Indian J Dairy Sci 77(2): 179-184
https://doi.org/10.33785/IJDS.2024.v77i02.012

RESEARCH ARTICLE

Impact of climate services on the operational decision of Murrah buffalo farmers in Haryana

Manjunath K V[1], D Anil Kumar Reddy[1], Sanchita Garai[1], H R Meena[1], Raj Kumar[1], Mukesh Bhakat[2], Goutam Mondal[3], Anjali Aggarwal[4] and Sanjit Maiti[1](✉)

Received: 03 August 2023 / Accepted: 24 September 2023 / Published online: 23 April 2024

Abstract: Global warming and its concomitant changes in mean climate variables and climate variability have an impact on animal feed and fodder, animal health, production, and water availability. Buffaloes are the mainstay of the Indian dairy economy and the backbone of the rural economy and dairy industry in the Haryana state in particular. Murrah buffalo-based production system has to be imparted the ability to withstand the adversities associated with climate change as well as to maintain their productivity. Therefore, the present study was undertaken to develop climate services and analyze their impact on Murrah buffalo farmers' operational decision-making related to dairy farming. The study was conducted in the Hisar, Jind, and Rohtak districts of Haryana state. Two blocks were selected randomly from each district and from each block three experimental villages and one control village were selected, resulting in 18 experimental and 6 control villages in total. The three experimental villages of each block were randomly assigned to the intervention mode of either WhatsApp, Text SMS, and Mobile application which was exclusively developed for the present study thus resulting in 6 villages each receiving treatment through WhatsApp, Text SMS, and Mobile application. From each village, 15 farmers were selected randomly and provided with treatment i.e., weekly THI-based Murrah buffalo climate service module. The findings of the study revealed a positive treatment effect of the climate services on various practices like the adoption of improved varieties of fodder, and nutrition management through the inclusion of oilcake, miner mixture in animal diets. The adoption of rubber mats, providing chopped fodder, use of bedding materials and covering open spaces of the animal shed during winter, the practice of deworming the herd and maintenance of cattle shed hygiene, and others. Hence, the climate services for Murrah buffalo farmers were found to be a potential adaptation tool to enhance the resilience capacity of vulnerable dairy farmers to adapt to climate change.

Keywords: Climate change, Climate services, Weather, Impact, THI, Murrah buffalo

Introduction

Livestock production systems all across the world are being directly impacted by the phenomenon of global climate change. The detrimental consequences of global warming affecting both productive and reproductive performance (Upadhyay et al. 2007) is due to the combination of genetic factors of the animal and climatic factors affecting livestock such as temperature, relative humidity, solar radiation, precipitation, and wind speed (Hahn et al. 2003). These changes will significantly influence livestock production due to reduced feed intake, milk production and productivity, livestock diseases, conception rates, animal growth, water availability, and feed and fodder production and availability (Rojas et al. 2017). The negative impact of temperature rise on total milk production for India has been estimated about more than 15 MT by 2050 (Upadhyaya et al. 2013). High heat load in lactating buffaloes reduces their milk production and shortens the duration of lactation length (Upadhyay et al. 2007). As a result, dairy farming in India is highly vulnerable to weather and climate risks, and advanced adaption strategies such as weather forecasting and forecast-based climate services assist in minimizing losses while sustaining production through suitable weather-related livestock management practices (Vashisth et al. 2013). Various amelioration strategies to adverse impacts of climate change on dairy animals include providing sprinklers aided with a fan under the shade during hot dry summers (Ahmad et al. 2019), wallowing which is highly efficient in reducing heat stress (Aggarwal and Singh 2008), loose housing with a shade (may be shed) and open area for night hours (Aggarwal and Singh, 2008), regular showers in addition to wallowing facilities during summer (Mishra 2021, Roy et al. 1968), nutritional

[1]Dairy Extension Division, ICAR-National Dairy Research Institute, Karnal-132001, Haryana
[2]Livestock Production and Management, ICAR-National Dairy Research Institute, Karnal-132001, Haryana
[3]Animal Nutrition Division, ICAR-National Dairy Research Institute, Karnal-132001, Haryana
[4]Animal Physiology Division, ICAR-National Dairy Research Institute, Karnal-132001, Haryana

Sanjit Maiti(✉)
Dairy Extension Division
ICAR-National Dairy Research Institute, Karnal-132 001, Haryana
Email: Sanjit.Maiti@icar.gov.in/sanjit.ndri@gmail.com
Mobile: 9466967086

adjustment strategies through balanced feeding, concentrates, etc (Pankaj et al. 2013).

