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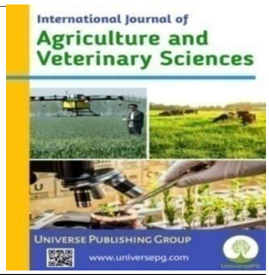

Consequence of Environmental Change on the Animal's Health and Productivity: A Brief Review

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ABSTRACT

The effects of climate change, especially global warming, can greatly affect the production performance and health of animals around the world. The national average temperature has increased by 1°C since 1970. Most livestock owners in the country feel that climate change is affecting livestock production and health. The main impacts of climate change on livestock production include feed shortages, water shortages, reduced livestock genetic resources, reduced productivity, and reduced mature weight and/or longer time to reach mature weight depending on their importance. Higher temperatures resulting from climate change may increase the rate of development of certain pathogens or parasites that have one or more life cycle stages outside the animal host. Furthermore, the spatial distribution and availability of pasture and water is highly dependent on the pattern and availability of rainfall. Feed and water shortages contribute to reduced livestock productivity and reproductive performance. These include slow growth rate of animals, loss of body condition, reduced milk production and poor reproductive performance of mature animals. Drought bulls that are debilitated and in poor physical condition cannot provide sufficient drought energy for plowing and thus hinder crop cultivation. Bush encroachment, as well as population pressure, leads to reduced availability of good pastures thus climate change will have far-reaching consequences for animal production and health especially in vulnerable parts of the world where it is essential for nutrition and livelihoods. Again, climate change affects livestock health through several pathways; which are effects on pathogens, effects on hosts, effects on vectors, such as changes in precipitation and temperature regimes that can affect both the distribution and abundance of disease vectors; and effects on epidemiology, such as altered transmission rates between hosts. This review is conducted to explore the potential impacts of climate change on livestock health and production.

Keywords: Livestock, Adaptation, Global warming, Climate change, Impact, and Production.

INTRODUCTION:

Domestic animals are the only means of livelihood for millions of families worldwide. It is estimated that out of one billion people, 701 million who live in poverty depend on their livestock for food, income, traction and transportation (Oyhantçabal *et al.*, 2010). The livestock sector is a fast-growing agricultural subsector, accounting for 34% of agricultural GDP & growing, driven by population growth, urbanization and rising incomes in developing countries. Demand for all livestock products is expected to double in sub-Saharan Africa and South Asia by 2049 (Alexandratos and Bruinsma, 2012). On the other hand, climate change over the past 31 years has already reduced global agricultural production in the range of 1-6% per decade (Thornton *et al*., 2015; Hassen *et al*., 2022).

Climate change is a likely cause of disease conditions and is expected to have overwhelming negative impacts on human and animal health (Rabinowitz and Conti, 2013). Global climate change threatens serious social upheaval, population displacement, economic hardship and environmental degradation. Furthermore, climate change is now an accepted fact, affecting all ecosystems and will continue if unchecked (Yatoo *et al*., 2012). Climate change affects the emergence and spread of disease hosts or vectors and pathogens and their reproduction, development and disease transmission. Consequently, this affects distribution, host-parasite relationships and its assemblages in new areas. Climate change can greatly affect animal health directly and indirectly (ESAP, 2009; Ekhlas *et al*., 2014).

Direct effects of climate on animal diseases may be more pronounced for vector-borne diseases, soil-related, water or flood-related, rodent-related, or air temperature/humidity related and more sensitive to climate (Grace, 2015). Indirect effects follow more complex pathways and include those arising from the efforts of animals to adapt to thermal environments or the effects of climate on pathogen populations, the distribution of vector-borne diseases, and host resistance to the distribution of vector-borne diseases & Immunity to food-borne diseases (Yatoo *et al*., 2012). Furthermore, climate change may affect livestock health through a number of factors, including the extent and abundance of vectors and wildlife reservoirs, and the survival of pathogens in the environment (ESAP, 2009). Higher temperatures resulting from climate change may increase the rate of development of certain pathogens or parasites that have one or more life cycle stages outside the animal host. This can shorten the generation time and, possibly, increase the total number of generations per year, thereby increasing the pathogen/parasite population size (Chauhan and Ghosh, 2014). Rising temperatures increase the spatial distribution and intensity of existing pests and diseases, which in turn can affect livestock productivity or, in some extreme cases, lead to livestock mortality (Musemwa, 2012).

