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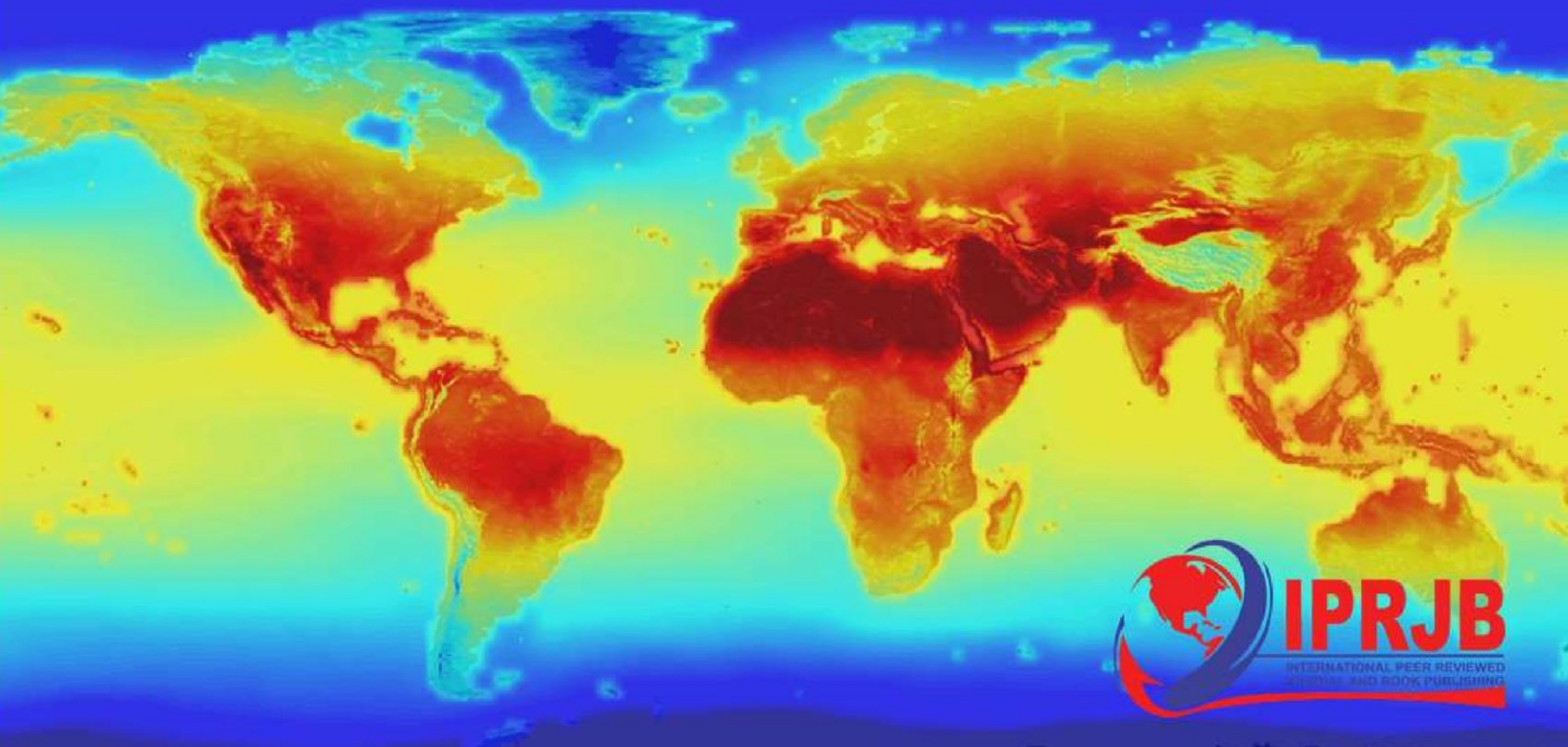

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Impact of Climate Change on Animal Health and Production

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Abstract

Purpose: To examine the impact of climate change on animal health and production.

Methodology: To review an existing literatures concerning impact of climate change on animal health and production.

