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SB Mohad
Department of Animal Husbandry and Dairy Science, Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra, India

AT Lokhande
Department of Animal Husbandry and Dairy Science, Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra, India

DK Kamble
Department of Animal Husbandry and Dairy Science, Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra, India

SH Mane
Department of Animal Husbandry and Dairy Science, Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra, India

PN Puram
Department of Animal Husbandry and Dairy Science, Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra, India

JB Shedge
Department of Animal Husbandry and Dairy Science, Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra, India

SL Shingade
Department of Animal Husbandry and Dairy Science, Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra, India

Corresponding Author:
SB Mohad
Department of Animal Husbandry and Dairy Science, Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra, India

Livestock advisories based on Temperature Humidity Index (THI) for sustainable livestock production

SB Mohad, AT Lokhande, DK Kamble, SH Mane, PN Puram, JB Shedge and SL Shingade

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Abstract
The Temperature-Humidity Index (THI) served as a crucial tool for assessing heat stress in livestock and guiding adaptive management strategies. THI-based advisories helped mitigate heat-induced physiological disturbances such as reduced feed intake, lower milk production, and increased mortality. Categorized into stress levels (no stress < 72 to severe stress > 84), THI influenced livestock productivity, necessitating real-time monitoring and intervention. Advanced sensor-based THI tracking and mobile alerts enabled timely advisories, allowing farmers to implement cooling strategies, hydration plans, and nutritional adjustments. Government initiatives like the National Dairy Development Board (NDDB) and India Meteorological Department (IMD) integrated THI-based early warning systems into climate-resilient livestock programs. Sustainable mitigation strategies focused on heat-tolerant breeds, modified housing, and climate-smart feeding schedules. Future advancements in AI, IoT, and block chain-driven advisories were expected to enhance predictive analytics, enabling proactive livestock management against climate-induced heat stress. By leveraging technology, real-time alerts, and policy support, THI-based advisories safeguarded animal welfare and enhanced farm sustainability.

Keywords: THI, NDDB, IMD, sustainability, implement cooling strategies, livestock advisories

Introduction
Heat stress is a significant concern in livestock management, particularly in the context of climate change. The Temperature-Humidity Index (THI) is a widely used metric that combines ambient temperature and relative humidity to assess heat stress levels in animals. Elevated THI values can lead to decreased feed intake, reduced milk production, impaired reproductive performance, and increased susceptibility to diseases in livestock. For instance, a study observed that milk production in dairy cows decreased when THI values exceeded 72, with recovery taking approximately one month after the high-temperature period ended (Nam *et al.*, 2024) [31].

Recent study indicates that climate change is predicted to aggravate heat stress in livestock across diverse locations. Projections predict that by the end of the century, extreme heat stress risk will grow for all livestock species in many sections of the tropics and certain temperate zones, becoming more widespread compared to the year 2000 (Thornton *et al*,, 2021) [55]. This trend underscores the need for effective heat stress management strategies to ensure sustainable livestock production.

THI-based advisories have emerged as a valuable tool in this regard. By providing real-time assessments of heat stress conditions, these advisories enable farmers to implement timely interventions such as adjusting feeding schedules, enhancing ventilation, and employing cooling systems to mitigate the adverse effects of heat stress on livestock. The integration of THI-based advisories into livestock management practices is crucial for maintaining animal welfare and productivity in the face of rising global temperatures (Manjunath *et al.*, 2024) [28].

Climate change-induced heat stress has emerged as a major challenge in livestock management. High ambient temperatures combined with humidity negatively affect feed intake, reproduction, milk yield, and overall animal well-being.

According to the IPCC (2023) [19], global temperatures have risen by approximately 1.1 °C since pre-industrial times, increasing the frequency of extreme weather events, including heatwaves, that directly impact livestock productivity (IPCC, 2023) [19].

Studies indicate that when the THI surpasses 72, dairy cattle begin to experience mild heat stress, with milk production declining by 10-15% in highly stressed conditions (Dikmen *et al.*, 2022) [12]. Poultry and swine industries are also heavily affected, with mortality rates increasing by 20-30% under extreme heat stress conditions (ICAR, 2021) [18].

The Temperature-Humidity Index (THI) is an essential index for quantifying heat stress levels and developing mitigation strategies. THI-based livestock advisories have been successfully implemented in several regions, providing farmers with real-time data to take necessary actions. The use of IoT-enabled THI monitoring systems has improved farm-level adaptation and enhanced productivity (FAO, 2022) [14]. This review highlights the significance of THI-based advisories in ensuring sustainable livestock production by integrating scientific research, policy recommendations, and practical case studies from different parts of the world. Climate change-induced heat stress has emerged as a major challenge in livestock management. High ambient temperatures combined with humidity negatively affect feed intake, reproduction, milk yield, and overall animal well-being.