According to ECARD, (2012), the developmental stages of vectors such as ticks and flies are often highly dependent on temperature and transmit most diseases. Cattle, goats, horses and sheep are also vulnerable to a wide range of nematode worm infections, many of which are influenced by climatic conditions at specific temperatures during their developmental stages. Understanding the relationship between climate change and livestock diseases is important for better management of animal health problems. However, current knowledge of the relationship between climate change impacts and animal health is lacking, especially in Africa despite the economic importance of livestock agriculture. Therefore, one of the objectives of this paper is to provide an overview of the effects of climate change on livestock health. Ethiopia is home to Africa's largest livestock population and is the continent's top livestock producer and exporter. Although domestic demand for livestock products in Ethiopia is driven by the export potential of the urban middle and upper classes, the main force driving the expansion and intensification of livestock production (McDonald and Simon, 2011). Ethiopia's recent livestock population estimates that the country has about 57.82 million cattle, 28.88 million sheep, 29.71 million goats, 2.09 million horses, 7.89 million goats, 60.52 million poultry, 5.93 million bees, 0.42 million chickens and 42 million has chickens (CSA, 2016). They are an important component of almost all agricultural systems in Ethiopia and provide draft energy, milk, meat, manure, hides, skins and other products (Funk *et al*., 2012; Bekere *et al*., 2022).

Ethiopia has a diverse climate, with different sizes and diversity of major agronomic zones that make it suitable for supporting large numbers and classes of livestock (Funk *et al*., 2012). However, the country is isolated from climate variability and extremes (Alebachew & Woldeamlak, 2011). Long-term climate outcomes associated with changes in rainfall patterns, rainfall variability and temperature have increased the frequency of droughts and floods (World Bank, 2010). Thus climate and location are undoubtedly the most significant of the factors affecting live-stock production. In fact, climatic features such as ambient temperature and rainfall patterns have a great influence on the cycle of availability of pasture and food resources throughout the year in animal populations. This means that pastures in the rainy season have high availability and show good nutriational quality whereas dry season pastures have poor nutritional quality with high fiber and low protein content, often resulting in reduced animal production (Abebe, 2017).

Review of Literature

Animal Diseases and Climate Change Linkage

The distribution of infectious diseases and the timing and severity of disease outbreaks are often linked to climate. Climate change may affect livestock diseases through both direct and indirect pathways. The direct effect of climate on animal diseases is pronounced for vector-borne, soil-related, water or flood-related, rodent-related, or air temperature humidity related and climate-sensitive diseases. These direct or indirect effects of weather and climate can be spatial, affecting climate distribution, affecting the timing of an outbreak with temporal weather, or related to the severity of an outbreak (Grace *et al.*, 2015). Global climate change alters ecological architecture, causing both geographic and acoustic changes (Slenning, 2010). These changes affect the efficiency and transmission pattern of the pathogen and increase its spectrum in the host (Brook and Hoberg, 2007). An expanded spectrum of pathogens increases the susceptibility of animals to disease and, thus, supports the pathogenicity of the causative agent. Therefore, livestock systems are sensitive to changes in the severity and distribution of livestock diseases. The incidence of external parasites (43.4%) ranked first as a problem in warm temperate regions. Vector-borne diseases are particularly sensitive to climate change, particularly as changes in rainfall and temperature regimes can affect both the dis-tribution and abundance of disease vectors (Dhakal *et al.*, 2013). Arthropod vectors are more active at higher temperatures, thus they feed more regularly to maintain their increased metabolic activity, increasing the likelihood of transmission of infection between hosts. Small changes in vector characteristics can lead to significant changes in disease (Grace *et al.*, 2015). There is a link between climatic and epidemiological conditions of disease agents. Temperature, precipitation, humidity & other climatic factors that affect the reproduction, development, behavior and population dynamics of helminths, arthropod vectors and the pathogens they carry. Climate change affects the emergence, spread of disease hosts or vectors, pathogens and their reproduction, development & transmission (ESAP, 2009). The OIE Scientific Commission concluded that climate change may be an important factor in determining the spread of some diseases, particularly those that are vector-borne. The two most commonly reported emerging and resurgent cattle diseases in recent OIE surveys are catarrhal fever and RVF (OIE, 2008). The global distribution of bluetongue virus infections has changed greatly in recent years and climate change may be partly responsible for these profound changes in the global distribution of bluetongue virus (Wilson & Mellor, 2008). Studies have shown that disease vectors are affected by temperature and indicate the possible role of humidity and rainfall (Wittmann, 2002).

