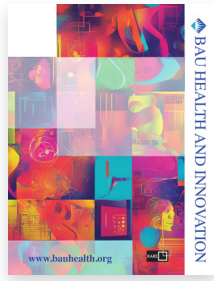
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Review

Effect of Climate Change on Foods, Health, and Eating Habits

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Abstract

Climate change (CC) is reshaping our world in profound ways, particularly impacting our food systems, health, and daily eating habits. As global temperatures rise and weather patterns become more unpredictable, farming is facing significant challenges. Crops that once thrived are now struggling, leading to reduced yields and heightened food insecurity. Extreme weather events, such as droughts and floods, further disrupt food production and distribution, causing widespread hunger and malnutrition. These environmental changes threaten food production, quality, prices, and distribution systems on a global scale. Recent studies suggest that adopting plant-based diets can significantly reduce greenhouse gas emissions. In addition, plant-based foods generally use less energy, land, and water, and have lower greenhouse gas intensities than animal-based foods. CC may influence the prevalence of seasonal affective disorder, affecting eating habits and potentially leading to overeating or unhealthy food choices. The economic impacts of CC are vast, affecting agriculture, food security, and health systems, potentially leading to increased poverty and inequality, further impacting food access and health outcomes. In summary, CC profoundly affects food systems, health, and eating habits through complex interactions that influence food availability, quality, and consumption patterns, with significant implications for global health and well-being.

Keywords: Climate, climate change, eating habits, food, health.

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Climate change (CC) refers to long-term changes in temperature and weather patterns that are having far-reaching impacts on the planet and human society. This phenomenon of climate alteration is influencing nearly all facets of existence, from the natural environment to human health and economic systems. On a global scale, we are witnessing escalating temperatures, alterations in rainfall distribution, and a surge in the severity of heatwaves, along with more frequent occurrences of severe weather conditions such as droughts, floods, and storms. These changes are detrimentally impacting numerous systems that are essential for maintaining adequate nutrition and food security.[1,2] The environmental emergency created by CC is escalating more rapidly than earlier forecasts had anticipated. A range of projections now foresee alarming and potentially devastating consequences of this ecological crisis on human populations and natural habitats around the world.[3] The Earth's temperature has already risen by 1.2°C compared to pre-industrial times, and the past several years have seen some of the hottest years on record globally. The anticipated hazards to human health and the incidence of malnutrition are projected to be more severe with a 2°C increase in global average temperature compared to a 1.5°C rise. Specifically, it is estimated that the number of people facing hunger globally could increase to between 530–550 million at 1.5°C and 540–590 million at 2°C of warming.[4] Biodiversity loss in agriculture is another consequence, reducing the ability of food systems to respond to shocks

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and stresses. These changes are expected to drive up food prices globally, which could increase by between 31% and 106% by 2050.[5,6] Such price fluctuations negatively affect household food availability, nutritional quality, and access to social and health services. These impacts particularly affect children under the age of five and can have long-term consequences, such as impaired cognitive functioning and future income potential. Furthermore, CC has been shown to have detrimental effects on maternal health and birth outcomes, contributing to the intergenerational transmission of malnutrition.[7]

