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Grassroots farmers' perceptions on climate change and adaptation in arid region of Rajasthan

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Understanding farmers' perspectives to climate change and adaptation is essential in designing effective and informed strategies to combat the associated vulnerability. The study assessed farmers' perceptions to changing climatic conditions, their impacts, adaptation measures and constraints to adaptation in Bikaner district of Rajasthan. Our results showed that farmers perceived change in the distribution of rainfall, rise in temperature, increase in frequency of heat waves and droughts in the region. Further, degradation of common property resources, uncertainty in crop yields, increased soil salinity, farm unemployment and reduction in consumption were some of the potential non-climatic impacts as perceived by the farmers. As climate adaptation measures, farmers resorted to disease/heat tolerant varieties, plant protection chemicals and water conservation techniques. Moreover, lack of access to institutional credit, poorly defined property rights, inadequate infrastructure and information gaps were some of the major barriers to climate adaptation in the region. The study provides a useful guide for identifying region-specific issues and implementable adaptation strategies. Policy actions are needed in creating awareness, improving climate information services and development of infrastructure for climate resilient farming.

Keywords: Adaptation, Barriers, Climate change, Perceptions

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The impacts of climate change on agriculture and farm livelihoods have been recognized as one of the major challenges to the sustainable development. Climate aberrations impacts agriculture in several ways such as by reducing crop productivity[1,2], changes in water availability, soil erosion, proliferation of pest and diseases and most importantly by affecting socio-economic stability of farm communities. The impact of climate change is highly conspicuous in the semi-arid region of India, given its geo-ecological fragility reflected by low and erratic rainfall pattern, poor soil fertility and its inherent socio-economic instabilities[3,4]. Although the impacts of climate change are inimical to agriculture and food security, they can be restricted by implementing adaptation strategies[5]. However, perception of farmers on climate change and its associated risks is a necessary prerequisite for developing suitable adaptations[6-8], which can shape the preparedness of farmers to climatic induced risks[9,10]. It should be noted that misconception about climate change and its impacts risks may only result in inadequate adaptation, which may exacerbate farm vulnerability through greater exposure to livelihoods shocks[11]. Thus, this paper attempts to elicit grass-root perspectives on climate impacts, adaptation measures adopted to cope up against climate change and barriers that prevent effective adaptation in Bikaner district of Rajasthan.

Materials and Methods

Study area

The study was undertaken in the Bikaner district, located in north-western part of Rajasthan State. Spread over the two agro-climatic zones of hyper-arid irrigated western plain and transitional plain of inland zone, the district covers a geographical area of 30, 239 sq.km of which only a miniscule tract of land is covered with forest (0.82%). Nearly 66% of Bikaner's population resides in rural areas with agriculture and animal husbandry as their primary occupation. Pearl millet, moth bean, cluster bean & sesame, chickpea, mustard and wheat are the major crops grown in

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Table 1 — Characteristics of farm households

Parameter	*Govindsar*	*Jhajhu*	*Chandsar*	*Ghesura*	Overall
Age (years)	39.07	39.07	38.40	37.97	38.63
Female headed households (%)	17.54	21.50	14.50	25.50	19.76
SC Population (%)	9.83	12.85	8.75	13.95	11.35
Literacy rate (%)	68.50	72.54	66.75	62.50	67.57
All seasonal homes (%)	77.50	75.75	73.50	68.71	73.87
Access to electricity (%)	85.21	86.52	79.50	81.50	83.18
Access to safe drinking water (%)	60.52	59.50	52.41	48.58	55.25
Marginal farmers (%)	82.50	75.75	78.50	71.50	77.06

Source: Field survey, 2019

Bikaner. Of the total gross sown area (2.04 Mha), more than 50% is rainfed, which makes its agriculture and agriculture-based livelihoods highly vulnerable to climatic variations. Located close to the Thar Desert, the climate conditions in Bikaner are extremely hot and arid, with temperature ranging from about 0°C in winter to beyond 45°C in summer. The district receives an average annual rainfall of 250 mm, about 90% of which occur during the south-west monsoon season. Among the districts of Rajasthan, Bikaner is one of the most chronically drought prone areas. The district is experiencing several environmental issues such as shifting sand dunes and dust storm causing desertification, soil salinity and alkalinity[12] and inadequate water availability particularly due to depleting ground water resources. Such environmental risks will be further confounded with climatic variations, posing an imminent danger to the food and livelihood sustainability in the region. Besides, most of the studies assessing vulnerability of Indian Agriculture to climate change have classified Bikaner as a highly vulnerable district[13,14].

