



## Prioritization of climate induced gender specific vulnerability issues in crop and dairy enterprises

RITU CHAKRAVARTY<sup>1</sup>, KUPPUSAMY PONNUSAMY<sup>1</sup>✉ and R SENDHIL<sup>2</sup>

ICAR-National Dairy Research Institute, Karnal, Haryana 132 001 India

Received: 31 March 2021; Accepted: 30 July 2021

### ABSTRACT

The study identified and prioritized the climate induced gender specific vulnerability of the selected households pursuing crop and dairy enterprises in the three villages, one each from Karnal, Yamunanagar and Sirsa districts of Haryana, adopted under the Technology Demonstration Component of the National Innovations in Climate Resilient Agriculture (NICRA) Project. As per the Intergovernmental Panel on Climate Change, data were collected from 90 households (30 households / village) and then computed the overall vulnerability index based on the exposure, sensitivity and adaptive capacity indices, using 17 indicators extracted through Principal Component Analysis. High vulnerability was found in 21.11% households (mean vulnerability index value of 0.6201) and 41.11% households were found vulnerable to a medium level (mean vulnerability index value 0.3631). Significant difference was revealed in the overall exposure and overall adaptive capacity between districts. The overall vulnerability was found highest in Yamunanagar (0.3846), followed by Sirsa (0.3671) and Karnal (0.3043) districts. The identified gender prioritization of vulnerability issues needs to be addressed in each district as well as on aggregate basis for increasing resilience and decreasing gendered household vulnerability.

**Keywords:** Climate induced vulnerability, Crop and dairy, Gender, Participatory rural appraisal, Principal component analysis

Crop and dairy farming play critical role in livelihood and nutritional security of India. These farm enterprises are sensitive to climate change and climate variability, which pose serious long term challenges to productivity and profitability. Vulnerability has emerged as a cross-cutting theme in research on the human dimensions of global environmental change (Downing *et al.* 2000, Kasperson and Kasperson 2001, Polsky *et al.* 2003).

The small holder farmers bear the major brunt of climate change due to inadequate resources for adaptation. The experts predicted a fall in agricultural productivity of northern India to a tune of 25%, between 2003 and 2080s due to climate change (Cline 2007). Climate change exerts long term impacts on agriculture such as loss of fertile agricultural land, decreased agricultural productivity, increased outbreak of pest and diseases and deterioration of soil health. Dairy farming too, faces direct and indirect impacts such as heat stress in animals resulting in reduced feed intakes and milk production, increased disease incidence, decreased reproductive performance and shortage of feeds and fodder (Ponnusamy *et al.* 2019).

All populations are potentially vulnerable to climate change and gender-differentiated risks significantly affect

access to resources, decision-making processes and division of labour among men and women. Experience has shown that vulnerability to climate change tends to differ within countries, within communities and even within households (Daze 2011) and men and women farmers perceive and respond to climate change differently, to sustain their livelihoods and food security (Babugura *et al.* 2010). This has serious implications on gendered adaptive capacity and means of ensuring resilience in crop and dairy enterprises. Effective and equitable adaptation calls for an understanding of the dynamics of vulnerability, influenced by gender. Therefore, gender differences must be an integral part of vulnerability assessments while planning adaptation strategies. Therefore, a study was undertaken to assess the vulnerability of the farm households towards impacts of climate change and variability and prioritization of the identified vulnerability issues by the male and female respondents.

### MATERIALS AND METHODS

The present study was carried out in Karnal, Yamunanagar and Sirsa districts of Haryana, under the umbrella of the Technology Demonstration Component (TDC) of NICRA project during 2016–17. Three villages, one from each district adopted under TDC-NICRA were purposively selected. From each village, 30 households pursuing crop and dairy farming were selected.

Present address: <sup>1</sup>ICAR-National Dairy Research Institute, Karnal, Haryana. <sup>2</sup>ICAR-Indian Institute for Wheat and Barley Research, Karnal, Haryana. ✉Corresponding author email: ponnysamyk@hotmail.com

**Data source:** The study employed mainly primary data from 90 households, collected by personal interview through a developed and pre-tested schedule encompassing the socio-economic profile, variables related to exposure, sensitivity and adaptive capacity of the households. Prioritization was done through gender vulnerability issue ranking matrix, using Participatory Rural Appraisal. Secondary data sources were the Agriculture Contingency Plans of Karnal, Yamunanagar and Sirsa districts of Haryana, Average Maximum-Minimum temperature data sets of Indian Meteorological Department (IMD) for the period 1901–2015, Average district rainfall IMD datasets from 1951–2000 and Haryana district rainfall data 1966 onwards.

**Vulnerability assessment:** As vulnerability is a condition which is not explicitly observable, it has to be captured using proxy measures. In this study the Indicator based approach was used to assess the climate induced vulnerability of households in crop and dairy enterprises.

