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IMPACT OF CLIMATE CHANGE ON LIVESTOCK HEALTH AND PRODUCTIVITY

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ABSTRACT

Climate change has emerged as a major global challenge affecting livestock health, animal welfare, and agricultural productivity. Increasing temperatures, changing rainfall patterns, frequent droughts, floods, and extreme weather events negatively influence the physiological functions, reproductive performance, nutritional status, and disease resistance of farm animals. Heat stress is one of the most significant consequences of climate change, particularly in cattle, buffaloes, sheep, goats, and poultry. Exposure to elevated environmental temperatures can reduce feed intake, milk production, growth rate, fertility, and overall animal performance. Furthermore, changing climatic conditions may influence the distribution and transmission of infectious diseases, parasites, and vector-borne infections. These challenges are particularly important in developing countries, where livestock production systems often have limited resources for climate adaptation. This research examines the relationship between climate change, livestock health, and productivity, with particular attention to heat stress, animal nutrition, disease prevalence, reproductive performance, and animal welfare. It also explores practical adaptation strategies, including improved housing, appropriate feeding practices, water management, vaccination, genetic selection, and climate-resilient livestock management. The study emphasizes the importance of sustainable veterinary practices and effective government policies to reduce climate-related risks. Strengthening livestock management and veterinary healthcare systems can improve animal welfare, protect farmers' livelihoods, and support sustainable livestock production under changing climatic conditions.

KEYWORDS:*Climate change, livestock health, animal welfare, heat stress, animal productivity, dairy cattle, buffaloes, poultry production, reproductive performance, infectious diseases, animal nutrition, veterinary medicine, climate adaptation, sustainable livestock farming, environmental stress.*

INTRODUCTION

Climate change is one of the most important environmental challenges affecting agriculture and livestock production worldwide. Increasing global temperatures, irregular rainfall, prolonged droughts, floods, and extreme weather conditions are creating serious difficulties for livestock farming. Anuta, A., Wang, X., & Kinay, P. (2025). found that Animals depend on suitable environmental conditions for maintaining normal physiological functions, reproductive performance, growth, and production. Changes in temperature and environmental conditions can disturb these functions and negatively influence livestock health and welfare.Livestock production plays an essential role in food security, agricultural development, and rural livelihoods. Cattle, buffaloes, sheep, goats, and poultry provide milk, meat, eggs, hides, and other valuable products. Millions of farming households depend on livestock as a major source of income and economic stability. However, climate-related environmental stress can reduce animal productivity and increase the cost of livestock management. Farmers may experience financial losses because of reduced milk production, poor weight gain, reproductive problems, and increased veterinary expenses.Heat stress is one of the most significant effects of climate change on livestock. Animals exposed to high environmental temperatures may experience increased respiration rates, excessive sweating, reduced feed consumption, dehydration, and physiological disturbances. Dairy cattle and buffaloes are particularly vulnerable when temperature and humidity remain high for extended periods. Heat stress can reduce milk yield and milk quality while negatively affecting fertility and reproductive efficiency. Poultry birds may also experience reduced egg

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production, poor growth, and increased mortality during extreme heat conditions.Climate change also influences the availability and nutritional quality of animal feed. Droughts, irregular rainfall, and changing agricultural conditions can reduce the production of grasses, fodder crops, and other livestock feed resources. Poor-quality feed may result in nutritional deficiencies, reduced immunity, lower growth rates, and decreased reproductive performance. Limited access to clean drinking water further increases the risk of dehydration and metabolic disturbances. These challenges can become particularly serious in regions where livestock production depends heavily on seasonal grazing and locally available fodder.Another important concern is the potential effect of climate change on infectious and parasitic diseases.

