

Indigenous knowledge about climate change: Validating the perceptions of dryland farmers in Tamil Nadu

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Climate change is expected to adversely affect agricultural production in India. This study was undertaken to understand the dryland farmers' perceptions about climate change, its impacts and indigenous adaptation measures they pursue. From the analysis of data collected from 200 dryland farmers of Villupuram and Virudhunagar districts in Tamil Nadu, it was found that 81 % of farmers experienced climate change in terms of decreasing and unpredictable rainfall, increasing temperature and delayed onset of monsoon. Analysis of climate trend validated their perceptions. Farmers are convinced that climate change has affected their farming through frequent crop failures, declining crop and livestock yield, reduced water level in tanks and wells and new pest and diseases. Amidst various constraints, farmers strive to adapt to climate change by manipulating sowing date, reducing fertilizer application, selecting alternate crops and drought tolerant varieties, etc. Elderly farmers adapt more to climate change while access to irrigation gives leverage to try alternate farming practices.

Keywords: Climate change, Perception, Impact, Adaptation, Adoption

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During the past century, the atmospheric temperature had increased by 0.74°C due to unscrupulous anthropogenic green house gas emissions. This trend is going to aggravate by the year 2100, with a probable average global temperature rise of 1.8°C to 4.0°C and a possible maximum rise of up to 6.4°C. The consequence of global warming has already manifested in the form of frequent occurrence of warm and drought years, decline in glaciers and snow cover, heavy precipitation and flash floods, sea level rise, etc. It is very likely that such extreme events will continue to become more frequent, posing potential threat to ecosystems especially agricultural production and productivity throughout the world. Adding to the misery, non-climatic stresses such as population, poverty, unequal access to resources, etc. are increasing the vulnerability of the system by reducing its adaptive capacity¹. The impact of such an unprecedented climate change would be particularly severe in the tropical areas, which mainly consists of developing countries, including India². Many studies have analysed the changing trend of temperature and

rainfall over different regions of India and examined its impacts on growth, development and yield of different crops³.

To mention a few, the decreasing trend in the mean annual rainfall has disturbed the crop acreage, duration and productivity in Karnataka⁴, while consistently rising temperature and varying rainfall patterns over Haryana and Bihar have negatively affected the yield of wheat⁵. Similarly, decreasing chill units at lower altitudes and increasing chill units at higher altitudes have forced the apple cultivation in Himachal Pradesh to expand towards higher altitudes⁶. On the other hand, although no clear trend has emerged in the rainfall pattern over some regions like North-Eastern India and Mahanadi River Basin, temperature is definitely showing a rising trend^{7,8}.

Policy response to climate change includes mitigation of green house gases that contribute to the adverse changes in the Earth's climate, and adaptation to potential impacts caused by the changing climate⁹. As the developed and developing countries are still at loggerheads regarding whom to bear the responsibility for reducing green house gases, there is an urgent need to explore suitable adaptation strategies which make ecosystem more resilient to

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absorb larger shocks due to climate change¹⁰. In doing so, one must take into account local community's understanding of climate change, because even though climate change is a global phenomenon, adaptation is largely site specific¹¹. Moreover, indigenous knowledge is borne out of continuous experimentation, innovation and adaptations, blending many knowledge systems to solve local problems¹².

Hence, a better understanding of farmers' perceptions of climate change, its impacts on agriculture, ongoing adaptation measures and the factors influencing in adopting them is needed to craft policies and programmes aimed at promoting successful adaptation of the agricultural sector^{13,14,15,16,17}. In this milieu, this study has been undertaken in Tamil Nadu focussing on the dryland farmers of Villupuram and Virudhunagar districts, because they are the most ecologically, socially and politically marginalized, lagging behind on most economic and health indices; and that climate change will be yet another stress in a vulnerable system because of their geographic exposure, low incomes, greater reliance on climate sensitive sectors and weaker capacity to adapt¹⁸.

