change. The region had experienced drought in every 16th year during the 18th and 19th centuries, which increased thrice from 1968 to 1992, and now has become the recurrent annual phenomenon. The average annual rainfall of the region continued to be below average during 2004-2017 (GoI, 2018). The severity of low rainfall was such that 40% of the net sown area remained fallow, which resulted in 30% less in food grains output (GoI, 2018). Farmers are majorly grown Wheat, Soybean, Tur, Rapeseed, Paddy, Gram, Maize, Groundnut, Jowar, and Bajra.

The status of socioeconomic features of the Bundelkhand region vis-à-vis Uttar Pradesh and all-India are described below (Table 1). The socioeconomic variables like the dependency rate, workforce participation, literacy rate, and per capita income are relatively low or poor as compared to Uttar Pradesh and India. The region also lagged in access to basic amenities, viz. rely on forest resources of cooking, drinking water, medical facility, all seasonal houses, toilet facility, and electricity connection over to that of Uttar Pradesh as well as India.

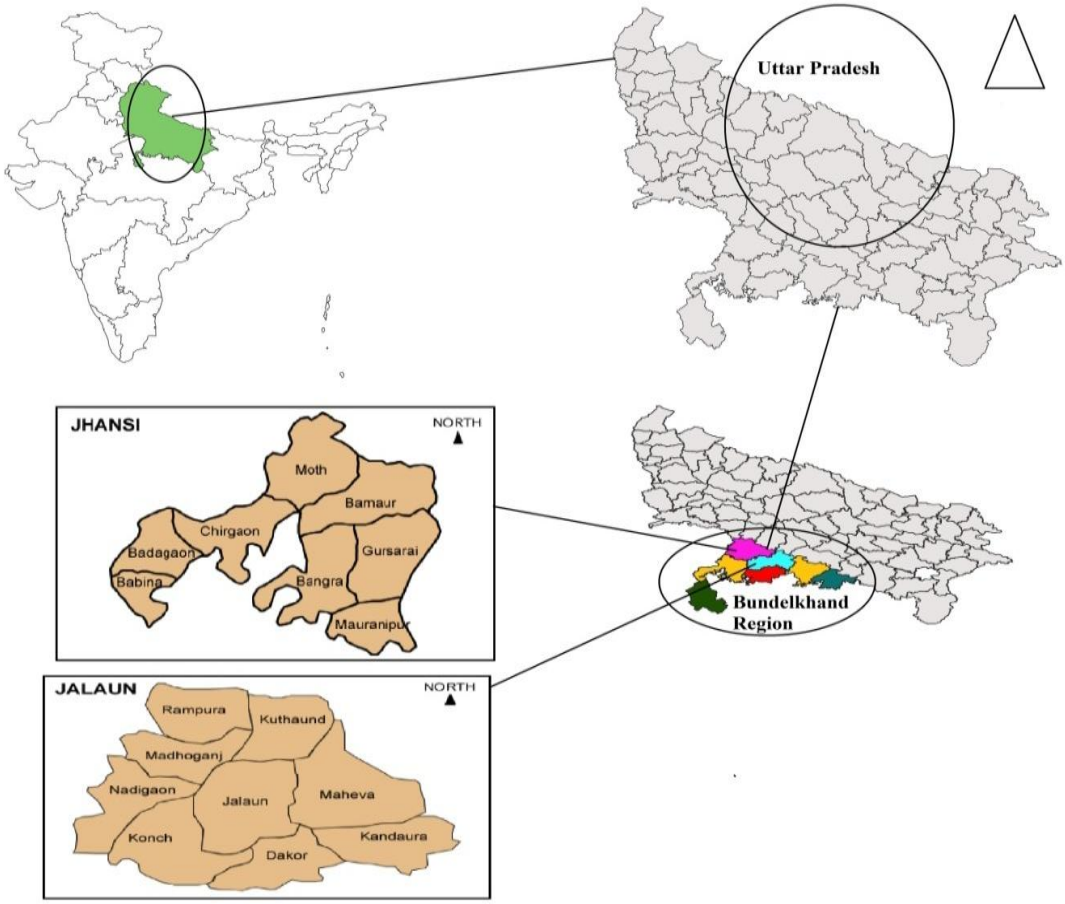

Fig. 1. Map of the study region
Source: Author's figure

Table 1. Socioeconomic status of Bundelkhand Region, Uttar Pradesh and India

Indicators	Bundelkhand	Uttar Pradesh	India
Dependency Rate (%)	79.00	77.80	55.51
Workforce Participation Rate (%)	39.50	32.90	55.90
Literacy Rate (%)	55.80	57.30	74.01
Sex Ratio (per 1000 Men)	877	912	943
Population Density (per Square Kilometre)	329	829	416
Crude Birth Rate (%)	30.50	18.10	19.00
Crude Death Rate (%)	9.60	3.70	7.30
Per capita income* (in Indian Rupees)	19, 000	43, 861	86, 454
Poverty Rate (%)	37.38	29.43	23.60
Marginal Farmers (%)	88.62	80.18	86.20
Population rely on forest for cooking (%)	88.64	85.24	81.72
Population drinking water (%)	97.86	98.18	99.14
Female- headed Households (%)	36.41	11.15	12.97
Population access of Govt. medical facility (%)	40.69	44.54	49.60
Population having all seasonal houses (%)	70.64	75.53	60.92
Population having toilet facility (%)	36.45	39.20	51.77
Population having electricity connection (%)	80.10	91.78	89.70

*Source: Census, 2011. Note: *related to year 2011-12; 1 US$= 69.49 Indian Rupees (INR)*

2.2 Sample Design and Study Period

