

CLIMATE CHANGE IMPACT ON PRODUCTION ACTIVITIES OF DIETARY ITEMS

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ABSTRACT

Global climate change is expected to have extensive and complicated consequences on food systems that vary across time and space and are significantly impacted by socioeconomic factors. Climate change would affect agricultural yields and revenues, food costs, delivery reliability, food quality, and, most critically, food safety, according to historical statistical research and integrated assessment models. Due to their limited ability to invest in adaptable institutions and technologies in the face of growing climate hazards, low-income food producers and consumers will be especially vulnerable. Although there may be some synergies between mitigation, adaptation, and food security, potential efforts like waste reduction and agricultural intensification need to be carefully managed to ensure that costs and gains are distributed fairly.

Keywords: Dietary items, production, climate change.

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INTRODUCTION

It is now commonly acknowledged that one of the most important concerns of our time is achieving food security in the face of growing food demand, competition for dwindling resources, and the environment's diminishing ability to mitigate growing human impacts [1]. Climate change is one of several interconnected trends and risks that threaten agriculture and food systems. Other factors influencing the future of food security include rapid biodiversity loss, alterations in land cover, freshwater availability, ocean acidification, and changes in the nitrogen and phosphorus cycles. Ultimately, future food security for all will depend on managing the interactions between socioeconomic and environmental changes. Climate change, particularly increasing climate variability, is arguably

one of the greatest threats to food security, especially for low-income individuals and communities, who have less capacity for adaptation and rely on climate-sensitive activities like agriculture. The goal of this study is to present a critical summary of the substantial body of research on the intimate connection between food systems and climate change. It will look at how climate change affects food security in different parts of the world, emphasize more general problems with food systems that go beyond food production, and describe the possibilities and difficulties of combining mitigation, adaptation, and food security measures [2].

There is ample evidence on the causes and trends of both observed and anticipated climate change. While both are impacted by

the same radiative forcing, it is helpful to distinguish between short-term increases in climate variability and long-term (decadal) trends. Without all-encompassing mitigation, humanity will eventually need to adjust to slow shifts in precipitation and temperature. Adaptation may need to be incremental or transformational, depending on the direction and speed of these trends. Increased temporal and spatial variability in temperature, precipitation, and winds, especially with relation to the frequency and severity of extreme events, are current manifestations of climate change. These extreme events are likely to include more frequent and intense heat waves, heavier precipitation events leading to flooding, stronger tropical cyclones, and higher sea levels due to storm surges [3]. Additionally, longer dry spells and the area affected by drought are expected to increase, while the frequency and intensity of cold spells and frosts will likely decrease. Consequently, in the short term, increasing climate variability has a more significant impact than long-term mean value changes, necessitating a focus on climate risk management for adaptation. This focus will remain crucial, even as the need to address long-term changes in mean values becomes more pressing. Food chain activities include the manufacturing and distribution of inputs (such as seeds, animal feed, fertilizers, and pest control), agricultural production (crops, livestock, fisheries, and wild foods), primary and secondary processing, packaging, storage, transport, distribution, marketing, retail, catering, domestic food management, and waste disposal. These supply chains are sometimes linked by a "cold chain," which uses constant refrigeration to prolong and guarantee the shelf life of both processed and fresh foods. Crucially, food systems include not just these actions but also their results and management [4]. Everybody is involved in

food systems, working for a variety of goals, such as making a living, making money, protecting the environment, and obtaining food for social, recreational, and nutritional purposes.

Food systems worldwide are undergoing significant changes due to various demand-side factors, including population growth, changing consumption patterns, urbanization, and income distribution. At the same time, supply trends are influenced by climate change, competition for resources like water, energy, and land, and the interplay between food production and other ecosystem services. Additionally, shifts in institutional and social processes are affecting the food system, such as trade liberalization, the market penetration of transnational food companies, the restructuring of retail towards supermarkets, food industry marketing, and evolving consumer attitudes regarding social status, health, and sustainability. Generally, there is no single global food system; instead, there exists a network of partially connected supply chains for specific products, which can be global—like soy protein—or more localized, as seen with cassava and other staple crops. Compared to other resource-based businesses like mining and minerals, the food industry is particularly competitive and fragmented [5-8]. Less than 20% of retail sales by value are accounted for by the top 50 food processors, which means that their share of overall food consumption across formal, informal, and nonmarket channels is much lower.

