The Haryana Veterinarian (June, 2025) **64(1),** 15-20 ISSN 0033-4359 (P) **Research Article**

BOVINE AND BUBALINE MILK PRODUCTION IN CHANGING CLIMATIC SCENARIO -A PANEL DATA ANALYSIS

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ABSTRACT

The present study was based on the 10 years (2010- 2019) of secondary data of milk yield and milk production from buffalo, crossbred and indigenous cattle and the climatic parameters i.e., annual data of minimum, maximum, and mean temperature, the incidence of heavy rainfall, the incidence of heat and cold waves, temperature humidity index (THI), and potential evapotranspiration (PET). Panel data with a fixed-effects model was applied to see the effects of changing climate on dairy bovine's milk production in the long time span. Research findings revealed that THI and PET of summer and rainy seasons have significant relation with the production level of bovines. Along with THI and heatwaves, PET was identified as one of the imperative indicators to correlate the effect of climate change with dairy bovine's milk production. Hence, it was suggested that adopting climate-resilient livestock technology as adopted by farmers of the study area was the only way to ameliorate the adverse effects of climate change and provide comfort to the livestock with sustainable production.

Keywords: Climate change, Dairy Bovine milk production, Panel data, Potential evapotranspiration, Temperature Humidity Index

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Recent study of Pasqui and Giuseppe (2019) was clearly indicative that climate is changing. As the global warming increases, risk on food security, ecosystem, animal species and biodiversity increases simultaneously. Further, it was a well-known fact that tropical as well as temperate countries showing increasing concern about the thermal comfort of livestock. At local as well as global level the occurrence of extreme events such as the heat waves, cold waves are increasing.

The Indian livestock sector was showing compound annual growth rate of 8.24 per cent during 2014-15 to 2018-19. Positively, the contribution of livestock sector in total agriculture and allied sector was 28.63 per cent in 2018-19 at current price (National Accounts Statistics, 2020). Presently, India is the world's largest milk producer with total milk production as198.4 million tonnes in 2019-20 (NDDB, 2019-20). Temperature, precipitation, relative humidity, wind velocity etc., have seasonal divergent effects in dairy production. At the all-India level, Upadhyay *et al.* (2009) reported that due toheat stress,the annual total milk loss was 1.8 million tonnes (approximately 2% of the total milk production of the country) amounting to the extent of Rs. 2661.62 crores per year.

When the surrounding ambient temperature of cattle crosses the thermo-neutral zone, heat stress is felt by them (Allen *et al.*, 2013). During that time, energy requirement increases to maintain the body temperaturewhich leads to less energy availability for milk production (Collier *et al.*, 2011). Heat stress suppresses the immune and endocrine system thereby enhances susceptibility of an animal to various diseases. The strong effect of climatic conditions has been seen on livestock productivity generally and on the dairy sector in particular.

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Haryana being the home tract of the world famous *Murrah* buffalo has a prominent place in animal husbandry and dairying map of the country with top performing states in terms of milk production i.e., showing 9.3 per cent of growth rate in comparison to India showing 6.5 per cent of growth rate in milk production (BAHS, 2019) and having per capita availability of milk as 1087 grams per day (Fig. 1) as compare to National Av. 407 grams/day (Livestock census, 2019). Further, out of 22 districts in Haryana, 15 districts come in the range of medium to high vulnerability towards climate change (Rao *et al.*, 2016).

Therefore, comprehensive analyses of the connection between climatic effects and dairy bovine productivity are of increasing importance. A numbers of studies on impact of climate change on livestock specifically during experiment trial or in research dairy farms/large dairy farms, have been briefly reviewed, that clearly established the susceptibility of livestock to extreme climate conditions (IPCC, 2014). The present research paper gives emphasis on connection between dairy bovine milk production and climatic variables in different seasons in a long time span.

Our analysis adopts temperature humidity index, incidences of heavy rainfall, incidences of heat waves, incidences of cold waves and potential evapo-transpiration to capture the climatic effects on dairy bovine productivity.

MATERIALS AND METHODS

Research area: All district of state Haryana were selected to correlate the season wise milk production of cross bred, indigenous cattle and buffalo with the climatic parameters of ten years.