Changes in temperature, rainfall, and humidity may influence the survival, reproduction, and geographical distribution of disease-causing organisms and their vectors. Ticks, mosquitoes, flies, and other disease-transmitting organisms may become active in new locations or during longer periods of the year. Cartwright, S. L., Schmied, J., Karrow, N., & Mallard, B. A. (2023). Explained that Such changes can increase veterinary healthcare requirements and create additional challenges for disease surveillance and prevention. However, disease patterns differ according to geographical conditions, animal species, management practices, and local ecological factors.In developing countries, including Pakistan, climate-related livestock challenges are especially important because many farmers depend on traditional livestock production systems. Limited access to cooling facilities, veterinary services, quality feed, clean water, and financial resources can increase animal vulnerability. Therefore, appropriate adaptation strategies are necessary to protect livestock health and productivity. Improved animal housing, shade, ventilation, balanced nutrition, water availability, vaccination, disease monitoring, and climate-resilient breeding practices can help reduce environmental stress. This research investigates how climate change affects livestock health and productivity and identifies practical approaches for promoting sustainable animal production and welfare.

RESEARCH QUESTION

1. How does climate change affect livestock health, animal welfare, reproductive performance, and productivity, and which adaptation strategies can reduce its negative effects?

RESEARCH OBJECTIVES

1. To examine the effects of climate change on livestock health and physiological functions.

LITERATURE REVIEW

Climate change has become an important factor influencing the sustainability of livestock production systems. Rising temperatures, changing precipitation patterns, prolonged droughts, and extreme weather events create environmental conditions that challenge animal production. Habeeb, A. A., Osman, S. F., Teama, F. E., & Gad, A. E. (2023). Explains that Livestock animals require suitable environmental conditions to maintain normal body temperature, metabolism, growth, and reproductive functions. When environmental conditions exceed their adaptive capacity, animals experience physiological stress, which can reduce their productive performance. Anuta et al. (2025) explain that climate-related

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environmental stress affects livestock homeostasis and creates interconnected challenges for animal health, productivity, and agricultural systems. Their review also highlights the importance of climate-smart agricultural practices for improving livestock resilience.Livestock production is particularly vulnerable in tropical and subtropical regions because animals frequently experience high temperatures combined with humidity and intense solar radiation. These conditions can increase the environmental heat load and reduce animals' ability to lose excess body heat. The severity of the effects depends on animal species, breed, age, nutritional status, housing conditions, and management practices. High-producing animals may experience additional difficulties because their metabolic activities generate considerable internal heat. Therefore, climate change does not affect all livestock species equally, and adaptation strategies must consider their different physiological requirements.Heat stress occurs when animals cannot maintain their normal body temperature because environmental heat exceeds their ability to dissipate it. Under high-temperature conditions, animals activate physiological mechanisms such as increased respiration, sweating, panting, and water consumption. These responses help regulate body temperature but require additional energy and can interfere with normal biological functions. Prolonged heat exposure may result in dehydration, oxidative stress, metabolic disturbances, and reduced immune performance.Cartwright et al. (2023) examined the impact of heat stress on dairy cattle and discussed its relationship with animal health and thermotolerance. Their review emphasizes that heat stress influences physiological responses and creates challenges for dairy production. Animals exposed to persistent heat may show reduced activity, altered feeding behaviour, increased respiratory rates, and difficulty maintaining thermal balance. These responses can negatively affect animal welfare and increase susceptibility to additional health problems.

Heat stress can also influence the immune system. Physiological changes associated with excessive environmental heat may interfere with immune responses and increase the vulnerability of animals to infections. Dairy cattle may experience increased health-management requirements during periods of severe heat exposure. In poultry, high temperatures can disturb normal metabolic processes, reduce feed intake, and negatively affect growth and egg production. Therefore, maintaining appropriate environmental conditions is essential for protecting animal health. de Souza, W. M., Fumagalli, M. J., de Lima, S. T., Parise, P. L., Carvalho, D. C., Hernandez, C., ... & Weaver, S. C. (2024). revealed that Dairy cattle are particularly sensitive to environmental heat because milk production requires substantial metabolic energy. When temperatures increase, cows generally reduce feed intake to minimize internal heat production. Reduced nutrient consumption can decrease the availability of energy and protein required for milk synthesis. As a result, milk yield may decline, and changes may occur in milk composition, including fat and protein levels.Habeeb et al. (2023) discussed the detrimental effects of high environmental temperatures on the physiological responses, growth, milk production, and reproductive efficiency of ruminants. Their findings indicate that heat exposure can interfere with several important production-related processes. Dairy cows experiencing heat stress may also require longer recovery periods and additional management interventions.The impact of heat stress on dairy production depends on the duration and intensity of exposure. High humidity can make heat dissipation more difficult, even when temperatures are not exceptionally high. Buffaloes may also experience considerable heat-related difficulties because of their dark skin and limited sweating capacity. Providing shade, adequate drinking water, ventilation, and suitable cooling facilities can help reduce environmental stress and protect dairy productivity.

