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Climate change and buffalo farming in major milk producing states of India – Present status and need for addressing concerns

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ABSTRACT

The climate change is posing unprecedented challenges for the society in general and the farming community in particular, the world over. Large ruminants including buffaloes are generally considered as large contributors to greenhouse emissions and therefore playing a significant role in climate change. Buffaloes producing more than half of India's milk with significantly lesser population (only 36.66% of total bovine population) form the backbone of the Indian dairy farming. This livestock species is reportedly contributing 3.73 Tg of methane annually which is about 40% of the total livestock methane emissions. Uttar Pradesh is the highest methane emitting state adding roughly 15% to India's methane emissions. Further, the states of Haryana and Punjab have more than 60% of their livestock in form of buffaloes and so are the major contributors of methane in these states. Owing to it, higher feed efficiency and higher value of produce (milk and meat mainly), buffaloes are preferred by the farmers in India – a fact proved by significant growth with increase of ~18% expected in buffalo population by 2023. The body structures of buffaloes make them quite susceptible to adverse effects of weather vagaries. As India is already short of feed and fodder resources for the livestock, the perceived climate change era poses many challenges for this species to improve productivity in a climate resilient and sustainable manner. This paper analysis the buffalo farming in important milk producing states of India *vis-a-vis* climate change considerations for the benefit of policy makers and researchers to take appropriate mitigation and adaptive measures for making buffalo farming climate resilient and environment friendly.

Key words: Buffalo, Climate change, Methane

Climate is a critical factor in the lives and livelihood of the people and socio-economic development as a whole. Climate change will thus affect all living beings on the earth. Demand for animal products is anticipated to increase significantly in the future while competition for resources will intensify, dictating that livestock systems must increase both productivity and efficiency. All livestock production systems are sensitive to climate change and at the same time contribute to the phenomenon. Livestock farming contributes about 26% to the agricultural GDP and provides employment to about 20 million people, mostly in rural India. However, climate change is likely to be gradually a more difficult challenge to the growth of the livestock sector in India. The anticipated rise in temperature between 2.3 and 4.8°C over the entire country together with increased precipitation resulting from climate change is likely to aggravate the heat stress in dairy animals, adversely affecting their productive and reproductive performance, and hence reducing the total area where high yielding dairy animals can be economically reared (Sirohi and Michaelowa 2007).

Milk in India is a staple food for large vegetarian population. In context of poverty and malnutrition, milk has a special role to play - for its many nutritional advantages as well as providing supplementary income to farmers in rural areas. The demand for milk is increasing annually by >10% while the production is increasing only at around 4% (NDDB estimates). To make up the gap, buffalo dairy systems are best available option. Since the buffaloes form such an important part of our livestock agriculture, it is necessary that this sector should be well prepared to meet all challenges of climate change. While mitigation strategies are long term and require extensive research, identification of livestock having inherent adaptation capabilities, from the existing population, is the best available option in present scenario.

Buffaloes – importance as a livestock for India

The buffaloes, ranked 2nd contribution wise, overall contribute more than 13% to the world and 35% to Asia's milk production with an annual growth rate of 3.5%, over 2.1% the cow milk production (IDF 2013). As per FAO report of 2013 (Table 1), in India, the buffaloes are

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Table 1. Status of buffaloes in the World, Asia and India

	Population (Million heads)			Milk production (Million tonnes)			Meat production (Million tonnes)		
	World	Asia	India	World	Asia	India	World	Asia	India
Total bovine (Cattle + Buffalo)	161.37	682.84	298.40	737.99	276.70	130.60	67.71	17.69	2.58
Total buffalo	193.82	187.86	109.40	102.04	99.22	70.00	3.72	3.32	1.61
Buffaloes as % of total bovine	11.67	27.51	36.66	13.83	35.86	53.60	5.49	18.77	62.40

(FAO STAT 2013).

Table 2. India milk – production, availability and contribution of buffaloes

Year	Total milk produced (Million tonnes)	Buffalo milk (Million tonnes)	Contribution of buffaloes (%)	Per capita availability (g/day)
1950-51	17	09.2	54	124
1960-61	20	11.1	55	124
1970-71	22	12.6	57	112
1980-81	32	17.3	54	128
1990-91	54	29.7	55	176
2000-01	81	43.4	54	220
2010-11	122	62.3	51	281
2020-21*	160	88.0	55	400

*Anticipated at present rate of growth and production level.

(Own calculations based on 19th All India Livestock census statistics; economic reports and estimates).

contributing >50% to total milk production and > 60% to meat production although population of this species stands only at 36% of total livestock.

India has been the leading milk producer since 2000 and since 2011, the country has met WHO standards for per capita milk availability – around 310 g/day in 2014 (Table 2).

Why is buffalo a preferred livestock in India?

