Climate change and nutrition-associated diseases

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Climate change has multiple negative effects on global public health; reduced quality and quantity of crops result in increased food and financial insecurities leading to malnutrition (undernutrition and obesity) and diet-related non-communicable diseases, such as diabetes mellitus and cardiovascular diseases. In addition, food systems substantially contribute to greenhouse gas emissions and a shift towards sustainability is required to preserve human and planetary health.

> “In 2020 … three billion people could not afford a healthy diet”

Natural and human-induced climate change affects almost every aspect of human society, including food systems. While global warming compounded by climate-related natural disasters impairs the ability to grow enough nutritional quality food to feed nine billion people, food systems account for ~30% of global greenhouse gas emissions (GHGe) and contribute to environmental and biodiversity degradation and deforestation. Unsustainable food systems reduce people's access to affordable, healthy diets, increasing their risk of poor health and diet-related diseases. The global community needs to make a hard pivot to ensure food systems are sustainable for human and planetary health.

Climate change can influence diets and nutrition via various pathways. Warming temperatures, erratic rainfall and extreme weather events affect crop yield potential[1], leading to increased food and financial insecurity. Low-income and middle-income countries (LMICs) in Africa and Southeast Asia will experience the largest reductions in food availability, leading to both decreased deaths attributed to overweight and obesity and increased deaths attributed to underweight[2]. The nutritional quality of certain grains and legumes will also decline with elevated atmospheric CO_2 concentration, leading to increased risk of zinc and iron deficiency among the nearly two billion people living in LMICs whose zinc and iron uptake depends ~70% on these crops[3]. In high-income countries (HICs) and Western Pacific LMICs, climate change-associated reduction in fruit and vegetable consumption was the main risk factor for diet-related non-communicable diseases (NCDs; for example, type 2 diabetes mellitus, cardiovascular diseases and some cancers) and death[2].

While the quantity and quality of food will decrease, the price of staple crops will increase, reducing affordability of a safe and nutritious diet, particularly for low-income populations. This reduction in food affordability will be compounded by an increase in economic losses (for example, lost livelihoods) related to climate change and extreme weather events. In 2020, two billion people were food insecure, and three billion people could not afford a healthy diet[4]. These numbers will probably rise; in 2019, every 1 °C temperature increase was associated with a 1.64% global increase in the probability of severe food insecurity[1], which in turn drives malnutrition (both undernutrition and overweight/obesity) and diet-related NCDs (FIG. 1).

Of note, climate change can influence nutrition through the infectious disease pathway. Malnutrition can worsen infectious diseases, which in turn are influenced by water security and can increase the risk of malnutrition, by reducing nutrient absorption. Changing environmental conditions facilitate the transmission of many water-borne, air-borne, food-borne and vector-borne pathogens[1], with potential knock-on effects on the burden of malnutrition. The largest increases in the prevalence of infectious diseases with epidemic potential (for example, Dengue virus and Zika virus infections) will be in HICs[1]. However, according to the *Lancet* Countdown on Health and Climate Change, LMICs will remain substantially more vulnerable to infectious diseases than HICs[1].

These changes in the burdens of undernutrition, overweight/obesity and diet-related NCDs will be costly. The financial and human capacity of health systems will be stretched even further owing to the climate change-related rising incidence of infectious diseases. The COVID-19 pandemic demonstrates how this added strain on already fragile health systems can lead to huge disruptions and disparities in access to care.

The global goal set forth by the Paris Agreement (the legally binding international treaty on climate change signed by 196 Parties at the 21st Conference of Parties (COP21) in 2015) involves halving GHGe and keeping the global temperature rise to <1.5 °C. As a substantial amount of global warming is already inevitable, swift action across the food systems to mitigate climate change is needed, including shifts towards more plant-rich diets. The diets of populations living in HICs contribute 41% more emissions than those of people living in LMICs,

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https://doi.org/10.1038/s41572-021-00329-3