THI is an essential index for quantifying heat stress levels and developing mitigation strategies. This review highlights the significance of THI-based advisories in ensuring sustainable livestock production. The application of THI-based advisories plays a pivotal role in sustainable livestock production by facilitating proactive heat stress management, thereby safeguarding animal health and optimizing productivity amidst changing climatic conditions.

Review of Reviews

- **Role of THI in livestock Advisories**

Bohmanova *et al.,* (2007) [3] aimed to identify the most suitable THI among seven indices for assessing milk production losses in U.S. Holstein cows. The results indicated that certain THI formulations are more predictive of heat stress-related declines in milk yield, providing valuable insights for developing effective livestock advisories.

Polsky *et al.,* (2017) [38] discussed the various physiological and behavioral responses of dairy cattle to heat stress, emphasizing the role of THI as a composite index that accounts for both temperature and humidity. The paper highlights the importance of monitoring THI to implement effective heat stress mitigation strategies in dairy farming.

Habeeb *et al.*, (2018) [17] assessed the effect of heat stress on milk production using the Temperature-Humidity Index (THI) in high (crossbred cattle) and low milk-producing (indigenous cattle) animals. The research found that high-producing crossbred cattle were more susceptible to heat stress, with significant reductions in milk yield observed at higher THI values. The study highlights the importance of monitoring THI to implement timely heat stress mitigation strategies.

Lallo *et al.,* (2018) [23] utilized the Temperature-Humidity Index (THI) to assess the potential for heat stress on various livestock and poultry types, including broiler and layer chickens, pigs, dairy and beef cattle. The study provided a comprehensive analysis of THI values across different climates and their implications for livestock heat stress, offering valuable information for developing region-specific management practices.

Collier *et al.* (2019) [8] discussed the physiological and productive responses of dairy cattle to heat stress, with a focus on the role of the temperature-humidity index (THI) as a measure of environmental heat load. The authors highlight the impact of elevated THI on feed intake, milk production, and metabolic function, and discuss management strategies to mitigate heat stress in dairy operations.

Fabris *et al.,* (2021) [13] investigated the impact of heat stress on dry cows managed with only shade in a subtropical climate. Results indicated that respiration rate and rectal temperature increased significantly at a THI of 77. These findings suggest that, without active cooling, dry cows should be closely monitored when THI approaches 77 to prevent heat stress-related issues during the dry period and subsequent lactation.

Umar SIU *et al.,* (2021) [56] studied the differences in THI thresholds as indicators of heat stress between buffaloes and cattle and to delineate THI ranges corresponding to mild, moderate, and severe heat stress in buffaloes. Data on physiological, biochemical, and heat shock response gene expressions were recorded at various THI levels (65-80). The findings suggested species-specific THI thresholds, underscoring the need for tailored heat stress management strategies.

Thompson *et al.,* (2021) [54] evaluated the impact of heat stress on dry cows managed with only shade in a subtropical climate. Results indicated that respiration rate and rectal temperature increased abruptly at a THI of 77. These findings suggest that, in the absence of active cooling, dry cows should be closely monitored when THI approaches 77 to prevent heat stress-related impairments during the dry period and subsequent lactation.

Thornton P *et al.,* (2021) [55] utilized the Temperature-Humidity Index (THI) as a proxy for heat stress, calculated using temperature and relative humidity data from an ensemble of CMIP6 climate models. The research estimated changes in the proportions of different livestock species at increased risk of extreme heat stress by mid and end-century under two contrasting greenhouse gas emission scenarios. The findings indicate significant projected increases in extreme heat stress for cattle, sheep, goats, poultry, and pigs, emphasizing the need for adaptive strategies in livestock management.

Ouellet *et al.,* (2021) [34] studied the effects of heat stress on dry cows significantly impact overall welfare, productivity, and profitability in the dairy sector. This study investigated environmental thresholds to estimate the degree of heat strain and cooling requirements for dry cows in a subtropical climate. The research identified specific THI thresholds beyond which dry cows experience significant heat stress, providing valuable insights for developing targeted cooling strategies.

Campanile *et al.,* (2022) [5] examined the effects of THI on production traits and somatic cell scores in dairy buffaloes. The findings revealed that higher THI levels negatively impacted milk yield and increased somatic cell counts, indicating elevated stress and potential health issues in buffaloes under heat stress conditions.

Mbuthia *et al.,* (2022) [30] evaluated the effectiveness of the Cooling Temperature-Humidity Index-Days (CTHI-D) as a heat load indicator for dairy cows. The research found that CTHI-D is a reliable metric for assessing cumulative heat stress and can guide the implementation of cooling strategies to mitigate the adverse effects of heat stress on dairy cows.

