IMPACT OF CLIMATE CHANGE ON DAIRY HUSBANDRY - A REVIEW

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INTRODUCTION

Weather and climate have been not stationary and have always been subjected to variability due to natural forces since the formation of earth. Human influence has contributed to the observed global scale changes in the frequency and intensity of daily temperature extremes since the mid-20th century. Latest report of the Intergovernmental Panel on Climate Change (IPCC), 2014 stated that the global average combined land and ocean surface temperature showed a warming of 0.85ºC [0.65 to 1.06ºC] over the period from 1880 to 2012. Impacts from climate-related extremes, like heat waves, floods, droughts, cyclones and wildfires, revealed significant vulnerability and exposure of some ecosystems to current climate variability over the world. Following the global trend, mean surface temperature over India has also risen over the past century and that rise was found to be around 0.6ºC (Chackancherry *et al*., 2017). Simulation model studies suggested that the rise was primarily anthropogenic as in the case of global scenario. It was predicted that continued emission of greenhouse gases would cause further warming and long-lasting changes in all components of the climate system, increasing the likelihood of severe, pervasive and irreversible impacts for people and ecosystems.

The climate change is expected to have severe impact on livestock production systems across the world. Global climate change could alter temperature and water availability affecting the productivity of crop and livestock systems (Hatfield *et al*., 2008). Environmental stress reduced the health and productivity of livestock resulting in significant economic losses. The outcomes included decreased growth, reduced reproduction, increased susceptibility to diseases and ultimately delayed initiation of lactation. Besides these physiological impacts, climate change may badly affect the geographically restricted rare breed populations and there is a high risk of these breeds being lost in localised disasters (Hoffmann, 2010). Rapid and unprecedented scale of changes in the livestock production systems by controlling production environment and animal genetic material to meet the rising demand for animal products, made climate change an additional important factor influencing livestock sector (Pilling and Hoffmann, 2011).

Assessment of heat stress by bioclimatic indices

The measurement of dynamic fluctuations of climatic factors due to climate change and the combined effect of different factors on biological activities of animals have to be accounted and analysed in depth. The combined effects of various factors are arithmetically expressed as bioclimatic indices and these indices are absolutely necessary to quantify and assess the impact of heat stress on animals.

Bioclimatic indices account for the combined effects of temperature, solar radiation, wind velocity and relative humidity above the animal's thermo-neutral set point. It indicates the potential effect of heat load on productive and reproductive performance of cows and linked to the economic viability of various animal production systems. Over the last 150 years, more than 100 indices have been developed based on temperature and relative humidity and most of them were intended for human applications to represent the thermodynamics between the body and the thermal environment (Jendritzky *et al*., 2002). Temperature Humidity Index (THI) incorporating ambient temperature and relative humidity has been widely used to assess heat stress in cattle for more than 40 years. Several formulae with varying weightage on temperature and relative humidity were developed by scientists. The primary difference among most of the thermal stress index equations was on the level of emphasis placed on relative humidity and temperature, therefore different equations could be suited for different geographic areas (Bohmanova *et al.,* 2007). In humid climate, indices with more emphasis on relative humidity were found to be suitable. However indices with more weightage on ambient temperature were preferred in climates where relative humidity did not reach the extent that could compromise evaporative cooling.

The Livestock Weather Safety Index (LWSI) formulated by the Livestock Conservation Institute (1970) was considered as the basis for classifying the various categories of THI. As per this index, THI value of 70 or less was considered as normal, 71-78 as alert and 79-83 as danger. THI 83 or above was classified as emergency and requires immediate attention. Practically the predictive value of THI was only slightly better than dry bulb temperature alone, because of the very high correlations between most of the TH Indices with dry bulb temperature. Therefore, according to Dikmen and Hansen (2009) THI was more or less similar to dry bulb temperature.

The drawback of THI is that it does not count other important climatic factors like solar load and wind velocity. Gaughan *et al.* (2008) formulated a new Heat Load Index (HLI) considering black globe temperature, wind speed and relative humidity and has been widely used as a heat load warning guide in Australia.

Baeta *et al.* (1987) developed an Equivalent Temperature Index (ETI) combining the effects of air temperature, relative humidity and air velocity to evaluate the impacts on heat dissipation and lactation performance in Holstein and Jersey dairy cows. The ETI and HLI having significant correlation with rectal temperature and respiration rate were the best indices to evaluate the stress in dairy cattle in tropical environments (De Silva *et al.,* 2007). ETI was categorised as safe (<30), caution (30-34), extreme caution (34-38) and danger (>38) and HLI was also categorised as safe (<89), caution (89-92), extreme caution (92-95) and danger (>95).

