Climate Induce Food Security Challenges: Impact on Animal and Human Health

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Abstract

Climate change is a complex global issue influenced by both natural and human-caused factors in recent decades. Climate change is a serious concern that is projected to have a severe influence on food security and the region's level of living. This study highlights the impact of climate change on various aspects of economy, livestock, agricultural productivity, ecology, food supply chains, nutrition, health of humans and animals. The greenhouse effect causes the temperature to rise with the increase in greenhouse gas emissions in the atmosphere. According to forecasts, global warming will continue to rise by two degrees Celsius until the year 2100, leading to substantial economic losses worldwide. Due to increased photosynthesis, the concentration of CO_2, which makes up a large amount of greenhouse gases, is rising at an alarming rate. Rising temperatures counteract this effect by increasing crop respiration rates, disrupting the food supply chain. It can contribute to changes in health risks to human, exacerbating current health problems. This chapter examines the scientific evidence regarding the impact of climate change on human infectious diseases. This study suggests strategies to adapt and mitigate the impacts of climate change on food security, including its health implications for humans and animals.

Keywords: Climate change, Food security, Greenhouse, Global warming, Mitigations, Adaptations

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Introduction

Climate change is posing a growing threat to ecosystem services, affecting both their quantity and quality. Supporting services like soil formation, biomass production, nitrogen cycling, production of oxygen, and the water cycle are all impacted by climate change (Scholes, 2016). Additionally, jeopardized are provisioning services including fuel, food, water, and lumber. There are interruptions to regulating services such pollination process, seed dispersal, decomposition, flooding prevention, and carbon sequestration. It is anticipated that cultural services, such as social interactions, spiritual values, and tourism, will decrease. Ecosystem management, restoration, conservation, and protection are crucial for adapting to and lessening these impacts. The services that natural systems offer to society, ecosystem structures, and species interactions are all impacted by climate change (Bakure et al., 2022).

1. Impact of Climate Change on Agriculture

Global nutrition and food security are at risk due to climate change. The greenhouse effect is causing temperatures to rise with the emission of greenhouse gases in the atmosphere. The primary causes of climate change, greenhouse gases including methane, carbon dioxide, and nitrous oxide, are released as a result of a number of agricultural practices. The term "greenhouse" comes from these gases' ability to retain solar heat, which warms the atmosphere (Leal Filho et al., 2022). An outline of how agriculture and climate change interact. World economic losses would result from an increase in the average world temperature (Figure 1). Higher growth and productivity of plants have resulted from increased photosynthesis, but the temperature effect has increased due to increased crop metabolic rate and evapotranspiration, increased infestation of pests, a shift in weed flora, and shorter crop duration. The carbon dioxide concentration, which is a major cause of greenhouse gases, is rising at an alarming rate (Bibi et al., 2023). The number of microbes and the enzymes they produce in soil are also impacted by climate change. Its effects on metabolical processes and plant physiology, as well as its possible and documented effects on plant yield and growth, insect infestation, and mitigation techniques. Climate change affects many soil processes, especially those connected to soil fertility, even though it is a gradual process that involves only modest changes in the weather and precipitation over extended periods of time. Changes in the moisture levels in the soil are brought on by climate change, which also raises soil temperature as well as CO_2 levels (Malhi et al., 2021).

1. Adaptive Measures

The negative effects of the future weather on agriculture may be lessened with the aid of adaptation techniques. The best ways to adapt

to climate change include changing the planting schedule, managing irrigation and nutrients, developing better crop varieties, and increasing the size of agricultural lands. There are numerous choices available for enhancing the fertility of the soil and plant growth, ranging from conventional soil supplements to creative solutions. Biochar and biostimulants are two such cutting-edge alternatives that are receiving a lot of attention (Bibi et al., 2023).