Data collection method

In our study we used both primary and secondary level information. Multistage sampling technique was employed to select sample households wherein in the first stage; two blocks namely, *Kolayat* and *Lunkaransar* were purposely selected. In the second stage, four villages (*Govindsar, Jhajhu, Chandsar and Ghesura),* two from each block were chosen. Finally, a total sample of 120 households (30 from each village) was randomly selected for exploring grass-roots perceptions and adaptation measures to climate changes. The socio-economic profile of the farm households across four villages is described in Table 1. The average age of the surveyed farmer was around 38 years. About 77% of the sample consisted of marginal farmers. Overall, nearly 67% of the households were found to be literate. 19% of the farm households were headed by females. In terms of basic amenities about 83, 74 and 55% of the households had access to electricity, all season homes and drinking water, respectively.

Table 2 — Farmers' perceptions on climate change

Parameters	Percentage of farmers
Change in the distribution of rainfall	83
Change in onset of monsoon	81
Change in cessation of monsoon	64
Reduction in rainy days	63
Increased incidence of heat waves	63
Increase in temperature	55
Recurrence of droughts/ dry spells	44

Source: Field survey, 2019

Further, individual primary survey and focus group discussions (FGDs) were organized among the farmers during which they were asked open-ended questions relating to the perceptions on climate change and variation, socio-economic hardships being suffered and the obstacles faced in coping against the climatic risks. Also, enquiry was made regarding the measures that farmers were practicing in response to the changing climatic conditions. Further using data on climate variables, the farmers' perceptions on climate change were verified, by observing variation in rainfall and temperature from their long-term average for the period 1958-2019.

Results and Discussion

Farmers' perceptions on climate change

From the surveys and FGDs conducted in the selected villages of Bikaner district, it was revealed that majority of the farmers (83%) reported an increased erraticism in the distribution of rainfall (Table 2). A large proportion of the respondents reported significant variations in the arrival and withdrawal of monsoon over the past few years. Nearly 63% of the farmers perceived reduction in the number of rainy days and increased frequency of heat

waves in the region. Further, an increase in temperature was reported by the 55% of the farmers. About 44% of the farmers agreed that drought/ dry spells have become more frequent over the years making farming unpredictable and riskier.

Rainfall and temperature pattern

Long-term variation and trend in climate variables were examined for 62 years period from 1958 to 2019. Figure 1 and 2 show rainfall and temperature anomalies, calculated by taking difference between the actual value and long-term average. In line with the farmers' perception, both the minimum and maximum temperatures showed an increasing trend of 0.018°C/year and 0.0064°C/year, respectively. However, the rise in minimum temperature was more pronounced compared to the rise in maximum temperature in the district. Significant changes were observed in the quantum of annual rainfall, indicating rising oscillations in precipitation as perceived by the farmers.

Impact of climate change

Climate related risks adversely affect socio-economic stability of rural households[15]. As shown in Table 3, about 88% of the farmers perceived that over the past few years changing climatic conditions have degraded the quality of common property resources (ponds, wells, etc.) in their villages. They unanimously expressed rising uncertainty in crop yields, resulting from climate variations. A large portion of the respondents agreed that soil salinity has increased over the years and 59% reported rising infiltrations of pest and diseases. Moreover, 60% reported depletion and shortage of water resources (surface, ground water and others) as emerging issues in the region. Climate induced perturbation leading to production risks render farmers to lose their

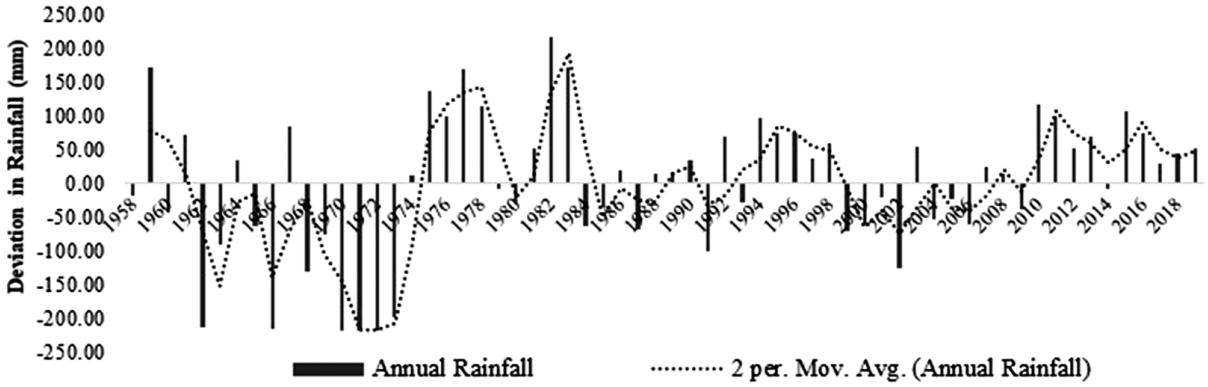

Fig. 1 — Rainfall deviation in Bikaner district, Rajasthan (1958-2019).
Source: Authors own calculation using India Meteorological Department (IMD) database, New Delhi