As per the 19th All India Livestock Census, while most other local livestock including cattle have registered negative growth, buffaloes have managed to register overall growth in the country despite widespread slaughtering by meat industry which made India the largest beef exporter country. Since production of milk is continuously increasing in the country, the increase is attributable mainly to buffaloes. This also suggest that the farmers are preferring buffaloes over other livestock because of its inherited advantages such as better feed conversion efficiency, sustainable on poor feed and forage quality, higher returns from milk (buffalo milk across breeds has more than 8% fat and in India milk is valued on the basis of fat), better nutritive value of milk (higher amounts of SNF including sugar, protein, calcium and vitamins), meat industry processing meat of spent and non-productive animals, less fertility related problems and more number of productive years in comparison to cross bred cows, better adaptability to harsh environment and higher disease resistance as compared to cross bred cows.

Socio-economics of buffalo farming in India

Most of the available data on socio-economics points towards very high level of dependency of rural livelihood especially of small farmers on buffalo farming. In fact, as mentioned earlier because of higher economic returns and better adaptability, buffalo has higher role in the socio economics of rural India. Moreover, women has greater role in buffalo farming and look after their feeding, management and healthcare (Figs 1 and 2). This in fact gives them an additional source of income as well as provides food security for the family.

SDAU (2006) had reported returns per buffalo at ₹ 8,277 for landless owners and ₹12,833 for owners with 2 hectares of land in north Gujarat and Kutch region. Another study by Chaudhary and Singh (2012) in the Kutch region of Gujarat on Banni buffalo production system reported that the owners earned ₹ 9,582 per buffalo during the period 2009–2011. Studies by Kumar *et al.* (2011) conducted on 200 buffalo farmers in the Hisar and Karnal districts of Haryana during 2007–2008 calculated that the average net profit of milk production of a buffalo per day was highest on small herd size group (₹ 20.18) followed by medium (₹ 18.64) and large size group (₹ 18.35) in Hisar district. In Karnal district, the net or gains per day was highest on small (₹ 21.35) followed by large (₹ 20.39) and medium herd size group (₹ 20.16). The net profit per buffalo per day was higher in winter season and lowest in summer season in case of small herd size groups in Hisar district. Kumar

Figs 1–2. **1.** A women farmer overseeing treatment of her buffalo during an infertility camp organized by CIRB, Hisar **2.** A women milking her buffalo.

(2004) calculated cost of milk production from buffaloes to be ₹ 11.01–17.47 with ₹ 29,190 (landless) to ₹ 3 09, 643 (large) as average net family returns per farm household in the irrigated zone and ₹ 24,069 (landless) to ₹ 1, 45, 809 (large) in the rain fed zone across the state of Haryana.

Haryana, the home state to the better breeds of buffalo – Murrah, has very high number of farmers practicing mixed farming with buffaloes. The number of buffaloes per thousand households in rural parts of the state is 1,778, which is more than three times the corresponding national value (Table 1). This makes buffaloes the backbone of the rural economy and dairy industry in the state, as is also as indicated by contribution of more than 75% in terms of milk production in the state. Table 1 gives more details of the statistical account of buffaloes in the state.

Status of milk production in Uttar Pradesh, Haryana, Punjab, Rajasthan and Gujarat

The 5 Indian states – Uttar Pradesh, Haryana and Punjab in the north and Rajasthan and Gujarat in west represent 31.6% of India's total population and 26.6% of total geographical area of the country.

The five states viz. Uttar Pradesh, Haryana, Punjab, Rajasthan and Gujrat are among the top milk producing states contributing 48.6% to total milk production of India. As per the NDDB report (http: //www.nddb.org/information/stats/milkprodstate), these five states are producing more than 64 million tonnes of milk in 2012–13 (Fig. 3) and are the states where buffaloes form major livestock/dairy animal (Fig. 4). All these states together produce almost half (48.6%) of country's milk production with UP contributing highest at 17.6% owing to the largest share of buffalo population. Probably the agroclimatic conditions and preference for buffalo products are the driving force for continuously increasing buffalo population in these states. When the average land holding of farmers across the county are dwindling, buffalo husbandry is providing additional source of income to the owners.

Table 3. Population and area of proposed states for the study

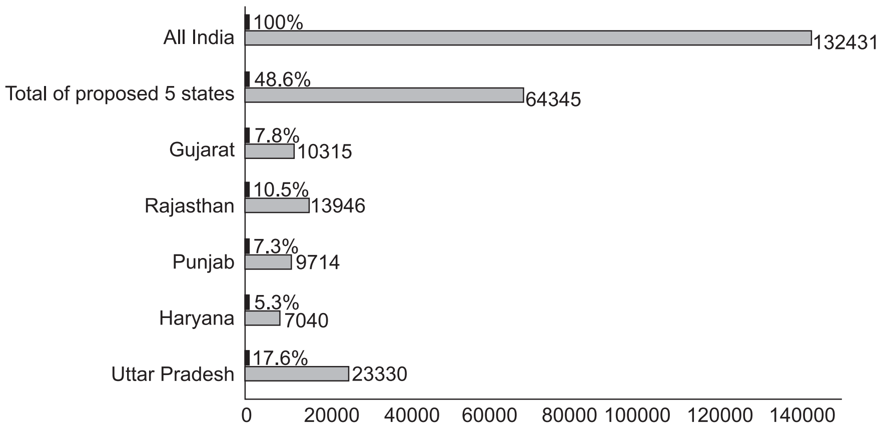
State	Population (2011 census)	% of India total population	Geographical area (Sq. km)	% of total India Geo. area
Uttar Pradesh	199,581,477	16.5	240,928	7.3
Haryana	25,753,081	2.1	44,212	1.3
Punjab	27,704,236	2.3	50,362	1.5
Rajasthan	68,621,012	5.7	342,239	10.4
Gujarat	60,383,628	5.0	196,024	6.0
Total of 5 states	38,20,43,434	31.6	8,73,765	26.6
All India	1,210,193,422	100.0	3,287,240	100.0