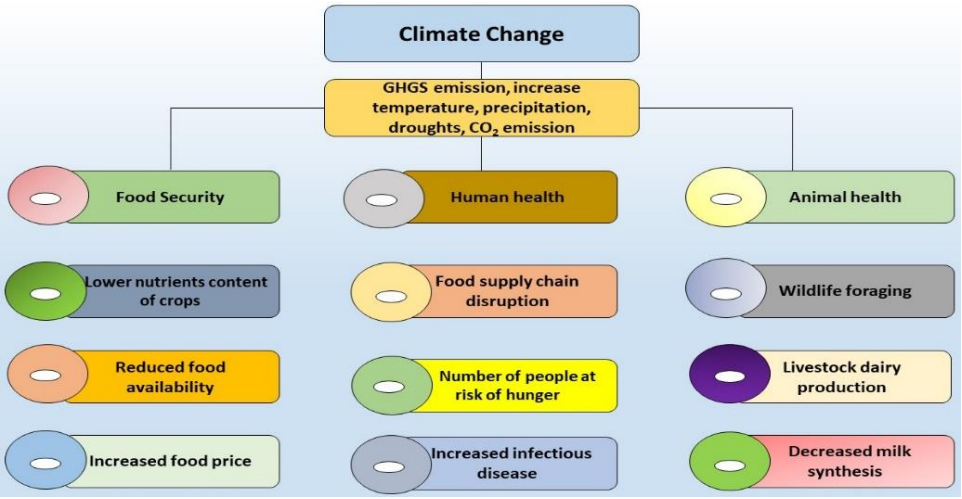

Fig. 1: Climate Induced Impacts on Food Security, Human and Animal Health.

2. Impact on Crop Production

A significant drop in crop production could result from climate change linked to rising temperatures and rising CO_2. Crop productivity is susceptible to climate fluctuation (Figure 2). Additionally, there has been a rise in extreme weather conditions in recent years, including droughts, floods, and heat waves caused by rainfall. It is difficult to increase food output to satisfy growing demands brought on by population growth while also addressing the risks posed by climate change (Robert et al., 2017). Therefore, in order to reduce negative effects, we need to focus more on research on adaptation and mitigation, capacity building, policy changes, national collaboration, and the availability of national funding and other resources. The effects of climate change could be lessened by simple adaptation techniques like using crops that are climate-ready or resistant to heat stress, changing the dates of planting, enhancing water conservation and handling techniques, employing effective fertilizers and irrigation supervisors, diversifying crops, and enhancing pest control (Farooq et al., 2023).

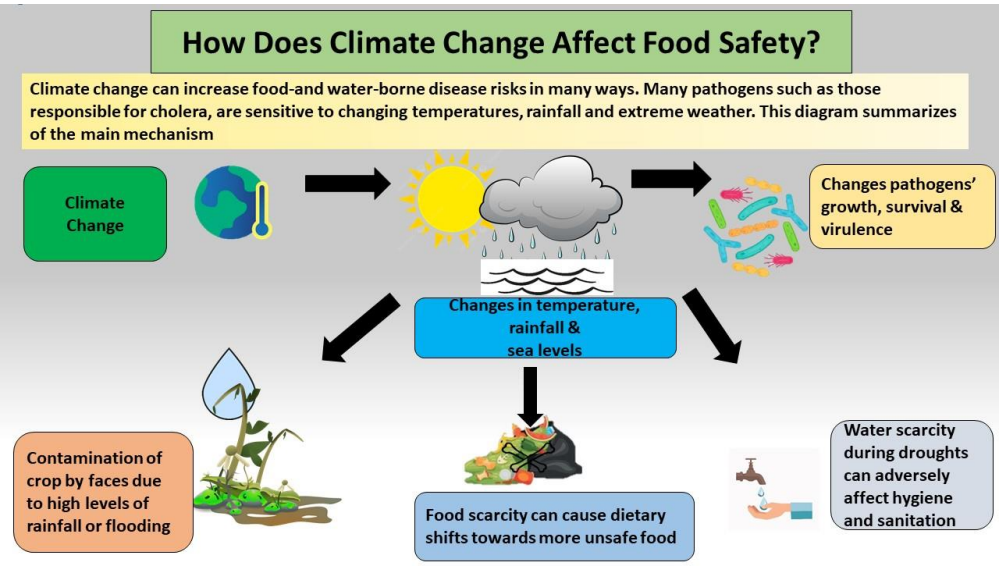

Fig. 2: Mechanism of Climate Change Affect Food Safety.

3. Livestock Impacts

Nowadays, the cattle industry is crucial to the supply and security of food. Meat, milk, and eggs are examples of livestock products that account for 15% and 31% of the world's per capita protein and calorie intake, respectively (Roberts et al., 2017). The general well-being as well as resiliency of many communities are enhanced by the various additional services that livestock provide, such as draught power, transportation, nutrients for deficient soils, source of income and diversification, and financial capital (Godde et al., 2021). By directly impairing animals' adaptive response systems, changing the distribution and frequency of illnesses, and resulting in heat stress and associated welfare problems, climate change lowers livestock productivity. Indirectly, it affects the availability of crops for feeding and the quality of forages (Escarcha et al., 2018). Heat stress, metabolic disorders, oxidative stress, and immunological suppression all have a significant impact on

livestock health, increasing the likelihood of illness occurrence and mortality. The reproduction, pathogenicity, spread of infectious illnesses and/or their vectors, and parasite growth and dispersion are all examples of indirect health consequences (Ali et al., 2020).