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Climate change can negatively affect the growth and meat production of livestock animals. High temperatures may reduce voluntary feed intake, resulting in insufficient nutrient availability for muscle development and body-weight gain. Animals experiencing prolonged heat stress may use more energy for thermoregulation rather than growth. This can increase the time required to reach market weight and raise production expenses.Poultry and pigs are also affected by high environmental temperatures. Heat stress can alter metabolic activity, digestive functions, and feeding behaviour. In poultry, excessive heat may reduce body-weight gain and negatively affect meat quality. In pigs, thermal stress can interfere with growth performance and reproductive functions. Prates (2025) discusses the physiological and molecular responses of monogastric livestock to heat stress and highlights the importance of appropriate nutritional and environmental management.Meat production systems may also experience economic losses because of reduced growth efficiency, increased mortality risks, and additional cooling expenses. Muzzo, B. I., Ramsey, R. D., Bladen, K., & Villalba, J. J. (2025). Elaborated on Therefore, livestock farmers should monitor environmental temperatures and provide appropriate housing and feeding conditions to maintain animal performance.Reproductive efficiency is an essential factor determining the profitability and sustainability of livestock production. Climate-related heat stress can negatively influence reproductive hormones, ovarian functions, sperm quality, fertilization, and embryo development. In female animals, elevated temperatures may interfere with normal reproductive cycles and reduce conception success. Heat exposure during pregnancy can also create additional physiological challenges for the mother and developing offspring.Male reproductive performance may also be affected by excessive environmental heat. Elevated temperatures can disturb normal testicular functions and negatively influence sperm production, sperm motility, and semen quality.

Animal nutrition is closely connected with climatic and environmental conditions. Climate change can influence pasture growth, fodder production, crop quality, and the availability of agricultural by-products used in livestock feeding. Prolonged droughts may reduce the availability of green fodder, while irregular rainfall can negatively affect crop production and grazing conditions. These challenges can increase competition for feed resources and raise livestock production costs.Muzzo et al. (2025) examined changes in climate and their implications for cattle nutrition and management. Their review highlights how changing temperature and precipitation patterns can affect pastureland, forage availability, and nutritional quality. Reduced feed availability can contribute to nutritional deficiencies, poor body condition, reduced growth, and lower reproductive performance.Heat stress can further complicate nutritional management because animals often reduce feed intake during hot weather. Farmers may need to adjust feeding schedules, provide balanced rations, and maintain adequate mineral and vitamin supplementation. Feeding animals during cooler periods, ensuring access to clean water, and storing fodder for periods of shortage are important measures for maintaining nutritional stability.Changing environmental conditions can influence the occurrence, distribution, and transmission of infectious and parasitic diseases. Temperature, rainfall, and humidity affect the development and survival of pathogens and disease-transmitting vectors. Ticks, mosquitoes, flies, and other arthropods may expand into geographical areas that previously had unsuitable climatic conditions. This can expose livestock populations to diseases and parasites that were previously uncommon in particular regions.De Souza and Weaver (2024) explain that climatic and environmental changes can influence the reproduction, survival, and geographical distribution of disease vectors. Their review emphasizes that the relationship between climate change and vector-

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borne diseases is complex because different environmental conditions may produce different effects on disease transmission.

