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Impact of Climate Change on Animal Health and Mitigation Strategies: A Review

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ABSTRACT

Climate change, a global phenomenon of present time, has emerged as the greatest challenge of the world in the twenty-first century. The impact of climate change is multifaceted and affects various aspects of the ecosystems as human, animals and environment. Climate change is one among the major threat for the sustainability of livestock systems. The direct effects of climate change on animal health are mainly due to changes in environmental conditions such as air temperature, relative humility, precipitation, drought and flood and reflect mainly in the form of heat stress and reproductive problems. Indirect effects lead to infectious, vector borne and parasitic diseases occurrence. The mitigation strategies should focus upon climate resilient breeding and shelter management practices along with sustainable disease surveillance, conservation of natural habitats and society awareness and education.

Key words: Animal health, Climate change, Diseases, Mitigation.

Climate change, a global phenomenon of present time, has emerged as the greatest challenge of the world in the twenty-first century. Rising earth's surface temperature is one of the most threatening factors coming into view. The substantial changes in the earth's climate have an impact on ecosystems, economics and societies in a variety of ways. Changes in weather patterns, melting of glaciers at the poles and an increase in sea levels, as well as modified precipitation patterns *etc*. are the consequences of climate change.

Various human activities like the combustion of fossil fuels, deforestation, industrialisation and rapid urbanisation are contributing to the transformation of the earth's climate at an unprecedented rate by generation of greenhouse gases. The carbon dioxide is generated through uses of huge amount of fossil fuels as coal and oils. Methane and nitrous oxide are produced by city landfills, rice fields, use of nitrogen fertilizers in agriculture and livestock farming. Methane and nitrous oxide have shorter half-life in atmosphere therefore instead of powerful greenhouse gas effect carbon dioxide has major role for climate change. Agriculture, forestry and other land use contributes to 22 per cent of global emission out of which enteric fermentation (CH_4) has only 5 per cent emission (IPCC, 2022).

Climate change scenario at global and national level

Human activities, principally through emissions of greenhouse gases, have unequivocally caused global warming, with global surface temperature increasing 1.1°C in 2011-2020. Rise in temperature is more over land (1.59°C) than over the ocean (0.88°C). Global greenhouse gas emissions have continued to increase. Global net anthropogenic GHG emissions have been estimated to be 59±6.6 GtCO2-eq9 in 2019, about 12% (6.5 GtCO2-eq) higher than in 2010 and 54% (21 GtCO2-eq) higher than in 1990, with the largest share and growth in gross GHG emissions occurring in CO2 from fossil fuels combustion and industrial processes (CO2-FFI) followed by methane, whereas the highest relative growth occurred in fluorinated gases (F-gases), starting from low levels in 1990. Average annual GHG emissions during 2010–2019 were higher than in any previous decade on record (IPCC, 2023).

In developing nations, like India, there is rapid population expansion, economic reform, rapid urbanization, industrial infrastructure development and environmental degradation; global warming and climate change is more challenging to manage. The Indian Meteorological Department recorded temperature increase over the Indian region is almost similar to the global average in its "Statement on Climate of India during 2018" report. India's average temperature increased by roughly 0.7°C between 1901 and 2018 and it is anticipated to increase by approximately 4.4°C by the year 2100.

Over the Indian-Gangetic plains and the Western Ghats, monsoon rainfall decreased by around 6% between 1951 and 2015. In contrast, in central India, the intensity of heavy

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rainfall rose by over 75% over the same period. From 1951 to 2016, droughts' frequency and geographic area greatly increased particularly regions across central India, the southwest coast, the southern peninsula and northeastern India. The east coast of India had more frequent and intense, very severe cyclonic storms than the west coast during 2000-2018 (Krishnan *et al.,* 2020). These changes have far-reaching consequences, not only for human societies but also for the vast array of animal species inhabiting diverse ecosystems across the planet.

