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Review Article

Impact of climate change on Ethiopian livestock health and their productivity

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Abstract

Livestock are vital for providing income, food, security, and mental health benefits to more than a billion people living in poverty-affected households. The major global challenges include declining rainfall, shortages of feed and water, disease outbreaks, and rising temperatures, many of which are associated with climate change. Climate change has a major impact on livestock production and health. Climate change affects both directly and indirectly the emergence of animal diseases and zoonoses by modifying natural ecosystems and enabling pathogens to spread into new regions, thereby threatening wildlife, domestic animals and humans. Climate change and severe weather conditions impact the well-being and productivity of livestock. As temperatures rise due to climate change, certain pathogens that have at least one life cycle stage outside their host animal may develop more quickly outside the host. Climate change influences livestock health through multiple pathways, particularly via its effects on pathogens, hosts, and vector dynamics. Similarly, it affects livestock production by contributing to feed and water shortages, loss of genetic resources, reduced productivity, decreased mature weight and prolonged time required to attain maturity. Additionally, the location and availability of pasture and water are greatly influenced by the pattern and amount of rainfall. However, limited information exists regarding how changes in distribution and impacts may manifest under different climate change scenarios, particularly with respect to livestock health and production. Therefore, the aim of the present paper is to review the impacts of climate change on animal health and productivity in Ethiopia.

Keywords: Animal diseases, Animal health, Animal production, Climate change, Impact

Highlights

- Long-standing alterations of climatic conditions are driven largely by greenhouse gas emissions and human activities
- Climate change impacts include rising global temperatures, altered rainfall patterns and extreme droughts, floods and storms
- Climate change influences animal health by affecting pathogens, hosts and vectors, leading to increased disease outbreaks and reduced overall animal productivity
- Intensification of vector-borne and climate-sensitive diseases, along with their prevalence in new regions, threatens biodiversity and One Health security
- Development of adaptation and mitigation strategies under a One Health approach is necessary to protect animal and public health

INTRODUCTION

According to the Intergovernmental Panel on Climate Change (IPCC), climate change is defined as a long-term alteration in the state of the climate, identified through changes in the mean and/or variability of climatic properties, and persisting over an extended period (Intergovernmental Panel on Climate Change [IPCC], 2007). It encompasses circumstances including rising sea levels, shifts in precipitation patterns in terms of strength, timing, and location, fluctuations in temperature, and an increased severity, along with the occurrence of extreme weather events such as droughts, floods, and hurricanes (Nkondze et al., 2014).

Climate change results primarily from the global rise in average air and ocean temperatures, along with increasing sea levels, and has become a major factor influencing both global and regional ecosystems. The global climate has been warming at an unprecedented rate, according to the IPCC (2007), accompanied by

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changes in precipitation patterns, flooding, wind, and the increasing frequency of extreme weather events. The Earth's average temperature has risen substantially over time in recent decades compared with the previous century and is expected to continue rising unless strong mitigation measures are adopted, particularly by highly industrialized nations to reduce greenhouse gas emissions. Agriculture and animal husbandry are highly susceptible to climate variations in developing nations. The health and production of livestock can be greatly affected by changing climate conditions (Kimaro & Chibinga, 2013).

Africa has been recognized as one of the most climate-vulnerable regions (IPCC, 2014). The climate of Africa is already warmer than it was a century ago, and model-based predictions suggest this warming will not only persist but likely accelerate under most scenarios. Climate change and variability are currently affecting rain-fed farming and livestock in Sub-Saharan Africa negatively. These changes are driven by both natural processes and human-related activities, with over 90% of current CCV linked to human actions. Furthermore, the growing human population and increased demand for agricultural land exacerbate CCV by accelerating deforestation, destroying vegetation cover and contributing to widespread environmental degradation (Hulme et al., 2001; Christensen et al., 2007).