It is projected that the effects of global climate change on food systems will be wide-ranging, intricate, and time-varying, greatly impacted by both current and developing social and economic circumstances. The models sometimes extend to human welfare outcomes, such as malnutrition prevalence. A less common

approach involves Ricardian (hedonic) analyses of land values, which consider how farmers allocate their activities over time and across landscapes. Researchers explain the various methodologies used in this field. Significant uncertainties within these integrated assessment models include the direction and rate of climate change at subglobal levels and the extent to which mitigation and adaptation actions and their feedback effects are incorporated. Both statistical and hedonic studies face limitations in extrapolating beyond historical climatic conditions. Furthermore, it is difficult to differentiate climate change from other important factors influencing food systems. However, as will be covered in the next subsections, there is strong evidence that climate change would affect not only food yields but also food quality, safety, and delivery dependability. Notably, in light of climate change, food safety management is becoming a crucial issue for future food systems [9].

PRODUCTION ACTIVITIES

According to the IPCC's scientific consensus, average temperature increases of 1-3°C are forecast to boost crop yields in temperate countries up until 2050, whereas yield decreases are predicted in tropical regions with limited water resources. As mean temperatures rise beyond 2050, all regions will probably see yield losses; however, offsetting institutional variables, such as better global markets, may keep food supplies stable. Major changes in food production are projected after 2050, with researchers indicating that by the end of the 21st century, mean growing season temperatures are expected to match current extremes in temperate areas and surpass them in tropical and subtropical regions, leading to significant impacts on food production [10].

Recent studies suggest that the IPCC's projections up to 2050 may be overly

optimistic for several reasons: observed climate change is occurring faster than predicted; certain climatic variables, such as temperature extremes, may have a greater influence than previously thought; specific fishing and farming systems are unexpectedly sensitive; global food markets are not optimally integrated; and the interactions between climate change and factors such as poverty, population growth, and dietary changes are profound. Furthermore, little is known about other food systems, such as wild foods, which could become more significant amid crop and livestock failures linked to climate change [11-13]. On the other hand, socioeconomic development and adaptation measures that could lessen the anticipated effects of climate change are not taken into consideration by many models. For example, new methods in fisheries science that combine biophysical and social models indicate that the production of fish meal may be more significantly impacted by society reactions to climate change than by the direct consequences of climate change.

Fisheries

Compared to livestock or crops, marine fisheries have more advanced modeling attempts to forecast future climatic influences on global productivity. Eight of the ten ocean basins in the world have seen an annual reduction in primary production of 1%, indicating that climate-related changes have already had an impact on ocean productivity. Under high greenhouse gas emissions, a multispecies model of marine capture fisheries predicts a change in maximum catch potential of less than 1% between 2005 and 2055. However, significant spatial variations are anticipated, with increases of 18 to 45% in Nordic fishing zones and declines exceeding 20% in Indonesian zones [14-17]. Models for aquaculture have not yet been developed. Inland aquaculture is becoming a larger

share of total fish consumption and may be vulnerable to water scarcity and the increasing frequency and intensity of flooding. Rising ambient temperatures are linked to a higher incidence of harmful algal blooms, which produce lethal toxins, particularly affecting shellfish. Long-term changes in algal communities can have extensive impacts on marine ecosystems, thereby influencing food availability and safety for human populations.

Crops

Climate change influences crop growth through a variety of mechanisms, resulting in both positive and negative effects. These mechanisms include alterations in phenology, heat stress, water stress, waterlogging, and changes in pest and disease populations. While there have been limited attempts to provide global estimates of crop production under climate change, researchers employing general circulation models predict a decline in per capita food production globally. Specifically, two models forecast yield changes for 2050 ranging from -27% to +9% in developing countries and -9% to +23% in developed countries for three key staples: maize, rice, and wheat, assuming a carbon fertilization effect [18]. However, a more cautious view emphasizes that due to numerous uncertainties, making reliable global-scale predictions for any timeframe is currently not feasible.

Historical data reveal that between 1981 and 2002, six major crops experienced significant climate-related yield reductions totaling 40 million tons per year globally. Nonetheless, these losses have been offset by technological advancements. Due to varying yield trends and climatic conditions, there is variation between nations and crops. Significant spatial variance in the responses of rice, wheat, maize, and soy yields to quantifiable climate trends during the past 30 years has

been revealed by a recent thorough statistical analysis. Notably, rice has generally performed better at higher latitudes, and there is no discernible relationship between yield responses and a country's geographic location or level of development [19].

Much of the research on specific crops targets particular regions that exhibit greater homogeneity in agro-ecosystems, climate, farming practices, and market conditions compared to global assessments. Researchers have conducted a systematic review of model-based studies on future crop yields in South Asia and Africa. Under high greenhouse gas emission scenarios, no impacts are projected before 2050; however, beyond 2050, significant yield variations are expected in South Asia, with maize declining by 16% and sorghum by 11%, and in Africa, where wheat may decrease by 17%, maize by 5%, sorghum by 15%, and millet by 10%. Statistical studies provide empirical evidence and added detail; for instance, historical data from maize trials in Africa indicate that both water availability and heat significantly affect rain-fed maize yields, with each day above 30°C resulting in an average yield reduction of 1%, and 1.7% under drought conditions.