Findings: Climate change is seen as a major threat to the survival of many species of animal, ecosystems and the sustainability of livestock production systems globally. Livestock production and health are considerably vulnerable to the impact of climate change. Since several decades back, climate change has become the major issue affecting global and regional ecosystems and people are working on it. Although yet it is real and is happening with concomitant changes in precipitation, flooding, heavy winds, and the frequency of severe events, increased temperature, and changes in humidity. It is evidenced that it will become worse in the future life. Climate change has direct and indirect impacts on emerging and reemerging animal diseases and zoonoses since it disrupts natural ecosystems and allows diseasecausing pathogens to move into new areas where they may harm wild life, domestic species, and humans.

The interaction between animal production and climate change is complex since animal production contributes to climate change. However to the reverse and worse condition, climate change highly affects animal production. Thus, the increased threat of climate change on the animal production and health sectors needs the hands of various stakeholders to work collaboratively.

Keywords: *Animal Health and Production, Climate Change, Emerging and Re-Emerging Diseases*

INTRODUCTION

Livestock is one of the fastest growing sub-sectors of agriculture: a doubling of demand for animal source foods is expected for developing countries and a 70% increase for the world as a whole [1]. Most African farmers depend on livestock for income, food and animal products [2], and are known to keep cattle as an insurance policy for when droughts ruin annual crops [3].

Climate change is a result of the global increase in average air and ocean temperatures, and rising average sea levels and has become the main issue affecting global and regional natural eco-systems [4]. The world's climate was reported to be warming at a faster rate than ever before [5] with concomitant changes in precipitation, flooding, winds and the frequency of extreme events such as El Niño [6]. It will become worse in future with more impacts to rural poor communities of developing countries [7].

Climate change effects on both the environments and animals directly or in directly. *Direct* effects are species by altering their physical environments and *indirect* effects are species by altering interspecific interactions such as predation and competition. Agriculture and livestock are amongst the most climate sensitive economic sectors in the developing countries. Livestock production and health are significantly vulnerable to the impact of climate change [7]. Climate change has negative effects on livestock health in many aspects and can exacerbate disease in livestock and some diseases are especially sensitive to climate change [8]. Based on IPCC [4] report, global changes in temperature may affect the incidence andrange of several infectious diseases within endemic areas and their introduction to free areas [9]. Approximately 80% of emerging infectious diseases affecting humans and a rising number of these diseases (for instance, severe acute respiratory syndrome (SARS), monkey pox, Marburg diseases and Ebola) are spread by contact with wildlife [10]. A report by IAEA [11] indicated that the most important immediate consequences of global warming would be an increased incidence in deadly infectious diseases in wildlife, livestock, and people.

Vector borne diseases are particularly affected by weather patterns and long-term climatic factors strongly influence of outbreaks. Most of these diseases are caused by insects and their population dynamics is dependent on the prevailing weather conditions, specifically temperature and humidity [11]. Because arthropods are highly sensitive to environmental and seasonal temperatures, the range of vector-borne diseases such as bluetongue, west Nile fever, Venezuelan equine encephalitis, rift valley fever, African horse sickness and visceral leishmaniasis may be limited or exacerbated by the distribution of competent vectors [12]. The rapid spread of the above mentioned diseases has been driven by climate change. In addition, animal parasites including tick-borne diseases in Africa and New world screwworm (*Cochliomyia hominivorax)* in south America had been reported to spread to new regions, causing negative impact on livestock production and causing direct and/or indirect effects on public health [13].

In developing countries, the productivity of the livestock resources and the benefits obtained from livestock sector does not proportionate with the livestock population due to various constraints [14]. Among these challenges climate change is the important factors which are mostly create low production performance and animal problems. Therefore, the aim of this paper is:

✓ To review an existing literatures concerning impact of climate change on animal health and production.

LITERATURE REVIEW Climate Change

Climate change is caused by accumulation of Green House Gases (GHG) in the atmosphere which leads to global warming. Based on IPCC report some of the GHGs in the atmosphere include carbon dioxide (CO2), methane (CH4) and nitric oxide (N2O) [4]. At global scale, the main cause of greenhouse gas (GHG) emissions is from carbon dioxide (70%), primarily from burning of fossil fuel (petroleum) imported from industrialized countries, while the other sources for GHG are methane and nitrous oxide caused by deforestation and agricultural activities, particularly the use of pesticides [15].

