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Review Article

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Review on The Impact of Climate Change on Approach to Epidemiology of Livestock Diseases Control

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ABSTRACT

The livestock sector globally is highly dynamic. In developing countries, it is evolving in response to rapidly increasing demand for livestock products. In developed countries, demand for livestock products is stagnating, while many production systems are increasing their efficiency and environmental sustainability. Currently, the world is facing a number of challenges, of which Global climate change is a priority area. Agriculture and livestock are amongst the most climate sensitive economic sectors in the developing countries. Climates comprises many factors including temperature, rainfall, humidity, winds and altitude hat can have both direct and indirect effects on animal production and health. It can also affect the quality and quantity of feedstuffs such as pasture, forage and grain and the severity and distribution of livestock diseases and parasites. Infectious diseases of animals are of huge socioeconomic and public health importance. The earth's temperature has risen at an average of 0.3 to 0.7 °C since 1900 & 20-30% of all vertebrate animals are expected to get extinct if the average temperature rises by 2-3 °C. The early consequences of global climate change (GCC) are well documented. However, future impacts on ecosystem health, and on the health of humans, domestic animals, and wildlife, are much less well understood. A two-pronged approach must be adapted to tackle the alarming situation arising out of climate change impacts. Adaptation may involve the measures for future adaptation to the disease onslaught and the Mitigation focuses on reducing the level of agents/factors leading to the climate change. One health concept in one health triad needs to be followed in spirit to avert the otherwise sure to come impacts of climate change.

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Abbreviations and Acronyms

ASF African Swine Fever
CH4 Methane
CO2 Carbon Dioxide
DNA Deoxyribonucleic Acid
EIP Extrinsic Incubation Period
ENSO El Nino Southern Oscillation
FMD Foot and Mouth Disease
GCC Global Climate Change
GDP Gross Domestic Product
IFAD International Fund for Agricultural Development
IPCC Intergovernmental Panel for Climate Change
LSD Lumpy Skin Disease
N2O Nitrous Oxide
PPM Part Per Million
PPR Peste Des Petits Ruminants
RVF Rift Valley Fever
USD United States Dollar
UV-B Ultraviolet

Introduction

Livestock provide numerous economic and social benefits. This sector employs at least 1.3 billion people globally and directly supports the livelihoods of 600 million smallholder farmers in developing countries [1]. In Africa, over 50% of rural households are dependent on livestock for their livelihoods [2]. Livestock play a major role in the agricultural sector in developing nations, and the livestock sector contributes 40% to the agricultural GDP. Global demand for foods of animal origin is growing and it is apparent that the livestock sector will need to expand [3]. In addition to providing animal proteins, livestock rearing facilitates other types of agricultural production. For example, mixed crop-livestock systems produce half the world's cereals [4]. It also plays important role in the rural economy of a country as supplementing family incomes and generating gainful employment in the rural sector, particularly among the landless laborers, small and marginal farmers and women [5].

The total demand for livestock products in Africa is expected to almost quadruple by 2050, in large part to help feed the over 1.2 billion more people projected to be added to the continent during that time. The success of livestock industry depends on the health of the livestock. Good health increases the productivity and any compromise on health ground [6]. Infectious animal diseases continue to have an impact on the overall development in terms of lowered productivity, cause financial losses, harm the environment, affect human health, and tend to increase poverty particularly in developing world. Livestock as a sector is extremely important to the global economy and to rural livelihoods. As of 2013, there was an estimated 38 billion livestock in the world. The diseases result in loss of economy of the state, thus the knowledge of occurrence and pattern of animal diseases becomes vital in the management, as the main objective of the good management is to reduce the disease incidence and increase the productivities and reproduction [2].

Climate change and warmer temperatures alter the transmission dynamics of disease that spread from animals to humans. Increased risk of zoonoses comes from warming temperatures that promote the survival of the animal disease host by allowing them to overwinter when they normally would not be able to. Consequently, hosts both susceptible and infected proliferate in numbers and increase the risk of infecting humans [7]. In addition to carbon dioxide (CO2), human activities add methane (CH4) and nitrous oxide (N2O) to the atmosphere. These gases are generated in city landfills, livestock farms, rice fields and through the use of nitrogenous fertilizers. Some greenhouse gases are manufactured artificially, such as the fluorinated gases used in refrigeration and air-conditioning systems. Livestock are adversely affected by the detrimental effects of extreme weather. Climatic extremes and seasonal fluctuations in herbage quantity and quality will affect the well-being of livestock, and will lead to declines in production and reproduction efficiency [8]. Climate change is a major threat to the sustainability of livestock systems globally. Consequently, adaptation to, and mitigation of the detrimental effects of extreme climates has played a major role in combating the climatic impact on livestock [9].

