



## Adaptation practices followed by dairy farmers under adverse climatic conditions in western dry region of India

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Received: 9 May 2016; Accepted: 5 July 2016

### ABSTRACT

The investigation was conducted in western dry region of India utilizing a descriptive research design. Data were collected through personal interview and focus group discussion. The data were analysed using frequency and percentage. The findings of present study show that majority of the dairy farmers were providing feed twice a day followed by feeding their animals at early morning and late evening, less than recommended floor space in animal house, consult veterinarian + ethno-veterinary practices for managing reproductive problems, using natural service for breeding purpose and growing fodder trees (Khejri, Babul, Ber, Jaal, Ardu and Neem etc.) as a coping strategy to meet the shortage of forage under adverse climatic conditions.

**Key words:** Adaptation, Climatic condition, Dairy farmer, Western dry region

The Intergovernmental Panel on Climate Change (IPCC 2007) defines climate change as change in state of the climate that can be identified by change in the mean/or variability of its properties that persist for an extended period, typically decade or longer. Developing countries are the most vulnerable to climate change impacts because they have fewer resources to adapt socially, technologically and financially (UNFCCC 2007). In India, as the world, majority of poorest people depend on farming and livestock keeping for their livelihood i.e. food, fibre, income, security and companionship (Chakravarty *et al.* 2012). A large sector of rural-poor community relies heavily on the natural resource base of their livelihood. Climate change puts extra burden on the social and economic conditions that the poorest already face and increasing their vulnerabilities due to the dependence of their livelihoods on climate sensitive natural resources i.e. agriculture and livestock keeping. So the negative impacts of climate change are more severely felt by poor people. Research studies from India have found that meteorological parameters like temperature, humidity and rainfall explain 52 and 84% variations in seasonality of Foot and Mouth Disease (FMD) in cattle in hyper-endemic division of Andhra and meso-endemic region of Maharashtra states, respectively (Ramarao 1988). Singh *et al.* (1996) reported that higher incidence of clinical mastitis in dairy animals during hot and humid weather conditions

due to increased heat stress and greater fly population associated with hot-humid conditions.

Adaptation is identified as one of the policy options to reduce the negative impact of climate change (Adger *et al.* 2003). Common adaptation methods in agriculture include use of new crop varieties and livestock species that are more suited to drier conditions, irrigation, crop diversification, mixed crop-livestock farming systems and changing planting dates (Bradshaw *et al.* 2004, Nhemachena and Hassan 2007). Various studies in different countries show that without adaptation, climate change is generally detrimental to the agriculture sector; but with adaptation, vulnerability can largely be reduced. The degree to which an agricultural system is affected by climate change depends on its adaptive capacity. Indeed, adaptive capacity is the ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damage, to take advantage of opportunities, or to cope with the consequences (IPCC 2001). Thus, the adaptive capacity of a system or society describes its ability to modify its characteristics or behaviour so as to cope better with changes in external conditions. Stern (2006) stressed that there is increasing recognition of the need for nations, communities and individuals to adapt to some level of climate change, irrespective of the level of mitigation. Adaptation is necessary to avoid or reduce the negative impacts and to explore any potential benefits of climate change. Adaptation to climate change will therefore have very important social and economic implications. A myriad of socio-economic pressures, coupled with climate variability, may therefore, weaken a country's capability to cope and adapt to long-term changes. The situation is worse

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for the regions which were historically already at the disadvantageous position among which western dry region is one. Cropping intensity and productivity are one of the lowest in the region as compared to the other regions which compelled the farmers to adopt the dairy farming as one of the major source of livelihood, thereby, this region was found to be most suitable for conducting such type of study. Due to emerging threat of climate variability, this source is also at risk. Under the circumstances discussed above, it arises a need for a study which focus on the adaptation practices followed by dairy farmers under adverse climatic conditions in western dry region of India.

