Indian Journal of Traditional Knowledge
Vol 20(2), April 2021, pp 512-519

Farmers' perception on climate extremes and their coping mechanism: evidences from disaster prone regions of India

V Kanwal[a], S Sirohi*[,b,#] & P Chand*[,c,†]

[a]Punjab Agricultural University, Ludhiana, Punjab, India
[b]Embassy of India to the EU, Belgium and Luxembourg, Brussels, Belgium
[c]ICAR-National Institute of Agricultural Economics and Policy Research, New Delhi 110 012, India
E-mail: [†]prem.chand@icar.gov.in; [#]smitasirohi@yahoo.com

Received 06 December 2019; revised 23 December 2020

The state of Rajasthan is highly vulnerable to climatic extremes. The perception of local communities regarding climate change and their indigenous coping management strategies is important for decision-making and policy formation. In this paper, the perceptions of farmers and their coping strategies were studied using primary data collected from 180 farmers of Bikaner and Kota districts. The data were collected through personal interviews as well as focused group discussions. The findings indicated that the risk of droughts, rainfall anomalies and wind-storms increased over the decade. The people at drought-prone regions were more food insecure in comparison to flood-affected regions. However, their traditional wisdom and indigenous species like *Khimp* (*Leptadenia pyrotechnica*), *Kair* (*Capparis decidua*), *Phog* (*Calligonum polygonoides*), *Khejri* (*Prosopis cineraria*), etc. helped them in coping with climate extremes. Adjustments in the dates of sowing, deep summer ploughing in morning hours, dry sowing, increased seed rate, mixed cropping and farming; especially crop-livestock integration were common coping management strategies. Farmers perceived that with modernization of agriculture, biodiversity of the region is declining. The study suggests that local communities need to be incentivized for conserving these species. These indigenous products have high market value. Therefore, the value chains of these products need to be strengthened by providing processing equipment such as solar drier at subsidized rates.

Keywords: Agro-biodiversity conservation, Arid ecosystem, Natural disasters, Sustainability, Traditional practices
IPC Code: Int Cl.[21]: E04H 9/16, F16K 27/12, G01W 1/06, G04G 17/08

Natural disasters as a result of climate change are shaping human race since long. The climate risk is an important researchable issue among scholars lately; climatic extremes being the result of the same. It becomes important to study climatic extremes, as at times they are known to wipe out entire civilizations[1]. Scientific evidences suggest that the climate extremes that have been a part of the past may occur in future as well, with larger frequencies and intensities[2]. Climate extremes like drought and flood are the result of aberrant annual precipitation. These disasters usually negatively affect the local economy; however the perception of local community about a natural disaster may vary from its broader impact. A local affluent family having resource endowments may not foresee the probable effect of disasters due to availability of easy escape mechanisms; while a resource-poor household will experience this effect the most. In general, the perception of a community reflects the local issues and potential policy dimensions which are important for decision making, framing appropriate developmental policies and formulating adaptive capacities associated with catastrophes[3,4]. Over time, local communities have evolved ways to combat harmful impact of these catastrophes. In order to improve the resilience of local people and communities against climate change, there is need to understand these risks from their perspective. Most of the studies on climate change focus on the impact of climatic extremes keeping aside the local perception. Therefore, this study was carried out to understand the indigenous communities' perception of weather-related risks and the mechanisms adopted by them to mitigate these risks in semi-arid regions of India. These regions are the most vulnerable to climatic extremes, particularly due to prevailing poverty and under nutrition, resource shortages, unsafe geographic locations, lack of technologies in the form of updated early warning system, lack of mitigation options, support services, etc.[5-8].

*Corresponding authors

Rajasthan is the desert state of India characterized by aberrant weather conditions. Several studies have reported that occurrence of droughts is a frequent phenomenon in the state, affecting crop and livestock sector adversely[9-11]. However, Southern Rajasthan is known to be hit by frequent floods[12]. This study is based on primary survey conducted in desert (Bikaner) and flood prone (Kota) districts of Rajasthan. Long-surviving traditional indigenous knowledge on coping strategies has been helpful in mitigating the climate risk and thereby making the community more resilient in arid and semi-arid regions[13-16]. This paper makes attempts to study the perception of farming communities towards the risk of climate extremes and the coping mechanism they resort to in order to mitigate these risks.