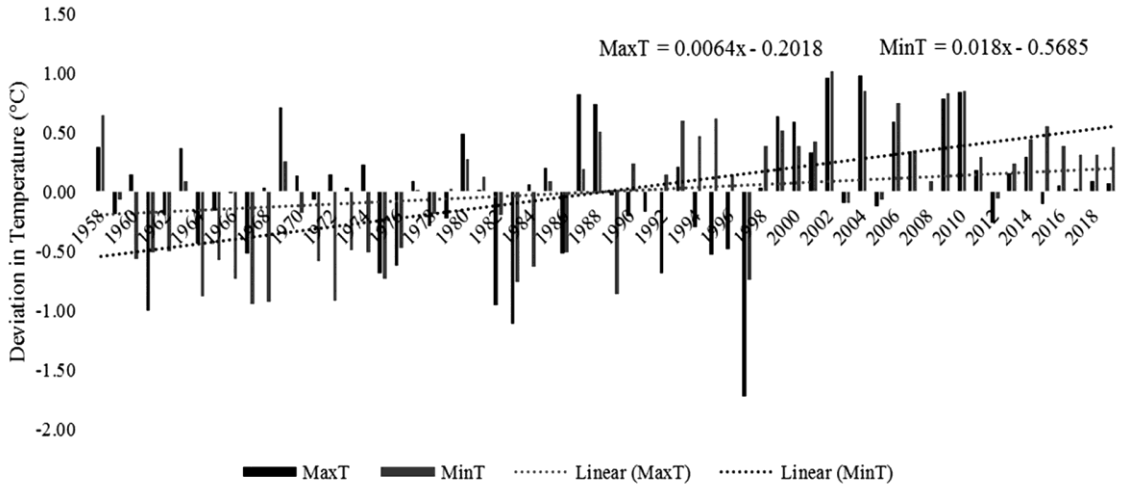

Fig. 2 — Maximum and minimum temperature anomalies and linear trend for Bikaner district, Rajasthan (1958-2019). Source: Authors own calculation using India Meteorological Department (IMD) database, New Delhi.

Table 3 — Perceived impacts of climate change

Indicators	Percentage of farmers
Decline in quality of common property resources	88
Higher salinity	69
Increase in pest and diseases	59
Reduction in net income	56
Uncertain agricultural investment	52
Uncertainty in crop yield	51
Decline in agricultural employment	38
Reduction in consumption expenditure	33
Selling/mortgage of precious metals	31
Depletion and shortage of water resources	60
Increase in agricultural expenses	45
Decline in soil fertility	20
Labour scarcity	18

Source: Field survey, 2019

livelihoods and often push them into perpetual debt cycle. The farmers also opined that climatic aberrations causing crop losses is adversely impacting their net income (56%) and further leading to decline of employment in agriculture (38%). Further, 33% of the farmers reported that successive crop failures due to unpredictable weather perils have compelled them to curtail their consumption expenditures, while 31% expressed resorting to mortgage or selling of assets to compensate for income erosion.

Climate adaptation strategies

There are four probable cases that can be visualized in case of climate perception and adaptation premise, *first* farmers perceive changes in climatic conditions and make suitable adjustments; *second*, farmers perceive changes in climate but do not adapt due to certain barriers; *third* farmers do not perceive change in climate and thus do not adopt adaptations; and *finally* farmers do not perceive change in climate, but still undertake adaptation either due to demonstration or imitation effect to enhance their yield and profitability. In our survey, we found that most of the farmers perceive some sort of change in climate and thus made adaptations that were well within their technical and financial ambit. It is important to mention here that the choices of adaptation strategies are not mutually exclusive and therefore farmers reported to choose more than one strategy at a particular time. As evident from the Table 4, majority of the farmers across the selected villages opted for disease resistant varieties. About 66% reported on using plant protection chemicals and 64% reported making adjustments in sowing dates. Farmers were also found making suitable