#### MATERIALS AND METHODS

*Locale of the study:* Nine districts of Rajasthan, viz. Barmer, Bikaner, Churu, Jaisalmer, Jalor, Jhunjhunu, Jodhpur, Nagaur and Sikar constitute the western dry region of India. It is located in the North-Western part of India between 24° 31' to 30° 12' North latitudes and 69° 15' to 76° 42' East longitudes. It is surrounded by Punjab in North, Gujarat in South, Pakistan in West and Aravalis in East (Planning Commission 2007). Rains are scanty and erratic, rate of evaporation is high, there are no perennial rivers and ground water table is very deep and is often brackish. Vegetation is sparse. The average rainfall is about 400 mm but with very high year to year variations. The climate of the region ranges from semi-arid to arid. The average temperature varies from 47°C in May–June to less than 2°C in December–January (Rathore 2005).

*Sampling plan:* The present study was conducted purposively in western dry region of India. Livestock is the major source of livelihood in the region, as evident from the density of livestock (170/sq. km) which is highest as compared to a national average (161/sq. km). Both crops and animals are prone to the vagaries of nature. Frequent droughts lead to decline in productivity and reduced performance and even death of animals (Planning Commission 2007). Out of 9 districts of region, Barmer, Jaisalmer Sikar and Jhunjhunu were selected purposively considering average annual rainfall. Two districts having minimum rainfall (Barmer and Jaisalmer) and two districts with maximum rainfall (Sikar and Jhunjhunu) were selected for the present study. Two tehsils were selected randomly from each identified district and from each selected tehsil, two villages were selected randomly. After the selection of the villages, a preliminary survey was conducted in the selected villages and a list of farmers was prepared who were practicing dairy farming. Farmers were categorized into 3 categories viz. those who were having up to 2 animals, 3–5 animals and more than 5 animals. From each category, farmers were selected proportionately, however, a total of 15 dairy farmers were selected from each village representing each category of farmers. Thus, 4 districts, 8 tehsils, 16 villages and 240 dairy farmers were selected to conduct the study.

The descriptive research design was used in this present study. Existing adaptation practices were assessed by

developing interview schedule during May–August, 2013.

*Data analysis:* The data were analyzed by using statistical tools like percentage and frequency to draw meaningful conclusions from the study.

#### RESULTS AND DISCUSSION

##### *Breeding management*

In the adverse climatic conditions, breeding management should be such that the productivity and reproductive performance of the animals can be maintained above the economic threshold level. Selection of breed, maintenance of exotic blood level and upgradation should also be as per the climatic conditions.

*Available breeds in the study area:* Results show that majority (56.25%) of the dairy farmers were having non-descript animals followed by crossbred cows (HF, Jersey; 16.25%), desi cattle (11.67%), crossbred + non-descript animals (11.67%), desi cattle + non-descript animals (2.91%) and crossbred + desi cattle + non-descript animals (1.25%); respectively. It can be concluded that study area is dominated by the non-descript cattle because of their better adaptability to adverse climatic conditions, survive on low quality feed, fodder and water, less susceptibility to the diseases, etc. Further, it was observed that only 16.25% farmers were keeping crossbred cows. It can be concluded that a very less number of farmers were rearing crossbred cows because of less survivability, higher disease incidence and drastic reduction of milk yield. Past studies also reported that milk yield of crossbred cows in India (e.g., Karan Fries, Karan Swiss, Holstein and Jersey crosses) are negatively correlated with temperature-humidity index (Shinde *et al.* 1990, Kulkarni *et al.* 1998, Mandal *et al.* 2002).

*Method of mating being followed:* Findings of study revealed that majority (67.92%) of the dairy farmers were using natural service for breeding purpose. This might be due to lack of AI facilities. This was followed by AI (16.25%). While, 15.83% of the dairy farmers had followed both (Natural + AI). This may be attributed to the easy availability of natural services and low success rate of AI may be due to the extreme climatic conditions.

*Level of exotic inheritance for better adaptation under hot weather condition:* About 54.60% of the dairy farmers perceived that if level of exotic inheritance is 50% then there would be better adaptation under hot weather conditions. However, 45.40% of the dairy farmers felt that the level of exotic inheritance should be 25% for better adaptation. None of the farmers were in the favour of maintaining exotic inheritance at 62.50% because at this level survival of the exotic animal was found to be very difficult under adverse climatic conditions. A recent study in India showed that crossbreeding of defined indigenous breeds like Gir, Tharparkar and Sahiwal should be inarguably stopped. Also, in view of stagnated performance over generations of crossbreds which are comparable to defined indigenous breeds depending on level of input use and negligible genetic gain per annum in crossbred population since introduction of massive crossbreeding

programme (1960 onwards), it can be recommended that grading up of non-descript indigenous breeds should be done with defined indigenous dairy breeds which will result in maintenance of adaptive characteristics of both breeds of *Bos indicus* cattle along with concomitant increase in milk production. Atleast this policy should be adopted in drought prone and rainfed regions where fodder and water availability is poor (Misra and Mandal 2010).