Projected changes in Africa's average yearly rainfall are expected to be small and diverse. Projected changes in rainfall indicate a decrease of about 10% in southern Africa and the Horn of Africa. Conversely, the Sahel region could experience an increase of up to 16%. However, these projections are subject to model uncertainty. The challenge in modeling rainfall change in the Sahel lies in the high degree of natural variability in annual rainfall and the limited availability of long-term records (Jost, 2002). Climate change represents an additional stressor to already threatened habitats, ecosystems, and species in Africa, with the potential to drive species migration and habitat loss. Approximately half of Africa's biodiversity faces threats largely attributable to habitat loss and various human activities (Boko et al., 2007). Ethiopia, which hosts the maximum livestock population in Africa and is the continent's leading livestock producer, faces particular risks. The growth in Ethiopia's domestic animal product demand is mainly fueled by the urban middle and upper classes, while the potential for exports remains a major motivator for expanding and intensifying livestock production (MacDonald & Simon, 2011). However, the country is highly vulnerable to climatic variability and extremes. Rising temperatures may accelerate the development of pathogens and parasites with life cycle stages outside their animal hosts. Impact of climate change on livestock health, affecting pathogens, hosts, and vectors in several ways including host dynamics. Long-term changes in rainfall and temperature patterns have led to an increase in drought events. Thus, climate and location are the most important factors that influence livestock production. Climatological factors like temperature and rainfall significantly affect the seasonal availability of pastures and food resources for animals throughout the year. Therefore, the objective of this seminar paper was to review the impact of climate change on animal health and productivity in Ethiopia.

Historical background

Climate change involves the long-term shifts in weather and climate patterns on Earth. It took extensive research over nearly a hundred years to persuade the scientific community that human actions can impact the planet's climate system. In the 19^{th} century, experiments indicated that gases like carbon dioxide emitted by humans could accumulate in the atmosphere and trap heat. By the late 1950s, measurements of CO2 provided some of the initial evidence supporting the theory of global warming. Climate is a crucial factor that can influence disease patterns and is expected to cause notable adverse effects on human and animal health (Rabinowitz & Conti, 2013). It also contributes to serious social disruption, population displacement, economic hardship, and environmental degradation (Ethiopian Society of Animal Production [ESAP], 2009). Furthermore, climate change is now widely accepted a fact, affecting all ecosystems and will go on if left uncontrolled (Yatoo et al., 2012; Abdela & Jilo, 2016).

Definition of climate change

Climate change refers to notable and sustained shifts in climate-related factors like temperature, rainfall patterns (timing and amount), carbon dioxide levels, solar energy, and their interactions with wind, typically observed over a span of 30 years or more (IPCC, 2007). A persistent and significant shift in a region's typical weather patterns over an extended period can indicate climate change. Factors influencing climate include solar energy alterations, shifts in Earth's orbital patterns, and variations in atmospheric greenhouse gases. Data from diverse sources allow scientists to piece together historical climate conditions (Nzuma et al., 2010).

Factors causing climate change

Climate change stems from the build-up of greenhouse gases (GHGs) in the atmosphere, leading to global warming (IPCC, 2013). Globally, three primary gases drive climate change: carbon dioxide (CO_2), accounting for about 70%, mainly from fossil fuel combustion like petroleum imported from developed nations; methane (CH_4), and nitrous oxide (N_2O), produced through deforestation and agricultural practices, especially pesticide use. Livestock play a role in climate change by releasing greenhouse gases directly through processes like enteric fermentation and indirectly via activities such as feed production, deforestation, and overgrazing (Steinfeld et al., 2006). Emissions from livestock can originate at various stages of their production cycle, significantly influencing the carbon cycle and contributing to global warming. At the farm level, CH_4 and N_2O are emitted from manure and digestive processes. In ruminants, CH_4 is generated during the fermentation of fibrous feeds in the rumen and is exhaled. Nitrous oxide released from manure during storage, and additional CH_4 is produced under anaerobic, warm conditions during manure storage (McKee, 2008). As depicted in Fig. 1, environmental challenges including the greenhouse effect, ozone depletion, air pollution are intricately linked to far-reaching consequences such as biodiversity loss, zoonotic disease emergence, malnutrition, and adverse health and socio-economic outcomes.

