Climate Change and Animal Diseases Spread

Subjects: Agricultural Economics & Policy
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Increasing temperatures and wind speeds exacerbate disease development, while the precipitation anomaly index negatively impacts animal epidemics, with humidity showing minimal influence

Keywords: climate change ; air quality ; health ; animal diseases

1. Introduction

Global climate change (CC) is an established fact, evident through temperature rise, ocean warming, and sea-level elevation, yielding complex and far-reaching impacts. During 2011–2020, the global surface temperature exceeded that of 1850–1900 by 1.09 [0.95 to 1.20] °C. The probability of global warming exceeding 1.5 °C in the near future (2021–2040) stands at a minimum of 50%, even in scenarios of very low greenhouse gas emissions [1]. CC is anticipated to escalate the frequency and severity of extreme events [2]. The Sixth Assessment Report by the IPCC underscores the increasing global influence of CC on ecosystems (terrestrial, freshwater, and oceanic) and human systems (water security, food production, health and well-being, urban areas, settlements, infrastructure, etc.). These effects are not uniform across regions. China, as one of the most sensitive and significant regions, exemplifies the impact of global CC. From 1951 to 2021, China witnessed an annual mean surface temperature rise rate of 0.26 °C/10 years, significantly surpassing the global average of 0.15 °C/10 years for the same period. Additionally, between 1961 and 2021, China experienced a rising trend in average annual precipitation and extreme heavy precipitation events. Since the late 1990s, extreme high-temperature events have shown a notable increase, while extremely low-temperature events have exhibited a significant decrease [3].

Presently, animal diseases pose a significant threat to the global economy and public health. Existing studies reveal that the adverse impact of animal epidemics extends beyond animals and animal husbandry itself, permeating a broader spectrum encompassing production, daily life, and trade systems. This influence ripples downstream in the industrial chain through the food system, affecting human well-being and health through human–animal interactions, and impacting consumer welfare via trade and consumption [4][5][6]. Furthermore, nearly one-fifth of the global population engages in the production, processing, and marketing of animals and their products. For these individuals, animal diseases transcend being solely a health concern, as they also jeopardize their livelihoods [7]. China, as the world’s largest livestock producer, grapples with the persistent threat of animal diseases. According to statistics from the Veterinary Bulletin of the Ministry of Agriculture and Rural Affairs, animal diseases have perennially perplexed animal husbandry in China. From 2013 to 2014, the H7N9 flu epidemic wreaked havoc on China’s poultry industry, resulting in direct economic losses exceeding 100 billion RMB. During the same period, the outbreak of PPR imposed restrictions on the live sheep trade, significantly driving down live sheep prices and inflicting substantial losses upon Chinese farmers.

2. Climate Change and Animal Disease

CC is an ongoing phenomenon that has been identified as a threat to various ecosystems around the world. It has a direct impact on the health and well-being of humans and animals. One of the significant impacts of CC is the potential exacerbation of animal diseases. The emergence of new infectious diseases or the re-emergence of previously controlled diseases can be linked to changes in the environment, including temperature, precipitation, and extreme weather events [8][9]. This literature review considers the relationship between CC and animal diseases and discusses the possible mechanisms through which CC can exacerbate outbreaks of animal diseases. CC can have a direct or indirect impact on animal health. Direct impacts include heat stress, dehydration, and changes in habitat availability [10][11]. Indirect impacts include changes in the distribution and abundance of vectors and hosts, alteration of the host–pathogen relationship, and changes in the duration and intensity of infectious diseases. These impacts can increase the likelihood of the emergence or re-emergence of infectious diseases in animals. A study conducted by Altizer et al. [11] found that CC is a significant driver of emerging infectious diseases in animals. The study found that temperature increases, extreme weather events, and changes in precipitation patterns have contributed to the emergence of several infectious diseases, including avian influenza, West Nile virus, and Lyme disease. Similarly, a study by Altizer et al. [11] found that CC has been linked to the re-emergence of several infectious diseases in wild animals in the Arctic and sub-Arctic regions. The study found that the warming of these regions has led to changes in the distribution and abundance of wildlife hosts and vectors, resulting in the emergence of infectious diseases, such as brucellosis and tularemia. Furthermore, a study by Swaminathan et al. [12] highlighted the potential for CC to exacerbate the spread of infectious diseases in domestic animals.

CC can lead to changes in the distribution and abundance of vectors and hosts, which can increase the risk of transmission of several infectious diseases, including bluetongue virus and Rift Valley fever. The impact of CC on animal diseases can be attributed to several mechanisms. One of the primary mechanisms is the alteration of the host–pathogen relationship. Changes in temperature, precipitation, and humidity can affect the host's immune system and the pathogen's replication rate, leading to an increase in the likelihood of disease transmission [12]. Another mechanism is the change in the distribution and abundance of vectors and hosts. Changes in temperature and precipitation can alter the habitat and behavior of vectors and hosts, leading to changes in the geographical range and seasonality of infectious diseases [12]. For example, the expansion of the geographical range of the Asian tiger mosquito has been linked to CC, which has led to the transmission of several infectious diseases, including dengue fever and chikungunya [13]. In conclusion, CC is a significant driver of emerging and re-emerging infectious diseases in animals. The impact of CC on animal diseases can be attributed to several mechanisms, including alterations in the host–pathogen relationship and changes in the distribution and abundance of vectors and hosts. Understanding the relationship between CC and animal diseases is crucial for developing effective strategies for the prevention and control of these diseases.

3. Climate Change and Transmission Ecology of Animal Disease

CC has been identified as a significant factor in the transmission ecology of animal diseases. The changing climate is affecting the distribution and abundance of vector-borne diseases, such as mosquito-borne diseases, tick-borne diseases, and water-borne diseases, which are responsible for significant public health concerns worldwide [8][14][15]. The increase in global temperature has resulted in changes in the habitat and behavior of vectors, leading to the expansion of their range and an increased risk of disease transmission. For instance, the increased occurrence of warm weather due to CC has resulted in the expansion of the geographical range of diseases such as Lyme disease and West Nile virus in North America. Furthermore, CC can also impact the host–pathogen relationship by altering the physiology and behavior of animals, thereby affecting the prevalence of diseases. For example, CC has been linked to the spread of a fungal disease, white-nose syndrome, that has decimated bat populations in North America [16]. To mitigate the impacts of CC on the transmission ecology of animal diseases, it is important to implement effective disease surveillance and control measures, as well as to address the underlying environmental and social factors that contribute to disease transmission [17][18]. Additionally, there is a need for greater research and collaboration among public health professionals, ecologists, and climatologists to develop effective strategies for preventing and controlling the spread of animal diseases in the face of CC.

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