A multi-Stage sampling technique was used to select study sites and households. At the first stage of sampling, two districts, namely Jhansi and Jalaun from a total of 7 districts in the Bundelkhand region of Uttar Pradesh were selected. There are five sub-divisions (i.e., Tehsils) in each selected district, and at the second stage, all five *Tehsils* from each district were chosen. At the third stage, one Development Block was selected purposively. At the fourth stage, one village from each selected block was chosen randomly. Finally, 20 households from each village were selected randomly. Thus, a total of 2 Districts, 10 *Tehsils*, 10 *Developmental Blocks*, 10 *Villages,* and 200 *farm households* were selected from the region for study. The households comprised of marginal (<1.0 hectare, ha), small (1-2 ha), semi-medium (2-4 ha), medium (4-10 ha) and large (>10 ha) categories of farms. In all the categories, selected farmers have consisted of 20% of households from above noted each land size category from selected study villages. A well-structured and pre-tested schedule was prepared to collect information from selected households for capturing farmers' perception of climate change and variability during the past decade and their choice of adaption strategy. The farm survey was undertaken during May-June 2018 soon after harvest of the winter crop to elicit information on climate-related variables and agricultural extension services. The survey data related to the agricultural year 2017-18 (July-June).

2.3 Estimation Method

The main focus of this study was to integrate gender sensitive indicators, and to develop a Gender Sensitive Livelihood Vulnerability Index (GSLVI) that could be applicable at any scale, be it national, state, region, district, village, and even at the household level. The GSLVI helps to identify the most vulnerable members' group of society and study of vulnerability within the community. The data (indicators) collected through farm survey were grouped into three sub-components of exposure, sensitivity, and adaptive capacity. The indicators chosen were representative of focal development policy objective, a stepwise method for addressing climate change impacts, development linkages, and the economic, social, and environmental dimensions related to vulnerability [9].