**Selection of indicators:** Initially 35 indicators were selected based on literature review and researcher's experience and subjected to expert judgement. All indicators securing a relevance score of more than 0.71 were retained. To bring the values of indicators to a comparable range, normalization was done. Post normalization, the non-suitable indicators were eliminated using Principal Component Analysis (PCA). Principal components having Eigen values of greater than 1 were selected. For the present study, cut-off of the communality value were decided as 0.50. The final indicators were extracted based on communality values, factor loadings and per cent of total variance explained. The exposure index was composed of five extracted variables: loss due to decrease in yield of crops due to climate change, economic loss due to loss of crop/harvest/produce in extreme climate condition, loss due to increase disease incidence in animals, loss due to increased disease incidence in crops and economic loss in dairying due to climate change. The variables extracted for sensitivity index were: crossbreds to total animals reared, cash to total crops grown, total annual production in crops, total annual production in dairying, total gross annual income and membership in groups and societies. Adaptive capacity index composed of: per capita off-farm income, experience in crop and dairy farming, farm size, number of weather advisories received annually, proportion of family members in off-farm enterprises and number of adaptation options accessible.

**Assigning weightage:** Weights were determined for the selected indicators based on factor loadings of selected principal components and Eigen values. Varimax rotation was used for each indicator. The determined weight was added to each value of the indicator for each household. Separate PCA was done for exposure, sensitivity and adaptive capacity indicators.

**Computation of vulnerability index:** Vulnerability is the degree to which a system is susceptible to and unable to cope with adverse effects of climate change (IPCC 2007).

It is a function of the character, magnitude and rate of climate variation to which a system is exposed, its sensitivity and its adaptive capacity (McCarthy *et al.* 2001). The exposure, sensitivity and adaptive capacity values in each household were estimated for each indicator. The vulnerability index was computed by subtracting the adaptive capacity index from the aggregate exposure and sensitivity indices based on the equation, given by IPCC, 2007—

$$\text{Vulnerability} = (\text{Exposure} + \text{Sensitivity}) - \text{Adaptive Capacity}$$

## RESULTS AND DISCUSSION

Five principal components were developed using exposure variables of which two components were extracted (Table 1). The developed weights showed that exposure to climate change and variability profoundly affected the crop and dairy enterprises in terms of causing yield decrease (0.2676), economic loss due to loss of crop/ harvest/ produce (0.2572) and economic loss in dairying (0.1915) as depicted in Table 1.

Similarly, 6 principal components were developed using sensitivity variables of which four components were extracted. The developed weights showed (Table 1) that the sensitivity of the households was affected to a greater extent by total gross annual income (0.3070), crossbreds to total animals reared (0.1817), total annual production in crops (0.1685) and membership in groups and societies (0.1576). Considering variables affecting the adaptive capacity of the households, six principal components were developed using variables of which four components were extracted. The developed weights showed that the adaptive capacity of the households was influenced to a greater extent by farm size (0.1478), number of weather advisories received annually (0.1391), per capita off-farm income (0.1119) and number of adaptation options accessible (0.1117) as presented in Table 1.

The overall adaptive capacity index of the households was low (0.117038); therefore this led to a high vulnerability index value as depicted in Fig. 1. This draws support from O'Brien (2004) who emphasized that adaptability defines vulnerability.

High vulnerability was found in 21.11% households (mean vulnerability index value of 0.6201) and 41.11% households were vulnerable to a medium level (mean vulnerability index value 0.3631) as depicted in Table 2. Though 37.78% households were found less vulnerable

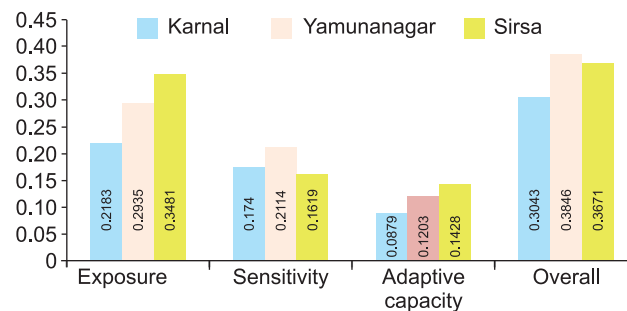


Fig. 1. Index scores for vulnerability in the study area.