Using weather information, agricultural producers may be able to make better decisions whose outcomes are influenced by the weather vagaries. In contrast to crop farmers (60%), only a small fraction of livestock farmers (32%), reported using weather data in their farming activities. For decisions regarding the movement of livestock, ranchers increasingly used weather forecasting data (Frisvold and Murugesan 2013). The digital iCow advisory services have quipped dairy farmers with basic, timely knowledge and solutions that improved their production. The advisories on health and disease, deworming, managing fodder, optimum feeding, reproduction management, and other dairy management practices have assisted dairy farmers to realize higher outputs and consequently improve their incomes (Marwa et al. 2020). Weather-based advisories had a positive treatment effect on operational decisions of dairy management, such as watering management, feeding management, shelter management, and vaccination scheduling (Manjusree et al. 2022).

Haryana is having largest Murrah buffalo density among states, with a population of 5.1 million Murrah buffalo out of a total 6.6 million, accounting for 77% of the total buffalo population (Breed survey 2013). Central Haryana is considered as the breeding tract of Murrah buffalo (Parmar and Sangwan 2016). This makes Murrah buffaloes the backbone of the state's rural economy and dairy industry, which contributes to more than 75% of the state's milk production (Balhara et al. 2017).

Haryana has a semi-arid, subtropical climate with scarce, excessive and untimely rains, heat waves, cold waves and hot winds during summer, dust storms, fog, frost, and hails, all of which have a negative impact on crop and livestock production (Singh et al. 2008). Extremely hot summers and very cold winters are common in Haryana. While summer's mean temperature ranges from 48 to 35 degrees Celsius, the winter's average ranges from 3 to 9 degrees Celsius. Climate projections for the state is quite alarming with both Mean maximum and Minimum temperature projected to increase by 1.3^0C and 2.1^0C towards mid-century, respectively and mean annual rainfall is projected to decrease marginally by about 63 mm (3%) by 2050s (HSAPCC 2011). Out of 22 districts in Haryana, 15 districts are in the range of medium to high vulnerability towards climate change (Rao et al. 2016).

Given the significance of Haryana's Murrah buffalo cropping system and the fact that it is very sensitive to climate change, timely and reliable climate services are essential for managing day to day livestock operations and minimising losses (Rathore and Chattopadhyay 2016) thereby building the resilience of the buffalo-based farming system to the changing climatic conditions. Thus, the present study was formulated to develop THI based climate services for the Murrah buffalo farmers of Haryana and to assess its impact on the operational decision making.

Materials and Methods

Sampling

The study was purposively conducted in the Hisar, Jind and Rohtak districts of central Haryana which is considered as breeding tract of Murrah buffalo having higher concentration of Murrah buffalo (Parmar and Sangwan 2016). Two blocks from each district thus 6 blocks in total were selected randomly i.e. Agroha and Barwala block from Hisar district, Pillukhera and Safindo block from Jind district and Meham and Rohtak block of Rohtak district. Four villages from each block were then randomly chosen, three of which were experimental villages which were randomly administered treatment through WhatsApp, text message, or a mobile application, and one of which was a control village. Thus, the study covered a total of 24 villages resulting in 18 experimental villages (6 each WhatsApp, Text SMS and Mobile Application) and 6 control villages. Finally, farmers who had been rearing Murrah buffalo for the last 10 years and had a minimum herd size of 4 Murrah buffalo and 15 such farmers from each village were randomly selected as respondents. Hence, the total sample size of the present study was 360. Farmers in experimental villages were provided with treatment i.e., a weekly module on the climate information and THI-based advisories on Murrah buffalo rearing. The experimental and control group has undergone a pre-test as well as a post-test before and after the treatment was administered. The collected primary and secondary data from the study area was tabulated and statistically analyzed using statistical tools, like mean, frequency, standard deviation, range, cumulative square root frequency method, regression coefficient, etc. to arrive at a conclusion.

