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Impact of Climate Change on Livestock Health and Productivity

Sanan Thaer Abdal-Wahab[1*], Hussam Majid Shihab Alobaidi[2], Mariam Jamal[3], Zainab J. Kadeem[4], Mohammed Ahmed Mustafa[5], Khadija Fahim Mohsen[6], Liwaa Ali Hussein[7], Hasan Abdullah[8]

[1]Department of Medical Laboratory Techniques, Al-Turath University, Baghdad, Iraq; [2]Al-Iraqia University Department Of Administrative And Financial Affairs; [3]College of Pharmacy, Al-Bayan University, Baghdad, Iraq; [4]Department of Medical Laboratory Techniques, College of Medical Techniques, Al-Farahidi University, Baghdad, Iraq; [5]Department of Biology, College of Education, University of Samarra, Iraq; [6]Department of Medical Laboratories Technology, Al-Nisour University College, Baghdad, Iraq; [7]Mazaya University College, Iraq; [8]Department of Optical Techniques, Al-Zahrawi University College, Karbala, Iraq.

Abstract | Climate variability has become an important issue threatening the health and productivity of livestock, with enhanced temperature, uneven rainfall, and enhanced frequency of severe weather contributing to heat stress, water deficits, and the incidence of disease. This study evaluates the role of climate variability in influencing the welfare of livestock in arid, semi-arid, and humid environments using main physiological, environmental, and economic factors contributing to livestock wellbeing. Impacts include decreased milk production (15-25%) and weight loss in beef cows (18-22%), with water and pasture deficiencies raising the reliance on supplemental feeding by 65% during dry periods. Humidity and rainfall also promote increased disease levels, with tick infestations (40%) and respiratory diseases (35%) most common in humid areas. Additional economic losses from lost productivity, raised feed costs, and elevated veterinary bills further tighten the belts of livestock farmers, especially small farmers. To curb these effects, adaptation measures that include breeding thermally tolerant animals, enhancing the housing and cooling systems, employing sustainable water use, and advanced veterinary care are advised. The results highlight the importance of climatic resilient animal husbandry measures to maintain productivity and economic feasibility in the face of shifting weather patterns.

Keywords | Climate change, Livestock health, Heat stress, Disease prevalence, Productivity loss

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***Correspondence** | Sanan Thaer Abdal-Wahab, Department of Medical Laboratory Techniques, Al-Turath University, Baghdad, Iraq; **Email:** mariam.j@albayan.edu.iq
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INTRODUCTION

The factual evidence about climate change produces widespread global complications that affect both ecosystems and both economies and human lives (Abdela, 2016). Livestock production remains the most affected sector because it supports worldwide food stability as well as rural economies and financial security (Abdurehman and Ameha, 2018). Recent studies by Hsu *et al.* (2024) and Govindarajan *et al.* (2023) emphasize that climate-induced stresses on livestock systems are now evident across multiple continents, amplifying risks to smallholder farmers. Livestock farmers experience growing pressures due to changing climate patterns which cause temperature alterations alongside altered precipitation behavior as well as heightened occurrences of extreme weather (Ali, 2018). These environmental factors damage the physical condition of animals together with blocking normal grazing patterns while lowering water and food availability and resulting in disease transmission among livestock (Ali *et al*., 2020; Kadham *et al*., 2023). Knowledge about climate change impacts on livestock health together with productivity status is essential for creating successful adaptation plans to preserve this crucial economic sector (Bekele, 2017; Karupusamy *et al*., 2023; Saadh *et al*., 2024).