Agriculture and livestock keeping are amongst the most climate-sensitive economic sectors and rural poor communities are more exposed to the effects of climate change. Evidence from the Intergovernmental Panel (IPCC) on Climate Change is now overwhelmingly convincing that climate change is real, that it will become worse, and that the poorest and most vulnerable people will be the worst affected. The International Fund for Agricultural Development (IFAD) acknowledges climate change as one of the factors affecting rural poverty and as one of the challenges it needs to address [10]. While climate change is a global phenomenon, its negative impacts are more severely felt by poor people in developing countries who rely heavily on the natural resource base for their livelihoods. The IPCC predicts that by 2100 the increase in global average surface temperature may be between 1.8 and 4.0 °C. With global average temperature increases of only 1.5 – 2.5°C degrees, approximately 20-30 percent of plant and animal species are expected to be at risk of extinction [2].

Anthropogenic inputs to the level of greenhouse gases in the atmosphere have led to planetary warming and a dramatic change to the Earth's climate over the past two centuries. Between 1880 and 2012 the global temperatures increased by an average of 0.85°C, and are forecasted to reach an increase of between 1.5°C to 4°C by the end of the century (Parkinson and Butler, 2006). Although methane and nitrous oxide have a potentially very powerful greenhouse gas effect, they have not been released into the atmosphere is such large quantities as CO2, and their half-life in the atmosphere is shorter. This means that CO2 originating from human activities is the gas with the biggest impact on climate change. Climate change manifests itself through increasing variation in the weather, including temperature, precipitation and wind. Scientific research confirms climate change is occurring and expected to aggravate in coming decades [11,12]. The effects of environmental change and warming have been the most severe in the northern latitudes compared to other regions. IPCC's fifth assessment report, scientists found that temperatures in the Arctic had risen at over twice the rate of the global average and may reach increase between 1.5 and 5.8°C by the end of the century [12]. Understanding of the relation between climate change and livestock disease is critical for better management of animal health problems. Therefore, the objective of this review to give an overview on the effects of climate changes on livestock diseases and animal production.

Literature Review

Overview of Infectious Diseases

Globally, the direct impacts of livestock diseases are decreasing, but the total impacts may actually be increasing, because in a globalized and highly interconnected world and the effects of disease extend far beyond animal sickness and mortality [13]. The global impact of infectious animal diseases is likely to be affected by many factors that cannot be predicted with confidence, including, changes to livestock management practices, changes to the physical environment, developments in animal genetics, new scientific or technological advances, and influence from climate change. A more predictable factor which can affect the future of infectious animal disease is the climate change [14]. In the developing world, these diseases continue to limit productivity, constrain development and exacerbate poverty through financial loss as well as being zoonotic [15].

Governments spend colossal sums of money in the control of these diseases [16]. There have been relatively few changes in the distribution, prevalence and impact of many epidemic and endemic diseases of livestock over the last two decades, particularly in Africa, with a few exceptions such as the global eradication of rinderpest [13]. Over this time, there have also been a general decline in the quality of changing disease status in much of the developing world is the lack of data, a critical area where progress needs to be made if disease diagnostics, monitoring and impact assessment are to be made effective and sustainable. Over the long term, future disease trends could be heavily modified by climate change [17,14].

Overview of Climate Change or Variability

Climate is an integral part of ecosystems and organisms have adapted to their regional climate over time. Climate is the composite of all many varied, day-to-day weather conditions in a region over a considerable time. This time period should be ideally long enough to establish the entire relevant statistical infrastructure necessary to describe the variations in a regions' weather including absolute extremes, mean values and the frequency of departures from the mean [18]. Climate depends on other components of the global climatic systems such as the ocean, the polar ice sheets, and land surfaces with their varied vegetations. Climate variability is the manner in which climatic variables (such as temperature and precipitation) depart from some average state, either above or below the average value even between short periods [19].

