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21. Climate Change Impact on Animal Husbandry and Livestock

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Abstract:

Climate change impacts livestock growth, production, reproductive performance, morbidity, mortality, and feed supply. Livestock are responsible for 14.5% of total anthropogenic greenhouse gas emissions. While livestock are affected and contribute to climate change through emissions, adaptation and mitigation actions can limit its effects. Research directions are needed, especially in developing countries, to sustain the growing demand for livestock products and limit future climate change extent. The chapter discusses the impact of climate change on animal health and production, focusing on India's leading producer of milk, fish, poultry, and livestock. It highlights challenges such as depleting natural resources, climate change, and reduced farm income. The chapter emphasizes the need for effective adaptations and prioritization to cope with the detrimental effects of climate change on animal health and production.

Keywords:

Animal health, Climatic changes, Influence of climate.

21.1 Introduction:

Climate change refers to the variability in the Earth's climate over long durations, ranging from decades to millions of years. It involves shifts in weather patterns, such as melting glaciers at poles and rising water levels in oceans and seas, which raise the possibility of catastrophic flooding worldwide.

The Inter-Governmental Panel on Climate Change (IPCC) and the FAO highlight that agriculture, land use, and fossil fuels are the three major contributors to the rise in greenhouse gases (GHGs) seen during the previous 250 years. Livestock, agriculture, and farming lead to an increase in the production of GHGs in the form of methane and nitrous oxide (N2O) from excess usage of nitrogenous fertilizers. The livestock industry is the most susceptible due to its impact and major source of greenhouse gases. According to the FAO, livestock contributes 18% of total global GHG emissions, more than the share contributed by transport. Climate change indirectly affects physiological processes like reproduction and production in the nation. In India, more than half of the population relies directly on climate-sensitive industries like agriculture, forestry, and fisheries. Climate plays a significant role in the system of animal production and has an impact both directly and indirectly. This review paper provides a better understanding of how climate change affects animal health and the problems faced by livestock farmers, taking into account future mitigation plans for sustainable animal welfare. Climate change has many elements, affecting biological and human systems in different ways.

The considerable spatial heterogeneity of climate change impacts has been widely studied; global average temperature increases mask considerable differences in temperature rise between land and sea and between high latitudes and low latitudes; precipitation increases are very likely in high latitudes, while decreases are likely in most of the tropics and subtropical land regions (IPCC 2007). It is widely projected that as the planet warms, climate and weather variability will increase. Changes in the frequency and severity of extreme climate events and in the variability of weather patterns will have significant consequences for human and natural systems. Increasing frequencies of heat stress, drought, and flooding events are projected for the rest of this century, and these are expected to have many adverse effects over and above the impacts due to changes in mean variables alone (IPCC 2012). Livestock play a major role in the agricultural sector in developing nations, and the livestock sector contributes 40% to the agricultural GDP. Global demand for foods of animal origin is growing, and it is apparent that the livestock sector will need to expand (FAO, 2009). Livestock are adversely affected by the detrimental effects of extreme weather. Climatic extremes and seasonal fluctuations in herbage quantity and quality will affect the well-being of livestock and lead to declines in production and reproduction efficiency (Sejian, 2013).

Climate change is a major threat to the sustainability of livestock systems globally. Consequently, adaptation to and mitigation of the detrimental effects of extreme climates have played a major role in combating the climatic impact on livestock (Sejian et al., 2015a). There is little doubt that climate change will have an impact on livestock performance in many regions, and as per most predictive models, the impact will be detrimental. Climate change may manifest itself as rapid changes in climate in the short term (a couple of years) or more subtle changes over decades. Generally, climate change is associated with an increasing global temperature. Various climate model projections suggest that by the year 2100, the mean global temperature may be 1.1–6.4 °C warmer than in 2010. The difficulty facing livestock is weather extremes, e.g., intense heat waves, floods, and droughts. In addition to production losses, extreme events also result in livestock deaths (Gaughan and Cawsell-Smith, 2015). Animals can adapt to hot climates; however, the response mechanisms that are helpful for survival may be detrimental to performance. In this article, we make an attempt to project the adverse impact of climate change on livestock production.

