

# Farmers Perception on Climate Change and Its Management Strategies: A Micro Analysis of Rajasthan

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## ABSTRACT

*The present investigation was carried out in Rajasthan aiming to study the farmer's perception and adaptation strategies of climate change in agriculture and to investigate the sensitivity of changes in climate and linked impact on local agriculture among farmers. Problem Confrontation Index (PCI) was adopted to rank major constraints. Data were collected on related parameters from 366 households of Udaipur and Bikaner districts. Results showed that mid-drought was the major constraint perceived among farmers. A decline in income, earned through both farming and livestock rearing stands as the most serious impact agricultural households perceived due to climate change, followed by water scarcity and decline in crop yield. Respondents indicated a 39 per cent decline in household income, 65 per cent decline in water for irrigation, and a 28 per cent decline in crop yield due to the change in climate. Other problems also included livestock mortality, increase in weed infestation, and emergence of new pests and diseases. Age of the household head, extent of literacy and access to climate information, especially through television, were found to affect farmers' awareness about climate change. The major cope-up strategies included sowing of moisture tolerate short duration varieties in crop farming, arranging for fodder storage, increasing concentrate feeds to the livestock, and protecting animals by hanging wet gunny bags on thatched shed in livestock rearing. The results of the present study will be useful for appropriate policy actions against the ill-effect of climate change in the study region and geographically and climatically identical regions of the country.*

**Key words:** Climate change; Farmers' perception; Mitigation strategies;

Small and marginal farmers are the most vulnerable group to the effect of climate change and variability in the developing world. The degradation of the environment through poor land use and deforestation is a serious concern; farmers are aware that these activities result in more floods and droughts but have failed to stop as there are few alternatives (Khamis, 2006). Farmers' perception pertains to the increasing temperature and untimely rainfall. However, the way farmers perceived the changes in climate significantly varies across agro-ecologies, farming experience, gender, and educational level (Ndamani & Watanabe, 2015). The food production is critically dependent on local temperature, precipitation conditions, and various factors. About 76 million ha of rain fed area, which is about 56 per cent of total arable land, supports 40 per

cent of human population, 78 per cent of cattle, 64 per cent of sheep and 75 per cent of goat population in the rain fed region of our country. The rain fed agriculture has a larger share of area under rice (42%), pulses (77%), oilseeds (66%) and nutritious cereals (85%). It carries a much higher degree of risk and is characterized by high variability in production, low yields, and low returns, often not even covering the cost of cultivation for several crops in many regions. Attempts to incorporate changes in farming practices in this region require farmers to adapt them, and this adaptation requires resources that could be used for other purposes (Nelson et al., 2010). It is clear that climate change presents a significant threat to the future of Indian agriculture (Jayaraman, 2011), especially to the rain-fed agriculture. Most climate change models predict that

damage will be disproportionately borne by small farmers, particularly rain-fed agriculturalists in the third World (Altieri & Koochafkan, 2008). Some studies suggested a positive influence of farm income, educational level, access to information through television and radio on perception level of the farmers about the changing climate and their impacts. It was also found that younger farmers had a higher educational level and hence the higher perception level. (Debela *et al.*, 2015). Climate parameters play a key role in the decision-making of the households in semi-arid areas of Kenya regarding their farming practices (Bewket, 2013 and Kalungu *et al.*, 2013).

Farmers' perception on climate changes and its impacts on the agricultural production have resulted in the adjustment of agricultural calendar and adoption of different adaptation strategies. Significant association between the observed changes in agricultural practices and household gender were observed among small holder farmers in semi-arid and sub-humid regions (Kalungu, Filho, & Harris, 2013). New land management practices such as leveling, FYM application, and summer ploughing were also practiced (Surendran *et al.*, 2016). Farmers have taken number of measures like early planting, drip irrigation, farm ponds and increase in number of irrigations for mulberry and rice crops as strategies to cope with the changing climatic condition and its impact (Shankara, *et al.*, 2013).

In this study, farmers' perceptions on the change in various weather parameters over the years and their coping strategies to those changes have been explored using psychometric approach.