Study area

This study is a part of the Ph.D. research work titled "Efficacy of Weather Based Crop Insurance as an Adaptation Strategy to Climate Change" of first author. To begin with, a detailed vulnerability mapping of Tamil Nadu agriculture to climate change was done to identify the vulnerable districts. Using a variety of indicators, *viz.*, growth and instability in – south west monsoon rainfall, north east monsoon rainfall, area and yield of 13 major crops; growth in - Crop Diversification Index, Net Cultivated Area and Cropping Intensity Index, it was found that apart from erstwhile Thanjavur and Pudukottai districts which were less vulnerable, all other districts fall under different categories of perceptible vulnerability. Based on the results of vulnerability analysis and considering the presence of Weather Based Crop Insurance Scheme (WBCIS), Villupuram of erstwhile South Arcot district (Vulnerable) and Virudhunagar of erstwhile Ramanathapuram district (Vulnerable) were selected as representatives of ICICI-Lombard and Agricultural Insurance Company of India operated districts respectively. Marakkanam, Gingee, kallakurichi and Chinnasalem blocks of Villupuram and Kariapatti, Tiruchuli, Narikudi and Vembakottai

blocks of Virudhunagar were randomly selected in consultation with the experienced Agricultural Officers at the District level Joint Director Office. Further, Siruvadi, Sathyamangalam, Indhili, Nayinarpalayam, Mudukankulam, Mandabasalai, Veeracholan and Edhirkottai firkhas (An administrative unit of a group of revenue villages) of each of the above blocks were randomly chosen in consultation with the experienced Agricultural Officers of the respective block level Assistant Director Office. Thus, 25 farmers from each *firkha* were randomly surveyed during June-July 2012 amounting to 200 farmers across 122 villages.

Data

This study is principally based on the primary data obtained from the farmers using a structured schedule. Information regarding their perceptions about climate change, its impacts on agriculture and various adaptation measures they practice to overcome its adverse impacts were recorded. To validate their perceptions, long term temperature and rainfall trend of the regions were analysed using the data obtained from India Meteorological Department, Pune and Season and crop Report, Government of Tamil Nadu.

Methodology

Descriptive statistics has been used to provide insights into farmers' perceptions while Microsoft Excel has been used to analyse the meteorological data to present the patterns and trends in the form of graphs.

The adaptation strategies practised by farmers were analysed using Garrett Ranking Technique which identify and rank various strategies based on the calculated mean score. The prime advantage of this technique over simple frequency distribution is that the strategies are arranged based on their importance from the point of view of respondents. Hence, the same number of response on two or more strategies may get different ranks. Garrett's formula for converting normal rank into percent was given by:

$$\text{Per cent position} = 100 \times (R_{ij} - 0.5) / N_j$$

where,

R_{ij} = rank given for i^{th} factor by j^{th} individual;

N_j = number of factors ranked by j^{th} individual

The per cent position of each rank is converted into scores referring to the table given by Garrett & Woodworth (1969). For each strategy, the scores of individual respondents are added together and divided by the total number of the respondents for whom scores are added. These mean scores for all the factors are arranged in descending order, ranks are given and most important factors are identified.

Binary logit model has been used to analyse the factors influencing the farmers to adopt various adaptation measures to overcome the adverse impacts of climate change. In order to determine whether adaptation is undertaken in response to observation to climate change, a probability model is used where the binary dependent variable is a dummy for undertaking any adaptation at all (*i.e.* Y_i has only two possible values 1 or 0, for either adapting or not adapting to climate change). Thus,

$$Y_i = X_i a + \varepsilon_i$$

It is assumed that the probability of observing farmer “i” undertaking any adaptation at all ($Y_i = 1$) depends on a vector of independent variables (X_i), unknown parameters (α), and the stochastic error term (ε_i). The probability of observing farmer “i” undertaking any adaptation at all, $P(Y_i = 1/X_i)$ has empirically been modelled as a function of independent variables such as age, education, farming experience, family size, social participation, farm

holding size, access to irrigation, livestock ownership, off-farm occupation and access to credit.

Results and discussion

Socio-economic characteristics of sampled households

The socio-economic characteristics of the farm household are believed to have differential impacts on a farmer’s perception about climate change and his ability to adapt to it (Table 1). The age of the farmer represents his experience in farming. The experienced farmers are expected to have a higher probability of perceiving climate change as they are exposed to past and present climatic conditions over a longer horizon of their life span. On an average, the sampled farmers were 57 yrs of age with 37 yrs of farming experience. Attaining higher levels of education helps farmers to access information on improved technology and resources. Around one-third of the sampled farmers fall under each category of uneducated, primary and secondary level of education, and only 3.5 % of them have attained graduation. A larger family is normally associated with a higher labour endowment. The average size of the sampled households is 5 persons and one adult from almost all the households were going for work under Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS). About 14 % of the sampled farmers have associated themselves with one or other social groups like

