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# Adverse Impacts of Climate Changes on One Health: A Review

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**Abstract**

Climate change has myriad implications for the health of humans, our ecosystems, and the ecological processes that sustain them. Climate change refers to a change in the state of the climate which is attributed directly or indirectly to human activity that alter the composition of the global atmosphere and which is in addition to natural climate variability observed over a comparable period. It has many effects including increasingly erratic weather patterns; more frequent extreme weather events and the like. This seminar paper aimed to reviews various impact of climate change on one health besides to its respective implications. Climate change has cascading impact chains from physical features to people, with social and economic consequences affecting livelihoods and food and nutrition security while much attention is given to extreme weather events. The mechanisms through which health is affected are both direct: heat-related incidents, extreme temperatures and extreme weather events (floods, drought, storms) and indirect: water quality, air pollution, land use change, and ecological changes. These mechanisms interact with certain social dynamics to produce negative health outcomes. One health is an approach aimed to address a health threat at the human-animal-environment interface based on collaboration, communication, and coordination across all relevant sectors and disciplines, with the ultimate goal of achieving optimal health outcomes for both people and animals it is applicable at the subnational, national, regional, and global level. Infectious zoonotic diseases are a main One Health issue, as these diseases transmit from animals to humans and vice versa. The environment, where humans interact with farm animals, pets or wild animals, plays an important role for disease transmission. The ecosystem and how it is shaped by human activities like agriculture, is an important determinant for the risk assessment of zoonoses transmitted by wildlife. Thus, Climate change represents a crucial example of an environmental factor severely impacting wild and domestic animal populations, food chains and human health.

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## Introduction

The Intergovernmental Panel on Climate Change (IPCC) defines climate change as a change in the state of the climate that can be identified (for example by using statistical tests) by changes in the mean and/or the variability of its properties and that persist for an extended period, typically decades or longer [47]. Effects of climate change include: increasingly erratic weather patterns; more frequent extreme weather events (such as droughts, tropical storms and floods); and longer-term stresses, such as rises in temperature and sea levels [43].

Climate change has cascading impact chains from physical features to people, with social and economic consequences affecting livelihoods and food and nutrition security [27]. While much attention is given to extreme weather events, the less dramatic, slow and incremental impacts of climate change are equally important in their cumulative impact on human well-being [71].

The relationship between health and climate change is complex. The mechanisms through which health is affected are both direct: heat-related incidents, extreme temperatures and extreme weather events (floods, drought, storms) and indirect: water quality, air pollution, land use change, and ecological changes. These mechanisms interact with certain social dynamics to produce negative health outcomes. Social dynamics include age, gender, health status, socioeconomic status, social capital, public health infrastructure and mobility and conflict status. The resulting impact on health and well-being includes loss of livelihoods, mental illness, increased food and water-borne infections; increased vector-borne diseases; respiratory and cardiovascular diseases, and under nutrition [44,92].

Climate change poses immediate and long-term threats to human health and survival across the globe [14]. As evidence of climate change and its impact continues to be amassed it has become clear that many of the causes of climate change are anthropogenic in nature through lifestyles, consumption and choices that pollute and exploit resources in an unsustainable manner [2,36,54]. The future health impacts of climate change are well documented, with forecasts made of increasing health problems caused by heat waves, storms, floods, fires, droughts and infectious diseases [32,62,66,]. It is also predicted that climate change will have detrimental effects upon agriculture and fisheries, and may even result in collapsing ecosystems [62,66].

The consequences of climate change are likely to lead to an increased demand on emergency and health services. Add to this the challenges of meeting local healthcare needs in a post peak-oil scenario, with possible limited access to medicines, transport and energy difficulties, and we could be facing a massive public health disaster which will need to be addressed by Health Services [30,62,63]. The responsibility of healthcare practitioners to protect and promote the health of the public should be extended to working to prevent climate change according to some authors [37].

The consequential social and environmental changes due to globalization, interconnectedness, travel, trade, and an emphasis on economic and political supremacy are unprecedented. Disruption in the natural biogeochemical cycles as a result of anthropogenic climate change is now gradually approaching the safety limit for all life forms on Earth [65]. Given the alteration in the Planets life-sustaining systems, climate change has been identified as the greatest global health threat of the 21st century [90].