Additionally, the impacts of climate change extend beyond yields to affect food quality, which could be critical for future food security [20]. A meta-analysis of found that elevated CO₂ levels (540–958 ppm) reduced the protein concentration of wheat, barley, rice, and potatoes by 10%–15%, and soy by a statistically significant 1.4%. Other climate change effects on food quality during crop production include increased risks from flooding, contamination of agricultural land, groundwater and surface water with heavy metals, agricultural residues, and hazardous wastes, as observed during the European floods of 2002 and in

the United States after Hurricane Katrina in 2005.

Livestock

Global projections regarding the impact of climate change on livestock production are currently lacking. The complexity of livestock production systems, difficulties in isolating and integrating climatic and non-climatic effects, the variety of potential adaptive responses at both technical and social levels, and the challenge of distinguishing the effects on animals from those related to changes in feed all contribute to this uncertainty. Researchers have conducted a comprehensive review of livestock and climate change effects in low- and middle-income countries, highlighting the lack of system-wide approaches as a significant gap in scientific knowledge. It is anticipated that climate change will mainly impact livestock production directly through its effects on pasture and feed supplies, water availability, diseases, and genetic diversity. Climate trends in Europe are connected to the introduction and spread of bluetongue, a virus that affects ruminants, according to recent modeling. Everyone agrees that variations in rangeland systems will affect them just as much, if not more, than changes in average conditions. As drought events are predicted to increase in frequency, livestock keepers in arid and semi-arid regions will be especially sensitive to animal mortality [21, 22].

Food Safety

Every year, diarrheal illnesses kill about 2 million people, mostly children from low-income homes in developing nations. Food-borne infections like *Salmonella* and *Campylobacter*, which are frequently spread through foods produced from animals including milk, meat, and seafood, are responsible for the majority of cases. According to scientific consensus, the total burden of infectious diseases would be

greatly increased by climate change, even though the epidemiological responses of individual pathogens may differ. In light of climate change, mycotoxins pose a serious threat to the safety of plant-based foods. Around a quarter of the global annual maize crop is contaminated with mycotoxins—fungal by-products that pose health risks even at low levels and are responsible for high fatality rates during acute outbreaks for instance in Kenya in 2004. Historically, acute mycotoxicoses have predominantly affected poorer populations, especially during food shortages. Beyond health risks, there are substantial losses to harvests and food security, disproportionately impacting households reliant on locally grown maize. The long-term effects of climate change on mycotoxins are complex and region-specific; while rising temperatures may eliminate certain mycotoxin-producing species in some tropical areas, infections could increase in cooler tropical regions and temperate zones. For instance, projections suggest that mycotoxin levels linked to cereal diseases like *Fusarium* head blight in wheat will surpass EU limits by 2050 [26-28]. Additionally, the emergence of new plant fungal diseases under climate change may introduce further mycotoxin risks to humans. Scientists are concerned that the rising incidence of disease may lead to the overuse or misuse of pesticides and veterinary medicines, particularly in the fisheries sector.

IMPACT OF AGRICULTURAL SYSTEMS

A recent series of reviews analyzes the impacts of climate change on agricultural systems in specific countries or regions, offering an integrative overview. China exemplifies the complexities involved. Over the past 50 years, precipitation patterns have shifted, and heat waves have become more frequent. While runoff in the Pearl River has increased due to higher

precipitation, it has declined in the Yangtze and Yellow Rivers. Future changes in water availability for agriculture remain uncertain because of limitations in current precipitation models under climate change. In arid regions, rising water withdrawals for agriculture surpass the additional water flows from melting glaciers, which will only provide temporary relief [29]. Although the rice-growing area has expanded northward, wheat yields have declined due to rising daytime temperatures. Future yield predictions show both increases and decreases, heavily influenced by the effects of CO₂ fertilization, which are still not fully understood. Other poorly understood factors, such as pests, diseases, surface-level ozone, and the potential for adaptation strategies, are not included in these models. Examining numerous interacting elements, both climatic and nonclimatic, and carefully taking into account social and spatial variations in outcomes are the strengths of country- or region-based studies [30]. For example, experts contend that because of the increased danger of drought at lower latitudes, yield improvements at high latitudes in Russia under high emission scenarios will not improve national food availability. By highlighting concerns of rising inequality and inadequate reinvestment in agricultural growth, integrated economic models provide insight into the possible long-term cumulative effects of climate change on agricultural economies and food systems.

