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# Seasonal Variations and Its Impacts on Livestock Production Systems with a Special Reference to Dairy Animals: An Appraisal

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ABSTRACT

Seasonal climatic variations is one of the most important environmental issues at present, the devastating impact of which is visualized on the ecology, ecosystem, and species survival. The livestock sector, which has been the source of animal protein for ever-increasing human masses, is subjected to the increased environmental temperature and higher frequency of extreme events. The impact of a high degree of heat stress is found to have a direct bearing on the milk production, growth, feed intake, reproductive efficiency, and disease incidence of the animals. The environmental temperature above the thermo-neutral zone of the animals has not only been adversely affecting the productivity and survival in the intensive livestock production systems, but the impact is equally seen in the extensive systems. Besides reduced milk production and change in composition, the impact of heat stress on dairy animals, in general, can be seen from the reduction of sperm quantity and quality in case of male and a marked decline in fertility and embryo quality in the case of females. The paper analyses varied aspects of climate change impacts on production, productivity, reproduction, and health of livestock, with a special focus on dairy animals.

## 1. Introduction

Seasonal climatic variations, that denote a significant variation in average weather conditions, has been a global challenge and requires concerted efforts by each and every country to tackle its long-term implications. Although the terminologies of ‘climate change’ and ‘global warming’ are often used interchangeably, the latter is just a single aspect of the former. While a range of natural and human factors influence the climate scenario, the faster warming up of the globe registered since the mid-20<sup>th</sup> century than in the past is largely linked to anthropogenic factors <sup>[1]</sup>. The greenhouse effect of the

earth, i.e. trapping of the heat by the atmospheric gases and preventing it to radiate into space, is leading the atmosphere and ocean to warm up. It is alarming to note that the 1<sup>st</sup> decade of the 21<sup>st</sup> Century (years 2000-2009) was hotter than any other decade in the past 1,300 years. Further, the year 2016 was the hottest on the earth as per the available record. As per the Intergovernmental Panel on Climate Change (IPCC) report on Global Warming, the average global temperature for the decade 2009-2018 was about 0.93°C above the pre-industrial baseline <sup>[2]</sup>. Further, according to the World Meteorological Organization (WMO), the 20 warmest years on record have been only during the past 22 years <sup>[2]</sup>. Increasing emissions of green-

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house gases (GHGs), viz., carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>), nitrous oxide (N<sub>2</sub>O), ozone (O<sub>3</sub>) and chlorofluorocarbons, those we generate through the activities like burning of fossil fuels like coal, oil, and gas for electricity, heat, and transportation; deforestation; construction of roads; fertilizer use in agriculture; livestock production and different industrial production systems have been identified as the primary reason of the rapidly changing climate of the globe [3]. The livestock sector has also been a significant contributor to greenhouse gas emission (CH<sub>4</sub>) that has been leading to climate change [4,5]. A dramatic decline in Arctic sea-ice, loss of Antarctic ice sheet and sea-level rise of 3.6 mm/year during 2006-15 [6] are some of the visualized larger impacts of climate change, besides its adverse impact on biodiversity, agriculture, and increased periodicity & intensity of natural calamities.

The livestock sector, which has been contributing to much needed animal protein source of the increasing population of the country, are subjected to the threat of climate change today. These sectors are not only providing much needed requirements of milk, meat, and eggs but have been a source of several non-food items viz., wool, hair, hides and dungs. The use of livestock as a draft animal is existent in the country for centuries. Rightly known as 'moving banks', livestock has been providing all necessary support to the small and marginal livestock & poultry farmers and land-less livestock keepers to overcome emergency monetary needs. In a country like India where over half of the population depends on agriculture, which remains as the seasonal activity, a large share of these farming communities depends on livestock for assured income round the year. Further, such farming practice becomes a primary livelihood avenue for the inhabitants of hilly areas and harsh climatic regions. Providing livelihood to 2/3<sup>rd</sup> of rural India livestock sector contributes 4.1% of Gross Domestic Product (GDP) and 27.3% of total agriculture GDP. The country also exports animal products to the tune of US\$ 4.33 billion (Rs. 30,309 crores) in 2018-19, in which buffalo meat contributed a share of about 83% (US\$ 3.60 billion/ Rs. 25,168 crores) [7]. As per the latest statistics, the sector is providing 187.75 million tonnes of milk, 103.32 billion eggs and 8.11 million tonnes of meat in 2017-18, the total output value of the livestock sector in India is estimated at Rs. 749,405 crores [8].

