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Impact of climate change (heat stress) on livestock: adaptation and mitigation strategies for sustainable production

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ABSTRACT

It is reported sporadically in different countries of the world including India that climate change has adverse effect on livestock productivity, particularly on milk production and growth which is reflected in meat production indirectly. Climate Change poses formidable challenge to the development of livestock sector in India. The rise in temperature between 2 to 3 °C over the entire country together with increased humidity resulting from climate change is likely to aggravate the heat stress in dairy animals resulting in reduced growth and milk production. Quantification of these potential impacts of climate on livestock production allows producers to gain a better understanding of the magnitude of the changes in production levels and potential indicators of livestock response, on which managemental actions depend. Economic losses resulting from temperature-induced reductions in production may justify adaptation and mitigation of adverse impact of climate change on animal. So in this paper impact of climate change on feed intake, production, reproduction, physiology, disease occurrence in livestock, poultry etc were discussed. Moreover different adaptive and mitigation measures were discussed to reduce adverse negative effect of climate change for sustainable livestock production.

Key words: Adaptation, Climate Change, Impact, Mitigation, Production.

Livestock is an integral part of agriculture in India as most of the people due to multifarious reasons depend on the livestock for their economic support. Due to rapid growth of human population, demand for milk and meat is increasing day by day. India possesses second largest number of cattle next to Brazil (13 % of world population), largest number of buffaloes (56 % of world population) in the world (FAO, 2014). St-Pierre *et al.* (2003) estimated a total economic annual loss incurred by the US farm animals due to heat stress between 1.69 to 2.36 billion US dollars. About 58 % of this occurs in the dairy industry, 20 % in the beef industry, 15 % in pigs and the remaining 7 % in the poultry industry.

Domestic animals are homoeothermic which means that they must maintain their body temperature within a relatively narrow zone to remain healthy and productive. The ambient temperature above or below thermo neutral zone produces stress to the animal which ultimately hampers production, reproduction and growth. Four environmental factors which influence effective temperature are: 1) air temperature, 2) relative humidity, 3) air movement and 4) solar radiation. The temperature-humidity index (THI) is used commonly to indicate the degree of stress on dairy cattle. When the THI exceeds 74, high producing dairy cows are affected adversely.

Dairy cows respond to heat stress in several ways: 1) reduced feed intake, 2) increased water intake, 3) changed metabolic rate and maintenance requirements, 4) increased evaporative water loss, 5)increased respiration rate, 6) changed blood hormone profile and 7) increased body temperature. European-type cattle are considered to be comfortable in the temperature range of 5 to 20° C, i.e. within this zone there is no heat stress problem. Body temperature is maintained with a minimum expenditure of energy, thus leaving a maximum portion of energy for productive processes. With increasing environmental heat load caused by high temperature, intensive solar radiation, high humidity, low air movement or a combination of several of these factors, defense mechanisms against overheating - sweating and panting come into operation. If cooling derived from these activities is insufficient, body temperature rises. This depresses appetite, which in turn reduces meat and milk production.

IMPACT OF CLIMATE CHANGE ON LIVESTOCK PRODUCTION

Impact on growth and milk yield: Livestock Weather Safety Index (LWSI) was developed to classify the combined intensity of temperature and humidity into four categories of THI values: THI less than or equal to 74 is Normal, THI 75–78 is Alert, THI 79–83 is Danger and THI value 84 and above is Emergency condition (Eigenberg *et al*, 2007). Experience over time suggested that the THI-based LWSI was a valuable tool for producers, even though it lacked

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recognition of the effects of thermal radiation and wind speed. Warnings, with respect to these categories, were issued by the United States Weather Bureau to alert producers to potential heat stress conditions (Nienbar and Hann, 1998).

Berman (2005) determined environmental threshold temperatures for dairy cows based on environmental factors and characteristics of the cows. Environmental factors included temperature, humidity, wind speed and direction, while cow characteristics included body weight, milk production level and hair coat colour. The threshold temperatures signaled when environmental intervention should begin in order to limit production loss. The ability to withstand heat varies considerably. Heat tolerance is low in young animals, in animals that are on a low level of feeding, in dehydrated, in high producing, and in non-acclimatized animals. It is also low in European-type cattle as compared with Indian type cattle. At a temperature of 29° C and 40 % relative humidity the milk yield of Holstein, Jersey and Brown Swiss cows was 93, 97, and 98 % of normal, but when relative humidity was increased to 90 %, yields were 69, 75, and 83 % of normal respectively.