The indicator-based approach in a specific set or combination was used to measure the vulnerability by computing indices. Before combining indicators to measure vulnerability, the indicators were first normalized to scale of zero (0) and one (1) using equation (1 & 2), if the indicator has a positive relationship with targeted indices, viz., exposure, sensitivity, and adaptive capacity, then equation (1) was emploed.

$$CZI_f = \frac{K_i - K_{min}}{K_{max} - K_{min}} \quad (1)$$

Where, CZI_f is the original sub-component for the community ***i*** and $K_{max} - K_{min}$ are the

minimum and maximum values, respectively. For each sub-component, the vulnerability was determined using survey data. For example, a variable that represents frequency, such as the percentage of farmers who have changed their cropping pattern, the minimum value was set at 0 (zero) and a maximum value at 100. Further, if the predicted value of a subcomponent is negatively associated with the targeted index was calculated using equation (2).

$$CZI_f = \frac{K_i - K_{max}}{K_{min} - K_{max}} \quad (2)$$

After each component was standardized to scale noted above, the mean of each sub-component was estimated by using equation 3 to calculate the value of each major component.

$$K_h = \frac{\sum_{i=1}^{n} index\, K_f^i}{n} \quad (3)$$

Where, K_h is one of the three components of the community h, exposure (EXP), sensitivity (SENS) and Adaptive capacity (ADP), index K_f^i represents the sub-component indexed by *i*, that make up for each major component, and *n* is the number of subcomponent in each major component. Once the values for exposure, sensitivity and adaptive capacity for the community level were calculated, the two contributing factors (exposure and sensitivity) were combined using equation (4) to obtain the community level potential livelihood vulnerability index (PLVI).

$$PLVI_d = E_d\text{-}S_d \quad (4)$$

Where $PLVI_d$ is the potential livelihood vulnerability index score for the community d, E_d is the calculated exposure score for the community d, and S is the sensitivity score for the community d. Further, adaptive capacity has included in the system, which is represented by A_d (Eq. 5). We have scaled the PLVI and GSLVI based on the results obtained from the vulnerability index score, i.e., -1 (least vulnerable) to 1 (most vulnerable).

$$GSLVI_d = (E_d - A_d) * S_d \, . \quad (5)$$

2.4 Selection of Rational Indicators

It is a foremost task to select an appropriate indicator, without which the calculated results cannot be generalized or compared. Therefore, after in-depth literature review, this study identifies several candidate indicators for the three dimensions, viz., exposure, sensitivity and adaptive capacity.

Exposure refers to stress caused by changes in frequency, intensity/magnitude, duration, and nature of climate stress [10]. A region like Bundelkhand with higher degraded land resources experiences greater adverse impacts of climate change. Agriculture, which is the main source of livelihood for farmers, is also exposed to widespread warming. It reveals that the development of an exposure index is a prerequisite for different farm communities using their perceptions of climate change to identify the most exposed community. The present study uses farmers' perception of climate change to develop a rational exposure index (Table 2).

Sensitivity" is the degree to which the system is affected either adversely or beneficially, by climate-related stimuli [11]. It measures the ability of a system to respond to climate change impact, which is found by both socio-economic and ecological situations and identifies the level at which environmental stresses that will influence a group. Population below the poverty line (BPL) reflects that a section of the population is deprived of resources and highly sensitive in the system [12]. Abid et al. [13] find that a higher dependency on the household head, low diversification in agriculture, and lack of non-farm employment opportunities are key indicators influencing farmers' choices of adaptation measures. With these pieces of evidence, the present study has used socioeconomic and demographic data to develop a sensitivity index for different communities (Table 2).

Adaptive capacity refers to the ability of a system to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences [11]. In order to understand gender-sensitive livelihood vulnerability, there is a prerequisite to identify a system's capacity to overcome. There are several studies which have been conducted to assess farmers' perception, [14,15]; these studies specifically designed the questions to capture farmers' exposure to changing climate. Based on these studies, questions are framed in the scheduled. Also, surveyed farmers have adopted differential adaptations to enhanced adaptive capacity, viz., technical advice from Kisan Call center, crop insurance, sowing date adjustment, cropping pattern change, and crop diversification. Aforesaid, indicators have taken as adaptive capacity indicators (Table 2).