Table 4 — Adaptation to climate change

Climate adaptations strategies	Percentage of farmers
Adoption of disease resistant varieties	80
Use of new plant protection chemicals	66
Adjustment in sowing dates	64
Water conservation through rainwater harvesting	63
Development of check dams	43
Adoption of less water consuming varieties	42
Adoption of heat tolerant crop varieties	42
Adjustment of harvest dates	32
Use of ultramodern wireless based monitoring system	29
Bore well digging	28
Early maturing varieties	23
Planted trees in surrounding fields	23
Crop rotation	21
Development and maintenance of watersheds	20

Source: Field survey, 2019

efforts to conserve water through rainwater harvesting structures/ techniques. Moreover, adaptive measures like choosing heat tolerant varieties, less water consuming varieties, early maturing varieties and adjustments of harvesting date against climatic aberrations were some of the other potential practices adopted by the farmers to cope up against climate change. Furthermore, 21% of the farmers adopted crop rotation as an adaptation strategy.

Barriers to climate adaptation

There are several factors that limit implementation of adaptation by the farmers. Such factors relate to technological, economic, informational, institutional and social arena that translate into weak coping capacity. It is essential to assess farmers' perception on barriers, to understand the relative importance of the factors affecting their adaptation decisions. Majority of the farmers unanimously agreed that lack of access to institutional credit (91%) followed by insecure and poorly defined property rights (81%) were the major deterrents to adaptation in the study areas (Fig. 3). Farmers also reported lack of suitable infrastructure in the form of inadequate transportation facilities (74%), insufficient storage houses for food grains (67%) and lack of pucca/all-weather roads (60%) as some of the major obstacles in adaptation. In our grass-root enquiry about 65% of the farmers expressed that higher cost of altering farm operations limits their capacity to make suitable farm adjustments to changing climatic conditions.

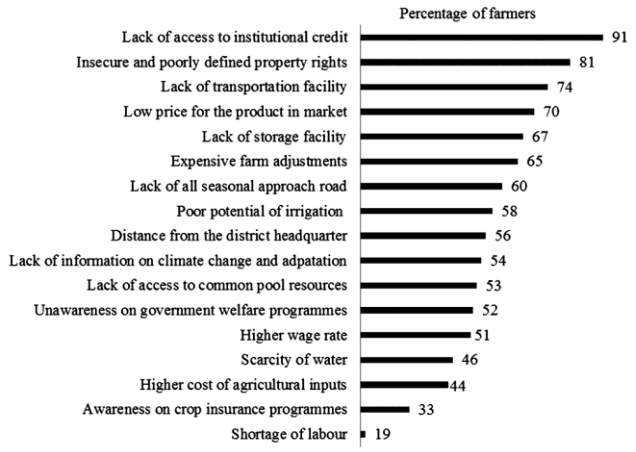

Fig. 3 — Barriers to climate adaptation
Source: Field survey, 2019

Moreover, poor potential of irrigation in their region and lack of access to common pool resources were other potential barriers as perceived by 58 and 53% of the farmers respectively. Lack of adequate information about climate change and adaptation, unawareness on crop insurance and government welfare programs were identified as major informational barriers that hinders farmers to undertake adaptation activities and livelihood diversification. Rising agri-input cost, high wage rate and scarcity of labor as perceived by nearly 44, 51 and 19% of the respondents were other obstacles that prevent farmers to adopt better farm management practices against climate risks, respectively.

Conclusion

Assessment of farmers' perceptions and associated risks is essential to develop and facilitate effective farm level adaptations and to secure livelihoods. In this study farm perspectives were elicited on climate change, adaptation and barriers in Bikaner district of Rajasthan. Large number of the farmers perceived changes in climatic parameters. Several risk management strategies were adopted by the farmers to cope up against climate induced perturbations. However, adaptation faces several constraints ranging from climate change and adaptation related knowledge/ informational gaps, economic costs of farm-level adaptations, limited access to credit and markets. Hence there is a need to eliminate information gaps and lack of communications relating to climate change and adaptation by developing region specific climate advisories. Institutional capacities must be strengthened to accurately forecast weather, exchange of district or plot level information among farmers and for extension of credit and farm inputs. This could facilitate adoption of climate resilient practices and strategies among the farm communities. Further, encouraging adoption of crop insurance, diversification of livelihood and mainstreaming climate change and adaptation in the regional programs will help reduce farm vulnerability.

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Conflict of Interest

Authors declare they have no conflict of Interest.

Author Contributions

N P S, B A, S K S and N R K conceived the idea and prepared the manuscript and SS helped in collection of field data. All authors reviewed and approved the final manuscript.

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