Climate change-related impacts on the ecosystems are likely to affect population by creating favorable conditions for disease vectors or disease pathogens as well as placing the communities at high risk of malnutrition, diarrheal diseases and other environmental health effects attributable to climate change [19]. There is important evidence to show that climate change affects the occurrence and distribution of human diseases and malnutrition. Changes in the frequency and spread of infectious diseases are some of the most widely documented potential effects of climate change, and could have significant consequences for human health as well as economic and societal impacts [10]. Therefore, the objective of this review is,To assess the potential impacts of climate change induced on one health issues and other related implications.

## Impacts of climate changes on one health

It is necessary to distinguish between climate and weather in order to understand the concept of climate change [45]. Weather refers to meteorological elements at a specific location and time. Climate refers to the average weather over a specific period of time. By using statistical tests, the change in the state of the climate can be identified and generally, the variability persists for an extended period of time [45]. Climate is the statistical description of a phenomenon such as droughts [45].

One Health is a concept that has gained popularity during the last years, especially since the Tripartite engagement of the World Health Organization (WHO), the Food and Agriculture Organization (FAO) and the World Organization for Animal Health (OIE) in 2010 [25].

The Tripartite defines One Health as: An approach to address a health threat at the human-animal-environment interface based on collaboration, communication, and coordination across all relevant sectors and disciplines, with the ultimate goal of achieving optimal health outcomes for both people and animals; a One Health approach is applicable at the subnational, national, regional, and global level [26].

Infectious zoonotic diseases are a main One Health issue, as these diseases transmit from animals to humans and vice versa. The environment, where humans interact with farm animals, pets or wild animals, plays an important role for disease transmission. The ecosystem and how it is shaped by human activities like agriculture, is an important determinant for the risk assessment of zoonoses transmitted by wildlife [56]. Climate change represents a crucial example of an environmental factor severely impacting wild and domestic animal populations, food chains and human health [1,9,89,].

Changes of the climate like altering temperatures can play a considerable role in the spread of diseases. It can affect the migration and adaptation of infectious pathogens like bacteria, viruses, parasites and fungi. Through climate change, infectious pathogens may find new habitats, which can cause diseases in new and previously unaffected geographical regions [97].

Mycotoxin producing fungi are an example of plant pathogens, whose incidence is modified by climate changes. Among mycotoxins, aflatoxins are especially poisonous and these naturally occurring toxins may contaminate feed and food and adversely affect animal and human health [7]. Further, the carry-over of pollutants from farm animals to human food is influenced by the environment as well as by the animal metabolism, and it is associated to health risks for humans consuming foods of animal origin and also for animals [29].

**One Health and the environment**

When reviewing One Health activities, veterinary as well as medical themes prevail and the environment is often neglected [42]. Nevertheless, the environment is all around us, it depends on and affects human and animal health in many ways. For example, healthy soils and clean water can prevent the spread of diseases, and clean environments in slaughterhouses, preservation of natural habitats of animals and biodiversity can contribute to fewer disease infections in animals and humans [51,53,74].

Climate change is another perspective demonstrating ecological changes affecting environmental, animal and human health. It is displayed that how One Health considerations can aid in solving issues resulting from climate change, such as livestock farming, food security, food safety and sanitation. Integrating public health concerns as well as animal and environmental health perspectives can contribute to enhanced and more contextual problem solving [99].

**Environmental changes modulating risk factors for health:**

A good example for environmental changes is provided by climate change. Events driven by climate changes may increase the availability of toxicants for food-producing organisms: erosion of soils from flooding, heavy rainfall, thawing of frozen soil and forest fires release mercury from trapping environments into the ecosystem [21]. Factors such as temperature and humidity affect the availability of toxic pollutants like lead, causing adverse health effects in animals and humans [57].

It can also aid the distribution of some zoonotic vectors, which in turn affect disease epidemiology. Climatic changes may affect some regions and some populations more than others. More data are needed for a thorough risk assessment, since drivers of vector populations show specific patterns according to vector species and regions [97].