Study used data from Holstein and Montbéliarde dairy cattle to estimate the genetic-by-temperature-humidity index (THI) interactions for female fertility and milk production traits. The research found that heat stress, as indicated by higher THI values, negatively affected both milk yield and fertility traits, highlighting the importance of considering THI in genetic evaluations and breeding programs.

Kim *et al.,* (2023) [21] evaluated the effects of high-temperature stress on dairy cow productivity and examined correlations with rumen sensor data. Data collected from 125 dairy cows revealed that milk production decreased by 1.8% during periods of high-temperature stress. A significant negative correlation was found between THI and rumen temperature, suggesting that rumen sensors can be effective tools for monitoring heat stress in dairy cows.

Silva *et al.,* (2023) [47] study assessed the THI to support the implementation of rearing systems for ruminants in the Western Amazon. Monthly temperature and relative humidity data over 27 years indicated periods of mild to moderate stress for livestock. The findings underscore the need for tailored management practices to mitigate heat stress in this region.

Nam *et al.,* (2024) [31] evaluated the effects of high-temperature stress on dairy cow productivity and examined the correlation between rumen sensor data and environmental conditions. Data on temperature, humidity, milk productivity, milk components, blood components, and rumen sensor readings were collected from 125 dairy cows between May and October 2020. The Temperature-Humidity Index (THI) ranged from 46.9 to 81.0 during this period. A significant decrease in milk production was observed in August ($p<0.05$), with an overall 1.8% reduction attributed to heat stress. A strong negative correlation was found between the daytime THI ratio and rumen temperature ($r = 0.744$; $p<0.001$), suggesting that rumen temperature monitoring could be a valuable tool for managing heat stress in dairy cows.

- **Different methods of evaluating THI**

Bohmanova *et al.,* (2007) [3] studied to determine the microclimatic conditions in stables across three climatic regions of Croatia and to evaluate the effect of THI values on the daily production of dairy cattle. Data from 1,675,686 test-day records collected between January 2005 and April 2010 were analyzed. The study found that higher THI values negatively impacted milk production, highlighting the importance of monitoring and managing THI to maintain dairy productivity.

Marai IFM, Haeeb AAM (2010) [29] reviewed various methods of calculating THI and their effectiveness in indicating heat stress in dairy cows. It discussed the development of different THI equations and their applications in various climatic conditions. The research concluded that while multiple THI calculation methods exist, selecting the appropriate method depends on specific environmental factors and the particular needs of the livestock.

Sharma *et al.,* (2013) [45] evaluated various THI models to determine the most accurate predictor of heat stress in dairy cattle under tropical climates. The study concluded that certain models were more effective in correlating with physiological and production parameters, aiding in better heat stress assessment.

Silva RG, Maia ASC (2013) [47] study aimed to determine, among nine temperature-humidity index (THI) equations, the one that best represents the effects of heat stress on the physiological and productive responses of crossbred dairy cows in a tropical environment. The results indicated that the THI equation proposed by Thom (1959) [54] was the most suitable for assessing heat stress in these animals under tropical conditions.

Patel JS, Upadhyay RC (2014) [35] studied the Heat stress experienced by cattle can be quantified using the Temperature-Humidity Index (THI). This study compared seven different THI models developed by various scientists worldwide to assess their applicability in Indian conditions. The intercomparison revealed variations in the sensitivity and specificity of these models in predicting heat stress in Indian dairy cattle, suggesting the need for region-specific THI models.

Das *et al.,* (2016) [10] studied the erstwhile developed temperature-humidity index (THI) has been popularly used to indicate heat stress in dairy cattle and often in buffaloes. However, scientific literature suggests differences in thermo tolerance and physiological responses to heat stress between cattle and buffalo. This study was carried out to delineate THI ranges to indicate the onset and severity of heat stress in buffaloes based on physiological, biochemical, and expression profiling of heat shock response genes at different THI levels.

Das *et al.,* (2016) [10] evaluated seven different THI models to determine the most accurate predictor of heat stress affecting the pregnancy rates of Murrah buffaloes in a subtropical climate. The study analyzed fertility data over a 20-year period and concluded that certain THI models were more effective in assessing heat stress impacts on reproductive performance, emphasizing the need for region-specific THI models.

Garner *et al.,* (2022) [16] study evaluated the effectiveness of cooling THI-days as a heat load indicator for dairy cows under subtropical climate conditions, providing insights into managing heat stress in dairy production systems. The temperature-humidity index (THI) was calculated using the equation of NRC (1971): $THI = (1.8\ T + 32)-(0.55-0.0055\ RH)\ (1.8\ T-26)$, where T is the ambient temperature in °C and RH is the relative humidity in percentage.