## METHODOLOGY

Rajasthan is geographically the largest and the eighth most populous state of India. The state has barely 1.16 per cent of the water resources of the country as against its share 11 per cent in total geographical area. It faces a drought or drought-like situation once in every three years as extreme event. Average annual rainfall ranges from 150 mm in northwest part to 900 mm in south-east. Due to scarcity of surface water, agriculture production to a great extent in Rajasthan is critically dependent on the vagaries of monsoon and ground water resources. Land, human resources, crop and livestock activities are highly integrated and more or less cyclic in nature. This paper is built on primary survey conducted

during 2015-16 in two district of Rajasthan *viz.* Udaipur and Bikaner, as a part of a larger study that aimed at understanding the perception and adaptation strategies against climate change.

These districts differ in their agro-climatic, physiographic conditions and socio-economic development. The soils are deficit in NPK in both the districts, comprising of Lithosole at foot hills and alluvial in plains, desert and sand dunes. The productivity of important crops found to be poor (wheat 29.74, Bajra 10.57, and maize 17.71 qtl/ha). The average rainfall during 2014-15 was deficit by 2.4 per cent for Udaipur and surplus for Bikaner (29%). Maize, gram, sorghum, pearl millets, moth bean, mustard and cluster bean are the main crops grown in these districts. The irrigation intensity is higher for Bikaner (171%) than 104 per cent for Udaipur district while it was 113 per cent for state as a whole (Directorate of economics and statistics, Rajasthan, Jaipur, 2015). The net shown area is about 29.15 per cent in Udaipur and 52.13 per cent for Bikaner and the cropping intensity was also low 147 per cent and 122 per cent for these districts against 138 per cent for the state.

A multistage random sampling technique was adopted to select the districts and villages. Two districts were selected randomly and subsequently 5-6 villages from each selected district were chosen randomly. From each village we randomly selected around 30 farmers. In this survey, besides the information of livestock services, we also included questions related to climate risks perceptions, and impact perceived on an average on different attributes of livelihood farmers. Based on the landholding size the sample households were post-classified into three categories, *viz.* small ( $\leq 1.5$  ha), medium (1.5 to 2.5ha) and large ( $\geq 2.5$ ha).

Descriptive statistics were used to understand the characteristic of sample respondents. The nature of agriculture and extent of vulnerability to climate change were of many types. To understand different types of climatic constraints they face, frequency tables were used. In prioritizing the type of constraint that is more likely to affect agriculture as perceived by the respondents, Problem Confrontation Index (PCI) was adopted. The index is computed by assigning different weights to different constraints /characters concerned, usually of the weights as in Likert scale, and have been used in several studies to observe the extent that a

constraint or a given character dominates among others (Ndamani & Watanabe, 2015). Based on the respondents ranking in a 0-3 Likert scale, PCI indices were calculated using

$$PCI = PR \times 3 + PO \times 2 + PS \times 1 + PN \times 0$$

Where, PCI is the Problem Confrontation Index, PR, PO, PS and PN are the number of respondents expressed a given climate constraint as “Regular”, “Often”, “Sometimes” and “Never” respectively. The logistic regression model was used to identify the factors that determine farmers’ awareness on changing climate. Logit models were reported to be the most appropriate econometric models to apply to the evaluation of qualitative dependent variables that have dichotomous groups (i.e. ‘aware’ and ‘unaware’) while the independent variables are categorical, continuous and dummy (Ndamani & Watanabe, 2016, Wood et al., 2014, Debela et al., 2015). These models are commonly and widely used since they guarantee that the estimated probability increases lie within the range of 0 to 1 and display a sigmoid curve conforming to the theory of adoption. To represent the status of technology adoption, which may partially reflect how connected a respondent is to the development in technology, a dummy representing the use of a local and hybrid variety of the major crop was used. A hybrid variety adopter was assumed to be better informed, and hence expecting a positive exposure to changing climate. Another dummy variable indicating possession and absence of a tractor was used to represent asset holding/wealth status of the respondents. As wealthy farmers, in general, are socially better connected, a positive response towards climate change awareness was expected.

