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Dairy farmers' adaptive options to climate variability in Southern Telangana zone

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Abstract
Dairy farmers' adaptive options to climate variability in Southern Telangana zone, an ex-post facto research design was adopted with a multistage random sampling method. Six mandals from each district of Mahabubnagar and Nalgonda were selected purposively based on climate variability data and two villages from each Mandal were selected by simple random sampling technique. Based on the available dairy farmers' population in the selected villages, 10% of the sample size (254 respondents) from 24 villages in 12 mandals of Southern Telangana zone was selected for the study.
The study revealed that, to combat the effect of climate variability, dairy farmers in Southern Telangana zone were practicing various feeding, breeding, health care, management related and other climate variability adaptive options. To find the relative importance among the adaptive options, an exclusive climate variability adaptation index was developed and based on this index ranking has given to the dairy farmers' adaptive options to climate variability. It was observed that providing the shelter, mixed farming followed by selling of few animals from the herd to meet emergency expenses during extreme climatic events were the most preferred climate variability adaptive options in the study area.

Keywords: Dairy farmers, Climate variability adaptive options, Climate variability adaptation index, Southern Telangana zone

1. Introduction
In the struggle for survival, the fittest win out at the expense of their rivals because they succeed in adapting themselves best to their environment. ***- Charles Darwin***

Climate is defined as the average weather patterns existing throughout several years over a large portion of earth's surface. Climate variability refers to the variations in the mean state of the climate and variations in other parameters (such as the occurrence of extremes) on all temporal and spatial scales beyond that of individual weather events. Extreme maximum and minimum figures help convey the degree of climate variability (Anderson, 2011) [1]. Climate variability is recognized as the greatest global challenge for societies in the 21st century and it is one of the most serious long term challenges facing livestock owners around the world. Rise in temperature due to climate change is likely to affect livestock production and health (Srivastava, 2010) [2]. Climate variability is already a hard reality for a majority of Indian dairy farmers. India, which faced drought conditions at least once in every three years over the last few decades, is amongst the most vulnerable and drought prone countries in the world. Climate variability could produce drier conditions in arid and semi-arid regions like Telangana state leading to more severe droughts, and is more dynamic and adapting to this is more challenging.
On Nov 24, 2015, the Telangana government declared drought in 7 out of 10 districts. In southern Telangana zone drought was declared in all mandals of Mahabubnagar district and 59 mandals of Nalgonda district. In these circumstances, it is necessary to assess dairy farmers' adaptive options to climate variability to enable policy makers to develop policy interventions to protect dairy farmers from economic losses. Keeping in view of all these, a research study was undertaken on the adaptation options followed by the dairy farmers in Southern Telangana zone to cope up the effect of climate variability.

2. Materials and methods
An ex-post facto research design was adopted with a multistage random sampling method. India's youngest state "Telangana" was selected purposively for the present study because it is

semi-arid area and has a predominantly hot and dry climate. The severe drought in Telangana has caused acute shortage of water which worsened the agriculture and animal husbandry. As per the data collected from Telangana State Development Planning Society, In between 2010 to 2015, 8 out of 64 mandals in Mahabubnagar district and 7 out of 59 mandals in Nalgonda district were drought declared continuously for three times out of six spells of drought. Among these drought hit mandals, six mandals from each district were selected by simple random sampling method by using lottery method, thus a total of twelve mandals, namely Keshampet, Madgul, Uppununthala, Kodangal, Waddepalle, and Aiza in Mahabubnagar district and Yadagirigutta, Munugode, Narayanapur, Chandur, Chinthapalle and Devarakonda in Nalgonda district were selected for the study. Based on the available dairy farmers' population in the selected villages, 10% of the sample size (254 respondents) from 24 villages in 12 mandals of Southern Telangana zone was selected for the study.

After careful perusal of relevant literature and discussion with the pioneers who were associated with the climate variability projects and experts in the universities and animal husbandry and agriculture department, a list of 36 adaptive options selected which are normally considered as dairy farmers' adaptive options to climate variability. To develop Climate variability adaptation index, the adaptive options with detailed instructions were sent to the judges i.e. experts in the field of climate, scientists and faculty of veterinary and agricultural universities and experienced animal husbandry personnel. Based on the weighted means of all the items, finally 25 adaptive options were constituted the dairy farmers' adaptive options to climate variability in Southern Telangana zone. In the interview schedule dairy farmers adaptive options to climate variability were framed under 5 categories viz. adaptive options related to feeding, breeding, health care, management and other adaptive options.