Climate change and animal diseases linkage

The distribution of infectious diseases affecting humans, animals, and plants, as well as the timing and intensity of outbreaks, is closely linked to climatic factors. Climate change may influence livestock diseases through several direct and indirect pathways. The direct impacts on animal diseases are particularly pronounced for conditions that are vector-borne, soil-associated, water- or flood-associated, rodent-associated, temperature or humidity dependent and generally sensitive to climatic variation. These effects can be spatial, altering the geographical distribution of diseases, or temporal, influencing the timing and intensity of outbreaks (Grace et al., 2015).

Additionally, climate change has indirect effects on livestock health arising from modifications in production systems (Seo & Mendelsohn, 2008; Lancelot et al., 2015). Climate change may have an impact on different cardinal physiological reactions. WHO had emphasized that climate change is likely to cause changes in ecological systems that will affect the risk of infectious diseases (Dave et al., 2015).

Significant impacts of microclimatic variations on rectal temperature, respiration rate, and pulse rate of growing calves across different months (Das et al., 2015). Global climate change impacts ecological structures, leading to geographical and phonological shifts (Slenning, 2010). These changes can influence the efficiency and transmission patterns of pathogens, potentially expanding their range within host populations (Brook & Hoberg, 2007). A broader range of pathogens raises the risk of disease in animals, which can also increase the severity of the infectious agents involved. As a result, livestock systems become more vulnerable to variations in the severity and distribution of livestock diseases.

Among livestock health challenges, the incidence of external parasites ranks highest (43.3%) in warm temperate regions. Vector-borne diseases are greatly affected by climate change because shifts in rainfall and temperature influence where and how many vectors exist (Dhakal et al., 2013). Arthropod vectors tend to be more active at higher temperatures, thus they feed more regularly to sustain the increases in their metabolic functions, enhancing chances of transmission of infections between hosts. Even minor shifts in vector characteristics can lead

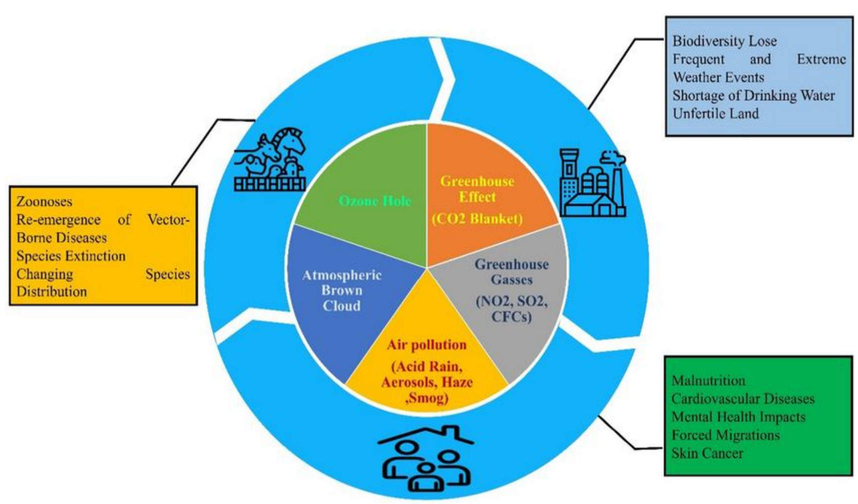

Fig. 1. Factors contributing to climate change (Source: Shafique et al., 2024)

to considerble alterations in disease dynamics (Grace et al., 2015). There is a strong linkage between climate and the epidemiology of disease agents. Temperature, precipitation, humidity and other climatic variables influence the reproduction, development, behavior and population dynamics of helminths, arthropod vectors and pathogens. Thus, climate change directly affects the emergence and proliferation of disease hosts and vectors, as well as pathogen breeding, development and transmission (ESAP, 2009).