**RESULTS AND DISCUSSION**

*Socio-economic characteristics:* The key characteristics of sample households as classified based on the landholding size are given in Table 1. The study region contained about 39 per cent of small farmers, 25 per cent of medium and 36 per cent of large farmers. On an average, about 77 per cent of household-heads were literate, having high literacy levels. The education level had positive and significant relationship with land holding size, indicating that larger the farm size, higher was the literacy level. Majority of farmers (61%) were practicing agriculture as main profession. Still, 39 per cent of them practiced agriculture as a secondary

occupation. Experiences in farming were not significantly different among different categories of farmers. Average land holding size was 3ha/household. The total number of livestock reared per family was more than 3 animals and average milk yield was about 8.0 liters/day. Medium farmers have realized slightly higher milk yield than the rest.

**Table 1. Socio economic features of the sample respondents (N=366)**

Indicators	Small	Medium	Large	All
<i>Education level (%)</i>				
Illiterate	26.6	21.4	18.6	22.7
Primary	27.8	18.5	14.8	20.4
Secondary	28.6	20.8	9.9	19.8
Senior Secondary	15.7	26.4	32.5	24.6
Above Sr. Secondary	1.3	12.9	24.2	12.5
<i>Farming as occupation (%)</i>				
Main	56.3	58.4	69.8	61.3
Subsidiary	43.7	41.6	30.2	38.7
Experience (Years)	44.3	48.1	52.4	48.2
Family Size (No.)	4.91	5.25	6.82	5.11
Av. land holding (ha.)	1.05	1.86	4.53	3.07
Total Livestock (No.)	3.53	3.87	3.70	3.74
Av.milk yield (lit/day)	5.57	5.79	5.68	5.73
<i>Household head (%)</i>				
Male	95.4	93.2	96.1	94.9
Female	4.6	6.8	3.9	5.1
Annual household income (Rs. Lakh)	0.76	0.83	0.97	0.85
<i>Housing condition (%)</i>				
Pucca House	78.6	82.8	94.9	84.4
Kuchha house	21.4	17.2	05.1	15.6
<i>Distance from main market (% farmer)</i>				
≤10Km	24.4	26.6	28.3	21.4
≥10Km	75.6	73.4	71.7	78.6
<i>Shortage of drinking water (%)</i>				
More frequent	72.6	63.5	50.5	62.2
Frequent	16.5	9.7	18.9	15.0
No problem	10.9	26.8	30.6	22.8
No. of respondents	143	91	132	366

Note: Author’s own calculation

Majority of farm households were headed by male in both the districts (95%). More than 84 per cent farmers had *pucca* deviling houses and the extent of *pucca* houses was more with large farmers. Proximity to market infrastructure make the villagers life difficult. We found that on an average 21 per cent of farmers have to travel more than 10 km to purchase/sell their

daily required goods and services. About 62 per cent respondents have expressed that we face scarcity of drinking water very frequently and only 23 per cent said that we have no problem related to the water. This may be due to the fact that large farmers have created their own source of drinking water. These observations clearly indicate that there were significant differences in socio-economic characteristics of respondents selected for the study. Further, the metrological department data shows that at every third year, a drought situation arises in Rajasthan and these events affect the agriculture production, livestock and other livelihood means. During 1987 to 2015, more than six extreme events related to climate had occurred. The years 1987, 1992 and 2004 were the server drought years in Rajasthan. During the years 2006, 2010 and 2015, there had been heavy rain, hailstorm and high speed winds that had damaged the standing crops.

*Intensity of perceived climate constraints:* The level of perception of different climate change events was recorded and PCI index was used in ranking. The frequency of occurrences and the PCI indices were calculated and the results obtained are presented in fig 1. While the perception of climate change was common among a sizeable section of respondents, not all the respondents were found homogenous. The level of perception varied on the type of constraints they encountered. Moreover, perceived frequency of

occurrence of a weather event varied within a type. For example, among different types of constraints perceived, mid drought was as found most prevalent, receiving the highest PCI score of 73. But the intensity of occurrence was perceived differently, that nearly equal size of respondents reported it as 'regular', 'often' and 'sometimes' categories. Despite the difference, mid-drought seems to be the major event perceived by the climate change perceivers. Early drought appears to be the next major constraint the respondents faced. The PCI score stood at 48. Unlike the 'mid-drought' event, the 'early-drought' seems to be less frequent. The level of perception was relatively high among 'Often' and 'Sometimes' categories. Just four respondents reported it as a 'Regular' event. Terminal-drought seems to be still infrequent, followed by the high temperature constraint. Thus, drought, in particular, the mid-drought, seems to be the major constraint perceived by the climate change respondents.