In order to quantify the dairy farmers' adaptive options to climate variability, an exclusive climate variability adaptation index (CVAI) was developed by using the following formula:

$$\text{Climate Variability Adaptation index} = \frac{\text{Obtained score}}{\text{Maximum obtainable score}} \text{ (CVAI)}$$

Based on this score ranking had given to dairy farmers' adaptive options to climate variability.

3. Results and discussion

In the study area dairy farmers were practicing different dairy farming practices among them majority were helping them to reduce climate variability effects the results were present in the table 1.

Table 1: Adaptive options of dairy farmers to climate variability (Climate variability adaptation)

n = 254

S. No.	Dairy farmers' adaptive options to climate variability	P (4) F (%)	PP (3) F (%)	D (2) F (%)	NP (1) F (%)
I.	**Adaptive options related to feeding**				
1.	**Mixed farming:** to increase income through different sources and its by-products are useful for one another.	251 (98.82)	0 (0.00)	0 (0.00)	3 (1.18)
2.	**Concentrates:** Provision of additional concentrates for maintaining productivity and body weight of dairy animal.	104 (40.94)	0 (0.00)	68 (26.77)	82 (32.28)
3.	**Minerals and feed additives:** Providing minerals like K, Na, Mg etc and feed additives like Vitamins A, D, E etc. to maintain dairy productivity and health.	24 (9.45)	51 (20.08)	0 (0.00)	179 (70.47)
4.	**Unconventional feed resources:** Providing vegetables, leafy vegetables mango seed kernels, sugar cane bagasse, etc.	198 (77.95)	19 (7.48)	0 (0.00)	37 (14.57)
5.	**Change in feeding schedule:** Providing ration during cooler parts of the day i.e. early morning and late evening.	181 (71.26)	0 (0.00)	0 (0.00)	73 (28.74)
6.	**Feeding with chopped fodder:** to avoid wastage of fodder.	72 (28.34)	18 (7.09)	0 (0.00)	164 (64.57)
7.	**Preservation of fodder:** Preserving fodder in the form of hay, also storing paddy straw, and other crop residues.	248 (97.64)	0 (0.00)	3 (1.18)	3 (1.18)
8.	**Water:** Providing additional, frequent clean and fresh drinking water.	107 (42.13)	0 (0.00)	135 (53.15)	12 (4.72)
II.	**Adaptive options related to breeding**				
1.	**Anestrus animals and Repeat breeders:** Providing treatment to the anestrus animals and repeat breeders.	245 (96.46)	0 (0.00)	0 (0.00)	9 (3.54)
2.	**Culling:** Culling the infertile and unproductive animals.	226 (88.98)	0 (0.00)	0 (0.00)	28 (11.02)
3.	Replacement of exotic breeds with local breeds which are heat tolerant.	7 (2.76)	0 (0.00)	0 (0.00)	247 (97.24)
III	**Adaptive options related to health care**				
1.	**Providing curative healthcare facilities:** consulting the veterinarians for treatment of infectious diseases.	221 (87.01)	26 (10.23)	0 (0.00)	7 (2.76)
2.	**Vaccination:** Regular vaccination to the animals for disease prevention.	101 (39.76)	61 (24.02)	0 (0.00)	92 (36.22)
3.	**Deworming:** Regular deworming to the animals.	40 (15.74)	209 (82.28)	0 (0.00)	5 (1.97)
4.	**Isolation:** Isolation of sick animals.	88 (34.65)	0 (0.00)	0 (0.00)	166 (65.35)
5.	**Control of vectors:** Fogging with herbs like neem leaves to prevent vectors like mosquitoes, flies etc.	236 (92.91)	0 (0.00)	0 (0.00)	18 (7.08)
IV.	**Adaptive options related to Management**				