Role of buffaloes in climate change

As per Govt of India, Ministry of Environment and Forests (MOEF) reports, buffaloes produce from 9.8 to 54.40 kg/head/year of methane equaling 205.8 to 1142.4 carbon dioxide equivalents per head per year (Table 4).

Table 4. Country specific coefficents, published by Minsitry of Environment and Forests (MOEF) 2004, Govt. of India (in kg/animal/year)

Category of buffalo	CH_4 enteric fermentation	Manure management	Total CH_4	Total CH_4 as CO_2 equivalent
<1yr	8.00	1.80	9.80	205.8
1-3 yrs	22.00	3.40	25.40	533.4
> 3 yrs	44.00	4.00	48.00	1008
Dairy	50.00	4.40	54.40	1142.4
Average	31.00	3.40	34.40	722.4



	Uttar Pradesh	Haryana	Punjab	Rajasthan	Gujarat	Total of proposed 5 states	All India
■ % share of All India milk production	17.6	5.3	7.3	10.5	7.8	48.6	100
■ Milk production (×1000 tonnes)	23,330	7,040	9,714	13,946	10,315	64,345	132,431

Fig. 3. Status of milk production in Uttar Pradesh, Haryana, Punjab, Rajasthan and Gujarat.
Source: 19th Livestock Census-2012 All India Report

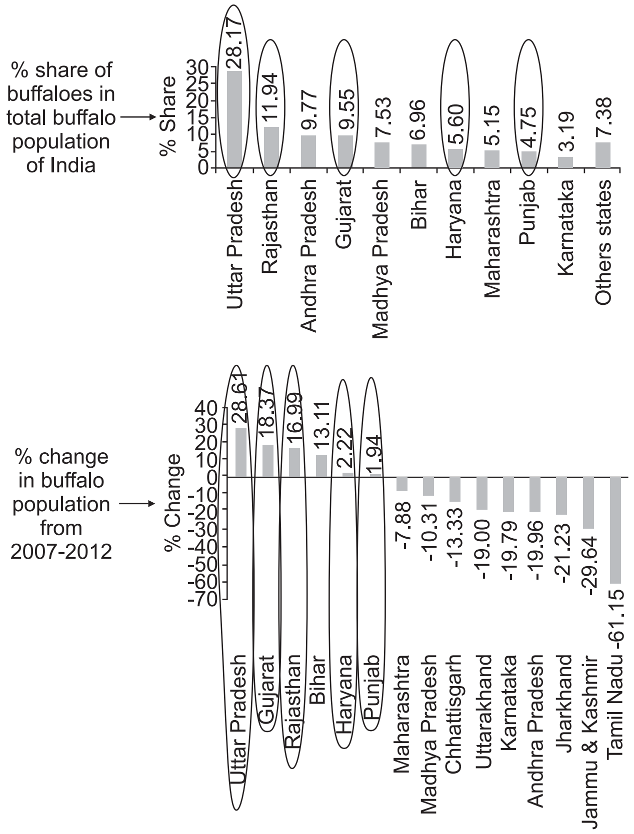


Fig. 4. Share and variations in buffalo population in Indian states.

Extrapolating this data with population of buffaloes in states suggest that the buffaloes are emitting 4.34 MT of carbon dioxide equivalents (CO_2e per year) which form a major portion of the GHG emissions in these states (Table 5).

Remarks and explanation: Carbon dioxide equivalent" or "CO_2e" is a term for describing different greenhouse gases in a common unit. For any quantity and type of greenhouse gas, CO_2e signifies the amount of CO_2 which would have the equivalent global warming impact. A quantity of GHG can be expressed as CO_2e by multiplying the amount of the GHG by its GWP. E.g. if 1kg of methane is emitted, this can be expressed as 25 kg of CO_2e (1kg CH4 × 21 = 21 kg CO_2e).