How is livestock production affected by climate change?

- The Indian Council of Agricultural Research states that climate change-induced changes in pasture availability may decrease **livestock carrying capacity** by 10-40% by 2050.
- Higher temperatures and changing precipitation patterns cause heat stress in livestock, reducing output and increasing susceptibility to illness. **Milk yield** can decline by 3-20% or more, while conception rates may drop to 0% in severe situations.
- Indian research shows that temperature, humidity, and rainfall contribute to 52-84% of variations in the seasonality of Foot and Mouth disease in cattle in hyper-endemic regions. Altered rainfall patterns affect animal productivity, and diseases linked to moisture may increase.
- **Heat stress** in India's cattle and buffaloes results in an annual loss of over Rs 2,700 crore. Additionally, it is estimated that milk production will be negatively impacted by 1.6 million tonnes in 2020 and over 15 million tonnes in 2050.
- Temperature, precipitation, drought, storms, and floods all influence fish farming, with both positive and negative effects. Certain species may be unable to tolerate altered conditions, while others may become viable alternatives.

21.2 Potential Impact of Climate Change on Livestock:

Climate change is a significant threat to livestock production, affecting food security and overall production performance. Global warming, precipitation variation, and temperature increase are causing significant impacts on livestock production and reproduction. Heat stress is a major source of production loss in the dairy and beef industry. Managing animals to reduce climate change's impact remains a challenge. Potential impacts include changes in water availability, animal growth and milk production, feed crop and forage quality, diseases, reproduction, and biodiversity.

These effects are mainly due to increased atmospheric temperature, carbon dioxide concentration, and precipitation variation. Forage quantity and quality are affected by a combination of temperature, CO2 and precipitation variation. Livestock diseases are mainly affected by increased temperature and precipitation variation. High ambient temperature decreases fertility in poultry, rabbits, and horses, and exposure to extreme heat stress can reduce conception rates. The effects of climate change on livestock production can be classified as direct and indirect effects.

21.2.1 Impact of Climate Change on Livestock:

The greatest impacts of global warming on animals are expected to be visible in grazing systems in arid and semi-arid areas, where higher temperatures and decreasing rainfall reduce yields and contribute to degradation. Higher temperatures also reduce animal feed intake and lower feed conversion rates, with growing seasons potentially becoming shorter in many grazing lands, particularly in sub-Saharan Africa. The probability of extreme weather events, such as droughts and floods, is likely to increase. In non-grazing systems, the direct impacts are expected to be limited and mostly indirect, resulting from reduced yields and increased prices of feed used in animal production.

The development of energy-saving programs may also result in increased energy prices. A warmer climate may also increase the costs of keeping animals cool by building adapted housing and using cooling devices. However, some positive effects can be addressed, such as reducing cold stress experienced by livestock raised outside and reducing maintenance energy requirements and heating in animal housing.

21.2.2 Influence of Climate Change on Animal Feed Fodder and Water Availability:

Climate change has significantly impacted fodder quantity and quality, with a 2°C increase potentially affecting pasture and cattle productivity in arid and semiarid environments. The rise in biosphere temperature has altered the quantity and distribution of annual precipitation, leading to increased heat waves and droughts, which affect vegetation in different ecological regions.

However, as temperatures rise, atmospheric CO2 is stimulated, encouraging plant growth and enhancing water use efficiency. Humid conditions may also enhance water use efficiency by plants and soil-water availability, potentially benefiting warmer and humid temperate zones. Climate change also affects the length and timing of forage availability, with the quality of forage relying on nondigestible fibers (NDF). As forage quality declines, these NDFs increase, causing methane emissions. Studies have shown a 22% decrease in methane emissions when starchy concentrates are fed, suggesting a need to reduce forage consumption and replace it with grain to minimize increased methane emissions. Water availability is also a significant concern for the livestock industry, as it depends on water for animal drinking, feed crops, and product processes. A temperature rise may result in two to three times increased animal water consumption, accounting for around 8% of all human water consumption worldwide. To address this issue, it is necessary to grow crops and rear cattle in livestock systems that use less water in areas with scarce water. Research on the effects of decreased water availability for land-based livestock systems due to climate change is limited.