Climate change is a factor that has the potential to alter ecosystems and the many resources and services they provide to each other and to society. The resulting impacts on ecosystems could be positive or negative depending on whether these species were invasive or were valuable. Climate change disruptions are causing large losses to natural habitats and wildlife in developing countries. These disruptions create environmental refugees ("people fleeing from environmental crises, whether natural or anthropogenic events, and whether short or long term). Reasons for displacement include land degradation, drought, deforestation, natural disasters, and other environmental changes that interact destructively with poverty and population pressure [20].Climatologists and other experts in atmospheric and biological sciences tell us that climatic changes are occurring as a result of imbalances between incoming and outgoing radiation in the atmosphere [21].

Global Impacts of Climate Change

Climate change effects include among other things such as sea level rise, changes in the intensity, timing and spatial distribution of precipitation, changes in temperature and the frequency, intensity and duration of extreme climate events such as droughts, floods, and tropical storms. The issue of climate change and its impacts on livelihood has been well documented by different researchers globally [22,23].

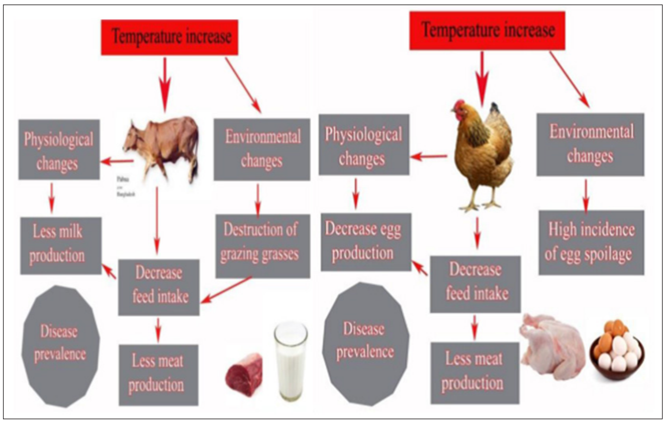
Africa is already a continent under pressure from climate stresses and is highly vulnerable to the impacts of climate change. It is estimated that one third of African people already live in drought-prone areas and that 220 million are exposed to drought each year (IPPC, 2002). Africa is particularly vulnerable to climate change because a large proportion of the population resides in rural areas and is heavily dependent on climate-sensitive livelihoods such as agriculture, and on water and non-timber forest products. Many factors are reported to be contributing to the current impacts of climate variability in Africa and they include poverty, illiteracy and lack of skills, weak institutions, limited infrastructure, lack of technology and information, low levels of primary education and health care, poor access to resources, low management capabilities and armed conflicts [24, 25, 22].

Impact of Climate Change on Livestock Production

The role of livestock sub-sector is very crucial for the economic development of agriculture-based Africa. Livestock provides daily protein and milk dietary requirements of the population, thus playing an important role in providing nutrition and health [18]. Environmental stressors reduce body weight, average daily gain and body condition of livestock. Declines in the milk yield are pronounced and milk quality is affected [26,27].

Any reduction in production in this sector will result in a loss in rural household income, and an increase in unemployment in the rural areas. A series of studies have described a greater risk of mortality during the hottest months and an increased death rate during extreme weather events [28-30,17]. The economic impacts of diseases are increasingly difficult to quantify largely because of the complexity of the effects that they may have, but they may be enormous [31]. In low-income countries, zoonoses and diseases recently emerged from animals make up 26% of the infectious disease burden and 10% of the total disease burden [32].

Generally, the higher producing animals are the most affected. Adaptation to prolonged stressors may be accompanied by production losses. As indicated on the figure Climate changes create stress in livestock and poultry. A high temperature will increase body metabolism which will cause less growth in livestock. This leads to less meat, milk and egg production [33,34]. Increasing or maintaining current production levels in an increasingly hostile environment is not a sustainable option. It may make better sense to look at using adapted animals, albeit with lower production levels and also lower input costs rather than try to infuse 'stress tolerance' genes into non-adapted breeds [35,36].



Source: [33]

Figure 1: Effect of Climate Change on Cattle and Chicken

Impact of Climate Change on Animal Genetics Resource

Animal genetic diversity is critical for food security and rural development. It allows farmers to select stocks or develop new breeds in response to changing conditions, including climate change, new or resurgent disease threats, new knowledge of human nutritional requirements and Changing market conditions or changing societal needs all of which are largely unpredictable. What is predictable is increased future human demand for food. The effects will be most acute in developing countries, where the increase in demand is expected to be greatest and occur at a rate faster than increases in production and where climate change is projected to have its greatest impact [2,3].