Desertification and climate change are inextricably linked through feed backs between land degradation and precipitation. Less rain leads to soil compaction and hardening, making the land an able to absorb rain water. These could have disastrous effects as rain become less frequent but heavier [16]. The increased use of chemical-based agricultural inputs, including artificial fertilizers, pesticides, and herbicides, and their impacts on soil and water quality will likely exacerbate the effects of climate change by further degrading other ecosystems, such as Coral reefs and rivers, decreasing the land's ability to produce food. It is much easier for farmers in developed countries to endure a climatic set back than those in poorer nations, where 80% of the popular lives in rural areas and approximately 40% of the economy is supported by rain agriculture. For example, as grazing areas dry up in sub-sheep, and wild life dependent on access to grazing areas for food will suffer. This will lead to greater conflict between people and animals [17].

Climate changes are released in the atmosphere both by natural sources and anthropogenic (human related) activities. Climate change is disrupting natural ecosystems by providing more suitable environments for infectious diseases allowing disease-causing bacteria, viruses, and fungi to move into new areas where they may harm wild life and domestic species, as well as humans [4]. Climate change has had an unprecedented worldwide impact on emerging and re-emerging animal diseases and zoonoses. There is evidence that the increasing occurrence of tropical infectious diseases in the mid latitudes is linked to global warming. Climate change influences local weather conditions and therefore has a significant impact on the presence of insects and their geographical distribution [11].

Climate Change and Livestock

The links between animal production and climate change are complex and multi-directional [18] can be viewed in terms of: (1) contribution of animal production to climate change and (2) impact of climate change on livestock production. Animal production and climate change are inter-linked in complex and multi-directional ways [18]. Livestock agriculture accounts for 35-40% of methane and nearly 70% of nitrous oxide worldwide, gases that rise mainly from the digestive processes of animals, and animal's waste. Levels will continue to rise as animals numbers grow to meet the increasing demands for meat and milk from developing countries. Agricultural emissions of nitrous oxide from manure and the production of artificial fertilizers are projected to increase by

35-60% by 2030. Some developing regions will have very large increases, including parts of East Asia with an increase of 35% from enteric fermentation and 86% for manure management [19]. Deforestation for animal production accounts for 85.5% of all carbon oxide life stock related emission and 34% of Carbon dioxide, methane and nitrous oxide emission. The increased production of beef in South America and Soybean production for feed transported to Europe is leading to deforestation of the rain forest, which has a great impact on the emission of GHG. Soya bean production for feed also causes loses of biodiversity and chemical population [20].

On the other hand, animals are intrinsically dependent on the environment, and any fluctuation in weather and climate can affect them through water scarcity, environmental changes such as desertification, and feed and water availability, access, and appropriateness. Climate change will not only impact the health and welfare of animals, but also the more than billion people who depend on them. Climate change influences livestock production by affecting the conditions governing animal production, fodder crop production and animal health. The distribution of infectious diseases, (human, animal and plant) and the timing and intensity of disease outbreaks are often closely linked to climate. Climate change may affect livestock disease through Bluetongue virus [21].

Climate change is seen as a major threat to the survival of many species, ecosystems and the sustainability of livestock production systems in many parts of the world. Climate change has negative effects on livestock health in many aspects. It may influence livestock health through a number of factors, including the range and abundance of vectors and wildlife reservoirs, the survival of pathogens in the environment. Climate change can exacerbate disease in livestock and some diseases are especially sensitive to climate change. Indeed a better understanding of the effect of climate change on animal health is crucial and good for recommendations on how to lessen its potential impact [8]. Intensification of animal farming may not ever truly be sustainable, unless, among other things, there is concomitant attention to the health and behavioral needs of the animals, a meaningful effort to provide them with a life worth living.

Climate change influences local weather conditions and therefore has significant impacts on the presence of insects and their geographical distribution and has had an unprecedented worldwide impact on emerging and re-emerging animal diseases and zoonoses [11]; resulting in negative effects on livestock health in many aspects [8]. Not only climate change, the production system of animals may also have negative impacts on animal diseases. For example, intensifying production systems will increase the opportunity for emerging and re-emerging animal diseases and management systems need to be developed to minimize their direct and indirect effects on production and profitability. The relationship is in fact a continuous interplay in which changes in one element of the complex system lead to changes in other parts of a system [22] (see Figure 1).