Table 1. Number of extracted principal components using exposure, sensitivity and adaptive capacity variables, communality and developed weights

| Exposure variable | PC1    | PC2    | Communality (h <sup>2</sup> ) | Developed weights |
|-------------------|--------|--------|-------------------------------|-------------------|
| YIELDDECC         | 0.902  | 0.149  | 0.8358                        | 0.2676            |
| ECOLOSSC          | 0.825  | 0.185  | 0.7148                        | 0.2572            |
| DISEASED          | 0.755  | −0.188 | 0.6053                        | 0.1444            |
| DISEASEC          | −0.254 | 0.773  | 0.6620                        | 0.1322            |
| ECOLOSSD          | −0.066 | 0.818  | 0.6735                        | 0.1915            |

| Sensitivity variable              | PC1    | PC2    | PC3    | PC4    | Communality (h <sup>2</sup> ) | Developed weights |
|-----------------------------------|--------|--------|--------|--------|-------------------------------|-------------------|
| CB2TOTAL                          | −0.359 | 0.292  | 0.488  | 0.516  | 0.7185                        | 0.1817            |
| CASHTOTAL                         | 0.400  | −0.614 | −0.396 | 0.306  | 0.7874                        | −0.0589           |
| ANNUALPROC                        | 0.545  | 0.448  | −0.382 | 0.258  | 0.7102                        | 0.1685            |
| ANNUALPROD                        | 0.391  | −0.196 | 0.638  | −0.384 | 0.7457                        | 0.0871            |
| INCOME                            | 0.62   | 0.561  | 0.176  | 0.226  | 0.7812                        | 0.3070            |
| MEMSHIP                           | 0.459  | −0.496 | 0.383  | 0.467  | 0.8214                        | 0.1576            |
| <i>Adaptive capacity variable</i> |        |        |        |        |                               |                   |
| PCOFFINCOME                       | −0.319 | 0.261  | 0.596  | 0.361  | 0.6554                        | 0.1119            |
| EXP                               | 0.486  | −0.729 | 0.258  | −0.080 | 0.8405                        | −0.0081           |
| FARMSIZE                          | 0.664  | 0.466  | 0.011  | 0.046  | 0.6602                        | 0.1478            |
| ADVISORIES                        | 0.780  | 0.020  | 0.242  | 0.075  | 0.6730                        | 0.1391            |
| OFFFARMENT                        | −0.154 | −0.179 | −0.263 | 0.747  | 0.6829                        | 0.0188            |
| OPTSACC                           | 0.679  | 0.312  | 0.105  | −0.199 | 0.6089                        | 0.1117            |

(mean vulnerability index value 0.1901), assessment of vulnerability to climate change has to be done periodically since vulnerability is dynamic and requires constant monitoring.

The values of climate induced vulnerability in the 3 districts showed highest exposure index value (0.3481) in Sirsa district, which could be due to its prevailing arid conditions and climate stresses such as droughts, heat waves and salinity. Sensitivity, reflecting the conditions which could trigger an impact, was highest (0.2114) in Yamunanagar district whereas, the adaptive capacity of the farming households or, their capacity to cope with and overcome the negative impacts of climate change and climate variability, was highest (0.1428) in Sirsa district.

The overall vulnerability was therefore found highest in Yamunanagar (0.3846), followed by Sirsa (0.3671) and Karnal (0.3043) districts. The present findings are in conformity with the district level mapping of climate sensitivity index of India (O'Brien 2004) wherein, climate sensitivity in districts of Haryana is reported to range from high to highest and vulnerability from medium to highest.

Significant difference was observed in the overall

exposure and overall adaptive capacity (0.023) between districts (0.127). This could be due to the varying level in climate exposure, cropping systems and agro-ecological regions and the accessibility of adaptation options (Ponnusamy and Devi 2017).

Gender ranking of the vulnerability issues in the three districts as well as the pooled prioritization as perceived by the women and men are presented in Table 3. Women accorded top priority for increased disease incidence in animals and crops (overall ranking score 10) followed by climate extremity at time of harvest (overall ranking score 13), since women were predominantly involved in dairy farming activities and responsible for caring of animals. The men prioritized lack of timely adaptation information (overall ranking score 7), increased disease incidence in animals and crops (with ranking score 17), increased pest incidence on animals and crops (with score 18) and decrease in milk production (with score of 19), as they are responsible for information seeking and maintaining the household income.

Though, the NICRA Project has maintained regular information supply to the farmers, the issue has been prioritized as farmers are now more aware of climate impacts and importance of adaptation, therefore, they require timely information continuously in future also. The present findings are in line with the observations of Babugura *et al.* (2010) that men and women were equally concerned with climatic impacts on food security and livelihoods (Daze 2011), emphasizing that access to information is a major factor determining ability to act on adaptation.