Climate change and livestock health: Climate change has significantly impacted the emergence and resurgence of animal diseases and zoonoses worldwide (Dave et al., 2015). It disrupts natural ecosystems by creating favorable environments for infectious agents, thereby enabling bacteria, viruses and fungi to expand into new regions and threaten wildlife, domestic animals and humans (IPCC, 2007). Climate change can influence infectious diseases of livestock through several pathways: pathogen-related effects including elevated temperatures that accelerate the development of pathogens; host-related effects such as shifts in disease distribution that expose new or more susceptible animal populations; vector-related effects including changes in rainfall and temperature regimes that alter both the distribution and abundance of disease vectors; and epidemiological effects, including modified transmission dynamics and increased spread between hosts (Baylis & Githeko, 2006). Climate change also accelerates the enigma of antimicrobial resistance, another threat to public health due to the increasing incidence of resistant pathogenic infections (Abbass et al., 2022).

Climate change and vectors: Vectors serve as intermediate hosts that carry and transmit pathogens to susceptible organisms, which subsequently become infected hosts. Risk from vector-borne diseases is intrinsically sensitive to changing climate. Many arthropod vectors are found directly depend on multiple impacts of weather and climate, including the impact of temperature extremes on mortality rates, the combined effects of temperature and humidity on activity and host-seeking behavior, the influence of temperature on developmental progression between life stages, and the role of rainfall in creating breeding habitats for insect vectors. Climate has also indirect impacts on vector occurrence by determining qualities of habitat and animal hosts for blood meals (Medlock & Leach, 2015; Parham et al., 2015; Ogden & Lindsay, 2016).

Variations in rainfall patterns and temperature fluctuations could influence where disease vectors are found (Grace et al., 2015). Arthropod vectors are generally more active at elevated temperatures, which increases feeding frequency to sustain heightened metabolic activity, thereby enhancing the probability of pathogen transmission between hosts (Grace et al., 2015). Arthropod vectors are cold-blooded and thus sensitive to climatic factors, like; temperature, precipitation, humidity and other climatic factors that influence the survival, production, development, behavior and population dynamics of the arthropod vectors. Climate variables affect the suitability of habitats, where vectors are found, their population sizes, as well as the frequency and timing of their activity, especially biting behavior, across different seasons (Abdela & Jilo, 2016). All of the above climate and weather-dependent factors may, therefore, be impacted by climate change resulting in changes to where and when environments may be suitable for vectors and vector-borne pathogens to thrive(IPCC, 2013).

Climate change and pathogen: Warmer temperatures and higher humidity usually speeds up the growth of parasites and pathogens that go through part of their life cycle outside the host (Grace et al., 2015; Abdela & Jilo, 2016). Climatic factors such as wind also play a role in pathogen dispersal. Pathogens may be transmitted directly between animals or indirectly through intermediate hosts, and the latter are often strongly influenced by environmental conditions including temperature and rainfall. Elevated temperatures associated with climate change may therefore increase pathogen prevalence by enhancing survival and transmission through intermediate hosts and vectors (Kutz et al., 2005).

Extreme flooding provide favourable conditions for the spread of many waterborne pathogens, whereas drought and desiccation tend to reduce the survival of most pathogens (Grace et al., 2015). Climate change influences the rate of development of parasites, increasing the number of generations per year and thereby extending both the temporal and geographical distribution of the infections. Conversely, certain pathogens are highly sensitive to elevated temperatures, and their survival may decline as the climate warms. Pathogens and parasites that depend on moist or dry conditions are similarly affected by shifts in precipitation, soil moisture, and the frequency of extreme weather events (Kimaro & Chibinga, 2013).

Climate change impact on livestock production

Impact of climate on livestock feed resources: The most significant effect of climate change on livestock production is the alteration of feed resources. Climate change may affect the livestock feed resources affecting both its quality and quantity. Hot and dry seasons have been shown to cause the greatest reductions in biomass yield of different grass species growing in lowland environments (Morton, 2007). On the other hand, many semi-arid regions are expected to see lower rainfall due to climate change (Hopkins, 2000). The growing season for pastures is likely to get shorter in many tropical areas, which may also lead to more unpredictable rainfall patterns and more frequent droughts (IPCC, 2007). Droughts and delays in rainfall result in increased livestock mortality, higher susceptibility to disease, and physical deterioration due to the need for animals to travel long distances in search of water and pastures. Bekele (2017) further reported that severe drought directly reduces the growth of palatable grass species, hinders the regeneration of fodder plants in pastures, and limits forest fodder availability.