1.	Providing the shelter.	254 (100.00)	0 (0.00)	0 (0.00)	0 (0.00)
2.	Additional washing or sprinkling of cattle and buffaloes.	101 (39.76)	0 (0.00)	125 (49.21)	28 (11.02)
3.	Planting trees around the shelter to provide shade and protects from direct sunlight and hot winds.	232 (91.34)	0 (0.00)	0 (0.00)	22 (8.66)
4.	**Grazing time:** Change in grazing time during hotter days.	204 (80.31)	0 (0.00)	0 (0.00)	50 (19.68)
5.	Use of gunny bags as curtains hanged on the sides of the shelter and frequent sprinkling of water on gunny bags.	117 (46.06)	0 (0.00)	0 (0.00)	137 (53.94)
6.	Using foggers/ misters/ sprinklers/ fans/ mist and fan system etc. in the shed.	5 (1.97)	0 (0.00)	3 (1.18)	246 (96.85)
V.	**Other adaptive options**				
1.	Livestock insurance.	13 (5.11)	68 (26.77)	17 (6.69)	156 (61.41)
2.	Selling of few animals from the herd to meet emergency expenses during extreme climatic events.	250 (98.43)	0 (0.00)	0 (0.00)	4 (1.57)
3.	Farming with non-farming activities for additional source of income.	47 (18.5)	0 (0.00)	8 (3.15)	199 (78.35)

Note: Practiced (P), partially practiced (P P), Discontinued (D), Never Practiced (N P)

4. Adaptive options related to feeding

4.1 Mixed farming: Mixed farming systems, in which crops and livestock are integrated on the same farm, are the backbone of smallholder production in the developing countries of the tropics (Thornton *et al.* 2014)[3]. These are particularly important for livelihoods and food security. Therefore, majority (98.82%) of the dairy farmers (table 1) in the study area were practicing mixed farming to increase income through different sources and it's by products were useful for one another. When the study area was being affected by severe drought, fluctuations in the monsoon patterns, one source of income used to be lost, while farmer used to maintain his family from other source of income. This might be the reason for practicing mixed farming as an adaptive option. Esiobu and Onubuogu (2014) [4] n their study reported that mixed farming as an adaptation option of livestock farmers to climate change in Imo State, Nigeria.

4.2 Provision of additional concentrates: Provision of additional concentrates for maintaining productivity and body weight of dairy animal during hotter days. About 40.94 per cent of the respondents were practicing this adaptive option. They used to offer additional concentrates to their animals for maintaining productivity and body weight of the animal during the heat stress. Due to high cost of the concentrate feed 32.28 per cent were never practiced and 26.77 per cent were discontinued it. Further analysis revealed that cows fed high crude protein diets had lower respiratory rates and slightly lowers rectal temperatures, possibly related to improved digestion of the diet or altered metabolism. Many researchers (Upadhyay *et al.* 2009 [5], Prasad, 2010[6], Sirohi and Sirohi, 2010[7]) reported that the composition of the diet is believed to be important in alleviating heat stress.

4.3 Provision of minerals and feed additives: Providing minerals like K, Na, Mg, etc. and feed additives like vitamins A, D, E etc. are essential to maintain dairy productivity and health. Only 9.45 per cent of the respondents were practicing, means they were providing 1 per cent of the mineral mixture and feed additives in the ration on regular basis. But 20.08 per cent of the respondents were partially practicing *i.e.,* they were providing mineral mixture irregularly only to anoestrus animals, pregnant animals and to milch animals. Maiti *et al.* (2014) [8] also reported that providing mineral supplementation and feed additives was an adaptation strategy in his study to maintain proper livestock productivity. Majority (70.47%) of the respondents never practiced it. This might be due to that they were unaware of benefits of mineral mixture and feed additives, non-availability and cost involvement.

4.4 Provision of unconventional feed resources: Providing vegetables, leafy vegetables mango seed kernels, sugar cane bagasse, etc. More than three-fourth of the respondents were practicing (77.95%) this adaptive option. In the study area most of the dairy farmers used to provide "Kudithi" (In local vernacular language), which consists of nearly three fourth of the water, rice flour, rice water, kitchen waste (vegetables and leafy vegetables), rice bran and little bit salt. Generally they provided Kudithi two times in a day i.e., during morning and evening. Government has to educate the dairy farmers regarding fodder tree plantation and bring awareness about effective utilization of locally available unconventional feed resources.

4.5 Change in feeding schedule: Providing ration during cooler parts of the day i.e., during early morning and late evening. Majority (71.26%) of the respondents were practicing this. They felt that the day time feeding during hotter days was the cause of restlessness, uneasiness, and discomfort in their animal. During normal days they were feeding their animals between 7 am to 8:30 am in the morning and from 5pm to 6 pm at evening just before milking or during milking, but during hotter days they used to feed their dairy animals at early morning between 5 am to 6:30 am and from 6pm to 7:30pm at late evening. Depends on the availability, respondents fed their animals frequently and in small quantity of fodder throughout the day. Sirohi and Sirohi (2010) [7] reported that the frequency of feeding should be increased and small quantities of the ration should be given during the day to improve the dry matter intake and to reduce heat stress during summer.