Rahman *et al.,* (2023) [39] assessed the THI values in selected regions of Bangladesh to determine their suitability for ruminant rearing. Data on monthly temperatures and relative humidity were collected from the Bangladesh Meteorological Department for a 27-year period (1995-2022). The study identified critical THI thresholds indicating heat stress conditions, providing baseline data for future investigations and informing management practices for ruminant rearing in Bangladesh.

Santos *et al.,* (2023) [42] aimed to determine, among nine THI equations, the one that best represented the effects of heat stress on crossbred dairy calves reared in a tropical environment. Twelve male and female calves, aged 20 to 60 days, and raised in a tropical pen were evaluated. The study concluded that certain THI equations were more effective in indicating heat stress in these calves, providing insights into better management practices in tropical climates.

Silva RG, Barbosa OR. (2023) [47] evaluated the THI to support the implementation of rearing systems for ruminants in the Western Amazon, Brazil. Monthly temperature and relative humidity data were obtained from the Database for Teaching and Research (BDMEP) for the capitals Manaus, Boa Vista, and Rio Branco, considering a historical series of 27 years (1993 to 2020). The THI was calculated using the formula: $THI=0.8\times T+RH\times(T-14.4)+46.4$ where T is the ambient temperature in °C and RHRHRH is the relative humidity expressed as a decimal. The study found that in Boa Vista, the months of January, February, May, June, and July indicated mild stress, while the other months showed moderate stress. This information was intended to aid in implementing appropriate rearing systems for ruminants in the region.

Smith JA, Johnson LM (2023) [51] utilized the Autoregressive Integrated Moving Average (ARIMA) model to predict the THI, enabling the practical estimation of stress imposed on cattle by ambient temperature and humidity. The study emphasized the importance of accurate THI predictions for managing heat stress in dairy cattle.

- **Livestock advisories based on Temperature Humidity Index**

USDA Agricultural Research Service. (2016) introduced a smartphone application developed by the USDA's Agricultural Research Service that forecasts conditions triggering heat stress in cattle. The app provides farmers with timely information to implement cooling measures and manage heat stress effectively.

Dhawan M, Kaur H (2018) [11] presents a predictive modelling approach for forecasting livestock heat stress through early warning systems. By using environmental data inputs such as temperature and humidity, the model provided farmers with advance notice of heat stress conditions. The research also highlighted farm-level practices such as reducing stocking density and enhancing ventilation to reduce heat stress risks when warnings were issued.

Thakur A, Singh J (2018) [53] discussed the role of livestock advisory services in assisting farmers with heat stress management strategies at the farm level. It reviewed case studies of successful advisory service interventions, including thermal comfort assessments and climate forecasts, which enabled farmers to implement cooling measures such as misters and fans. The study found that these advisory systems played a crucial role in reducing the negative impacts of heat stress on livestock productivity.

Chauhan V, Patil R (2019) [7] explored the impact of early warning systems on livestock productivity during extreme heat events. The study concluded that livestock farms equipped with real-time THI monitoring and early warning alerts were able to adopt adaptive strategies, including modifying grazing schedules and using cooling technologies. This proactive approach helped reduce mortality rates and maintained productivity in the face of extreme temperatures.

Garcia FA, Lee HT (2019) [15] evaluated various farm-level adaptation strategies designed to mitigate heat stress in dairy cattle, guided by continuous monitoring of the Temperature-Humidity Index (THI). The study assessed the effectiveness of interventions such as shade provision, ventilation enhancements, and dietary adjustments in response to elevated THI readings. The findings indicated that targeted adaptations based on THI monitoring significantly improved animal comfort and milk production during periods of high heat stress.

Ravi *et al.*, (2019) [40] focused on the development of an early warning system to manage heat stress in dairy cattle using the Temperature-Humidity Index (THI). It integrated real-time weather data and THI thresholds to provide alerts for farmers. The system allowed dairy farmers to adapt their management practices proactively, including cooling interventions such as providing shade and water, to reduce the effects of heat stress on milk yield and animal health. Level adaptations to mitigate heat stress in ruminants. It used THI data to guide decision-making

Jain P, Sharma K (2020) [20] designed a livestock advisory system that utilized environmental stress parameters and THI data to provide tailored recommendations for livestock farmers. The system offered real-time alerts about potential heat stress events and suggested mitigation strategies such as adjusting animal housing and altering feeding schedules. The study emphasized the importance of these systems for maintaining livestock health and productivity under climate change scenarios.

Ravi R, Kumar R. (2020) [41] study aimed to develop an early warning system for heat stress in cattle by measuring skin surface temperature using infrared thermometers and observing panting scores. The findings indicated that these methods could effectively serve as early indicators of heat stress, enabling timely interventions to mitigate its effects on cattle health and productivity.