Collection of data: The study was entirely based on secondary data. Livestock milk production and yield data of rainy, summer and winter season of 19 districts of Haryana were obtained from integrated sample survey, Dairying andAnimal Husbandry Department, Panchkula, Government of Haryana, from the period of 2010 to 2019. To establish the empirical relationship between milk production and milk yield of different seasons with the average of season wise climatic parameters i.e., temperature humidity index (THI) and potential evapo-transpiration (PET), data were extracted from Terra climate. Further, rainfall data were extracted (grid scale of 0.25*0.25) to determine incidence of heavy rainfall and annual data of minimum, maximum and mean temperature (grid scale of 0.50*0.50) were extracted from Indian Meteorological Department, Pune to determine incidence of heat waves and cold waves.

Climatic condition of research area: Scanty rains, excess and untimely rains, heat waves (loo), cold waves, high and hot winds during summer, dust storms, fog, frost and hails are important weather abnormalities occurring in the state and adversely affect the agriculture production (Singh and Singh, 2018). Haryana is extremely hot in summer with a temperature of around 45º C and mild in winter. Trends in climatic scenario of Haryana have been clearly shown in Figs. 2(a), (b), (c), which is indicative of increasing maximum and minimum temperature and decreasing trends in rainfall and in Fig. 2(d) the distribution of average THI and PET over the months have been shown.

Panel data fixed effects model (FEM):

Panel data approach, suggested by Deschenes and Greenstone (2007) was followed. All the district boundaries were adjusted to the year 2004 in order to account for changes in the administrative boundaries of districts due to formation of new districts. The effect of climate change was studied in terms of changes in production and productivity trends in the Haryana region. Our panel consists of 10 years' data from 2010 to 2019 for 19 districts of Haryana of climatic parameters mentioned above and milk yield and milk production data from buffalo, crossbred cattle and indigenous cattle.

The word "fixed effect" is owing to fact that intercept may differ across subjects (district) but intercept does not vary over time i.e., time invariant (Gujarati, 2012). The effect of changing climate on milk production with fixed effect panel model is specified as: $\ln Y_{it} = D_i + T_i + \beta X_{it} + \varepsilon_{it}$

Where,

The district and time denote by subscripts i and t in equation, respectively.

The dependent variable Y is the milk production,

D represents the district fixed effects.

T represents time fixed effects controlling the difference in milk production which could be due to the changes in technology, infrastructure, human capital, etc.

X is a vector of climatic parameters.

β are parameters on climatic parameters and ε is the error-term.

Equation (I) was estimated as log-linear to reduce excessive variation in the dependent variable.

All the concerned climatic variables were taken as independent variables whereas, average season wise milk production and milk yield of indigenous cattle, cross breed cattle and buffalo were taken as dependent variables.

RESULT AND DISCUSSION

Analysis of panel data set of climatic variables with bovine productivity season wise:

Summer (March to June), rainy (July to October) and winter (November to February) season milk production data of buffalo, crossbred cattle and indigenous cattle were analyzed with corresponding season wise data of THI, PET and incidence of cold wave, heat wave, heavy rainfall.

Analysis of season wise bovine milk production (Table 1) revealed that rainy season milk production of buffalo and crossbred cattle have significant negative relation with rainy season THI (-10.414±1.70) and PET (-0.987±0.320) of study area. While, indigenous cattle milk production was not found to be of any significant relation with corresponding THI and PET. In summer season all three livestock species i.e., buffalo, crossbred cattle and indigenous cattle showed significant negative relation (Table 2) with PET of summer season with the magnitude of -1.588 ± 0.269, -0.418 ± 0.108 and -0.060 ± 0.023, respectively. Furthermore, heat waves were significantly affected the milk production of buffalo and indigenous cattle in summer. Although, in winter season only milk production of buffalo (Table 3) had significant negative relation with incidence of cold wave whereas, no variables showed significant association either negative or positive with crossbred and indigenous cattle milk production. Results of the present study clearly shows that PET was negatively associated significantly with milk production and yield in both seasons i.e., rainy and summer seasons.

The findings of present research reveals that milk yield and milk production of livestock have significant negative association with THI, PET, incidence of heat waves and cold waves. The rainy season of study area has high temperature with high humidity, which act as critical factors for livestock productivity however, winter months' temperature does not affect the milk production significantly. In the summer seasons, THI did not show any significant

Table 1. Estimates of climatic parameters and bovine milk production in rainy season

Climatic parameters	Buffalo		Crossbred cattle		Indigenous cattle	
	Coefficient (SE)	P-value	Coefficient (SE)	P-value	Coefficient (SE)	P-value
Incidence of heavy rain fall	0.029 (2.636)	0.991	1.853 (1.057)	0.182	4.774 (55.212)	0.931
THI Rainy	-10.414*** (1.70)	0.000	-4.181*** (0.682)	0.000	-35.109 (35.613)	0.326
PET Rainy	-0.987*** (0.320)	0.002	-0.668*** (0.128)	0.000	-8.157 (6.703)	0.226
R-squared	0.287	0.313	0.030			
Number of observations	190					