Among the numerous factors influencing livestock production, climate and geographical location are the most critical. Environmental factors including temperature and rainfall patterns, greatly influence the yearly availability of pasture and feed resources for animal populations (Fereja, 2016). In addition to these indirect effects, the direct influence of climatic variables such as temperature, humidity, and wind speed has been documented, with impacts on livestock growth rate, milk production, wool yield, and reproductive performance (Houghton et al., 2001).

Effects of climate change on water resources: According to De Wit and Stankiewicz (2006), and Bekele (2017), decreases in perennial drainage could significantly reduce access to surface water across nearly 25% of Africa by the century's end (Morton, 2007). Rising heat stress is expected to lead to higher water needs for livestock, which may cause overuse of water sources. According to the IPCC (2007), climate change is likely to negatively affect water resources and freshwater ecosystems by decreasing both the availability and quality of water. Climate change is projected to affect developing countries, particularly subsistence or smallholder farmers disproportionately. Furthermore, small farm sizes, low technology and low capitalization are likely to increase vulnerability of livestock production in developing countries (Bekele, 2017). Fig. 2 illustrates the cascade of effects of greenhouse gas emissions and climate change, linking environmental disruptions with reduced agricultural

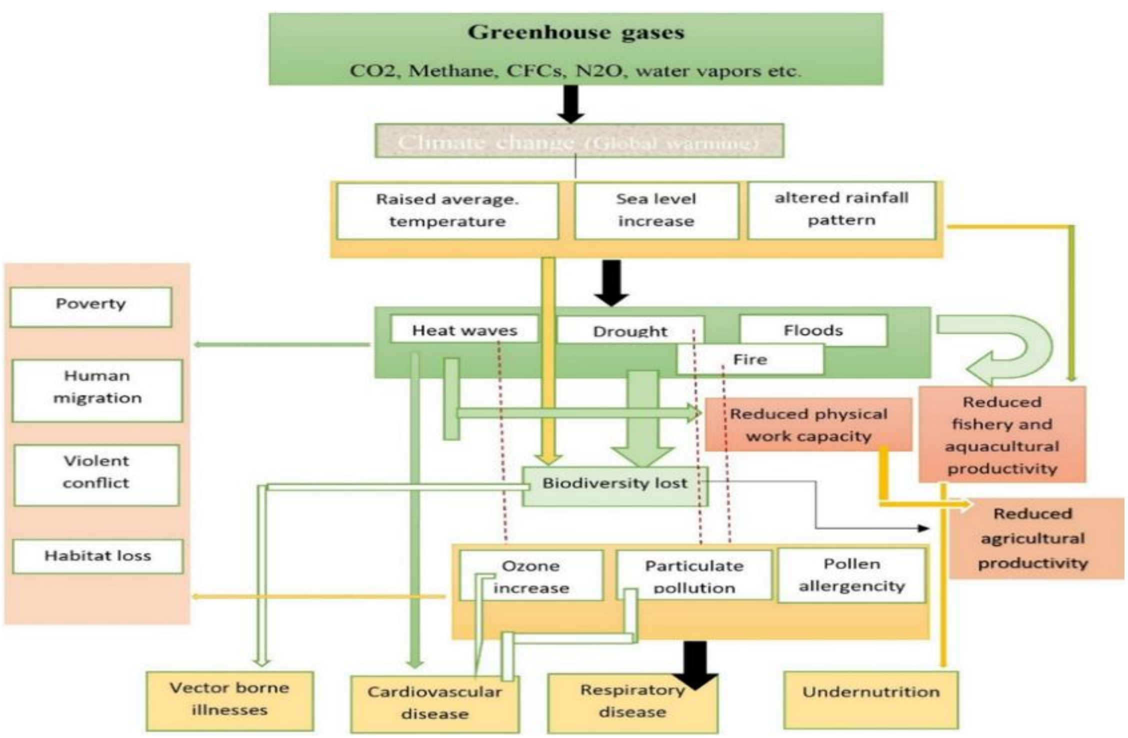

Fig. 2. Impact of climate change on One Health perspective (Source: Shafique et al., 2024)

productivity, biodiversity loss, and increased risks of human diseases.