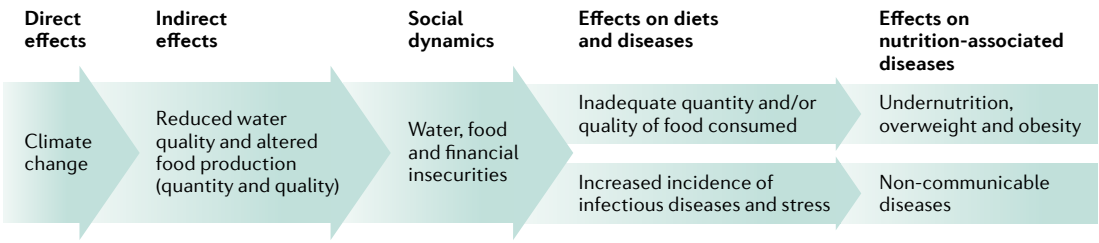

Fig. 1 | **Effects of climate change on nutrition-associated diseases.** The main ways in which climate change influences diet and nutrition-associated diseases.

primarily owing to disproportionately higher red meat consumption[1], and substantially contribute to environmental degradation and diet-related NCDs, putting enormous strains on the planet and health systems[5].

Consuming red and processed meat is beset by inequities. Livestock require large amounts of land and water and are responsible for ~40% of tropical deforestation[6]. Up to 77% of agricultural land is used for rearing cattle, but red meat and dairy only provide 18% of the total calories consumed by the human population[7]. Feeding livestock is incredibly inefficient — 25 kg of feed for 1 kg of red meat[8]. Cattle meat production has doubled over the past 50 years, as wealth increased. However, how much red and processed meat is optimal for human health is debated, with some studies suggesting overconsumption can be a risk for diet-related NCDs[5]. There are considerable inequalities in the global consumption, with HICs consuming nearly ten times the amount of red meat compared with many LMICs (source: the Food and Agriculture Organization of the United Nations). These inequalities are exacerbated by the differential cost of a plant-based diet (much more affordable in HICs). Thus, whereas the consumption of animal-based foods must be reduced in HICs, increasing it in LMICs could benefit the nutrition status of their populations, particularly young children.

The EAT–*Lancet* Commission proposed a Planetary Health Diet, rich in plant-based foods, that can improve health while reducing environmental degradation[5]. Adopting the Planetary Health Diet recommendations has been associated with a 34% greater reduction in premature mortality (through effects on diet-related NCDs), over three times higher reduction in GHGe, and better attainment of global health and environmental goals than following current national dietary guidelines[9]. However, shifts towards the Planetary Health Diet will look different across regions given the existing inequities in the intake of the different foods.

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Drastic changes to what types of crop are produced (and how) and to food distribution through the supply chain are necessary to prevent climate change-related strains on already resource-constrained health systems globally. Yet, in 2020, only half of the world's countries had a national adaptation plan for health[1]. However, the WHO Manifesto for a Healthy Recovery from COVID-19 provides a blueprint for protecting natural systems that supports well-being, potentially leading to equitable climate change mitigation.

The Paris Agreement target — <1.5 °C temperature rise by 2100 — will not be met unless action is taken to reduce GHGe across different components and parties of food and health systems. Farmers need the tools, technologies and knowledge to improve the yields of agriculture production in underperforming areas. Governments should incentivize the re-orientation of agriculture towards crops that are both climate-resilient and nutrition-resilient; reduction in food loss on farms and across value chains; and minimization of food waste at the retail and household levels. Individuals can contribute by making changes to the types of food they consume — while staying within the recommended calorie intake; increasing the proportion of plant foods; prioritizing sustainably raised and harvested animal foods (chicken and other foul, bivalves and small fish); and minimizing highly processed, packaged foods, which are also detrimental to health. Governments and private sector parties need to assist consumers in making these dietary shifts by ensuring these foods are available where people shop daily and that these foods are affordable, convenient and palatable. Health system actors should facilitate healthy communities by becoming allies in supporting healthy food environments and ensuring that dietary guidance and nutrition counselling are provided at the point of care. While the Glasgow Climate Pact made at the 2021 COP26 failed to consider food systems in its negotiations, the next COP27 meeting in Egypt in 2022 is the world's opportunity to consider food as part of the solution for both human and planetary health.

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Competing interests
The authors declare no competing interests.