METHODOLOGY

The present research adopts a systematic literature-based approach to investigate the impact of climate change on livestock health and productivity. The study focuses on identifying and examining scientific evidence related to environmental temperature, heat stress, animal nutrition, reproductive performance, infectious diseases, animal welfare, and livestock production. Relevant scientific literature published between 2023 and 2025 is considered to ensure that the research reflects recent developments in veterinary science and animal production. Information is obtained from peer-reviewed research articles, review papers, scientific journals, veterinary publications, and relevant reports available through academic databases, including Google Scholar, PubMed, ScienceDirect, and Frontiers. The selected literature is evaluated according to its relevance to the research objectives, scientific quality, publication date, and contribution to understanding climate-related livestock challenges. Particular attention is given to studies involving dairy cattle, buffaloes, sheep, goats, poultry, and other farm animals. The collected information is organized into major themes, including heat stress, physiological changes, milk production, growth performance, reproductive health, disease prevalence, feed availability, and climate adaptation. Furthermore, the research examines different management interventions, such as improved ventilation, shade provision, cooling systems, balanced feeding, water management, vaccination, and genetic selection for heat tolerance. The study also considers the situation of livestock farmers in developing countries, particularly Pakistan, where high temperatures, seasonal fodder shortages, and limited veterinary resources may increase climate-related production challenges. Information from different publications is compared to identify similarities, differences, research gaps, and possible solutions. Appropriate attention is given to the reliability of the sources and the accuracy of scientific interpretations.

DATA ANALYSIS

The data analysis process is based on the systematic examination, classification, comparison, and interpretation of information obtained from scientific publications and research reports. The collected literature is organized into different categories according to the major effects of climate change on livestock health and productivity. These categories include heat stress, physiological disturbances, milk production, meat production, reproductive performance, infectious diseases, animal nutrition, water availability, and animal welfare. Each category is examined to identify the major findings reported by previous researchers and understand the relationship between environmental conditions and livestock performance. Qualitative content analysis is used to identify recurring themes and patterns in the selected publications. For example, studies discussing increased environmental temperatures are examined to understand their association with reduced feed intake, increased respiration rates, dehydration, and changes in metabolic activity. Research concerning dairy animals is evaluated to identify reported relationships between heat exposure and milk production, while studies on reproductive health are examined for evidence of changes in fertility, conception rates, and reproductive cycles. Information concerning poultry and small ruminants is also compared to identify differences in species-specific responses to environmental stress. Furthermore, the analysis considers how nutritional management, housing facilities, vaccination, veterinary care, and genetic improvement influence the ability of animals to

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tolerate changing climatic conditions. Where comparable quantitative findings are reported in the literature, they are interpreted in relation to the study population, animal species, environmental conditions, and research methods. Different studies are not treated as directly comparable when their measurement methods or experimental conditions differ. The analysis also identifies the challenges experienced by smallholder livestock farmers, especially in developing countries where financial limitations and inadequate infrastructure can restrict adaptation opportunities. The findings are interpreted according to the research objectives, and the major results are presented in a descriptive and thematic manner. This approach provides an overall understanding of climate-related risks and helps identify practical recommendations for improving livestock productivity and animal welfare.

RESEARCH DESIGN

This research follows a descriptive and exploratory research design based on a review of existing scientific literature. The descriptive component examines the major effects of climate change on livestock health, production, reproduction, nutrition, and welfare, while the exploratory component investigates possible adaptation and mitigation strategies. The research uses a non-experimental approach because it does not involve direct manipulation of environmental conditions or biological treatments. Instead, it evaluates previously published scientific findings to develop a comprehensive understanding of the research problem. The main units of analysis include livestock species such as cattle, buffaloes, sheep, goats, and poultry, with particular attention to their responses to increasing temperatures, changing rainfall patterns, droughts, and extreme weather events. The study also considers different livestock production systems, including intensive, semi-intensive, and traditional farming systems. Scientific publications from 2023 to 2025 are used as the principal literature selection period. Relevant publications are identified through academic databases and selected according to their scientific relevance and connection with the research objectives. The information is classified into thematic areas to facilitate comparison and interpretation. The research design also incorporates a regional perspective by considering livestock production challenges in Pakistan and other developing countries. Particular attention is given to the relationship between environmental stress, animal management, and farmers' economic conditions. The findings are synthesized to identify major trends, knowledge gaps, and practical recommendations. This research design is appropriate because climate change affects livestock through multiple interconnected factors that require examination from veterinary, nutritional, environmental, and agricultural perspectives.

