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Climate Change, Gender and Adaptation Strategies in Dryland Systems of South Asia

A Household Level Analysis in Andhra Pradesh, Karnataka and Rajasthan States of India

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International Crops Research Institute for the Semi-Arid Tropics
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Contents

Executive summary

There is a blossoming literature on gender and climate change issues broadly focused on the adverse effects of climate condition. These studies are mostly focused on gender inequalities in agrarian communities of developing countries where the dependence on climatic conditions for living is more apparent. Frequently, the issues of climate change, poverty, gender and economic empowerment are addressed as the most prominent in developing regions. In some cases, the studies narrow down the focus to specific weather events like droughts, floods or natural disasters in rural communities. The agrarian communities of backward areas in South Asia are some of the representative examples which are frequently presented in climate change and gender studies.

A special emphasis is given on the gender factor in India as a determinant for unequal distribution of climate change impacts both on household and community. However, a quantitative research on role of gender in climate change and livelihoods in rural India is often missing. Therefore, we conducted a quantitative research in India to understand the role of gender in the current and anticipated climate change impacts. The main objective of the study was to investigate the linkages between gender and climate change. More specifically the study focused on gender-wise perceptions of climate change, understanding coping strategies followed by gender, participation of gender in decision-making and vulnerability of male and female households to the poverty. The analysis was carried out during 2012-13 based on a survey of 1019 randomly sampled households in six districts of Andhra Pradesh (Anantapur and Kurnool), Karnataka (Bijapur), and western Rajasthan (Jaisalmer, Barmer and Jodhpur) as action sites.

The results showed that most of the households had encountered more than one shock and drought was the most severe shock encountered by males and females in all three states/regions followed by irregular weather in Andhra Pradesh and untimely rains in Karnataka. Hailstorm was also a major shock encountered in Rajasthan. It was also found that the male and female households had same level of perception of drought, flood, animal disease and temperature fluctuations. The percentages of female households who observed these shocks were more than those of male households.

Gender perception on the effects of shocks showed that the perceptions of pest damage to crops, depletion of groundwater, loss of income, major changes in cropping pattern and food insecurity/shortage varied in Andhra Pradesh. In Rajasthan loss of assets and death of livestock were also found to be effects of climate change. In Karnataka there were no differences in perceptions of climate change effects between gender.

Farmers also adopted both farm-based and nonfarm-based coping strategies to mitigate the negative effects of climate change. In Andhra Pradesh, male households adopted supplemental irrigation (20%), fallowing land (19%) and improved crop production practices (18%) as the major coping strategies. For female households, change in planting date was a major coping strategy (20%). In Karnataka, 82% of male farmers adopted improved crop production practices followed by providing supplemental irrigation and change in planting date. Female households also followed the same adaptation strategies. In Rajasthan, both the male and female households followed improved crop production practices, supplemental irrigation, change in planting date, fallowing land and maintaining poultry and goats. However, male and female households significantly differed in using additional skill development activities and change in cropping pattern.

Borrowing money from relatives, shifting to nonfarm employment, out-migration to cities and relying on assistance from government were the major nonfarm-based strategies followed by male and female households in all the three states.

Female households in Andhra Pradesh performed better than male households with an annual household net income of ₹ 100,168 compared to ₹ 72,425 per male household due to better off-farm income. In Karnataka and Rajasthan also, the net income as well as per capita net income between male and female households varied significantly.

The determinants of the household income for both male and female were also analyzed and found that farm size, household size, distance to market for sales, owning livestock, farm mechanization, providing supplemental irrigation and region (location of the farm) were the important determinants of income of male households. Similarly, farm size, owning livestock, providing supplemental irrigation and region (location of the farm) were important determinants for female households. Compared to male households, female households offered more opportunities for making joint decisions.

Based on the existing income levels of the households in the study regions, household vulnerability (in terms of expected poverty) was worked out. The results showed that 764 male households were vulnerable to poverty in 2013 and 94% of them were likely continue to be vulnerable next year (2014) also. In the case of female households, out of 58 vulnerable households, 86% will continue to be vulnerable next year also and they will be relatively better than male households in moving from vulnerable to less vulnerable. In order to make the households less vulnerable, different adaptation strategies that could yield comparatively higher income than the pure rainfed situations were identified.

The major recommendations of the study include piloting of the suggested adaptation strategies on cluster basis such as improved livestock production activities, supplemental irrigation, farm mechanization and additional skill development programs focusing on soil and moisture conservation, sprinkler irrigation and livestock management. Further, a hybrid weather-based crop and livestock insurance product over the existing purely crop-based insurance products and developing public–private partnership models on business cases such as micro-irrigation (drip and sprinkler), farm pond construction for supplemental irrigation and small farm mechanization are suggested.

1. Introduction: Why gender and climate change are important and how these could be addressed?

Climate change has multi-dimensional effect on humanity in terms of several socioeconomic parameters. It threatens to have far-reaching environmental change that could have severe impacts on societies throughout the world. Its negative impacts are becoming evident in many spheres due to long-term average changes in rainfall, severe drought and irregular weather conditions. A recent study on its impact on agriculture in India shows that there will be substantial loss in crop yields (Palanisami et al. 2014c). Another study on vulnerability of households in dryland systems of India shows that about 94% of the households in Andhra Pradesh, 62% in Karnataka and 87% in Rajasthan fall under vulnerable category and the rest under less vulnerable category (Palanisami et al. 2014b).

An important emerging area of climate change research is to study its impacts on gender. Researchers have attempted the multiple effects of climate change on gender in developing countries by introducing socio-demographic and economic parameters like population, educational status and economic growth (UNDP 2009, UNECA 2009, World Bank 2009, Gender CC 2011). There are also numerous in-depth and country-specific studies pertaining to the above issues, often clustered in well elaborated web platforms (Eldis 2013, OECD 2013, World Bank 2013). Many of the global and regional studies suggest that the agrarian communities within less developed parts of South Asia offer some representative examples of existent gender inequalities (Lambrou and Nelson 2010, Øvstegård et al. 2010, Suman 2011). It is generally hypothesized that climate change related shocks affect women more negatively than men in terms of agricultural production, food security, health, water and energy resources, etc. Further, it is argued that climate change will affect the livelihoods of men and women differently, given the roles and responsibilities they have at the household and community levels. Women in developing countries have lower income, less control over decision-making and so they are highly vulnerable to climate change impacts. According to Arrora-Johnson (2011), 70% of the population (1.3 million) in the developing world living below the poverty line are women. Taking gender into consideration, in analyzing the impacts of climate change, will help to understand its full potential impacts on the society leading to better protection and adaptation to its negative effects.

Drylands cover about 41.3% of the earth's surface. In developing countries, 72% of the land areas are drylands. According to 4th National Report to United Nations Convention to Combat Desertification (UNCCD), out of 328 million ha of total geographical area of India, 228 million ha (69%) of area falls under dryland, i.e., arid, semi-arid and dry subhumid and these areas are heavily populated. Degradation has severe implications for livelihood and food security for millions of people living in these areas. The severity of vulnerability of the people depending on agriculture, especially women are very high because research predicts that overall climate change will have negative impact on agriculture (Keane et al. 2009). In most of the developing countries, women play a major part in all agricultural activities at farm level. They are involved right from nursery/sowing stage of the crop to harvesting. Hence it is pertinent to study the linkage between gender and impacts of climate change. Using the data collected from the CRP1.1 sites, the proposed study will focus on these gender related issues. Such a study will help to compare the negative impact of climate change on women livelihood in agriculture in rainfed and irrigated typologies. Specifically, the following hypotheses will be tested.

2. Key questions

2.1 Perception of climate change shocks by gender

a) Do men and women households have the same perception of climate change and its shocks? If different, what factors are perceived as most important by men and women?

b) What are their perceptions about the effects of shocks?

2.2 Coping strategies by gender

a) Do men and women apply similar coping strategies to overcome the effects of climate change?

b) What are the prominent strategies: gender-wise?

2.3 Irrigation typologies and gender role

Do irrigated farms influence the gender role in crop production?

2.4 Determinants of changes in lives of men and women due to climate change

a) What are the factors that determine the changes in livelihood of men and women? Do these factors differ between men and women?

b) Who is more vulnerable to poverty, male or female households?

2.5 Role of women in decisions on cropping patterns

a) Do women in household have any say in deciding on cropping patterns?

b) Who dominates in such decisions?

c) What are the sources of information on changes in cropping patterns as perceived by men and women?

These questions will contribute to achieving the following overall objectives of the study.

3. Objectives

The main objective is to study the linkage between gender and climate change. More specifically, the study focuses on:

- Understanding gender-wise differences and similarity of perception of climate change
- Investigating gender disaggregated coping strategies
- Identifying the different irrigation typologies and role of gender in adopting them
- Understanding the share of genders in farm operation decisions
- Estimating the vulnerability of male and female households to poverty and analyzing its implication.

The following hypotheses will be tested using the data collected:

- Genders have different perception of climate change, its shocks and coping strategies
- Women have substantial role in adopting irrigation typologies
- Women have substantial part in taking farming decisions
- Vulnerability of households to poverty are same for both genders

4. Review of literature

There is substantial literature on gender issues and climate change. For example, Goh (2012) gives a very detailed review of literature on the subject. He shows that climate change affects women's and men's assets and well-being differently, its impacts mostly related to agricultural production, food security, health, water and energy sources, climate-induced migration and conflict, and climate related natural disasters. Two hypotheses are tested on the above stated six areas of impact: (i) climate-related shocks affect men's and women's well-being and assets differently; and (ii) climate-related shocks affect women more negatively than men.

A study by Quisumbing et al. (2011) on effects of floods and droughts, show that the impact depends on involvement in agricultural production and exposure to weather risk. Brody et al. (2008) concluded that failure to include women in decision-making process will not only widen the gender inequalities but also undermine the effectiveness of climate change responses. In a case study of Namibia, Angula (2010) found that the changes in climate affect men and women differently. Compared to female-headed households, widowed and bachelor households find harder to balance the risks and vulnerability to impacts of climatic variability and changes. Also the study showed that in rural households whose main livelihoods are from agriculture, women have a stronger link to environmental and climate related sectors. Parikh (2007) provides a framework to analyze gender and climate change concerns keeping in view the strengths and vulnerability of poor women in particular.

In India, new research projects are undertaken; for example, 'Gender and State Climate Change Action Plans in India: Research and policies to enable poor women and rural communities adapt to climate change'. The project will investigate the role of women in decision-making, gender budgeting, existing adaptation interventions, the role of local self-governance and community and the rights/entitlements of poor women and men in adaptation plans. The project uses Uttar Pradesh, West Bengal, Uttarakhand and Madhya Pradesh states for case studies. The National Action Plan on Climate Change (NAPCC)-India addresses the impacts of climate change in terms of reducing vulnerability and increasing resilience without sacrificing its development and growth goals and running well into 2017 (Suman 2011). A new pilot 'Climate Innovation Center @ Gender and Agriculture' with a small budget allocation from the XII plan period is proposed (Government of India 2013).

A study undertaken by FAO (Food and Agriculture Organization of the United Nations) on food security in Andhra Pradesh, India concluded that there is a strong gender dimension to the way in which climate variability is experienced and expressed by farmers in their coping strategies to ensure their livelihoods and food security (Lambrou and Nelson 2010). Women and men perceptions of impacts of dry conditions differ in important ways.