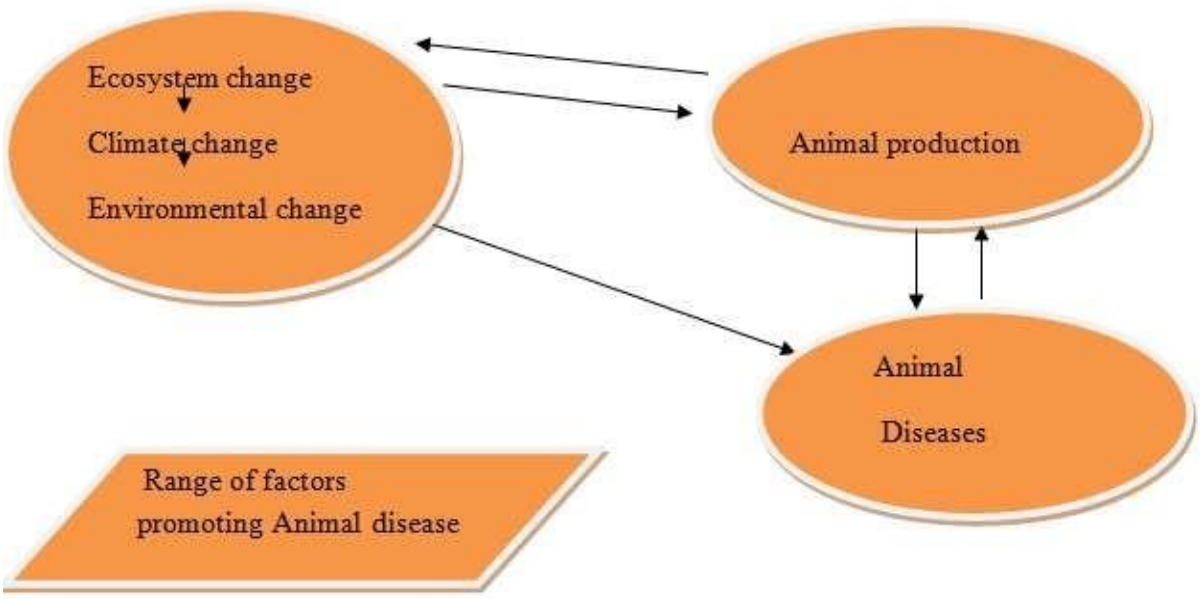

Figure 1: Relationship between Climatic Change, Environmental Change, Animal Production and Animal Diseases **Source: [22].**

Impact of Climate Change on Animal Production

Climate change will have far-reaching consequences for animal production, particularly in vulnerable parts of the world where it is vital for nutrition and livelihoods. The impact of climate change can heighten the vulnerability of livestock systems and exacerbate existing stresses upon them, such as drought. The livestock production and productivities will be one of the most susceptible sectors to climate change due to changes in hydrological cycle, temperature balance and rainfall patterns which have a negative impact on livestock production and productivity. The direct impacts of air temperature, humidity and wind speed capable of influencing growth rate, milk production, wool production and reproduction has been reported by [23].

In IPCC third Assessment Report [5], there was a section devoted that the vulnerability of animal production, warming those animal production facilities will be affected both directly and indirectly by climate change. The direct effects include the interchange of heat between the animal and its environment, associated with temperature, humidity, wind spread and thermal production. These are factors that influence animal performance (growth, milk and wool production, reproduction), as well as animal health and welfare. The indirect effects include the influence of climate on the quantity and quality of fodder crops and grains, and severity and distribution of diseases and parasites. When the magnitudes (intensity and duration) of adverse climate conditions exceed certain limits, with little or no possibility of recovery, animal functions are adversely affected as a result of stress, at least in the short term. Genetic variation, the stage in the life cycle and nutritional status also influence their vulnerability and resilience to environmental stress.