Climate change produces most visible effects through temperature increases which strongly affect animal heat tolerance (Bernabucci, 2019; Al-Saadi and Shwan, 2024). The increase in temperatures threatens animals by reducing feed consumption while simultaneously affecting their reproduction capabilities and their ability to grow and produce milk and meat reduces (Bogale and Erena, 2022; Ahmad *et al*., 2019). Temperature elevations and heat stress disrupt metabolism while impeding the immune defense mechanism making animals more prone to diseases (Chauhan, 2014; Alhaqmuhamad *et al*., 2019; Zangana *et al*., 2022). An accelerated drainage of water because of heat causes additional physiological burden on animals (Cheng *et al*., 2022; Noman and Ahmad, 2023). The combined effect of heat stress with dehydration produces a negative impact on productivity at multiple levels and death in certain sensitive species including dairy cattle and poultry (Das, 2017; Ahmad and Noman, 2023; Ahmad *et al*., 2024). Elevated humidity in the climate leads to ideal breeding conditions for pathogen-transmitting agents and disease-causing biological agents (Das, 2018; Laylani *et al*., 2024; Ahmad, 2025). Climate change changes how diseases propagate throughout communities (Desalegn, 2016; Mohamad *et al*., 2025; Ramadhan *et al*., 2025). Warming temperatures and shifting rainfall patterns allow parasites, germs, and viruses to infiltrate cattle land and expose them to new or stronger disease strains (Gaughan, 2015; Saadoon *et al*., 2025; Saed *et al*., 2024). Vector-borne diseases like foot-and-mouth, tick infestations (Getu et al., 2015), and avian influenza are increasing, raising veterinary expenses and decreasing herd productivity (Abdulateef *et al*., 2024; Abed *et al*., 2024). Long-term drought and flooding spread waterborne and respiratory infections that harm animals (Grossi *et al*., 2019; Thabet and Alsalame, 2024; Alsalame and Laylani, 2024). Improved surveillance (Grossi *et al*., 2019), timely detection, and disease control will reduce climate change's demand-side consequences on disease incidence and losses (Hristov, 2018; Abdulnabi *et al*., 2024; Alsalame, 2019; Al-Aameli *et al*., 2019).

MATERIALS AND METHODS

Study design

The study evaluated climate change's impact on animal health and productivity in three climatic zones. Over six months, 50 farms in arid, semi-arid, and humid conditions were surveyed, analyzing seasonal fluctuations in climate-induced effects. Farms used various management systems.

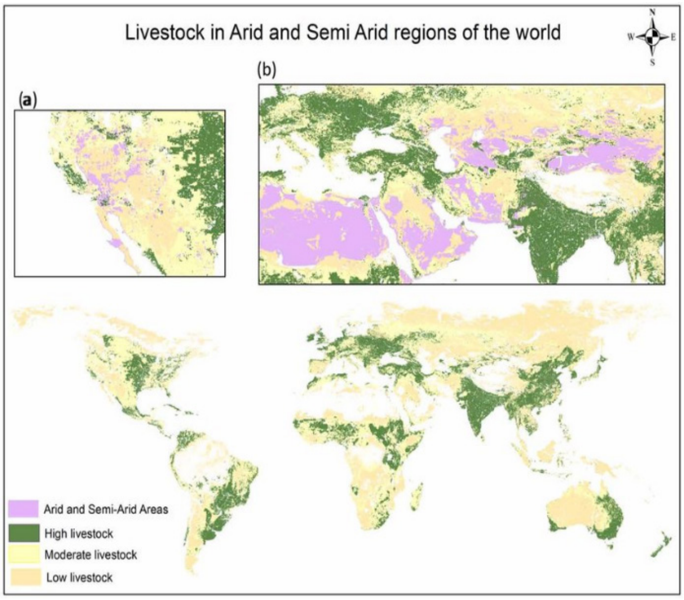

Figure 1: Study locations across different climatic zones.

Data collection

A data collection using a combination of direct measurement of livestock, farm record analysis, and meteorological data was employed. The research centered on physiological parameters, productivity factors, and climatic variables, all measured at weekly frequencies.

Climate data collection

Meteorological data were obtained from local weather stations near the study farms (Husen *et al*., 2022). The key climate parameters recorded included:

- Temperature (°C): Recorded at morning and afternoon using digital temperature sensors.
- Relative Humidity (%): Measured using hygrometers placed within livestock shelters.
- Rainfall (mm): Collected from regional meteorological department records.
- Wind speed (km/h): Measured using portable anemometers at study sites.