The ongoing and developing scenario of the Covid-19 pandemic highlights how the health impact of an infectious disease can be modulated by a number of diverse, environment-related factors, including meteorological conditions, air pollutants, sewage and wastewater management and even by industrial chemicals, which are widespread, persistent and immune toxic [17,35,52,93,].

**Anthropogenic activities as a source of One Health risk factors through the environment**

Anthropogenic activities are main drivers that shape the environment [64,72]. Environment-modifying human activities include improper disposal of toxic waste, impacts of industrial emissions, utilization of polluted wastewater or manure on pastures and crops used as animal feed. The presence of zoonotic agents in manure is a recognized problem, and methods for anaerobic digestion and manure storage are envisaged to reduce the potential risks [13].

Some pollutants may bioaccumulate in farm animals, and the human exposure is mediated and modified through the animal metabolism and ecology. An example of the industrial impact of exposure to pollutants is the persistent and bioaccumulating hexachlorocyclohexane, a by-product of the insecticide lindane. In an instance in Italy, the insecticide accumulated in industrial waste was found in animals, feed and humans [5].

Concerning pesticides, the European Food Safety Authority (EFSA) has recommended approaches beyond the characterization of hazards and towards the risk assessment of different ecosystems through the integration of datasets coming from disciplines like ecology, biology and toxicology [22]. Intriguingly, the intensive use of herbicides such as glyphosate and glufosinate is suggested to increase the selective pressure towards antibiotic resistance in environmental bacterial communities, indicating yet another link between chemical pollution and a typical One Health issue such as AMR [59].

**Impacts of climate change on human health-driven environmental change**

The prevalence of some of the tropical diseases and other threats to human health depend largely on local climate. According to the Intergovernmental Panel on Climate Change [47], extreme temperatures can lead directly to loss of life, while climate-related disturbances in ecological systems can indirectly impact the incidence of infectious diseases. On the other hand, warm temperatures can increase air and water pollution, which in turn harm human health. Extreme weather can destroy shelter, contaminate water supplies, cripple crop and livestock production, tear apart existing health and other service infrastructures. This will ultimately increase the existing burden of disease and other non-health need of vulnerable human population. The magnitude and nature of climate change impacts on human health vary by region, by relative vulnerability of population groups, by the extent and duration of exposure to climate change itself and by societies ability to adapt to or cope with the change [47].

The relationships between human health and environmental changes due to climate change have been extensively summarized in (Figure 1). [66,75-77] and Direct effects from a warming climate have several correlations between heat waves and excess mortality [15].

Natural disasters such as floods, droughts, and intense storms have claimed millions of lives during the past two decades, and affected many more physically, mentally, or through the loss of property or livelihoods [46]. Further, the IPCCs midrange sea level rise projections (a 40-cm rise by the 2080s) will put 200 million people at risk for a range of health problems including displacement, salt water intrusion into fresh water aquifers, or disruption of stormwater drainage and sewage disposal [47-79].

Warmer temperatures are likely to affect air quality through changes in ozone concentrations, a known pulmonary irritant associated with pneumonia, chronic obstructive pulmonary disease, asthma, and premature mortality [20]. In addition, extensive research suggests that climate change will influence aeroallergens and related human allergic disorders through changes in pollen season [6,100]. Nutrition and food security will also be affected through changes in crop yields, unreliability of supplies, and impacts on prices [4,82].

Food- and waterborne diseases are likely to become a greater problem as climate changes. For example, flooding can contaminate drinking or recreational water with pollution from sewage lines or agricultural fields [60,87]. Heavy rainfall can overwhelm sewage systems and treatment plants, which then discharge excess wastewater directly into surface water bodies [78].

Disease outbreaks from most waterborne pathogens are distinctly seasonal and cluster in key watersheds [16]. There is strong evidence that links incidence of waterborne outbreaks

from pathogens such as Cryptosporidium [61], Escherichia coli 0157:H7 [37], and Campylobacter jejuni [37] following heavy rains. Storm events of 3 inches of rainfall within 24 hours can overwhelm combined sewer systems and lead to an overflow that contaminates recreational and drinking water sources [78].