4. Food Supply Chain Disruptions

The effects of climate change on feeds are frequently explained in terms of both quantity and quality. Increased temperatures and droughts are frequently cited as the causes of the decline in the amount of pastureland, farmland, and forage crop production (Crane et al., 2017). Significant yield decreases and changes in the temporal pattern of meadow production and livestock consumption are caused by a shift in seasonal trends from hotter to drier climates. Rising temperatures reduce the amount of pasture produced and lower the quality of the fodder species (Escarcha et al., 2018).

5. Economic Impacts

Animals that perform poorly have an impact on the economy since their performance is linked to other components of production, such nutrition and health. For instance, in pastoral systems, low animal performance brought on by drought-induced feed constraint is typically associated with financial losses. Many pastoral households in Africa are facing greater risks to their livelihood and food availability as a result of the ongoing financial damage in pastoral systems (Thamo et al., 2017). Economic effects in intensive systems occur as a result of impacted commerce, such as feed grain shortages brought on by lower harvests during droughts. It appears that heat stress and illness outbreaks have a direct effect on costs and earnings. They can also lead to a drop and volatility in animal stock prices and net values. Furthermore, a number of studies show that severe weather conditions like floods, cyclones, and droughts have a direct effect on animal stocks by raising rates of sickness and mortality (Escarcha et al., 2018).

6. Nutritional Impacts

The integrity of global food systems is threatened by a number of climate change-related effects, which also expose vulnerable populations to various types of malnutrition and reduce food security as well as diet quality. By directly affecting soil fertility, rainfall patterns, crop yields and food production, feeding-nutrient and anti-nutrient composition, and nutrition bioavailability, climate change exacerbates unsustainable food systems (Herforth et al., 2019). The global food supply contains less macro- and micronutrients as a result of these changes. Indirect effects, including pests, lead to more spoiling and food safety risks at several points in the food chain, from the initial cultivation to post-harvest storage to consumption. Every one of these elements could negatively affect human nutrition (Figure 3) (Owino et al., 2022).

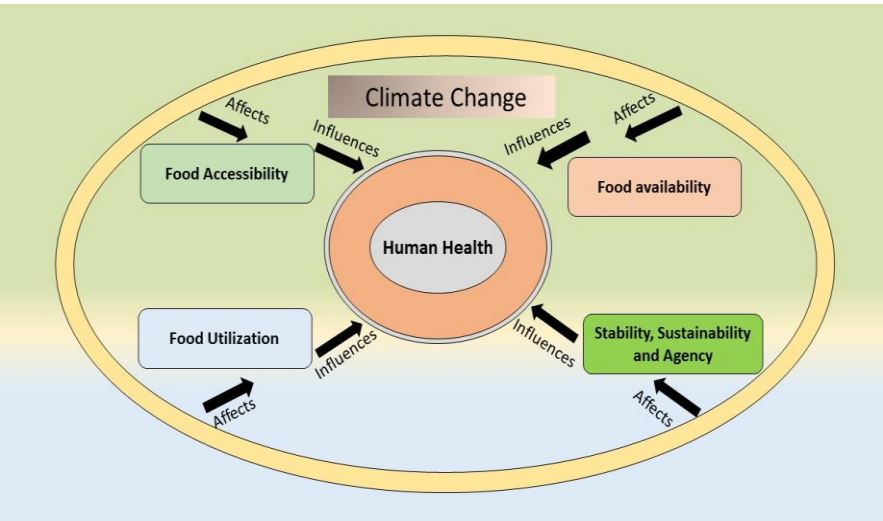

Fig. 3: Influence of Climate Change on Human Health.