Hahn (1999) reported the thermal comfort zone for optimum performance of adult cattle was 5 - 15°C. However, no significant changes in feed intake and physiological processes were observed even upto 25°C. However Dutt *et al*, (1992) reported that in Indian condition upper temperature limit of comfort zone for maximum milk yield was 27°C, about 2°C higher than the same reported in temperate countries. This was due to adaptation of crossbred cows developed through crossing between indigenous cows with exotic bulls of Jersey, Brown Swiss and Holstein Friesian breed. Studies have shown that milk yield of crossbred cows were negatively correlated with THI (Mandal *et al*, 2002a). The average daily milk yield of crossbred cows in the hot humid eastern part of the country was significantly reduced by rise of minimum temperature as rise in minimum temperature crossed the zone of thermo neutrality in cow (Kale and Basu, 1993).

It was observed that dry matter intake in cattle was declined with the increase of maximum temperature (T max), temperature humidity index (THI) during hot summer and hot humid rainy season (Upadhaya *et al*, 2007). This was due to negative effect of high temperature on the appetite centre of hypothalamus.The influence of climatic conditions on milk production has also been observed in Haryana cows. The rising temperature decreased dry matter intake and milk yield (Lal *et al*, 1987). The milk yield of Sahiwal cows also exhibited declining trend due to increase in temperature and relative humidity (Mandal *et al*, 2002b). It was also reported that growth rate of crossbred cattle and buffaloes is more sensitive to rise in THI than Zebu cattle. Time to attain puberty was observed to prolong by 5-17 days due to decline in growth rate at high temperature.

Multiple regression analysis between the different micro climatological parameters and milk yield of cows maintained at divisional farm of the institute (ICAR Research Complex for Eastern Region, Patna) were done. It was observed that air temperature (AT), effective temperature (ET), temperature humidity index (THI) significantly ($P< 0.01$) effect average daily milk yield, average weekly milk yield, average monthly milk yield, daily total milk yield of cows. However, relative humidity had highly significant ($P < 0.01$) effect on average weekly milk yield and average monthly milk yield of cow. It was found that average daily milk yield, average weekly milk yield, average monthly milk yield, daily total milk yield of cows were reduced significantly ($P < 0.05$) by 0.886, 1.868, 2.471 and 4.375 kg respectively per unit increase of THI (Das, 2012). It was also observed that average weekly milk yield and average monthly milk yield were decreased significantly ($P < 0.05$) by 0.062 and 0.069 kg respectively per % rise of relative humidity.

Impact on physiological responses: A significant effect due to the change of the micro climatological components on various cardinal physiological reactions i.e.rectal temperature, respiration rate and pulse rate of growing calves in different months was reported by Das, 2012. Overall mean rectal temperature, respiration rate and pulse rate during the period of study were 101.88 0F ± 0.07, 30.74 ± 1.11 and 71.03 ± 1.02 respectivelyRegression analysis revealed that AT and RH had significant ($P < 0.05$) effect but THI and ET had highly significant ($P<0.01$) effect on the rectal temperature of calves. All the micro climatological components had highly significant ($P<0.01$) effect on respiration rate. It was also observed that rectal temperature and respiration rate were increased significantly ($P < 0.05$) per unit increase of AT, RH and THI (Das, 2012).

Impact on animal reproduction: It is reported that the heat stress reduces length and intensity of estrous period therefore less conception rate occurs. So heat stress may reduce the fertility of dairy cows in summer by poor expression of behavioural signs of oestrus due to a reduced estradiol secretion from the dominant follicle. In these situations the calving interval becomes longer. So lifetime production of dairy animal comes down. Heat stress during pregnancy slows down growth of the foetus due to decreased blood supply to the uterus which causes placental insufficiency to provide maternal nutrient, so leads to decreased fetal growth and calf size. Even there is early embryonic death in cows exposed to heat stress. Heat stress also leads to reduced seminal volume and sperm concentration. It is reported that ejaculate volume, concentration of spermatozoa and sperm motility in bulls are lower in summer than in winter season (Samal, 2013).

Impact on egg and meat production in poultry: The thermoregulation characteristics of poultry differ to some

extent from those of mammals due to their high rate of metabolism associated with more intensive heat production and low heat dissipation capacity caused by their feathers and lack of sweat glands. Above 30°C the feed and energy intake declines to such an extent that birds are no more able to compensate for it, production declines rapidly and the rate of mortality increases. Several studies reported that high ambient temperatures decrease the digestibility of nutrients in poultry which might be due to reduced activity of trypsin, chymotrypsin, and amylase (Hai *et al*., 2000). Consequently, the lower and by most insufficient nutrient supply limits egg production , egg mass and shell quality of egg in layers, and the growth rate in broilers.

