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Dairy in Distress: How Climate Change is Shaping the Industry

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ABSTRACT

The dairy industry facing unprecedented issues driven by the complex relation between climate change and global demand for dairy products. As climate patterns displace globally, the agricultural sector including dairy production is balanced to experience significant interference. This paper explores the relationship between climate change and the dairy industry by examining their impacts on production systems, waste management, and animal health. Climate change amplifies the existing vulnerabilities within the dairy sector by affecting production, reproduction, and animal health. Heat stress emerges as a critical concern, influencing milk production, fertility, and prone to diseases. The rapid increase in temperature influences dairy animals' physiological changes and metabolic disturbances, leading to reduced productivity and increased health risks. This paper highlights the necessity for collaborative efforts among policymakers, researchers, and industry stakeholders to tackle the challenges raised in the dairy sector by climate change. The industry can navigate these challenges by implementing adaptive strategies and innovative solutions while ensuring environmental sustainability and food security for future generations.

Keywords: Climate change, Dairy industry, Global warming, Dairy products

Introduction

In the coming decades, a wave of demand for dairy products is expected significantly in animal production with heightened concerns about food and water security throughout the 21st century worldwide. Concurrently, shifts in global climate patterns are expected to lead to localized climate variations which can affect both, impact local and global agricultural systems. Key findings of Active Group I of the Intergovernmental Panel on Climate Change (IPCC) were outlined in the Fourth Assessment Report (AR4) (IPCC, 2007) to ensure the clear warming of the climatic system. Furthermore, for many centuries the expectations indicate that man-made global warming is due to the extended timescales linked with climate dynamics and feedback mechanisms. In the 21st century, it's estimated that the surface air temperature has increased to an amount from 1.1 to 2.9 °C under "low circumstances", on the other hand, from 2.4 to 6.4 °C under "high circumstances". It is estimated that the IPCC report showed with over 90% confidence a rise in heat waves and high rain with above 66% confidence and enhanced in droughts, Weather systems, and extremely high waves. However, the intensity of these activities can vary across different regions [1].

The impacts of global warming may be different globally. Notably, areas most prone to the adverse effects, include the high-latitude regions of North America, Northern Europe, Northern Asia, and west-central Asia along with the Mediterranean basin. The inferred impacts of climate change including soil degradation, water shortage, and pathogen spread can affect badly the areas of industrialized livestock systems that contain high numbers of animals and may outweigh direct effects like heat stress on animals. In short, in developing countries, the pastoral and mixed farming systems are likely to be more susceptible due to reduced rainfall and increased drought risks [2].

With the increase in global population and urbanization rates, it is estimated that doubling of meat consumption by 2050. It is crucial to enhance the livestock sector's sustainability to achieve a balance between animal production and consumption while enhancing this sector. Water efficiency will be essential for requiring systems with lower water demands for animal rearing. Addressing These challenges will necessitate efforts from policymakers, research institutions, and extension services to address production losses, enhance product quality, combat land degradation, and secure animal health from anticipated climate changes. While comprehensive estimation of global livestock system evolution under climate change remains challenging. This paper provides the significant effects of global warming on livestock production [3].

The dairy industry's impact on climate change

In the 26 studies taken from the current literature analyzed, the dairy sector is a major part to climate change as compared to other sectors of agriculture, even when the motivation behind the studies remains widely variable. For instance, the major section of studies (19 out of 26) examined raw milk and a specific dairy product and showcased their distribution to global temperature increase. Among these 19 studies, the scientists who worked on unpasteurized milk at the milk production centers stage different productive systems (i.e. pasture-based versus confined dairy systems) with raw milk production. They also analyzed the effects of greenhouse gas emissions from dairy farms resulting from different on-farm practices. One of them used methodological choices and achieved unknown results on GHG emissions. Some scientists focus on specific dairy products including processed milk, cheese, and butter [5].

The different agents of GHG producers have been identified with the value chain of milking animals. However, all studies identify that milking farms make a major contribution to increased temperature and raw dairy products account for 80% of the entire carbon footprint (CF). Methane is the basic source of greenhouse gas emissions at this stage as emissions from microbial fermentation and to a limited degree. The N2O (nitrous oxide) emissions from urea are utilized in-farm and out-of-farm to produce feed. Additionally, from manure management N2O and CH4 emissions, and carbon dioxide (CO2) emissions through water usage and energy on the farm [6].

During the second phase, the dairy factory collected unpasteurized milk from milking farms. At this stage, a carbon footprint is mainly influenced by unpasteurized milk selection, sanitation, and results like used energy and enveloping. In the subsequent stage, the prepared miking products are divided for retail and achieved by consumers in the last stage. Moreover, product waste, refrigeration of perishable dairy products, and transportation are related to the final two stages of GHG emissions. Subsequently, milking farms and factories face product loss, when the wastage is more relevant to the seller and customers stages than item losses occur at milking units. [7].

Climate change has a significant interaction with the dairy sector. On one side the dairy sector is significantly influenced by climate change and affects other segments of the environment. In the opposite direction, climate change impacts the dairy sector such as its value chains and associated environmental burdens. Moreover, other non-climate factors may affect the dairy sector in the future [4].