#### Feeding management

Reduction in voluntary feed intake in heat stressed dairy animals is the major reason for decrease in milk productivity. In such situation, the practical approaches to increase the dry matter intake (DMI), which is the key to good nutrient balance and greater nutrient density to be followed. Feed intake declines with hot conditions and rations must be reformulated in an attempt to deliver an adequate quantity of nutrients for sustaining the productivity. The addition of fat to the diets of lactating

dairy animals is another practice that has the potential to reduce the heat increment due to the greater energy density and high energy conversion efficiency. Although, the results of the research on the positive effects of dietary fat during hot weather are not robust (Skaar *et al.* 1989, Huber *et al.* 1994, Chan *et al.* 1997). The results of feeding management are presented in the Table 1.

*Feeding pattern followed during heat stress:* Results presented in Table 1 revealed that less than half (48.33%) of the dairy farmers were following feeding pattern as “no specific changes of forage in the ration”. This might be due to seasonal fluctuation in dairy feed availability, lack of technical knowledge of production, management, utilization and conservation of forage, farmers were resource poor, unable to afford quality feed and lack of capital to invest in fodder production. This was followed by “increasing the proportion of forage in the ration and decreasing the proportion of concentrate” (32.92%), “as per nutritional requirement” (15.00%) and “decreasing the proportion of

Table 1. Distribution of respondents according to their feeding management

		(n=240)	
Adaptation practices	Frequency	Percentage	
<i>Feeding pattern followed during heat stress</i>			
Increasing the proportion of forage in the ration only	2	0.84	
Increasing the proportion of forage in the ration and decreasing the proportion of concentrate	79	32.92	
Decreasing the proportion of forage in the ration and increasing the proportion of concentrate	7	2.91	
No specific changes of forage in the ration	116	48.33	
As per nutritional requirement	36	15.00	
<i>Schedule of feeding practiced during extremes of weather</i>			
Feeding early morning and late evening	220	91.67	
Feeding during milking time	1	0.41	
Feeding during early morning, afternoon and evening	16	6.67	
Feeding anytime	3	1.25	
<i>Frequency of feeding</i>			
Once a day	1	0.41	
Twice a day	221	92.09	
Thrice a day	18	7.50	
<i>Feed additives used during hot/cold weather</i>			
Mineral mixture	89	37.08	
No feed additive is used	151	62.92	
<i>Coping strategy for shortage of fodder during drought</i>			
Hay making (Kasni grass, lucerne, oat and natural grasses)	32	13.34	
Purchase fodder from market (wheat straw)	6	2.50	
Hay making + purchase fodder from market	164	68.33	
Hay making + urea treated straws + purchase fodder from market	8	3.33	
Hay making + urea treated straws + complete feed blocks + purchase fodder from market	5	2.08	
<i>Adaptation practices</i>			
Followed no strategy	25	10.42	
<i>Feeding strategy followed during drought situation</i>			
Crop residues (Bajra, Jowar, Barley, Guar and Moong)	8	3.33	
Use of unconventional feeding stuffs likes tree leaves-(Khejri, Babul, Ber, Ardu, Jaal, Neem) and Moong straw, grain husk	5	2.08	
Crop residues + unconventional feeding stuffs	156	65.00	
Crop residues + unconventional feeding stuffs + grazing animals along roads/open fields	44	18.34	
Unconventional feeding stuffs + grazing animals along roads/open fields + migration	27	11.25	
<i>Feeding practice followed during extremes of weather</i>			
Providing extra ration to animals	72	30.00	
Providing feed and fodder to maintain production and growth at minimum level	61	25.40	
Maintaining desired production by purchasing supplements from outside	11	4.60	
Migration	25	10.40	
Scavenging	71	29.60	
<i>Source of drinking water</i>			
Public tube well	160	66.67	
Rain water harvesting tank	40	16.67	
Private tube well	20	8.33	
Public hand pump	20	8.33	
<i>Watering practices during hot weather</i>			
Providing water in trough kept in shed	169	70.40	
Providing water from open sources	71	29.60	
<i>Frequency of watering</i>			
Twice a day	35	14.58	
Thrice a day	106	44.17	
As and when water	99	41.25	