Fifteen CGIAR centers under CCAFS are currently engaged in climate smart agriculture (CSA) practices (i.e., transformative changes in agricultural practices) (Kristjanson 2014). The study targets women, youths and other vulnerable groups, in agricultural research for development to increase the likelihood of achieving the gender related outcome: empowerment of women and marginalized groups, through increased access to and control over productive assets, inputs, information, food and markets, and strengthened participation in decision-making processes. The research focuses on gender-sensitive CSA practices and emphasizes the importance of both qualitative and quantitative approaches. The present study uses quantitative methods to study the linkage between gender and climate change.

5. Study area and data

A long list of target regions in South Asia were discussed and proposed during the dryland system workshop in Dubai in 2012[1]. Using the criteria such as aridity index, length of growing period (<90 d, <180 d), land use (rainfed + forest/rangeland) and resource degradation (water and wind erosion), three regions in India, viz., Rajasthan, Andhra Pradesh and Karnataka were selected and grouped under the Strategic Research Themes (SRT2 and SRT3) where SRT2 aims at reducing vulnerability and SRT3 aims at sustainable intensification. Among the selected regions, SRT2 is represented by Rajasthan, while SRT2 and SRT3 are represented both by Karnataka and Andhra Pradesh. The selected regions are shown in Figure 1. The present study also tries to address the Intermediate Development Outcomes (IDOs) of gender empowerment[2].

A total of 1019 farmers were interviewed. Out of 1019 farmers surveyed, 64 households were female-headed and the remaining 955 were male-headed households. Distribution of the sample gender-wise is given in Table 1.

Table 1. Distribution of sample households according to gender in India.

	No. of households		
State	Female headed	Male headed	Total
Andhra Pradesh	20	493	513
Karnataka	16	234	250
Rajasthan	28	228	256
Total	64	955	1,019

The sample was composed of 31%, 25% and 44% of female households from Andhra Pradesh, Karnataka and Rajasthan respectively. Among the three states, Andhra Pradesh had the highest percentage of male households (52%). The representations from the other two states are equal with 24% each (Fig. 2).

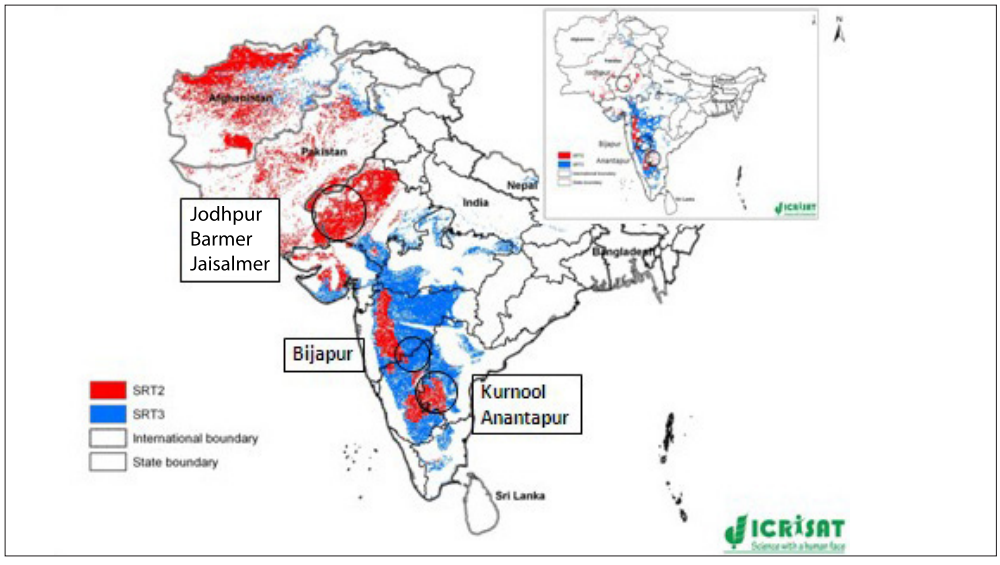

Figure 1. Study area action sites in India.

1. CRP1.1 Dryland Systems Framework Development Workshop on Integrated Agricultural Systems for Food Security and Improved Livelihoods in Dry Areas (Dryland Systems), 30 January–1 February 2012, Dubai.
2. The Intermediate Development Outcome (IDO) 1 refers to the more resilient livelihoods for vulnerable households in marginal areas whereas IDO 2 refers to the more sustainable and higher income per capita for intensifiable households.

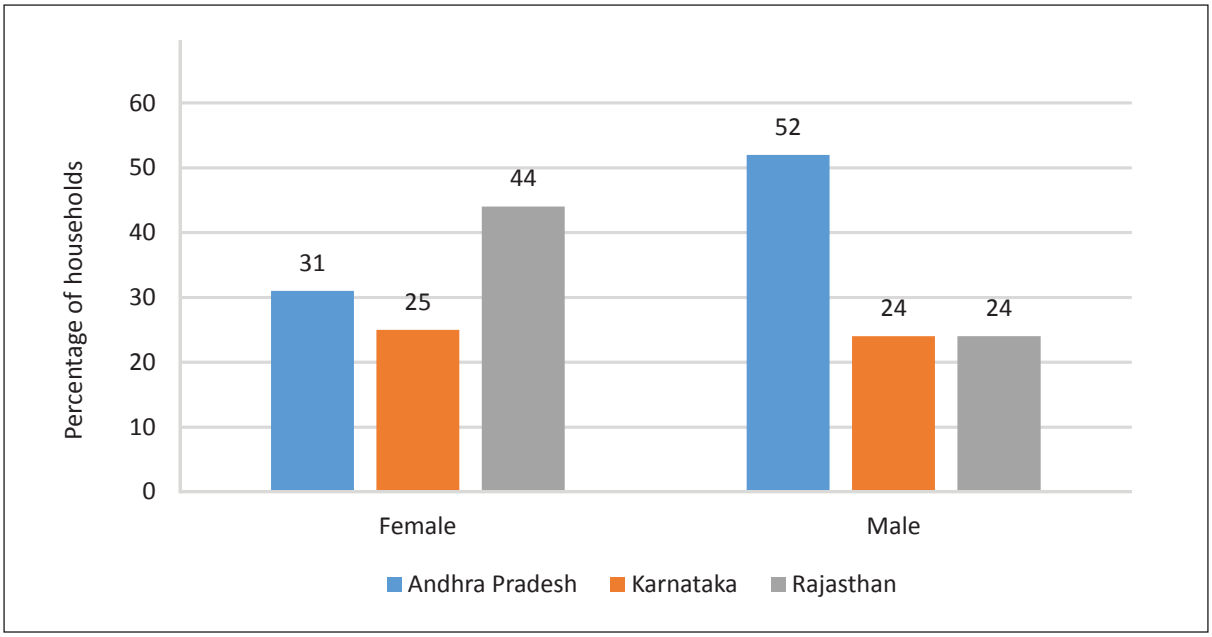

Figure 2. Distribution of sample households gender-wise in three states of India.

6. Methodologies

The present study applies percentage analysis, statistical tests, like Z-test and t-test and econometric tools to address the questions stated in section 2.

In order to find the determinants of income of households the following regression model was used:

$$Y = \beta_0 + \beta_1 h + \beta_2 f + \varepsilon \quad (1)$$

where h is a vector of household characteristics such as age, experience, marital status, etc. and f is a vector of farm specific variables such as farm size, livestock ownership, adoption of farm mechanization, etc. Gender-wise regression equations were fitted.

Household vulnerability to poverty was examined using expected poverty approach. The approach formulated by Chaudhuri et al. (2002) and Christiaensen and Subba Rao (2004) forms the basis. In this approach, vulnerability is defined in terms of probability. Vulnerability is the probability for a poor person today to continue to be poor tomorrow also or to become rich (not poor or above poverty line) tomorrow. In other words the approach specifies the transition probabilities between two states of well-being, viz., vulnerable (poor) and less vulnerable.

In the expected poverty approach, vulnerability is understood as the prospect of a person who is now poor will continue to be poor in the future also or the prospect of a person who is not poor will become poor in the future. In the present study, it refers to the probability that the consumption (income) level of a rainfed farmer who encounters climatic shocks (such as drought, irregular weather, untimely rain, etc.), falls below the poverty line.

The methodology proposed by Chaudhuri et al. (2002) was followed in the study. It helps to estimate vulnerability to poverty using cross-sectional data. The relationship between per capita consumption expenditure of a household h, denoted by c_h and observable household characteristics denoted by X_h is specified by the equation:

$$\ln c_h = X_h \beta + e_h \quad (2)$$

The observable household characteristics include many socioeconomic variables such as age, education, experience, farm size, household size, climatic shocks encountered, etc. β is a vector of parameters and e_h is a random disturbance term with mean 0.

The vulnerability to poverty depends not only on the average consumption of the individual but also on the variance of consumption. For example, a farmer whose income from farm fluctuates due to many climatic shocks and other factors is more vulnerable to poverty than a government salaried person whose average income is similar to that of the farmer. Hence, the variance of the consumption expenditure is also assumed to be related to socioeconomic factors, i.e., the variance of the error term is assumed to be related to the household characteristics X_h by the relation:

$$\sigma_{e,h}^2 = X_h\theta \tag{3}$$

where θ is a set of parameters. The three-stage Feasible Generalized Least Squares (FGLS) approach suggested by Amemiya (1977) is followed to estimate the parameter vectors β and θ. The approach is briefly explained below:

Equation 1 is first estimated by Ordinary Least Squares (OLS) procedure and using its residuals, $e_{OLS,h}^2$ is computed. These residuals are then regressed on X_h, using OLS, to estimate:

$$\hat{e}_{OLS,h}^2 = X_h\theta + \eta_h \tag{4}$$

The predicted value of the residual is given by $X_h\hat{\theta}_{OLS}$. These values are used in equation 4 to transform it as:

$$\frac{\hat{e}_{OLS,h}^2}{X_h\hat{\theta}_{OLS}} = \frac{X_h\theta}{X_h\hat{\theta}_{OLS}} + \frac{\eta_h}{X_h\hat{\theta}_{OLS}} \tag{5}$$

This equation is estimated using OLS and the estimate of the vector θ, denoted by $\hat{\theta}_{FGLS}$ is asymptotically efficient estimate of θ and $X_h\hat{\theta}_{FGLS}$, gives a consistent estimate of $\sigma_{e,h}^2$, the variance of idiosyncratic component of household consumption (Chaudhuri et al. 2002). Now equation 1 can be transformed as:

$$\frac{\ln c_h}{\hat{\sigma}_{e,h}} = \left(\frac{X_h}{\hat{\sigma}_{e,h}}\right)\beta + \frac{e_h}{\hat{\sigma}_{e,h}} \tag{6}$$

This equation can be estimated by using OLS to provide a consistent and asymptotically efficient estimate, $\hat{\beta}_{FGLS}$, of the parameter vector β. Finally, for each household h, the estimated mean log consumption and variance are given by

$$\begin{aligned} E\left[\ln c_h \mid X_h\right] &= X_h\hat{\beta}_{FGLS} \\ V\left[\ln c_h \mid X_h\right] &= \hat{\sigma}_{e,h}^2 = X_h\hat{\theta}_{FGLS} \end{aligned} \tag{7}$$

We now make the assumption that consumption is log-normally distributed. This assumption leads to computing the probability of a household's consumption below a threshold limit, z, that is, the probability that the household will be poor as:

$$\hat{v}_h = \Pr\left(\ln c_h < \ln z \mid X_h\right) = \Phi\left(\frac{\ln z - X_h\beta_{FGLS}}{\sqrt{X_h\hat{\theta}_{FGLS}}}\right) \tag{8}$$

This approach requires per capita consumption expenditure of each farmer. So in this approach, each farmer's net income from crop and livestock was computed and per capita income was derived. For some farmers, the net income was negative, i.e., loss. In order to include these farmers into further analysis, the net income for each of them was put as ₹ 1. We assume that farmers do not save and hence the full income is used for consumption. The above analysis was done gender-wise to ascertain the vulnerability to poverty.