Effects of a Changing Climate

The phenomenon of CC poses a significant and multifaceted threat to reproductive health, particularly impacting the most vulnerable and marginalized populations. The risks are especially acute in areas with low income and high urban density, where communities may face greater exposure to environmental hazards and have limited access to resources for adaptation or mitigation.[8] Expectant mothers and young children are particularly vulnerable to the health impacts of CC. They face both immediate and long-term risks from factors such as extreme temperatures, severe weather events, and air pollution, which can affect their health through various direct and indirect pathways.[9] One of the key pathways is the impact of CC on food production and distribution. Human-caused CC is expected to affect the quality and quantity of food produced, as well as the ability to distribute it equitably. Disruptions to agriculture, fisheries, and livestock, which are crucial for food production, can lead to food insecurity and malnutrition, with significant consequences for maternal and child health.[10] Furthermore, the health impacts of CC are multifaceted and intersecting. Extreme heat, air pollution, and increasing allergens can exacerbate a range of health issues, including heat-related illnesses, cardiovascular problems, and respiratory conditions. These factors can affect water and food quality, leading to the spread of waterborne diseases such as cryptosporidiosis, as well as increasing the risk of malnutrition. Cryptosporidiosis can exacerbate malnutrition by causing severe diarrhea that leads to nutrient loss and dehydration, particularly in vulnerable populations such as children, creating a cycle where malnutrition increases susceptibility to infections and those infections further worsen nutritional status.[11,12] Beyond these direct health impacts, CC can also contribute to indirect effects, such as forced migration, mental health issues, and the rise of vector-borne diseases due to ecological shifts. These complex and far-reaching consequences underscore the urgent need to address the climate crisis and its disproportionate impact on vulnerable populations, including expectant mothers and young children.[13] In summary, the connection between CC and reproductive health is multifaceted and deeply concerning. The risks span from immediate health impacts to long-term, systemic challenges that require comprehensive, multisectoral solutions to protect the well-being of those most vulnerable to the effects of a changing climate.

CC and Food Systems

CC has multifaceted effects on food systems. Agricultural production faces challenges due to increased temperatures, water stress, and elevated CO2 levels, potentially reducing crop yields. In addition, elevated atmospheric CO2 concentrations impact nutrient content in crops, affecting overall food quality. Ocean warming and acidification, linked to CC, can reduce fish catch potential and alter nutrient content in seafood. These combined effects pose risks to global food security, potentially disrupting the supply of nutritious foods and leading to increased insecurity.[14] Studies indicate that higher CO2 levels can decrease essential micronutrients such as zinc, iron, and protein, particularly in crops such as wheat, rice, and soybeans. These crops, which follow the C3 photosynthesis pathway, may see protein reductions of 7–15% under elevated CO2. Legumes and C4 crops experience smaller reductions. In addition to protein, CO2 increases can also lower concentrations of zinc, iron, and other nutrients such as phosphorus, calcium, and magnesium. By 2050, global nutrient availability is expected to decline by 19.5% for protein, 13.6% for iron, and 14.6% for zinc.[7,15,16]

CC affects various properties of crops, such as fruits, vegetables, and other plants, such as nutrients, secondary metabolites, and sensory properties. Increased temperature affects properties such as antioxidant content, sugar content, nutrient content, texture, and color in fruits and tends to reduce the vitamin content in certain types of fruits.[17] Research has shown that elevated carbon dioxide (CO2) levels can positively impact fruit crops by increasing yield, flavor, and nutritional content. For instance, tomatoes grown under elevated CO2 concentrations have demonstrated yield increases of up to 80%. While nutrients such as fructose, glucose, total soluble sugars, total antioxidant capacity, total phenols, and ascorbic acid tend to increase, protein, nitrate, magnesium, iron, and zinc concentrations in the edible portions of vegetables may decrease. Specific effects can vary depending on the crop and nutrient, and other factors such as temperature also play a role in nutrient availability.[18]

Obesity and CC

The first systematic review on the relationship between global warming and the obesity epidemic aimed to determine if these two factors share common determinants and pathways. The authors proposed a conceptual model linking global warming and obesity, focusing on land use, urbanization, motorized transportation, agricultural productivity, population growth, industrialization, and the fossil fuel economy.[19] Global warming influences obesity by affecting food supply, prices, and adaptive thermogenesis, while also contributing to CC through higher energy consumption. Mild-to-moderate food insecurity, coupled with the availability of cheap, processed foods, is linked to higher obesity rates. Rising temperatures, reduced physical activity, and food price volatility may increase reliance on processed foods, further driving obesity. This creates a cycle where global warming leads to higher obesity rates, which in turn contribute to greater greenhouse gas emissions.[19,20]