21.2.3 Influence of Climate Change on Livestock Health and Diseases:

Climate change-related livestock health issues exist due to variations in climatic temperature, humidity, and radiation. These changes can affect the health and production of animals, affecting physiological processes such as rectal temperature, pulse and respiration rate, metabolic rate, endocrine status, oxidative status, metabolism of glucose, protein, and lipid, liver functionality, and no esterified fatty acids (NEFA). Dairy cows adapt to fluctuating environmental conditions, causing disturbances in their homoeothermic status. Heat-stressed animals have a high rectal temperature and respiration rate, and plasma albumin concentrations increase during heat-stress-free periods. High lactation after parturition causes the formation of non-esterified fatty acids (NEFA) and energy deficits, affecting cow longevity and fitness. Factors like nutrition imbalances and deficiencies exaggerate the effects of heat stress, affecting reproduction, production performance, and individual growth. Thermal stress reduces feed intakes, feed conversion ratios, and utilization of feeds, disrupting the metabolism of carbohydrates and proteins, mineral and hormone balances, and secretions of blood metabolites.

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21.3 Climate Change Affects Pathogens:

Infectious cycles for diseases related to warm or cold seasons can vary depending on the duration of the warm season. Extreme weather conditions, such as flooding, can cause pollution from agricultural land to animal farms, leading to the spread of entero-haemorrhagic Escherichia coli and Cryptosporidium parasites. This contamination threatens livestock and water systems, putting people at risk of acquiring zoonotic diseases. Climate change, such as heat stress, can reduce vertebrate cellular immunity, affecting the body's immune response and causing the degeneration of lymphoid organs. This decrease in T helper 1 lymphocytes can lead to pathogens for animal sickness, such as viruses, cow dria, anaplasma, and some bacteria like Brucella, targeting the immune systems of animals and birds and causing mortality. Animal husbandry is a crucial asset for resource-poor farmers, accounting for 40% of the world's agricultural GDP and relying on 1.3 billion people for their livelihood. Heat stress is one of the main reasons for lower productivity in the dairy and cattle industries, with India experiencing significant monetary losses of nearly 2% of total milk production. Heat stress is a significant issue that affects animal productivity in tropical belts and arid areas, particularly in dairy cows, ewes, goat milk production, buffalo production, beef cattle, pigs, and poultry. The National Innovation on Climate Resilient Agriculture (NICRA) project has found that an increase in $4^{O}C$ temperatures during the summer has adverse effects on lactation and milk production in crossbred buffaloes and cattle. The milk yield decline varies from 10–30% in the first lactation to 5-20% in the second and third lactation. Heavy-weight beef cattle with thick coats and darker colors are at high risk of heat stress, as global warming may decrease ruminant body size, carcass weight, and fat thickness.

Larger pigs also experience higher reductions in growth, carcass weight, and feed intake. Low productivity at temperatures above 30 °C could also pose a threat to the poultry business. Heat stress on birds reduces body weight gain, FCR, carcass weight, and protein and calorie content in the muscles. Under hotter conditions, egg quality may also be negatively impacted. Climate change has the potential to impact parasite populations and animal production, particularly in the tropics.

Higher temperatures may increase the development of pathogens and parasites that spend some of their life cycle outside their animal host, leading to larger populations. Changes in precipitation, soil moisture, and flood frequency may also affect these pathogens and parasites. Climate change may affect the distribution and abundance of disease vectors, as well as the frequency of extreme events. Prolonged high temperatures may affect metabolic rate, endocrine status, oxidative status, glucose, protein, and lipid metabolism, liver functionality, non-esterified fatty acids (NEFA), saliva production, and salivary HCO3- content. Future patterns of international trade, local animal transportation, and farm size may be driven by climate change and may affect disease transmission. Climate change in West Africa has indirect effects on vectors, affecting their abundance and distribution and influencing disease patterns. Changes in ecosystems may lead to new species mixtures, exposing hosts to novel pathogens and vectors. This could result in the loss of trypanotolerence, an adaptive trait in the sub-humid zone, increasing the risk of future disease.