The estimates from the World Bank show that 1.29 billion people were living on less than US$ 1.25 a day (World Bank 2008, Deressa et al. 2009). The population on poverty line has dropped from 43% in 1990 to 22% during 2005-08. The poverty line also varies from country to country and it is US$ 2 for medium poverty line for the developing countries (World Bank 2012). In India, the Planning Commission estimated poverty level and it varied from state to state. The monthly per capita income is ₹ 860 for Andhra Pradesh, ₹ 902 for Karnataka and ₹ 905 for Rajasthan (Government of India, Planning Commission, July 2013), which is close to the actual average per capita income of Andhra Pradesh and Rajasthan (cross-sectional data). In the present study, the level of poverty used was as stated by World Bank estimates of US$ 1.25 adjusted to US$ 1.5 due to the inflation, which is equivalent to ₹ 100 per day. This is also equal to the wage rate of National Rural Employment Guarantee Act for 2010-11 (NREGA 2014). The probabilities of transition from vulnerable to vulnerable, vulnerable to less vulnerable, less vulnerable to less vulnerable and less vulnerable to vulnerable were worked out using equations 7 and 8. Per capita income of each farmer (gender-wise) was used as the dependent variable and socioeconomic variables, climate shocks experienced, adaptation strategies followed were used as independent variables.

7. Results and discussions

7.1 Perception of climate change shocks

Farm households were questioned on the major shocks encountered by them during the past 10 years. Multiple responses were observed across the regions and many households replied that they have encountered more than one shock due to climate change. Drought (S1) is the most severe shock encountered by farmers with an average of 95% from three regions (Table 2). The next severe shock is irregular weather (S6) reported by 64%. Untimely rain (S5), the third severe shock, has an overall percentage of 54. Overall, the fourth shock, viz., hailstorm (S2) was encountered by 47% of the farmers. The other prominent shocks were animal disease (S4), temperature high fluctuation (S7), flood (S3) and temperature low fluctuation (S8).

7.2 Perception of gender on climate change and its shocks

Farmers' perception of different shocks encountered by them were analyzed gender-wise (Fig. 3). Table 2 presents the percentage of farmers who observed different shocks. In all the three states, drought is the most severe shock encountered by both male and female households. It was encountered by 91%, 98% and 100% of male households and 100%, 100% and 93% of the female households respectively in Andhra Pradesh, Karnataka and Rajasthan. The next major shock encountered by households was irregular weather and differed between states. In Andhra Pradesh irregular weather is the second major shock which was experienced by 61% and 90% of the male and female households respectively. In Karnataka, untimely rain is the second major shock. It was encountered by 93% and 100% of male and female households respectively. Irregular weather is the third major shock. In Rajasthan, hailstorm is also a major shock as it was encountered by 99% and 93% of male and female households respectively. Animal disease and untimely rain are the other major shocks which are experienced by both the genders.

Table 2. Shocks encountered by households gender-wise in the three study regions[1].

State	Gender	Number of households	Households (%)							
			S1	S2	S3	S4	S5	S6	S7	S8
Andhra Pradesh	Male	493	91.3	35.3	3.4	19.5	21.5	60.6	1.2	0.4
	Female	20	100.0	55.0	0.0	10.0	40.0	90.0	0.0	0.0
Karnataka	Male	234	98.3	17.5	3.4	24.4	92.7	68.4	3.4	0.0
	Female	16	100.0	18.8	18.8	31.3	100.0	68.8	6.3	0.0
Rajasthan	Male	228	99.6	99.1	14.5	89.5	80.3	61.4	59.2	33.3
	Female	28	92.9	92.9	10.7	85.7	82.1	71.4	46.4	32.1
Total	Male	955	95.0	46.2	6.1	37.4	53.0	62.7	15.6	8.2
	Female	64	96.9	62.5	9.4	48.4	73.4	76.6	21.9	14.1

1. S1 = Drought; S2 = Hailstorm; S3 = Flood; S4 = Animal disease; S5 = Untimely rains; S6 = Irregular weather; S7 = Temperature (high) fluctuation; and S8 = Temperature (low) fluctuation.

Overall (Fig. 3), both male and female households have experienced same shocks. The percentage of females who encountered climate shocks is slightly more than that of males for each shock. For example, about 95% and 97% of male and female households respectively have encountered drought. The next shock encountered by them is irregular weather. About 63% and 77% of male and female households respectively have encountered this shock. The third major shock is untimely rain which was encountered by 53% of the male households and 73% of the female households.

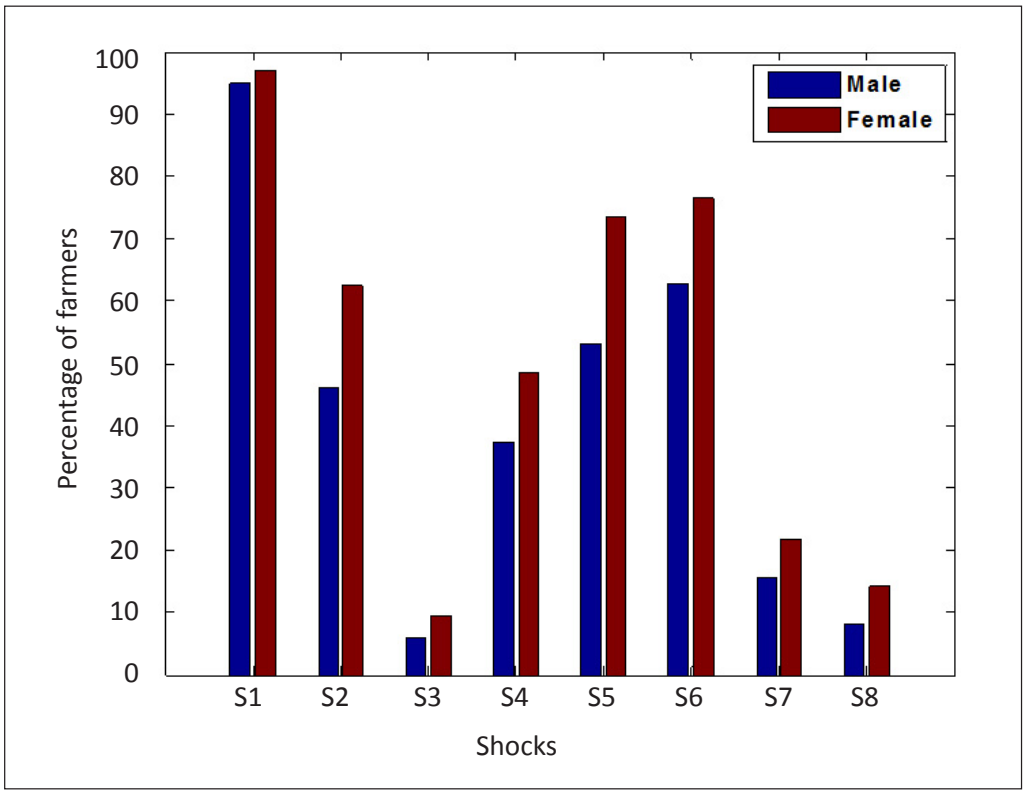

Figure 3. Shocks encountered gender-wise.

Table 3. Results on testing the significance between the genders in the perception of shocks.

	p-value[1]			
Shock	Andhra Pradesh	Karnataka	Rajasthan	All states
Drought	0.1676	0.598	0.0019***	0.5025
Hailstorm	0.072*	0.9006	0.0116**	0.04778**
Flood	0.3984	0.0038***	0.5892	0.7528
Animal disease	0.2908	0.5369	0.5475	0.2244
Untimely rain	0.0511*	0.2641	0.8128	0.00705***
Irregular weather	0.0081***	0.9752	0.3011	0.05264*
Temperature (high) fluctuation	0.6197	0.5564	0.1962	0.5419
Temperature (low) fluctuation	0.7753		0.8995	0.00001***

1. *, ** and *** = Significant at 10%, 5% and 1% levels respectively.

To test whether there is significance between the genders in the perception of shocks, Z-test for testing the significance of the two proportions was applied for each shock (Table 3). The results from all the states show that male and female households have same level of perception on drought, flood, animal disease and temperature (high) fluctuation, whereas their perceptions differed significantly for hailstorm, untimely rain, irregular weather and temperature (low) fluctuation. The percentages of female households who observed these shocks are more than those of male households. In Karnataka, the perceptions of male and female households differ significantly with respect to flood only whereas in Rajasthan their perceptions differ for drought and hailstorm. In Andhra Pradesh, perceptions of irregular weather differ highly between genders followed by untimely rain and hailstorm at 10% significance level.

7.3 Perceptions about the effects of shocks

Information related to perceptions of the effects of climate related shocks on agriculture, health and income was also collected. Crop failure, pest damage to crops, loss of income, depletion of groundwater and food security/shortage were major effects of climate shocks (Table 4). In all the three states and overall, crop failure, pest damage to crops and loss of income are the first three major effects of crops perceived by both male and female households (Fig. 4).

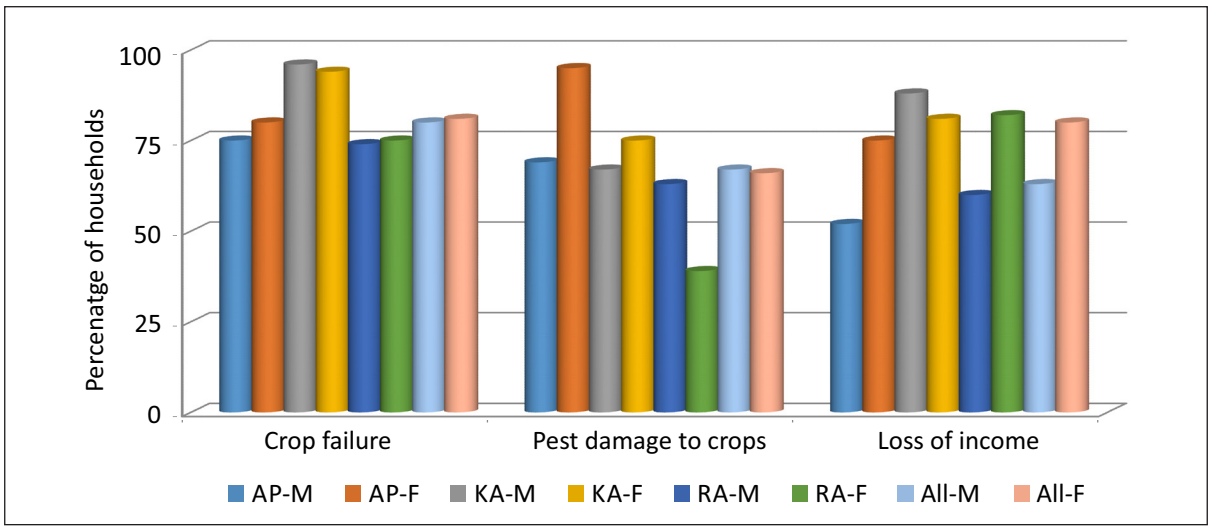

Figure 4. Gender-wise perception of climatic shocks in the three states (Note: AP = Andhra Pradesh; KA = Karnataka; RA = Rajasthan; All = All States; M = Male; F = Female).