Impact on feed and fodder production: Shortage of feed and fodder to the tune of 40 % dry fodder, 36 % green fodder and 52 % concentrate on dry matter basis and poor quality roughage, primarily crop residues, is already one of the major constraints in expression of full genetic potential in livestock production in India. Higher temperatures increase lignin formation in plant tissues and thereby reduce the digestibility and rates of degradation of fodder and crop residues in the ruminants (Deinem *et al*, 1968). This will lead to reduced nutrient availability for animals and ultimately to a reduction in livestock production. So, in view of this situation of feed and fodder availability the adverse impact of climate change on crop production will further increase the gap between availability and requirement of feed and fodder.

Impact on disease incidence: It is reported that increased milk somatic cell counts and a high incidence of clinical mastitis in dairy cattle occur during hot summer months. Reduction of thermal stress by air conditioning or shade management resulted in a lower frequency of clinical mastitis in cows than those exposed to their natural environments. Singh *et al*. (1996) reported higher incidence of clinical mastitis in dairy animals during hot and humid weather due to increased heat stress and greater fly population associated with hot–humid conditions. Kumar *et al.* (2004) reported that the hot–humid weather conditions were found to aggravate the infestation of cattle ticks like, *Boophilus microplus*, *Haemaphysalis bispinosa* and *Hyalomma anatolicum* which act as vector for various protozoan diseases.

ADAPTATION AND MITIGATION MEASURES

Adaptation by housing and management: Adaptation with reference to climate change is referred to as adjustment of natural, human or livestock systems to new or changing environment which moderates harm or uses beneficial opportunities. Adaptation can reduce the current risks of climate change impacts and can be used for addressing emerging risks. Dairy cattle production in hot climates may be improved in two ways: (1) by adapting the animal to the climate through selection, breeding and acclimatization; (2) by adapting the climate to the animal by providing protective structures and cooling devices**.**

The first way poses a biological, the second a technical problem. For the solution of both these problems it is important to know the qualitative and quantitative responses of the animal to various degrees of heat stress. Promoting indigenous breeds for rearing is another way of adaptation as indigenous breeds of animal are more heat tolerant than cross bred and exotic breeds. It was observed that adverse effect of heat stress such as reduction of milk yield was found to be least in indigenous cattle ie Sahiwal and Deoni in comparison to Jersey and Red Sindhi crosses.

Livestock management, in reality, is the manipulation of the animal environment to promote the most efficient production of meat, milk and wool. A better understanding of climatological stress and adaptations will greatly enhance managerial capabilities (Stott, 1981). Several management practices are available to ameliorate heat stress, each with positive and negative properties. Housing provides the most potential control over environmental stressors; however, it comes at a relatively high initial investment cost per head.

Shed for livestock is considered essential to minimize loss in milk production and reproductive efficiency. Sheds can improve animal comfort and productivity and should be designed to maximize ventilation and protection from the solar load. It is reported that well designed shed would reduce heat load on animal around 30-40 %. The design and management of shed for dairy cattle vary in different areas and climates. A shed space of 60 square feet per animal is considered adequate. The larger space allotments provide more open area for ventilation, which is a critical factor in hot, humid climate. Extensive comparisons of shed materials and the impact of roof size and orientation of shed on the micro - climate of shade were studied by different workers (Armstrong, 1994). Hay is proved to be suitable low cost roofing material for cattle sheds. However, corrugated steel sheet is the most popular shade material because of its better durability and low maintenance requirements.

Das *et al.* (2015) observed in a study that orientation of cattle shed has significant effect on microclimate of shed and milk yield of crossbred cow in coastal region. Cattle sheds should be designed and orientated in such a way that the animals are exposed to a large proportion of the cool sky. The clear north sky acts as a cold sink. Hence, under an extremely hot, low rainfall (10 to 12 cm) climate, an east-west orientation is preferable as the ground under the shed will remain cooler. An orientation with the long axis north and south will expose the area under the shed to the morning and afternoon sun and assist in keeping it dry. So, this type of orientation of shed is suitable in sub temperate to temperate climate of hilly region. The height for cattle sheds would be 10 to 12 ft. The top of a shelter should be painted white, so as to reflect much of the incident solar radiation; the

underside should be painted black, so as to reduce the radiant heat reflected from the ground onto the animals (Bianca, 1964). Crops provide cooler surroundings for cattle shelter than bare ground. Tree plantation around the animal shed produces long term cooling effect on the animal.