The Intergovernmental Panel on Climate Change (IPCC) report on biological diversity and likewise the report of the Convention on Biological Diversity on climate change contain little mention of agricultural biodiversity largely ignores livestock diversity [12]. In a survey on threats to livestock diversity, climate change was only mentioned as a minor factor in the context of extensive land-based production systems. The findings show that many stakeholders do not yet perceive climate change as a problem for the management and conservation of livestock biodiversity (FAO, 2009c). While substantial differences in thermal tolerance lie between species, there are also differences between breeds of a species. Ruminants generally have a higher degree of thermal tolerance than monogastric species, but species and breed environmental envelopes overlap [27]. The ability to thermoregulation depends on complex interactions among anatomical and physiological factors. Factors such as properties of the skin and hair, sweating and respiration capacity, tissue insulation, the relationship between surface area per unit body weight or relative lung size, endocrinological profiles and metabolic heat production are known to influence heat loads, but the underlying physiological, behavioural or genetic mechanisms are largely unknown [37].

Climate and Animal Disease

Many important animal diseases are affected directly or indirectly by weather and climate. These links may be spatial, with climate affecting distribution, temporal with weather affecting the timing of an outbreak, or related to the intensity of an outbreak. These potential consequences of significant and permanent climatic changes are altered patterns of diseases in animal and human populations [38]. Vector-borne diseases, certain directly transmitted diseases, food/water borne and aerosol-transmitted diseases are affected by climate variability or change. Non-vector-borne diseases affected by climate have the pathogen or parasite spending a period of time outside of the host, subject to environmental influence [39,38]. In tropical and temperate climates, some diseases, particularly protozoan and viruses are transmitted by arthropod vectors such as mosquitoes, midges and ticks. If the trends of climate change depict a more humid Earth, the likelihood of disease emergence, incidence, spread and threats to human, animal and plant hosts will rise and the existing evidence on climate change indicates that this is the case [40]. The following are examples of some diseases associated with climate:

Bacterial Diseases

Survival and successful germination of spores of Bacillus anthracis causing anthrax, which is highly fatal infectious disease of warm-blooded animals, including humans, is affected by environmental factors like suitable temperature, humidity and moisture. Outbreaks of such diseases are often associated with alternating heavy rainfall and drought, and high temperatures [41]. Blackleg, an acute infectious clostridial disease mainly affecting young cattle, which is also spore-forming, is associated with high temperature and heavy rainfall. Certain bacteria, such as Dermatophilus congolensis, the causative agent of Dermatophilosis and Pasteurella multocida that causes Haemorrhagic Septicaemia (Pasteurellosis) in bovines, survive well outside the host in moist environments. Both diseases are associated with areas of high humidity and occur during the rainy seasons. In general, bacterial diseases are transmitted from livestock products and kill more people each year as compared to HIV or malaria [42,43].

Viral Diseases

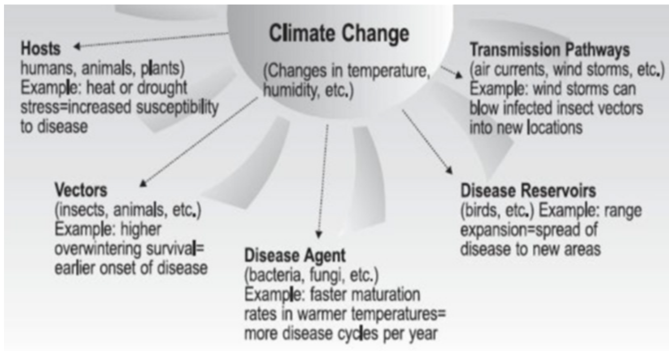
Foot-and-mouth disease is a highly contagious, viral infection with considerable economic importance to Africa. Transmission is mainly by contact between infected and susceptible animals, or contact with contaminated animal products or equipment. However, spread by wind occurs since the virus survives well at relative humidity below 60%, which makes wind-borne spread favorable in humid, cold weather [42]. Lumpy skin disease (LSD) is an acute to chronic viral disease of cattle characterized by skin nodules that may have inverted conical necrosis (sitfast) with lymphadenitis accompanied by a persistent fever. Epidemics of LSD are associated with rainy seasons. The disease spreads in river basins and areas conducive to insect multiplication [44].