Effects of climate on milk production: When environmental temperatures deviate from the thermoneutral (comfort) zone, dairy cattle experience either heat or cold stress. Animals with high productivity and increased internal heat generation are more tolerant to heat stress. Holstein dairy cows are especially susceptible to heat stress, with feedlot cattle also being significantly affected (Berman, 2005). As milk yield increases, animals become more susceptible to thermal stress, thereby lowering the threshold temperature at which milk losses occur.

Livestock production is closely linked with climatic conditions. The distribution and accessibility of land and water resources for grazing are closely linked to rainfall patterns and their occurrence (Aklilu et al., 2013; Bekele, 2017). Climate and seasonal changes have a large impact on animal behavior, primarily due to how their nervous and endocrine systems respond to environmental factors. This, in turn, affects the health and productivity of animals (Sejian et al., 2010; Baumgard et al., 2012). Climate change represents a major threat to the sustainability and long-term viability of global livestock production systems. Heat and nutritional challenges negatively impact dairy herds by increasing mortality rates and decreasing growth and reproductive performance, resulting in notable economic losses for farms that rely on less adaptable breeds. The effects of heat stress are particularly harmful, leading to decreased milk yield and impaired reproductive functions in dairy cattle. Animals of high genetic merit are vulnerable to climatic stressors under tropical conditions due to elevated ambient temperatures and humidity levels (Gaughan et al., 2008; Martello et al., 2010; Bekele, 2017). According to Parsons et al. (2001), high temperatures can reduce feed intake, suppress milk production, and induce energy deficits, which collectively diminish fertility, fitness, and longevity.

Climate impact on egg and meat production in poultry: The thermoregulatory characteristics of poultry differ considerably from mammals because of their high metabolic rate and intensive heat production, combined with limited heat dissipation due to feather coverage and absence of sweat glands.At ambient temperatures above 30°C, feed and energy intake decline to such an extent that birds can no longer physiologically compensate, resulting in reduced production and increased mortality. Several studies reported that high ambient temperatures decrease the digestibility of nutrients in poultry, which might be due to reduced activity of trypsin, chymotrypsin, and amylase (Das, 2017). Consequently, inadequate nutrient availability compromises egg production, egg mass and shell quality in layers, while significantly reducing growth rates in broilers (Amundson et al., 2006).