The Lancet Commission on Obesity's 2019 report on the Global Syndemic of Obesity, Undernutrition, and CC identifies CC as a pandemic due to its widespread impact on health.[21] Obesity, undernutrition, and CC are interconnected, with obesity, stunting, and food insecurity occurring in the same children and population. The agricultural system contributes to greenhouse gas emissions, with cattle production generating methane, contributing to obesity, colon cancer, and cardiovascular disease.[21,22] CC also increases atmospheric water uptake, leading to severe hurricanes, flooding rains, fires, and droughts. Increased atmospheric CO2 decreases crop yields and increases ocean acidification, disproportionately impacting poor populations, especially in the global south. Fossil fuel use for transportation also increases greenhouse gas emissions, obesity rates, and health issues. Poor air quality is associated with obesity in children and adults and may contribute to asthma.[23]

Seasonal Affective Disorder (SAD) and Eating Habits

SAD is a cyclical mood disorder that typically occurs during the autumn and winter seasons and gradually improves in the subsequent spring and summer seasons.[24] This condition is characterized by a recurrent pattern of depression that coincides with the changing of the seasons. The onset of SAD is often gradual, with symptoms gradually worsening as the days become shorter and the weather becomes colder and darker. One of the hallmark features of SAD is the presence of atypical vegetative symptoms, which refer to changes in appetite, sleep, and energy levels. In contrast to typical depression, where individuals often experience a loss of appetite and insomnia, individuals with SAD more commonly exhibit hyperphagia (increased appetite and food consumption) and carbohydrate cravings.[25] This increased appetite and carbohydrate intake during the winter depressive episodes may involve discrete binge-eating episodes, where the individual consumes large amounts of food accompanied by a sense of loss of control over their eating.[26] The underlying mechanisms behind these atypical vegetative symptoms in SAD are not fully understood, but they are thought to be related to the body's biological response to the changing seasons. The reduced exposure to sunlight during the winter months can disrupt the body's circadian rhythms and hormone regulation, leading to changes in appetite, sleep, and energy levels.[27] Recent research has also highlighted the potential role of nutrition and dietary factors in the development and management of major depressive disorders, including SAD. A systematic review of 31,424 participants found that Vitamin D supplementation may help to mitigate depression symptoms.[28] Other essential nutrients, such as B Vitamins, omega-3 polyunsaturated fatty acids, zinc, and antioxidants, have also been implicated in the pathogenesis of depression, as deficiencies in these nutrients can lead to memory function, cognitive impairment, and depression.[29,30] Healthy dietary patterns, such as the Mediterranean and Dietary Approaches to Stop Hypertension diets, are linked to a reduced risk of depression due to their focus on whole, unprocessed foods such as fruits, vegetables, whole grains, lean proteins, and healthy fats. While much research has examined nutrient deficiencies and general depression, there is a need for further investigation into how these dietary factors specifically affect SAD. This research could lead to more targeted dietary interventions for those experiencing this seasonal type of depression.

Impact of Climate on Eating Disorders

Research has explored the complex relationship between climate and eating disorder pathology. While various biological, psychological, and sociocultural factors come into play, the climatic conditions of a region may have a significant influence on the risk of developing eating disorders. A growing body of evidence suggests that warm-weather climates, in particular, may heighten the risk factors associated with disordered eating.