forage in the ration and increasing the proportion of concentrate” (2.91%). While, only 0.84% of the dairy farmers had followed feeding pattern as “increasing the proportion of forage in the ration only” to their dairy animals. It is astonishing to note that less number of the dairy farmers were feeding concentrate to their dairy animals because of that reproductive and productive performance were found very low. Low amount of feeding of concentrate to the animals might be attributed to the low availability of concentrate, high cost of concentrate and lack of knowledge regarding positive effect of concentrate feeding on reproductive and productive performance of animals.

*Schedule of feeding practiced during extremes of weather:* A perusal of Table 1 shows that most of the dairy farmers (91.67%) were feeding their animals at early morning and late evening as temperature becomes pleasant during these timings so that animal can eat a sufficient quantity of feed comfortably. This was followed by feeding during early morning, afternoon and evening (6.67%). This type of feeding schedule was followed by the farmers who were giving feed thrice a day. A very less number of the farmers (1.25%) were feeding to their animals anytime during extremes of weather.

*Frequency of feeding:* Most (92.09%) of the dairy farmers were providing feed twice a day followed by thrice a day (7.50%) and once a day (0.41%), respectively (Table 1). As majority of the respondents were providing feed twice a day, which seems to be not a good practice thereby they may be made aware about increasing the frequency of the feeding by splitting of feed for a day. In the latter case, the aim of the farmer was to save the life of the animals instead of production and productivity. It can be concluded that most of the respondents of such area kept their animals underfed because of scarcity of feed and fodder and unaffordability to purchase the feed and fodder.

*Feed additives used during hot/cold weather:* It has been observed from Table 1 that majority (62.92%) of the dairy farmers were not using feed additives. While, only 37.08% of the dairy farmers were using mineral mixture as feed additive during hot/cold weather. This might be due to the lack of knowledge among the farmers. In the study area, however, feed additives for managing heat or cold stress, were provided to the respondents by the State Government’s Animal Husbandry Department/NGO who are provoking and providing only mineral mixture to them. They were unaware about other feed additives like bypass fat and protein which are more prominent to reduce the heat stress.

*Coping strategy for shortage of fodder during drought:* A critical look on Table 1 revealed that majority (68.33%) of the dairy farmers were following “hay making (Kasni grass, Lucerne, Oat and natural grasses) + purchase from market (Wheat straw)” as a coping strategy for shortage of fodder during drought. This was followed by “hay making” (13.34%), “followed no strategy” during drought (10.42%). This might be due to that they were having survival income for their livelihood from other sources to combat drought

thereby not giving much attention to animals because of their limitation. Further, they were used to conserve/reserve enough feed and fodder for their animals during the lean period. A lesser number of the respondents (3.33%) were following “hay making + urea treated straws + purchase fodder from market” and 2.50% “purchased fodder from market” to mitigate the fodder shortage condition. However, only 2.08% of the dairy farmers had followed coping strategy as “hay making + urea treated straws + complete feed blocks + purchase fodder from market”.

*Feeding strategy followed during drought situation:* It is apparent from the Table 1 that majority (65.00%) of the dairy farmers were feeding “crop residues + unconventional stuffs” as a feeding strategy during a drought situation. This was followed by “crop residues + unconventional feeding stuffs + grazing animals along roads/open fields” (18.34%); “unconventional feeding stuffs + grazing animals along roads/open fields + migration” (11.25%) and “crop residues” (Bajra, Jowar, Barley, Guar and Moong; 3.33%). Whereas, 2.08% of them had used “unconventional feeding stuffs (tree leaves, Moong straw and grain husk)” as a feeding strategy during drought situation. The tree leaves used for feeding to dairy animals were found to be Khejri (*Prosopis cineraria*), Babul (*Acacia nilotica*), Ber (*Zizyphus spp.*), Ardu (*Ailanthus sp.*), Jaal (*Salvadora oleoides*) and Neem (*Azadirachta indica*). Due to drought, the shortage of water is common phenomenon which inhibits growing of fodder crops and almost grazing land become barren without any prominent vegetation for grazing of animals. Under these circumstances for sustaining milk production and productivity, respondents were used to feed dry fodder along with unconventional feeding stuffs. They have no alternative except the dry fodder due to their poor affordability.