Climate change is also expected to affect the ecology of avian influenza viruses. The distribution of avian influenza viruses among wild birds is uneven, as it is influenced by both bird species and eco-geography [37]. Climate change is reported to affect wild bird distribution in a variety of ways. Northward shifts in distributions have been reported in many species and have been attributed to climate change. Declines in the number of species undertaking long-distance migrations have been observed in many instances. All these changes in population, distribution and movement patterns can affect the redistribution of avian influenza viruses among birds of different age classes, species and flyways [45].

Some diseases are transmitted by vectors, such as arthropods (e.g. mosquitoes, lice and ticks) or rodents, which are sensitive to changes in climatic conditions, especially temperature and humidity [46]. One of these diseases is Rift Valley fever (RVF), which is a zoonotic viral disease transmitted by Aedes and Culex mosquitoes. Epizootics of RVF are associated with periods of heavy rainfall and flooding or in East Africa, with the combination of heavy rainfall following drought associated with El Nino Southern Oscillation (ENSO) [47,48]. Bluetongue, is a viral infection of ruminants transmitted by a vector (Culicoides biting midges) whose distributions are largely dependent on environmental variables such as temperature, moisture and wind [49].

Helminthes

Climate appears to be more frequently associated with the seasonal occurrence of non-vector borne animal diseases than their spatial distribution. By contrast, the associations of vector-borne diseases with climate are equally apparent in time and space a reflection of the strong influence of climate on both the spatial and temporal distributions of the intermediate vectors [17]. Helminth diseases (e.g. cestodiases, nematodiases and trematodiases) may also be affected by climatic changes. All evidence indicates that the effects of temperature and water-related variables on helminths are more pronounced in temperate and colder northern latitudes as well as in high altitude areas, where modifications of these variables appear to be more pronounced [17,50].



Source: [51]

Figure 2: Multiple Effects That Can Influence Performance and Health

The role of the environment becomes more pronounced in case of diseases whose agents/pathogens have to spend some time period outside the host in the environment whether in the form of spore, vegetative organism or larvae or as a developmental stage in the intermediate host. Diseases which are transmitted and introduced into other susceptible hosts by vectors are also highly influenced by climatic factors [52,48]. There are a number of specific climatic factors that are associated with disease occurrence in livestock potulation which include: increased precipitation, variations in dry season patterns and others.

Increased Precipitation

Under a rapidly changing environment, pathogens can find new ecosystems in which to survive, thrive or expand. For instance, for a pathogen to survive, humidity outside the host is an important factor. This partially explains why diseases follow floods and rainfall. It is for this reason that humid tropical areas usually carry higher disease burdens than ecological zones that experience extreme cold or very hot and dry climates. Heavy rainfall especially following drought, can cause insect population booms by increasing larval habitats, flooding events may increase water-borne diseases such as cholera or leptospirosis and storms can increase transport of waste water diseases to groundwater [53,54]. Evidence of water contamination following heavy rains has been documented for Cryptosporidium, Giardia, and bacterial disease [55,56].

Increased Heat and Drought

High temperatures may cause heat stroke, heat exhaustion, heat syncope, heat cramps, and ultimately organ dysfunction. These heat-induced complications occur when the body temperature rises 3 to 4 °C above normal. Animal diseases generate a wide range of biophysical and socio-economic impacts that may be both direct and indirect, and may vary from localized to global [13]. Extreme temperatures often are lethal to the survival of disease-causing pathogens but incremental changes in temperature may exert varying effects [57]. Temperature may modify the growth of disease carrying vectors by altering their biting rates, as well as affect vector population dynamics and alter the rate at which they come into contact with humans. Finally, a shift in temperature regime can alter the length of the transmission season. Disease carrying vectors may adapt to changes in temperature by changing geographical distribution. Another possibility is that vectors undergo an evolutionary response to adapt to increasing temperatures [52].

Unseasonable drought can cause rivers to slow, creating more stagnant pools that are ideal vector breeding habitats. climate change can be expected to impact the livestock sector by increasing the risk of heat stress, its intensity and frequency, modifying available water, modifying quantities and quality of available and accessible food, and modifying distribution, intensity and frequency of diseases and parasites. However, the risks and shocks go far beyond these [58,59]. In these circumstances due to limited water resources, livestock and wildlife tend to congregate resulting in pathogen transmission. Restricted food availability due to limited vegetation growth, leading to stress, immunosuppression and finally predispose animals to different diseases [60,36]. The increased and random movement of animals during drought in search of food also plays an important role in disease transmission [36].