Results and Discussion

It is apparent from the Table1 that half of the respondents were middle aged farmers having medium farming experience of 18-32 years and around one third of them owing a land holding size of 2-4 ha. It is also clear that majority of the farmers were in medium to high knowledge level categories regarding climate change, its impacts and adoption practices related with concerned system. Most of respondents perceived weather based advisory services as highly useful in their farming activities. Nearly half of the respondents had possessed small herd size and had an annual income of 5.86-9.17 lakhs.

Herd size and production profile of the dairy animal

Table 2 depicts the number of animals in milk and dry animals as well as heifer and calves maintained in the herd among all three dairy animal types. It is also observed from the same table 3 that the average productivity of buffalo was 8.20 liters and 9.73 liters per day during summer and winter, respectively. Results also show that the productivity of crossbred cattle was 13.34 liters and 15.29 liters per day and indigenous cattle of the region had productivity of only 3.64 liters/day and 4.11 liters/day during

summer and winter, respectively. All three species of dairy animal reach their peak yield after 2-4 weeks, with a lactation length of 282 days in buffalo, 254 days in indigenous cattle, and 291.25 days in crossbred cattle.

Impact of climate services on feed and fodder management

A. Using improved/multicut varieties of fodder crops

Results from Table 4 show that there was a considerable increase in the number of farmers who have adopted the improved multicut varieties of fodder crops as a result of climate services in all three modes of intervention i.e., Text SMS, WhatsApp, and Mobile App. Dairy is the major contributor to the livelihood of farmers in the region and most of them were stall feeding with almost no grazing, demand for a continuous regular supply of green fodder might be a reason behind the already significant majority of farmers using these improved varieties. Ghosh et al. (2016) in their study have also stressed that the development of improved varieties of perennial grasses, fodder crops and legumes and fodder trees has a role to address the fodder issues like supply-demand gap, silage preparation and etc.

In order to increase fodder productivity and meet fodder demand, Singh et al. (2022) advocated raising awareness about the necessity of using high quality seed of improved fodder varieties and increasing the seed replacement rate from the current 2%-3% to at least 10%.

B. Use of Oil cakes in the animal feed

It's obvious from the results of the Table 4, that the climate services had a positive treatment effect on the use of oil seed cakes on the animals in terms of an increase in the number of farmers adopting the practice. Oilseed cakes due to their rich protein content, they are used as animal feed, especially for ruminants and fish (Ramachandran et al. 2007), they are highly

Table 1: Socio-economic profile of the respondents (n=360)

Variable	Categories	% of farmers
Age	Young (<35 years)	20.83
	Middle (35-55 years)	48.06
	Elder (>55 years)	31.11
Farming experience	10-18 years	22.50
	18-32 years	44.44
	32-50 years	33.06
Operational land holding	< 1 ha	20.55
	1-2 ha	27.50
	2-4 ha	32.80
	4-10 ha	18.05
	>10 ha	1.11
Annual income	2-5.85 lakhs	37.50
	5.86-9.17 lakhs	48.33
	9.18-19 lakhs	14.17
Knowledge on climate change & its impact on livestock (Range: 6-20)	Low (6-11.23)	26.39
	Medium (11.24-14.18)	39.44
	High (14.19-20)	34.17
Perception regarding weather based advisory services (Range: 47-77)	Least useful (47-60.01)	23.89
	Moderately useful (60.02-66.87)	34.72
	Highly useful (66.88-77)	41.39
Herd size (Standard Animal Unit)	Small (3.9-7.84)	47.22
	Medium (7.85-12.06)	36.67
	Large (12.07-35.95)	16.11

Table 2: Average household holding of different types of dairy animals (n=360)

Category	Buffalo (n=360)	Indigenous cattle (n=86)	Cross-bred cattle (n=74)
In Milk	4.37	1.27	1.59
Dry	1.30	0.37	0.41
Heifer	0.88	0.50	0.54
Calves	1.11	0.47	0.54
Total	7.66	2.62	3.10

nutritive and make a significant contribution to the energy content (Rakita et al. 2023) of the animal diet as part of a balanced ration and help in maintaining milk production. Mustard, cotton, groundnut, and soybean were the most commonly used oil cakes, which were fed to the animals twice a day, in the morning and late at night.