Black Globe Humidity Index (BGHI) is a comfort index for dairy cows based on the effects of dry bulb temperature, relative humidity, solar radiation and air velocity. Black Globe Humidity Index less than or equal to 70 had little impact on dairy cattle, but BGHI greater than or equal to 75 markedly reduced feed intake. Respiration rates and rectal temperatures of dairy cattle were directly related to BGHI (Buffington *et al*., 1981). BGHI showed a significant correlation with heart rate and respiratory rate in Holstein dairy cows in Brazil (Avila *et al.,* 2013). In tropical humid climate of Kerala BGHI, Livestock Poultry Heat Stress Index (LPHSI) and HLI were the major bioclimatic indices to be accounted to analyse the physiological, biochemical and behavioural responses of dairy cows to thermal stress (Harikumar, 2017).

According to Schüller *et al*. (2014) the THI formula described by Kendall and Webster (2009) THI = (1.8 x AT + 32)-(0.55 - 0.0055 x RH) x (1.8 x AT - 26) can be used as common standard THI for both tropical or subtropical areas to analyse the thermal stress in dairy cows by considering 73 as the threshold THI.

Climate change and nutrition

In tropics and subtropics many local breeds are comparatively well adapted to high atmospheric temperature. Problems associated with the feed availability might be the major challenges faced by such breeds in changing climate. In grazing lands, pasture productivity and forage quality would have been affected by climate change. The chances of shrub cover increase in some grass lands due to climate change probably reduced the digestibility and nutritional quality of pastures (Illius, 1997; Morgan *et al.*, 2007). High temperature tends to increase lignification of plant tissue. The elevated levels of secondary metabolites reduced the digestibility of forages. Increases in temperature, carbon dioxide levels, precipitation and nitrogen deposition perhaps increased the primary production in pastures (Tubiello *et al*., 2007). In temperate regions, the predicted increase in temperature might have benefited the growth of productive forage species and favoured high yielding livestock breeds requiring good quality diets. As a consequence of climate change semi arid areas were predicted to experience lower rain fall. The greater variability in rain fall patterns and frequent droughts might have decreased the growing periods of forages in tropics (Pilling and Hoffmann, 2011). These conditions may predisposed the risk of nutritional stress of animals for long periods. Besides, the animals may have to walk longer distances in search of food and water and overgrazing of neighbouring areas due to continuous movement of animals in search of food and water. Conflict over access to water and grazing land was another potential hazard during drought.

Heat stress and milk production

The immediate effect of climate change is heat stress and it badly affects the physiological activities of livestock. In dairy cows, milk production is highly sensitive to heat stress and variation in milk production could be attributed to various heat stress associated factors like reduced feed intake, scarcity of quality feed stuff etc. The responses of cows to maintain normal body temperature in heat stress were reflected in reduced feed intake and subsequent 10 to 25 per cent reduction in milk production and decreased milk fat content. In majority of lactating cows, reduction in energy intake resulted in negative energy balance that was associated with a variety of metabolic changes with respect to the dominant physiological stages of lactation. However reduction in dry matter intake (DMI) could only be accounted for 40 to 50 per cent of the decrease in milk production in heat-stressed cows and the rest could be explained by other heat-stress induced changes (Baumgard *et al.,* 2006). Cows in early lactation had the lowest DMI and used body reserves to compensate the effects of heat stress. Pregnant multiparous cows in mid-lactation had greater intake reductions of 22 per cent compared to first-lactation cows (9 per cent) when subjected to heat stress (García and Díaz-Royón, 2016).

The variation in milk production and milk constituents can be analysed with respect to the THI during heat stress. Increase in THI significantly decreased milk and fat yields in lactating dairy cows under humid climatic conditions (Hossein-Zadeh *et al.,* 2013). Holstein cows when exposed to a THI greater than 68 in field conditions, a decrease of 0.27 kg of milk per THI unit was noticed (Bernabucci *et al*., 2010) and might have reached 0.88 kg of milk per THI unit (West *et al.*, 2003). Whereas in temperate climate, reduction in milk yield by 0.1 per cent per unit increase above the threshold of HLI 80 in Holstein dairy cattle was observed (Hammami *et al.,* 2013).