4.6 Feeding with chopped fodder: Feeding with chopped fodder to avoid wastage of fodder. Dairy animals when they were offered with green or dry fodder without chopping, nearly 30 per cent of the fodder used to be wasted as the fodder was soiled with feces, urine and other dirt in the shed. When fed with stemmed fodder like sorghum, Bajra and hybrid Napier, animals generally used to prefer to consume

only leaves other than stems. In the study area, only 28.34 per cent of the respondents were adapted the feeding of their animals with chopped fodder, but the majority (64.57%) of the respondents never practiced this.

4.7 Preservation of fodder: It was concluded from table1, that in the study area dairy farmers were practicing adaptive options related to feeding like preservation of fodder (97.64%) i.e., respondents were preserving fodder in the form of hay and also they were storing paddy straw and other crop residues. But respondents were not preserving the fodder in the form of silage. Availability of nutritious fodder throughout the year is very essential for dairy farming. But it varies from season to season. Therefore, every dairy farmer must preserve the surplus fodder in the form of silage or hay.

4.8 Providing additional frequent clean and fresh drinking water: From the results as shown in table1 it was clear that in the study area 42.13 per cent of the respondents were providing additional, frequent clean and fresh drinking water to the dairy animals to reduce heat stress during hotter days. Drinking water intake was positively correlated to most of the factors including milk yield, dry matter intake (Axegärd, 2017) [9]. Upadhyay *et al.* (2009) [5] reported that adequate supply of cool, fresh and clean water is essential to minimize the effects of heat stress in lactating cows and buffaloes. Majority (53.15%) of the respondents were discontinued this adaptive option of providing drinking water frequently to their animals because of non-availability of water in the study area when was severely affected by drought. Under MGNREGA (Mahatma Gandhi National Rural Employment Guarantee Act) scheme, government provided drinking water troughs in the villages for cattle. Farmers used to let their animals to drink water in those troughs.

5. Adaptive options related to breeding

5.1 Treatment to the anestrous animals and repeat breeders: Reproductive efficiency is the key factor affecting profitability in many livestock production systems therefore, majority of the respondents (96.46%) were providing treatment to the anestrus animals and repeat breeders mostly by the veterinarians. Infertility and repeat breeding (Meena *et al.* 2008) [10] and extreme climate, affects the reproductive efficiency (Nanda *et al.* 2003) [11]. Losses were in form of infertility, less lactation per animal and less number of new born obtained from an animal in her life.

5.2 Culling the infertile and unproductive animals

Culling is the removal of undesirable animals from the herd to facilitate the entry of replacement heifers for improving the herd performance or to keep the herd size constant and dairy farm will become more profitable. Infertility is the single largest reason for culling female animals from a herd in India with 41 per cent of total animals being culled due to infertility (Genusabsindia, 2013) [12]. The above reasons confirm the results as shown in table 1, that the majority (88.98%) of the respondents were practicing this adaptive option, whereas 11.02 per cent were never practiced which might be due to traditional beliefs.

5.3 Replacement of exotic breeds with local breeds

Only 2.76 per cent of the respondents were practicing, and majority (97.24%) never practiced this adaptive option. This might be due to the fact that the *Bos indicus* animals (Zebu) have greater thermoregulatory ability than *Bos Taurus* (European). Such thermoregulatory efficiency of *Bos indicus* cattle is due to lower internal heat production and/or higher heat dissipation to the environment. Thus, these breeds are more resistant to hyperthermia (Adeyemo *et al.* 1979) [13] and also they were comparing local breeds with exotic breeds' milk yield which was more, though the same was greatly affected during heat stress.

6. Adaptive options related to health care

6.1 Providing curative healthcare facilities: The majority (87.01%) of the dairy farmers were providing curative healthcare facilities to their animals to maintain good health. Now a days, most of the dairy farmers were not depending on the quacks as earlier days, they were consulting nearby veterinarians for treatment in the study area. If doctor was engaged with other work, then well trained para veterinarians were consulted to treat general cases, but emergencies were dealt by veterinary doctors only, this might be attributed to above trend. Livestock diseases are strongly influenced by climate change and transmission of infectious diseases transmitted by ticks, flies, mosquitoes and other arthropods may be of great concern with respect to the changing climate (Pattanaik and Sharma, 2010) [14].