7. Impact of Climate Induced Food Security Challenges on Animal Health

i. Disease Spread and Zoonotic Risk

Climate change has an impact on the agricultural industry because it altered the water cycle, causing less rain in dry regions and more rain in wetter ones like monsoon and tropical regions. The nations of the Eastern Mediterranean and North Africa, including Israel and Qatar, are the most water-stressed. Longer and more severe droughts will occur, making it nearly impossible to live in many marginal areas. Drought, when combined with heat waves, will result in a shortage of potable water and losses in agricultural output. Growing problems with water insecurity may lead to more contaminated irrigation water being used for farming, which increases the risk of waterborne and foodborne illnesses. Once more endangering food security and safety, waterborne viruses and parasites have the potential to feed the never-ending cycle that includes food and waterborne illnesses. Additionally, diseases that are prevalent in tropical regions are prone to move to temperate zones, impacting both developed and developing countries. Infectious disorders like cholera, dengue fever, yellow fever, encephalitis, and malaria are among those predicted to rise (Wu et al., 2016).

ii. Heat Stress

Animal welfare and productivity are impacted by high ambient temperatures. It was previously believed that animals' decreased

breeding rates during heat stroke were caused by their lowered feed intake. Recent research, however, has demonstrated that heat stress disturbs the levels of free radicals, leading to oxidative damage to cells and mitochondria. Heat stress does, in fact, restructure how the body uses its resources, such as energy, protein, and fat (Liu et al., 2017). The metabolic rates are lowered by heat stress. As a result, the metabolism of animals under heat stress no longer prioritizes growth, production, reproduction, or health. The severity and duration of heat stress determine how severe its consequences are. The biochemical, cellular, and metabolic alterations that take place in farm animals under heat stress are explained in detail in this article. Reduced milk synthesis was typically linked to prolonged heat stress (Belhadj slimen et al., 2016).

iii. Wildlife Health

Thermal optima move toward high latitudes and high altitudes as the atmosphere's temperature rises. The last several years have seen a rise in global precipitation, which has an impact on animals as well. Through trophic interaction, biomass production, and hydrological balance, climate change disrupts the dynamic state. The behavior, development, migration, and foraging of wildlife are all directly impacted by changing climate regimes (Sattar et al., 2021).

iv. Quality and Availability of Food

The major or primary source of the greenhouse effect is the rise in carbon dioxide levels. Global warming, often known as the greenhouse effect, raises temperature levels, which has sharp impact on the ecosystem and food safety for animals (Sattar et al., 2021). Malnutrition is impacted by climate change through mechanisms that alter food's nutritional value. A balanced diet includes both macronutrients and micronutrients, which promote proper growth and wellness and ward against illness. Plant shape, developmental process, molecular function, and physiological responses are all impacted by climate change. Although increased CO2 encourages greater yields, it also modifies the balance of the plant's mineral composition, carbon metabolism, and nutrient-use efficiency. Legumes are susceptible to oxidative damage from drought and hot temperatures, which is more likely to impact the macronutrients (Giulia et al., 2020).

8. Mitigation and Adaptive Strategies

1. Agricultural Adaptation

Because conservation agriculture promotes minimal soil disturbance, diversity of crops, and soil cover management, it has the ability to undo the damage that conventional tillage has inflicted over time. Additionally, conservation agriculture reduces greenhouse gas emissions. Alternate drying of rice, mid-season drainage, better cattle nutrition, increased N-use productivity, and soil carbon are some easy ways to decrease GHGs emissions. Modest adaptation measures including altering planting dates and cultivars, may lessen the effects of climate change. increased terrestrial carbon sequestration and less fertilizer consumption (Farooq et al., 2023). Crop rotation, soil cover, and minimal soil disturbance are the cornerstones of conservation agriculture. Zero tillage is used to grow wheat in South Asia because it lowers expenses by 15-16% and produces yields that are greater with less fluctuation. Although no-till techniques have little effect on carbon storage, they are viewed as a replacement to traditional tillage because of their claims of carbon retention to slow down climate change. Due to financial incentives, market exchanges for necessary supplies, and perceived benefits, farmers embrace. The adoption of environmentally friendly farming practices, such as zero tillage, is influenced by these factors (Malhi et al., 2021).

2. Drought Resistant Crops

Long-term trends including rising temperatures, higher atmospheric CO_2 levels, and the emission of atmospheric greenhouse gases (carbon monoxide, methane, and nitrous oxide) are referred to as climate change (Naveenkumar et al., 2018). There are several adaption measures that have been proposed to mitigate the effects of climate change. are the procedures for adjusting to the effects of climate change, according to the conclusions of the IPCC (Intergovernmental Panel on Climate Change). Throughout history, farmers have adjusted their cultural practices and adopted new crop varieties in response to environmental changes. Changes in harvest and planting dates, cropping sequence, improved irrigation water management, fertilizer optimization, and the implementation of different tillage techniques are examples of these adaptations at the farm level (Korres et al., 2016).