Effects of Climate on Animal Disease Epidemiology

There is a link between climate and epidemiological conditions of disease agents. Temperature, precipitation, humidity, and other climatic factors are known to affect the reproduction, development, behavior, and population dynamics of the helminthes, arthropod vectors and the pathogen they carry. Climate change influences the emergence and proliferation of disease hosts or vectors and pathogens and their breeding, development and disease transmission [61,60]. The OIE Scientific Commission has concluded that climate changes are likely to be an important factor in determining the spread of some diseases, especially those that are vector-borne. The two most mentioned emerging and re-emerging cattle diseases in a recent OIE survey are Catarrhal fever (Bluetongue) and Rift Valley fever [62]. The livestock systems are susceptible to changes in severity and distribution of livestock diseases and parasites as potential consequences [63].

Effects on the Pathogens

Climatic changes can 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 [61]. The increased spectrum of pathogens increases the disease susceptibility of the animal and thus, supports the pathogenicity of the causative agent. 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 their animal host. This may shorten generation times and possibly, increase the total number of generations per year, leading to higher pathogen/ parasite population sizes [64,54].

Effects on the Hosts

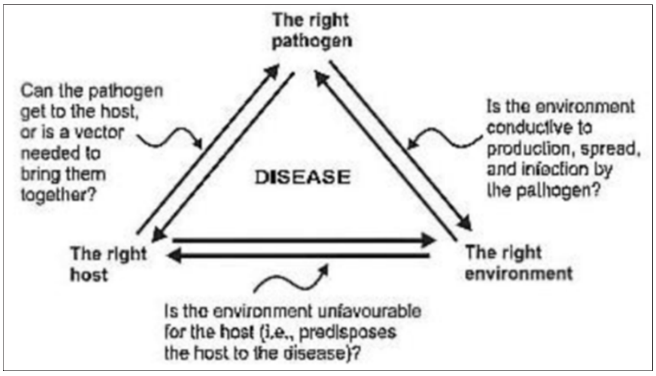
Some livestock will be exposed to new pathogens and vectors as their range increases and impacts can be severe. Climate stress (heat, inadequate food and water) can also lower host immunity. Climate change may bring about substantial shifts in disease distribution and outbreaks of severe disease could occur in previously unexposed animal populations (possibly with the breakdown of endemic stability) [52]. Endemic stability occurs when the disease is less severe in younger than older individuals, when the infection is common or endemic and when there is lifelong immunity after infection. Certain tick-borne diseases of livestock in Africa, such as anaplasmosis, babesiosis and cowdriosis, show a degree of endemic stability [65,60]. Mammalian cellular immunity can be suppressed following heightened exposure to ultraviolet B (UVB) radiation an expected outcome of stratospheric ozone depletion. In particular, there is depression of the number of T helper 1 lymphocytes, the cells involved in the immune response to intracellular pathogens. In terms of animal disease, such pathogens include viruses, rickettsia (such as Cowdria and Anaplasma, the causative agents of heartwater and anaplasmosis) and some bacteria, such as Brucella, the organism causing brucellosis [66].

Effects on the Vectors

Changes in rainfall and temperature regimes may affect both the distribution and the abundance of disease vectors, as can changes in the frequency of extreme events [67]. Arthropod vectors tend to be more active at higher temperatures, therefore they feed more regularly to sustain the increase in their metabolic functions and enhancing chances of infections being transmitted between hosts. Small changes in vector characteristics can produce substantial changes in disease [54]. Arthropod vectors are cold-blooded (ectothermic) and thus especially sensitive to climatic factors. Temperature, precipitation, humidity, and other climatic factors influence the survival, production, development, behavior, and population dynamics of the arthropod vectors (ESAP, 2009). Climatic changes are going to cause extremes in the weather leading to heavy rainfall. This weather condition can lead to increase in the spread of rodent-borne diseases [68,69].

increased temperature and moisture level may reduce restrictions on insect distribution and may allow them to flourish in areas previously not fit for the vectors to survive. Mosquitoes can now be found at Everest base camp, traditionally a place where low temperatures and high altitude have deterred the insect. A mean annual temperature increases of 0.9 °C has caused this shift in their distribution. Changes to temperature and moisture will lead to increases or decreases in the abundance of many disease vectors [47,66].