Impact of Climate Change on Milk and Beef Production

Milk production from dairy cattle and conception rates can fall dramatically, and vulnerable animals may die as a result of extreme events [4]. Changes of temperature and relative air humidity during a hot summer the effects of selected microclimate parameters have been assessed based on the THI (temperature-humidity index) in relation to milk production [24]. The optimal ambient temperature for dairy cows is between 5 to 15°C. Over 15°C the animals start to sweat, although they are still able to maintain the equilibrium between heat production and heat dissipation. Heat dissipation by sweating gradually increases and although it becomes quite intense above the upper critical temperature (25°C) the cow is no more able to maintain the heat balance at such high temperatures. Kadreze et al. [25] found that on days of heat stress the amount of water lost through evaporation may be up to or even exceed the amount of water excreted in the milk. The high rate of water loss stresses the importance of water supply for dairy cows at high temperatures. In beef cattle the unfavorable meteorological conditions directly affect the animals and their physiology as discussed in the above section for dairy cows. Extreme weather conditions diminish the growth performance (weight gain, feed intake and feed conversion potential) of beef calves, particularly of those kept outdoors [26].

Impacts of Climate Change on Animal Health

Climate change is expected to affect disease and pest's distributions, range of prevalence, incidence and seasonality but the degree of change remains highly uncertain. It is expected to affect both pathogen and vector habitat through changes in temperature, precipitation, humidity and wind patterns. Heat stress and drought are likely to have further negative impacts on animal and human health and disease resistance [4]. It has been reported that animals in Afar regional state had suffered from the burden of endemic and varieties of newly emerged animal diseases which can be linked to climate change and extreme weather conditions. Cold-blooded vectors are sensitive to direct effects of climate such as temperature, rain fall patterns and wind. Rising temperature influences the production and maturity rate of infective agents as well as the survival rate of the vector organisms, thereby further influencing disease transmission [4]. Climate also affects their distribution and abundance through its effects on host plants and animals [27].

Climate change can have direct and indirect effects on infectious diseases. Direct effects manifest as reduced capacity of the hosts to mount a response to infection (e.g., due to heat stress) or increased development rates of pathogens and vectors. Indirect effects, on the other hand are associated with climate-driven ecosystem changes or socio-cultural and behavioral adaptations which could also amplify vector/pathogen development or increase vector-pathogen-host contact. The socio-cultural and behavioral adaptations include livelihood practices such as increased frequency and range of migration often associated with pastoral communities. Direct pathways include processes that affect host immunity and/or pathogen and vector development dynamics, while indirect processes include processes that destabilize disease ecology, leading to an increase or decrease of contact between vectors, pathogens and hosts, or increased persistence of pathogens in an environment [28].

It was described that landscape changes that remove portions of host populations (example habitat alteration or destruction), alteration of host migration patterns (example habitat fragmentation) and increased host density were factors that affect animal diseases emergence and re-emergence [10]. The geographical distribution of vector-borne diseases is influenced by the geographical distribution of both vertebrate host and the distribution of the vector; other contagious diseases are also subject to a degree of environmental influences, including parasite life cycles which can be transmitted by wind-borne aerosol spread [29]. Increased precipitation may also cause changes in the prevalence and intensity of parasite infestations, increasing host mortality in wild and domestic species [12].

Climate change may have significant impacts on the emergence, spread and distribution of livestock diseases. Temperature has substantial effects on pathogens that spent part of their life cycles outside a mammalian host such as the agents that cause anthrax, black quarter and dermatophilosis, helminths, etc [28]. In nature pathogens can be transmitted directly between animals or indirectly through intermediate hosts. Indirect transmission aids are often affected by environmental conditions such as temperature and rain fall. Higher temperatures associated with climate change may contribute to an increase in pathogens with intermediate hosts and vectors or in erased survival of animals that labor disease [30]. Survival of some parasites was reported to be increased by warmer temperatures and milder winters in the north central United States and Northern Canada. Climate change would lead animals to be stressed by heat [31] and as result becoming more susceptible to parasitic and infectious diseases [32].

The more contact between wildlife populations and domestic species, the higher the likelihood of exposure to novel pathogens, leading to emergence of new diseases in humans and animals [33]. For example neutralizing anti-bodies against Para-influenza (PI)-3 virus which is relatively common in cattle and have been found in Huemui deer in Chile (a species which is in danger extinction) [34]. For contagious animal diseases, climate may be associated with seasonal occurrence of diseases rather than with spatial propagation. These is evidence for pathogens or parasitic diseases such as fasciolosis in areas with higher temperatures, when seasonality is extended as a consequence of the increased survival of the parasite outside the host or conversely, shortened by increased summer dryness that decreases their numbers [29].