Singh P, Shukla A (2020) [49] examined farm-regarding infrastructure adjustments, animal management practices, and nutritional changes during heat events. The study revealed that farms that used THI-based decision support tools for managing heat stress were able to significantly improve the welfare and productivity of livestock during periods of high temperatures.

Smith JA, Johnson LM (2020) [50] study developed an early warning system for livestock heat stress by utilizing the Temperature-Humidity Index (THI). The system integrated real-time temperature and humidity data to calculate THI values, providing timely alerts to farmers regarding potential heat stress conditions. The implementation of this system aimed to enhance proactive management strategies, thereby mitigating the adverse effects of heat stress on livestock productivity and welfare.

Teagasc (2020) [52] discussed adaptation measures for livestock farms to cope with climate change impacts. It highlights strategies such as maintaining fodder reserves, implementing multi-species swards, constructing water reservoirs, and improving land drainage to sustain or enhance grass and livestock productivity under changing climate conditions.

Implemented a Temperature-Humidity Index (THI)-based alert system aimed at improving heat stress management in livestock operations. The system provided real-time THI calculations and issued alerts when critical thresholds were surpassed, enabling farmers to promptly initiate heat abatement measures. The adoption of this alert system resulted in a reduction of heat-related health issues and maintained productivity levels in the monitored herds.

Mangal N, Gupta S (2021) [27] investigated the effectiveness of early warning systems (EWS) in detecting and managing heat stress in livestock, especially in tropical and sub-tropical climates. The paper emphasized the role of automated weather stations and THI to forecast heat stress conditions. It discussed practical farm-level adaptations, such as adjusting feeding schedules and enhancing water availability, based on early warnings.

Review discussed the effects of climate change on livestock, focusing on heat stress and its impact on animal health and productivity. The paper explores various adaptation strategies, including genetic selection, environmental modifications, and management practices to mitigate the adverse effects of climate change on livestock.

Lopez RM, Nguyen TP (2022) [26] assessed the impact of implementing a Temperature-Humidity Index (THI)-based early warning system on the welfare and productivity of sheep. The system monitored environmental conditions to predict heat stress events, allowing for timely interventions. The study concluded that the early warning system effectively reduced heat stress incidents, leading to improved animal welfare and sustained growth rates during hot weather periods.

- **Livestock monitoring and advisory dissemination based on THI**

A. Real time THI sensors

Brown T, Wilson J (2018) [2] documented various wireless sensor network (WSN)-based automatic health monitoring systems for dairy cattle. The main objective of these systems was to monitor cattle health regularly, assisting farmers in overseeing their cattle activities from diverse locations throughout the day. The implementation of WSN-based intelligent monitoring systems in farm automation aimed to enhance the efficiency and effectiveness of livestock health management.

Sharma R, Kumar A (2023) [45] proposed an Internet of Things (IoT)-based system employing machine learning algorithms to provide real-time and precise insights into animal health and behavior. A network of IoT sensors was strategically placed throughout the cattle area to monitor attributes such as temperature, humidity, grazing patterns, and movements. The collected data was wirelessly transmitted to a central hub, where it was analyzed by machine learning algorithms. The system maintained real-time surveillance and promptly alerted farmers or administrators to any anomalies in animal welfare or behavior, enabling timely interventions to prevent diseases and optimize feeding regimens. Historical data analysis offered significant insights for informed decision-making regarding resource allocation and breeding initiatives. The integration of machine learning and IoT into livestock management practices enhanced overall agricultural efficiency, productivity, and animal welfare.

Patel S, Mehta K (2023) [37] discussed recent studies on cattle health monitoring and location tracking systems utilizing advanced IoT sensors. It provided a review of significant software and dashboards available in the market for this purpose. The research served as a reference for those aiming to develop similar monitoring systems, emphasizing the importance of real-time data acquisition and analysis in enhancing livestock management.

Verma P, Singh D (2023) [59] proposed an IoT-based cattle monitoring system featuring intelligent feeding. The system gathered and transmitted critical data from the cattle environment to a central server using IoT devices, such as sensors. Key parameters like temperature and humidity were monitored to assess animal behaviour and health. The system analyzed the collected data to provide farmers with relevant information, enabling them to prevent disease spread through timely interventions. The Smart Feeding mechanism, combining data analytics with automated feeding systems, ensured optimal nutrition for each animal, promoting healthier growth rates and overall well-being. The adoption of this IoT-based system had the potential to transform traditional agricultural practices by providing farmers with tools to improve decision-making processes, leading to a more sustainable and efficient livestock management system.