**Indirect Impacts**

**Malnutrition:** Good nutrition is essential for good health. Deficiencies in energy, fat, protein, nutrient or vitamin intake led to malnutrition with major consequences for peoples physical and mental health. Malnutrition has detrimental and lasting health consequences often limiting a person's physical and intellectual development, particularly those who are affected as infants or as young children. Additionally, malnutrition vastly increases people's susceptibility to acquiring, and dying from infectious diseases [3,12,81].

Malnutrition is considered the most important health risk globally as it accounts for an estimated 15% of total disease burden in DALYs. At present, under-nutrition causes 1.7 million deaths per year in Africa and is currently estimated to be the largest contributor to climate change related mortality around the world [75,76].

Moreover, leading scientists in development and humanitarian research agree that climate change will likely worsen existing production and consumption stresses in food-insecure countries [8,82,83]. Bloem [8] explain that access to food relies on two key factors: availability (through the market or subsistent production) and affordability (through monetary income). Available evidence strongly indicates that climate change will negatively affect food availability and affordability across African countries.

Generally, expectations are that food prices will rise moderately in line with increases in temperature until 2050. After 2050, however, food prices are expected to increase substantially as temperatures further increase, with the value of sugar and rice, for example, expected to rise by 80% [82].

**Communicable diseases**

Communicable diseases result from infection by pathogens such as viruses, bacteria, fungi, protozoa, and parasites. Communicable diseases are transmitted by physical contact with infected humans, vector organisms or with contaminated substances (water, food, objects, and air). Climate changes are expected to affect the lifecycle and modes of transmission of many infectious diseases. The ability of a pathogen to spread is affected by its ability to mature and replicate. Temperature and moisture availability are two environmental factors influenced by climate change that affect pathogen proliferation. Temperature has a particularly strong effect on the rate of pathogen replication and maturation. Further, these two climate factors also affect the survivability and density of vectors in a particular area therefore increasing the likelihood of infection up to certain thresholds [96].

Although the environment has a dominant influence on the diversity of pathogens in a region, this diversity is also influenced by human population size and density, the age of a settlement and the population's disease control efforts [18,85].

**Water borne diseases**

Water-borne diseases are caused by protozoa, viruses or bacteria which typically populate the intestines of humans. Water is often connected to disease spread due to its role in the life cycle of vectors or its direct effect on the health of people. Climate change alterations to the hydrologic cycle will affect water distributions worldwide [47-50]. The IPCC expects water availability and quality to be affected in various parts of Africa posing a threat to human populations.

The spread of water-borne disease after extreme climate change-related weather events, such as floods or heavy rainfall or unseasonably warm seasons (such as longer warm periods, extending growing seasons) are expected to be particularly high in Africa due to limited infrastructure and control programs at the sources of these diseases [82,83].

**Vector borne disease**

There has been a worldwide resurgence in, and a redistribution of many old infectious diseases (Table 3). The WHO (1996) estimates 30 new infectious diseases emerged from 1975 to 1995 with some experts suggesting that some of these are possibly connected to climate change [14,68]. Global climate change may have a major influence on vector-borne disease epidemiology [23,34,86].

**Direct impacts**

**Extreme weather events and their direct effects**

The direct health effects of climate change with the potential for greatest impacts are the forces that create droughts and floods. Unfortunately, this is an area for which there is insufficient data [48]. Working Group II of the IPCC, in its discussion of climate changes in Africa, is inconclusive with regards to any changes in the frequency or size of EWEs but suggests there might be a slight increase in droughts for example in the second half of the 21st century and that there may be more frequent and stronger tropical storms off the southern Indian Ocean. Since EWEs are relatively location specific, regions with a history of a specific EWE will tend to continue to experience such events. Inland and coastal floods have been the most frequent EWE [24].

**UV related cancers and diseases**

This is a range of health effects that will increase in importance as population's lifespan begin to lengthen. Climate change may alter human exposure to UVR in several ways, with limited predictability and variation among regions [67]. The IPCC concluded that excessive UVR exposure was responsible for 1.5 million disability adjusted life years and 60,000 premature deaths worldwide in 2000 from skin, eye, and cardio-respiratory diseases [12].