C. Use of mineral mixture to maintain productivity and health

In terms of an increase in farmers adopting the use of mineral mixture, climate services had a positive treatment impact (Table 4) in all three modes of intervention i.e., text SMS, WhatsApp, and Mobile App. An increase in milk production and a significant difference in first postpartum estrus and conception rate were observed in animals supplemented with the mineral mixture (Kumar et al. 2020). Cariappa et al. (2022) in their study have also reported that the Anionic mineral mixture prevents milk fever and improves farmer income.

D. Providing chopped fodder to avoid wastage

Table 4 depicts the slight increase in the adoption of the practice of providing chopped fodder. The majority of the respondents were already using the chopped fodder for their animals for better digestion, to avoid fodder wastage also the chopping of fodder enables the better mixing of different feed and fodders like dry and green fodder, wheat husk, paddy husk, etc. Manohar et al. (2014) from their study have found that, all the respondents in the study region used to chop dry fodder before feeding while 70 per cent of respondent chopped green fodder. Abilzhanuly (2019) in his study found that, feeding cattle chopped hay results in a weight gain of 35% when compared to feeding cattle non chopped hay.

Impact of climate services on the health, hygiene and housing practices

A. Calcium supplementation

Results from Table 5 depict the positive treatment effect of climate services on the use of calcium supplementation in the number of farmers adopting the use of calcium supplementation. A study by KVK Jabalpur (MP) has found that balance feeding with feed

Table 3: Production profile of the livestock in the sampled households (n=360)

Productive Parameters	Buffalo (n=360)	Indigenous cattle (n=86)	Cross-bred cattle (n=74)
	Mean±SD		
Milk yield in Summer (lit/day)	8.20±1.31	3.64±1.13	13.34±1.29
Milk yield in Winter (lit/day)	9.73±1.48	4.11±1.28	15.29±1.32
Lactation Length (Days)	282.44±13.15	254.65±11.31	291.25±7.18
Peak Yield (Kg)	15.09±1.37	5.74±1.58	18.00±1.33
Dry period (days)	146.15±14.15	155.89 ± 3.18	101.05 ± 4.76

Table 4: Impact of climate services on feed and fodder management (n=360)

	Improved fodder varieties		Oil seedcakes		mineral mixture		chopped fodder	
Treatment group	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Control (n=90)	77.78	80.00	86.66	80.00	12.22	8.88	90.00	90.00
Text SMS (n=90)	81.11	88.88	83.33	93.33	14.44	24.44	93.33	96.66
WhatsApp (n=90)	76.66	85.55	76.66	87.77	10.00	21.11	94.44	97.77
Mobile App (n=90)	82.22	95.50	77.77	92.22	16.66	30.00	88.88	94.44

Table 5: Impact of climate services on animal health, hygiene and housing practices (n=360)

	Calcium supplementation		Deworming		Use of rubber mats		Shed hygiene		Mosquito nets	
Treatment group	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Control (n=90)	42.22	40.00	36.66	38.88	64.44	65.55	73.33	68.88	70.00	71.11
Text SMS (n=90)	44.44	47.77	47.77	57.77	58.88	63.33	75.55	87.77	75.55	81.11
WhatsApp (n=90)	33.33	38.88	41.11	55.55	60.00	67.77	67.77	84.44	68.88	75.55
Mobile App (n=90)	38.88	42.22	44.44	61.11	63.33	72.22	77.77	91.11	62.22	68.88

supplements like mineral mixture @ 50g and calcium supplementation @100ml per day per animal during last two months of pregnancy in buffaloes has resulted in reduction of post-partum problems by 40%, increased in milk yield by 25.80% and 40.31% increase in net returns (Annual Report 2015-16 ICAR-ATARI, Jabalpur). In dairy cows, low blood calcium levels after calving can be troublesome, especially for older cows. Acidogenic salts in the diet prior to calving and oral calcium supplements after calving reduce postpartum health and production-related problems (Vagnoni et al. 2021).