Seasonal climatic variations, which has been identified as one of the most important environmental issues of the present time and having a widespread destructive impact on ecology, ecosystem and species survival, has been expected to intensify the vulnerability of living beings, including livestock. As per the 20<sup>th</sup> Livestock Census (2012) of the Government of India, the country possesses 536.76

million livestock, which includes 193.46 million cattle (2<sup>nd</sup> in the world), 109.85 million buffaloes (1<sup>st</sup> in the world), 148.88 million goats (2<sup>nd</sup> in the world), 74.26 million sheep (3<sup>rd</sup> in the world), 9.06 million pigs, 0.39 million mithun, 0.34 million of horse & ponies, 0.12 million of donkeys and 0.25 million camels, and also 851.81 million poultry birds [9]. Although the livestock sector by itself as a large source of methane emission is looked upon as a serious threat to climate change impacts, the production systems of these sectors are not devoid of the quirks of climate change impacts. In this context, an attempt has been made to analyse varied facets of climate change impacts on production, productivity, physiology and health of livestock, with special reference to dairy animals.

## 2. Impact of Seasonal Variations on Livestock

The impact of climate change is not only visualized in terms of an increase in environmental temperature, but also the incidence of increased frequency of extreme events, such as the number of hot days and the number of heatwaves. [10] explained the heat waves as the combination of duration and air temperature intensity which strongly affect human activities and also the productivity of the farm animals and their health. The livestock systems, be it grazing-based system, mixed farming system, or industrialized system, likely to be negatively impacted by climate change, especially by global warming [11]. The impact of climate change leading to a high degree of heat stress on the livestock found to have a direct bearing on milk production by dairy animals and growth of animals, and further bringing down the reproductive efficiency of the animals and increasing disease incidence [12, 13, 5]. Heat stress, leading to the environment temperature above the thermo-neutral zone of the animals, has been the most important climatic stress experienced in the Indian subcontinent, adversely affecting livestock productivity and also their survival [14]. The higher temperature and changing precipitation have also been impacting fodder crops and forage plant production (IFAD, 2010), thereby indirectly distressing livestock production. Climate change is not only found to affect the intensive livestock production systems, but the impact is also equally experienced in the extensive systems [15].

### 2.1 Impact on Dairy Milk Production

Heat stress has been the most important direct impact of climate change on dairy animals. A decrease in milk production, leading to a significant income loss of the dairy farmers is being envisaged with the increase of temperature regimes through climate change impacts in

the coming years. A body temperature of more than 35°C reported stimulating the stress in lactating dairy cows<sup>[16]</sup>. Heat stress during the dry period was found to decrease the milk yield in dairy cows in the following lactation and such conditions resulted in reduced milk yield in early and mid-lactations by 14% and 35% respectively<sup>[17]</sup>. According to<sup>[12]</sup> the heat stress caused in hot and humid environmental conditions lead to increased breathing rates of the animals, reducing their feed consumption and increasing water intake. To dissipate body heat in such high ambient temperature, the animals largely rely on sweating and panting, which however decreases at high relative humidity. Therefore, during hot and humid summer the animal cannot eliminate sufficient body heat, leading to a rise of their body temperature, thereby declining productivity. Although the susceptibility of livestock to heat stress is largely dependent on the species and their genetic potential, life stage, and nutritional status<sup>[12, 18]</sup>, the animals at lower latitudes have been found to be less impacted by higher temperatures than those at higher latitudes. According to them, the thermal comfort zone in tropical breeds is found to be much higher owing to their better adaptation to heat and lower food intake by most of the domestic cattle in smallholder systems. While studies have shown a significant adverse impact of heat stress on milk production and also its composition in dairy animals, the results were more pronounced especially in the animals with high genetic merits<sup>[19, 20, 21, 22]</sup>. In tropical conditions, the native breeds were observed to perform better as compared to exotic breeds and their crosses<sup>[23, 24]</sup>.<sup>[25]</sup> reported that irrespective of feed intake, the high temperatures condition in the tropical regions can lead to a reduction of milk yield by one-third to half of the potential of modern cow breeds. The negative impact of heat stress on the milk composition, both organic and inorganic components, was reported by<sup>[26]</sup>, including those of alteration of cheese making properties and the merchandise value of milk, thereby impacting significantly the economic output of the producers.

Studies have shown that temperature-humidity index (THI) to have a negative correlation with the milk yield in crossbred cows in India viz., Karan Fries, Karan Swiss, and Holstein and Jersey crosses<sup>[27, 28, 29, 30]</sup>. According to<sup>[31]</sup> lactating cows, in general, do not experience any stress when THI is <72 but are subject to severe stress at THI exceeding 88.