*Feeding practice followed during extremes of weather:* About 30% of the dairy farmers were “providing extra ration to animals” as a feeding practice followed during extremes of weather. This is due to less availability of feeding stuff during drought. This was followed by “scavenging” (29.60%), “providing feed and fodder to maintain production and growth at minimum level” (25.00%), “migration” (10.40%) and maintaining desired production by purchasing supplements from outside (4.60%); respectively (Table 1). The farmers who can grow only *rabi* crops they could store crop residues of this season. However, the farmers who were having their own irrigation facilities could grow two or three crops in a year enabling them to store a sufficient quantity of feed & fodder materials. Though, only few farmers were having such kind of facilities as creation of them is too costly due to low water table. Scarcity of feeding materials in the study area forced the farmers to purchase feed stuff from the distance places which further increases the cost of feeding. From the above discussion, it can be concluded that farmers of this area were used to store feed and fodder materials in the form of crop residues, weeds and grasses in advance for life saving feeding of their animals during drought as well as in the

extreme climatic conditions.

*Source of drinking water:* It was found from the Table 1 that major source of drinking water was public tube well (66.67%) followed by rain water harvesting tank (16.67%). An equal number (8.33%) of public hand pumps and private tube wells served as the drinking water sources. Due to high water table, cost of the drilling tube well is too high thereby; individual farmers were unable to make their own tube wells. Keeping in view the facts, government has developed tube wells in the area to supply drinking water, however, some wealthy farmers managed to have their own tube wells.

*Watering practices during hot weather:* It could also be visualized from the Table 1 that majority (70.40%) of the dairy farmers were providing water in trough kept in shed while, 29.60% of the dairy farmers were providing water from open sources. It can be inferred that a sizeable proportion of the respondents were providing water from open sources which can not be considered hygienic. However, during discussion with the farmers it was surfaced that they were forced to provide water from open sources as sufficient drinking water is not available on daily basis.

*Frequency of watering:* About 44.17% of the dairy farmers were providing water to animals thrice a day followed by *as and when* water required by the animals (41.25%). While, 14.58% of the dairy farmers had provided water twice a day to their animals (Table 1). It is concluded that in accordance of high temperature prevailing in the area, frequency of watering seems to be not sufficient. The farmers who were providing water twice a day may be advised to increase the frequency of water to reduce the heat stress of animal.

#### *Shelter management*

In the hot environment, energy exchanges by radiation are dominant, while convective energy exchanges tend to dominate in cold environments. Therefore, the first step to moderate the stressful effects of a hot climate is to protect the dairy animals from direct and indirect solar radiation. Shade against solar radiation could be provided by either trees or construction made of straw and other locally available materials. Trees are considered to be the most effective shades as their leaves are cooled by vaporization. The appropriate height of the shading structure and the area of shade available/animal are also important in offering adequate protection to the animals. For tropical climates, generally enclosed shelters are not recommended because they decrease natural air velocity. Experimental studies have shown that thick walled, all-brick stall with a black exterior and white-washed under-surface adds to the thermal stress of sheltered crossbreds during Indian summer. Instead, straw thatched sheds or tall, simple asbestos shades with reflective white outside and absorptive black on the under-surface of roof with plenty of shady trees in the surroundings to act as heat sinks are suitable for crossbred animals (Thomas 1966). The findings of shelter management are presented in Table 2.

*Type of housing system:* Majority (62.90%) of the dairy farmers were having “conventional housing system” followed by 20 and 17.10% of the respondents who followed “partially close & open housing system” and “loose/open housing system”; respectively (Table 2). Close housing system is not suitable for the tropical climate, therefore, farmers may be advised to follow loose housing system to mitigate the ill effects of heat stress on animals and this may improve the productivity of the animals. The farmers were also advised to plant plenty of trees in the animal shed to optimize the micro climate of the surrounding of the shed. Trees also act as wind break to save the animals from desiccating westerly during summer.