B. Deworming of animals at optimum intervals

Results from Table 5 reveal that there was a positive treatment effect of the climate services on the number of farmers adopting the practice of deworming of their animals. Findings of Thapa Shrestha *et al.* (2020) have reported that milk production in cows and buffaloes increased steadily in the first month after administering the deworming. The study revealed the importance of deworming and management practises in controlling the prevalence of parasitic diseases. And it also recommended that, in order to achieve the intended goals in deworming activities, sensible use of anthelminthic medications, and effective farm management, periodic monitoring of the incidence of Gastrointestinal parasites among farm animals is required (Gunathilaka et al. 2018).

C. Use of rubber mats for animals

Climate services had a positive treatment effect on the adaption of rubber mats for animals as revealed in Table 5. The gap still existing might be due to the cost element involved in the purchase of cow mats specially for small and marginal farmers. Use of cow mats provides a non-slippery surface, reducing injuries to their feet and knees, and are easy to clean and disinfect thereby reducing chances of infection or udder diseases. On the concrete floor, the average minimum slippage amounted to 4.4 occurrences, whereas the rubber mat floor saw only 2.6 instances. Housing cows on the rubber mat floor resulted in a notable 30.4% boost in milk production when compared to the concrete floor, primarily due to the increased comfort it offered (Jain et al. 2013).

D. Proper disposal of dung, urine, drainage facility, and hygiene maintenance in the animal shed

Results from Table 5 show that there was a positive treatment effect of the climate services on the adaption of the practice of "proper disposal of dung, urine, drainage facility, and hygiene maintenance in the animal shed, etc." Since the practice is simple and doesn't involve any extra cost, at the same time shed hygiene has a positive effect on animal health by controlling disease-causing pathogens and their vectors, so the practice was adapted by the farmers. A study by Rathod et al. (2017) has disclosed that the incidence of subclinical mastitis in dairy animals was more in case of the animal sheds that were less hygienic, which ultimately affects the milk yield and economic returns, highlighting proper shed hygiene's underlying contribution to animals health and production.

E. Use of mosquito nets around the shelter to prevent flies, mosquitoes, and other vectors

Results from Table 5 display that there was a positive treatment effect of the climate services on the adaption of mosquito nets around the shelter to prevent flies, mosquitoes, and other vectors. Since there was a high mosquito and flies problem in the region and almost two-thirds of them were using mosquito nets, The lack of an appropriate shed to install the net and the cost were cited as constraints, while few claimed that alternative methods, such as fogging and the use of mosquito coils and liquid, were sufficient for control. Haque et al. (2021) in their study have reported that, despite the fact that mosquito nets help prevent mosquitoes, flies etc which are the vectors of many diseases including lumpy skin disease, most farmers (91.17 %) did not use one in their cattle barn at night.

Conclusion

The changing climatic conditions pose a serious threat to dairy animals in general and Murrah buffaloes in particular, which are highly sensitive to heat stress. Reliable climate information and related advisory services recommending timely weather-related management practices can make dairy farming climate resilient. The exclusive climate services developed for the Murrah had a positive treatment effect on all the operational decision-making of the herd management and hence should be given utmost priority in making available these services to farmers on a regular basis. Climate Services which link the climatic information with available climate resilient dairy farming practices is an important adaptation strategy assisting vulnerable dairy farming populations in coping with the climate of today and of the future. Extension agents' role is imperative in creating climate literacy among farmers, convincing them of the importance of these climate services, interpreting these scientific advisories, and further assistance at all stages of implementation for enhanced uptake and utilization of climate services.