Several pathogens, such as parasites that spend part of their life cycle as free stages outside the host, temperature and humidity may affect the duration of survival. Climate change could modify the rate of development of parasites, increasing in some cases the number of generations and then extending the temporal and geographical distribution. New world screwworm infestations had been observed to increase in spring and summer and decrease in autumn and winter in South America [35]. On the other hand, leishmaniasis in humans has been associated with the increased frequency of drought as this facilitates reproduction and growth of adult sandflies [36].

Wild birds are known to be reservoirs for several pathogens, including west Nile virus (WNV) and serve as amplifying hosts for the virus in nature [37]. The migration of birds is driven in part by seasonal climatic factors and any change in climatic conditions may modify the direction and intensity of spread of disease. Similar disease ecology and wildlife interactions of pathogens

associated with birds have been observed for Newcastlediseases, WNV and influenza-A virus [37, 38].

On the other hand, the mosquitos' genus *Culex* species such as *Culex pipiens* and *Culex restuans* play an important role as vectors, for WNV. Bluetongue virus, which is transmitted by *Culicoides* species, midges has been historically distributed between latitudes 40° N and 35° S [39]. *Vesiculo viruses* which cause vascular stomatitis can be insect-transmitted and has been isolated from species of midges (*Culicoides* species) and hlevotomine flies, including sand flies (*Lutzomyta* species) and black flies (Simuliidae species). Antibodies to *Vesiculo* virus has been detected in monkeys, marsupials, bats, carnivores, deer and rodents throughout America. Seasonal variation is observed in the occurrence of virus and it disappears at the end of rainy season in tropical areas and at the time of the first frosts in temperate zone [40].

Climate Change on Epidemiology of Animal Diseases

Diseases that were previously limited only to tropical areas are now spreading to other previously cooler areas [41]. Pathogens that were restricted by seasonal weather patterns can invade new areas and find new susceptible species as the climate warms and/or the winters get milder [11]. The role of environmental pathogen load is perhaps more obvious still in the case of fecal-oral or waterborne transmission. Food poisoning is usually due to fecal contamination of food items. The natural cycle of Avian Influenza Virus in mallard ducks, it is for a most natural host, involves ingestion of water containing the virus. Natural avian influenza virus replication occurs mainly in the distal end of the enteric duck tract [42]. Virus deposited migratory water fowl during summer breeding at higher latitudes may be stored in permafrost conditions in sub-arctic regions and survive for centuries. Likewise the anaerobe *Bacillus anthrax* bacteria survive for decades in the form spores in the soil [43].

Disease agents transmitted by arthropods form a distinct, albeit related category. Indirect transmission of protozoan disease agents may be facilitated by most ticks. Soft ticks feeding on warthogs play a role in the transmission of African Swine Fever (ASF) [44]. The causative agent of ASF, a DNA virus, may survive for eight years in the tick vector. Some insect-borne disease can survive in dormant form. For example, Rift valley fever (RVF) virus may survive in mosquito eggs for years, until a prolonged heavy rain fall facilitates an a making of *Aedes* mosquitoes, feeding on ruminants and thus kick-starting a RVF outbreak [45]. Infected ruminants that end up in densely populated irrigation schemes may also attract mosquitoes feeding on humans and thus contribute to the transmission of RVF among humans. Midges are sometimes blow by wind across wider geographic areas. These will probably what happened with bluetongue virus introduction in the United Kingdom, in the summer of 2006, after the virus had first spread west wards across Belgium [46]. It was observed that flare up of the *Schmallelgberg* virus in the United Kingdom in early 2012 resulted from wind carried infected midges arriving from main land Europe [47].

In the direct-indirect transmission spectrum, directly, swiftly transmitted common flue, short lived fevers, fecal-oral, food and vector-borne transmission to more prominent free living parasite stage can be noted. In this regard ectoparasite and myiasis causing insects may be considered. Arthropod pests are strongly modulated by climatic and weather conditions [48]. The effect of climate change

on the tsetse flies, the vector of human and animal trypanosomiasis, is rather different, deposit certain similarities between tsetse and the screwworm fly life history [49]. The effects of climate change on disease distribution may take many different forms, compression and generalization. The tsetse fly distribution in Ethiopia entails a gradual encroachment of the country's central high and plateau [50], recorded since the 1960s, the old world screwworm fly colonized the Arabian peninsula, first the Mesopotamia valley in Iraq and later parts of Yemen, the course two decades [51].