*Approximate height of the shed:* A glance at Table 2 shows that majority (62.10%) of the dairy farmer followed 10 feet height of shed followed by 10–12 feet (37.50%), however, only 0.40% of the farmers had followed 12–15 feet height of shed. It may be inferred that shed height is not appropriate and it might be due to higher cost of construction materials as transportation facilities are scarce in the area. Another reason might be the lack of awareness among the farmers regarding the relationship between heat regulation and height of the shed.

*Floor space available per animal:* Most (87.08%) of the dairy farmers had followed “less than recommended” floor space in animal house. This may be due to the lack of knowledge among the farmers. Whereas, 9.17 and 3.75% of the dairy farmers followed “more than recommended” and “recommended (3.5×7.0 m<sup>2</sup>)” floor space per animal; respectively. In majority of the cases, sufficient space is not provided to the animal resulting in overcrowding in the shed. This may provide conducive atmosphere for spread of diseases, difficulty in farm operation and ultimately reduction in productive performance of the animals. It may be concluded that farmers are not aware about the space requirement of animals (Table 2).

*Management practices adopted to cope up extremes of weather:* About 35.42% of the dairy farmers were following “bedding in winter + water wetting during summer + keeping under the trees during day time in summer” as a management practice adopted to cope up extremes of weather. This was followed by “bedding in winter + water wetting during summer + keeping inside during day time and outside during night” (16.25%); “water wetting during summer + keeping under the trees during day time in summer” (15.00%); “coverage of windows in winter + water wetting during summer + proper ventilation + keeping under the trees during day time in summer” (10.42%); “bedding in winter + coverage of windows in winter + water wetting during summer + keeping inside during day time and outside during night” (8.33%) and “bedding in winter + water wetting during summer + proper ventilation + keeping inside during day time and outside during night” (7.91%). Whereas, 6.67% of the farmers followed “bedding in winter + coverage of windows in winter + water wetting during summer + keeping under the trees during day time in summer” to cope up extremes of weather. From the above

results, it can be concluded that farmers were using management practices as per their availability in the area to cope up extremes of weather (Table 2).

*Shed orientation for proper light and ventilation:* The investigation revealed that 47.90% of the dairy farmers were followed North-South shed orientation followed by orientation by 34.20% and East-West shed orientation by 17.90%. It can be concluded that a large chunk of the respondent were not following proper shed orientation which is found to be the north-south orientation, this adversely affect the climate inside the animal shed (Table 2).

Table 2. Distribution of respondents according to their shelter management

Adaptation practices	(n=240)	
	Frequency	Percentage
<i>Type of housing system</i>		
Loose/open house system	41	17.10
Conventional house system	151	62.90
Partially close and open house system	48	20.00
<i>Approximate height of the shed</i>		
10 feet	149	62.10
10-12 feet	90	37.50
12-15 feet	1	0.40
<i>Floor space available/animal</i>		
As per recommended (3.5 × 7.0 m <sup>2</sup> )	9	3.75
Less than recommended	209	87.08
More than recommended	22	9.17
<i>Management practices adopted to cope up extremes of weather</i>		
Bedding in winter + water wetting during summer + keeping under the trees during day time in summer	85	35.42
Bedding in winter + coverage of windows in winter + water wetting during summer + keeping under the trees during day time in summer	16	6.67
Bedding in winter + coverage of windows in winter + water wetting during summer + keeping inside during day time and outside during night	20	8.33
Bedding in winter + water wetting during summer + proper ventilation + keeping inside during day time and outside during night	19	7.91
Water wetting during summer + keeping under the trees during day time in summer	36	15.00
Bedding in winter + water wetting during summer + keeping inside during day time and outside during night	39	16.25
Coverage of windows in winter + water wetting during summer + proper ventilation + keeping under the trees during day time in summer	25	10.42
<i>Shed orientation for proper light and ventilation</i>		
North-South	115	47.90
East-West	43	17.90
Any orientation	82	34.20