*Perceived impact and extent of climate change:* The response with respect to the impacts perceived by the agricultural households, and the extent to which climate change influenced different economic and livelihood attributes were recorded and the results are presented in fig.2. The ranks marked against different attributes depict us a clear picture of order. We observe that decline in income, earned primarily through both farming and livestock rearing in the study region, stands as the most

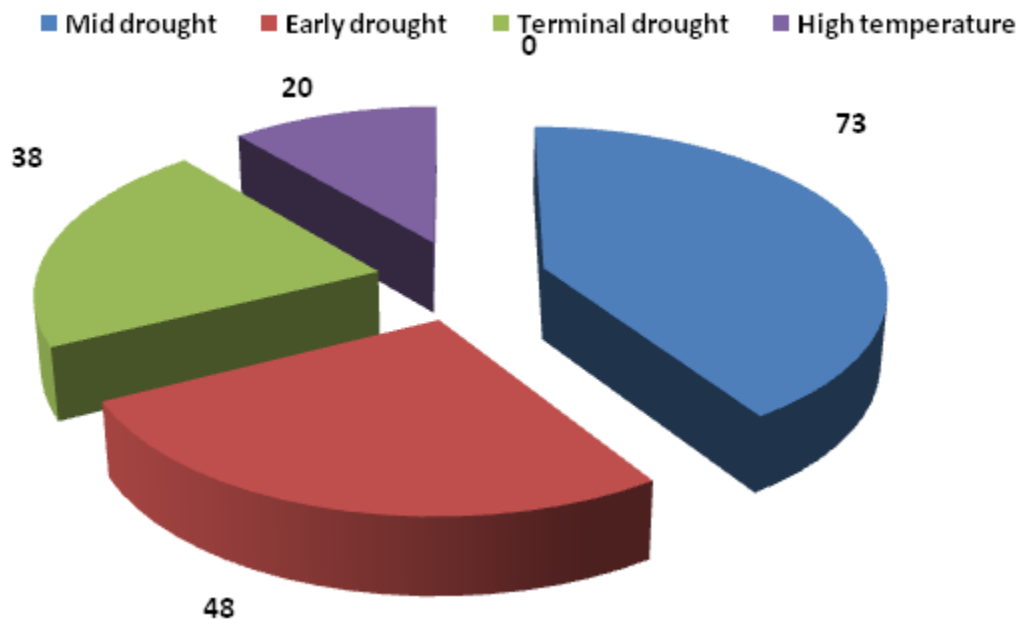
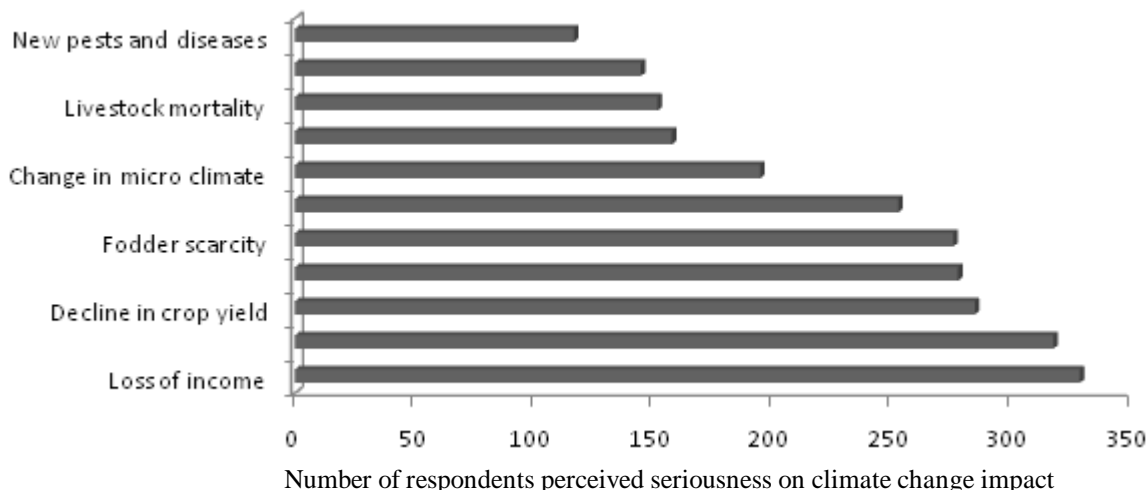