6.2 Vaccination: Majority (39.76%) of the respondents were practicing, followed by 24.02% were partially practicing vaccination because of awareness on the Animal Husbandry department, Government of Telangana state, vaccination programmes against Foot and mouth disease (FMD) twice in a year during September and March, Haemorrhagic septicemia (HS), Black quarter (BQ) annually before monsoon (twice a year in endemic areas), and Brucellosis vaccine only once i.e., at 4-8 months of age females in effected herds. It was also observed that some respondents didn't practice vaccination due to misconception of reduction in milk yield.

6.3 Deworming: It is known that parasite eggs tend to concentrate more in the lower part of the forage plants, thus short pastures due to drought conditions can increase the potential parasite load. Thornton *et al.* (2014) [3] reported that changes in rainfall and temperature regimes may affect both the distribution and the abundance of disease-causing vectors. Majority (82.28%) of the dairy farmers were partially practicing deworming schedule i.e., they were doing deworming their animals since 10-15 days age of the calf, at monthly interval up to 6 months, thereafter they used to go for deworming by the advice of veterinarians when the animal was suffered with any gastro intestinal problems and 15.74 per cent of the respondents in the study area were regularly practicing deworming to their dairy animals. This would tend to suggest that strategic parasite control programs are more important especially during drought situations.

6.4 Isolation of sick animals: Isolation of sick animals is one of the important bio security practices to minimize or to eliminate the spread of disease within the herd and it is an apt to be one adaptation tool to combat the potential spread of vector borne diseases, infectious diseases which are affected by climate variability. The respondents (34.65%) were practicing this adaptive option i.e., they were isolating sick animals away from healthy animals. Can and Altuğ (2014) [15] reported that to prevent disease spreading, 68 per cent of the

small scale dairy farmers in Hatay and Turkey were isolating sick animals from herd. Majority (65.35%) of the respondents were never practiced this adaptive option might be due to unawareness regarding bio security practices and poor training. Farmers must be motivated to change their behaviour in the 'right' direction to improve bio security at farm-level (Kristensen and Jakobsen 2011) [16].

6.5 Control of vectors:
Fogging with herbs like neem *(Azadirachta indica)* leaves to prevent vectors like mosquitoes flies etc. It is a common practice in the study area to control vectors. Majority (92.91%) of the respondents were practicing it. Depending on the farm size, availability and severity few were also using chemical repellents. It is estimated that average global temperatures will have risen by 1.0–3.5°C by 2100, increasing the likelihood of many vector-borne diseases (Githeko, *et al*. 2000) [17]. Control of vectors plays a major role to prevent diseases. Neem *(Azadirachta indica)* is a natural insecticide that has been widely tested against mosquitoes and is nonhazardous to man and other mammals (Fallatah and Khater, 2010) [18]. Limonoids which are present in neem *(Azadirachta indica)* leaves like nimocinolide and isonimocinolide affect fecundity in house flies (Musca domestica).

7. Adaptive options related to management
7.1 Providing the shelter: Providing the shelter either natural (trees) or artificial, are the most simple method to reduce the impact of high solar radiation. When enough natural shade is unavailable, artificial structures may be constructed. All the respondents were providing the shelter to their dairy animals. They were using different types of shelters to protect their animals like natural shelters like tree shades, artificial shelters with different roofs like thatched roof, tiles roof, asbestos roof etc. Shades are effective in reducing heat stress and physiological responses in the dairy animals. Proper ventilation in a shelter is important for the relief from heat stress. The protected animals show lower physiological responses like respiration rate, pulse rate, rectal temperature, and skin temperature during afternoon and yield more milk and protein (Singh and Upadhyay, 2009)[19]. Providing shade for cattle reduces respiration rate at the peak of the day in all environments and body temperature in moderate hot environments (Brown-Brandl *et al.* 2010) [20].