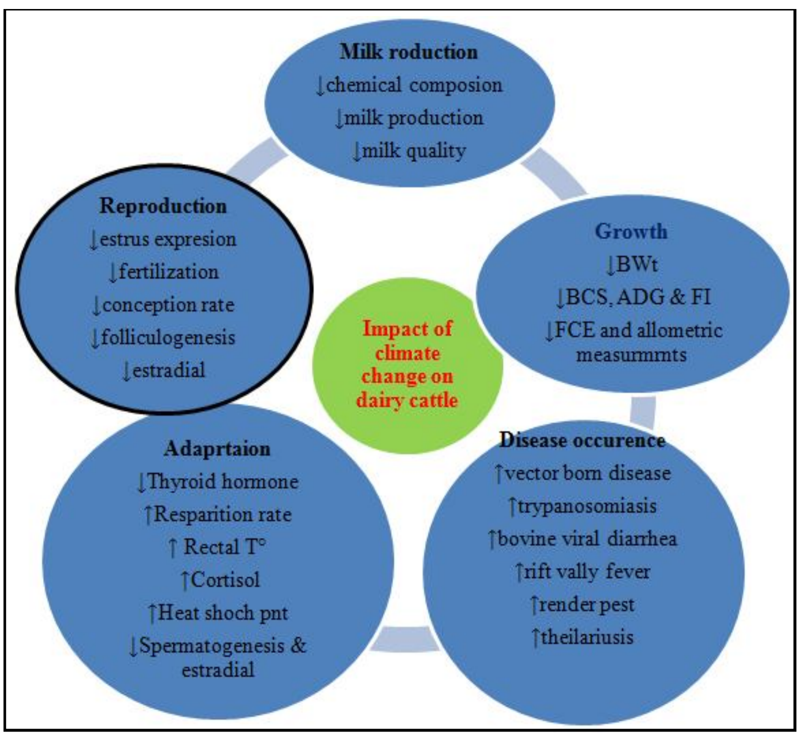

Fig. 3. Impact of climatic change on dairy cattle (Source: Tadesse and Dereje, 2018)

Effects of climate change on livestock reproduction: High ambient temperatures compromise reproductive efficiency in both male and female farm animals, rendering reproductive functions susceptible to climate change (Bekele, 2017). Heat stress also has a negative impact on reproductive function (Amundson et al., 2006; Bekele, 2017). The dry period is especially important because it involves the involution of the mammary glands and can influence endocrine responses. These changes may increase the risk of fetal abortions, shorten the length of gestation, lower calf birth weight, and negatively affect the maturation of follicles and oocytes, which are crucial for the postpartum reproductive cycle (Bilby et al., 2008). Reproductive activity is primarily regulated by hypothalamic GnRH and the gonadotropins (FSH and LH) secreted by the anterior pituitary (Madan & Prakash, 2007; Bekele, 2017). Heat stress lowers conception rates by reducing the length and intensity of estrus. Poor estrus expression is linked to reduced estradiol secretion from dominant follicles, thereby prolonging calving intervals (Das, 2017). This ultimately decreases the lifetime productivity of dairy animals. The heat stress may cause damage to the somatic cells in the follicles, such as theca and granulosa cells. Heat stress can also damage somatic cells of ovarian follicles (theca and granulosa cells), suppress estradiol synthesis and lead to early embryonic loss in cows. Male fertility is equally compromised, as heat stress reduces seminal volume and sperm concentration (Das, 2017). It is reported that, ejaculate volume, concentration of spermatozoa and sperm motilityin bulls have been consistently observed to decline during the summer months compared to the winter season (Samal, 2013; Das, 2017). Fig. 3 demonstrates the multifaceted impact of climate change on dairy cattle, encompassing reduced milk yield and quality, impaired reproduction and growth, increased disease occurrence, and physiological stress adaptations

Thus, One Health strategy emphasizes safeguarding the well-being of humans, animals and the ecosystem against potential hazards. Integrated approaches through One Health save human and animal lives and reduce the overall costs incurred separately (Das et al., 2025).

Conclusion and recommendations

The present review provides an update of existing literature on potential climate change impact on livestock health and productivity in many aspects. Climate change influences livestock health through multiple factors, including the diversity of vectors and wildlife reservoirs, as well as the ability of pathogens to survive in the environment. It can exacerbate the occurrence and severity of livestock diseases, with certain diseases being particularly climate-sensitive. In addition, climate change has a negative effect on livestock production by contributing to feed resource shortages, water scarcity, and reduced overall productivity. Therefore, developing a comprehensive understanding of the interactions between climate change, animal health, along with production is essential to provide effective recommendations for mitigating its potential impacts.

Thus, based on the above conclusions, several recommendations are put forward, *Viz,* the awareness of livestock owners and professionals on climate change must be enhanced through training programmes.The incorporation of additional inputs into pasture and livestock production, particularly in climatically favorable zones, should be implemented. Furthermore, it is essential to promote awareness among stakeholders in environmental conservation, animal production and animal health by promoting integrated and systematic approaches. Developing strategies for sustainable animal farming, efficient land use and climate change adaptation and mitigation is essential. Research with focus on assessment of implementation of adaptation measures and customizing them according to specific locations and livestock production systems. Studies on livestock improvement strategies, particularly the use of genetic selection, are necessary to mitigate the impacts of climate change. Thus, improving the productivity of dairy cattle while reducing overall herd size is essential for enhancing efficiency and sustainability.

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