The impact of climate change on the production, reproduction, and health of dairy animals

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Many aspects such as growth, average daily gain, feed conversion efficiency, milk and meat production, reproduction, disease occurrence, fertility, and parasitic infestation are influenced by the multifaceted impact of high temperatures on dairy cows. Dairy production and its quality are significantly affected by climate change, especially in high milk-producing animals through altering feed utilization efficiency, dry matter intake, and physiological variables. In semi-arid grazing areas, the livestock production systems face multiple stressors during heat stress periods that lead to loss of body condition, weight, and milk yield. High-yielding dairy animals are more prone to heat pressure due to increased metabolic heat. Increasing temperatures affect the physiological responses in animals like raising body temperature, respiration rates, and blood, resulting in imbalances in ion concentrations and metabolic disturbances. Heat stress also reduces dry feed intake, and milk production with increased maintenance energy requirements. Additionally, animals are more vulnerable to heat pressure in early and late lactation stages and first parity, experiencing decreased milk yield [9].

Reproduction is mostly affected during heat stress periods, resulting in reduced conception rates and increased rates of abortion. Heat stress affects hormonal levels, and disrupts gametogenesis, folliculogenesis, ovulation, and embryonic development leading to fertility issues, early embryonic mortality, and longer calving intervals. The dairy animals' health is compromised under heat stress conditions which are characterized by metabolic, physiological, and hormonal changes that weaken immunity levels. Heat stress can influence decreased thyroid activity, reduced rumen motility, and feed intake. It also increased the prevalence of infections and disease vectors that take part in compromised health-causing conditions like mastitis, lameness, parasitic infestations, and reduced resistance to diseases [8].

The factors contributing to the rise in temperature and the global distribution of livestock

The recent climate change analysis showcases the many advancements that enabled the upper troposphere to co-exist and significantly enhance human activities. The rising temperature is a strange gift from all factors that are attributed to human activities. These factors encompass the increasing greenhouse gas (GHG) concentrations in the atmosphere and alterations in Earth's surface like deforestation, increased aerosol presence, and methane emissions from farming [10].

The Intergovernmental Panel on Climate Change highlighted humans are playing a big role in temperature rise since the mid-twentieth century. Furthermore, a minimal probability (below 5%) of solely natural causes increases climatic changes. Climate change indicates effects like the heightened magnitude and occurrence of droughts, rainfall, floods, and high temperatures that significantly impact worldwide agriculture, farmer's incomes, livelihoods, and food security [11]. Based on climatic estimation global warming is anticipated to accelerate with a projection increase of 5.5°C by 2050 and the average surface temperature is expected to rise by 1.5°C by 2100. Furthermore, a notable increase annually in hot days in areas classified as 'extreme vulnerability,' 'severe,' and 'moderate,' indicating the enlargement in climatic challenges [12].

Animal behavior toward heat stress

Local species are more thermotolerant compared to crossbreds or exotic species due to evolutionary advantages. Zebu cattle (B. indicus) over B. taurus species have superior adaptive capacities of thermotolerant due to gene expression and acclimatization mechanisms under heat stress conditions. Small ruminants demonstrate positive adaptation to high temperatures as compared to large ruminants and other ruminant species [13]. The heat stress affects the animal physiology, metabolism, and production. During heat stress, animals exhibit various correlated behavioral responses such as posture changes, seeking shade, wallowing, reduced rumen digestion, and decreased physical activities. Animals reduce metabolic heat production by decreasing feed consumption and rumination during the warmth of the day. If animals cannot balance heat levels through practical heat loss mechanisms, they start evaporative cooling, such as panting or increased respiration frequency processes. Subsequently, the entire body temperature increases under prolonged as the capacity for heat dissipation diminishes. Animals faced to heat stress also display different cardiovascular functions that are crucial for thermoregulation [14].

The homeostasis process maintained through the acclimatization to heat stress involves temporary rewiring of the endocrine system. The metabolic heat generation is reduced by declining Circulating levels of thyroid hormones, triiodothyronine (T3), and thyroxine (T4) up to 30–40%. The higher glucocorticoid levels can cause stimulation of the hypothalamic-pituitary-adrenal axis which modulates energy metabolism (lipid/glucose) during stressful periods. Higher glucocorticoid levels can influence the uncoupling of the somatotropic axis by altering GH-dependent insulin-like growth factor I (IGF-I) production and release from the liver. The role of prolactin in heat stress remains unclear, it is estimated through reports that no change like an increase or decrease occurs in prolactin levels in heat-stressed cattle [15].

Conclusion

In the resolution, the climate change gifting serious challenges to the dairy industry faces significant challenges due to climate change, with significance for production, waste management, and animal welfare. Studies highlight that dairy farms are major contributors to global warming, as enteric fermentation expels the methane emissions and nitrous oxide emissions from various sources being primary concerns. Overall, need of collaboration among stakeholders to mitigate the dairy sector's environmental footprint and ensure its long-term sustainability in a changing climate.

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