7.2 Additional washing or sprinkling of cattle and buffaloes: 39.76% of the respondents were practicing this adaptive option. They used to wash or sprinkle their cattle and buffaloes with water two times a day, morning and evening daily during hotter days to reduce heat stress. 49.21 per cent were discontinued it due to severe water scarcity in their areas, they were washing or sprinkling very less frequently and they were majorly using water for drinking purpose. The benefits to sprinkled cattle have been proved to include: lowering body temperature, decreasing respiration rate and maintaining feed consumption (Gaughan *et al.* 2004) [21].

7.3 Planting trees around the shelter: Trees itself provide shade also helps in protecting the dairy animals from direct sunlight and hot winds. This is one of the common climate variability adaptive options in the study area which was practiced by majority (91.34%) of the dairy farmers. This practice was economical, therefore, higher level of adoption was observed. Mostly they were planting Neem (*Azadirachta indica*) which was helping in vector control, Subabul (*Leucaena leucocephala*) and Acasia (*Acacia catechu*) were also used as fodder trees.

7.4 Change in grazing time: Change in grazing time during hotter days i.e., from 6 am to 10 am and again at evening from 4:30 pm to 6:30 pm depending on hotness of the day. More than three-fourth of the respondents (80.31%) were changed the grazing time during hotter days to protect their animals from the heat stress. Due to increase in maximum temperatures in the study area they avoided grazing during hotter days i.e., between 11.00 am to 4.00 pm. It is one of the wisest adaptive options to combat climate variability in the study area because the failure of homeostasis at high temperatures might lead to reduced productivity or even death (Blackshaw and Blackshaw, 1994) [22].

7.5. Use of gunny bags as curtains and frequent sprinkling of water on gunny bags: Use of gunny bags as curtains hanged on the sides of the shelter and frequent sprinkling of water on gunny bags, this would prevent hot winds and creates cooler environment in the shelter. This practice was also least costly, but due to extreme climate variability (drought) conditions lead water scarcity, only 46.06 per cent were practicing this adaptive option. The dairy farmers who didn't provide artificial shelter were hanging gunny bags to tree branches as curtains to prevent sunshine during day time. It could be inferred that farmers preferred to keep animal shelter cool to cope up heat stress.

7.6. Using foggers/misters/sprinklers/fans/mist and fan system etc. in the shed: The major objective of a cooling system is to reduce the air temperature inside the cattle or buffalo shed, so as to keep the animal's body temperature as close as possible to normal. The single use of a sprinkling and fan system for 30 minutes before milking, has proved to be useful to relief dairy cow heat stress, in terms of efficiency to reduce the impact of heat waves under a grazing system (Valtorta *et al.* 2002) [23]. There was only 1.97 per cent of the respondents in the study area were practicing this adaptive option and 1.18 per cent were discontinued due to high cost involvement. Majority (96.85%) of the dairy farmers were never practiced this adaptive option.

8. Other adaptive options
8.1 Livestock insurance: Animal health can be affected directly or indirectly by climate change, especially rising temperatures. The direct effects are related to the increase of temperature, which increases the potential for morbidity and death. The indirect effects are related to the impacts of climate change on microbial communities (pathogens or parasites), spreading of vector-borne diseases, food-borne diseases, host resistance, and feed and water scarcity (Nardone *et al.* 2010) [24]. Therefore, Livestock insurance is an adaptive option to cope up economic losses. As the results shown in the table 1 in the study area 5.11 per cent were practicing this adaptive option. 26.77 per cent were partially practicing i.e., they insured only few animals in the herd and not going for renewal. 6.69 per cent and 61.41 pecent were discontinued and never practiced might be due to economic problems. Esiobu and Onubuogu (2014) [4] and Maiti *et al.* (2014) [8] reported in their studies that livestock insurance is an adaptive option to cope up climate change.

8.2 Selling of few animals from the herd to meet emergency expenses during extreme climatic events: Livestock can also provide a buffer against losses due to climate variability. Yirga (2007) [27] reported that livestock in addition to serving as a source of power for farming and manure for fertilizing soil also serve as asset and insurance against shocks. Therefore, in the study area majority (98.43%) were selling of few animals from the herd to meet emergency expenses during extreme climatic events. Mostly they were selling bullocks during dry monsoon and again they were buying during the time of need. This adaptive option was helping them to maintain, adjust feed and fodder requirements of milch animals during shortage period.