*** p<0.01, ** p<0.05, * p<0.1, Data in parenthesis indicate standard error

Table 2. Estimates of climatic parameters and bovine milk production in summer season

Climatic parameters	Buffalo		Crossbred cattle		Indigenous cattle	
	Coefficient (SE)	P-value	Coefficient (SE)	P-value	Coefficient (SE)	P-value
Incidence of heat waves	-2.975** (1.478)	0.046	0.400 (0.595)	0.503	-0.268** (0.127)	0.007
THI Summer	13.480 (4.383)	0.503	-4.831*** (1.766)	0.007	-0.018 (0.378)	0.962
PET Summer	-1.588*** (0.269)	0.000	-0.418*** (0.108)	0.000	-0.060** (0.023)	0.001
R-squared	0.276	0.139	0.095			
Number of observations	190					

*** p<0.01, ** p<0.05, * p<0.1, Data in parenthesis indicate standard error

Table 3. Estimates of climatic parameters and bovine milk production in winter season

Climatic parameters	Buffalo		Crossbred cattle		Indigenous cattle	
	Coefficient (SE)	P-value	Coefficient (SE)	P-value	Coefficient (SE)	P-value
Incidence of cold waves	-219.031** (90.310)	0.017	1.296 (0.977)	0.187	-2.959 (39.884)	0.941
THI winter	-355.860 (215.079)	0.160	0.921 (2.326)	0.693	-146.859 (94.985)	0.125
PET winter	11.950 (43.056)	0.782	0.709 (0.466)	0.131	23.423 (19.015)	0.220
R-squared	0.043	0.119	0.033			
Number of observations	190					

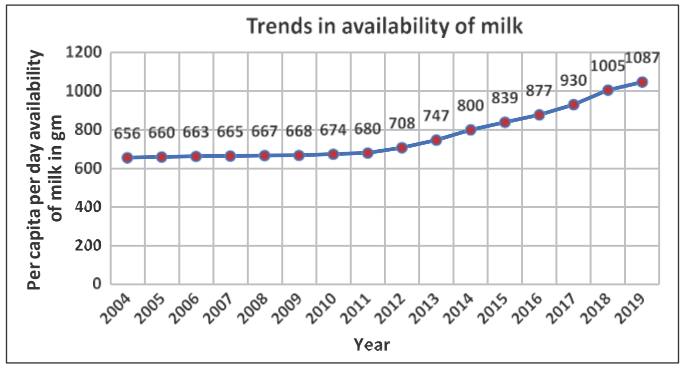
*** p<0.01, ** p<0.05, * p<0.1, Data in parenthesis indicate standard error

negative correlationin buffalo as indicated in previous studies (Kadzere *et al.*, 2002; Mukherjee *et al.*, 2013; Key and Sneeringer, 2014) which shows significant negative correlation with intake of dry matter, and consequently, a negative correlation has been reportedbetween THI and milk production, milk yield.

It may be due to the fact that the respondents of the study area are highly dependent on buffalo farming as they were having high producing *Murrah* breed of buffaloes (breeding tract) and more concerned about maintaining their productivity in different seasons. Furthermore, dairy farmers of present research area were knowledgeable and adopted different climate resilient livestock technologies to combat heat stress such as providing shed to animals, provision of fan, fogging system, sprinkler etc. to alter the surroundings micro climate of livestock, modification of feed ingredients and feeding timings during hot days (Loura *et al.*, 2021; Singh *et al.*, 2018; Singh *et al.*, 2010). Awareness towards climate change particularly heat stress effect on animals with adoption of different practices to combat climate change have been well documented (Maiti *et al.*, 2014; Maiti *et al.*, 2015 and Dutta *et al.*, 2015). Theresult of the present study is also in line with aforesaid results i.e., farmers of Haryana region who were well aware of technology or practices being implemented in summer season. Together with adoption of technology to cope with heat stress in the study area, buffalo calving mostly occurs in winter months (Kamble *et al.*, 2014) and in the summer season majority of the buffalo pass through dry periods. May be due to this reason, productivity of buffalo was not much affected by heat stress although their reproductive efficiency may be deteriorated. Díaz *et al.* (2020) also found negative correlation between THI and reproductive behavior and a positive correlation between the onset of ovarian activity and reproductive behavior. High levels of THI have a negative effect on the resumption of ovarian activity and reproductive behavior in *Bos indicus* especially if high THI occurs during the last trimester of gestation.