Climate change Impact on health of livestock

Climate change may have a significant impact on the emergence, spread and distribution of livestock diseases. For example, the distribution and impacts of animal vector-borne diseases such as Rift Valley fever, African horse sickness, and bluetongue vary significantly with seasonal and long-term climate change (Thornton & Gerber, 2010). Climate change may affect livestock infectious diseases in several ways; Effects on pathogens, such as high temperatures affecting pathogen or parasite growth rates, Effects on the host, such as changes in disease distribution that may affect populations of susceptible animals, effects on vectors, such as changes in rainfall and temperature regimes that may affect both the distribution and abundance of disease vectors, and effects on epidemiology, such as altered infection rates between hosts (Baylis & Githeko, 2006). Although there is no consensus that a warmer world will necessarily lead to a more disease-ridden world, disease risk may increase for a variety of other reasons, such as the increasing complexity and scale of market chains and, in particular, the inevitable intensification of production systems the place (Randolph, 2008).

Climate change impact on the vectors

Arthropod vectors are cold-blooded and thus particularly sensitive to climatic factors. Temperature, rainfall, humidity and other climatic factors affect the survival, production, development, and behavior and population dynamics of arthropod vectors. Subsequently, climatic factors influence habitat suitability, distribution and abundance; Intensity and temporal pattern of vector activity throughout the year. Climate change may affect disease vectors through several mechanisms. First, temperature and humidity often impose limits on their distribution. Often, low temperatures are limiting because of high winter mortality and relatively slow rates of population recovery in warmer seasons. Conversely, high temperatures are limiting therefore, cold regions that were previously too cold for vectors may begin to flourish with climate change; Warm regions can become warmer and still allow for vectors if rainfall or humidity increases. Conversely, these areas may become less suitable for vectors if moisture levels remain unchanged or decrease, with concomitant increases in moisture-stress (Baylis & Githeko, 2006). Climate change will affect arthropod vectors, their life cycles and life histories, thereby altering the distribution of both vectors and pathogens and the ability of arthropods to transmit pathogens. Therefore, animals will be exposed to different parasites and/or diseases, as indicated by predicted changes in the distribution of, for example, the tsetse fly in Africa, which will put more pressure on production and livestock survival (Tabachnick, 2010). Research studies in India have shown that meteorological parameters such as temperature, humidity and rainfall explain 53 and 85% of the variation in seasonality of FMD in cattle in the hyper-endemic division of Andhra Pradesh and the mesoendemic region of Maharashtra state, respectively (Ramara, 1988). Livestock infestations are exacerbated by hot-humid weather, *B. microplus*, *H. bispinosa* and *H. anatolicum* (Kumar *et al.,* 2004). Feeding frequency of arthropod vectors may also increase with increasing temperature. Many vectors must feed twice on a suitable host before infection is possible-once to acquire infection and, after EIP, once to transmit it. For many blood-feeding arthropods, feeding frequency is determined by the time required for egg development. For example, *C. sonorensis* females feed every 4 days at 31 °C but every ~15 days at 14 °C. At warmer temperatures, the vector is more likely to receive the two feeds of suitable hosts required for successful transmission (Baylis & Githeko, 2006).