Effects of climate change

The impact of climate change is multifaceted and affects various aspects of the ecosystems as human, animals and environment. These are some key impacts:

- **Temperature rise:** Global temperatures have been rising, leading to more frequent and severe heat waves. This can result in health problems, heat stress and an increased demand for cooling infrastructure.
- **Extreme weather events:** Climate change is associated with an increase in the frequency and intensity of extreme weather events, such as hurricanes, droughts, floods and wildfires. These events can cause widespread damage to infrastructure, agriculture and human settlements.
- **Sea level rise:** The melting of polar ice caps and glaciers, along with the thermal expansion of sea water, contributes to rising sea levels. This poses a significant threat to low-lying coastal areas, leading to erosion, saltwater intrusion and the displacement of communities.
- **Impact on agriculture:** Agricultural productivity through changes in temperature, rainfall and the frequency of extreme events. Farmers face challenges in adapting their practices to the evolving climate conditions.
- **Biodiversity loss:** Climate change contributes to the loss of biodiversity, affecting ecosystems and the species that inhabit them.
- **Health risks:** Climate change can have direct and indirect impacts on human as well as animals health. Increased temperatures can exacerbate heat-related illnesses and changes in the distribution of vector-borne diseases.

Impact of climate change on animals

Climate change is one among the major threat for the sustainability of livestock systems. Climatic factors such as ambient temperature, relative humidity, direct and indirect solar radiation and rain fall influence on feed and water availability, fodder quality, heat stress, production, animal growth, reproduction and disease occurrence. These impacts are primarily due to an increase in temperature and atmospheric carbon dioxide (CO_2) concentration, precipitation variation and a combination of these factors (Henry *et al.,* 2012; Nardone *et al.,* 2010 and Thornton *et al.,* 2009).

Temperature affects most of the critical factors for livestock production, such as water availability, animal production, reproduction and health. Forage quantity and quality are affected by a combination of increases in temperature, CO_2 and precipitation variation. Diseases occurrence is mainly affected by an increase in temperature and variation in rain fall pattern. The effects of climate change on animal health may be considered into two categories direct and indirect.

Direct effect of climate change on animal health

The direct effects are mainly due to changes in environmental conditions such as air temperature, relative humility, precipitation, drought and floods. These environmental conditions are responsible for temperature-related animal morbidity and mortality.

Heat stress

Animals have a range of ambient environmental temperatures that are optimal for their physiological processes, known as their thermal comfort zone. Animals experience heat stress when the temperature rises above the critical temperature of the range. Heat stress in animals is dependent on temperature, humidity, species, breed, age and physiological status.

Heat stress also affects their metabolism, physiology, hormones and immune system in animals. The physiological changes result in decreased rumen motility and rumination in ruminants (Nardone *et al.,* 2010; Soriani *et al.,* 2013). Decrease in thyroid activity resulting further lesser metabolic heat production (Helal *et al.,* 2010). Feed intake and feed utilization efficiency of animal exposed to heat stress have decreased (Hooda *et al.,* 2010).

Animals belonging to higher latitude area will be more affected by the rise of temperatures than the animals located in lower latitude area, because livestock in lower latitudes are usually well adapted to high environmental temperatures and droughts (Thornton *et al.,* 2009). Intensive rearing systems having more control over climate exposure will be comparatively less affected by climate change.

The long-term impact of environmental transformation on animal health status can be physiologically assessed by monitoring various physiological processes such as rectal temperature, pulse and respiration rate, metabolic rate, endocrine status, oxidative status (Bernabucci *et al.,* 2002). Metabolism of glucose, protein and lipid, liver functionality (reduced cholesterol and albumin), non-esterified fatty acids (NEFA) also found in heat stressed animals. In severe cases mortality may be encountered due to heat stress. According to Nardone *et al*. (2010), temperature increases between 1-5°C may cause substantial mortality in grazing cattle.