IMPACT OF COMMUNITY AND CONTINENTS GEOGRAPHY

The primary concern for food systems in the context of climate change is their diminished ability to ensure food security for impoverished populations who are vulnerable to hunger and malnutrition. Climate change is expected to impact all four recognized components of food

security: availability, access, utilization, and stability over time. Most literature on climate change and food systems focuses on the effects on agricultural yields, which directly influence food availability [31-33]. However, the impacts on incomes and livelihoods—thus affecting access to food—are equally critical to overall food security. Vulnerability to climate change, as measured by the IPCC through the interconnected factors of exposure, sensitivity, and adaptive capacity, is not uniformly distributed. Evidence suggests that greater exposure to climate variability and sensitivity of food systems is often linked to lower adaptive capacity, particularly in tropical drylands. Nonetheless, global analyses do not show a consistent historical correlation between a country's gross domestic product (a common measure of adaptive capacity) and the sensitivity of crop yields to climate change. Significant spatial differences based on particular climate exposures are also revealed by mapping food security vulnerability in tropical regions.

The distribution of climatic risks is probably outweighed by the large differences in wealth, and consequently in adaptation capacity and food access, regardless of the strength of relationships across vulnerability components. According to a study of integrated modeling studies, the effects of climate change would disproportionately affect the poor and worsen inequality over time, slowing the worldwide rate of poverty reduction [34].

Low-income individuals are expected to be more vulnerable to the effects of climate change on agriculture, including reduced consumption due to a higher percentage of their income being spent on food, diminished income generation from climate-sensitive agricultural and ecosystem sectors, and decreased adaptive capacity due to fewer assets.

Smallholder agriculture is the primary source of income for almost 2.3 billion rural residents. Most low-income rural households in many nations are marginal net food buyers, frequently buying and selling diverse items at different periods. A household's capacity to preserve its asset base or reinvest in agriculture may be compromised by frequent extreme weather occurrences, which could result in long-term food insecurity, poor health, and lower economic productivity. Longitudinal household survey research in Malawi indicates that climate shocks can affect how households secure food through labor, trade, and transfers from family and social networks, as well as their agricultural production. The impact of climate variability on food access is context-specific, influenced by factors such as the geographical extent of a climate shock and the functioning of food markets. Even in high-income countries, socioeconomic factors, such as farm size, play a significant role in determining the effects of climate change on farm incomes [35].

The fact that low-income households' food systems may be especially vulnerable to climate shocks and trends is another source of vulnerability that hasn't been thoroughly discussed in the literature to date. There are parallel food chains for various socioeconomic strata in many nations, particularly for fresh foods including fruits, vegetables, seafood, meat, and dairy. Food chains that cater to the impoverished in rural areas frequently employ little refrigeration, but they mostly rely on structured quality control, long-distance transportation, and secondary processing. Price transmission is frequently erratic and weak between remote rural food markets and global commodity markets. Under increasing climate variability, these factors contribute to heightened sensitivity to sudden declines in food quality, safety, and availability at the

local level. This situation is exacerbated by limited access to public services and humanitarian assistance during crises, as well as in the long term, isolation from market signals that could inform farming decisions. However, the future is likely to see greater integration of poor farmers into global markets. While some may benefit from rising agricultural prices, non-agricultural rural households in parts of Africa and Asia could experience poverty rates increasing by as much as 50% [36, 37]. Although climate change significantly impacts rural farming communities, more than half of the world's population now lives in urban areas, making affordability a critical concern. Poor urban consumers are affected by rising food prices, but their vulnerability is generally lower than that of rural consumers, as they tend to spend a smaller percentage of their income on food and have better access to food markets. Evidence shows that the negative effects of climate change on agricultural yields typically result in smaller increases in poverty prevalence at the national level. Despite these complexities, the direct impacts of rising food prices since 2007 on human health and well-being, along with associated social unrest, underscore the serious future challenges climate change poses to food availability and access. According to research, child hunger might increase by 20% by 2050, especially in Africa and Asia, if climate change is not stopped. Due to their limited access to clean water, food quality control, medical services, and public health activities like mosquito control, disadvantaged populations are predicted to be disproportionately affected by the negative consequences of climate change on human health.

CONCLUSION

There are considerable uncertainties regarding the effects of food systems on

climate change and vice versa. The wide ranges in our estimates highlight this uncertainty; for example, direct and indirect greenhouse gas emissions from food systems account about 20-30% of total global anthropogenic emissions. If we fail to adapt quickly enough, the net effect of climate change on the global food system is expected to be substantial. Both models and empirical data indicate significant disparities in the impacts on food systems across different regions and between poorer and wealthier populations. Making accurate long-term estimates for adaptation requirements is made more difficult by the interaction of climate change with other global environmental, demographic, and economic factors.

The availability of food will be directly impacted by climate change at every stage of the food chain, but agriculture will be most severely impacted because of its critical role in supplying food and supporting impoverished areas. There will be more intricate and varied indirect repercussions on poverty, livelihoods, health, and nutrition. Other important aspects of food security, such as food safety, may also be greatly impacted by climate change, while the majority of study has been on effects on crop yields and, to a lesser extent, food prices.

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