Climate change impact on the pathogens

Higher temperatures and greater humidity generally increase the rate of development of parasites and pathogens that spend part of their life cycle outside the host. Changes in air can affect the spread of pathogens. Flooding following extreme climate events provides favorable conditions for many waterborne pathogens. Drought and desiccation are detrimental to most pathogens (Grace *et al.,* 2015). Increased rates of development due to higher temperatures may shorten the generation time and, possibly, increase the total number of generations per year, thereby increasing the pathogen/parasite population size. Conversely, some pathogens are sensitive to high temperatures and their survival may decrease with climate warming. Pathogens and parasites sensitive to wet or dry conditions may be affected by changes in rainfall, soil moisture and load frequency (Kimaro & Chibinga, 2013). Climate change can affect the spread of certain pathogens and vectors. Some pathogens/parasites and many vectors experience significant mortality during cold winters; Warm winters can increase the likelihood of successful overwintering (Harvell, 2002). Lengthening the warm season may increase or decrease the number of warm- or cold-related disease transmission cycles in a year, respectively. Arthropod vectors require warmer weather so the transmission season for arthropod-borne diseases may be extended. Some pathogens/parasites and many vectors experience significant mortality during cold winters; Warm winters can increase the likelihood of successful overwintering (Witman & Bayliss, 2000). Extreme weather events, for example, flooding can carry a risk of *Cryptosporidium* parasites and entero-haemorrhagic *E. coli* Appears as diffuse pollution from agricultural land. It poses a clear threat to other livestock and is also a zoonotic risk to humans through contamination of water supplies. Production-limiting diseases also deserve increasing attention (Wittmann & Baylis, 2000; Hayle *et al*., 2020).

Climate change impact on epidemiology of disease

Climate change may not only affect the survival of pathogens or parasites or intermediate vectors but may also alter transmission rates between hosts in other ways. Future patterns of international trade, local livestock transport, and farm size are factors that will be driven in part by climate change and may affect disease transmission. Other indirect effects: Climate change may also affect the abundance and/ or distribution of competitors, predators and vector parasites, thus influencing disease patterns. It may also be that changes in ecosystems, driven by climate change and other drivers that affect land use, may give rise to new mixes of species, thereby exposing hosts to new pathogens and vectors and leading to the emergence of new diseases (WHO, 1996). The effects of climate change on livestock diseases are likely to be complex, and studying them will require going beyond any simple assessment of temperature effects on rainfall and distribution, although this is a start. Examples of this type of analysis are done for various livestock diseases in developing countries. It appears that climate change is likely to affect the distribution of the brown-eared tick, *R. appendiculatus*, and the primary vector of ECF, is a disease that affects both grazing and mixed systems in East and Southern Africa. Expand into western and central parts of South Africa (Rogers, 1996). In another study looking at the potential impact of climate change on a major disease of cattle in African livestock systems, trypanosomiasis of cattle (Thornton *et al*., 2006) investigated climate-driven changes in habitat suitability for ticks fly vectors. Although climate will alter habitat suitability for the tsetse fly, population impacts on trypanosomiasis risk through bush clearance may be greater than those caused by climate change. Randolph, (2008) warns that climate change will necessarily lead to an increase in disease risk in general, and there is no a priori reason to expect that infectious agents in general determine a greater risk of infection and exposure of livestock to that risk. More integrated assessments, which go beyond the distributional effects of disease vectors, have been attempted; although to date these have had a developed-country focus (Randolph, 2008). White *et al.* (2003) simulated the increased vulnerability of livestock to ticks in the Australian beef industry (*B. microplus*). They calculated the economic losses associated with reduced tick populations and productivity, and assessed breed change as an adaptation option. Their findings are perhaps more interesting in relation to the uncertainties and assumptions made and their main conclusion that climate change risk assessments should be extended to all relevant variables, where possible. It noted that new studies are focusing on the spread of animal diseases and pests from low to mid-latitudes due to warming.

Models project that bluetongue, which mostly affects sheep and occasionally goats and deer, will spread from the tropics to the mid-latitudes. Most assessments do not explicitly consider impacts on livestock health as a combined function of CO_2 and climate. Whether CO_2 effects are important in this case is largely unknown. Perhaps more than other livestock-related impacts, climate change impacts on livestock diseases suffer from inherent problems of predictability. This is partly due to the nature of the disease (Anon, 2006). As noted in (Baylis & Githeko, 2006), climate change-driven changes in livestock production in Africa, if they occur, could have many indirect and unpredictable effects on infectious animal diseases on the continent. It appears, the combination of drought followed by high rainfall has led to widespread outbreaks of diseases such as RVF and bluetongue in East Africa and African horse sickness in the Republic of South Africa (Baylis & Githeko, 2006). It is likely that certain vector-borne disease outbreaks will become more common in parts of Africa; we are very limited in predicting when and where these may occur. In addition, it has been noted that there is a tendency to oversimplify the mechanisms by which climate change may affect disease transmission. In general, many factors are at work, and thus considerable work is needed on disease dynamics and how they may adapt to a changing climate. These factors make assessing the impact of livestock diseases in developing countries particularly challenging (Kovats *et al.,* 2001).