Production and production diseases

Productivity from livestock is highly influenced by environmental factors mainly through production and metablic disorders. Best production is obtained from animals when they are living in optimal environmental conditions. The negative impacts on livestock productivity, health and animal performance are influenced and affected by various factors like increasing environmental temperatures followed by humidity, wind velocity and radiation. Among different climatic variables, ambient temperature fluctuations have the most drastic effect on production and animal welfare.

There have been estimated significant monetary losses of nearly 2% of the total milk production in India. Thermal stress due to climatic changes causes a reduction in feed intakes. It also reduces the feed conversion ratio (FCR) and utilization of feeds. Production disorders such as ketosis, milk fever, fat cow syndrome and various deficiency disorders may be outcome of changing climate and improper nutrition.

The poultry industry may also be compromised by low production at temperatures higher than 30°C (Esminger *et al.,* 1990). Heat stress on birds will reduce body weight gain, feed intake and carcass weight and protein and muscle calorie content (Tankson *et al.,* 2001).

Reproductive disorders

Reproduction efficiency of both male and female may be affected by heat stress. In male animals semen quality and libido get affected by higher environmental temperature. The sertoli cells are primary target for heat stress (Ahmad *et al.,* 2022). Heat stress has also been associated with lower sperm concentration and quality in bulls, pigs and poultry (Karaca *et al.,* 2002; Kunavongkrita *et al.,* 2005).

In females, follicular dynamics and expression of estrus sign are disturbed due to rising environmental temperatures and humidity. This may lead to a high incidence of silent heat in animals. (Barati *et al.,* 2008) reported the alteration in oocyte growth and quality of cow and pig leading to impairment of embryo development and pregnancy as adverse effect of heat stress. Poor fertility may be attributed to increased energy deficits and heat stress in cows (De Rensis and Scaramuzzi, 2003; King *et al.,* 2006).

In poultry, heat stress has detrimental effect on reproduction efficiency and consequently egg production because of reduced feed intake and interruption of ovulation (Nardone *et al.,* 2010). Hot climate also have negative effect on egg quality, such as egg weight and shell weight and thickness *etc*. (Mashaly *et al.,* 2004).

Indirect effects

Indirect effects of climate change on animal health and production are due to microbial density and distribution of vector-borne diseases, food and water shortages, or foodborne diseases (Lacetera, 2019).

Disease occurrence

The epidemiology of diseases will be influenced by any climate-related factor that modifies the interrelationship between hosts, pathogens and environment (triangle relationship). Under a changing climate scenario, there may be an increased probability of the emergence of many zoonotic and parasitic diseases. Climate change could change how diseases travel, outbreaks of serious illnesses or even the introduction of new diseases that could affect livestock that isn't typically exposed to these kinds of illnesses

Vector borne diseases

The vector borne diseases, survival of the vector, its replication, distribution, density, the vector biting rate and the pathogen's incubation rate within the vector are of particular importance. Arthropod vectors are affected by climatic variables such as precipitation, temperature, humidity and other environmental conditions that might influence their survival, reproduction, development, behaviour and population dynamics. Since vectors like cattle ticks (*Boophilus microplus, Haemaphysalis bispinosa* and *Hyalomma anatolicum*) are coldblooded, climate of atmosphere affects availability of their habitats, abundance, distribution and the severity and seasonal pattern of vector activity. Generally arthropod vectors are markedly increased in numbers during the hot, humid weather condition and animals are worst affected by them during these favrouable climatic conditions (Sridhar *et al*., 2020).

Climate change affects pathogens

The number of infectious cycles that may occur for diseases related to the warm or cold seasons within a year may grow or decrease depending on how long the warm season is maintained. Extreme weather conditions such as flooding cause pollution to runoff from the agricultural land to animal farms and this runoff mixed with the water supply in farms can be the source of entero-haemorrhagic *Escherichia coli* and Cryptosporidium parasites. This threatens other livestock and because it contaminates water systems, it also puts people in danger of acquiring zoonotic diseases. Along with diseases that limit production, future challenges in controlling parasitic zoonoses such as those connected to climate change require further attention (Polley and Thompson, 2009).