Table 4. Gender-wise perception about the effects of shocks.

Effects of shocks	Andhra Pradesh			Karnataka			Rajasthan			All states		
	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total
Pest damage to crops	342 (69)	19 (95)	361 (70)	157 (67)	12 (75)	169 (68)	144 (63)	11 (39)	155 (61)	643 (67)	42 (66)	685 (67)
Illness of family member due to extreme weather	102 (21)	5 (25)	107 (21)	49 (21)	3 (19)	52 (21)	162 (71)	20 (71)	182 (71)	313 (33)	28 (44)	341 (34)
Change in soil salinity and decrease/increase in soil moisture	32 (6)	2 (10)	34 (7)	67 (29)	5 (31)	72 (29)	100 (44)	8 (29)	108 (42)	199 (21)	15 (23)	214 (21)
Major changes in crop pattern	60 (12)	0 (0)	60 (12)	40 (17)	5 (31)	45 (18)	11 (5)	1 (4)	12 (5)	111 (12)	6 (9)	117 (12)
Major changes in livestock asset	24 (5)	0 (0)	24(5)	9 (4)	1 (6)	10 (4)	22 (10)	0 (0)	22 (9)	55 (6)	1 (2)	56 (6)
Major changes in farm investment	34 (7)	3 (15)	37 (7)	6 (3)	0 (0)	6 (2)	10 (4)	0 (0)	10 (4)	50 (5)	3 (5)	53 (5)
Crop failure	371 (75)	16 (80)	387 (75)	225 (96)	15 (94)	240 (96)	168 (74)	21 (75)	189 (74)	764 (80)	52 (81)	816 (80)
Depletion of groundwater	137 (28)	10 (50)	147 (29)	168 (72)	11 (69)	179 (72)	74 (32)	6 (21)	80 (31)	379 (40)	27 (42)	406 (40)
Loss of assets	39 (8)	2 (10)	41 (8)	54 (23)	6 (38)	60 (24)	40 (18)	1 (4)	41 (16)	133 (14)	9 (14)	142 (14)
Loss of income	258 (52)	15 (75)	273 (53)	205 (88)	13 (81)	218 (87)	137 (60)	23 (82)	160 (63)	600 (63)	51 (80)	651 (64)
Food insecurity/shortage	154 (31)	10 (50)	164 (32)	43 (18)	3 (19)	46 (18)	157 (69)	18 (64)	175 (68)	354 (37)	31 (48)	385 (38)
Death of livestock	30 (6)	1 (5)	31 (6)	26 (11)	0 (0)	26 (10)	185 (81)	19 (68)	204 (80)	241 (25)	20 (31)	261 (26)
Decline in consumption	35 (7)	2 (10)	37 (7)	6 (3)	0 (0)	6 (2)	40 (18)	5 (18)	45 (18)	81 (9)	7 (11)	88 (9)
Decline in health	51 (10)	3 (15)	54 (11)	30 (13)	2 (13)	32 (13)	116 (51)	14 (50)	130 (51)	197 (21)	19 (30)	216 (21)

Note: Figures in parentheses denote percentage values of data on number of households.

Table 5. Statistical tests on gender-wise effects of shocks in three states of India.

	Andhra Pradesh			Karnataka			Rajasthan			All States		
Effects of shocks	z-value	p-value	Significance	z-value	p-value	Significance	z-value	p-value	Significance	z-value	p-value	Significance
Pest damage to crops	-2.46	0.01	**	-0.65	0.51	NS	2.44	0.01	**	0.281	0.778	NS
Illness of family member due to extreme weather	-0.47	0.64	NS	0.21	0.83	NS	-0.04	0.97	NS	-1.801	0.072	*
Change in soil salinity and decrease/increase in soil moisture	-0.62	0.54	NS	-0.22	0.82	NS	1.55	0.12	NS	-0.494	0.621	NS
Major changes in crop pattern	1.66	0.10	*	-1.43	0.15	NS	0.30	0.77	NS	0.546	0.585	NS
Major changes in livestock asset	1.01	0.31	NS	-0.47	0.63	NS	1.72	0.09	*	1.426	0.154	NS
Major changes in farm investment	-1.37	0.17	NS	0.65	0.52	NS	1.13	0.26	NS	0.191	0.848	NS
Crop failure	-0.48	0.63	NS	0.47	0.63	NS	-0.15	0.88	NS	-0.242	0.808	NS
Depletion of groundwater	-2.15	0.03	**	0.26	0.79	NS	1.19	0.23	NS	-0.396	0.692	NS
Loss of assets	-0.34	0.74	NS	-1.31	0.19	NS	1.90	0.06	*	-0.03	0.976	NS
Loss of income	-1.99	0.05	**	0.74	0.46	NS	-2.27	0.02	**	-2.718	0.007	***
Food insecurity/shortage	-1.76	0.08	*	-0.04	0.97	NS	0.49	0.62	NS	-1.816	0.069	*
Death of livestock	0.20	0.84	NS	1.41	0.16	NS	1.65	0.10	*	-1.067	0.286	NS
Decline in consumption	-0.49	0.62	NS	0.65	0.52	NS	-0.04	0.97	NS	-0.677	0.498	NS
Decline in health	-0.67	0.51	NS	0.04	0.97	NS	0.09	0.93	NS	-1.717	0.086	*

Note: NS = Nonsignificant; *, ** and *** = Significant at 10%, 5% and 1% levels respectively.

To test the significance difference in the perceptions of gender on effects of shocks, Z-test was applied for each shock. In Andhra Pradesh, the two genders differ significantly on their perceptions of the following effects of climate change: pest damage to crops, depletion of groundwater, loss of income, major changes in cropping pattern and food insecurity/shortage (Table 5). In Karnataka, the perceptions of all the effects of climate change do not differ significantly between the genders. In Rajasthan, pest damage to crops, loss of income, major changes in livestock asset, loss of assets and death of livestock are the effects of climate change on which the male and female households differ in their perceptions. It is interesting to note the difference in perceptions of livestock, as it is an important component of livelihood for Rajasthan farmers.

Thus for the effects of most of the shocks, there is no significant difference in the perception between the genders. Perception of males and females are significantly different with respect to illness of family members due to extreme weather, loss of income, food insecurity/shortage and decline in health.

7.4 Major decisions by gender

Women play a substantial role in taking decisions on crop activities. Table 6 shows that many decisions are taken jointly. In male-headed households, the decisions are taken jointly ranging between 23 and 57%; for example, on household food, 57.1% of the households take joint decision. In male households, females are provided with very minimal power to take independent decisions and the percentages are negligible. Similarly in female households the percentage of joint decisions range from 18.8 to 43.8 while the percentage of independent decisions range from 14.1 to 28.1.

Table 6. Role of genders in farm and socioeconomic decisions.

	Decision (%) in male household				Decision (%) in female household			
Activity	Male	Female	Jointly	Collectively	Male	Female	Jointly	Collectively
Crop input	38.1	0.9	54.0	6.9	28.1	25.0	35.9	10.9
Harvesting/transport	33.7	0.8	44.2	21.3	25.0	17.2	39.1	18.8
Livestock input	21.4	0.8	54.6	23.2	10.9	23.4	39.1	26.6
Hired labor	28.0	0.4	38.8	32.8	20.3	17.2	20.3	42.2
Household food	25.0	4.4	57.1	13.5	17.2	28.1	42.2	12.5
Education	22.5	0.5	33.8	43.1	15.6	17.2	35.9	31.3
Health	24.2	0.5	39.8	35.5	10.9	28.1	40.6	20.3
Social events	20.1	0.6	38.0	41.3	4.7	26.6	43.8	25.0
Personal transport	25.1	0.2	23.2	51.2	18.8	14.1	18.8	48.4
Housing	15.5	0.7	26.0	57.8	1.6	20.3	40.6	37.5

7.5 Coping strategies by gender

Farmers adopted different coping strategies, both farm-based and nonfarm-based, to tide over the negative effects of climate change shocks. There were 13 farm-based and 6 nonfarm-based coping strategies used by the farmers.

In Andhra Pradesh, for male households, providing supplemental irrigation (20%), leaving land fallow (19%) and following improved crop production practices (18%) are the major coping strategies (Table 7). For female households, change in planting date is a major strategy and it is followed by 20% of the households while all other strategies are followed by 10 to 15%

of households. In Karnataka, following improved crop production practices ranks first among the coping strategies with 82% of the male households adopting it. Next strategy is providing supplemental irrigation and it is adopted by 55% of them. About 42% of them adopt change in planting date as a coping mechanism. The female households of Karnataka use the same three coping strategies with 75%, 75% and 50% of adoption respectively. In Rajasthan both male and female households adopt same coping mechanisms. About 51% of the male households and 57% of the female households use additional skill development activities in farming. The second major coping mechanism for them is to leave the land fallow with adoption being 49% and 36% respectively. Maintaining poultry and goats is the third strategy with 16% and 25% of the male and female households respectively adopting it.

On the whole, about 25% of the male and 19% of the female households left land fallow. Besides this, three prominent coping strategies among male households were: (i) following improved crop production practices (FS10), (ii) providing supplemental irrigation (FS8), and (iii) additional skill development activities (FS1). Among female households also the same strategies were prominent. Additional skill development activities (FS1) had a maximum share of 30% while the strategy of following improved crop production practices (FS10) and providing supplemental irrigation had a share of 23% each (Table 7).

Statistical tests conducted showed that the difference between the genders in using most of the farm-based coping strategies was not significant (Table 8). Male and female households significantly differ in using additional skill development activities (FS1) and change in cropping pattern (FS2); FS1 is adopted by 19% and 30% of male and female households respectively while change in cropping pattern is used by 10% and 35% of male and female households respectively.

In Andhra Pradesh, borrowing money from relatives, out-migration to cities and relying on assistance from government are the three major nonfarm-based strategies for the male households. For the female households, borrowing money from relatives, shifting to nonfarm employment and relying on assistance from government are the major strategies. In Karnataka and Rajasthan, borrowing money from relatives, relying on assistance from government and out-migration to cities are the important nonfarm strategies for both male and female households (Fig. 5 and Table 8). Migration of male farmers has also exposed women to the workload and decision-making at farm level.

Overall, borrowing money from relatives (NFS1), relying on assistance from government (NFS2) and out-migration to cities (NFS3) are the three strategies adopted by male households (Table 9). These were adopted by 84%, 48% and 43% of the farmers respectively. For female households, NFS1, shifting to nonfarm employment (NFS4) and NFS2 were the important nonfarm-based strategies with adoption of 75%, 66% and 53% respectively. Borrowing money from relatives (NFS1) and shifting to nonfarm employment (NFS4) differ significantly between the two genders.