Climate change impact on incidence of disease

It has been reported that the hot summer months lead to increased milk somatic cell counts and a higher incidence of clinical mastitis in dairy cattle. Reduction of thermal stress through air conditioning or shade management results in a lower frequency of clinical mastitis compared to cows exposed to the natural environment. Populations are associated with hot-humid conditions. Kumar *et al*. (2004) reported that hot-humid weather was found to increase tick infestation in cattle like, *B. microplus*, *H. bispinosa* and *H. anatolicum* which act as vectors of various protozoan diseases (Kumar *et al.,* 2004).

Climate change impact on the hosts

Mammalian cell immunity may be suppressed following elevated exposure to UVB radiation, an expected consequence of stratospheric ozone depletion. Therefore, ozone-depleting greenhouse-gas emissions may affect some animal diseases, which are not studied in cattle. A more important effect may be on genetic resistance to disease. Although animals often develop genetic immunity to diseases they are exposed to, they can be highly susceptible to "new" diseases. Climate change may cause significant changes in disease distribution, and disruption of local stability may lead to severe disease outbreaks in previously unexposed animal populations (Baylis & Githeko, 2006).

Climate change impact on the feed resources of livestock

One of the most important impacts of climate change on livestock production is changes in forage resources (Abbett, 2009) as droughts and delays in the onset of rains lead to poor grass regeneration, water scarcity and heat stress on livestock. Again, droughts and delays in rainfall lead to increased livestock mortality, disease risk, and physical deterioration due to long distance travel for water and pasture.

Digambar, (2011) reported that due to severe drought, there is a direct impact on the growth of palatable grass species and low rainfall is reducing the regeneration of forage species in pastures and forest fodder resulting in loss of diversity and quality. Cattle feed this has led to a decline in the cattle population, which has further affected the production of milk, milk products and meat. Drought also affects livestock by drying up wetlands, pastures, water resources and streams and reducing the availability of drinking water for livestock. Changes in temperature, precipitation regimes and CO2 levels will affect grassland productivity and species composition and dynamics, leading to changes in animal diets and possibly reduced nutrient availability for animals (Digambar, 2011).

Climate change effects on resources of water

De Wit & Stankiewicz, (2006) calculated that perennial drainage reductions will significantly affect access to current surface water across 26 percent of Africa by the end of this century. Morton, (2007) believed that climate change affects mostly developing countries, especially among the population referred to as subsistence or smallholder farmers. Furthermore, small farm sizes, low technology and low capital may increase the vulnerability of livestock production. Rivers, lakes and rainwater supplies are threatened by climate change, which reduces the availability of water for livestock production (Gammada *et al*., 2022).

Climate *change* effects on production of milk

Livestock and climate change have a close relationship. The spatial distribution and availability of pasture and water is highly dependent on rainfall patterns and availability (Akalilu *et al*., 2013). Changes in precipitation patterns and temperature ranges affect food availability, grazing limits, forage quality, weeds, and pest and disease prevalence. Thus, changes in climatic factors such as the frequency and severity of extreme events such as temperature, precipitation, and drought directly affect livestock yields. Climatic factors or seasonal changes greatly affect animal behavior due to neuro-endocrine responses to climatic factors, thereby affecting animal production and health (Baumgard *et al*., 2012). Climate change is a major threat to the viability and sustainability of livestock production systems in many regions of the world (Gaughan *et al*., 2009). High-yielding animals are more affected by climatic factors, especially those grown in tropical conditions, due to high air temperature and relative humidity (Martello *et al*., 2010). Parons *et al*. (2001) argued that high temperatures can reduce feed intake, reduce milk production and lead to energy deficits that can reduce cow fertility, health and longevity. Modeling work using the Cornell Net Carbohydrate and Protein System Model (Chase, 2006) suggested that maintenance energy requirements of a dairy cow weighing 636 kg at 33^{o}C produces 37 kg of milk per day compared to the energy requirements at 17^{o}C. For the same temperature increase, dry matter intake was predicted to decrease by 19% and milk by 33% (Thornton *et al*., 2008).