Material and Methods

Study area

Rajasthan is located in the North-Western part of the Indian subcontinent. The state occupies India's largest geographical as well as arid area and faces severe water scarcity due to erratic rainfall and groundwater overexploitation[17]. Agriculture is mainly rain-fed but rainfall therein is inadequate and aberrant. Average rainfall also varies widely across the regions. The extreme dry zones of western Rajasthan receive as low as 100 mm of rainfall annually, while the south-eastern part of the state receives as high as 1000 mm annually. The state is one of the most vulnerable to climate change accounting for more than 20% of high vulnerable districts of the country[18]. Keeping in view the vulnerability to climate change, we selected Rajasthan for the study so as to capture the perception of farming communities towards both drought and floods. The perception of households is substantiated with primary data on climate. Thereafter, the coping mechanisms against these disasters have been studied in detail.

Two districts, one from drought prone region (Bikaner) and other from flood region (Kota) were selected for the study. The district of Bikaner falling in Hyper Arid ago-climatic zone represents the drought situation while Kota district falling in Humid South-Eastern Plain represents flood condition. Geographically too, these districts better represent different parts of state where Bikaner is on the northwestern Thar Desert of the state while Kota is in south eastern part (Fig. 1). The district of Bikaner is characterized by an extremely hot

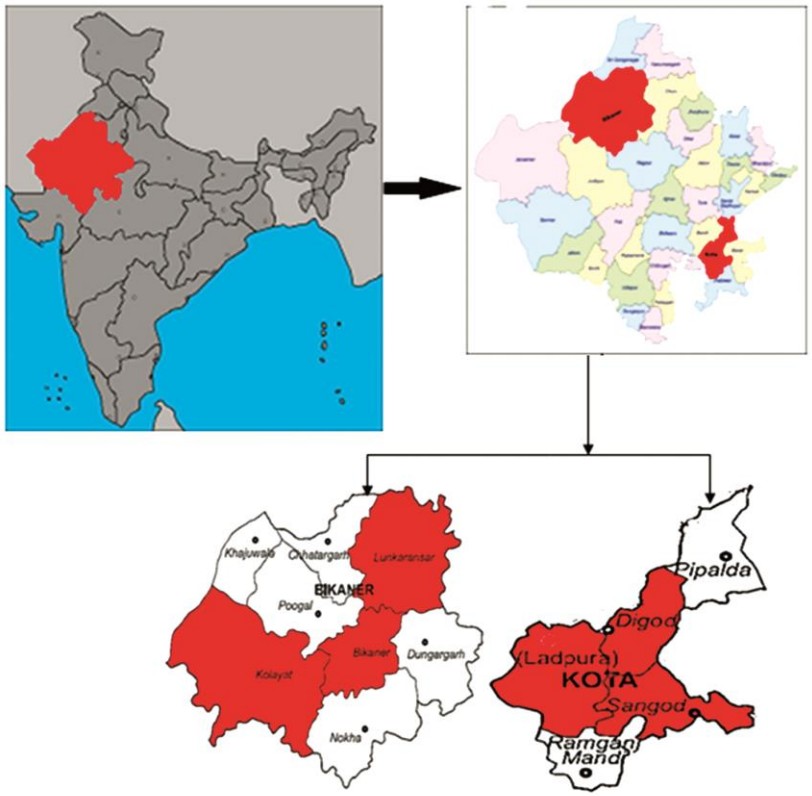


Fig. 1 — Location map of drought and flood prone regions, Rajasthan

and arid climate. In the summers, the temperature of the region goes beyond 45°C and dips down below 0°C in winters. Annual precipitation of this desert prone region is scanty (ranges 260-440 mm). The flood prone district of Kota comes under *humid and floods prone agro-climatic zone*. The Chambal is the principal perennial river of the district and the presence of this river leads to frequent flooding in the surrounding regions within the district.

Selection of tehsils and villages within these districts was guided by the objectives of capturing diverse perception of weather-related risks among farm communities and the mechanism thereby used for coping with such risks. There are eight tehsils in Bikaner, out of which three namely; Bikaner, Lunkaransar and Kolayat were selected randomly. From the selected tehsils, nine villages (three from each selected tehsil) were chosen randomly.