Spearman's rank correlation between vulnerability and

Table 2. Overall distribution of households under different categories of climate induced vulnerability with corresponding Average Index Values

| Category of vulnerability | Level         | Household frequency | %     | Mean±S.E.    |
|---------------------------|---------------|---------------------|-------|--------------|
| Low                       | < 0.2833      | 34                  | 37.78 | 0.1901±0.012 |
| Medium                    | 0.2823–0.4584 | 37                  | 41.11 | 0.3631±0.008 |
| High                      | > 0.4584      | 19                  | 21.11 | 0.6201±0.026 |

Table 3. Climate induced vulnerability issues ranking matrix of women and men in NICRA villages of three districts

| Climate induced vulnerability issue                                          | Response of women<br>(ranking)* |             |       |         | Response of men<br>(ranking)* |             |       |         |
|------------------------------------------------------------------------------|---------------------------------|-------------|-------|---------|-------------------------------|-------------|-------|---------|
|                                                                              | Karnal                          | Yamunanagar | Sirsa | Overall | Karnal                        | Yamunanagar | Sirsa | Overall |
| Decrease in yield                                                            | 2                               | 10          | 9     | 21      | 2                             | 15          | 5     | 22      |
| Climate extremity at time of harvest                                         | 1                               | 1           | 11    | 13      | 1                             | 5           | 16    | 22      |
| Decrease in milk production                                                  | 3                               | 11          | 5     | 19      | 3                             | 10          | 6     | 19      |
| Loss of wage due to climate extremity                                        | 4                               | 7           | 4     | 15      | 4                             | 9           | 15    | 28      |
| Increased disease incidence in animals and crop                              | 7                               | 2           | 1     | 10      | 7                             | 7           | 3     | 17      |
| Increased pest attack on animals and crops                                   | 6                               | 9           | 7     | 22      | 6                             | 8           | 4     | 18      |
| Lack of timely adaptation information                                        | 5                               | 5           | 13    | 23      | 5                             | 1           | 1     | 7       |
| Financial constraints for adaptation                                         | 8                               | 4           | 6     | 18      | 8                             | 4           | 14    | 26      |
| Lack of community cooperative action                                         | 11                              | 14          | 8     | 34      | 11                            | 2           | 11    | 24      |
| Lack of funds for livelihood options                                         | 10                              | 12          | 10    | 32      | 10                            | 6           | 10    | 26      |
| Lack of community action for maintaining<br>natural resources in the village | 12                              | 3           | 12    | 27      | 12                            | 11          | 9     | 32      |
| Lack of government assistance                                                | 9                               | 6           | 2     | 17      | 19                            | 3           | 2     | 24      |
| No SHGs in the village                                                       | 14                              | 8           | 3     | 25      | 14                            | 14          | 13    | 41      |
| Women dependent on husbands for<br>climate adaptation                        | 15                              | 15          | 16    | 46      | 15                            | 12          | 12    | 39      |
| Decrease in person's working capacity<br>due to deteriorated health          | 13                              | 13          | 14    | 40      | 13                            | 13          | 7     | 33      |
| Fatalistic attitude                                                          | 16                              | 16          | 15    | 47      | 16                            | 16          | 8     | 40      |

\*Lower scores indicate higher priority of issues.

socio-economic variables revealed that the ranks of land holding, herd size, extension contact and total gross annual income were highly correlated with vulnerability, indicating their importance in resilient crop and dairy production (Table 4). This clearly indicated that those farmers with better holding of land and animals as well as better exposure are also highly vulnerable to climate extremities as risk is also increasing in tune with quantum of transactions in farm commodities. However, higher annual gross income would strengthen the hands of farmers in the event of extreme climatic circumstances. Therefore, income augmentation of farmers should be one of the major options for building the resilience capacity of farmers in climate change prone areas and regions.

The medium to high vulnerability level of majority of households in the 3 districts to climate change warrant designing and implementation of a package of strategies at village level. The yield decrease and economic loss due to loss of crop/ harvest/ produce and in dairying due to climate change exposure in crop and dairy enterprises need continuous monitoring for indepth understanding and strategy development for resilient production. Awareness programmes and collective organization should be promoted to address the climate sensitive factors in the study area. For enhancing adaptive capacity, farm size, weather advisories received, per capita off farm income and adaptation options accessible may be included in the objectives and strategies of the climate change adaptation programmes. The gender prioritization of vulnerability has clearly revealed the issues that need to be addressed in each district as well as on aggregate basis for increasing resilience and decreasing gendered household vulnerability.

Table 4. Rank correlation between vulnerability and socio-economic variables

| Socio-economic variable          | Rank correlation (rs) |
|----------------------------------|-----------------------|
| Education                        | -0.176*               |
| Family education score           | 0.175*                |
| Family size                      | -0.104                |
| No. of livelihood options        | -0.008                |
| Land holding                     | 0.463**               |
| Herd size                        | 0.251**               |
| Mobility                         | 0.216*                |
| Extension contact                | 0.257**               |
| Credit and insurance utilization | -0.199*               |
| Total gross annual income        | 0.556**               |

\*,  $P < 0.05$ ; \*\*,  $P < 0.01$ .

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