Table 1— Socio-economic characteristics of sampled farm households

Sl.No.	Particulars	Villupuram	Virudhunagar	All farmers
1.	Sample size	100	100	200
2.	Average age of the farmers (years)	57	57	57
3.	Average farming experience of the farmers (years)	35	38	37
4.	Family size (No.)	4.7	6	5
5.	Club membership (yes=1; otherwise=0)	15	12	27 (13.5)
6.	Remittance (yes=1; otherwise=0)	89	88	177 (88.5)
7.	Livestock (yes=1; otherwise=0)	75	45	120 (60)
8.	Irrigation source (yes=1; otherwise=0)	92	30	122 (61)
9.	Off-farm occupation (yes=1; otherwise=0)	39	45	84 (42)
10.	Institutional credit (yes=1; otherwise=0)	52	58	110 (55)
11.	Holding type (No.)			
	Marginal (< 1 ha)	31	30	61 (30.5)
	Small (1 – 2 ha)	35	30	65 (32.5)
	Large (> 2 ha)	34	40	74 (37)
12.	Education (No.)			
	Uneducated	36	33	69 (34.5)
	Primary	28	30	58 (29)
	Higher secondary	29	37	66 (33)
	Graduation	7	0	7 (3.5)

Note: Figures in the parentheses indicate percentage to total.

Farmers Club, Self Help Groups (SHGs) and Joint Liability Groups to obtain loan from public sector banks.

Livestock plays a very important role in agriculture especially in dryland areas by serving as a store of value, source of traction and provision of manure to enrich the soil fertility. About 60 % of the sampled farmers possessed livestock such as bullock, cow, goat, sheep and poultry. While 92 % of the sampled farmers in Villupuram district had the advantage of irrigation in the form of bore wells or wells, only 30 % of their counterparts in Virudhunagar district could extract ground water as the water in that region is not highly suitable for irrigation. Keeping agriculture as main activity, over 40 % of the sampled farmers engaged in other occupations like farm business, hiring out farm labour and tractor, sale of irrigation water, charcoal making and other non-farm activities. Availability of credit eases the cash constraints and allows farmers to buy high value inputs like fertilizers. But only 55 % of the sampled farmers were able to access institutional credit in the study area. Though they are privileged to get interest less crop loan, they have to hypothecate jewels as security. All the sampled farmers were equally distributed across the marginal, small and big categories of farm holdings.

Perceptions about Climate change

The success of any adaptation strategies practised by farmers or implemented by the institutional agencies depends on their tendency to perceive and react favourably towards changes in climate and environment¹⁹. In the study area, about 162 of the 200 sampled farmers had perceived climate change in terms of various meteorological indicators (Fig. 1). Among them, 40 per cent of farmers observed that the quantity of rainfall has been decreasing over the years. The onset of monsoon was perceived by 38 % of farmers to be delayed nowadays than before. Even as 36 % of farmers reported increasing temperature, few among them felt that summer is extending. Another 36 % of the opinion was that the rainfall pattern has become more erratic and unpredictable than before. 16 % of farmers had perceived that the monthly frequency of rains has decreased with extended dry spells. 14 % and 9 % of farmers were observing frequent monsoon failures and increased drought years respectively. While 7 % of farmers could observe increased occurrence of heat waves, 6 % of farmers asserted that cyclones have replaced northeast monsoon in giving rains.

The perceptions of the sampled farmers were found to conform with the perceptions of farmers in many African countries and Eastern Himalayas^{11,13,16,19,20,21,22,23, 24,25,26,27,28,29,30,31}.

Actual Climate trend of Villupuram district

To validate the perceptions of the sampled farmers, the long term data on temperature and rainfall pertaining to the study districts were analysed.

The analysis of the long term average summer temperature (March-May) of Villupuram has shown a consistently increasing trend between 1994 and 2011 (Fig. 2).

Regarding rainfall, Fig. 3 clearly elucidates a highly erratic pattern of northeast monsoon (October-December) in Villupuram during 1994-95 to 2009-10. As the southwest monsoon's (June-September) trend is not showing any perceptible fluctuations over the years,