Buffaloes have been more susceptible to heat stress than cows<sup>[32]</sup>, as higher temperature leads to increased body heat loading and low potentiality of the animal to dissipate heat from the body surface, attributed to ill-developed sweat glands and possessing black-colored skin

<sup>[33, 34]</sup>. Working with crossbred (Balady X Friesian) dairy cows and buffaloes during the Egyptian summer season (July-September),<sup>[32]</sup> recorded up to 1 °C higher rectal temperature (RT) in buffaloes most of the time compared to cows.

Increasing body temperature, as a result of a rise in environmental temperature, found to reduce the milk production in Murrah buffaloes and also shortening their lactation periods<sup>[35]</sup>. The decline in milk yield was less at the mid-lactation stage than the late or early lactation stage. Further, the decline in yield was as much as 10-30% in first lactation and 5-20% in second or third lactation. Similarly, conducting a study with Murrah buffaloes,<sup>[36]</sup> also found that heat stress to have a harmful effect on milk yield, milk constituents, lactation length, and calving interval.

According to<sup>[37, 38]</sup> goats are the most adapted species among dairy animals to have a better adaptation to the heat stress in terms of production, reproduction and disease resistance. The pregnant and lactating ruminants, however, are more susceptible to heat stress than those of non-pregnant and non-lactating ones<sup>[32]</sup>.

## 2.2 Impact on Reproduction and other Physiological Functions

In general, the stress of any form including that of heat stress found to affect the reproductive performance of both male and female dairy cattle. While in the case of males the effect can be seen from the reduction of sperm quantity and quality, there can be a marked decline in fertility percentage, fertility and embryo quality in the case of females<sup>[39]</sup>.<sup>[40, 41]</sup> also reported a decline in semen quality parameters in cattle during heat stress conditions during summer. Heat stress, leading to an increase of body temperature beyond a normal range, creates the problem in heat dissipation and thereby reduces the physiological responses as well as the behaviour of the animals<sup>[42]</sup>. The thermal weather condition was also found to increase respiration rate, rectal temperature, and heart rate<sup>[43]</sup>. At temperatures above 23.4 °C and at high values of the thermal heat index, a decline in conception rates in cattle (*Bos Taurus*) was reported<sup>[44]</sup>. Reduced fertility in dairy cattle through adverse impact on oocyte maturation and early embryo development in higher summer temperature was also observed by<sup>[45]</sup>.<sup>[46]</sup> reported reduced reproductive performance in dairy cows showing the decreased intensity of estrous, reduced pre-ovulatory LH surge and decreased secretion of luteal progesterone under heat stress conditions. Disruption of several reproductive processes in hot summer conditions resulting in a marked decrease in conception rate in dairy cows was noticed worldwide<sup>[47]</sup>. A

strong impairment of reproductive processes is witnessed with body temperature reaching 39.5 °C, which may include disruption of oocyte developmental competence, attenuated embryonic growth and early embryonic death.

Heat stress has been negatively impacting the production and reproductive performances in buffaloes and has remained a serious issue, especially among the livestock keepers in tropical countries. It is found to have a direct effect on the breeding efficiency and reducing the intensity and duration of oestrus in female buffalo<sup>[48]</sup>.<sup>[49]</sup> registered low reproductive activity in buffalo during summer months at high temperature intensity and longer sunshine hours. With a pronounced estrus frequency during cool periods, the buffaloes started exhibiting estrus with the onset of monsoon.<sup>[50]</sup> also reported weak estrus expression and intensity of the heat during summer compared to winter in buffaloes. Similarly,<sup>[51, 52]</sup> linked the poor expression of estrus and low conception in buffaloes during hot months with low circulating levels of progesterone, estradiol, and luteinizing hormone. The low level of follicle stimulating hormone during the thermal stress period in summer also corroborated to low reproductive efficiency in buffaloes. Climate change scenarios constructed for India with projected maximum temperature of about 4 °C for the time period 2079-2099 likely to increase the uncomfortable days (THI>80) from existing 40 days at present (10.9% of the year) to 104 days (28.5% of the year)<sup>[35]</sup>. Working with buffaloes, the study further inferred that the increase of heat stress days with THI >80 are likely to have an adverse impact on estrus symptoms, duration and conception.

Vulnerable animals subjected to the temperature extremes viz., summer heatwaves and winter storms can result in their death<sup>[53]</sup>. Exceedingly high temperature or intense heatwave along with high humidity results in high production losses and sometimes death of the livestock<sup>[5]</sup>. Severe heatwaves were reported to cause substantial mortality in livestock in the USA and northern Europe on several occasions in recent decades<sup>[12]</sup>. A heatwave in 2006 was reported to result in the death of >30,000 dairy cows in California<sup>[54]</sup>.