Flood is localized phenomenon and affects a limited area hence selection of households in flood prone Kota was purposive unlike Bikaner. Out of five tehsils in the Kota, we chose three viz., Digod, Sangod and Ladpura based on rainfall intensity and outflow of rivers. Thereafter, exclusive list of tehsils and villages affected by frequent floods was obtained from district collector's office in Kota and three flood prone villages from each tehsil were selected at random. Thus, the study area comprises nine villages from drought-prone Bikaner and nine from flood-prone Kota.

Sampling, data collection and analysis

Complete enumeration of households was carried out in selected 18 villages to gather information on landholding and herd size of milch animals. In all, there were 4493 households in 18 sample villages (2849 in the Bikaner district and 1644 in the Kota district). After the complete enumeration of households in selected villages, 10 households from each village were selected based on probability proportionate to size of land holding and livestock herd size. We collected primary data from 180 households for the agriculture year 2018 by the conventional survey method on a well-structured and pre-tested schedule through personal interview. Additionally, we also carried out a focused group discussion to get detail understanding of the pooled coping mechanisms against the risks.

Results and Discussion

Results of the study have been discussed under four broad sub-heads that comprised socio-economic characteristics of sample households, perceived responses of communities on climate change, early forecasting of climatic risk and coping strategies adopted thereby.

Socio-economic characteristics

Perceiving a risk often depends upon the socio-economic characteristics of sample households. For instance, an educated and affluent section may not experience financial risk due to available monetary resources for easy compensation of their loss. Similarly, an old and experienced household head can identify potential climatic risk more easily as compare to their younger counterparts. The impact of risk might be different across different social groups and different asset holders. Thus, it is important to study socio-economic characteristics of the households.

In correspondence with male dominant societal tendencies, for a majority of households the head was male in both study regions (Table 1). Average household size reflects the mindset of a society as more the number of members in the household, less modernized it is considered. Average household size was seven in Bikaner and five in Kota reflecting intended backwardness of drought-prone Bikaner in comparison to flood affected Kota. The age of household head matters in several aspects of risks such as an old and experienced head is more likely to perceive a risk in advance and will be efficient in utilization of risk coping mechanism. The management of indigenous agriculture and natural resources to some extent depends on the age of the household head. The learning from the parents and older people in the society helps the younger members in managing the climatic risks more efficiently[19].

Table 1 — Socio-economic profile of households

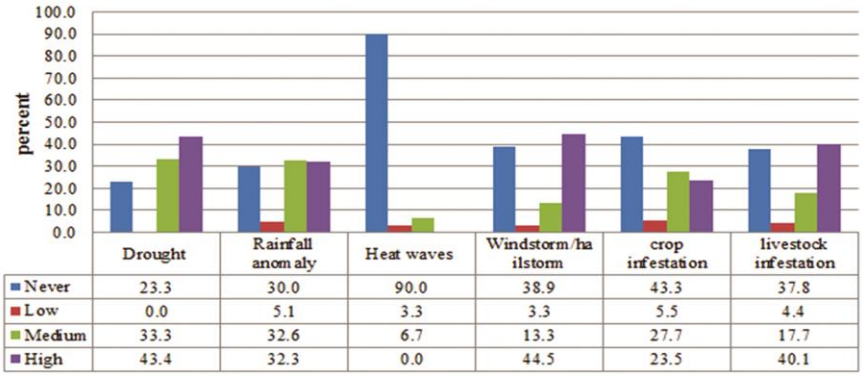
Particulars	Bikaner	Kota
Average age of household head (year)	52	49
Male (%)	92.0	88.0
Female (%)	8.0	12.0
Member in household (number)	7	5
Literate (%)	57.2	21.1
Schedule categories (%)	21.1	34.5
Hindu (%)	96.2	100.0
Kuccha& semi *pucca* structure	83.2	83.3
Average asset holding (Rs)	730200	657180
Average land holding (ha)	4.5	3.0
Irrigated holding (%)	22.0	94.0
BPL households (%)	20.5	45.0

The proportion of religious groups were found strictly in line with the national proportion as a majority (>90%) of the household were Hindu in both the districts while there were around 3.8% households that were Muslim by religion in Bikaner. Social group also has an important bearing on the perception of risk as some groups have pre-specified coping mechanism. Around 88.9% of sample households belonged to other backward class (OBC) and general category while this number was 65.5% in Kota. Around 21.1% sample households belonged to schedule caste (SC) in Bikaner and 12.7% in Kota. Remaining 21.8% sample households in Kota were Schedule Tribes (ST). A majority of sample households were residing in semi-*pucca* and *kuccha* type of houses in both the study areas while a small proportion was residing in *pucca* structures.