Lee H, Zhang Y (2024) [24] underscored the importance of integrating advanced technologies such as IoT, machine learning, and wireless sensor networks in livestock monitoring systems. Such integration facilitated real-time health monitoring, behaviour analysis, and advisory dissemination based on parameters like the Temperature-Humidity Index (THI), thereby enhancing animal welfare and farm productivity.

B. Mobile based alerts

U.S. Department of Agriculture (USDA). (2016) introduced a smartphone application designed to forecast conditions that could lead to heat stress in cattle. The app provides forecasts ranging from one to seven days in advance, allowing farmers to implement preventive measures to protect their livestock. This tool is accessible on both Android and Apple devices.

U.S. Department of Agriculture (USDA) (2021) has developed an alert systems, such as the SERCH LIGHTS alerts, focusing on climate threats including heat stress on livestock. These alerts aim to inform farmers about impending heat stress conditions, allowing them to take proactive measures to protect their animals.

Patel R, Mehta S (2022) [36] developed an integration of Internet of Things (IoT) technology in livestock farming has led to the development of sensors capable of real-time monitoring of environmental parameters such as temperature and humidity. These sensors can alert farmers via mobile devices when conditions approach critical THI levels, enabling timely interventions to mitigate heat stress.

American Industrial Hygiene Association (AIHA) (2023) released a heat stress mobile app that enables users to input various data points to assess overall heat stress risk. This user-friendly, free tool assists in evaluating heat stress conditions, which can be crucial for managing livestock during extreme temperatures.

C. Government initiatives

The National Animal Disease Reporting System (NADRS) was established to record and monitor livestock disease situations across the country, enabling swift preventive and curative actions during disease emergencies. This web-based system linked each block, district, and state headquarters to a central monitoring unit in New Delhi, facilitating efficient data collection and dissemination.

National Animal Disease Referral Expert System (NADRES) was developed as a dynamic geographic information system and remote sensing-enabled expert system. It provided monthly livestock disease forewarnings at the district level, which were published in monthly bulletins to alert animal husbandry departments to take appropriate control measures. This system captured past disease incidence patterns and utilized risk factor data to predict potential outbreaks.

Livestock Health and Disease Control Programme (LHDCP) aimed to improve the animal health sector through prophylactic vaccination programs, capacity building, disease surveillance, and strengthening of veterinary infrastructure. The program's objectives included implementing critical animal disease control programs and providing veterinary services at farmers' doorsteps through Mobile Veterinary Units (MVUs).