Table 2. Selected rational indicators for livelihood vulnerability index

Component	Indicators
Exposure	1. HHs feel that rainfall has declined (in %)
	2. HHs perceive that summer days become hotter (in %)
	3. HHs perceive that frequencies of droughts have increased (in %)
	4. HHs perceive that water level continuously has declined (in %)
Sensitivity	1. HHs using only forest-based energy resources for cooking purposes (in %)
	2. HHs using hand-pump (untreated) water for drinking (in %)
	3. HHs depends on government sources for irrigation (in %)
	4. Female-headed households (in %)
	5. HHs using 108 free medical facilities (in %)
	6. HHs do not have toilet facility (in %)
	7. HHs do not have all seasonal house (in %)
	8. HHs belong to Below Poverty Line category (in %)
	9. HHs do not have electricity connection (in %)
	10. Head of household does not attained school (in %)
Adaptive Capacity	1. HHs changes their cropping pattern (in %)
	2. HHs switch to non-farm activities (in %)
	3. HHs live in the joint family (in %)
	4. HHs Kisan Call Centre (in %)
	5. HHs started conservation of water bodies and soil to combat climate variability (in %)
	6. HHs secure their crop through crop insurance (in %)
	7. HHs have storage capacity to procure agriculture products (in %)
	8. HHs have taken professional training on climate change combating (in %)
	9. HHs aware about N.P.K ratio (in %)
	10. HHs have adjusting sowing dates (in %)
	11. HHs growing more than one crop (multiple cropping) (in %)

Source: Field survey data, 2018. Note: HHs indicates households

3. RESULTS AND DISCUSSION

3.1 Socio-economic Characteristics of the Surveyed Households

The socio-economic profile of sample households in the study area reflects the backwardness of female-headed households than that of male-headed households (Table 3)[1]. Nearly 50% of male-headed households are literates, while only 40% of female-headed households are literates. A gap in employment status between female-headed households and male-headed households also found. On an average, more than 70% of female-headed households are unemployed among the sample households that also reflect in the mean income figures. The majority of the population belong to the Hindu religion. As far as access to sanitation, drinking water, and electricity is a concern, Female-headed households have access to least than that of male-headed households. More than 30% of female-headed households are living under below poverty line. In totality, female-headed households have the least access to basic amenities that that of male-headed households.

3.2 What Surveyed Farmers' Perception of Climate Change

Farmers are at the forefront of the war against climate change. On an average, more than 50% of sample farmers are perceived that rainfall has declined, summer becomes hotter, frequency of drought has increased, and the water level has declined over the past five years (Fig. 2). However, the difference in farmer's perception has observed. More than 60% of female-headed households are perceived that rainfall has declined, while only 33% of farmers headed by female perceived. Similar differences in the perception of farmers of hotter summer, the persistence of drought, and decline in water level have also observed.

Apart from quantitative analysis, qualitative analysis was also carryout to captures farmers' experiences of changing climate. For instance, farmers reported that droughts have dual impacts

[1] *Female headed household indicates that female has main family member who is taking decisions of the family, while male headed household indicates that male has main family member who is taking decisions of r the family*

on livelihoods. Firstly, most of the farm families in survey villages had lost either their crops or cattle or both that was the first line of deference to deal with climate change. As the villagers themselves struggle to live during crisis time, the survival of cattle is the last thing in their minds. For instance, farmers belonging to Amra village of Jhansi district had 1500 livestock population, as against 8000 livestock population five years ago (i.e. 2012-13). Lastly, there is no provision of compensation in the event of cattle death. In a sense, livestock has not been considered as a resource in the State policy of Uttar Pradesh. Farmers perceive that the government has not made any visible and significant provisions for livestock survival during extreme climatic variability, making them dissuade from rearing livestock as an enterprise.