Livestock health and productivity assessment

The research evaluated heat stress, feed consumption, water intake, and productivity losses in cattle, sheep, and goats under various climatic conditions. Table 1 shows the most important physiological and productivity parameters observed across livestock species.

Table 1: Measured parameters for livestock health and productivity.

Parameter	Measurement method	Frequency
Body temperature (°C)	Digital thermometer (Rectal)	Weekly
Respiration rate (breaths/min)	Direct observation	Weekly
Feed intake (kg/day)	Weighing before and after feeding	Daily
Water consumption (L/day)	Manual recording	Daily
Weight gain (kg/month)	Digital weighing scale	Monthly
Disease incidence (%)	Veterinary reports	Monthly

Heat stress and animal behavior

Heat stress was assessed using the Temperature-Humidity Index (THI), calculated using:

$$THI = (0.8 \times T) + \left(\frac{RH}{100} \times (T - 14.4)\right) + 46.4$$

Where T is air temperature (°C) and RH is relative humidity (%). A THI above 72 was considered stressful, with animals showing increased panting, reduced feed intake, and abnormal behavior (Kebede, 2016).

Forage and water availability

For purposes of assessing climate change effects on food and water content (Koirala and Bhandari 2019), there has been monitoring on forage productivity and use patterns of water across the subject areas.

- Forage quality was rated according to visual condition, grazing behavior, and farmer-reported availability.
- Water sources were recorded, categorizing natural vs. artificial sources, and evaluating water shortages across various climate zones.

Table 2 shows the effect of seasonality on pasture growth, grazing period, and supplementary feeding requirement.

Table 2: Seasonal variations in forage availability.

Season	Forage growth (kg/ha)	Grazing duration (hours/day)	Supplementary feeding (%)
Dry season	300 – 500	3 – 5	65%
Wet season	800 – 1200	6 – 8	30%

Disease prevalence and veterinary observations

Livestock disease trends were monitored through routine veterinary check-ups and farmer surveys (Lacetera, 2019). Observations included:

- Heat-related disorders (e.g., dehydration, heatstroke).
- Parasitic infections, influenced by changing rainfall and humidity levels.
- Respiratory illnesses, prevalent in humid regions.

Disease prevalence was compared across climate zones, identifying regions with increased outbreaks linked to climate fluctuations.

Statistical analysis

Data were processed using SPSS v.26 and Microsoft Excel 2016. Descriptive statistics were employed to describe the effects of climate on livestock health. A Chi-square test was used to examine differences in disease prevalence among climate zones, and a one-way ANOVA was employed to find significant differences in livestock productivity owing to variations in climates (p-value < 0.05).

RESULTS AND DISCUSSION

Impact of climate variability on livestock health

Climate fluctuations impact animal health by altering temperature, humidity, and precipitation, influencing heat stress, disease incidence, and water intake. High temperatures in arid regions increase dehydration risk, while humidity promotes respiratory diseases and parasitic infestations. Recognizing these interactions is key to region-specific adaptation. Table 3 details climatic gradients, and Figure 3 illustrates their link to disease prevalence.

Table 3: Climatic conditions across study regions.

Climate zone	Mean temperature (°C)	Relative humidity (%)	Annual rainfall (mm)
Arid	36.5 ± 2.1	25 ± 3	250 ± 40
Semi-Arid	31.8 ± 1.7	40 ± 5	500 ± 60
Humid	28.2 ± 1.5	70 ± 4	1100 ± 80

Table 3 shows climatic differences between arid, semi-arid, and humid regions, affecting livestock health. Arid regions have the greatest heat stress hazards (36.5°C, 25% RH), whereas humid regions (70% RH, 1100 mm rainfall) have higher bacterial and parasitic risks. Semi-arid regions have intermediate conditions, ranging between heat stress and moisture-borne diseases.

Figure 3 shows that humidity (40%) and rainfall (45%) influence disease prevalence more than temperature (35%). This highlights the need for targeted disease prevention in high-rainfall and humid regions to mitigate climate-related health risks.