Worldwide, approximately 18 million people are blind as a result of cataracts, with the rate of cataracts surgery the lowest in Africa (Yorston *et al.*, 2001). As a result, in developing countries cataracts causes 50–90% of all blindness (Murray & Lopez, 1996).

The WHO confirms that instances of skin cancer have been increasing steadily in the two decades, especially in regions with high UVR exposure, with South Africa highlighted [67].

**Temperature and precipitation effects**

Increases in average temperature represent a very significant source of potential direct climate change impacts on human health. A major concern is that such increases may lead to temperatures beyond those comfortable (called heat stress)

for a region affecting mortality through thermal stress **(Figure 1)**. Heat stress affects individuals during extremes (in intensity and/or frequency) of local weather - in the coldest or warmest seasons for example. These environmental conditions can be further exacerbated by human activities such as deforestation and urbanization by affecting local climates by increasing local temperatures by 3+ °C (Hamilton, 1989).

**Air quality**

Climate change is expected to reduce air quality in some areas [47-50]; contributing to respiratory disorders [67]. The relationship between climate change and air quality is complex with many interacting mechanisms. For example, air quality influences can be of climatic/meteorologic (temperature, humidity, wind speed, wind direction and mixing height), natural (ground-level ozone and light-catalyzed air chemistry reactions, aeroallergens, forest fires, and dust from dry soils), or anthropogenic (using carbon-based fuels for local energy use, transportation, and agriculture) origin, resulting in eventual deposition of air pollutants [12,55,80].

Sunlight and high temperatures, combined with other pollutants such as nitrogen oxides and volatile organic compounds can cause ground-level ozone to increase. Ozone forms in the troposphere by the action of sunlight on ozone precursors (through photochemistry) from the by-products of burning carbon-based fuels. At the surface, an increase in temperature accelerates photochemical reaction rates (strong correlation between higher ozone levels and warmer days – but not always). Ground-level ozone can damage lung tissue and is especially harmful for those with asthma and other chronic lung diseases. Even those with moderate disease may be at risk from temperature rises above 16.5°C [58].

The increases of air pollutants due to climate change discussed above may influence cardio-respiratory disease [67] as well as by exposing patients with pre-existing conditions to dangerous temperature extremes, which stress the cardiovascular system. The WHO (2002) has estimated that poor air quality caused by climate change was responsible for over 2.4 million premature deaths in 2000 alone (1/3 by outdoor and 2/3 by indoor poor air quality) and accounts for approximately 2% of the global cardiopulmonary disease burden [79,90]. Exposure to outdoor air pollution accounted for approximately 2% of the global cardiopulmonary disease burden [11,95,].

## Conclusions and recommendations

Although health professionals are challenged with risks from climate change and its drivers, the adverse health outcomes need multidisciplinary Collaboration to be resolved. A phase change in global health is needed to move from a passive responder in partnership with other societal sectors to drive innovative alternatives. Generally, understanding the impacts of climate change on health from a One Health perspective requires working forwards and backwards to connect the species involved in the ecological web linking environmental changes to human health. Climate change has already had a profound effect on biological systems worldwide, and these impacts will be felt by the human population through a variety of mechanisms including: modifications in vector, reservoir, and pathogen lifecycles, and impacts on wildlife and plant diseases, disruptions of synchrony between interacting species, trophic cascades, and alteration or destruction of habitat. Each species responds to environmental changes differently, and in order to predict the movement of disease through ecosystems, we have to rely on expertise from the fields of veterinary, medical, and public health; and these health professionals must take into account the dynamic nature of ecosystems in a changing climate. Rapid environmental changes brought on by climate change intensify the importance of collaborative research and policy-making in order to protect the health of people, animals, and the environment.

- Based on the conclusion above, the following recommendations are forwaRelevant sectors should play a prominent role in advancing the concept of one health to maximize its application.
- Regular Factors responsible for inducing potential impacts on the approach should be minimized by taking appropriate mitigation measures.
- Regular Further researches should be done to indicate the detailed impact of climate change on one health.

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