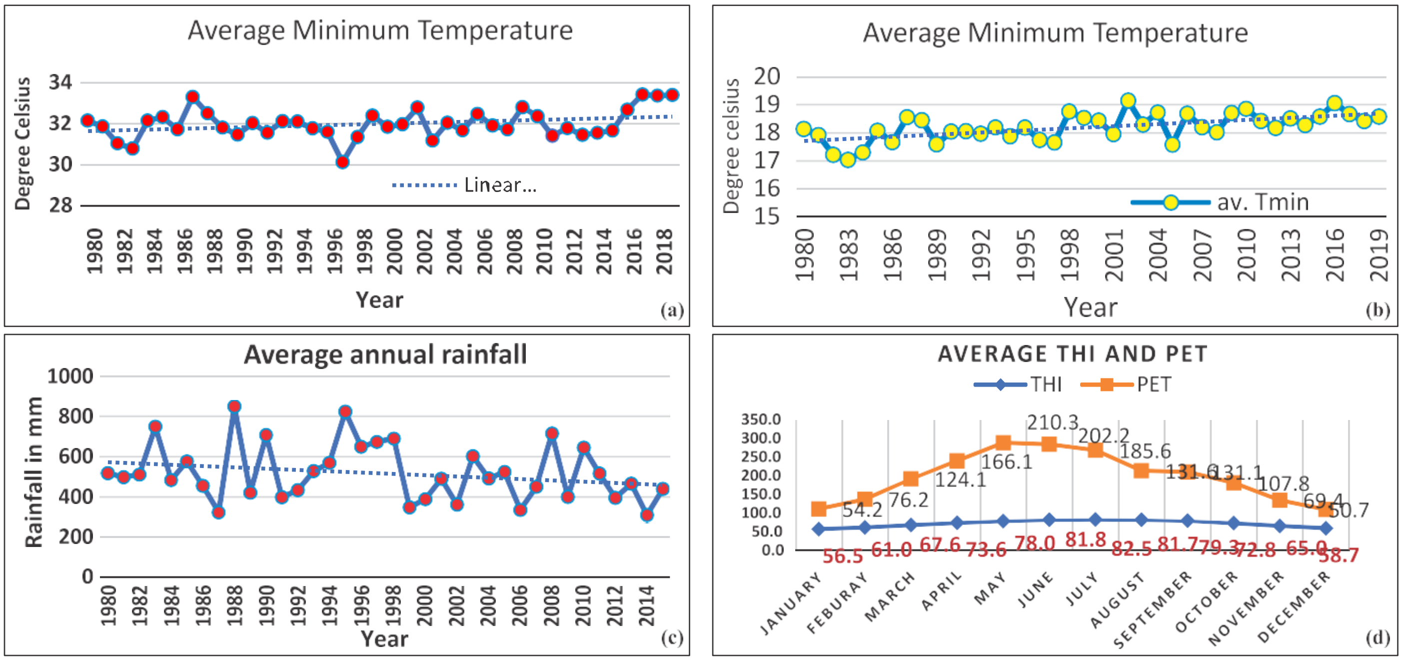
Crossbred cattle productivity has significant negative effects of heat stress. The reason may be the presence of exotic gene and another reason may be their season of calving i.e., crossbred cattle mostly calve during the months of March, April and during peak production they are exposed to high temperature. Research findings of many scientists (Collier *et al.*, 2008; Baumgard and Rhoads, 2013; Kumar *et al.*, 2014) shows that exotic genes of crossbred cattle cause a hindrance to adapt under tropical conditions compared to native breeds which survive and perform better as compared to exotic breeds and their crosses in hot climate.

It is a well-known fact that breeds from where they originate i.e., indigenous livestock are resistant to adverse effects of climate of their region. However, incidence of



(Integrated Sample survey, 2019-2020)

Fig. 1. Trends of per capita per day availability of milk in Haryana



(https://data.gov.in/, http://www.climatologylab.org/terraclimate.html)

Fig. 2. Average maximum (a), minimum (b), annual rainfall (c) and average monthly THI and PET (d) of Haryana region from the year 1980 to 2018

heat waves and cold waves cause significant negative effects on production since in the study area indigenous breeds were reared mostly by marginal to small farmers with less consideration on scientific rearing of livestock.