A study comparing female college students from warm, southeastern regions of the United States to those in

colder, northeastern regions found distinct differences in eating behaviors and body image concerns. Women residing in warmer climates had significantly lower body weight, more frequent episodes of bulimic behaviors such as binge eating and purging, and greater preoccupation with body shape and size. These findings indicate that living in a warm weather environment may exacerbate the social and cultural pressures surrounding thinness and appearance, ultimately increasing the vulnerability to developing clinical or subclinical eating disorders.[31] Furthermore, eating patterns and food consumption can be directly influenced by seasonal fluctuations in temperature and climate. Individuals living in cold-weather climates have been observed to alter their dietary intake and food preferences when transitioning to hot, humid environments, potentially as an adaptive response. Climatic parameters, such as latitude and average temperatures, may also play a role in the occurrence and prevalence of specific eating disorder diagnoses, such as anorexia nervosa.[32] Understanding the complex interplay between environmental factors, such as climate, and the development and maintenance of eating disorder pathology is crucial for informing prevention and treatment strategies. Further research is needed to explore these connections more comprehensively and elucidate the multifaceted mechanisms by which climatic conditions may influence disordered eating attitudes and behaviors across diverse populations.[33]

Global CC and the Global Economy

Global CC is one of the greatest environmental and economic threats the world has faced in recent decades. The increase in greenhouse gas concentrations in the atmosphere leads to an increase in temperatures worldwide and significant changes in climate patterns. These changes have both direct and indirect impacts on human health and also deeply affect the global economy.[34] Global agriculture, responsible for 30–40% of greenhouse gas emissions, is significantly impacted by CC.[35] Precipitation extremes, such as floods, forest fires, and droughts, significantly impact agricultural productivity.[36] The dependency on non-renewable resources also contributes to deforestation, affecting food and water supplies. Agriculture is an essential part of the economy, especially in developing countries, and its decline challenges farmers' quality of life and contributes to poverty.[37] The Intergovernmental Panel on Climate Change (IPCC) reports increased greenhouse gas concentrations in the air, with global temperatures predicted to rise from 1°C to 3.7°C by the end of the century.[35]

Tourism is a commercial activity with multiple dimensions, including job generation, revenue creation, foreign exchange, cross-cultural promotion, and business benefits.[38] However, CC is a significant threat to the industry, as the climate is essential for tourism. Variations in weather patterns, such as those in the IPCC report, can lead to challenges for local economies and the global tourism industry, such as the decline of ski seasons.[39] CC threatens socioagricultural, socioeconomic, and physical systems, impacting psychological well-being and affecting human and environmental health sustainability. Food security is also a concern, with compromised quality, higher prices, and inadequate distribution systems. Global forests face challenges from various climatic factors, and adaptation measures are crucial for decision-making. Rapid CCs make it harder to survive and adjust, requiring immediate attention at all levels. Policy implications can help mitigate the consequences of CC, especially in the agriculture sector.[35]

CC and Famines

The following 10 specific CCs affect food security: 1-Rising Temperatures, 2-Rising CO2 Levels, 3-Rising Temperature Extremes, 4-Rising Drought, 5-Intense Rainfall, Floods, and Tropical Storms, 6-Melting Glaciers and Changing River Flows, 7-Rising Sea Levels, 8-Pests and Diseases, 9-Weeds, 10-Rising Ozone. Extreme weather events can destroy the food system, disrupting food processing, packaging, and storage facilities, and affecting food prices. Rising temperatures and changing rainfall patterns can alter the distribution of animal diseases, which can reduce production. Fisheries are also expected to decline by 40% in the tropics. With the global population expected to reach 9 billion by 2050, total food production needs to increase by 70% from 2005–2007 levels. However, a 5°F to 9°F increase in the global average temperature could reduce cereal yields by 30% to 50% and further reduce the global food supply. This combination of reduced food production and increased food demand could lead to widespread social unrest and hunger, and potentially catastrophic global famine. To rewrite the future, we must create solutions such as efficiency and renewable energy to reduce greenhouse gas emissions by 80% by 2050.[40] By 2030, the combination of CC and poverty is estimated to affect between 35 million and 122 million people. Food, water, sanitation, and shelter are essential for human survival, but they are becoming harder to access for low-income communities in developing countries due to CC and institutional failure. Asia has the largest population in the world, and natural disasters have affected lower-

income communities the most.[41] Developing countries are facing increasing mortality due to climate-related heat, with increased diarrhea, malaria, undernutrition, dengue, and coastal flooding. To address these challenges, many developing countries have introduced schemes to help end hunger and improve nutrition.[42]