Fig. 1. PCI value constraints perceived



**Fig. 2. Perceived impact and extent of climate change on economic and social attributes**

**Table 2. Adaptation mechanisms to cope up the ill effects of climate changes**

System	Consequences	Adopted strategies	N=366
Practicing agriculture in rainfed conditions	Food, milk, meat and fodder scarcity due to low production, Increase in cost of production.	Sowing the moisture tolerant and Short-duration crops. Fodder storage, increasing concentrate feeding to livestock.	308 (84.15)
Goat, cattle and buffalo livestock system with low productivity, high mortality and incidences of diseases	Reduced income from livestock Problem for household nutritional security	Dry fodder storing to ensured fodder supply and keep local bred. During extreme hot, animals are protected by hanging wet gunny bags on thatched shed.	289 (78.96)
Pastureland over exploited grazing land due to open grazing leading to loss of bio- diversity	Shortage of fodder supply round the year	Protection of grazing land vegetative, trenches, formation of informal groups to protect the grazing lands introduction of concept fodder tree plantation and rotational grazing.	194 (53.01)
Surface Water resources (Ponds, Tanks, lake.)	Reduced scope to take-up irrigated crops due to faster depletion of water	Minimize loss through infiltration and. evaporation and de-silting, water filling by means of canal or pumps	129 (35.15)

*Note:* Figures in parentheses indicate per cent shares to total the total respondents

serious problem the agricultural households perceived due to climate change. Around 90 per cent of respondents report a decline, indicating the endemic effect of climate change in the study region. Water scarcity turns as the major issue in raising crops and resulting decline in yield were ranked as the next two major attributes perceived. The share of households reporting the changes are 87 per cent and 78 per cent respectively. Livestock production that provides sizeable share of household income appears next, and the reason lies on decline in fodder production that follows, which itself is the outcome of water scarcity felt due to change in climate

and resulting inequalities in rainfall distribution. Around 75 per cent households surveyed reported these impacts. There appear other impacts as well, ranging from reduction in soil health and micro-climatic variations to increasing incidences of weed infestation and emergence of new pests and diseases.

Apart from perception, the study also recorded the magnitude of change to which different attribute have undergone due to climate change as reported by the respondents. These changes are recorded as percent variations rather than absolute changes as the former allows for relative comparison of attributes. While this

may not allow absolute comparison, it provides us the understanding of order of change in values the households experience. Irrigation has reduced by more than 65 per cent resulting in a crop loss of around 28 per cent. A resulting reduction in fodder as well is reported to an extent of 30 per cent, causing a decline in livestock production by 32 per cent. These changes altogether have affected the total income to decline to an extent of 40 per cent. This is reflected as a reduction in household food consumption by around 18 per cent, which could have serious nutrition impacts, especially on marginal and small holder farmers who fell in poverty trap. The other attributes like weed infestations and emergence of new pests and diseases as well have undergone to serious changes. We believe that the negative sign reflects the fact that though higher age may indicate better experience in farming, it might also indicate poor access to information and technology as the high aged people might be less likely to engage them in information seeking, especially through modern technologies. Note that 48 per cent of the respondents aged more than 50 did not have access to information through television and 48 per cent of them reported that they are unaware of climate change. Influence of such behavior is better reflected in our analysis that access to information through television has significant positive influence on climate change awareness. While television can be thought of a non-modern method of information delivery, high age may correspond well with less personal interest with the device. Note that the other source, the newspaper, which is the major medium that delivers information to the elderly as they are habituated to, though, had a positive sign, proving to be insignificant in delivering awareness on climate change.