7.6 Irrigation typologies and gender role

The area under irrigation is increasing over the years in India. In dryland agriculture groundwater is used as the supplemental resource at critical stage of crop growth to reduce the crop losses and enhance the production. Farmers use different sources for irrigation, viz., canals, open wells, bore wells, *khadin*, *taanka* and *naadi*. They are either privately or community owned. The details of gender-wise ownership of the different sources of irrigation are given in Table 10.

Table 7. Farm-based coping strategies adopted by male (M) and female (F) households (no.) in three states of India.

	Andhra Pradesh			Karnataka			Rajasthan			All states		
Farm-based coping strategy	M	F	Total	M	F	Total	M	F	Total	M	F	Total
Did nothing (FS0)	56 (11)	3 (15)	59 (12)	0 (0)	0 (0)	0 (0)	22 (10)	0 (0)	22 (9)	78 (8)	3 (5)	81 (8)
Additional skill development activities (FS1)	49 (10)	3 (15)	52 (10)	12 (5)	0 (0)	12 (5)	117 (51)	16 (57)	133 (52)	178 (19)	19 (30)	197 (19)
Change in cropping pattern (FS2)	69 (14)	2 (10)	71 (14)	4 (2)	0 (0)	4 (2)	21 (9)	0 (0)	21 (8)	94 (10)	2 (3)	96 (9)
Sold livestock (FS3)	36 (7)	2 (10)	38 (7)	5 (2)	0 (0)	5 (2)	13 (6)	1 (4)	14 (5)	54 (6)	3 (5)	57 (6)
Left land fallow (FS4)	92 (19)	2 (10)	94 (18)	34 (15)	0 (0)	34 (14)	112 (49)	10 (36)	122 (48)	238 (25)	12 (19)	250 (25)
Sold part of land for alternative (FS5)	69 (14)	2 (10)	71 (14)	4 (5)	0 (0)	4 (2)	21 (9)	0 (0)	21 (8)	97 (10)	10 (16)	107 (11)
Leased out part of land for alternative/leased in (FS6)	51 (10)	3 (15)	54 (11)	44 (19)	2 (13)	46 (18)	11 (5)	1 (4)	12 (5)	106 (11)	6 (9)	112 (11)
Maintained poultry and goats (FS7)	43 (9)	3 (15)	46 (19)	17 (7)	0 (0)	17 (7)	37 (16)	7 (25)	44 (17)	97 (10)	10 (16)	107 (11)
Provided supplemental irrigation (FS8)	101 (20)	3 (15)	104 (20)	129 (55)	12 (75)	141 (56)	6 (3)	0 (0)	6 (2)	236 (25)	15 (23)	251 (25)
Invested in farm ponds (FS9)	22 (4)	2 (10)	24 (5)	8 (3)	0 (0)	8 (3)	8 (4)	0 (0)	8 (3)	104 (11)	9 (14)	113 (11)
Followed improved crop production practices (FS10)	91 (18)	3 (15)	94 (18)	192 (82)	12 (75)	204 (82)	1 (0)	0 (0)	1 (0)	284 (30)	15 (23)	299 (29)
Change in planting date (FS11)	63 (13)	4 (20)	67 (13)	99 (42)	8 (50)	107 (43)	3 (1)	0 (0)	3 (1)	47 (5)	6 (9)	53 (5)
Any other adaptation measure (FS12)	16 (3)	3 (15)	19 (14)	19 (8)	2 (13)	21 (8)	12 (5)	1 (4)	13 (5)	165 (17)	12 (19)	177 (17)

Note: Figures in parentheses are percentage values.

Table 8. Testing the significance of adoption of farm-based coping strategies.

Farm-based coping strategy	z-value	p-value	Significance[1]
Did nothing (FS0)	0.996	0.319	NS
Additional skill development activities(FS1)	-2.167	0.030	**
Change in cropping pattern (FS2)	1.781	0.075	*
Sold livestock (FS3)	0.326	0.745	NS
Keeping land fallow (FS4)	1.111	0.267	NS
Sold part of land for alternative (FS5)	-1.381	0.167	NS
Leased out part of land for alternative/leased in (FS6)	0.427	0.669	NS
Maintained poultry and goats (FS7)	0.341	0.733	NS
Provided supplemental irrigation (FS8)	0.229	0.819	NS
Invested in farm ponds (FS9)	-0.782	0.434	NS
Followed improved crop production practices (FS10)	1.072	0.284	NS
Change in planting date (FS11)	-1.553	0.120	NS
Any other adaptation measure (FS12)	-0.301	0.763	NS

1. NS = Nonsignificant; * and ** = Significant at 10% and 5% levels respectively.

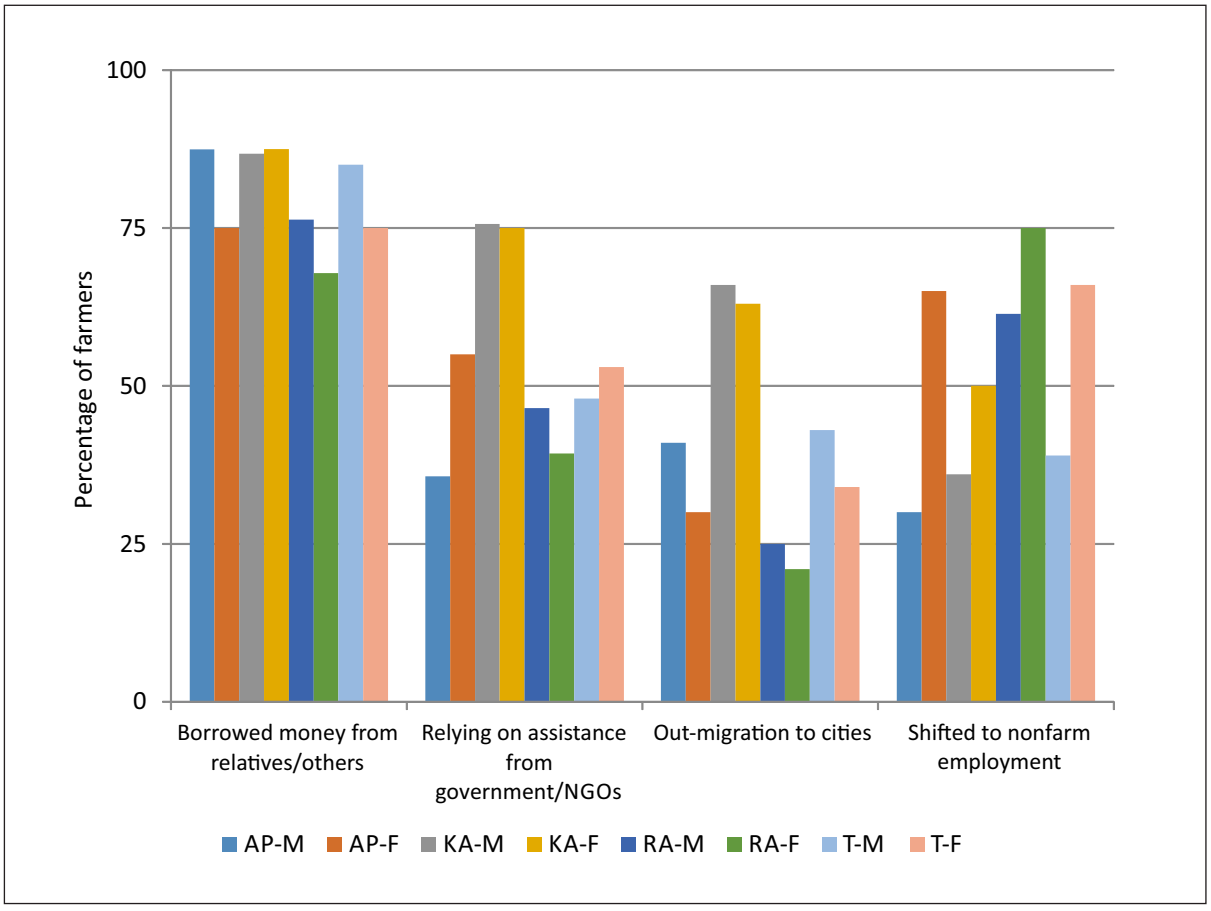

Figure 5. Major nonfarm coping strategies followed by households (Note: AP = Andhra Pradesh; KA = Karnataka; RA = Rajasthan; T = Total; M = Male; F = Female).

Table 9. Nonfarm-based coping strategies adopted by male and female households (no.)[1].

	Andhra Pradesh			Karnataka			Rajasthan			All states		
Nonfarm-based coping strategy	M	F	T	M	F	T	M	F	T	M	F	T
Borrowed money from relatives/ others (NFS1)	431 (87)[2]	15 (75)	446 (87)	203 (87)	14 (88)	217 (87)	174 (76)	19 (68)	193 (75)	808 (85)	48 (75)	856 (84)
Relying on assistance from government/NGOs (NFS2)	176 (36)	11 (55)	187 (36)	177 (76)	12 (75)	189 (76)	106 (46)	11 (39)	117 (46)	459 (48)	34 (53)	493 (48)
Less food consumption or changed food habits (NFS6)	147 (30)	10 (50)	1579 (31)	6 (3)	0 (0)	6 (2)	81 (36)	11 (39)	92 (36)	234 (25)	21 (33)	255 (25)
Shifted to nonfarm employment (NFS4)	150 (30)	13 (65)	163 (32)	85 (36)	8 (50)	93 (37)	140 (61)	21 (75)	161 (63)	375 (39)	42 (66)	417 (41)
Reduction in education level of the children (NFS5)	125 (25)	8 (40)	1339 (26)	111 (47)	7 (44)	118 (47)	74 (32)	12 (43)	86 (34)	310 (32)	27 (42)	337 (33)
Out-migration to cities (NFS3)	203 (41)	6 (30)	209 (41)	154 (66)	10 (63)	164 (66)	56 (25)	6 (21)	62 (24)	413 (43)	22 (34)	435 (43)

1. M = Male; F = Female; T = Total.
2. Figures in parentheses are percentage values.

Bore wells and *taanka* are the important sources of irrigation of farms owned by male and female households (Table 10). There are 234 male households and 14 female households who use private bore wells. Similarly there are 77 male and 15 female households who use private *taanka* which is specific to Rajasthan. For community owned sources of irrigation, 229 male and 35 female farmers use community owned *naadi*. Similarly, 227 male and 39 female farmers use community owned *khadin*. Other types of sources of irrigation are predominantly owned by males only.

In Andhra Pradesh, female households performed better than male households in generating farm income. The net income per farm for a female owned farm is ₹ 100,000 while it is ₹ 72,425 only for male owned farms due to possibly more off-farm income (Table 11). Similarly the per capita income of female households is higher than that of male households and there is not much difference between the socioeconomic variables. Livestock ownership differs substantially between the two genders, i.e., 54% for male households and 40% for female households respectively.

Table 10. Irrigation ownership and gender (no.)