Due to erratic climatic behaviour, a shortage of rainfall could not make a much positive impact on agriculture, livestock, and other livelihood systems in the region. The field experience in Jalaun and Jhansi districts also showed unequal rainfall in the region. In fact, it is visible that due to deforestation and frequent droughts in the past decade, the overall capacity of the region in harvesting and storing rainwater for the future has substantially reduced.

Table 3. Socioeconomic characteristics of the surveyed households

Characteristics	Jalaun District		Jhansi District	
	Male	Female	Male	Female
Literate Population (in % to total population)	50.24	42.35	49.76	45.21
Unemployed Population (in % to total population)	49.94	79.23	50.06	69.50
Mean Income (in □)	23014	18212	25798	20123
Mean Land Size (in acre)	0.26	0.18	0.35	0.21
Mean Age of the Household (in year)	31.36	28.21	30.04	30.50
Scheduled Caste Population (in % to total population)	13.82	12.25	7.81	13.25
Scheduled Tribe Population (in % to total population)	2.80	1.25	5.10	1.64
Religion (in % to Hindu population)	84.21	80.24	84.37	81.26
Marital Status (in % of Married to total family members)	52.39	60.32	53.32	62.21
Households having electricity connection (in %)	65.00	42.00	80.00	36.50
Households having Sanitation Facility (in %)	57.00	35.25	51.00	41.25
Households using Improved Drinking Water Facility (in %)	61.00	40.60	60.00	43.25
Households Below Poverty Line (in %)	29.00	35.50	26.00	31.25

Source: Field survey data, 2018

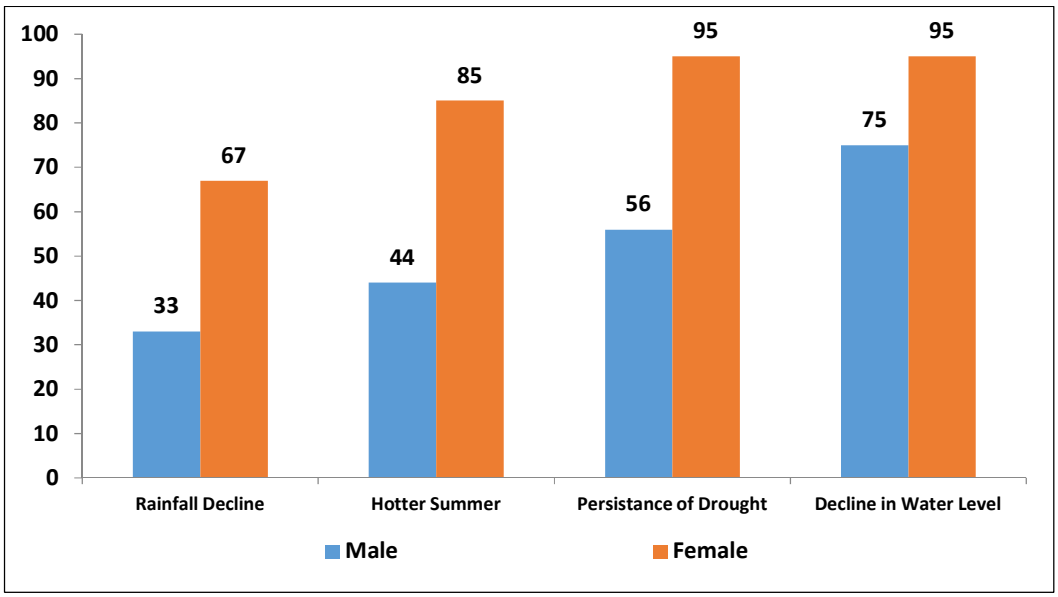

Fig. 2. Farmers' perception of climate change (in %)
Source: Field survey data, 2018