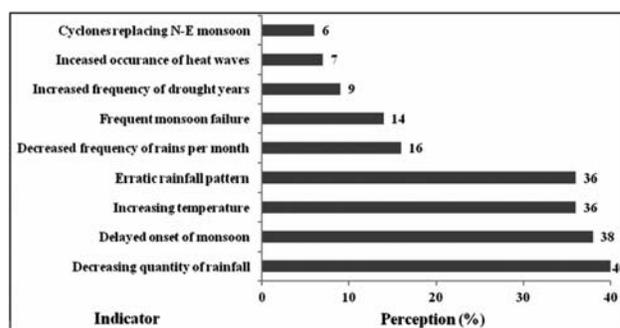


Fig. 1—Farmers' perceptions about climate change

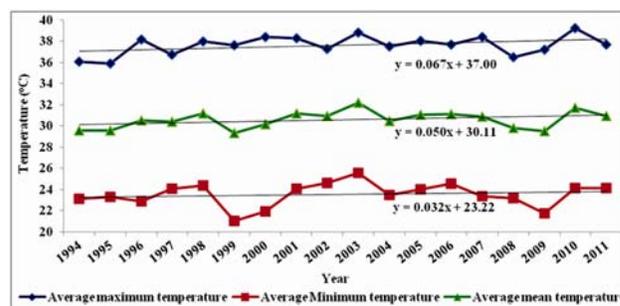


Fig. 2—Trend of summer temperature in Villupuram: 1994 to 2011

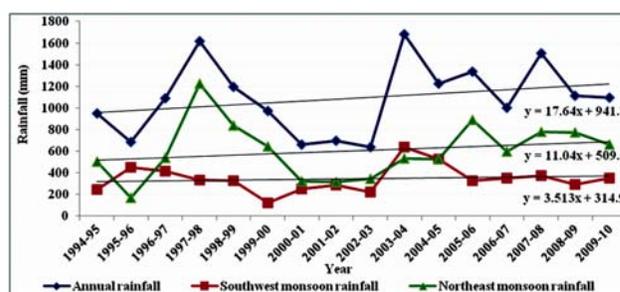


Fig. 3—Trend of rainfall in Villupuram: 1994-95 to 2009-10

the erratic trend of northeast monsoon has exactly replicated on the trend of annual rainfall of the district. Though the trend lines reveal an increasing quantity of rainfall over the years, the southwest monsoon rains have decreased since 2003-04 while the northeast monsoon rains were decreasing since 2005-06.

Actual Climate trend of Virudhunagar district

From the Fig. 4, it can be inferred that the average maximum temperature during summer months has been slightly declining in Virudhunagar since 1985. At the same time, the pattern of average minimum summer temperature shows an increasing trend. This pattern is found consistent with the trend observed in the Mymensingh region of Bangladesh³², Uttarakhand³³ and Kerala³⁴.

Similar to the trend observed in Villupuram, the rainfall pattern of Virudhunagar district is also highly fluctuating between years since 1985-86 (Fig. 5). But unlike in Villupuram, both southwest monsoon and annual rainfall are decreasing over the years. Even the overall increasing trend of northeast monsoon could not offset the decreasing trend of annual rainfall because of its declining trend since 2005-06.

Thus the above analysis has clearly substantiated the perceptions of Villupuram and Virudhunagar farmers about climate change.

Perceived Impacts of Climate change on Agriculture

Among the 162 farmers who perceived climate change, 125 farmers reported that climate change has affected their farming in one way or other (Fig. 6). About 63 % of farmers claimed that untimely rainfall occurring either early or late in the season greatly constrains the performance of the crop, by encouraging weeds in the first case and damaging the crop in the second case, ultimately leading to crop failure. According to 60 % of farmers crop yield has been declining over the years while one-third of farmers perceived declining water level in wells and tanks. While 13 % of farmers experienced more pest and disease incidences, 23 % of farmers could notice new pests like scale insect in cotton and stem borer in paddy.

About 20 % of farmers reported declining livestock yield. The cropping pattern has undergone a sea change, according to 15 % of farmers as long duration crops and varieties are getting replaced by short duration ones due to dearth of water. Going by the opinion of 12 % of farmers, the cropping season has

delayed by one to two months as the first rains of the monsoon are arriving late. In addition, 9 % of farmers were struggling to choose the crop for the season due to unpredictability of rainfall.

Adaptation strategies to Climate change

Traditionally farmers practise various adaptation strategies to secure both their occupation and income from the adversities caused by changing climate.