Furthermore, in rainy season both THI and PET, have significant negative relation with milk production and milk yield. In such condition, the amount of moisture present in the air is important because it has an impact on the rate of evaporative loss through skin and lungs. The quantity of moisture in the environment become critical factors when the mean daily temperature falls beyond the animal's comfort zone, to maintain the homeostasis of the animal (Bohmanova *et al.*, 2007). In this scenario, relative humidity in the air acts in concurrence with temperature. Higher the relative humidity, lesser the evaporative demand and, therefore, the lower evapo-transpiration. Bandyopadhyay *et al.* (2009) also found significant increase in ambient relative humidity in India. This finding was also in line with the study area, where high humidity in July and August months have been noticed.

Studies on cattle have shown that increasing temperatures resulted in decrease in voluntary intake of food, weight, fertility and milk production (Ben Salem and Bouraoui 2009; Hernández *et al.*, 2011; Gantner *et al.*, 2012). Furthermore, Collier *et al.* (2011) stated that heat stress in cattle is characterized by decreased feed intake which contributes to the decreased milk yield. According to Bouraoui *et al.* (2002) daily THI is negatively correlated to milk yield, and an increase of THI value from 68 to 78 decreases DMI by 9.6 percent and milk production by 21 percent.

Different livestock species have different effects to various climatic parameters. Cattle sweat more and thus can dissipate excessive heat more efficiently than other livestock and tolerate much higher temperatures along with lower relative humidity. While, heat stress condition in buffalo reduce the dry matter in take with decline in the ratio of forage to concentrate intake. Therefore, effects seen in the decline in milk yield is more in buffaloes that produce more milk. These complete pictures show significant connection between the level of milk yield and production and its declination linked with rise in daily mean ambient temperature.

However, research on potential effects of PET on livestock production either directly or indirectly got very negligible attention by scientific community as well as effects of high or low PET and its management on livestock system very less understand by the farmers as well. From the present study it was found that PET (indicative of drought severity) (Hobbins *et al.*, 2016; McEvoy *et al.*, 2016) was also one of the imperative indicators correlated with the effect of climate change with livestock productivity (Hennessy *et al.*, 2010). However, farmers are not much aware of the effect of higher PET. Because computation of PET includes precipitation, wind speed and sunshine hours along with temperature and relative humidity (Irmak *et al.*, 2012; Peterson *et al.*, 1995; Sun *et al.*, 2016), any change in these variables is likely to change the PET harshly or stressful conditions for agriculture and consequently for animals (Lavergne *et al.*, 2010; McCluney *et al.*, 2012). The increasing trends of PET was noticed during summer season in Haryana (Singh and Bala, 2012). The rate of evaporation depends on climatic conditions, specifically the radiative energy of the sun, wind, the vapour deficit of the air and temperature.

Therefore, there is a necessity to link PET to extraterrestrial solar radiation along with water vapor pressure and temperature, and incorporate this into the mitigation and adaptation strategy towards climate change specifically in livestock production system. Thus illustrating the importance of more rigorous calculations of PET in ecological models dealing with climate change (King *et al.*, 2015).

Livestock production performance is also affected in cold waves condition because larger proportion of energy is shifted towards maintenance of body temperature and thus productivity of livestock depends on the ability to keep normal and stable body temperature. An increase of minimum temperature of 4^{o} C causes milk production to increase by 1.4 per cent (Somoza *et al.*, 2018). This means that the improvement of climatic comfort of livestock has a positive impact on yield per cow.

The results of this study suggest the need for the implementation or scaling up of management options in the face of higher levels of heat stress caused by higher THI as wellas higher PET. The development of early warning systems for detection of heat stress, quantity of soil moisture, water level in regional level trigger the appropriate management responses. The training and sensitization of livestock farmers and extension officers in the region to better understand heat stress mitigation, including how to interpret indices like the THI, PET and how best the different adaptive capacity were prioritized based on those indices.Green fodder supplements and increased concentrate in the rations of ruminants in India would have the potential to mitigate impact of climate change by improving feeding efficiency (Sapkota *et al.*, 2019). An evaporative system which uses water mist with fan is more effective and economies water use in comparison to repeatedly bathing the animals.

Conclusively, selection of animals for heat tolerance, alteration in micro climate, nutritional management by adding more energy and mineral mixture in the animal diet, provision of day time shed, and infrastructure facilities for providing comfort to the livestock will help to counteract the adverse effects of changing climate. Further, there is need to increase their awareness as well as adaptive capacity towards climatic adverse effects such as PET.

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