Education and landholding also have an important bearing on the perception of risks[20]. In Bikaner a majority of heads of households were literate unlike Kota. Average landholding size was 4.5 ha in Bikaner and 3 ha in Kota while the average value of assets was ₹ 7.3 lakh and ₹ 6.5 lakh, respectively. Income of households is also an important factor in the event of risks as people having higher income usually perceive fewer risks as compare to others. Wealthy people are better placed to adapt to climate vulnerability than the poor do, as they could intensify their production systems and can go for improved technologies/inputs[21]. Around 1/5th of sample households were having below poverty line (BPL) cards in Bikaner while this proportion was 45% in Kota. Around 81.1% of sample households were earning less than a lakh per year in Bikaner while this proportion was 41.6% in Kota; indicating an unfair distribution of BPL cards. In line with our expectation and the choice of the sample districts for the study, we found that a majority of land (78.28%) was un-irrigated in drought-prone Bikaner while it was reverse in case of Kota where more than 90% of the land was irrigated.

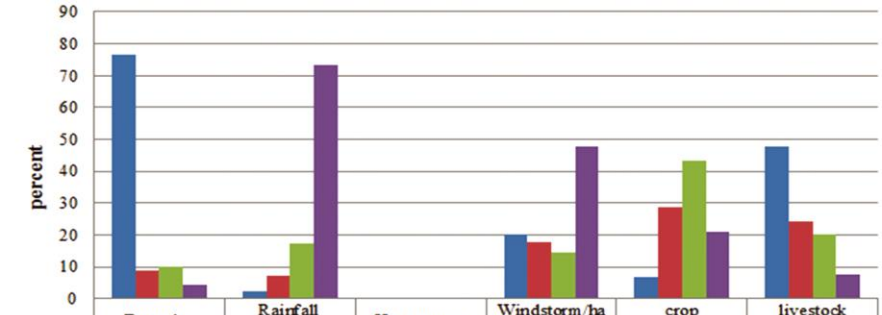
Weather and climate related risks

Figures 2 & 3 present the incidences of weather risks realization of sample households. Fairly a large section of sample households (43.4%) in Bikaner



	Drought	Rainfall anomaly	Heat waves	Windstorm/hailstorm	crop infestation	livestock infestation
Never	23.3	30.0	90.0	38.9	43.3	37.8
Low	0.0	5.1	3.3	3.3	5.5	4.4
Medium	33.3	32.6	6.7	13.3	27.7	17.7
High	43.4	32.3	0.0	44.5	23.5	40.1

Fig. 2 — Farmers' perception in drought prone region



	Drought	Rainfall anomaly	Heat waves	Windstorm/hailstorm	crop infestation	livestock infestation
Never	76.7	2.2	0	20	6.7	47.8
Low	8.8	7.1	0	17.7	28.8	24.4
Medium	10	17.3	0	14.4	43.3	20
High	4.5	73.4	0	47.9	21.2	7.8

Fig. 3 — Farmers' perception in flood prone region

revealed that they have experienced high incidences of drought in the last 10 years. Contrary to this, households of Kota stated that they have either not experienced the drought (76.7%) or experienced low intensity drought. Drought realization was less in Kota due to its geographical location in the flood-prone zone while Bikaner is located in the zone that experience frequent droughts. Around 30% of population in Bikaner reported that they have never experienced rainfall anomaly in the past 10 years while only 2.2% of sample households denied the incidence of rainfall anomaly in the flood-prone region. The probable explanation of the trend is that, a negative deviation of rainfall from normal is noticeable for Kota being flood-prone district, while it is a normal situation for Bikaner. Bikaner encounters frequent droughts and hence even a little excess of rainfall therein is perceived as rainfall anomaly by households.