### Healthcare management

Air temperature, relative humidity, intensity and duration of sunshine, precipitation etc., have important bearing on the occurrence of dairy animal diseases and spread of parasites. Successful control of disease requires timely and accurate diagnosis and adequate availability of veterinary medicines and vaccines. To oppose the effect of climate variability on the incidence of disease, the existing network of veterinary health support services will have to be strengthened in a big way, with particular emphasis on preventive healthcare services. Community strategy that

Table 3. Distribution of respondents according to their healthcare management

Adaptation practices	(n=240)	
	Frequency	Percentage
<i>Health management during extremes of weather</i>		
Preventive measures like vaccination is adopted	51	21.25
Regular endo and ecto parasite control	17	7.08
Regular checkup for lameness and mastitis	4	1.67
Preventive measures like vaccination + regular endo and ecto parasite control	29	12.09
Preventive measures like vaccination + regular endo and ecto parasite control + regular checkup for lameness and mastitis	63	26.25
Regular endo and ecto parasite control + regular checkup for lameness and mastitis	7	2.91
No practice followed	69	28.75
<i>Management of reproductive problems during extremes of weather</i>		
Consult veterinarian	4	1.67
Ethno-veterinary practices	9	3.75
Balanced feed + consult veterinarian	4	1.67
Consult veterinarian + ethno-veterinary practices	169	70.42
Balanced feed + consult veterinarian + ethno-veterinary practices	43	17.91
No attention given	11	4.58
<i>Practices adopted for sustainable milk production during heat stress</i>		
Feeding extra concentrate mixture to overcome heat stress	9	3.75
Feeding more green fodder during heat stress	6	2.50
Feeding during night hours + feeding and milking during cooler hours in summer	56	23.33
Grazing during early morning and in evening + feeding during night hours	33	13.75
Grazing during early morning and in evening + feeding extra concentrate mixture to overcome heat stress + feeding more green fodder during heat stress	12	5.00
Feeding and milking during cooler hours in summer + feeding extra concentrate mixture to overcome heat stress + feeding more green to fodder during heat stress	14	5.83
Feeding extra concentrate mixture to overcome heat stress + feeding more green fodder during heat stress + feeding during night hours	90	37.50
Feeding more green fodder during heat stress + feeding during night hours	20	8.34

compliments state interventions with the essential participation of local people to be followed (Jodha 1995). The results and discussion presented in Table 3.

*Health management during extremes of weather:* A sizable proportion (28.75%) of the dairy farmers did not use health management during extremes of weather. It might be due to the farmers were not aware about the health management practices to be followed during extremes of weather. The farmers may be provided the trainings in relation to the health management with special reference to climate variability. As far as health management of preventive measures like vaccination + regular endo and ecto parasite control + regular check-up for lameness and mastitis were concerned, 26.25% of the dairy farmers were using these practices. Whereas, 21.25, 12.09, 7.08 and 2.91% of the respondents had followed preventive measures like vaccination, vaccination + regular endo and ecto parasite control, regular endo and ecto parasite control and regular endo and ecto parasite control + regular check-up for lameness and mastitis; respectively. However, only 1.67% of the dairy farmers did use health management practice as a regular check-up for lameness and mastitis (Table 3).

*Management of reproductive problems during extremes of weather:* Most of the dairy farmers (70.42%) adopted “consult veterinarian + ethno-veterinary practices” for managing reproductive problems during extremes of weather. This was followed by “balanced feed + consult veterinarian + ethno-veterinary practices” (17.91%), “no attention given” (4.58%) and “ethno-veterinary practices” (3.75%). An equal proportion of the respondents (1.67%) used practices like “consult veterinarian” and “balanced feed + consult veterinarian”. It may be concluded that most of the farmers were consulting veterinarian subject to their availability in the area coupled with ethno-veterinary practices to manage the reproductive problems during extremes of weather (Table 3).