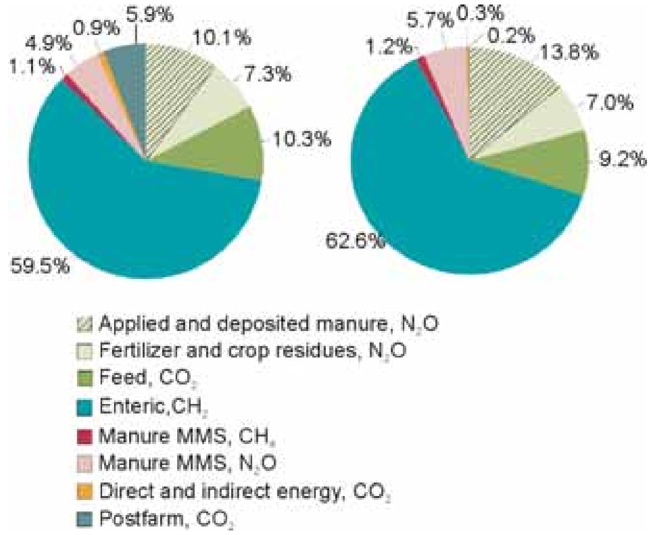


Fig. 5. Relative contribution of different process to GHG emission profile of (a) buffalo milk and (b) meat production (Adopted from Opio *et al.* 2013).

There are several procedures in buffalo farming which contribute to GHG emissions into the environment. Enteric methane emissions alone accounts for more than 60% of total methane produced from buffaloes (Fig. 5). Chhabra *et al*. (2013) concluded that the total methane emission (including emissions from enteric fermentation and manure management) from Indian livestock was 11.75 Tg/year for the year 2003 - approximately 91% (or 10.65 Tg) as enteric fermentation and 9% (or 1.09 Tg) as manure management. The paper also concludes that the cattle and buffalo are the major source of CH_4 emission (10.9 Tg), as compared to 0.86 Tg emissions from other livestock. Buffaloes overall contribute more than 40% to total methane emissions, although as compared to cow, their population is

Table 5. State wise estimates of contributions of buffaloes towards GHG emissions

State	Livestock population (millions)			Contribution of buffloes in state's enteric fermentation methane (Tg/year)	Contribution of buffloes in state's manure management emission (Mt/year)	Contribution of buffloes in state's total methane emission	Contribution of buffloes in state's CO_2 equivalent
	Total (Tg/year)	Buffalo emission (Tg/year)	% of total methane emission				
Uttar Pradesh	68.71	30.62	44.6	0.95	0.10	1.05	22.12
Haryana	8.81	6.08	69	0.19	0.02	0.21	4.39
Punjab	8.11	5.15	63.5	0.16	0.02	0.18	3.72
Rajasthan	57.73	12.97	22.5	0.4	0.04	0.45	9.37
Gujarat	27.12	10.4	38.3	0.32	0.03	0.36	7.51
Total of 5 states	170.48	65.22	38.3	2.02	0.21	2.24	47.11
All India	512.06	108.7	21.2	3.37	0.37	3.73	78.52

(Own calculations based on 19th livestock of India and country specific coefficients for methane emissions; MOEF 2004, Govt. of India).

comparatively less. Uttar Pradesh is the highest methne emitting state adding roughly 15% to India's methane emissions.

As per 19th All India Livestock census 2012, buffaloes alone in the country are adding 3.73 Tg of methane annually (Table 4) with five states - Uttar Pradesh, Haryana, Punjab, Rajasthan and Gujarat together emitting more than 47 million tonnes of carbon dioxide equivalent emissions per year (conducted in 2012). Roughly, the buffaloes contribute more than 40% to total methane emissions in these states. In sates of Haryana and Punjab, buffaloes are major source of methane as these states have more than 60% of their livestock as buffaloes.

Future climatic trends in India

Overall, there seems to be change in all-important climatic variables, which is likely to, more serious with intensification of buffalo farming along with increased demand for buffalo milk and meat products. Trends point towards erratic rainfall and environmental temperatures in important buffalo populated areas. The trends reveal that mean daily temperature is increasing across all states with predicted rise of about 2–4°C by 2050's (Fig. 6). Further, there is increase in precipitation in some states in months that usually do not get rains in India. This will increase incidences of floods and draughts, which will severely, affect the livestock. Trends in annual mean temperature for the period 1951–2010 represent a mix of increase, decrease or no change in different parts of the country - UP and Haryana no trends, decease in Punjab and increase in Gujarat and Rajasthan. The annual rainfall in UP and Punjab had declined and increased in Haryana, Gujarat and Rajasthan.

Most Indian states have extreme type of climate- very hot to very cold during some period in the year and receive rainfall mostly in monsoon season. Analysis of meteorological data for last century (1901–2010) for northern (UP, Haryana and Punjab) and north-western states (Gujarat and Rajasthan) harbouring most buffalo population reveals some very interesting facts (Table 6). The mean daily maximum temperature varied from 19.7 to 41.2°C and means daily minimum temperature varied from 5.8 to 27.8°C while the mean annual precipitation (abbreviated as Ppt. in Table) varied from a very low of 1 mm in Gujarat to a high of 307 mm in UP. From the trend analysis, it is quite visible that in most areas, the mean daily minimum temperature is rising and annual precipitation is on the decline – indicating accumulation of adverse weather condition in these areas. The frequency of extreme weather events – heat and cold waves, across states has increased during the last part of last century (1978–99).