Heat stress and reproduction

During heat stress as many as 80 per cent of oestrus behavioural signs are not detected and prolonged effect of heat stress shortened the intensity and duration of oestrus signs in dairy cows. Generally in the Northern hemisphere, there were periods of reduced fertility from June to September and in the Southern hemisphere from December to March (De Rensis *et al*., 2015).

Heat stress could have detrimental effect on reproductive cycle of cattle by disrupting spermatogenesis, oocyte development and maturation, embryonic development, impaired steroidogenesis in ovarian follicles and *corpus luteum*, loss of normal follicular dominance patterns, reduced uterine blood flow, placental growth and lactation (El-Tarabany and El-Tarabany, 2015; De Rensis *et al*., 2015). Reproductive inefficiency due to heat stress involved changes in ovarian function and embryonic development by reducing the competence of oocyte to be fertilized and the resulting embryo (Naqvi *et al*., 2012).

In tropical and subtropical climate, high heat load with THI more than 72 during 3 to 5 weeks before service and one week after service was associated with reduced conception rate in cattle (Morton *et al*., 2007). The negative association of THI with pregnancy rate of *Bos taurus* cross bred cows was evident and there was 2.06 per cent changes in pregnancy rate for each unit of change in THI during the first 21 days of the breeding season (Amundson *et al*., 2006).

Climate variables seemed to be highly relevant for conception rate, especially during three days before to one day after artificial insemination (García-Ispierto *et al*., 2007). The greatest negative impact of heat stress on conception rate was observed 21 to one day before breeding (Schüller *et al.*, 2014).

The effects of heat stress on embryo

development are multifactorial, but they were related to the reduced quality of oocytes and *corpus lutea*. There was a direct effect of heat stress on embryo survival during early pregnancy (De Rensis *et al.*, 2017). The embryo transfer using embryos at blastocyst stage was one of the effective methods to improve conception rate in summer since there was no inhibitory effect of high THI on embryos after blastocyst stage (Nabenishi *et al.,* 2011). Even small changes in temperature influence the degree of folding and conformation of nuclear proteins and could thereby perturb the sequence and extent of gene expression in young embryos. Maintaining an optimum animal comfort level is the most beneficial management step to achieve high production and productivity in dairy cows. Reducing the thermal stress by wetting and forced ventilation increased the cow comfort level in confined dairy cows and that reflected in the behaviour positively (Harikumar *et al*., 2018).

Climate change and disease outbreaks

The seasonal and geographical distributions of several infectious diseases mainly vector borne are influenced by climate. The alterations in temperature and humidity could directly and alterations in vegetations could indirectly affect the lifecycle of these pathogens, vectors and intermediate and final hosts (Epstein *et al.,* 1998). Specific short-term weather events or seasonal rainfall patterns could act as triggers for diseases like African Horse Sickness, *Peste des Petits Ruminants*, Rift Valley fever, blue tongue and anthrax (Martin *et al.*, 2008; Van-den-Bossch and Coetzer, 2008). Chances of increased flooding due to climate change could lead to spread of water borne diseases and diseases that are spread by vectors having aquatic phases in their life cycles (Hoberg *et al*., 2008). In droughts when large numbers of animals congregate at a limited number of water bodies due to water scarcity can also contribute to the spread of disease. Volatile weather might have disrupted long term ecological relationships that kept the spread of pathogens in check (de-La-Roque *et al*., 2008).

The prominent interacting factors which make the prediction of trends of disease distribution in changing climate were changes in the abundance of hosts including wild life, public health measures, trade, migration of human and animal populations, socio cultural, economic and political factors (de-La-Roque *et al*., 2008). Changes of seasonal climates like shorter or longer winters might have enabled pathogens to become established in new areas. Temporal overlaps of the active phases of life cycle of various organisms might have provided opportunities for disease transmission. Changes in temperature probably affected the transmission of vector borne diseases and beyond certain thresholds of temperature, pathogens were able to utilise additional species as vectors (Pilling and Hoffmann, 2011). Atmospheric warming and changes in the rainfall distribution perhaps lead to changes in the spatial or temporal distributions of diseases such as anthrax, black leg, haemorrhagic septicaemia and vector borne diseases that thrive in the presence of moisture (Baumgard *et al.,* 2012).

SUMMARY

The impact of climate change on animal production systems is a major concern in livestock production management practices. In dairy animals reduced milk production and lower reproductive rate combined with nutritional deficiencies are the major threats to be attended promptly. Animal production and productivity is often compromised and it invites the necessity for suitable stress alleviating measures and other animal welfare strategies. In future environment friendly sustainable livestock production systems should be highlighted to reduce the impact of climate change on both animals and humans.

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