References

Abilzhanuly T (2019) Method of fineness adjustment of shredded particles of stem fodder in open-type machines. Eur Asian J Bio Sci 13(1): 625-631

Aggarwal A, Singh, M (2008) Changes in skin and rectal temperature in lactating buffaloes provided with showers and wallowing during hot-dry season. Trop Anim Health Prod 40, 223–228. https://doi.org/10.1007/s11250-007-9084-3

Ahmad M, Bhatti JA, Abdullah M, Ullah R, ul Ain Q, Hasni MS, Uddin, R (2019) Different ambient management intervention techniques and their effect on milk production and physiological parameters of lactating NiliRavi buffaloes during hot dry summer of subtropical

region. Trop Anim Health Prod *51:*911-918. https://doi.org/10.1007/s11250-018-1774-5

Annual Report 2015-16 ICAR-Agricultural Technology Application Research Institute (ATARI), Zone VII, Jabalpur. https://atarijabalpur.icar.gov.in/upload/publication/APR-2015-16.pdf

Balhara A, Varij Nayan A, Dey K, Singh S, Dahiya, Inderjeet Singh (2017) Climate change and buffalo farming in major milk producing states of India-Present status and need for addressing concerns. Indian J Anim Sci 87(4) 403-411

Cariappa AG, Chandel BS, Sankhala G, Mani V, Dixit AK, Meena BS (2022) Anionic mineral mixture prevents milk fever and improves farmer income: evidence from a randomized controlled trial. Agric Econ Res Rev 35(1).

Estimated livestock population breed wise based on breed survey (2013) Department of animal husbandry, dairying & fisheries (animal husbandry statistics division) Krishi Bhawan, New Delhi 2013.

Frisvold GB, Murugeshan A (2013) Use of weather information for agricultural decision making. Weather Clim Soc 5: 55-69. https://doi.org/10.1175/WCAS-D-12-00022.1

Ghosh PK, Palsaniya DR, Srinivasan R (2016) Forage research in India: issues and strategies. Agric Res J *53*(1), 1-12. https://10.5958/2395-146X.2016.00001.6

Gunathilaka N, Niroshana D, Amarasinghe D, Udayanga L (2018) Prevalence of gastrointestinal parasitic infections and assessment of deworming program among cattle and buffaloes in Gampaha District, Sri Lanka. BioMed Res Int. https://doi.org/10.1155/2018/3048373

Hahn GL, Mader TL, Eigenberg RA (2003) Perspective on development of thermal indices for animal studies and management. EAAP Tech Series 7: 31-44

Haque MH, Roy RK, Yeasmin F, Fakhruzzaman M, Yeasmin T, Sazib MRI, Sarker S (2021) Prevalence and Management Practices of Lumpy Skin Disease (LSD) in Cattle at Natore District of Bangladesh. Eur J Agric Food Sci *3*(6):76-81. https://doi.org/10.24018/ejfood.2021.3.6.420

HSAPCC (Haryana State Action Plan on Climate Change) (2011). Draft report. Government of Haryana. https://faolex.fao.org/docs/pdf/ind194032.pdf

Jain SK, Mahale DM, Thakor NJ (2013) Effect of rubber mats on comfort of dairy animals. Int J Agricl Eng 6(2): 463-468

Kumar R, Rana DS, Kumari R, Gupta R and Singh M (2020) Effect of area specific mineral mixture feeding on productive and reproductive performance of dairy animals. J Entomol Zool Stud 8: 2407-2409

Manjusree RV, Maiti S, Garai S, Manjunath KV, Bhakat M, Dixit AKS SK Jha, Kadian KS (2022) Impact of agromet advisory services on farmers' operational decisions related to dairy farming in Thiruvananthapuram. Indian J Dairy Sci 75(3): 285-289. https://doi.org/10.33785/IJDS.2022.v75i03.012

Manohar DS, Goswami SC, Bais B (2014) Study on feeding management practices of buffaloes in relationship with selected traits of respondents in Jaipur district of Rajasthan, India. Indian Journal of Animal Research 48(2): 150-154

Marwa ME, Mburu J, Elizaphan R, Oburu J, Mwai O, Kahumbu S (2020) Impact of ICT based extension services on dairy production and household Welfare: the case of iCow service in Kenya. J Agric Sci 12(3): 1-12. https://doi.org/10.5539/jas.v12n3p141

Mishra SR (2021) Thermoregulatory responses in riverine buffaloes against heat stress: An updated review. J Thermal Biol 96:102844. https://doi.org/10.1016/j.jtherbio.2021.102844