Opportunities to Strengthen Linkages between Nutrition and CC

The World Health Organization emphasizes the need to strengthen the connections between nutrition and CC. Key opportunities include integrating nutrition into global climate frameworks, promoting gender equality, and adopting multisectoral approaches that address both issues, especially for vulnerable populations. The nutrition sector should focus on ensuring access to diverse, sustainable, and high-quality diets, shifting from traditional definitions to more holistic, systems-oriented strategies. Governments and partners are encouraged to transition from reactive responses to proactive preparedness in nutrition. Community engagement is vital for creating culturally appropriate solutions, and increased support is necessary to help communities adapt to climate-related risks. In addition, developing cross-sectoral indicators, such as resilience scales, would aid in integrated planning and monitoring progress.[43]

Climate Benefits of Changing Diet

Public health and the environment are deeply interconnected through the lens of food systems. Every stage of the food lifecycle – production, processing, distribution, and consumption – has substantial impacts on both human well-being and the planet.[44] Food systems contribute significantly to environmental challenges, including greenhouse gas emissions, excessive water use, and hazardous waste generation.[45] A critical aspect of this relationship lies in the contrast between animal-based and plant-based foods. Animal-based products, such as meat and dairy, require considerably more land, water, and energy than plant-based alternatives.[46] This is largely due to the resource-intensive nature of livestock production, which involves rearing, feeding, and processing animals. In contrast, plant-based foods – such as fruits, vegetables, and grains – generally have a much lower environmental footprint. Sustainable dietary patterns, such as the Mediterranean diet, offer a promising solution to reduce the environmental burden of food systems.[46] Characterized by a high intake of plant-based foods, limited red meat consumption, olive oil as the primary fat source, and moderate wine intake, the Mediterranean diet significantly lessens dependence on animal-based foods – the major contributors to greenhouse gas emissions and land degradation.[47,48]

Adopting the Mediterranean diet or similar plant-centric dietary approaches can lead to meaningful environmental benefits. Research suggests that a 40% reduction in meat and dairy consumption could result in a 20–30% decrease in greenhouse gas emissions.[46] In this way, shifting toward plant-based diets not only supports CC mitigation but also enhances personal health. Ultimately, the strong link between public health and the environmental impact of food systems highlights the urgency of adopting sustainable eating habits. Reducing the consumption of animal-based foods and embracing plant-based alternatives can significantly lower greenhouse gas emissions, conserve water, and reduce other environmental pressures associated with food production, benefiting both people and the planet.

Conclusion

The impacts of CC on the global food system, human health, and eating behaviors are significant and wide-ranging. Rising temperatures, shifting precipitation patterns, and extreme weather events are disrupting agricultural production, food distribution, and food access around the world. This is leading to reduced food security, nutritional deficiencies, and increases in diet-related illnesses such as obesity and malnutrition.

CC is also directly influencing human health and eating habits through pathways such as SAD, which can drive changes in appetite and food preferences. The mental health impacts of CC, including anxiety about food availability and safety, are also affecting how people approach their diets and eating routines.

At the same time, shifts in global food systems and individual dietary choices have the potential to mitigate CC through reduced greenhouse gas emissions. Transitioning to more plant-based, sustainable, and locally-sourced foods can lower the carbon footprint of our food systems.

As the effects of CC continue to escalate, it is crucial that we take comprehensive action to build climate resilience in food production, distribution, and consumption. This will require collaboration between policymakers, agricultural producers, food industry stakeholders, public health experts, and individual consumers. Only by addressing the intersections between climate, food, and health can we create a more sustainable, equitable, and nourishing global food system for the future.

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