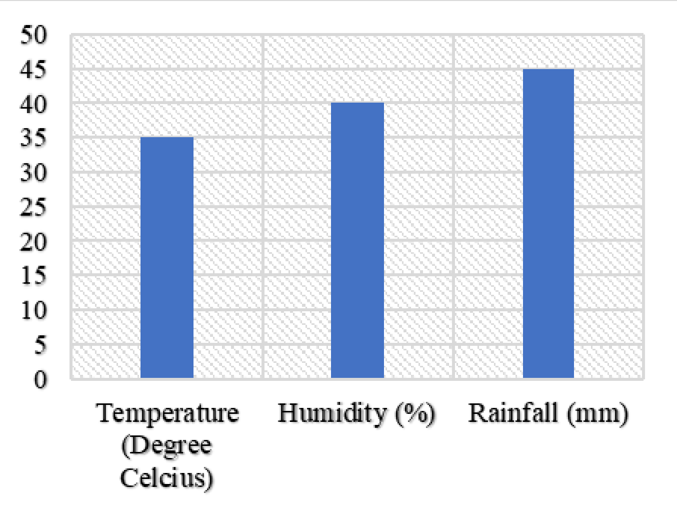

Figure 3: Relationship between climatic factors and disease prevalence.

Heat stress and livestock productivity decline

Heat stress is a major challenge for livestock, especially in arid regions. The Temperature-Humidity Index (THI) measures heat stress, with THI > 72 being stressful and > 80 causing severe effects. Heat stress reduces feed intake, weight gain, milk production, and can lead to mortality. Affected livestock exhibit panting, excessive sweating, and increased water consumption, impacting productivity. Table 4 shows the correlation between rising THI levels and production losses in cattle, sheep, and goats.

Table 4: Effects of THI on livestock productivity.

THI range	Observed effects	Productivity loss (%)
< 72	No stress	0
72 - 79	Mild stress (reduced feed intake)	8 - 12
80 - 89	Moderate stress (lower weight gain)	15 - 20
> 90	Severe stress (high mortality risk)	25 - 40

Table 4 shows that rising THI significantly reduces livestock productivity. Moderate heat stress (THI 72-79) causes 8-12% losses, while THI 80-89 increases losses to 15-20%, impairing weight gain and reproduction. Severe stress (THI > 90) leads to 25-40% losses, including high mortality risk. Prolonged heat lowers milk yield by 15-25% and beef weight by 18-22%. These findings highlight the need for ventilation, shade, water access, and heat-resistant livestock to sustain productivity.

Forage and water scarcity due to climate change

Availability of fodder and water sources are among key determinants affecting livestock production and well-being (Madziga, 2021). Climate change has increased the rate and severity of drought and unseasonal rains, leading to low grass coverage and scarcity of water. Table 5 shows seasonal fluctuations in the availability of forage and water intake and describes how climate variability affects the grazing situation and resource reliance in livestock farming.

Table 5: Seasonal differences in forage availability and water consumption.

Season	Forage growth (kg/ha)	Supplementary feeding (%)	Water consumption (L/day)
Dry season	350 – 500	65%	30 – 40
Wet season	900 – 1300	30%	50 – 60

Table 5 shows that water and forage intake drop in dry periods, increasing supplement reliance. Wet season pasture (900–1300 kg/ha) supports 30% supplementation, while dry season (350–500 kg/ha) requires 65% more. Water intake decreases from 50–60 L/day to 30–40 L/day, affecting livestock health. These findings stress the need for sustainable water conservation, grazing management, and climate-resilient forage crops.

Climate change and disease prevalence

Climate change has greatly transformed the incidence and distribution of animal diseases, as increasing temperatures, humidity, and changing rainfall patterns have provided favorable environments for the outbreak of disease. Heat stress, vector-borne diseases, and respiratory diseases have become increasingly prevalent in animals in arid (Mondal and Reddy, 2018), semi-arid, and humid areas. Extended exposure to elevated temperatures in dry regions worsens heat stress diseases, while tropical and semi-arid regions with high humidity facilitate the growth of parasites, ticks, and bacterial infections (Nayak *et al*., 2022). Table 6 shows the latest prevalence of climate-related diseases in various climatic regions, and Figure 4 shows the rising trend of disease outbreaks over time due to climate change.