Pankaj PK, Ramana DBV, Pourouchottamane R, Naskar S (2013) Livestock management under changing climate scenario in India. World J Vet Sci*,* 1(1): 25-32

Parmar BPS, Sangwan AK (2016) Delineation of elite Murrah buffalo breed tract in Haryana using geoinformatic techniques. Int J Advancement in Remote Sensing, GIS and Geography4(2) 1-11

Rakita S, Kokiæ B, Manoni M, Mazzoleni S, Lin P, Luciano A, Pinotti L (2023) Cold-Pressed Oilseed Cakes as Alternative and Sustainable Feed Ingredients: A Review. Foods 12(3): 432. https://doi.org/10.3390/foods12030432

Ramachandran S, Singh SK, Larroche C, Soccol CR, Pandey A (2007) Oil cakes and their biotechnological applications–A review. Bioresource Technol 98(10): 2000-2009. https://doi.org/10.1016/j.biortech.2006.08.002

Rao CR, Raju BM K, Rao AS, Rao KV, Rao VUM, Ramachandran K, Rao CS (2016) A district level assessment of vulnerability of Indian agriculture to climate change. Current Sci 1939-1946. https://doi.org/10.18520/cs/v110/i10/1939-1946.

Rathod P, Shivamurty V, Desai AR (2017) Economic losses due to subclinical mastitis in dairy animals: A study in Bidar district of Karnataka. Indian J Vet Sci Biotechnol 13(1): 37-41

Rathore LS, Chattopadhyay N (2016) *Weather and Climate Services for Farmers in India. Bulletin no: Vol 65(2)2016*, WMO, Geneva, Switzerland.

Rojas-Downing MM, Nejadhashemi AP, Harrigan T, Woznicki SA (2017) Climate change and livestock: Impacts, adaptation, and mitigation. Climate Risk Manage 16: 145-163. https://doi.org/10.1016/j.crm.2017.02.001

Roy A, Raizada BC, Tewari RBL, Pandey MD, Yadav PC, Sengupta BP (1968) Effect of management on the fertility of buffalo cows bred during summer. Indian J Anim Sci 38:554–560

Singh DN, Bohra JS, Tyagi V, Singh T, Banjara TR, Gupta G (2022) A review of India's fodder production status and opportunities. Grass Forage Sci 77(1): 1-10. https://doi.org/10.1111/gfs.12561

Singh S, Singh D, Rao (2008) Impact of Climatic Change on Agriculture over Haryana. Available From: https://www.researchgate.net/publication/322231410_Impact_of_Climatic_Change_on_Agriculture_over_Haryana

Thapa Shrestha U, Adhikari N, Kafle S, Shrestha N, Banjara MR, Steneroden K, Ghimire P (2020) Effect of deworming on milk production in dairy cattle and buffaloes infected with gastrointestinal parasites in the Kavrepalanchowk district of central Nepal. Vet Record Open, 7(1), e000380. https://doi.org/10.1136/vetreco-2019-000380

Upadhyay RC, Hooda OK, Aggarwal A, Singh SV, Chakravarty R, Sirohi S (2013) Indian livestock production has resilience for climate change. *Training compendium on climate resilient livestock and production system,* November 18 to December 1, 2013, NDRI, Karnal.

Upadhyay RC, Singh SV, Kumar A, Gupta SK, Ashutosh S (2007) Impact of Climate change on Milk production of Murrah buffaloes. Italian J Anim Sci 6 (2): 1329-1332. https://doi.org/10.4081/ijas.2007.s2.1329

Vagnoni DB, Davidson M, Rubio L, Oetzel GR, Comets E (2021) Effects of postpartum supplemental oral Ca for dairy cows fed prepartum dietary acidogenic salts. Animals 11(11): 3131. https://doi.org/10.3390/ani11113131

Vashisth A, Singh R, Das DK, Baloda R (2013) Weather Based Agromet Advisories for Enhancing the Production and Income of the Farmers under Changing Climate Scenario. Int J Agric Food Sci Technol 4(9):847-850