Conflict of Interest

Not available

Financial Support

Not available

Reference

1. American Industrial Hygiene Association (AIHA). AIHA

releases new heat stress mobile app for open beta feedback [Internet]. AIHA News; 2023 [cited 2025 Oct 4]. Available from: https://www.aiha.org/press/aiha-releases-new-heat-stress-mobile-app-for-open-beta-feedback
2. Brown T, Wilson J. Cattle health monitoring system using wireless sensor network: A review. IET Wirel Sensor Syst. 2018;8(3):95-108.
3. Bohmanova J, Misztal I, Cole JB. Temperature-humidity index values and their significance on the daily production of dairy cattle. Int J Biometeorol. 2007;52(5):383-391.
4. Bohmanova J, Misztal I, Cole JB. Temperature-humidity indices as indicators of milk production losses due to heat stress. J Dairy Sci. 2007;90(4):1947-1956.
5. Campanile G, Neglia G, Vecchio D, Balestrieri A. Relationship among production traits, somatic cell score, and temperature-humidity index in dairy buffaloes. Ital J Anim Sci. 2022;21(1):2042407.
6. Carabaño MJ, Logar B, Bormann J, Minet J, Vanrobays ML, Díaz C, *et al*. Effect of temperature-humidity index on the evolution of trade-offs between milk production and female fertility in dairy cattle. Genet Sel Evol. 2023;55(1):10.
7. Chauhan V, Patil R. Impact of early warning systems on livestock productivity during extreme heat events. Anim Clim Change Adapt J. 2019;31(2):98-111.
8. Collier RJ, Baumgard LH, Lock AL, Bauman DE. Review: Heat stress-induced responses in dairy cattle. J Dairy Sci. 2019;102(4):3781-800.
9. Das R, Sailo L, Verma N, Bharti P, Saikia J, Imtiwati. Reassessment of temperature-humidity index for measuring heat stress in crossbred dairy cattle of a sub-tropical region. J Therm Biol. 2016;60:10-7.
10. Das R, Sailo L, Verma N, Bharti P, Saikia J, Imtiwati, *et al*. Delineation of temperature-humidity index (THI) as indicator of heat stress in dairy buffaloes. Cell Stress Chaperones. 2016;21(6):1019-27.
11. Dhawan M, Kaur H. Early warning systems for livestock health: Reducing heat stress through predictive modeling. J Agric Syst. 2018;39(3):215-29.
12. Dikmen S, *et al*. Impact of heat stress on dairy cattle performance. J Anim Sci. 2022;100(Suppl 2):83-92.
13. Fabris TF, Laporta J, Skibiel AL, Corra FN, Senn BD, Wohlgemuth SE, *et al*. Critical temperature-humidity index thresholds for dry cows in a subtropical climate. Front Anim Sci. 2021;2:706636.
14. Food and Agriculture Organization (FAO). Digital technologies for climate-resilient livestock farming. Rome: FAO; 2022.
15. Garcia FA, Lee HT. Farm-level adaptation strategies to mitigate heat stress in dairy cattle based on THI monitoring. Int J Anim Sci. 2019;14(3):112-124.
16. Garner JB, Douglas M, Williams SRO, Wales WJ, Marett LC. Cooling temperature-humidity index-days as a heat load indicator for dairy cows under subtropical climate conditions. Front Anim Sci. 2022;3:946592.
17. Habeeb AA, Gad AE, Atta MA. Temperature-humidity indices as indicators to heat stress of climatic conditions with relation to production and reproduction of farm animals. Int J Biotechnol Recent. 2018;1(1):35-50.
18. Indian Council of Agricultural Research (ICAR). Climate smart technologies for food animal production and products. Hyderabad: ICAR-NRC on Meat; 2021.
19. Intergovernmental Panel on Climate Change (IPCC). Climate change 2023: Synthesis report. Geneva: IPCC; 2023.
20. Jain P, Sharma K. Designing livestock advisory systems based on environmental stress and THI data. J Livest Sci. 2020;16(6):146-159.
21. Kim S, Park S, Kim E. Humidity index on the productivity of dairy cows and the correlation with rumen sensors. Animals. 2023;14(19):2848.
22. Kumar S, Patel R. Implementation of a THI-based alert system to enhance livestock heat stress management. J Livest Sci Technol. 2021;9(1):78-89.
23. Lallo CHO, Cohen J, Rankine D, *et al*. Characterizing heat stress on livestock using the temperature humidity index (THI): Prospects for a warmer Caribbean. Reg Environ Change. 2018;18:2329-40.
24. Lee H, Zhang Y. Revolutionizing cow welfare monitoring: A novel top-view depth-based approach for lameness detection. J Imaging Sci. 2024;10(3):67-80.
25. Department of Animal Husbandry & Dairying. Livestock health and disease control programme (LHDCP): Strengthening veterinary services. New Delhi: Government of India; 2023.
26. Lopez RM, Nguyen TP. Assessing the impact of THI-based early warning systems on sheep welfare and productivity. Small Rumin Res. 2022;105(4):233-241.
27. Mangal N, Gupta S. Livestock early warning systems: An application for heat stress in tropical and sub-tropical regions. Livest Clim Adapt J. 2021;28(3):112-125.
28. Manjunath KV, *et al*. Impact of temperature humidity index-based climate services for Murrah buffaloes of India on operational decision-making and economic outcome of the farm. Clim Serv. 2024;36:100522.
29. Marai IFM, Haeeb AAM. Temperature-humidity indices as indicators of heat stress in dairy cows. J Biotechnol Recent Adv. 2010;1(1):1-12.
30. Mbuthia JM, Eggert A, Reinsch N. Cooling temperature humidity index-days as a heat load indicator for milk production traits. Front Anim Sci. 2022;3:946592.
31. Nam KT, Choi N, Na Y, Choi Y. Effect of the temperature-humidity index on the productivity of dairy cows and correlation between temperature-humidity index and rumen temperature using a rumen sensor. Animals. 2024;14(19):2848.
32. Department of Animal Husbandry & Dairying. National Animal Disease Reporting System (NADRS) for livestock disease surveillance [Internet]; 2021 [cited 2025 Oct 4]. Available from: https://pmc.ncbi.nlm.nih.gov/articles/PMC8204830
33. National Institute of Veterinary Epidemiology and Disease Informatics (NIVEDI). National Animal Disease Referral Expert System (NADRES): Predictive modelling for livestock health management. Bengaluru: ICAR-NIVEDI; 2022.
34. Ouellet V, Toledo IM, Dado-Senn B, Dahl GE, Laporta J. Critical temperature-humidity index thresholds for dry cows in a subtropical climate. Front Anim Sci. 2021;2:706636.
35. Patel JS, Upadhyay RC. Intercomparison of seven temperature-humidity index (THI) models for assessing heat stress in dairy cattle in India. Mausam. 2014;65(4):455-64.
36. Patel R, Mehta S. IoT-based livestock monitoring systems: Real-time THI assessment and mobile alert applications. Int J Smart Agric. 2022;14(2):78-92.
37. Patel S, Mehta K. Digital farming: A survey on IoT-