*Practices adapted for sustainable milk production during heat stress:* It has been observed that more than thirty per cent (37.50%) of the dairy farmers followed practices for sustainable milk production during heat stress like “feeding extra concentrate mixture to overcome heat stress + feeding more green fodder during heat stress + feeding during night hours”. This was followed by “feeding during night hours + feeding and milking during cooler hours in summer” (23.33%); “Grazing during early morning & in evening + feeding during night hours” (13.75%); “feeding more green fodder during heat stress + feeding during night hours” (8.34%); “feeding and milking during cooler hours in summer + feeding extra concentrate mixture to overcome heat stress + feeding more green fodder during heat stress” (5.83%); “grazing during early morning and in evening + feeding extra concentrate mixture to overcome heat stress + feeding more green fodder during heat stress” (5.00%) and “feeding extra concentrate mixture to overcome heat stress” (3.75%). Only 2.50% of them had followed practice as a “feeding more green fodder” for sustainable milk

production during heat stress. Farmers were using practices for sustainable milk production which were quite scientific. The possible reasons of these practices may be their experiences to deal with the heat stress (Table 3).

#### *Adaptation practices with respect to fodder production*

*Changes in cropping pattern followed during drought:* The present investigation revealed that about 41.25% of the dairy farmers were used to grow fodder trees like Khejri, Babul, Ber, Jaal, Ardu and Neem as a coping strategy to meet the shortage of forage during scarcity period. This was followed by “growing of perennial grasses + growing of fodder trees + alternate crop cultivation” (26.25%); “growing of fodder trees + alternate crop cultivation” (11.67%); “growing of perennial grasses (*Chikori* and *Dhaman* grasses; 5.42%)”; “drought resistant varieties + growing of perennial grasses + growing of fodder trees + alternate crop cultivation” (4.58%) and “use of drought resistant varieties + altering times of operation+ alternate crop cultivation” (4.17%). An equal number (3.33%) of the respondent followed strategies like “growing of perennial grasses + growing of fodder trees” and “use of short duration variety + growing of perennial grasses + growing of fodder trees + alternate crop cultivation”. It can be attributed to the intensity and volume of rainfall and other source of water for the production of fodder to feed their animals from time to time. These findings were similar to studies done by Dhaka *et al.* 2010; Kabubo-Mariara and Karanja 2006. They reported important adaptation practices as alternate crop cultivation and altering times of operation (Table 4).

Table 4. Distribution of respondents according to their adaptation practices with respect to fodder production

(n=240)		
Adaptation practices	Frequency	Percentage
<i>Changes in cropping pattern followed during drought</i>		
Growing of perennial grasses ( <i>Chikori</i> and <i>Dhaman</i> grasses)	13	5.42
Growing of fodder trees (Khejri, Babul, Ber, Jaal and Ardu, neem and pipol)	99	41.25
Growing of perennial grasses + growing of fodder trees	8	3.33
Use of drought resistant varieties + altering times of operation+ alternate crop cultivation	10	4.17
Growing of fodder trees + alternate crop cultivation	28	11.67
Growing of perennial grasses + growing of fodder trees + alternate crop cultivation	63	26.25
Use of short duration varieties + growing of perennial grasses + growing of fodder trees + alternate crop cultivation	8	3.33
Drought resistant varieties + growing of perennial grasses + growing of fodder trees + alternate crop cultivation	11	4.58

It can be concluded from the study that most of the respondents did not follow adaptation practices like feed additive and health management during extremes of weather. Hence, information on climate variability and adaptation should be made accessible to farmers using various means like leaflet, folder, hand out and magazine. This will ensure better understanding, as farmers will have different alternatives to learn from. It is suggested that government agencies, NGOs and community organizations should work in tandem with zeal to create awareness about the change in climatic conditions through appropriate communication methods which are available with farmers such as extension functionaries, farmer groups, input dealer, radio and television to deal with climate variability. Consequences arising out of this adverse situation can be mitigated by recommending suitable breeds of dairy animals those can perform better, growing drought resistant fodder crops, judicious use of conventional feeds, conserving the green fodder when it is in surplus. There is need to search for novel feed stuffs of which a small quantity can meet the animals' maintenance requirement. Tree leaves, fruits and vegetable waste, slaughter house waste products might be encouraged by preparing complete feed blocks. Feed and fodder banks should be encouraged. Hence, it is advised that the technology dissemination system must be streamlined by focusing its efforts towards the mitigating adverse effects of climate variability by suggesting the appropriate strategies achieved through conducting demonstrations, field exhibitions by KVKs, NGO's and veterinary colleges.

#### ACKNOWLEDGEMENT

Authors gratefully acknowledge the support of National Initiative on Climate Resilient Agriculture, NDRI, Karnal (Haryana) provided during the course of study.

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