8.3 Farming with non-farming activities for additional source of income: In a study, Chand *et al.* (2011) [25] have reported that if agriculture were to the sole source of income for small landholders, the majority of them would have remained poor. In developing countries like India where a majority of the population lives in rural areas, and diversion of rural economy towards non-farm activities has considerable potential to increase per capita income of the rural households (Ranganathan *et al.* 2016) [26]. Only 18.5 per cent of the respondents were practicing farming with non-farming activities whereas, 3.15 per cent and 78.35 per cent discontinued and never practiced repeatedly.

Based on CVAI score ranks had given to dairy farmers' adaptive options as follows

Table 2: Ranking of the dairy farmers' adaptive options to climate variability according to CVAI (Climate Variability Adaptation Index) score

(n=254)

S. No.	Dairy farmers' adaptive options to climate variability	CVAI index score	Rank
1.	Providing the shelter	1	I
2.	**Mixed farming:** to increase income through different sources and its by-products are useful for one another.	0.9911	II
3.	Selling of few animals from the herd to meet emergency expenses during extreme climatic events.	0.9881	III
4.	**Preservation of fodder:** Preserving fodder in the form of hay, also storing paddy straw, and other crop residues.	0.9832	IV
5.	**Anestrus animals and repeat breeders:** Providing treatment to the anestrus animals and repeat breeders.	0.9734	V
6.	**Providing curative healthcare facilities:** consulting the veterinarians for treatment of infectious diseases.	0.9537	VI
7.	**Control of vectors:** Fogging with herbs like neem leaves to prevent vectors like mosquitoes, flies etc.	0.9468	VII
8.	Planting trees around the shelter to provide shade and protects from direct sunlight and hot winds.	0.9350	VIII
9.	**Culling:** Culling the infertile and unproductive animals.	0.9173	IX
10.	**Unconventional feed resources:** Providing vegetables, leafy vegetables mango seed kernels, sugar cane bagasse, etc.	0.8720	X
11.	**Grazing time:** Change in grazing time during hotter days.	0.8523	XI
12.	**Change in feeding schedule:** Providing ration during cooler parts of the day i.e. early morning and late evening.	0.7844	XII
13.	**Deworming:** Regular deworming to the animals.	0.7795	XIII
14.	**Water:** Providing additional, frequent clean and fresh drinking water.	0.6988	XIV
15.	Use of gunny bags as curtains hanged on the sides of the shelter and frequent sprinkling of water on gunny bags.	0.5954	XV
16.	Additional washing or sprinkling of cattle and buffaloes.	0.6712	XVI
17.	**Vaccination:** Regular vaccination to the animals for disease prevention.	0.6683	XVII
18.	**Concentrates:** Provision of additional concentrates for maintaining productivity and body weight of dairy animal.	0.6240	XVIII
19.	**Isolation:** Isolation of sick animals.	0.5098	XIX
20.	**Feeding with chopped fodder:** to avoid wastage of fodder.	0.4980	XX
21.	Livestock insurance.	0.4389	XXI
22.	**Minerals and feed additives:** Providing minerals like K, Na, Mg etc and feed additives like Vitamins A, D, E etc. to maintain dairy productivity and health.	0.4212	XXII
23.	Farming with non-farming activities for additional source of income.	0.3966	XXIII
24.	Replacement of exotic breeds with local breeds which are heat tolerant.	0.2706	XXIV
25.	Using foggers/ misters/ sprinklers/ fans/ mist and fan system etc. in the shed.	0.2677	XXV

Dry monsoons, crop failures, full of debts are spelling doom and hitting the farmers hard in Telangana state. Climate variability can put various sectors at risk, threaten households' livelihoods. Due to cost effectiveness, most simple method to reduce the impact of climate variability, among all the adaptive options, providing the shelter, mixed farming followed by selling of few animals from the herd to meet emergency expenses during extreme climatic events were the most preferred climate variability adaptive options in the study area.

9. Conclusion

Dairy farmers in the study area followed adaptation options against the heat stress as it had a direct effect on the dairy animals' productivity of South ten Telangana zone due to higher level of temperature during summer. Dairy farmers were used to follow the cost effective and simple adaptive options according to their local conditions. It was also found that all the adaptive options has scientific root. Government policies need to support research and development that develops and diffuses the appropriate technologies to help farmers to adapt climate variability. Silage pits, hay making, cultivating fodder crops in barren lands should be taken up by the government to provide feed to animals in lean seasons. Participation of women should be encouraged in training programmes because of involvement of women in routine

dairy farming activities.

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