Effects of climate change on emergence and spread of animal diseases: as global temperature increases, the effects will be quite complex and vary from region to region. Though the extent of these effects is uncertain, it is known that those communities and regions with least resources, such as rural agricultural areas will be the most vulnerable to climate change [52]. Warmer and wetter (particularly warmer winters) will increase the risk and occurrence of animal diseases, as certain species that serve as disease vectors, such as biting flies and ticks, are more likely to survive year round. Certain existing parasitic diseases may also become more prevalent, or their geographical range may spread, if rain fall increases. This may contribute to an increase in disease spread, including zoonotic diseases [53].

Transportation of animals for personal, entertainment, or agricultural purposes also increases possibility for the introduction and subsequent presence of diseases and pests, including ticks and parasites, previously considered exotic. The viral infection bluetongue disease, for example, was once only a threat in Africa, now affects cattle and sheep in the whole of Europe [4]. The climate change responses are broadly consistent with other works that has highlighted the increase in the incidence of vector borne diseases in association with climate change. This increase is due to both the markedly altered vector population size and dynamics, and the increases in pathogen replication rates that are influenced directly by ambient temperatures during infection of the poikilothermic arthropod vectors [54].

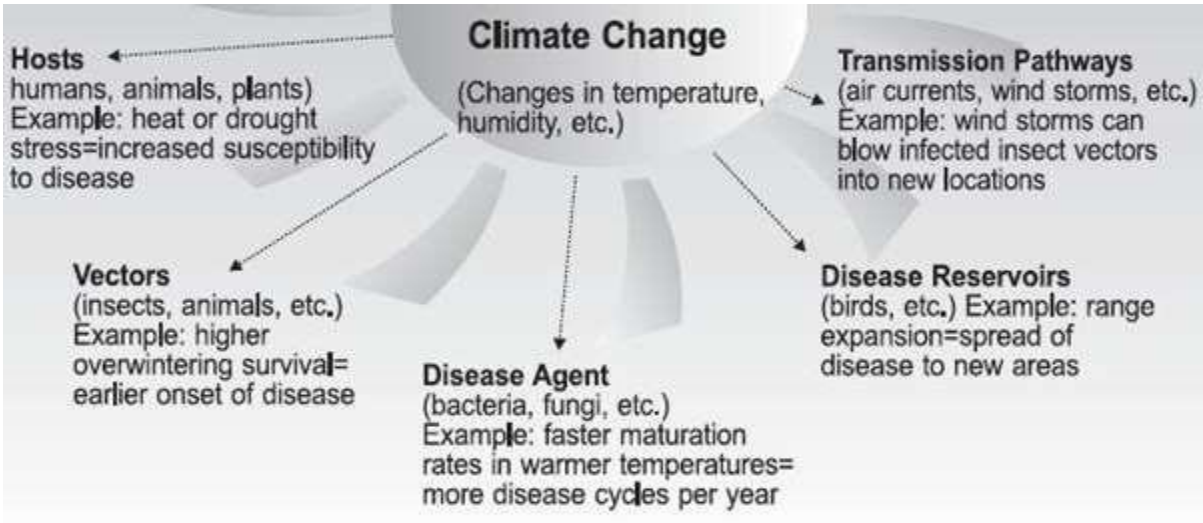

Figure 2: The Relationship between Climate Change and Animal Disease Source: [55].

Climate Change on Vectors of Animal Diseases

One consequence of significant and permanent changes to our climate is the alteration of disease patterns in humans and animals. These alterations may include the emergence of new disease syndromes and a change in the prevalence of existing diseases, particularly those spread by biting insects [56]. Climate change may cause vector-borne diseases to shift in distribution because the vectors' ecology and the pathogen development rate within them strongly depend on environmental conditions. In some cases, shifts to previously unexposed populations of humans and animals could have severe or even devastating consequences [57]. Vectors may reach out to wider geographical areas widening their distribution patterns to non immune areas, and may recruit new vectors or new strains resulting in the spread to new hosts [56].