On expected lines, people did not realize the risk from heat waves in flood-prone region. However, the response of farmers regarding heat waves in drought-prone went against our hypothesis of high incidences of heat waves in the region. A majority of households (90%) in the drought-prone region perceived that they have never experienced heat waves. The reason could be the adaptation of farmers to these events. Also, frequent subjection to high temperature in Bikaner must have made households less receptive and more resistant. Wind-storm and hail-storm are known to affect the crop, livestock and normal livelihood severely. Around 58% of sample households in Bikaner and 62% in Kota perceived that wind-storms and hail-storms causes medium to high risk in regions.

Pest and diseases are most prevalent in areas with high temperature and high humidity. Thus, higher incidence was expected in flood-prone Kota as compare to the dry desert of Bikaner. The results are in consonance with these facts as around 43.3% of households in Bikaner responded that they have never experienced pest and disease infestation in crops while in Kota this proportion of household was merely 6.7%. Just 5.5% of sample households in Bikaner and 28.8% in Kota experienced fewer incidences of risks in crops due to pest and diseases. Around 27.7% and 43.3% of sample households said that they realized medium incidences of pest and disease infestation of crops in Bikaner and Kota, respectively. The proportion of population realizing high incidence of this risk was almost equal in Bikaner (23.5%) and Kota (21.5%). Besides that, the pest and disease infestation among livestock was also a common phenomenon among cattle bearers of both the places. A majority of livestock holders realized high incidence of this risk in Bikaner while this proportion was only 7.8% in Kota.

Early forecasting of climatic risk

Focus Group Discussion (hereafter; FGD) revealed that most of the time community anticipates in advance; weather it is going to be an abundant or deficit year. Appearances of many colorful butterfly implies onset of abundant rainfall in the regions. Appearances of ants and termites in masses also indicate the same. Elders in villages also reported that on the advent of abundant rainfall there appear lush greenery and heavy flowering on some tree species such as *ficus* and *acacia*. Change in wind direction, movement of stars and clouds also dictate about the abundance or scarcity of rainfall in the region. Reporting from other studies also supports the findings[13,14].

Food insecurity in disaster-prone region

Food habits are acclimatization of climatic situations over a long time period. Rural people in India undertake subsistence agriculture and often depend upon what they grow in their fields. It came up from the study that in food scarce, 'drought-prone region', people were skipping morning meals (Table 2) but in abundance zone taking meal three times a day was normal. People in the drought-prone region are more food insecure in comparison to flood affected region. Temporary migration and borrowing money from nearby option is the most resorted option by people of flooded region in case of food and nutritional insecurities that is a frequent phenomenon in the state[22].

People in drought areas were more comfortable in changing dietary patterns over other available options. They were more dependent on fruits of locally available species of plant/trees like pods of *Khimp* (*Leptadenia pyrotechnica*), *Kair* (*Capparis decidua*), *Phoq* (*Calligonum polygonoides*), *Khejri* (*Prosopis cineraria*) for their food as well as earning, particularly during summer season (Fig. 4). Most of these species are rich in nutrients, fruits during summer and have medicinal values. Pods of *Leptadenia pyrotechnica*, known as *khimpoli* in Hindi are of medicinal value and used as vegetables. Besides this plant is also use for

Table 2 — Food security in disaster prone regions

Particulars	Detail	Bikaner	Kota
Number of meals	Two	97.7	10
	Three	2.3	90
Food adequacy	Get enough food all months	4.5	52.6
	Enough food only some months of the year	95.5	37.4
	No month of the year food is enough	0	10
Response to food insecurity	Less frequent meals	33.3	0
	Changing diet patterns	58.8	0
	Selling household assets to purchase food from market	5.5	3.2
	Members seeking outside employment	1.1	53.3
	Money borrowing from local sources	13.3	60.8
	Food aid from relatives or friends	7.8	30.2
Government food aids	Ration card	70	60
	BPL card	2.3	22.5