Elimination of direct solar radiation is essential, since the radiated heat load imposed on an animal by the midday sun is several times greater than the metabolic heat generated by the animal. So reduction of indirect radiation to a minimum is needed to be achieved. This is achieved by the absence of objects, such as nearby buildings, heavy wooden fences etc, which absorb heat and radiate it onto the animals. False ceiling with low cost materials in the shed was proved in a study to reduce heat stress in cattle and buffalo (Das *et al.* 2015).

Minimal interference with convective and evaporative heat loss from the animals, i.e. allowing natural air movement to carry heat and moisture away from the surface of the animals is very important. Ventilation system within livestock housing is very important factor and greatly affects the initial investment, energy consumption and cooling capacity. Cross ventilation is highly desirable to reduce heat load in animal shelter. So, increasing air movement with fans in the cattle shed, help to increase animal comfort and milk production. Fan should be fitted in cattle house @ one fan / 25 sq meter of space at a height of 8 - 9 ft from the floor (Das *et al.* 2015).

Evaporative cooling systems have improved the environment for lactating dairy cows in arid climates. These systems use high pressure, ûne mist and large volumes of air to evaporate moisture and cool the air surrounding the cow. There are questions regarding the effectiveness of evaporative cooling systems in climates with high relative humidity because when relative humidity increases above 70 %, the potential reduction in THI is less than 10 % (Collier *et al*, 2006).

Foggers disperse a very fine droplet of water which quickly evaporates, cools the surrounding air and raising the relative humidity. The design incorporates a ring of fogger nozzles attached to the exhaust side of the fan. As fog droplets are emitted they are immediately dispersed into fan's air stream where they soon evaporate. Animals are cooled as the cooled air is blown over their body and as they inspire the cooled air. Fogger systems are most effective in areas of low humidity. They are advantageous in the fact that they use less water (3-5 gallons/cow/day). Water filters must be cleaned or checked daily to prevent clogging of fogger nozzles. High pressure foggers should be used only in open-sided, ridge-vented, long shed. Small shed with side walls restrict air flow and evaporation of fog droplet. This reduces cooling and makes for excessively wet conditions in the barn (Bucklin *et al*, 1991).

In mist cooling system mister cool the air by same principle as fogger, animals are cooled primarily by inspiration of the cooled air, but a mist droplet is larger than a fog droplet. This system does not work well in windy conditions. In warm humid environments mist droplets are too large to fully evaporate and set on the ground. The consequence is wet bedding and feed which are predisposing factors of various respiratory diseases. To achieve greater heat losses from animal surfaces, droplets of water must wet the hide, as it is the drying process from the animal's hide that removes heat from the animal. So, in a study it was observed that sprinkling of cold water on body surface of animal followed by air circulation by electric fans for an hour twice daily before milking was found to be very effective for reducing heat stress and increasing milk yield (Bucklin *et al*, 1991, Tuener *et al*, 1992).

Modern technology can easily provide fully air conditioned animal houses thereby completely eliminating any heat stress problem. However, the cost of milk and meat produced in such way would in most instances is high (Bianca, 1964). It was reported that air conditioning in dairy shed for 24 h / d improved milk yield by 9.6 % in a subtropical environment. However, workout on cost of milk production indicated that air conditioning was not economical. New possibilities for cooling animals should be explored. An example for this line of approach is the cooling of animals by applying cooled air on their head and neck, a method tried out successfully by American workers. It was reported that zone-cooled cows (cooled air blown over the head and neck) produced on an average 19 % more milk yield than controls, although other scientists reported that it was also not economical (Collier *et al*, 2006).

Cooling pond effectively reduces body temperature in dairy cows. The primary mode of heat loss in cooling pond is conduction with a small amount lost by evaporative cooling after exiting the pond. Water temperature of the pond would be lesser than skin temperature of cow, thus a heat transfer gradient between the cow's body and the pond water was operative. This is common practice of reducing heat stress in buffalo and is called as wallowing.

Availability of drinking water will eliminate the need for the animals to move into the sun for obtaining water. Moreover water should be available round the clock particularly in hot summer season. Handling of animals during peak temperature hours i.e. mid - day to late afternoon should be avoided to reduce heat stress.