### 2.3 Impact on Feed Intake

Heat stress was found to have a direct relationship with declining physical activity of the animals and declining feed intake levels<sup>[55]</sup>. The reduction in feed intake in dairy animals was found to reduce milk production up to 50%<sup>[56]</sup>. Increased temperature has been shown to increase the lignin and cell wall components in plants leading to reduced digestibility and nutrients available for the animals<sup>[57]</sup>. Hot dry and hot humid conditions were shown to decrease

the feed intake in cross-bred Karan calves compared to the protected group of animals<sup>[58]</sup>. The buffaloes have been shown to reduce the feed intake by 9-13% in hot conditions, attributed to panting<sup>[59]</sup>.<sup>[54]</sup> reported that feed intake in lactating cows begin to decline at 25-26 °C and at the climatic condition of above 30 °C it reduces more rapidly and at 40 °C it may decline by as much as 40%. Studies carried out with buffalo heifers subjected to the high temperate condition of 40 °C in a climatic chamber resulted in a reduction of feed intake by 8-10%<sup>[60]</sup>.

### 2.4 Impact on Disease Incidence

Climate change may affect livestock in bringing infectious diseases in several ways<sup>[61]</sup>.<sup>[62]</sup> reported the climate change to have significant impacts on heat-related mortality & morbidity<sup>[13]</sup> and also the occurrence of climate-sensitive infectious diseases. According to<sup>[63]</sup>, the pathogens and parasites that spend some of their life cycles outside the animal hosts may increase their rate of development at higher temperatures leading to the rise of their populations. Climate change, impacting changes in rainfall patterns and temperature regimes may also affect the distribution and abundance of several disease vectors of livestock disease in the tropics viz., midges, ticks, flies and mosquitoes<sup>[18]</sup>.

The climate change mediated extreme weather events along with the variations in the rainfall often leads to the emergence of new pathogenic microbial strains, thereby incidence of new disease outbreaks in livestock. A higher incidence of clinical mastitis in dairy animals was reported by<sup>[64]</sup> during hot and humid weather, which was corroborated to heat stress and associated greater fly population. Climate warming may also reduce the survival of certain pathogens that are sensitive to high temperatures. Similarly, pathogens and parasites that are sensitive to moist or dry conditions may be affected by changes in precipitation and soil moisture<sup>[18]</sup>.

### 3. Adaptation Strategies

Animal adaptation is a function of several factors which are interrelated<sup>[65]</sup>. The susceptibility of the animals to environmental challenges has been found to increase with the selection of animals for higher production levels. While production system adjustments and genetic improvement for thermotolerance<sup>[66]</sup> are suggested as important adaptation strategies, the mitigation strategies are considered to be very important as short-term and immediate measures including changes in animal management systems through the provision of shade, cost-effective housing, fans, and sprinklers, and nutritional interventions,

rumen eco-system manipulation, etc.<sup>[65]</sup>. Construction of well-ventilated shelter under the big trees having a large canopy is found to provide the cooling effect of the wind. It may be ideal for the dairy animals to have the provision of bathing/showering in the summer season to release their heat, which can protect them from milk production loss and also improving reproductive efficiency. Effective livestock management strategies viz., dietary manipulation, the right selection of animal breeds, efficient manure management and adoption of certain advanced technologies have been proved to reduce the methane production in livestock systems, ultimately leading to the amelioration of climate change situations<sup>[67]</sup>. According to<sup>[13]</sup> diversification of livestock and crop varieties can increase drought and heatwave tolerance. Such diversity of crops and livestock animal integration is reported to be effective in combating the outbreaks of climate change-related diseases and pests<sup>[68, 69]</sup>.

#### 4. Conclusions

The influence of climate change on livestock production has been quite significant, which ultimately is impacting the livelihood and food security of millions of resource-scarce farmers. The impact has been more pronounced in arid and semi-arid regions and those breeds with high milk production capacity. To meet the increasing demand for milk and other animal produce in the coming years, the livestock production system needs significant expansion with a greater degree of intensification and inclusion of high-yielding varieties. The impact of such practice would further enhance the contribution of enteric greenhouse gas emission and thereby escalating climate change impacts. Appropriate mitigation practices and policy frameworks, therefore, are vital not only for assuring the ever-increasing demand for animal products but also for protecting the animals to survive in the adverse climatic conditions.

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