Insect-borne diseases are now present in temperate areas where the vector insects were nonexistent in the past e.g. trypanosomosis. Vector borne diseases are particularly affected by weather patterns and long-term climatic factors strongly influence the incidence of outbreaks. Most of these diseases are caused by insects and their population dynamics is dependent on the prevailing weather conditions, specifically temperature and humidity. It is now evident that diseases carried by insects and ticks are likely to be affected by environmental changes because these creatures are themselves very sensitive to vegetation type, temperature, humidity etc [11].

There is a global trend for mosquitoes and biting midges to populate and establish themselves in new ecosystems. Although there are several historical records of bluetongue outbreaks in Europe, the recurrent exotic introductions since 1998 have been alarming, with six strains of Bluetongue virus identified across 12 countries and occurring some 80km further north than ever previously reported [39]. These rapid spread has been driven by climate change, which has increased virus persistence in vector hosts during winter period and the North ward expansion of Culicoides imicola, an indigenous European midge species, thereby expanding the risk of transmission over larger geographical regions. In addition, animal parasites, including tick-borne diseases in Africa and New world screwworm (Cochliomyia hominivorax) in south America, have spread to new regions, causing negative impact on livestock production and causing direct or indirect effects on public health [13].

Understanding vector capacity is key to understanding diseases dynamics. Many significant livestock diseases have insects (mosquitoes or ticks) as part of their transmission cycle. Bluetongue disease in cattle, ASF in pigs and Rift valley fever in ruminants are just few disease named. In humans malaria is most significant. Rainfall patterns may also have clear impact on the life cycle of pathogens and diseases. In particular the expected accumulation of water can result in nesting sites for mosquitoes to breed and expand, and as a result serve as reservoirs and transmitters for diseases. Besides changes in rainfall patterns, climate change can result in increased frequency of sever climatic event which can result an important feature of vector distribution [50].

Increasing temperatures, combined with changes in rain fall and humidity, may have significant impacts on wildlife, domestic animal and human health and diseases. When combined with expanding human populations, these changes could increase demand on limited water resources, lead to more habitat destruction and provide yet more opportunities for infectious diseases to cross from one species to another [4]. Climate change, habitat destruction and urbanization, the introduction exotic and invasive species and population- all affect eco-system and human health. Climate change can also be viewed within the context of other physical and climatic cycles, such as El Nino Southern oscillation (El Nino), the North Atlantic oscillation, and cycles in solar radiation that have profound effects on the earth's climate. The effects of climate change on wild life disease can be summarized in terms of geographic range and distribution of wild life diseases, plant and animal phenology, and patterns of wild life diseases, community and eco-system composition, and habitat degradation [58].

Timing of recurring seasonal biologic cycles of some plants and animal species has already been affected by climate change [58]. The timing of biological cycles, such as the arrival of a bird species in spring and the availability of its preferred food source, is critical for successful breeding and survival. Several studies in Europe show that some migratory birds have changed their migration patterns in response to climate change by arriving earlier than records show historically [59, 60].

CONCLUSION

The world's climate changing is at more rapidly rate. Climate change is happening now with concomitant changes in precipitation, flooding, winds and frequency of extreme events such as El Nino. Climate change can have direct and indirect effects on infectious diseases through disrupting natural ecosystems and providing more suitable environments for infectious diseases allowing disease-causing bacteria, viruses, and fungi to move into new areas where they may harm domestic species and wild life as well as humans and it is exacerbating diseases in livestock. The distribution and incidence of vector borne diseases are directly influenced by climate since the geographical distributions of vectors are pre-determined by temperature and humidity. Animal production and climate change are inter-related in a complex ways. Thus, animal production systems can be sources of climate change through releasing gases and deforestation for production of animal feed while, climate change affects animal production through desertification, water scarcity, and changes in feed. However, both change in climate and production systems have impacts on diseases of animals finally leading to low productivity. Therefore, appropriate animal farming system and ecosystem management and climate adaptation strategies should be developed and implemented through collaboration.

Conflict of Interest

The authors declare that they do not have any competing interests.

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