*Adaptation strategies:* The particulars on number of response on types of problems, consequences and adoption strategies are presented Table 2. Results showed that households were practicing agriculture in rainfed conditions resulting in scarcity of food, milk, meat and fodder availability in the study area. About 84 per cent farmers indicated that they go for less water demanding crops with shorter duration. They also conveyed that they store the dry fodder for extreme/scarcie situations and increase the quantity of concentrates in animal feed. The livestock contribute significant income to the farming community, by means of providing milk, meat and other items. Due to climate

change the animals' yield/production reduced and incidences of diseases had increased leading to mortality and loss of livestock. About 78 per cent farmers have adopted strategies like storage of dry fodder, keeping indigenous animals etc.

During the extreme hot/cold weather conditions, farmers have used Indigenous knowledge (ITKs) like hanging of wet gunny bags against the hot wind on the cattle shed walls and closed thatched shed for sheltering animals. Pasture degradation possess threats to fodder supply and animal health. More than 53 per cent farmers were in opinion that pasture can be protected with strict action from local panchayat and the government. Therefore, farmers of both the districts have adopted community pasture management policy and have used conservation measures to protect the pasture lands. Our observation indicate that more than 35 per cent farmers used to protect the existing water resources under panchayat/government programmes by desilting or filling water through various means. The irrespective of the size of holding, the pattern of cropping and nature of crops, climate change remains as a universal phenomenon. A similar result was observed with the use of local and hybrid seeds. Possession of tractor, which was used as a proxy for asset holding of the farmer in one way, or as the status of wealth on the other way

## CONCLUSION

The study made a modest attempt to give a brief insight on the perception about climate change and its impact on livelihood attributes of farmers in the vulnerable region of Rajasthan. The majorities of the respondents were aware of the climatic change and its negative impact on agriculture and considered climate change as a salient risk to their future livelihood. Among the climatic constraints perceived by the farmers, 'mid-drought' was found to have the largest impact on crop production followed by early drought, terminal drought, and high temperature, decline in income, earned primarily through both farming and livestock rearing in the study region, stands as the most serious problem the agricultural households perceived due to climate change. Around 90 per cent of respondents report a decline, indicating the endemic effect of climate change in the study region. Water scarcity turns as the major issue in raising crops and resulting decline in yield were ranked

as the next two major attributes perceived. Irrigation has reduced by more than 65 per cent resulting in a crop loss of around 28 per cent. A resulting reduction in fodder as well is reported to an extent of 30 per cent, causing a decline in livestock production by 32 per cent. These changes altogether have affected the total income to decline to an extent of 40 per cent. The other attributes like weed infestations and emergence of new pests and diseases as well have undergone to serious changes. This study also identified the important factors determining the awareness of respondents about climate change. Among different factors, age, literacy, and access to climate information, especially through television, were found to have a significant influence on the awareness of climate change among the sample respondents. The hand, younger farmers were more informed about the changes in the weather and climatic conditions and their impacts. Moreover, literacy status and access to weather information through television and newspaper were found to have a positive impact on farmers' awareness on climate change. Creating awareness among farmers about the issues relating to climate change and also the mitigation options should

be carried out. In this regard, formal schooling may be less efficient for the aged, while field schools can be thought of active choice.

Therefore, efforts should be made that timely and accurate weather information is reached to farmers and farmers based organizations could prioritize to help farmers improve their information sharing and decision-making processes. Meteorological departments should be adequately disseminating accurate and timely weather information. Besides, this study revealed that the rate of occurrence of dry spells and drought is prevalent in the area. The government should, therefore, boost the capacity of research scientists and agricultural staff to develop and promote appropriate and effective technologies. The major impact was felt in increased water stress. Accordingly, farmers have adopted drought tolerant/resistant crop varieties that can sustain water stress, while maintaining average crop productivity. Other sort of coping-up behavior observed was shifting to alternate crops, diversification towards livestock rearing, shifting to non-farm activities, etc. Focusing policies on developing varieties that can withstand different climatic aberrations would retain the farmers into farming.

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