Farm management strategies

Perusal of various farm management strategies practised by farmers showed that inter/mixed cropping (e.g. sugarcane + groundnut, watermelon + groundnut) is the foremost strategy adopted by Villupuram farmers followed by alternate cropping with short duration vegetables (Table 2). Farmers usually manipulate the sowing date in accordance with the arrival of monsoon rains and reduce fertilizer

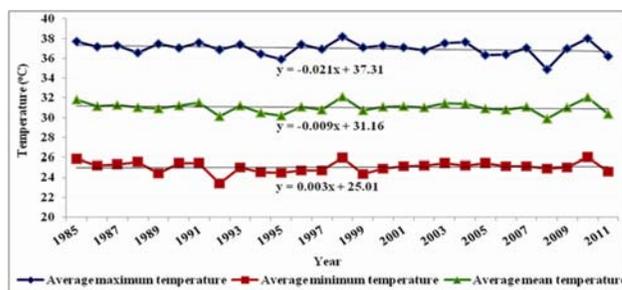


Fig. 4—Trend of summer temperature in Virudhunagar: 1985 to 2011

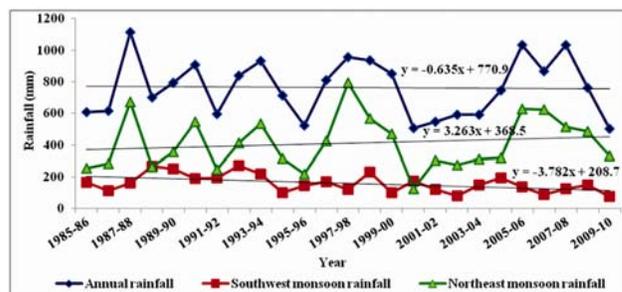


Fig. 5—Trend of rainfall in Virudhunagar: 1985-86 to 2009-10

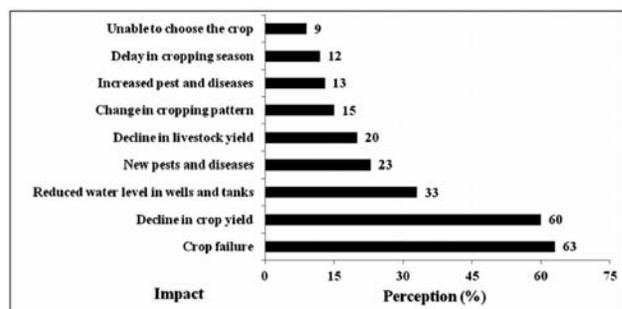


Fig. 6—Perceived impacts of climate change

application based on the reduced water availability. Moreover, they have to forego considerable area without cultivation to efficiently utilise the available water. A diversified crop rotation (e.g. groundnut-blackgram-watermelon-groundnut-paddy in Marakkanam block) is also a feature of this district.

The principal farm management strategy practised by Virudhunagar farmers is manipulating the sowing date followed by inter/mixed cropping (e.g. green gram and black gram in cotton as mixed crop and inter crop respectively in Thiruchuli block). They incorporate different varieties of paddy having different durations as a minimum guarantee strategy (e.g. Kariapatti and Thiruchuli blocks). Similarly, they shift to alternate crops and contingent crops after analysing the compelling situations (e.g. sesame instead of groundnut in Kariapatti and Narikudi blocks). Drought tolerant TKM-9 is the commonly grown paddy variety in this district.

Income management strategies

Farmers adopt various income management strategies to sustain their livelihood during climate adversities. Remittance from children forms the major source of buffer to the Villupuram farmers followed by loans from friends, relatives and moneylenders (Table 3). Majority of farmers depend on government's relief after any natural disasters. During failed seasons, farmers go for non-farm employments and even sell their livestock.

On the other hand, farmers in Virudhunagar district depend highly on government's relief followed by remittance, loans from friends and relatives and sale of livestock. Distress migration in search of life sustaining employment opportunities is a feature of this dry tract. Though not in a big way farmers in both the districts purchase crop insurance when they avail crop loan.

Constraints to Adoption

All the farmers who perceived climate change were facing certain constraints in adopting various adaptation strategies. Dearth of water for irrigation was the major constraint faced by 86 % of farmers, as water availability is the primary determinant for selecting any crop. Each crop needs a specific combination of temperature, rainfall, relative humidity, etc. for its normal growth, which is season specific. This season specificity hinders 72 % of farmers from opting for alternate crops. While 54 % of farmers cited labour shortage as main constraint,

40 % of farmers denounced the lack of timely availability of seeds and fertilizers.