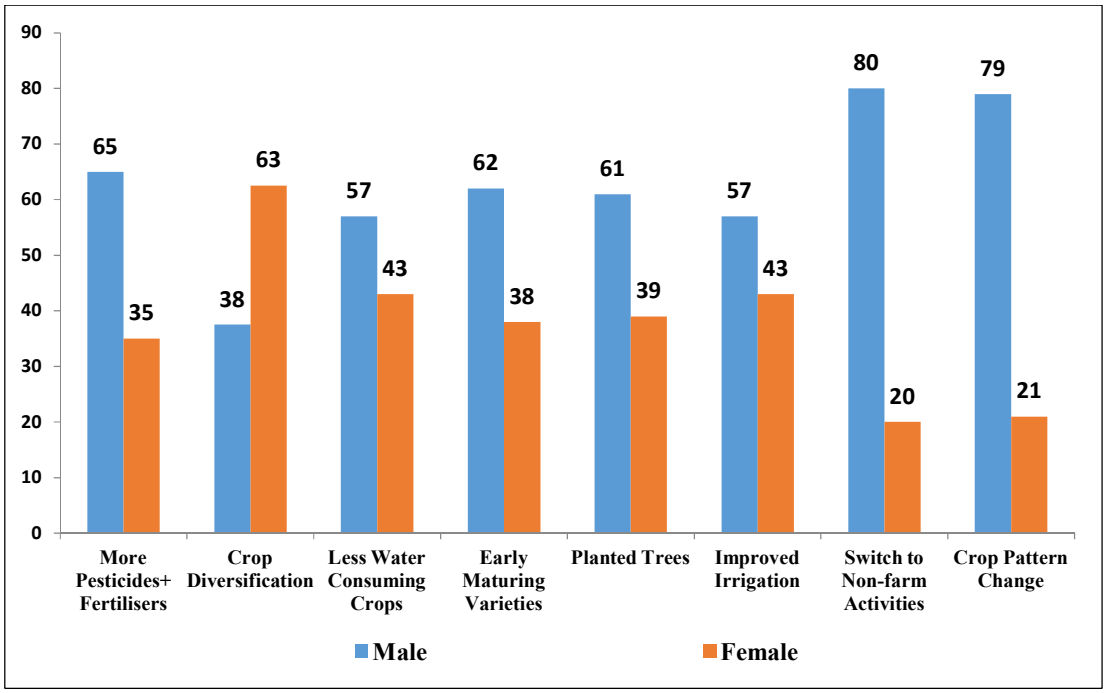

Fig. 3. Adaptation strategies adopted by surveyed households (in %)
Source: Field survey data, 2018

Table 4. District and gender wise indicators for exposure index

Indicators	Indices			
	Jalaun District		Jhansi District	
	Male	Female	Male	Female
Rainfall decline	0.77	0.90	0.56	0.60
Hotter Summer Days	0.90	0.92	0.98	0.90
Frequencies of drought increased	0.90	0.93	0.95	0.91
Water level decline	0.93	0.85	0.96	0.81
Exposure Index	0.88	0.90	0.86	0.81

Source: Field survey data, 2018

Table 5. District and gender wise indicators for sensitivity index

Indicators	Jalaun District		Jhansi District	
	Female	Male	Female	Male
Cooking Source	0.910	0.772	0.760	0.665
Hand pump	0.920	0.672	0.760	0.608
Irrigation Dependence on Govt.	0.890	0.561	0.730	0.445
Female headed HHs	0.830	0.649	0.630	0.540
Free Medical facility	0.730	0.489	0.690	0.400
Sanitation Facility	0.900	0.800	0.720	0.673
Nature of House	0.950	0.740	0.810	0.598
Below Poverty line	0.920	0.783	0.730	0.638
Electricity Access	0.930	0.850	0.690	0.640
Education Level	0.960	0.885	0.650	0.680
Sensitivity Index	0.894	0.720	0.717	0.589