21.3.1 Reproduction:

Heat stress may affect the effectiveness of both male and female reproduction. It impairs embryo development, pregnancy rate (Nardone et al., 2010) and oocyte quality and growth in pigs and cows (Barati et al., 2008). In addition, heat stress and increasing energy shortages may impair cow reproduction (King et al., 2006). Heat stress has also been linked to reduced sperm concentration and quality in bulls, pigs, and poultry. In females, follicular dynamics and estrus expression are modulated and disturbed due to rising environmental temperatures and humidity. This may lead to a high risk of incidence of silent estrus. During hotter summer, there are signs of being sexually inactive and the conception rate reduce, and embryonic mortality cases increases. In cases of cattle, there is a 20-30% reduction in conception rates during summer. Also, there is a reduction in In-Vitro Fertilisation (IVF) procedures' success during the summer season. Heat stress causes hypothalamic dysfunction which causes a reduction in the secretion of gonadotropin-releasing hormone (GnRH) and Luteinizing hormone (LH), as a result the ovulation rates in laying and breeder birds are decreased (Ebeid et al., 2012) Semen quality and libido get affected by heat stress. The primary target cells for heat stress are Sertoli cells (Ahmad et al., 2022). Existing climatic conditions and the rise of temperatures affects the testes and impose detrimental effects on the seminal parameters (semen volume, sperm concentration and sperm motility, live/ dead sperms). Heat stress prompts an increase in lipid peroxidation due to reactive oxygen free radical formation, as a result it damages testes. As a result, unfavorable circumstances impair spermatogenesis, increase the number of defective sperms and thus lead to the overall reduction of semen quality and sperm morphology of males, ultimately resulting in subfertility and infertility (Fouad et al., 2016). From the studies and literature, during heat stress, the acrosome and sperm plasma membrane was found to be damaged during ejaculation.

Future perspective In order to combat the "impact of climate change on animal health and animal production" it may be necessary to make management, technological, and infrastructure changes. The most effective adaption approach will depend on the environment itself and reducing greenhouse gas emissions (GHGs) in the landscape through the processes of conservation, restoration, and improved land management, are the most promising ways ahead. It is crucial to adopt good farming practices with strong farm biosecurity and herd health management in the future at the field level which can be achieved by the development and use of advanced techniques to link climatic data to an animal disease surveillance system, the manufacture of modern feeding management techniques along with fodder management techniques that can withstand salt and drought, development of disease-resistant animals by natural selection and breeding, as well as conservation and maintenance of the genetic diversity of local animals and lastly by the development of medicines and vaccines to combat endemic and emerging diseases brought on by climate change.

21.3.2 Mortality:

There is a strong relationship between drought and animal death. Projected increased temperature and reduced precipitation in such regions as southern Africa will lead to increased loss of domestic herbivores during extreme events in drought-prone areas. Heat-related mortality and morbidity could increase as temperature increase due to climate change. Warm and humid conditions that cause heat stress can affect livestock mortality .Reported that increases in temperature between 1 and 5°C might induce high mortality in grazing cattle. As a mitigation measure, they recommend sprinklers, shade, or similar management practices to cool the animals. Linked livestock mortality to several heat waves between 1994 and 2006 in the United States and northern Europe.