Source/Ownership of irrigation	Andhra Pradesh				Karnataka				Rajasthan				All states			
	Male	Female	Jointly	Total	Male	Female	Jointly	Total	Male	Female	Jointly	Total	Male	Female	Jointly	Total
Privately owned canals	0	0	0	0	2	0	0	2	1	1	0	2	3	1	0	4
Privately owned open well	0	0	0	0	50	3	0	53	3	0	0	3	53	3	0	56
Privately owned bore well	171	13	0	184	26	1	0	27	37	0	0	37	234	14	0	248
Privately owned *khadin*	0	0	0	0	0	0	0	0	5	0	0	5	5	0	0	5
Privately owned *taanka*	0	0	0	0	0	0	0	0	77	15	0	92	77	15	0	92
Privately owned *naadi*	0	0	0	0	0	0	0	0	14	0	0	14	14	0	0	14
Communally owned canals	0	0	0	0	21	0	0	21	30	0	0	30	51	0	0	51
Communally owned open well	0	0	0	0	9	0	0	9	115	22	0	137	124	22	0	146
Communally owned bore well	13	0	0	13	0	0	0	0	94	13	0	107	107	13	0	120
Communally owned *khadin*	0	0	0	0	0	0	0	0	227	39	0	266	227	39	0	266
Communally owned *taanka*	0	0	0	0	0	0	0	0	17	21	0	38	17	21	0	38
Communally owned *naadi*	0	0	0	0	1	0	0	1	228	35	0	263	229	35	0	264

Table 11. Mean values of household farm income and selected socioeconomic variables of male and female households.

	Andhra Pradesh		Karnataka		Rajasthan		All states	
Variable	Male	Female	Male	Female	Male	Female	Male	Female
Net crop revenue (₹)	39,453	67,640	259,317	104,344	37,616	-11,878	92,887	42,027
Livestock revenue (₹)	15,285	6,999	18,506	9,466	47,117	23,794	23,674	14,963
Net farm revenue (₹)	54,738	74,638	277,823	113,809	84,733	11,916	116,560	56,990
Off-farm income (₹)	17,688	25,530	74,157	30,253	29,040	10,552	34,234	20,158
Net income (₹)	72,425	100,168	351,979	144,062	113,773	22,468	150,795	77,148
Per capita income (₹)	15,446	21,524	67,784	32,041	22,465	9,253	29,725	18,104
Farm size (ha)	2.2	2.0	3.8	1.9	2.8	1.7	2.7	1.8
Household size (no.)	4.4	4.2	5.5	6.0	5.6	4.2	5.0	4.6
Distance to market (km)	6.6	3.3	31.6	22.6	12.8	9.7	14.2	10.9
Education level (score)	1.58	1.20	1.74	1.06	1.46	1.18	1.6	1.2
Age (years)	47.6	53.0	51.3	58.6	50.8	50.9	49.3	53.5
Marital status (1 if married, 0 otherwise)	1.0	0.4	1.0	0.9	0.9	0.3	1.0	0.5
Married (years)	27.0	36.6	29.1	36.8	30.2	31.0	28.3	34.2
Earning members (males)	1.89	1.50	1.59	1.38	1.82	0.93	1.80	1.22
Earning members (females)	1.69	1.65	1.27	1.31	0.74	1.00	1.36	1.28
Health status (6 point scale)	1.50	2.20	1.42	1.31	1.76	2.11	1.55	1.94
Farming experience (years)	24.0	26.5	22.5	20.9	32.7	29.1	25.7	26.2
Livestock ownership (%)	54.2	40.0	41.0	31.3	99.6	96.4	61.8	62.5
Adoption of farm mechanization (%)	78.7	75.0	28.2	25.0	37.7	17.9	56.5	37.5

In Karnataka there is significant difference between the incomes and per capita income of the two types of households. The net income of male and female households are respectively ₹ 351,979 and ₹ 144,062 showing that there is significant difference between the incomes generated by the two types of households. In Andhra Pradesh, there is not much difference with respect to many other socioeconomic variables. Livestock ownership of male and female households is 41% and 31.3% respectively.

In Rajasthan, female households have much lower income (₹ 22,468) compared to male households (₹ 113,773). The per capita income also differs drastically between male and female households. Livestock ownership is 99.6% of male households and 96.4% of female households. Figure 6 gives a comparison of the net farm revenue, off-farm income and net income for the two types of households in the three states.

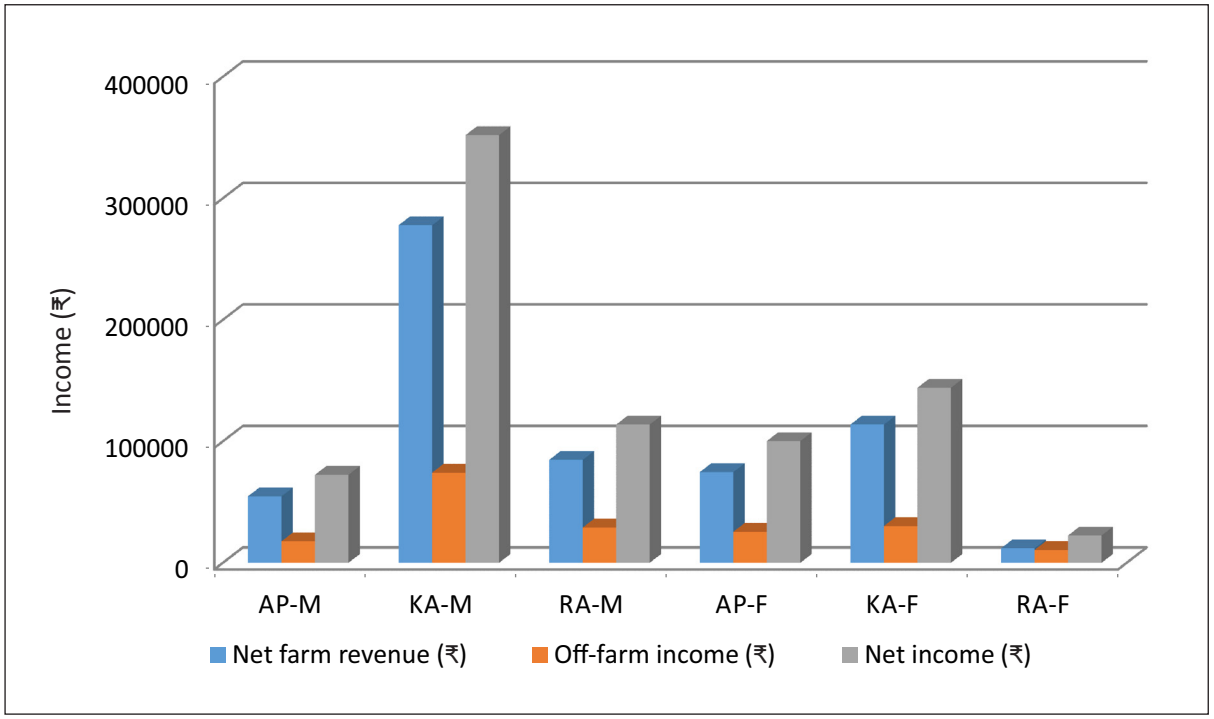

Figure 6. Gender-wise income of households in the study area (Note: AP = Andhra Pradesh; KA = Karnataka; RA = Rajasthan; M = Male; F = Female).

7.7 Determinants of household income

It is generally hypothesized that the income of the households depends on many farm specific and socioeconomic variables. In order to elucidate the determinants, a linear regression model was formulated with net income per hectare of the household as dependent variable; and farm specific parameters (farm size, livestock ownership, farm mechanization and providing supplemental irrigation) and socioeconomic parameters (household size, age, farming experience, etc.) as independent variables. The regression analysis was done gender-wise as it will help to identify the determinants of net income for the two types of households separately. The results of regression analysis show that farm size, household size, distance to market for sales, owning livestock, farm mechanization, providing supplemental irrigation and regions (locations of the farms – Karnataka and Rajasthan) are the important determinants of income of male households as the coefficients of these variables are statistically significant (Table 12). Similarly, for female households, farm size, owning livestock, providing supplemental irrigation and region (location of the farms – Karnataka) are important determinants. The marginal effect of each significant variable is provided in Table 13.

In male households, who possess an average of 2.93 ha, the marginal effect of farm size on net income per ha is ₹ 1,854, i.e., for every hectare of increase in farm size, the farmer will get additional net income of ₹ 1,854 (Table 13). Similarly, for every one member addition in the family, the net income per ha increases by ₹ 2,375 implying the importance of family labor contribution to crop production in dryland systems. Male households on an average travel about 15 km for selling their agricultural products. The marginal effect of this variable is ₹ 431. This shows that they have to travel to the locations where there is demand for the products. Livestock ownership which has 62% in the sample, has a high marginal effect of ₹ 25,425 thus indicating the major contribution of livestock in enhancing the household income. Similarly, adopting farm mechanization and providing supplemental irrigation will have marginal incomes of ₹ 18,376 and ₹ 30,215 respectively. These marginal incomes are higher when compared to the

Table 12. Determinants of income: gender-wise[1].

	Male households			Female households			All households		
Variable	Coefficient	SE	p-value	Coefficient	SE	p-value	Coefficient	SE	p-value
(Constant)	-15575.7	17501.6	0.374	38654.6	45045.6	0.396	-12043.6	14439.7	0.404
Household specific variables									
Household size	2375	1230.6	0.054*	-4582.9	4813.2	0.346	2064.5	1182.2	0.081*
Household education	3552	2155.5	0.1	-15557.4	15356.6	0.317	3429.5	2109	0.104
Household age	-227.4	346	0.511	-725.3	1069.7	0.501	-313.3	326.8	0.338
Household marital status	-957.7	12371.3	0.938	-9374.9	19168.5	0.627	-786.5	8858.9	0.929
Married (years)	366.1	295.4	0.216	-932.7	1225	0.451	357.8	280	0.202
Earning male members	3131.3	2594.9	0.228	6796.8	13924.9	0.628	3827.1	2527.2	0.13
Earning female members	-1512.9	2646.1	0.568	-8939.6	13104.3	0.499	-2156.2	2567.2	0.401
Health status	-2574.7	2262.4	0.255	-1836.6	6521.1	0.78	-2719.4	2127.8	0.202
Experience in farming	-115.5	229.1	0.614	1540.4	962.5	0.117	-17.8	218.8	0.935
Farm specific variables									
Farm size	1854.4	623.5	0.003***	13246.6	7264.8	0.075*	-1690	616.3	0.006***
Distance to market for sales	430.8	80.9	0.000***	-424.4	1118.6	0.706	433.2	80.3	0***
Livestock ownership	25425.3	4698.2	0.000***	46909.7	23550.4	0.053*	25110.5	4566.6	0***
Farm mechanization adopted	18376.3	4850.9	0.000***	34753.6	22383.3	0.128	18358.3	4680.4	0***
Supplemental irrigation provided	30215	6559.3	0.000***	67268.8	27903.4	0.020**	33201.5	6361.2	0***
Location of farm (Karnataka)	63607	6571.8	0.000***	84971.1	41005.3	0.044**	62089.8	6377	0***
Location of farm (Rajasthan)	20167.8	7162.3	0.005***	-34284.7	29742.5	0.256	15864.1	6825.7	0.02**
R2	0.256			0.426			0.25		
Sample size	890			59			949		

1. Dependent variable = Net income per hectare. *, ** and *** = Significant at 10%, 5% and 1% levels respectively.

Table 13. Marginal effect of the determinants of net income.