Table 6: Prevalence of climate-related diseases.

Disease type	Arid (%)	Semi-Arid (%)	Humid (%)
Heat stress disorders	35	20	10
Tick infestations	15	25	40
Respiratory infections	10	20	35
Foot and mouth disease	12	18	30

Table 6 shows that heat stress diseases are highest in dry areas (35%) due to hot temperatures and low humidity, leading to dehydration and metabolic disorders. In contrast, tick infestations (40%) and respiratory infections (35%) are more common in moist areas, where high humidity and rainfall foster parasitic and bacterial infections. Foot and Mouth Disease (FMD) is more prevalent in humid (30%) and semi-arid areas (18%) due to increased livestock mobility and moisture-promoted pathogen transmission.

These findings emphasize the need for climate-resilient disease prevention, including vector control, ventilation, and immunization.

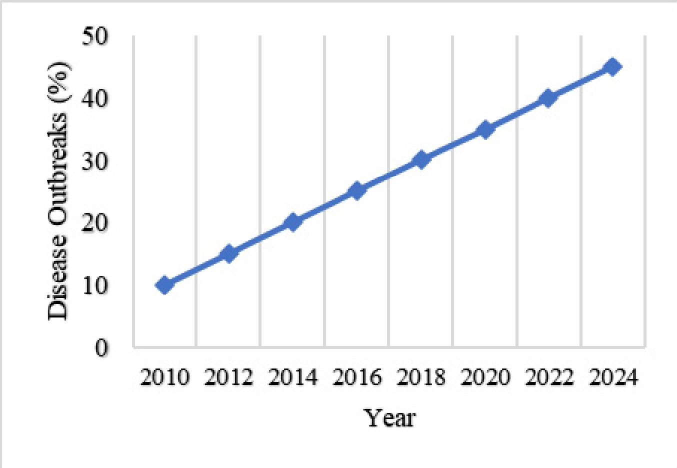

Figure 4: Disease outbreaks linked to climate change

Figure 4 shows a steady rise in disease outbreaks from 2010 to 2024, with prevalence increasing from 10% to 50%. This trend indicates that climate change has significantly contributed to the spread and severity of livestock diseases. Temperature, humidity, and rainfall fluctuations have created favorable conditions for pathogens, leading to more frequent and intense outbreaks. This highlights the urgent need for enhanced surveillance, early warning systems, and climate-resilient veterinary interventions.

Economic impact of climate change on livestock farmers

The financial cost of climate change to livestock production has been rising continuously, fueled by increased feed prices, veterinary costs, and productivity losses (Özkan *et al*., 2016). Table 7 illustrates the economic effects of climatic factors on livestock farmers, and Figure 5 displays the increasing expenses in terms of feed, veterinary services, and water scarcity.

Table 7: Economic losses due to climate-related factors.

Factor	Productivity loss (%)	Financial impact (USD per year)
Reduced milk yield	15 - 25	8,000 - 15,000
Increased feed costs	30 - 40	5,000 - 10,000
Higher veterinary expenses	20 - 30	3,000 - 7,000

Table 7 shows that lower milk yield leads to annual losses of $8,000 to $15,000, while higher feed costs add another $5,000 to $10,000, especially in drought-affected areas. Increased veterinary expenses due to diseases and heat stress contribute an additional $3,000 to $7,000 annually. These losses highlight the need for climate-resilient solutions, including improved pasture management, disease monitoring, and affordable feed alternatives.