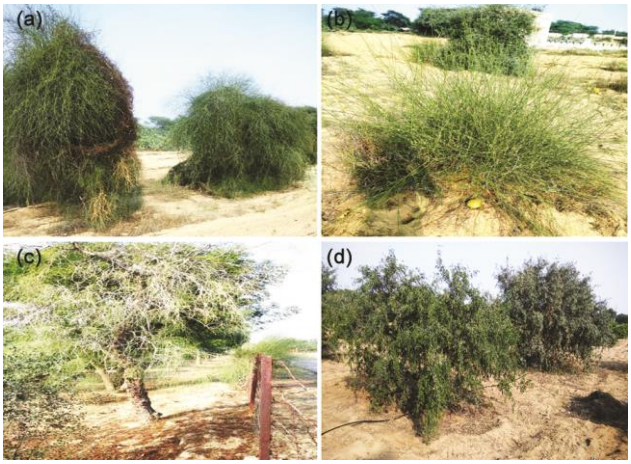


Fig. 4 — (a) *Kair* tree (*Capparis decidua*) (b) *Shrub of Khimp* (*Leptadenia pyrotechnica*) (c) *Phog shrub* (*Calligonum polygonoides*) and (d) *Khejri (Prosopis cineraria)*

making ropes, animal fodder, thatching purposes etc, and potentially can be used in textile industry[23,24]. The floral buds of *Calligonum polygonoides* are used as vegetable and are consumed with buttermilk and salt. This species also has the medicinal value as the plant extract is used for treatment of typhoid and its decoction is used to treat urinary problems in animals[25]. These two species also help in soil conservation and enriches soil with nutrients[26,27]. However, local people perceive that with mechanisation and crop intensification, these indigenous species are disappearing. Besides, a majority of households in both the regions had access to subsidized food that was additional risk mitigation option under the safety net programs like Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS).

Existence and adoption of risk management instruments

After looking into the exposure of households to various types of risks in disaster-prone regions, it is important to look into the availability of risk coping mechanism and their utilization. In this reference, detail information on the availability of various risk management options was sought from sample households. Mere availability of risk management options doesn't insure that the household has access to them and even if a household has access to them, they may or may not utilize them due to involvement of cost, lack of technical know-how or any other possible reasons. Table 3 provides the percentage of households utilizing the available strategies. Households' characteristics tend to influence utilization of particular risk management strategy.

Coping mechanisms against weather risks

Risk management options were analyzed under three heads in study region *viz.* crop related, input related and credit related measures. Crop related measures included adjustment made in sowing time, rotation of crops over the season, diversification of available land area and mixed farming. Input related measures include the option adopted by making necessary adjustments in the use of inputs such as land, seed, fertilizer and manure. Credit related measures are resorted primarily, to enhance income.

Against perceived climatic variations, adjustments in the dates of sowing and multiple sowing are done in both the regions if monsoon delays. Some of the farmers in Bikaner district reported that *Bhaldya* (dry sowing) practiced before the onset of monsoon. The tendency of adopting these measures is less among farmers in flood-prone region. These coping mechanisms emerged as costly affairs due to double losses, like loss of yield and input altogether. Farmers in the drought-prone region are turning to nutrient-rich millet crops particularly *jowar* (*Sorghum bicolor*), *bajra* (*Pennisetum glaucum*) and

Table 3 — Utilization of risk coping mechanism by households

Coping mechanisms	Strategy	Bikaner (%)	Kota (%)
Crop related	Changing plantation schedule	42.2	26.6
	Crop rotation	42.2	18.8
	Diversification	30.0	55.5
	Mixed farming	38.8	51.1
Input related	Extended land use	1.1	38.8
	Improved seeds	34.4	87.7
	Fertilizers and manure	25.4	90.0
Credit related	Multiple jobs	28.8	46.6
	Borrowing	87.7	85.5
	Selling assets	3.3	28.8
	Crop insurance	31.1	67.7

ragi (*Eleusine coracana*) in respective major growing seasons. Additionally, short duration varieties of popular crops (*soybean* and *guar*) are also advocated in the region. In the flood-prone regions of Kota, the water guzzling crops, particularly paddy, are popular among farmers. However, a large proportion of sample households were following crop and enterprise diversification to minimize climatic risks. Crop-livestock interaction is most common in both the regions. Crop diversification at drought-prone region was particularly towards *moth bean* and *guar* crop in event of calamity as against traditionally cultivated *jowar* and *bajra*. Groundnut, moong and sesamum emerged as other popular choices in the region particularly due to less water requirement in these crops. *Paddy*, *soyabean* and *urad* are the most popular choices of the farmers in the flood-prone region of Kota. Also, farmers of the drought-prone region revealed that they generally practice deep summer ploughing, especially during morning hours to expose soil-resting stages of insects or pests for predatory birds.