As per the State Actions Plans on climate change (2014, MoEF, Government of India), projected annual changes in mean daily temperature (maximum and minimum both) and precipitation have been estimated to rise in the current century (Table 7). The changes are very much likely to occur in north India (UP, Haryana and Punjab) where buffaloes form main component of dairy animals and hence more likely to be affected.

Projected buffalo methane emission vis-à-vis climate change in India

Buffaloes are increasingly preferred livestock species in India due to rising demand of its milk and meat. A likely increase of ~18% is expected in buffalo population by 2023 (Chhabra *et al.* 2013, Fig 7). As discussed earlier, the buffalo

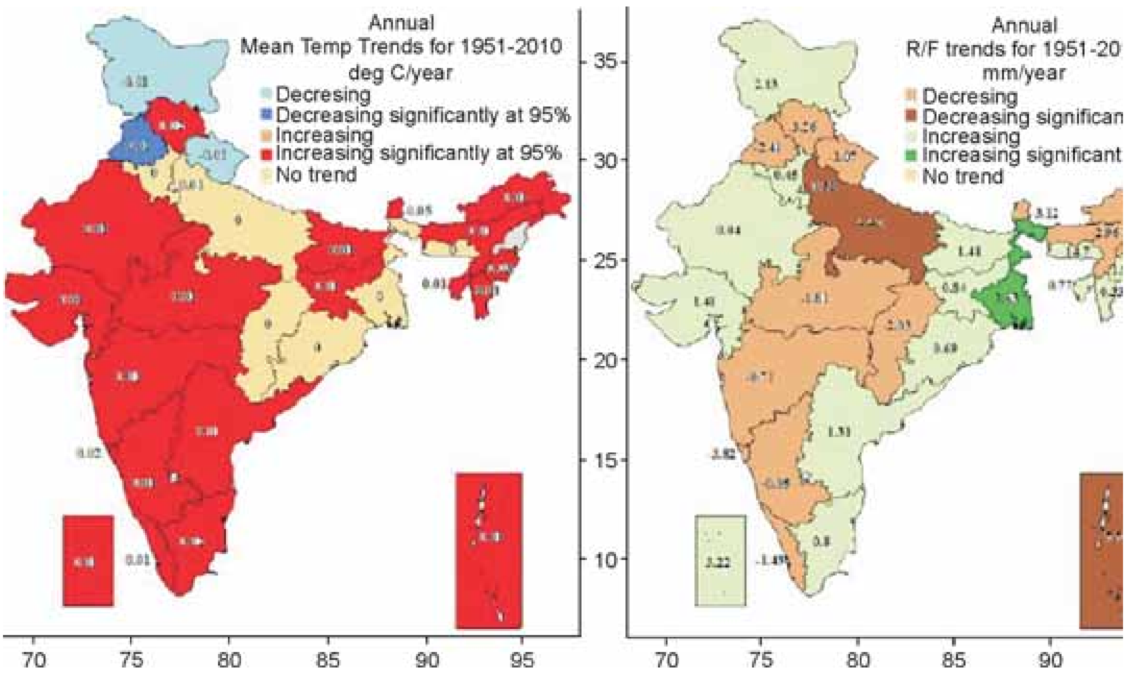


Fig. 6. All India annual mean temperature and rainfall trends for the period 1951–2010.
Source: IMD, 2013.

Table 6. Summary of climatic parameters – mean values, trends, extreme weather events and future projections

State	Annual mean values[1] (for 1901-2010)			Annual trends [2] (for 1951-2010) ('+' for increase; '-' for decrease)			Extreme weather events[3] (for 1901-1999) Number heat waves (number cold waves)			
	Mean daily Temp. (°C) (range)		Ppt. (mm/year) (range)	Mean daily temp (°C per year)		Ppt. (mm per year)	1901-10	1911-67	1968-77	1978-99
	Max.	Min.		Max.	Min.					
Uttar Pradesh (UP)	31.2 (21.6– 39.9)	18.7 (8.3–27.0)	72.6 (3.9–307.0)	No trend	No trend	– 4.42	– (21)	27(51)	3 (8)	42 (47)
Haryana	32.6 (21.3–41.2)	17.7 (5.8–27.8)	40.9 (3.2–133.1)	–0.02	+0.01	+0.45	– (–)	– (–)	1 (4)	2 (15)
Punjab	31.2 (19.7–40.7)	17.4 (6.2–27.1)	58.2 (5.4–200.2)	–0.01	–0.01	– 2.41	– (3)	– (34)	1 (4)	– (19)
Rajasthan	31.9 (22.4–40.3)	18.7 (8.2–27.5)	52.4 (3.0–214.0)	+0.01	+0.01	+0.04	– (11)	43 (124)	1 (7)	7 (53)
Gujarat	33.9 (27.1–39.6)	19.5 (8.8–27.1)	31.1 (1.0–125.7)	+0.01	+0.02	–0.01	– (2)	– (85)	2 (6)	– (6)