Source: Field survey data, 2018

Table 6. District and gender wise indicators for adaptive capacity index

Indicators	Jalaun District		Jhansi District	
	Female	Male	Female	Male
Cropping Pattern Change	0.020	0.075	0.100	0.342
Switch to Non-farm activities	0.100	0.178	0.150	0.350
Joint Family	0.060	0.178	0.249	0.284
Information Technology	0.044	0.131	0.167	0.291
Conservation of water bodies	0.090	0.165	0.213	0.281
Crop Insurance	0.090	0.198	0.250	0.270
Storage Capacity	0.130	0.232	0.350	0.325
Professional Training	0.208	0.280	0.208	0.236
Balance use of fertilizers	0.080	0.163	0.185	0.250
Adjustment in sowing dates	0.120	0.240	0.197	0.264
Multiple cropping system	0.083	0.211	0.200	0.282
Adaptive Capacity Index	0.093	0.186	0.206	0.289

Source: Field survey data, 2018

Table 7. District and gender wise livelihood vulnerability index

Indicators	Jalaun District		Jhansi District	
	Female	Male	Female	Male
Exposure Index	0.88	0.90	0.86	0.81
Sensitivity Index	0.894	0.720	0.717	0.589
Adaptive Capacity Index	0.093	0.186	0.206	0.289
Potential Livelihood Vulnerability Index	1.77	1.62	1.58	1.40
Livelihood Vulnerability Index	0.704	0.514	0.469	0.307

Source: Field survey data, 2018

3.3 Adaptation Strategies in Rainfed Agriculture

The sample households of the region adopted differential adaptation strategies to cope with changing climate. Surveyed households planted eucalyptus, citrus, and mango trees surrounding the farmlands and diversified their cropping pattern towards less water consuming crops (Fig. 3). Since Bundelkhand is a dry region and, therefore, irrigation has a potential impact on farm revenue. The study has observed that sample farmers had increased their irrigation coverage by digging ponds, storing surface rainwater and grow less water requiring drought-resistant varieties of Jowar (Pusa Chari- 615), Bajra (APFB-2), Kharif pulses (PUSA Arhar- 16), and oilseeds (RCC- 4). Few farm households believe that by increasing inputs, productivity could be increased. By assuming this, households have increased the use of bio-pesticides and fertilizers. The negligible numbers of sample households were engaged in non-farm employment opportunities during the offseason, and higher dependence on agriculture restricted farmers to change the cropping pattern and switch to non-farm employment activities.

Fig. 3 highlights the gender differential capacity among the surveyed households. In majority, male-headed households are much aware of local adaptations than that of female-headed households. Further, more than 60% of male-headed households have judicially used bio fertilizers and pesticides to boost agricultural production under sustainable agriculture agenda, while only 35% of female-headed households have used bio-fertilizers. Similar statistics also observed in the identified adaptation strategies. In totality, female-headed households are least adopted that of male-headed households.

3.4 Exposure Index (EI)

Exposure to changing climate change has a great impact on the livelihoods of the sample households. The calculated exposure index revealed that female-headed households are highly perceived that rainfall has declined; summer becomes hotter, frequencies of drought increased, and water level declined. In totality, female-headed households are highly exposed (perceived) to changing climate that that of male-headed households, i.e., 0.90 & 0.80. The present study findings are in the line of long-term climate statistics that show temperatures are

continuously increasing, and the nature of rainfall has now become more erratic in Jalaun and Jhansi (GoI, 2018).

3.5 Sensitivity Index (EI)

Higher persistence of poverty, wide variations in access to basic amenities, and solely dependent on natural resources for livelihoods are some of the primary factors making sample farmers sensitive to changing climate (Table 5). The calculated sensitivity indices show that female-headed households are highly sensitive. The present study findings reveal that more than 90% in Jalaun and 70% of female-headed households are using forest resources for cooking and consume untreated water extracted through a hand pump. Wood is the main source for cooking causes lung cancer and asthma in female-headed households. Untreated drinking water couple with wood not only increases sensitivity to climate change but also increases medical expenditure. Also, nearly 90% in Jalaun and more than 70% in Jhansi female-headed households depends for water for irrigation on government. Further, more than 70% female-headed households are not in a position to avail private medical services due to lower awareness and higher medical costs. Similarly, lower basic amenities, like sanitation, access to electricity, and education level are the primary contributor to the sensitivity in the female-headed households to climate change. This highlights that vulnerability in the region has multidimensional and multifunctional layers and also gender-sensitive.