Climate change impact on the production of egg and meat

The thermoregulation characteristics of poultry are somewhat different from those of mammals because of their higher metabolic rate due to more intensive heat production and lower heat dissipation capacity caused by their feathers and lack of sweat glands. Above 30°C, food and energy intake decreases to such an extent that birds are no longer able to compensate for it, production declines rapidly, and mortality increases. Several studies have reported that high ambient temperatures decrease nutrient digestibility in poultry, which may be due to decreased activity of trypsin, chymotrypsin, and amylase. Consequently, low and most inadequate nutrient supply limits egg production, egg mass & eggshell quality in layers, and growth rate of broilers (Amundson *et al*., 2006).

Climate change effects on the reproduction of livestock

Several studies have reported that high ambient temperatures decrease nutrient digestibility in poultry, which may be due to decreased activity of trypsin, chymotrypsin, and amylase. Consequently, low and most inadequate nutrient supply limits egg production, egg mass and eggshell quality in layers, and growth rate of broilers (Madan, 2007). It is reported that the length and intensity of the estrous period is reduced, so lower conception rates occur. Therefore, heat stress may reduce fertility in summer dairy cows by poor expression of behavioral signs of oestrus due to less estradiol secretion from dominant follicles. In this situation, the calving interval is longer. As a result, the lifetime production of dairy animals decreases. Heat stress during pregnancy slows fetal growth due to reduced blood supply to the uterus, which causes placental insufficiency to supply maternal nutrients, resulting in reduced fetal growth and calf size. Even fetal death occurs in cows exposed to heat stress. Heat stress also reduces seminal volume and sperm concentration. It has been reported that ejaculate volume, sperm concentration and sperm motility of bulls are lower in summer than in winter season (Samal, 2013).

CONCLUSION AND RECOMMENDATIONS:

Climate change has a negative impact on livestock health and productivity in several ways. It can affect livestock health through many factors, including the extent and abundance of vectors and wildlife reservoirs, and the survival of pathogens in the environment. This can increase livestock diseases and some diseases are particularly sensitive to climate change. Indeed a better understanding of the effects of climate change on animal health is important and good for recommendations on how to reduce its potential effects. Unfortunately, the determinants of resilience and adaptation that moderate this effect are already poorly understood. For example, adaptive capacity can be enhanced in the broader context of developing appropriate policy measures and institutional support to help livestock owners deal with all livestock health problems. Indeed, the development of an effective and sustainable animal health service, with associated surveillance and emergency preparedness measures and sustainable animal disease control and prevention programs, is the most important and most necessary adaptation strategy. This will protect the livestock population from the threats of climate change and climate variability. Again, the impact of climate change on livestock production and productivity is complex. Climate change can affect animal production and welfare, particularly due to increased air temperatures. However, knowledge of animal responses to heat stress during warmer months in different regions of the world, as well as during extreme heat events, can be used to assess the effects of global change. However, farmers are not sufficiently aware of the impact of global warming on their operations, resulting in deterioration in the quality and quantity of the natural pastures that most livestock owners rely on to feed their animals. Apart from that, the available water sources are not reliable, as they sometimes dry up due to high temperatures and lack of rainfall. They lost their lives due to excessive heat, water, food and unknown diseases. Therefore, the following recommendations are forwarded for future action.

The awareness of livestock owners and professional on climate change must be raised through training.

1) Selection of representative climatic stations should be considered for livestock enterprises, especially in arid and semi-arid regions.
2) Recording of additional inputs of pasture and livestock production should be implemented, especially in climatically favorable areas.
3) Successful adaptations can be shown to be a better way to deal with the negative consequences of climate change and associated drivers of disease.
4) Future needs assessment of climate change impact should be done, then it should be included in curriculum by concerned policy makers for veterinarians, animal production, and related professionals.

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CONFLICTS OF INTEREST:

The author(s) declare there are no potential conflicts of interest to publish it.

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