Feed and water availability

Depending on the geographical and seasonal conditions fodder quantity and quality is affected. An increase in temperature will be harmful for pasture and livestock production in arid and semiarid climate. This continuous rise in biospheric temperature has altered the quantity and distribution of the average annual precipitation and the primary climate change drivers including carbon dioxide (CO_2) to increase. Increased incidence of heat waves and droughts at different ecological regions, cause a detrimental impact on the vegetation of that zones. Climate change affects the length and timing of the forage's availability, the duration of the growing season is also a crucial element in determining the quality and amount of forage (Cheng *et al.,* 2022).

Water is scarce worldwide and the magnitude of water scarcity depends on the supply relative to the demand. Climate change contributed to water availability and water usage in animal production. Rising temperatures are likely to increase per animal and per land area animal water consumption and irrigation water use. Increased water salinity caused by sea-level rise is another concern.

Competition for water between livestock, crops and non-agricultural uses will increase in the coming decades and it requires more efficient production systems to address water scarcity issue (Konapala *et al.,* 2020).

Climate change and zoonosis

It is currently accepted that 80% of all animal pathogens are zoonotic agents and that 75% of emerging animal pathogens are zoonotic. It follows that zoonotic animal pathogens tend to associate with emerging processes twice as often as non zoonotic animal pathogens. The environmental changes affect the breeding, development and proliferation of specific parasite species and their hosts as well as their capacity to transmit diseases. Some of the examples of parasitic diseases of animals and humans include leishmaniosis, cryptosporidiosis, giardiosis, trypanosomiosis, shistosomiasis, filariosis, onchocerciosis *etc*. The pattern of these parasitic diseases is affected by change in the climate and environmental conditions in different parts of the world (Patz *et al*., 2000). Various countries have identified the emergence of leishmaniosis as a zoonosis linked to climate and environmental change. Climate change is believed to increase the risk of human exposure to cutaneous leishmaniosis in northern areas of the United States, by transforming the area into a more suitable habitat for the vector and reservoir species that transmit this disease. To the south of the American continent, the incidence, lethality and geographic distribution of visceral leishmaniosis has increased worryingly in recent years in Argentina, Brazil and Paraguay, where a change in the epidemiology of the disease has been observed, becoming established in urban and peri-urban areas with aggravated virulence (Oyhantcabal *et al*., 2010). Cutaneous and visceral leishmaniosis is also frequently reported from India.

Mitigation strategies

Adaptation strategies can improve the resilience of animals towards climate change (USDA, 2013). Mitigation measures could significantly reduce the impact of livestock on climate change (Dickie *et al.,* 2014). Adaptation and mitigation can make significant impacts if they become part of national and regional policies.

Climate-resilient animal breeding

Selective breeding programs play a pivotal role in developing animal breeds that can withstand the challenges posed by a changing climate. Through careful selection of traits such as heat tolerance, disease resistance and efficient resource utilization, scientists and farmers can create livestock varieties that are better adapted to rising temperatures and emerging diseases. These climate-resilient breeds not only ensure sustainable livestock production but also promote genetic diversity within animal populations, enhancing their overall resilience to environmental stressors Additionally, research into genomics and molecular biology allows for the identification of specific genes associated with desirable traits (Renaudeau *et al.,* 2012). Genetic modification techniques can be employed responsibly to introduce beneficial traits into animal populations, fostering resilience in the face of climate-related challenges. Some breeds are less affected by heat stress, such as smaller, lighter-colored animals, or breeds can show great physical and physiological adaptation to heat stress. If such trait is heritable, selective breeding for heat tolerance could be used to improve animal adaptation to climatic stress. Producers can switch breeds, for example, using more *Bos indicus* cattle (Barendse, 2017).

Management modifications

The modification of production and management systems involves diversification of livestock animals and crops, integration of livestock systems with forestry and crop production and changing the timing and locations of farm operations (IFAD, 2010). Diversification of livestock and crop varieties can increase drought and heat wave tolerance and may increase livestock production when animals are exposed to temperature and precipitation stresses. In addition, this diversity of crops and livestock animals is effective in fighting against climate change-related diseases.