23.3.3 Future Perspectives:

Responding to the challenges of global warming necessitates a paradigm shift in the practice of agriculture and in the role of livestock within farming systems. Science and technology are lacking in thematic issues, including those related to climatic adaptation, dissemination of new understandings in rangeland ecology (matching stocking rates with pasture production, adjusting herd and water point management to altered seasonal and spatial patterns of forage production, managing diet quality, more effective use of silage, pasture seeding and rotation, fire management to control woody thickening and using more suitable livestock breeds or species), and a holistic understanding of pastoral management (migratory pastoralist activities and a wide range of biosecurity activities to monitor and manage the spread of pests, weeds, and diseases). Integrating grain crops with pasture plants and livestock could result in a more diversified system that will be more resilient to higher temperatures, elevated carbon dioxide levels, uncertain precipitation changes, and other dramatic effects resulting from global climate change. The key thematic issues for effectively managing environmental stress and livestock production include (Sejian et al., 2015b):

- development of an early warning system;
- research to understand interactions among multiple stressors;
- development of simulation models;

- development of strategies to improve water-use efficiency and conservation for diversified production systems;
- exploitation of the genetic potential of native breeds; and
- Research on the development of suitable breeding programs and nutritional interventions.
- The integration of new technologies into research and technology transfer systems potentially offers many opportunities to further the development of climate change adaptation strategies. Epigenetic regulation of gene expression and thermal imprinting of the genome could also be part of the growing human population, and its increasing affluence would increase the global demand for livestock products. But the expected big changes in the climate globally will affect, directly or indirectly, animal productivity and health and the sustainability of livestock-based production systems. Extended periods of high air temperatures compromise the ability of livestock to dissipate excess body heat, which affects feed intake, milk production, and reproductive efficiency. However, by minimizing body temperature, greater feed intake could be encouraged. Moreover, the gross efficiency with which dietary nutrients are used by the livestock for performance could also be improved. The loss of electrolytes via skin secretions has to be minimized by improving the housing and cooling of the animals. An increase in the pregnancy rate of heat-stressed livestock could be achieved by improving various management conditions. Identification of genes associated with thermo tolerance and using these genes as markers in the breeding program or marker-assisted selection should be applied to identify animals adapted to thermal stress, considering genotype-environment interactions (G × E) in addition to higher productivity. Further research on climate-resilient animal agriculture is the need of the hour for sustainability in livestock farming systems, especially in hot, humid climatic regions.

What can be done to mitigate the effects of climate change on livestock production?

- **Indian Council of Agricultural Research (ICAR**) has developed an anti-methanogenic feed supplement **'Harit Dhara' (HD**), which can cut down cattle methane emissions by 17-20% and can also result in higher milk production.
- **The National Mission on Sustainable Agriculture** promotes improved agronomic practices, including soil health management, water use efficiency, judicious chemical use, crop diversification, and integrated farming systems. It aims to adopt location-specific approaches like crop-sericulture, agro-forestry, and fish farming for sustainable agriculture.
- **The National Livestock Mission (NLM)** aims to improve livestock production systems quantitatively and qualitatively while also increasing the capacity of all stakeholders. Since April 2019, the scheme has been implemented as a sub-scheme of the White Revolution – Rashtriya Pashudhan Vikas Yojana.
- **The Rashtriya Gokul Mission (RGM)** aims to improve indigenous cow breeds through breed improvement projects and the establishment of **Kamdhenu Breeding Centres**. These initiatives promote the preservation and enhancement of native breeds, which are well-suited to local conditions and have a lower environmental impact.
- **The Ministry of New and Renewable Energy** encourages the building of biogas facilities in livestock farms. Biogas generation provides a renewable source of energy but also helps to reduce methane emissions from livestock manure.

- **The National Programme for Bovine Breeding and Dairy Development (NPBBDD)** programme seeks to improve milk productivity, and breed quality, and promote scientific breeding and management practises in the dairy industry.
- **Integrated farming techniques** promote resource efficiency and reduce environmental impacts by combining crops, livestock, and other agricultural activities. These methods encourage the recycling of agricultural byproducts and the efficient use of resources.

21.4 Conclusion:

The nature and extent of climate change and heat stress impacts on feed nutrient absorption, utilization; animal production, reproduction, and health require further research. With a better understanding of cattle's metabolic and nutritional processes, management approaches could be modified to improve animal performance. Hence, there is a need to work on early warning of weather and its changing consequences for livestock owners, which will adapt and save productive livestock against severe weather conditions.

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