By lowering agricultural yields, especially in the early phases of growth, extreme heat and drought stress are endangering the world's food security. Plants that use drought escape techniques can either finish their life cycle faster or go into dormancy until the stress is reduced. Stress response mechanisms, including the synthesis of protective tiny particles, antioxidant enzymes, and modifications to phytohormones pathways, are all part of drought tolerance. By crossing better seeds and choosing offspring with higher yields under drought stress, traditional breeding enhances crops. In response to the challenges posed by climate change, molecular methods for breeding are being used more and more to create crop types that can withstand drought. These strategies seek to ensure food production in areas with limited water resources (Kim et al., 2023).

3. Technological Innovations

Technological advancements for mitigating climate change, including radiative forcing geoengineering, negative emissions, and traditional mitigation. The goal of traditional mitigation technologies is to lower CO_2 emissions from fossil fuels (Brown & Murray, 2013). The goal of negative emissions technologies is to lower carbon dioxide levels by capturing and sequestering atmospheric carbon. In order to stabilize or lower global temperatures, geoengineering approaches that use radiative forcing modify the earth's radiative energy budget. The use of alternate pathways is essential because it is clear that traditional mitigation measures alone will not be enough to reach the targets outlined in the Paris agreement. While some technologies on display may still be in their infancy, biogenic-based sequestration methods are somewhat developed and ready for immediate use (Fawzy et al., 2020).

4. Health Risk Adaptation

Public health is connected to industries such as agriculture, forestry, water and sanitation, and disaster preparedness through adaptation techniques. Promoting water conservation, drought-tolerant crops, and water-efficient irrigation-particularly in arid areas like the Sahara are a few examples. Flood risks can be decreased through flood management techniques including green infrastructure and watershed restoration (Panic & Ford, 2013). Resilience is increased by disaster preparedness measures like insurance plans and early warning systems. Global health systems are supported by the WHO's recommendations for climate-resilient healthcare facilities. Knowledge, evaluation, preparation, implementation, and monitoring are the five phases of adaptation. These tactics seek to lessen the effects of future climate change and boost system resilience (Bikomeye et al., 2021).

9. Future Directions

The effects of global warming on food supply and security are still unknown despite a great deal of research. Achieving future objectives requires an understanding of food security considerations and climate projections. Although there are still issues with variation in the climate and GHG emissions, research should take into account economic, political, social, and scientific concerns to lower uncertainty (Bedeke, 2023). Overcoming the uncertainties in research on climate requires addressing important issues. First, there needs to be an extensive knowledge of food safety and how it relates to climate variability. Second, it is necessary to estimate the full effects of the changing climate on food security, taking into account the social, political, and economic ramifications. Third, for food systems to effectively adapt to climate change, comprehensive world-wide, regional, national, and local climate change projections are essential. Finally, as human behavior affects food availability, stability, access, and utilization, it is critical to comprehend how mankind respond to climate variability. Addressing these issues will advance knowledge of hunger, undernourishment, and food security and help achieve future food security objectives. Research-based analysis is crucial to understand these interconnections for future planning. Future food productivity should incorporate strategies to decrease greenhouse gas emissions. Mitigation and adaptation strategies for climate change should aim to reduce emissions while boosting crop and livestock production. This ensures food security within a sustainable production system (Farooq et al., 2023).

Conclusion

Food production, security, and climate change are interconnected, with long-term climate variations affecting food availability, accessibility, and utilization. Changes in temperature and rainfall impact agricultural land, aquatic resources, and water availability. Climate change also increases pests, diseases, and disrupts biodiversity. These factors collectively threaten global food security. Climate change threatens food security for populations dependent on agriculture by reducing food production. By 2080, 5-170 million people may face famine, while over one billion are now hungry and over 2 billion suffer from malnutrition. Climate change increases the severity of natural disasters, impacting agriculture, livestock, fisheries, and forests. These changes affect various factors that determine food security, with potential cascading negative effects across sectors. A comprehensive understanding of the factors affecting food security and their multi-sectoral impacts is essential for effective mitigation and adaptation. Closing knowledge gaps on climate change's effects on food production, availability, and stability is critical. Diseases, natural disasters, and climate change negatively impact food production, with heat and cold stress reducing livestock milk and meat production, affecting both quantity and quality. Sustainable agriculture practices, such as agroforestry, are crucial for achieving food security by reducing carbon emissions, improving output, reducing food loss, and protecting the environment.

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