Robust surveillance

Improved veterinary surveillance systems are essential for tracking the diseases that are impacted by climate change. Veterinarians and researchers can more quickly and reliably identify new diseases by investing in cutting-edge diagnostic equipment and data analysis tools. Prompt reaction actions, including vaccination campaigns, treatment regimens and quarantines, are made possible by early discovery and contribute to the prevention of large-scale epidemics in animal populations. Working together to share surveillance data among nations and regions can yield a thorough understanding of disease dynamics and facilitate the quick implementation of preventative measures.

Effective preventive measures

The FAO Emergency Prevention System (EMPRES) (1994) has showed early warning, detection and response as the key to the prevention and control of both old and new infections and diseases in animals. Prevention and control of spread of disease across country boundaries has become the credo of the FAO/World Organisation for Animal Health (OIE) initiative, Global Framework for the Progressive Control of Transboundary Animal Diseases (GF-TAD). Progressive control pathways and regional roadmaps should be designed to counter the spread of high-impact infectious livestock diseases such as FMD, PPR and ASF. Similar, control pathways and roadmaps are needed for zoonotic diseases. Early detection and early response are key to the success of the Global Diseases Control Programme. Regular as well as blanket vaccinations are of utmost importance. The flare-up of new diseases and the persistence of chronic disease burden remain considerable, particularly in the developing world including India. Climate change-modulated vector- borne disease (VBD) complexes would appear to become more dynamic globally. In our country, the expertise in entomology and disease ecology within public veterinary services is inadequate to mount early warning and response mechanisms in the face of novel VBD emergencies. Improvements are required in integration of field veterinary work, laboratories and detection of critical control points. A "One Health" approach conveniently deals with the collective risk factors acting at the level of natural and farming landscapes, on-farm, in slaughter houses and processing and distribution circuits. "One Health" brings together health professionals engaged as veterinary practitioners, food inspectors, forest veterinarians, plant protection, natural resource management and, of course, food safety and public health. Removing the divides separating today disciplines, sectors, institutions and political boundaries, undoing the compartmentalization as prevailing in government organizational structures, presents the major challenge under the "One Health" umbrella. For FAO, the "One Health" notion extends to the Food Chain Crisis Management Framework, a platform for all health professionals within the Organization (Tekola *et al*., 2012).

Conservation of natural habitat

Two essential tactics for reducing the negative effects of climate change on animals are the preservation of natural habitats and the restoration of damaged ecosystems. Protected areas, animal corridors and forestry programs are examples of conservation measures that help to preserve biodiversity and guarantee the availability of vital habitats and food sources. In addition to removing carbon dioxide from the atmosphere, restoring damaged ecosystems like wetlands and forests also creates habitat for a variety of animal species. Governments, local communities and conservation organizations may work together to create and manage protected areas, which will shield delicate species and ecosystems from the effects of climate change.

Public awareness and education

Gaining support for mitigation initiatives requires educating the public about the complex relationship between animal health and climate change. Education campaigns aimed at farmers, lawmakers, the general public and others who care for animals can emphasize the value of sustainable living and appropriate environmental practices.

CONCLUSION

There has been a tendency to oversimplify the mechanisms by which climate change affects animal health and disease transmission as well as human health status. Indeed, only a limited number of studies present validation of the direct effects of climate change itself. The flare-up of insects and diseases of livestock origin and also the surge of food safety hazards, is likely to continue for decades to come. Risk analysis highlighting the implications of climate change in its broader context relies on the full consideration of the transmission ecology of insects, pests and diseases. Transmission involving prominent free-living parasite stages is arguably more likely to be modulated by environmental factors including temperature, humidity and weather conditions. Risk management of emerging disease complexes in which climate change plays a role is best addressed under a "One Health" umbrella.

Conflict of interest

There is no conflict of interest.

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