3.6 Adaptive Capacity Index (ADI)

An incentive to adopt is usually to minimize risks from crop failure and maximize net profits. Adaptation strategies encompass individual responses at micro-level and government intervention or assistance for adaptation to safeguard the interests and livelihoods of farmers. Farmers generally make rational choices from a set of adaptation strategies in the form of farm practices and technologies; available in their region. Farmers' choice of adaptation strategies normally reflects their risk-averse behaviours as the probability of adopting only those adaptation strategies for which benefits exceed the costs is the highest.

Upon looking deeper, found that differentiated the high adaptive capacity among the sample households (Table 6). Only 2% in Jalaun and 10% in Jhansi female-headed households have changed their cropping pattern in favour of less drought-prone crops, while 7% in Jalaun and 34% of female-headed households have changed their cropping pattern. Due to social hierarchy, female-headed households are restricted going out from home for searching non-farm employment opportunities. This also reflects that only 10% in Jalaun and 15% in Jhansi female-headed households have engaged in non-farm activities. Inequality also finds in the information access on various farm issues of climate change, having storage capacity, professional training in agriculture and awareness on balance use of fertilizers, adjusted sowing dates and taken multiple crops in a calendar year between male-headed households and female-headed households.

3.7 Livelihood Vulnerability Index

The relative strength and interaction of exposure, sensitivity, and adaptive capacity indices determined the vulnerability, and thereby the level of vulnerability of a particular district (Table 7). Indices of exposure for Jalaun and Jhansi indicate that female-headed households are highly exposed to climate change. In addition, sensitivity indices show that surveyed female-headed households are equally sensitive, whereas they have lower adaptive capacity to deal with climate change than that of male-headed households. Similarly, adaptive capacity plays a decisive role in the context of climate vulnerability among the surveyed households. In totality, female-headed households are potentially vulnerable to climate change than that of male-headed households in both districts.

4. CONCLUSION AND POLICY RECOMMENDATIONS

The study has attempted to investigate the nature, magnitude of livelihood vulnerability in the Bundelkhand region, India. Sample farmers are extremely exposed to climate change. The decline in water table & rainfall, and increase in temperatures (farmers' perception) are adding an additional layer of biophysical vulnerability in the system. Farmers adopted several adaptation strategies to overcome the current environmental crisis. However, the least basic amenities (sensitivity), low income, and literacy rate are main barriers to livelihood security.

Based on the present study findings, this study has prescribed region and issue-specific policy interventions. Firstly, the water table is

continuously declining, and thus creating a water crisis, even in the rainy season for agriculture and domestic consumption. Therefore, there is an immediate policy intervention is required to conserve water- bodies through the community participation model. Secondly, lower farm productivity also has a major barrier in the path of sustainable and secure livelihoods, where agriculture is the sole source of income. Therefore, less water consuming and early maturing varieties are not only increasing the farm productivity but also reduce input cost. Thirdly, the majority of female-headed households have relied on forest resources for cooking. Further, using wood as a cooking fuel also leads to chronic diseases, which further added expenditure in the budget. This problem can solve by tapping solar energy for cooking. Besides cooking, solar energy can be used for lighting and boiling water. Fourthly, open defecation is still a reality in the surveyed villages. Therefore, community toilets would be constructed on the community participation model. This not only saves water and time but also protects from several diseases. Lastly, this study highlights that female-headed households are highly vulnerable to that of male-headed households. Therefore, this study suggests that there is a need for gender-specific policy interventions to build a socioeconomic and demographical infrastructure as a mainstream climate policy.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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