[1]Based on monthly mean maximum and minimum temperature and total rainfall based upon 1901–2000 data. retrieved from http://www.imd.gov.in/doc/climateimp.pdf for stations: Bareilly (UP), Hisar (Haryana), Ludhiana (Punjab), Jaipur (Rajasthan) and Bhuj (Gujarat). [2] Based on Meteorological monograph no. Esso/imd/emrc/02/2013- State level climate change trends. India Meteorological Department (IMD), Earth System Science Organization, Ministry of Earth Sciences, Government of India. [3] Based on De *et al.* (2005).

population registered major growth in North and Western India especially in UP, Haryana, Punjab, Rajasthan and Gujarat. With improved productivity from animals, GHG emissions per unit of animal produce will also increase. Based on the non-linear population trends, Chhabra *et al.* (2013) predicted that while the methane emission from cattle may decrease by 4%, there is likely to be sharp increase of ~40% increase in methane emissions from buffaloes by the year 2023. A growth in population in this scenario will make buffaloes more and more relevant for addressing climate change. Therefore any policy aimed at reducing GHG emissions is not complete with addressing methane emissions from buffaloes.

Predicted adverse effects of climate change on buffalo production

The anticipated rise in temperature between 2.3 and 4.8°C over the entire country together with increased precipitation resulting from climate change is likely to aggravate the heat stress in dairy animals, adversely affecting their productive and reproductive performance, and hence reducing the total area where high yielding dairy animals can be economically reared (Sirohi and Michaelowa 2007). In fact, the impact of adverse climate change events will be huge on the low-income small farming enterprises in India.

Upadhyay *et al.* (2013) have made future projections related to climate change and its likely effects on the milk

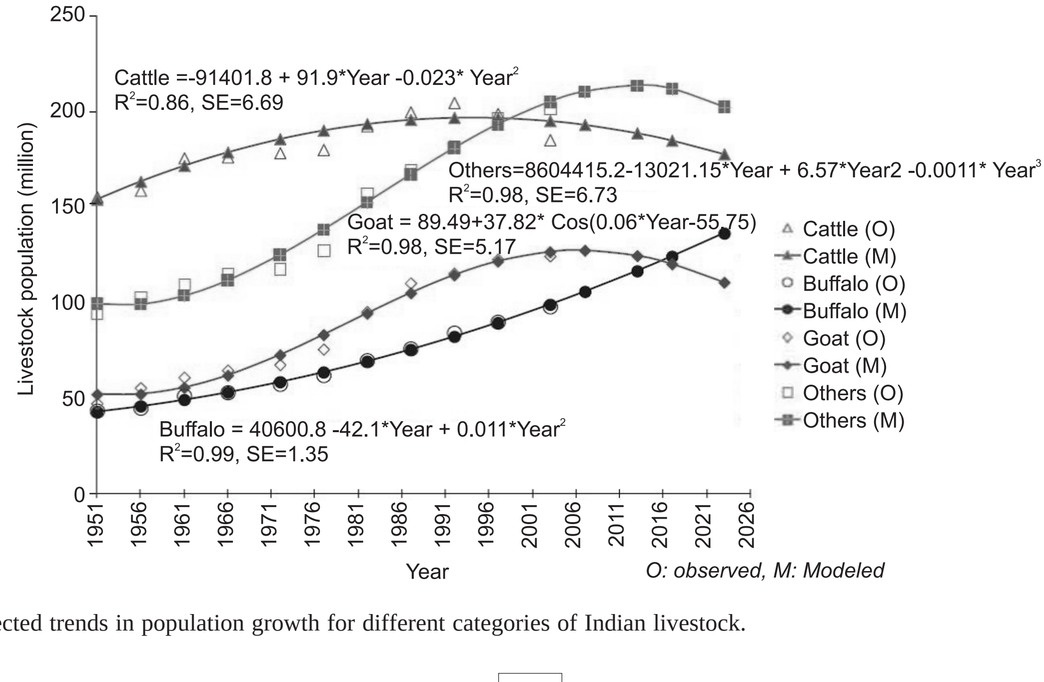


Fig. 7. Projected trends in population growth for different categories of Indian livestock.

Table 7. Future projections of changes in mean daily temp (°C) and precipitation

State	Projected annual change *('+' for increase; '-' for decrease)		
	Change in mean daily temp (°C)		% Change in precipitation
	Max.	Min.	
Uttar Pradesh (UP)	+2.1 post- and +1.8 pre-monsoon (2050's); +5.3 post and +4.5 pre-monsoon (2080's)	+ 2.3 post- and +2.5 pre-monsoon (2050's); +5.0 post and +5.3 pre-monsoon (2080's)	+15 to 20 (2050); +25 to 35 (2080)
Haryana	+1.3 (by 2050); +4.2 (by 2100)	+2.1 (by 2050); +4.7 (by 2100)	- 03.1 (by 2050); +16.6 (by 2100)
Punjab	+1.0 to 1.8 (by 2050); +4.0 to 4.4 (by 2100)	+1.9 to 2.1 (by 2050); +4.4 to 5.1 (by 2100)	+11.5 to + 20.8 (by 2050); Maximum increase predicted in non-monsoon season due to which chances of extreme weather conditions will also increase
Rajasthan	+2.0 to +2.5 (by 2050); +2.0 to -4.0 (by 2100)	Not mentioned but it is most likely that increase will be more in mean min. daily temperature as compared to mean max daily temp.	No significant change predicted except that the occurrences of floods and draughts will increase
Gujarat	+1.5 to +2.5 (by 2030)	+1.0 to + 4.0 (by 2030)	+6 to 8 (by 2030)