Changes in climate will influence arthropod vectors, their life cycles and life histories, resulting in changes in both vector and pathogen distribution and changes in the ability of arthropods to transmit pathogens. The ability of some insect vectors to become or remain infected with viruses varies with temperature. An increase in temperature may alter the balance between lifespan and the extrinsic incubation period (EIP), increasing or decreasing the proportion of infected vectors that live long enough to transmit the infection [69]. The extrinsic incubation period (EIP) is the time period between a vector feeding on an infected host and being able to transmit the infection onward to a susceptible host [68].



Source: [51]

Figure 3: Disease Triangle (The Relationships Between the Agents, The Host and The Environment)

Future Perspective to Combat the Effect of Climate Change
The impact of animal production on the environment and the climate is now recognised. In the applying life cycle analysis methodologies, FAO concluded that 18% of total emissions of greenhouse gases were attributable directly or indirectly to animal products. This calculation includes a very substantial contribution from the use of the land for livestock production (mainly deforestation to create pasture and arable land) (FAO, 2010). The IPCC instead analyses the contributions by sector, estimating that deforestation is responsible for almost 20% of global emissions and agriculture is responsible for only 10–12% [10,42].

Livestock also show differential performance in feed conversion and associated CH4 emissions, with the largest difference between ruminants and monogastrics. Thus, given the higher feed conversion efficiency of monogastrics, some GHG mitigation can be achieved by shifting production from ruminants to monogastrics, e.g., chicken, pigs or from large to small ruminants. Additionally, taking into account the large potential of ruminants to generate CH4 emissions via enteric fermentation, the following are specific GHG mitigation measures focused on ruminants: improving forage quality, such as forage with lower fibre and higher soluble carbohydrates changing from C4 to C3 grasses, dietary supplements to improve ruminant fibre digestion and productivity and reducing methanogenesis, such as dietary lipids, probiotics, proprionate precursors, enzymes in the form of cellulases or hemicellulases, or condensed tannins and saponins and manipulations of microbial populations in the rumen to reduce CH4 production [71-73].

Mitigation
Mitigation implies the human measures, structural and non-structural, undertaken to limit the adverse impacts of climate change by reducing the levels of GHGs in the atmosphere. This is accomplished through the development of appropriate technology for reducing emissions and capturing them at their source [10,74]. The response aims at reducing the overall production and release of all those agents/factors that tend to increase the phenomenon of global warming. This has to be taken care of by international agreements and commitments through implementation of environmental policies in letter and spirit by respective nations [75].

Adaptation
Climate change is already occurred even if mitigation efforts were immediately able to reduce global carbon emissions to zero, there will be certain and ongoing impacts from climate change that need to be addressed. Adaptation describes a set of responses to the actual and potential impacts of climate change to moderate the harm or take advantage of the opportunities that climate change may bring. In countries where the majority of poor people depend on agricultural income, proposed climate change adaptation strategies centre on increasing agricultural productivity and make their agriculture more diversified including livestock, fishery and forestry that less vulnerable to climate stress and shocks [73]. Beside to this Water management for agricultural production is a critical component that needs to adapt in the face of both climate and socio-economic pressures in the coming decades [76]. Adaptive responses are made through many ways and particularly focus on areas for future adaptation to the disease onslaught due to climatic changes which may include

Improve Surveillance and Response Capacity
Disease surveillance is an information-based activity that involves the collection and analysis of information on disease occurrence. Well-functioning surveillance systems and timely responses may reduce the cost of outbreaks by 95%. Most developing countries currently lack the capacity to detect disease. Promising surveillance and reporting opportunities for poor countries include Risk based (targeted) surveillance and Participatory disease surveillance [42]. This can enable farmers and planners to react appropriately and rapidly. This requires better access to information and greater capacity to interpret information and understand the implications of a given threat. At a local level, this requires training and awareness, improved understanding between farmers and extension workers and investment in information infrastructure. At the national level, greater investment may be required to improve meteorological data collection and dissemination so that information is available regularly and reliably [77].

Forecasting and Prediction of Disease
Satellite data are increasingly being used to aid disease prediction especially for those diseases that occur in epidemics. Disease prediction is also becoming an important tool since traditional knowledge is no longer reliable for designing coping mechanisms. Prediction however needs to be grounded on disease transmission patterns. Therefore, a good understanding about the disease and its epidemiology is important. Satellite data have also been found to overestimate rainfall in dry areas and underestimate it in the highlands. There is however a huge potential to calibrate these data based on the local Meteorology Station data in order to reliably use them in short-term disease prediction and longer-term forecasting [78,79].