Extending land for cultivation as a risk mitigating option is utilized by a limited number of households in Bikaner, due to water scarcity and less fertility. While in flood-prone Kota, this proportion is comparatively high. Farmers generally use improved seeds and fertilizers abundantly in the flood-prone region (87.7% and 90% respectively) as compared to drought-prone regions (34.4% and 25.4% respectively). During climatic extremes, a few individual in both the regions look for work other than traditional cultivation while borrowing from formal and informal sources is the most exercised option. In both the regions, major dependency of farmers is on the local money lenders particularly due to quick cash availability and ease in disposal of farm produce. A large section of farm households tend to sell household assets (particularly land and livestock) for mitigating the effect of natural disasters.

Changes in weather conditions often lead to pests and diseases infestation among important crops of the region. High temperature and high humidity often lead to pest infestation and frequent crop failures. To cope up with these situations, farmers are expected to use safety nets like insuring their crop against weather risks. In drought-prone region, near to *one-third* households have crop insurance as against *two-third* in flood-prone regions.

Conclusion

Farmers of Rajasthan realized that the risk of droughts, rainfall anomalies and wind-storms is increasing over time. People in the drought-prone region are more food insecure in comparison to flood-affected region. However, they adapt themselves by diversifying their dietary patterns towards climate resilient indigenous products. They depend on fruits of locally available species of plants/trees; like pods of *Khimp* (*Leptadenia pyrotechnica*), *Kair* (*Capparis decidua*), *Phog* (*Calligonum polygonoides*), *Khejri* (*Prosopis cineraria*), etc. for their food and earning; particularly during the *summer* season. However, these indigenous species are disappearing over the time, therefore there is need to preserve them. Local communities need to be incentivized for conserving the same. As these indigenous products have high market value, the value chains of these products need to be strengthened by providing processing equipment such as solar drier at subsidized rates. Adjustments in the dates of sowing, deep summer ploughing in morning hours, dry sowing, increased seed rate, mixed cropping and farming, especially crop-livestock integration are other common strategies followed by farmers. However, the crop-livestock integration requires strengthening livestock support services and extension system in the region[5,6].

Acknowledgement

Authors thankfully acknowledge the funding support provided by Indian Council of Social Science Research.

Conflict of Interest

Authors declare that there is no conflict of interest.

Author Contributions

S S and V K conceptualised the research idea. V K collected and analysed the data, and drafted the paper with P C. Paper was finalised by S S and P C.

References

1 Hodell D A, Curtis J H & Brenner M, Possible role of climate in the collapse of Classic Maya civilization, *Nature*, 375 (6530) (1995) 391-394.https://doi.org/10.1038/375391a0

2 Fisher S & Palmer R N, Managing water supplies during drought: triggers for operational responses, *Water Resour Update*, 3 (108) (1997) 14-31.

3 Palomo I, Climate change impacts on ecosystem services in high mountain areas: a literature review, *Mountain Res Dev*, 37 (2) (2017) 179-188.https://doi.org/10.1659/MRD-JOURNAL-D-16-00110.1

4 Smit B & Wandel J, Adaptation, adaptive capacity and vulnerability, *Global Environ Change*, 16 (3) (2006) 282-292.https://doi.org/10.1016/j.gloenvcha.2006.03.008

5 Chand P, Sirohi S & Sirohi S K, Using sustainable livestock production index for development of livestock sector: case study of an arid region in India, *J Appl Anim Res*, 39 (3) (2011) 234-238. https://doi.org/10.1080/09712119.2011.588396

6 Chand P, Sirohi S, Sirohi S K & Chahal V P, Estimation of demand and supply of livestock feed and fodder in Rajasthan: a disaggregated analysis, *Indian J Anim Sci*, 85 (11) 1229-1234.

7 Rapeli M, Cuadra C, Dahlberg R, Eydal G B, Hvinden B, *et al.*, Local social services in disaster management: is there a Nordic model?, *Int J Disaster Risk Reduct*, 27 (2018) 618-624.https://doi.org/10.1016/j.ijdrr.2017.07.018

8 Keerthiratne S & Tol R S, Impact of natural disasters on income inequality in Sri Lanka, *World Dev*, 105 (2018) 217-230.https://doi.org/10.1016/j.worlddev.2018.01.001

9 Chand, P & Sirohi S, District level sustainable livestock production index: tool for livestock development planning in Rajasthan, *Indian J Agric Econ*, 67 (2) (2012) 199-212. https://doi.org/10.22004/ag.econ.204806

10 Kanwal V, Sirohi S & Chand P, Effect of drought on livestock enterprise: evidence from Rajasthan, *Indian J Anim Sci*, 90 (1) (2020) 94-98.