FINDINGS

The findings synthesized from the reviewed literature indicate that climate change negatively influences livestock health, animal welfare, and productivity through several interconnected mechanisms. Increasing environmental temperatures and prolonged exposure to heat are identified as major challenges for farm animals, particularly in tropical and subtropical regions. Heat stress is associated with increased respiration rates, excessive water consumption, reduced feed intake, dehydration, and physiological disturbances. These responses can interfere with normal metabolic functions and reduce the productive performance of livestock. Dairy animals are particularly affected because heat stress can reduce milk production and negatively influence reproductive efficiency. The reviewed literature also indicates that high environmental temperatures can affect growth performance and feed conversion efficiency in meat-producing animals. Poultry birds may experience

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reduced feed consumption, slower growth, lower egg production, and increased mortality risks during severe heat conditions. Another important finding is that climate change can affect livestock nutrition through drought, irregular rainfall, reduced pasture growth, and shortages of quality fodder. Inadequate nutrition may contribute to poor body condition, reduced immunity, and reproductive problems. The literature also indicates that changing climatic conditions can influence the geographical distribution and activity of disease-transmitting vectors, creating additional challenges for livestock disease prevention. Animal welfare is another major concern because excessive heat, water shortages, and inadequate housing can cause discomfort and physiological stress. However, the reviewed studies suggest that appropriate management interventions can reduce several negative effects. Shade, ventilation, cooling facilities, sufficient drinking water, balanced feeding, disease monitoring, and climate-resilient breeding are important adaptation measures. The literature further suggests that the effectiveness of these interventions depends on local environmental conditions, animal species, available resources, and farm management practices. For developing countries such as Pakistan, affordable adaptation strategies and improved veterinary services are particularly important. Overall, the reviewed evidence indicates that integrated livestock management is necessary to reduce climate-related risks and maintain sustainable animal production.

CONCLUSION

Climate change represents a serious challenge to livestock health, animal welfare, and agricultural productivity worldwide. Increasing temperatures, irregular rainfall, droughts, floods, and extreme weather conditions can negatively influence the physiological functions and productive performance of farm animals. The present research highlights that heat stress is one of the most important pathways through which climate change affects livestock. Prolonged exposure to high temperatures can reduce feed consumption, increase dehydration, disturb metabolic functions, and negatively influence milk production, growth, and reproductive efficiency. Climate change can also affect the availability and nutritional quality of animal feed and water resources, increasing the risk of nutritional deficiencies and reduced animal performance. Furthermore, changing environmental conditions may influence the distribution and transmission of infectious and parasitic diseases, creating additional challenges for veterinary healthcare systems. Animal welfare is equally important because livestock exposed to excessive heat and inadequate environmental conditions may experience discomfort, physiological stress, and increased disease susceptibility. The reviewed literature indicates that effective adaptation strategies can reduce several of these negative effects. Improved animal housing, shade, ventilation, cooling facilities, balanced nutrition, clean drinking water, vaccination, regular veterinary examinations, and climate-resilient breeding programmes should be considered essential components of sustainable livestock management. In Pakistan and other developing countries, greater attention should be given to smallholder farmers because they may have limited financial and technological resources to manage climate-related challenges. Government institutions, veterinary professionals, agricultural researchers, and livestock farmers should work together to strengthen climate adaptation programmes and improve access to veterinary services. Farmer education, scientific research, effective policies, and investment in sustainable livestock infrastructure are also necessary. In conclusion, protecting livestock from climate change requires an integrated approach that combines veterinary healthcare, nutritional management, animal welfare, environmental protection, and sustainable agricultural practices. These efforts can

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help maintain livestock productivity, improve animal health, protect farmers' livelihoods, and strengthen long-term food security under changing climatic conditions.

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