Factors Influencing Adoption

As mentioned earlier, the socio-economic characteristics of the farm household determine the adoption of different adaptation strategies by farmers. The results of the logit analysis showed that age of the farmer, his access to irrigation and livestock ownership are the factors which significantly influence adoption. As revealed from the Table 4, the elderly farmers who have more experience in farming adopt more. Similarly, availability of irrigation gives the farmers leverage to try various strategies like inter/mixed cropping, contingent cropping, repeated sowing, etc. to sustain their occupation in order to maintain their livelihood. On the other hand, possession of livestock gives the farmers the option to skip farming during a

Table 2— Farm management strategies practised by farmers

Sl. No.	Strategies	Villupuram		Virudhunagar	
		Garrett Score	Rank	Garrett Score	Rank
1.	Inter/mixed cropping	79.00	1	73.12	2
2.	Alternate cropping	63.67	2	67.27	4
3.	Manipulating sowing date	58.29	3	86.34	1
4.	Reducing fertilizer application	57.33	4	48.45	7
5.	Reducing cultivated area	50.00	5	31.56	8
6.	Crop diversification	44.26	6	-	-
7.	Contingent cropping	38.12	7	50.00	6
8.	Drought tolerant varieties	34.71	8	61.32	5
9.	Water conservation practices	22.12	9	-	-
10.	Widening irrigation interval	16.18	10	-	-
11.	Combining paddy varieties of different duration	-	-	69.50	3
12.	Dry sowing	-	-	24.67	9

Table 3— Income management strategies practised by farmers

Sl. No.	Strategies	Villupuram		Virudhunagar	
		Garrett Score	Rank	Garrett Score	Rank
1.	Remittance	71.29	1	62.20	2
2.	Borrowing from friends and relatives	67.40	2	59.38	3
3.	Borrowing from money lenders	57.60	3	44.80	7
4.	Government relief	56.42	4	66.20	1
5.	Non-farm employment	43.63	5	46.00	6
6.	Sale of livestock	36.25	6	52.40	4
7.	Jewel loan from banks	34.67	7	32.40	8
8.	Crop insurance	32.33	8	26.33	9
9.	Migration	-	-	49.00	5

Table 4—Factors influencing adoption of adaptation strategies

Sl.No.	Factors	Coefficient	Standard error
1.	Age	0.069*	0.036
2.	Education	-0.014	0.051
3.	Farming experience	0.033	0.027
4.	Family size	0.151	0.139
5.	Social participation	0.002	0.656
6.	Farm holding size	-0.003	0.050
7.	Irrigation	1.200*	0.582
8.	Livestock	-0.920**	0.549
9.	Off-farm occupation	0.527	0.548
10.	Institutional credit	0.313	0.501

Note: * and ** indicate significance at 5% and 10% respectively.

distress season. In addition, family size, social participation, off-farm occupation and access to institutional credit positively influence adoption while education and farm holding size negatively influence adoption, though not significantly.

Conclusion and Policy Implications

The glaring reality of climate change manifested in the forms of increasing temperature, frequent droughts, erratic rains, receding glaciers, rising sea levels, etc. has necessitated the urgent need to devise appropriate adaptation strategies to sustain agriculture for the livelihood of mankind. This study which examined the understanding of dryland farmers in Tamil Nadu about climate change, found that about 81 % of the sampled farmers have experienced climate change in terms of decreasing quantity of rainfall, delayed onset of monsoon, increasing temperature, erratic rainfall pattern, etc. The trend analysis of the actual temperature and rainfall data also validated their perceptions. Farmers are convinced that climate change has affected their farming through frequent crop failures, declining crop and livestock yield, reduced water level in wells and tanks, occurrence of new pest and diseases, etc.

Even though farmers are constrained with lack of sufficient water, labour shortage, unavailability of inputs like seeds and fertilizers and season specificity of crops, they strive to maintain resilience in agriculture by adopting various indigenous adaptation strategies like manipulating the sowing date, reduction in fertilizer application, changing cropping pattern, selecting alternate crops and drought tolerant varieties, mixing different crops and even different varieties of a single crop. Few farmers have also hedged their production risk with crop insurance. The logit analysis of various socio-economic

characteristics of the farmers revealed that, elderly farmers who have more experience in farming adapt more to climate change while access to irrigation has given them leverage to try various alternate farming practices. However, possessing livestock gives them the option to skip farming during a distress season.

Hence, the Government should ensure timely availability of inputs like seeds and fertilizers in sufficient quantities. Investments should be made in constructing water harvesting structures like check dams, community ponds and wells, etc. in such dryland regions to conserve the scarce moisture. Furthermore, government policies need to support research and development of appropriate technologies like drought tolerant varieties, machineries and equipments to suit small farm holdings, efficient irrigation and cultivation practices, accurate long term climate forecasting, etc. and promote crop insurance in a big way to help these resource poor farmers to cope with changing climate.

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