Improve Animal Health Service Delivery
There has been a rising interest in better linking human, animal and environmental health, an approach called "One Health"or Eco health. One Health is the term used when approaches to tackling disease particularly zoonoses consider all components that might lead to, or increase, the threat of disease [79]. These include environmental and ecological/wildlife components as well as domestic animal and human factors. Community animal health programs have been successfully implemented in many countries but require an enabling national animal health policy especially in developing countries [80,62]. Despite their neglect, a number of zoonotic diseases are eminently controllable or manageable by One Health approaches, including infectious causes of abortion in livestock, which frequently result in febrile human disease, and human rabies transmitted via dog bites. Control or prevention is best achieved through integrated public health, veterinary medicine, animal management and ecological approaches [36].

One particular challenge for this is in the case of some zoonotic infections that do not cause clinical signs in their animal hosts, one of the most common examples of which is Campylobacter spp. infection of poultry, which globally is the most frequent cause of food poisoning in humans [81].

Support Eradication and Control of Priority Diseases

Rinderpest, a catastrophic disease of ruminants, was the second disease to be eradicated from the planet after smallpox. FAO estimates that eradication led to some USD 920 million in annual economic benefits in Africa alone, bringing immense benefits to livestock keepers. Global eradication may not be feasible, but many diseases can be controlled by a combination of treatment, vaccination, culling, and reduction of transmission [3]. Control is usually staged with initial measures used to reduce prevalence progressing to more rigorous and expensive methods to eliminate infection. Some control technologies with potential to improve control of climate sensitive disease include; Multivalent vaccines that can confer immunity to multiple diseases, thermo-tolerant vaccines that do not require a cold-chain, breeding for disease breeds and Insecticides (e.g. pyrethroids) which are effective against several multiple vectors [77].

Improve the Resilience of Livestock Systems

Genetic improvement programs targeting adaptive traits in high output and performance traits for developing countries in their management of animal genetic resources, and wider access to genetic resources and associated knowledge. Changes that could be instituted to help livestock farmers adapt better include Diversification of livestock and livelihoods, integrating livestock farming with agriculture [82]. Tress and legumes on mixed croplivestock farms can increase the resilience of farming systems by increasing species richness and abundance [83]. The longerterm effects of shocks such as drought on farming systems and livelihoods can be considerable for households in rural Ethiopia after the 1984 to 1985 famine caused by drought; it took on average 10 years for livestock holdings to recover to predrought levels [84]. In these households, livestock holdings were (and still are) enormously important as a form of savings and as a way to accumulate assets. Such shocks can move/households/ into poverty traps from/which it is difficult to escape. In these situations, national safety net programmes can play a critical role in helping households to adapt and become more resilient and food secure [3, 85-88].

Conclusions and Recommendations

Climate change has negative effect on livestock health in many aspects. Direct effects on animal disease are likely to be most pronounced for diseases that are vector- borne, soil associated, water or flood associated, rodent associated, or air temperature/ humidity associated and sensitive to climate. Climate change can exacerbate disease in livestock, and some diseases are especially sensitive to climate change. Therefore, successful adaptations and mitigation may be shown as better way of coping with the negative consequences of climate change and associated drivers of disease.

Livestock have important roles in providing income, food security and psychosocial benefits for over a billion poor households. Animal disease is the single greatest threat to livestock assets, a major risk to human health, and huge source of risk as new disease emerge every four months. In the coming decades, it is not unfathomable that the emergence and re-emergence of livestock disease will continue to command global attention.

Therefore, the following recommendations are forwarded for future action.

- Training about impact of climate change must be given for the livestock owners.
- An early warning system should be developed to predict climate changes in developing countries and generate information that the livestock owners can use to manage possible occurrences of livestock diseases.
- Targeted and strategic disease management interventions should be developed to moderate the multiplication of disease-causing pathogens and their vectors as a result of climate variability.
- Extension education should be undertaken to enlighten the livestock owners on the importance of strategic disease control, stocking density of animals and environmental conservation in order to mitigate against climate variability.
- Water should be provided by constructing more boreholes and water pans in the pastoral areas as it is the most important commodity for the sustenance of their livelihood for humans and livestock during drought.
- The government should create a national pasture/hay reserve for provision to pastoralists
- during severe droughts.

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