Other species of domestic animals than cattle are faced with similar hot climate problems. They all benefit from an artificially cooled indoor climate. New ways should be sought for providing inexpensive hot climate shelters and for reducing the costs of artificial cooling, thus making environmental control an economically more efficient tool. A Livestock Safety Monitor (LSM) has been developed by

Eigenberg *et al*. (2007), to provide an early warning device to producers based on current weather conditions. The LSM uses current weather parameters of temperature, humidity, air speed and solar radiation to determine heat stress.

Adaptation by nutritional intervention

- Take feed to cows, rather than cows to feed in hot weather. Walking to feed increases a cow's heat load, so reduce their walking during the hottest time of the day.
- Allow cattle grazing at night time in hot weather. So, night grazing may be practised for 2-3 hours to fulfil nutrient requirement partially and have sufficient exercise for normal physiological function.
- Highly digestible high-energy rations are an effective form of summer diet to help animals to control body temperature by reduction of excess heat. Providing cool drinking water and a low fiber diet renders comfort to the animals (Beede and Collier, 1986).
- Bypass fat was proved in a study to reduce heat stress in cattle and buffalo around 18 - 20 % (Terada, 1996).
- Increase the concentration of minerals and vitamins in the diet to compensate for the reduction in feed intake, particularly sodium, potassium, magnesium and niacin levels in the diet. Supplementing cows with 1.5–1.6 % DM of potassium and 0.5–0.6 % DM of sodium will potentially improve milk yield in heat-stressed cows. Include magnesium at 0.35–0.4 % DM to help to avoid metabolic problems (grass tetany) when feeding higher amounts of potassium. Including niacin (6 g/cow/day) may also be beneficial. It has been reported to reduce skin temperature and increase milk yield (West, 2003).
- Improvement in milk yield has also been reported by feeding 150–200 g/cow/day of sodium bicarbonate during hot weather to help buffer the rumen.
- The use of antioxidants such as Vit. E, Vit. A and selenium helps in reducing the impact of heat stress by oxidant balance, resulting in improved reproductive efficiency and animal health (Sejian *et al*, 2014).

Adaptation by reproductive intervention

- Progesterone supplementation during early pregnancy has proven beneficial in some studies. Supplementation of exogenous progesterone during summer heat stress has the potential to improve fertility (Fuquay, 1981)
- Friedman *et al (*2011) reported that heat synchronization with GnRH and PGF2á also improves fertility.
- The use of embryo transfer technology (ETT) is considered a potential strategy for minimizing the negative effects of heat stress on bovine reproduction by way of heat synchronization and multiple ovulations (Baruselli *et al*, 2011).

CONTRIBUTION OF LIVESTOCK ON CLIMATE CHANGE

The animal production system, which is vulnerable to climate change, is itself a large contributor to global warming through emission of methane and nitrous oxide.There are two sources of green house gas emissions from livestock:(a) From the digestive process: Methane is produced in herbivores as a by-product of 'enteric fermentation,' a digestive process by which carbohydrates are broken down by micro-organisms into simple molecules in the gut of the animal for absorption into the bloodstream. (b) From animal wastes: Animal wastes contain organic compounds such as carbohydrates and proteins. During the decomposition of livestock wastes under moist, oxygen free (anaerobic) environments, the anaerobic bacteria transform the carbon to methane (Sirohi and Michaelowa, 2007).

Animal wastes also contain nitrogen in the form of various complex compounds. The microbial processes of nitrification and de-nitrification forms nitrous oxide, which is emitted to the atmosphere.India emerges as the largest contributor to the livestock methane budget, simply because of its enormous livestock population, although the emission rate per animal in the country was much lower than in the developed countries. For instance, the annual methane production per animal was estimated to be 95 kg for the dairy cows in Germany, nearly threefold higher than 35 kg for the Indian cattle (Crutzen *et al*. 1986). The default enteric fermentation emission factors for cattle recommended by Inter-Governmental Panel on Climate Change (IPCC, 2001) for national GHG inventories are also much higher for the developed countries compared to the Indian sub-continent.