production in India. A projected temperature rise of 2–6 °C over existing temperatures for time slice 2070–2099 will adversely affect both milk production and reproductive functions. The negative impact of temperature rise on total milk production for India has been estimated about 1.6 million tonnes in 2020 and more than 15 million tonnes in 2050. Moreover, losses will be higher in Northern India for this period. Table 8 enumerates general effects of climate change likely to happen in buffalo production.

Buffaloes have higher sensitivity to heat due to their thick black skin, deep situated sparsely placed sweat glands and sparse body hairs. Heat dissipation from body is an energy demanding procedure, which accompanied by physiological responses, increase in surface temperature and sweating rate. A large portion of the available energy from food will be wasted in heat dissipation. Therefore, maintenance of thermal balance during climate change scenario during summer or hot-humid conditions will affect animal functions and productivity negatively.

Upadhyay *et al*. (2013) have made following observations on the adverse effects of climate change on buffalo production.

Milk production: Sudden changes in temperature, either a rise in Tmax during summer, i.e. heat wave, or a fall in T_{min} during winter, i.e. cold wave; cause a decline in milk yield. Both increase in T_{max} (>4°C above normal) during summer and decline in T_{min} (>3°C than normal) during winter negatively affect milk production. The decline in yield varies from 10–30% in first lactation and 5–20% in second and third lactation. The extent of decline in milk yield occurs less at mid lactation stage than either late or early stage. The negative impact of cold wave or heat wave on milk yield of buffaloes are not only observed on next day of extreme event but also on the subsequent day(s),

Table 8. General effects of climate change on buffalo production and natural resources

Effect of climate change	Effect on the buffalo production system	Impact on natural resources
Higher number of stressful days (THI more than 80) and increase in frequency of warm days High temperature	Higher water requirement - higher water use for animal intake and maintenance - For feed and fodder production - For cooling artificially by sprinklers /increasing wind velocity/air movement to sustain milk production	Water scarcity
Lesser area on pastures Less feed and fodder	Lesser fodder- lesser nutrition- lesser production	Fodder scarcity, soil erosion
Natural disasters- draughts and floods	Lesser fodder and migration to other areas	
Conditions favourable for disease causing organisms, pests and vectors	Higher incidence of disease occurrence- higher cost of production and maintenance of animals	Soil and water a pollution due to use vectors; food contamination due of antibiotics, insecticides and pesticides