11 Dutta D, KunduA & Patel N R, Predicting agricultural drought in eastern Rajasthan of India using NDVI and standardized precipitation index, *GeocartoInt*, 28 (3) (2013) 192-209. https://doi.org/10.1080/10106049.2012.679975

12 Kanwal V, Pandey D & Kumar S, A comparative analysis of crop diversification between flood and drought prone areas of Rajasthan, *Indian J Econ Dev*, 14 (1a) (2018)168-174.

13 Sarkar S, Padaria R N, Vijayragavan K, Pathak H, Kumar P & Jha G K, Assessing the potential of Indigenous Technological Knowledge (ITK) for adaptation to climate change in the Himalayan and arid ecosystems, *Indian J Tradit Know*, 14 (2) (2015) 251-257.

14 Kumar, S, Parveen F, Goyal S & Chauhan A, Indigenous herbal coolants for combating heat stress in the hot Indian arid zone, *Indian J Tradit Know*, 7 (4) 689-682.

15 Pareek A &Trivedi P C, Cultural values and indigenous knowledge of climate change and disaster prediction in Rajasthan, India, *Indian J Tradit Know*, 10 (1) (2011) 183-189.

16 Dessai S Lu & Risbey J S, On the role of climate scenarios for adaptation planning, *Global Environ Change*, Part A, 15 (2) (2005) 87-97.

17 Singh C, Osbahr H & Dorward P, The implications of rural perceptions of water scarcity on differential adaptation behaviour in Rajasthan, India, *Reg Environ Change*, 18 (2018) 2417–2432. https://doi.org/10.1007/s10113-018-1358-y

18 Rao C R, Raju B M K & Rao A S, A district level assessment of vulnerability of Indian agriculture to climate change, *Curr Sci*, 110 (10) (2016) 1939-1946.

19 Singh R K & Sureja A K, Indigenous knowledge and sustainable agricultural resources management under rainfed agro-ecosystem, *Indian J Tradit Know*, 7 (4) (2008) 642-654.

20 Gbetibouo G A & Ringler C, Mapping South African farming sector vulnerability to climate change and variability, (International Food Policy Research Institute, Washington, DC), 2009, Discussion Paper 885.

21 Singh R K, Zander K K, Kumar S, Singh A, Sheoran P, *et al.*, Perceptions of climate variability and livelihood adaptations relating to gender and wealth among the *Adi* community of the Eastern Indian Himalayas, *Appl Geogr*, 1 (86) (2017) 41-52. https://doi.org/10.1016/j.apgeog.2017.06.018

22 Kanwal V, Thorat V S & Chand P, Vulnerability of rural households to food and nutritional insecurity in arid regions of India: some evidence from Rajasthan, *Agric Econ Res Rev*, 32 (conf) (2019) 183-192.https://doi.org/10.22004/ag.econ.303662

23 Majumder P, Mondal S B, Mukhopadhya S & Sen K K, Chemical characteristic of Khimp fibre (*Leptadenia pyrotechnica*), *J Sci Ind Res*, 60 (2001) 675-677.

24 Kundu S K, Majumder P, Bhaduri S K & Das B K, Physical characteristics of khimp fibre, *Indian J Fibre Text Res*, 30 (2005) 153-156.

25 Katewa S & Galav P, Traditional herbal medicines from Shekhawati region of Rajasthan, *Indian J Tradit Know*, 4 (3) (2005) 237-245.

26 Saxena S & Singh S, Some observations of the sand dunes and vegetation of Bikaner district in Western Rajasthan, *Ann Arid Zone*, 15 (1976) 313-322.

27 Bewal S, Sharma S K & Rao S R, Analysis of intra-specific genetic variation in *Calligonum polygonoides L.* (Polygonaceae): a keystone species of Indian desert. *Cytologia* (Tokyo), 73 (4) (2008) 411-423. https://doi.org/10.1508/cytologia.73.411