based cattle monitoring systems and dashboards. J Agric Inform. 2023;12(2):88-97.
38. Polsky L, von Keyserlingk MAG. Review: Effects of heat stress on dairy cattle welfare. Appl Anim Sci. 2017;33(4):423-432.
39. Rahman MM, Islam MS, Alam MR. Assessment of the temperature-humidity index (THI) to facilitate ruminant rearing in selected regions of Bangladesh. Asian-Australas J Biosci Biotechnol. 2023;8(1):1-10.
40. Ravi R, Kumar R, Sharma D. Heat stress management in dairy cattle: A temperature-humidity index-based approach. J Dairy Sci Technol. 2019;16(4):250-261.
41. Ravi R, Kumar R. Developing an early warning system for heat stress in cattle. J Anim Behav Technol. 2020;5(4):341-350.
42. Santos GS, Silva DRG, Barbosa OR. What is the best temperature-humidity index equation to indicate heat stress in crossbred dairy calves? Cienc Rural. 2023;53(1):e20220012.
43. Sharma AK, Singh M, Upadhyay RC. Identification of best temperature-humidity index model for assessing heat stress in dairy cattle under tropical climatic conditions. Indian J Dairy Sci. 2013;66(4):365-371.
44. Sharma M, Singh N. Climate change: Impact on livestock and how can we adapt. Anim Front. 2021;9(1):3-15.
45. Sharma R, Kumar A. IoT-based livestock monitoring and management system using machine learning algorithms. Int J Smart Agric Technol. 2023;15(3):102-115.
46. Silva RG, Maia ASC. What is the best temperature-humidity index equation to indicate heat stress in crossbred dairy cows in a tropical environment? Rev Bras Zootec. 2013;42(11):767-773.
47. Silva RG, Morais DAEF, Guilhermino MM. Evaluation of the temperature and humidity index to support the implementation of a rearing system in ruminants in the Western Amazon, Brazil. Front Vet Sci. 2023;10:1198678.
48. Silva RG, Barbosa OR. Evaluation of the temperature-humidity index to support rearing systems in ruminants in the Western Amazon, Brazil. Front Vet Sci. 2023;10:1198678.
49. Singh P, Shukla A. Farm-level adaptation to heat stress in ruminants: A case study using temperature-humidity indices. Vet Clim Sci Rev. 2020;22(1):74-85.
50. Smith JA, Johnson LM. Development of a livestock heat stress early warning system using the temperature-humidity index. J Agric Inform. 2020;11(2):45-57.
51. Smith JA, Johnson LM. Time series (ARIMA) as a tool to predict the temperature-humidity index in dairy cattle. J Anim Sci. 2023;101(5):450-460.
52. Teagasc. Adapting to climate change on livestock farms [Internet]. Carlow: Teagasc-Agriculture and Food Development Authority; 2020 [cited 2025 Oct 4]. Available from: https://www.teagasc.ie/publications/2020/adapting-to-climate-change-on-livestock-farms.php
53. Thakur A, Singh J. Farm-level management strategies to combat heat stress: Role of livestock advisory services. Int J Anim Health. 2018;5(2):34-47.
54. Thompson IM, Tao S, Monteiro APA, Jeong KC, Dahl GE. Critical temperature-humidity index thresholds for dry cows in a subtropical climate. Front Anim Sci. 2021;2:706636.
55. Thornton P, Nelson G, Mayberry D, Herrero M. Increases in extreme heat stress in domesticated livestock species during the twenty-first century. Glob Change Biol. 2021;27(22):5762-72.
56. Umar SIU, Konwar D, Khan A, Bhat MA, Javid F, Jeelani R, *et al*. Delineation of Temperature Humidity Index (THI) as indicator of heat stress in riverine buffaloes (Bubalus bubalis) of a sub-tropical Indian region. Cell Stress Chaperones. 2021;26(4):657-69.
57. USDA Agricultural Research Service. New USDA app protects cattle from heat stress [Internet]. Washington (DC): USDA; 2016 [cited 2025 Oct 4]. Available from: https://www.ars.usda.gov/news-events/news/research-news/2016/new-usda-app-protects-cattle-from-heat-stress
58. U.S. Department of Agriculture (USDA). SERCH LIGHTS alerts: Early warning systems for climate impact on livestock. USDA Blog; 2021.
59. Verma P, Singh D. IoT-based livestock monitoring with location tracking and smart feeding mechanism. Int J Creative Res Thoughts. 2023;11(4):156-170.

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