	Male household		Female household	
Variable	Mean	Marginal income increase (₹ ha^{-1})	Mean	Marginal income increase (₹ ha^{-1})
Farm size (ha)	2.93	1,854	2	13,247
Household size (no.)	5.02	2,375	-	-
Distance to market for sales (km)	15.11	431	-	-
Livestock ownership (%)	62	25,425	61	46,910
Farm mechanization adopted (%)	61	18,376	-	-
Supplemental irrigation provided (%)	12	30,215	8	67,269
Location of household (Karnataka) (%)	25	63,607	27	84,971
Location of household (Rajasthan) (%)	22	20,168	-	-

cost of these interventions which roughly cost about ₹ 3,000-7,000 for small farm mechanization under custom hiring and ₹ 13,000 for providing supplemental irrigation. Compared to farmers in Andhra Pradesh which is comparatively more risk prone in terms of rainfall variation and income generation activities, farmers in Karnataka region can have a higher additional income of ₹ 63,607 whereas those located in Rajasthan can expect an additional income by ₹ 20,168. Thus we conclude that for male households, farm specific activities, viz., livestock ownership, farm mechanization and supplemental irrigation should be encouraged for getting higher income.

For female households, the average farm size is 2 ha with a marginal income of ₹ 13,247 per hectare (Table 13). This is comparatively higher than that of male households which is ₹ 1,854 only. About 61% of the female households possess livestock which will fetch them an additional income of ₹ 46,910. Providing supplemental irrigation is more profitable which will increase the income per hectare by ₹ 67,269 compared to the cost of ₹ 19,000 per hectare. Thus it can be concluded that for female households also, farm specific activities like, livestock ownership and providing supplemental irrigation will bring in higher income.

7.8 Household vulnerability: Gender-wise

Vulnerability mapping of households in the three states: gender-wise

The three stage feasible least squares procedure was applied to the survey data and probability of per capita income falling below the poverty line was worked out as per the methodology. The cutoff limit, viz., ₹ 100 per day was used to estimate the probabilities of poverty transitions. The results for male and female households are plotted in Figures 7 and 8. Logarithm of income is plotted against probability in these figures. The vertical line specifies the 50% probability and the horizontal line corresponds to logarithm of poverty threshold of ₹ 36,500 per year. These two lines divide the figure into four parts. The upper left part corresponds to those farmers whose present income is below the threshold and there is more than 50% probability that they will continue to be vulnerable. Points lying in the upper right part correspond to those households who are above the poverty threshold this year (2013) and have more than 50% probability to continue the same status next year (2014) also (less vulnerable). Households who are vulnerable now and have less than 50% change to move from that status next year (2014) are represented by the lower left part (vulnerable to less vulnerable). The lower right part specifies those households who are less vulnerable now (i.e., above poverty threshold) but less than 50% change to move from that status next year (2014) (less vulnerable to vulnerable).

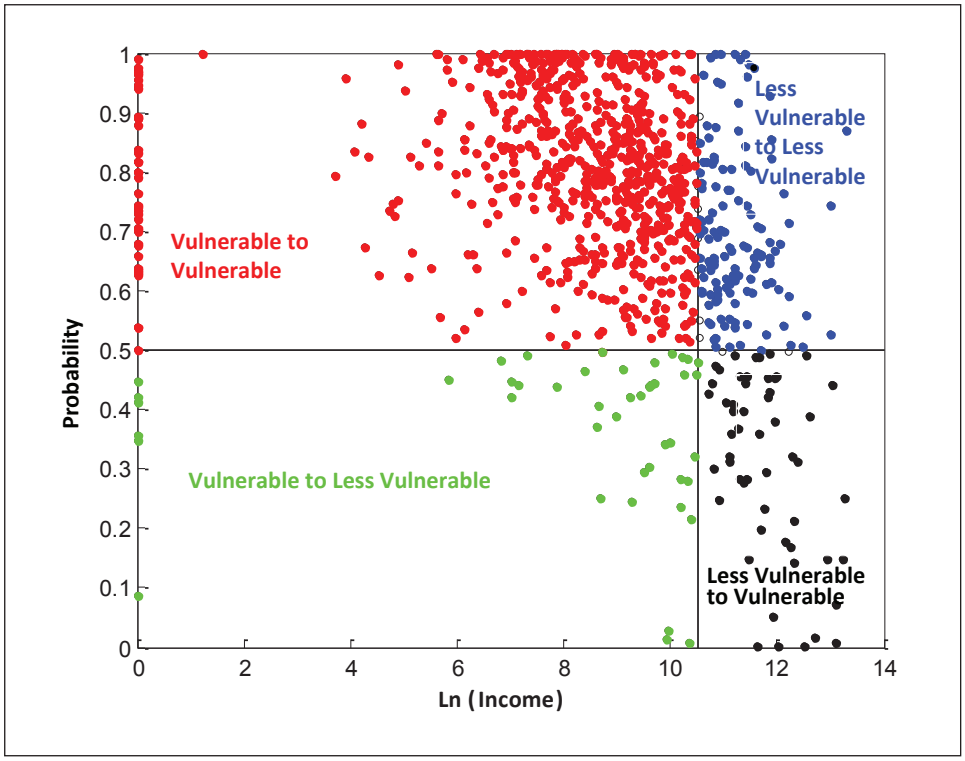

Figure 7. Male household vulnerability (income at ₹36,500 per year) plotted against Ln (income).

Table 14. Possible poverty transitions (with probability >0.5) among households of study area for per capita income of ₹ 36,500 per year.

	No. of households				
	Vulnerable to		Less vulnerable to		
Gender	Vulnerable	Less vulnerable	Vulnerable	Less vulnerable	Total
Male	720	44	57	134	955
Female	50	8	0	6	64

Of 764 male households who are vulnerable to poverty now, 720 of them are likely to continue to be vulnerable with probability more than 0.5 (Table 14), i.e., about 94% will continue to be vulnerable. In the case of female households, out of 58 vulnerable households, 50 (86%) will continue to be vulnerable with more than 50% probability. The statistical test for the equality of proportions rejected the null hypothesis that the proportions are equal. So we conclude that female households are relatively better than male households in transition from vulnerable to vulnerable.

Similarly out of 191 less vulnerable male households, 134 (70%) will continue to be less vulnerable. But all the six female households who are less vulnerable now will continue to be less vulnerable. However, these observations have certain limitations because of comparatively small number of female households in the sample.

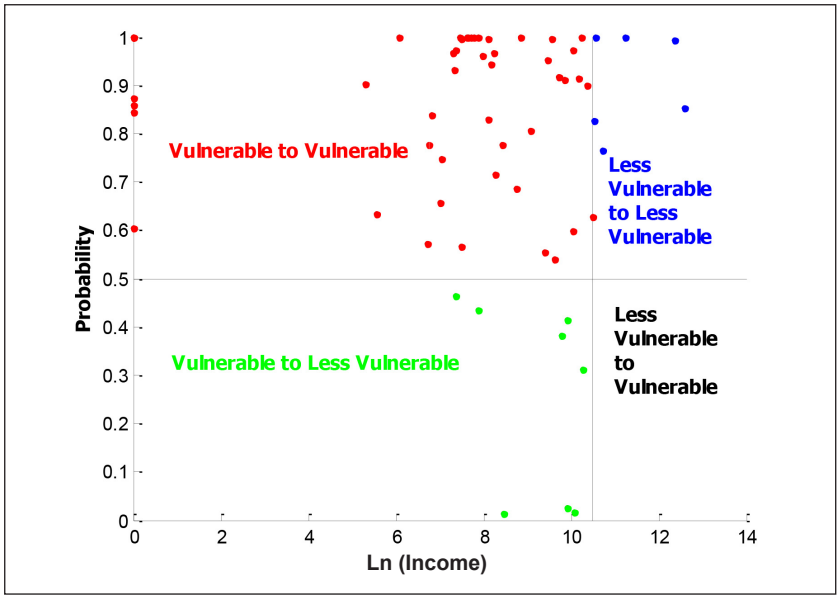

Figure 8. Female household vulnerability (income at ₹ 36,500 per year) plotted against Ln (income).

7.9 Adaptation strategies to address vulnerability: gender-wise

As already discussed in section 7.5, households adopt many adaptation strategies. In fact, many households follow more than one strategy. The most commonly used strategies and also strategies that will provide some additional income are listed below:

1. Improved crop production practices (FIC)
2. Owning livestock (LSW)
3. Changing planting date (CPD)
4. Additional skill development activities in farming (ASD) (i.e., skill oriented training on specific activities such as use of sprinklers, use of small machineries, integrated pest management, etc.)
5. Farm mechanization (FMM)
6. Providing supplemental irrigation (PSI)
7. Maintaining poultry and goats (MPG)

In total, 128 combinations of strategies are possible. However, in Andhra Pradesh, 60 combinations of strategies have been observed for male households and 11 for female households; while in Karnataka, 53 and 12 combinations respectively and in Rajasthan, 12 and 4 combinations of strategies respectively have been observed. An analysis was done to find out the most profitable (in terms of net income per ha) combination of strategies for each state gender-wise. Tables 15 and 16 give the first four combinations of strategies that will provide maximum net return in Andhra Pradesh. Pure rainfed male farmers with no adaptation strategies will earn only ₹ 8,788 as average net income per ha (Table 15). But when all the seven strategies are used, the male households can expect a maximum profit of ₹ 0.25 million ha^{-1}. When all strategies without livestock are used the expected net income per ha is ₹ 0.15 million. Hence, the marginal contribution of livestock ownership to net income is ₹ 0.10 million. Similarly when all strategies except change in planting date and additional skill development activities are followed, the net income realizable is ₹ 0.13 million ha^{-1}. Finally when change in planting date, additional skill development activity in farming and maintaining goats and poultry are omitted from the combination of strategies, the net income reduces to ₹ 0.01 million. Further, following improved crop production practices, farm mechanization and providing supplemental irrigation are common to all the four combination of strategies. Hence, these three strategies should be promoted for adoption.

Table 15. Most profitable combination of adaptation strategies for male households of Andhra Pradesh.

Combination of strategies	No. of farmers	Average net income (₹ ha^{-1})
Rainfed only	23	8,788
FIC+LSW+CPD+ASD+FMM+PSI+MPG	2	259,441
FIC+CPD+ ASD+FMM+PSI+MPG	1	154,872
FIC+LSW+FMM+PSI+MPG	1	136,090
FIC+LSW+FMM+PSI	1	99,949

Table 16. Most profitable combination of adaptation strategies for female households of Andhra Pradesh.

Combination of strategies	No. of farmers	Average net income (₹ ha^{-1})
Rainfed only	1	3,987
FIC+LSW+FMM+PSI	1	361,683
LSW	2	46,314
FIC+LSW+ASD+FMM+PSI	1	42,686
LSW+FMM	2	30,685

Table 16 shows the profitable adaptation combinations for female households. The average net income of female household is ₹ 3,987 ha^{-1} only when adapted to rainfed. The most profitable combination of strategies is improved crop production practices, livestock ownership, farm mechanization and providing supplemental irrigation. This combination of strategies will fetch the highest net income of ₹ 0.36 million ha^{-1}. All other three combinations have less than ₹ 50,000 ha^{-1} as the average net income.