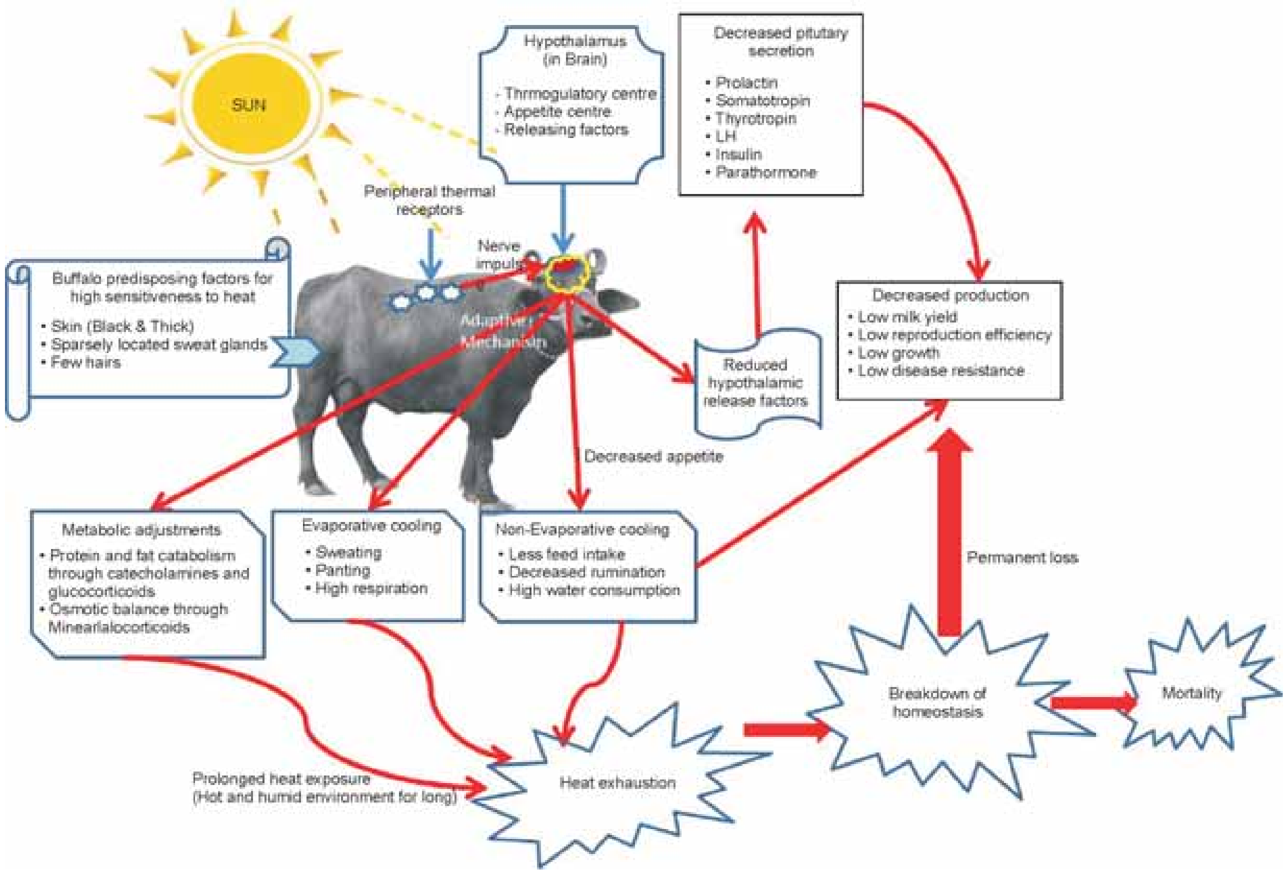


Fig. 8. Physiological responses in buffalo in response to heat stress.

thereby indicating that heat and cold waves cause short to long term cumulative effect on milk yield and production in cattle and buffaloes. Depending on stage of lactation, the return to normal milk yield takes 2–5 days normally after a shock (heat/cold) wave. The decline in milk yield and return to normal after an extreme event was also influenced by subsequent day(s) Tmax and Tmin.

Animal growth and reproduction: The rise in temperature negatively impact growth and time to attain puberty; negative impact of THI rise on animals growing at higher rates will be more than slow growing. A change in temperature with changes in photoperiodicity could lead to reproductive malfunctioning due to hormonal events mediated through pineal-hypothalamo-hypophysealgonadal axis. Hot dry summers with limited access to water affect buffaloes' estrus expressions particularly from March to June, when these animals have relatively non-functional gonads with less number of sperms in semen of males and poor expression of estrus in females- mainly due to higher thermal heat loads that animals are unable to dissipate.

Physiological responses and functions: When THI exceeds 80 during summer and hot-humid conditions, there is an increase in body heat storage beyond its capacity to tolerate heat in buffaloes. This adversely affects all physiological functions in the body. Fig. 8 summarizes the physiological mechanism of heat dissipation in buffaloes. Briefly, the stimulus in form of sunlight activates peripheral thermal receptors, which activate hypothamus for activating thermoregulatory centre, appetite centre and releasing factors in blood. Adaptive mechanism to heat works through metabolic adjustments, evaporative cooling, non-evaporative cooling and reducing hypothalamic release – which causes reduction in production through various hormones. Prolonged heat period severely affects the body homeostasis and can even cause death of the animal.

Animal diseases: Elevated temperature and humidity will favour spread and growth of insects/vectors. Incidences of diseases affecting buffaloes will spread in susceptible population. Frequency of diseases like FMD, HS and tick fever are most likely to higher due to climate change.

CONCLUSION

Buffaloes are the mainstay of Indian dairy livestock. This species has a major role in the rural livelihood in all major milk producing states of India and contributes to food security of rural masses. Available data on various parameters indicate the buffalo farming is highly vulnerable to climate change and can thus pose a challenge to the food security in country. Most commonly in India, farmers feed their animals, based on their traditional knowledge with crop residues, locally available one or two feed ingredients like brans, oil-cakes, chunnies, grains etc. and seasonally available green fodders with some offer some amounts of mineral mixture. In most of the cases, the quantity of feed/

fodder offered to animals is either more or less than the requirements leading to an imbalance of protein, energy and minerals in their ration. Ruminants like buffaloes maintained on such imbalanced ration cause high production of enteric methane due to incomplete feed digestion because of low feed conversion efficiency and also causing loss of nutrients leading to lower milk production, poor health and fertility of animals. The farmers need to inculcate scientific techniques to make their buffalo based dairy climate resilient and sustainable. Improved feeding practices like ration balancing can significantly reduce CH_4 production in buffaloes through reduction of gross energy loss of feeds. Issues related to fodder availability, shelter and dung management, optimum use of water resources have to be addressed and included in polices on dairy farming. Environmentalists, policy makers, agriculturists and society have to act in urgency to achieve this.

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