The differences in per head emissions are due to lower level and poor quality of feed intake in India. Methane production in livestock is related to the level of intake and digestibility of feed. The livestock characteristics (age, weight and species), health and living conditions influence the energy requirement. Higher methane production results from higher energy requirement and feed intake. The energy requirement of Asian cattle species *Bos indicus* is about 10 % lower than European and North American cattle species *Bos taurus* (NRC, 1996). In Indian conditions the animals are mostly fed on poor quality roughages of low digestibility and emit less methane than exotic cattle of developed countries fed with highly digestible feed. The estimates of total enteric emissions from Indian livestock vary widely from 6.17 to 10.4 million tons / year (Sirohi and Michaelowa, 2007).

APPROACHES FOR MITIGATION

Several mitigation options are available for methane emissions from livestock. In India, the possibility of capturing or preventing emissions from animal manure storage is limited as it is extensively used as fuel in the form of dry dung cakes. Hence, the scope of decreasing methane from livestock largely lies in improving rumen fermentation efficiency.

There are a number of nutritional technologies for improvement in rumen efficiency like, diet manipulation, direct inhibitors, feed additives, propionate enhancers,

methane oxidisers, probiotics, defaunation and hormones (Sirohi and Michaelowa, 2007). Field experiments in India involving some of these options have shown encouraging results with reduction potential ranging from about 6 to 32%.

Dietary manipulation through increased green fodder decreased methane production by 5.7 % (Singhal and Mohini, 2002). There is lower methane production when higher amount of leguminous fodder is included in the diet due to lower crude fiber content, higher digestibility of leguminous fodder and the faster rate of passage through the digestive system (Indira and Srividya, 2012).

Methane emissions may be reduced by feeding more concentrate and reducing the intake of forage. Increasing the concentrate in the diet of animals reduced methane by 15 – 32 % depending on the level of concentrate in diet (Singh and Mohini, 1999). This is because the fraction of feed converted to methane decreases when feed quality improves (Garnett 2007). Feed conversion efficiency is improved when animals are fed concentrates and growth rate improves. They reach slaughter weight sooner resulting in fewer emissions. The methane mitigation by molasses urea supplementation was 8.7 % (Srivastava and Garg, 2002). Methane production tends to be lower when forages are ensiled than when they are dried. It means that making silage of fodder enhances digestibility, so reduces methane production.

There are a number of feed additives that have been proposed for the reduction of methane emissions (Indira and Srividya, 2012). These are ionophores, antibiotics, halogenated compounds (condensed tannins, saponins or essential oils) and propionate precursors (fumarate and malate). Use of feed additives such as monensin could reduce methane emission by 21 % (De and Singh, 2001).Stimulation of propionate production could be the best alternative hydrogen sink to methane production in the rumen. Therefore a strategy for abatement of methane production should be considered with a strategy to enhance propionate production. Vaccines are being developed that contain an antigen derived from methanogenic bacteria and an immunogenic preparation that reduces the activity of rumen protozoa (Sejian *et al*, 2010). Bovine somatotropin (bST) and hormonal growth implants do not specifically suppress methane formation but improve the animal's performance and thereby reduce methane emissions (Garnett, 2007). In IVRI rumen manipulation was developed to improve fibre utilization and to reduce methane emission to the tune of 12 % in cross - bred calves and 25 % in buffalo.

Culling of unproductive animals as far as possible would reduce methane production. Reducing unproductive livestock numbers could be the best possible solution in countries where there are large livestock populations (513 million livestock in India) and who want to reduce their livestock related green house gas emissions (Indira and Srividya, 2012).

Enteric methane emission / kg dry matter intake has been observed to increase under severe heat. So, protection of animals from severe heat stress through proper housing and heat ameliorative measures will be effective in reducing methane emission.

In India major amount of dung of cattle and buffalo and all faecal material of all other livestock species is used as manure in agricultural fields which does not undergo much of anaerobic fermentation. Share of GHG emissions from manure management system was only 8 % of the global GHG emissions from manure management. Improvement in disposal of farm yard manure and its use for biogas production and use of biogas slurry in the field and in the pond as fish feed can reduce methane emission from manure. So, improved manure management ie biogas production would reduce methane emission.

CONCLUSION

Biometeorology has a key role in rational management to meet the challenges of thermal stress on livestock production systems. While the focus is primarily on cattle in warm or hot climates, the importance of dynamic animal responses to climatological changes applies to all species and climates.Animal housing and management is the high priority adaptation measure to minimize the effects of climate and climate change on livestock production. So climate resilient shed may be constructed at Govt. livestock farm for training and demonstration purpose. So, risk management, by considering perceived thermal challenges, then assessing the potential consequences and acting accordingly, will reduce the impact of climate changes.

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