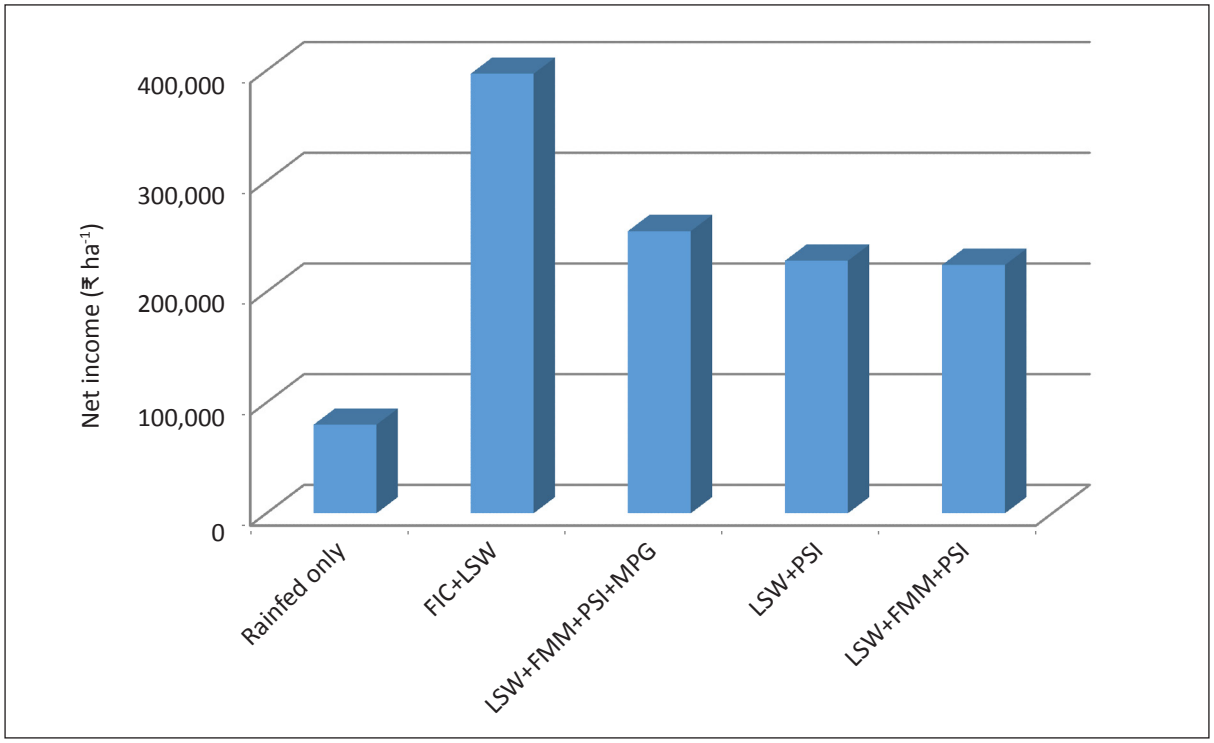

Figure 9. Most profitable combination of adaptation technologies for male households of Karnataka.

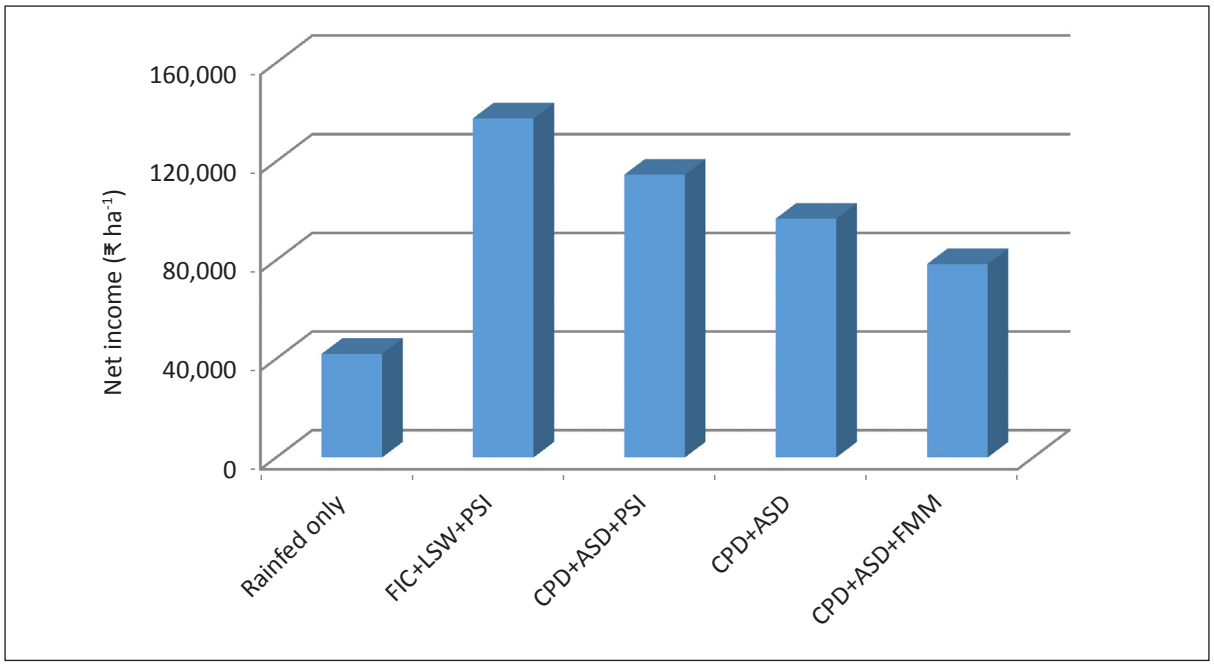

Figure 10. Most profitable combination of adaptation technologies for female households of Karnataka.

For male households of Karnataka, the expected net income is ₹ 80,054 ha^{-1}. But improved crop production practices (fertile soils and improved crop varieties) along with livestock production will give a maximum net income of ₹ 0.39 million ha^{-1} (Fig. 9) and this combination is recommended as a better package for adoption. Other three combinations will give a net income in the range of ₹ 0.22–₹ 0.25 million ha^{-1}.

For female households of Karnataka, the net realizable income for rainfed is ₹ 41,992 ha^{-1} only. But with improved crop production practices, owning livestock and providing supplemental irrigation the income can be raised to a maximum of ₹ 137,489 ha^{-1} (Fig. 10). Change in planting date and additional skill development activities in farming are common in the remaining three combinations.

In case of Rajasthan, male households, rainfed farming will fetch only ₹ 7,204 ha^{-1}. Livestock ownership and farm mechanization are most commonly used strategies. This combination will fetch a net income of ₹ 78,584 ha^{-1} only (Table 17). If farmers provide supplemental irrigation and maintain poultry and goats, a maximum net return of ₹ 148,514 ha^{-1} can be obtained. So the additional contribution of providing supplemental irrigation and maintaining poultry and goats is ₹ 69,930 ha^{-1}. Hence these four strategies are recommended.

Table 17. Most profitable combination of adaptation strategies for male households of Rajasthan.

Combination of strategies	No. of farmers	Average net income (₹ ha^{-1})
Rainfed only	1	7,204
LSW+FMM+PSI+MPG	1	148,514
FIC+LSW	2	137,729
LSW+FMM+PSI	9	98,231
LSW+FMM	60	78,584

Table 18 gives the profitable strategies for female households of Rajasthan. It shows livestock ownership and farm mechanization are most suitable as this combination will fetch a net return of ₹ 48,384 ha^{-1}.

Table 18. Most profitable combination of adaptation strategies for female households of Rajasthan.

Combination of strategies	No. of farmers	Average net income (₹ ha^{-1})
Rainfed only	0	-
LSW+FMM	4	48,384
LSW+FMM+MPG	1	5,413
LSW	14	4,839
LSW+MPG	4	2,521

Hence it is important to see how best these adaptation strategies are piloted and upscaled in the dryland systems in order to minimize the number of households falling under vulnerability grouping. Studies have shown that by incorporating different adaptation strategies in the drylands systems, it is possible to shift the household vulnerability groups from vulnerable to less vulnerable (Palanisami et al. 2014b). Also risk in the adaptation of these technologies can be well addressed when the households start adopting them. The benefit generated by adoption can be considered as the risk premium. As the risk premium increases, adaptation of these strategies also increases (Koundouri et al. 2003, Palanisami et al. 2014a).

8. Conclusions

The effects of climate change on gender constitute a major component in the international agenda that mostly focuses on less developed regions of the world. In all the three states, drought was the most severe shock encountered by both types of households and female households encountered slightly more than that of males. However, perception about the climate change impacts with respect to illness of family members due to extreme weather, loss of income and food insecurity varied significantly across the regions. Regarding the coping strategies, changes were seen in crop production activities and skill development activities which had helped in the adoption of crop production practices and providing supplemental irrigation.

In all the three regions, there was significant difference between the household incomes and per capita income of the gender groups. The major determinants of income variation or household vulnerability for male farmers were farm size, household size, distance to market for sales, owning livestock, farm mechanization, providing supplemental irrigation and location of the farm. Similarly, farm size, owning livestock, providing supplemental irrigation and location of the farm were the important determinants for female households. The female households offered more opportunities for making joint decisions compared to the male households.

As a consequence of existing income differences, about 94% of the male households will continue to be vulnerable next year (2014) also. In the case of female households, 86% will continue to be vulnerable next year (2014) also. Female households will be relatively better than male households in the transition from vulnerable to less vulnerable possibly indicating that female households will be more responding to income enhancement strategies. There are various adaptation strategies to address the vulnerability such as improved crop production practices, owning livestock, changing planting dates, additional skill development, farm mechanization, providing supplemental irrigation and maintaining poultry and goats. Different regions respond better to different combination of strategies for income enhancement of the households. Based on these observations, the following recommendations are drawn from the results of the analysis.

9. Recommendations

In order to improve the income level of the households, the major determinants identified in the study should be addressed. Improving livestock breeds and technologies, providing supplemental irrigation and farm mechanization are found to be particularly important.

As female households are comparatively less vulnerable, even though their transition from vulnerable to less vulnerable is much less, efforts to move them from the vulnerable category are important. Strategies such as enhanced skill development activities will be much effective. Adequate and focused skill oriented training programs to the households in selected technology adoption can be provided. In particular, technologies relating to soil and moisture conservation through small farm implements and use of sprinkler irrigation for supplemental irrigation can be focused under specialized training programs in the villages through the involvement of regional agricultural research stations and micro-irrigation companies. A public–private partnership (PPP) model can be developed for each of these interventions so that technology adoption will be easy and affordable by the small and marginal farmers. The transaction cost which is one of the constraints in technology adoption can be minimized through PPP models. Such PPP models can be later developed as “business cases” for upscaling.

Livestock production has been observed as one of the coping strategies in most of the regions and hence special programs on farm-level fodder production and livestock maintenance can be initiated by converging the ongoing government programs. There is a need to further improve farm mechanization due to labor scarcity and to perform timely farm operations.

As most of the households in drylands systems are risk averse in nature, in order to minimize the risk in crop and livestock production, a weather-based hybrid insurance product (mix of crop and livestock products) can be examined by involving the existing insurance providers in the region.

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