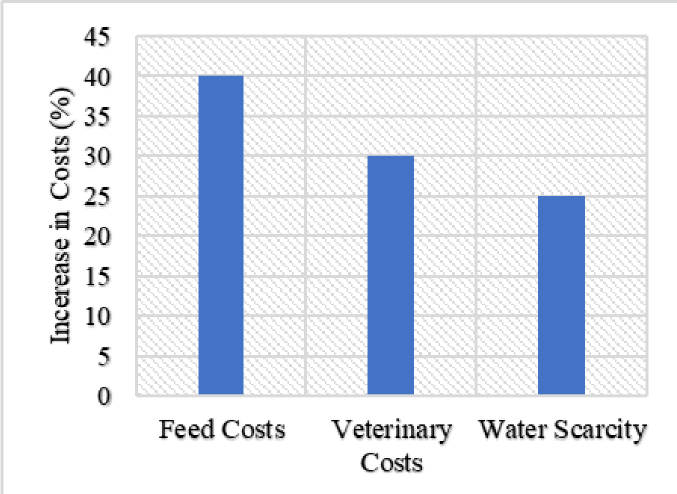

Figure 5: Rising costs of livestock farming due to climate variability.

Figure 5 shows that feed costs have increased by 40%, becoming the largest expense for livestock farmers, especially in drought-prone areas. Veterinary costs rose by 30% due to heat stress and infectious diseases, particularly in tropical regions. Water-related costs increased by 25%, reflecting the rising cost of water access in arid areas. These findings stress the need for financial support, including subsidies and climate adaptation programs, to ease the economic burden on farmers.

Implications of climate change on livestock farming

This research shows that climate change harms livestock health, productivity, and economic viability. Key trends include:

- Heat stress reduces productivity, especially in dairy cows and beef cattle (Sánchez *et al*., 2020), requiring cooling and shading in hot areas.
- Drought-induced forage and water shortages raise feeding costs, leading to higher production expenses and reliance on commercial feed.
- Climate affects disease rates, with respiratory disorders increasing in wet areas and heat stress-related illnesses in dry regions (Sejian *et al*., 2015), highlighting the need for better veterinary care.
- Smallholder producers face challenges like high feed prices, costly veterinary services, and economic losses (Singh and Ukey, 2024), requiring affordable livestock management improvements.

Strategies for climate-resilient livestock farming

To address climate change challenges, adaptation measures must boost livestock resilience and farm sustainability:

- Selective breeding of heat-tolerant livestock can

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improve resistance to extreme temperatures (Soumya *et al*., 2022).
- Cooling systems like ventilated barns and shaded shelters can reduce heat stress and its impact on feed intake.
- Efficient water management, including rainwater collection and better irrigation, ensures a steady water supply.
- Expanding animal health services and immunization programs is crucial to combat climate-related diseases. These strategies will improve resilience, maintain productivity (Tiruneh and Tegene, 2018), and minimize climate-related economic impacts.

CONCLUSION AND RECOMMENDATIONS

The study confirms that climate change has been disastrous to the livelihood of the livestock through impacts that have affected health, productivity and economic behavior to livestock producers as temperatures rise, rainfall becomes irregular, and disease incidences rise. These factors have combined to reduce milk production, animal weight and an additional load of cost to the growers especially the small ones due to heat stress by animals, limited forage and expenditure on vet services. Therefore, the measures required to adapt to climate change must focus on developing more resilient livestock, the use of efficient cooling systems, improvement of pastures and water as well as disease control and vaccination. Other policies and political instruments and measures of finance also have to be put in place to support climate proof livestock to enhance sustainable production and food security with the background of continuing climate change.

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NOVELTY STATEMENT

In this study, the new features include combining the THI measures with the forage availability and disease prevalence during the different seasons that determines the climate change impact on livestock production, health and loss. It provides regional recommendations and offers convenient changes such as heat-tolerant breeds, optimal feeding, and climate-proof veterinary care to increase livestock's resilience.

AUTHOR'S CONTRIBUTION

All of the trials were designed by AIA-A, MJ and ZJK. MAM and KFM conducted all of the tests, gathered the data, and composed the manuscript draft. LAH and HA helped with the data analysis that was done to prepare the work for submission to the journal. The final draft of the work was reviewed and approved by all authors for publication in the Journal of Animal and Health Production.

Ethical consideration

Not applicable.

Conflict of interest

The authors have declared no conflict of interest.

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