

Climate Change in Food Systems: Nutritional Implications and Adaptation Strategies

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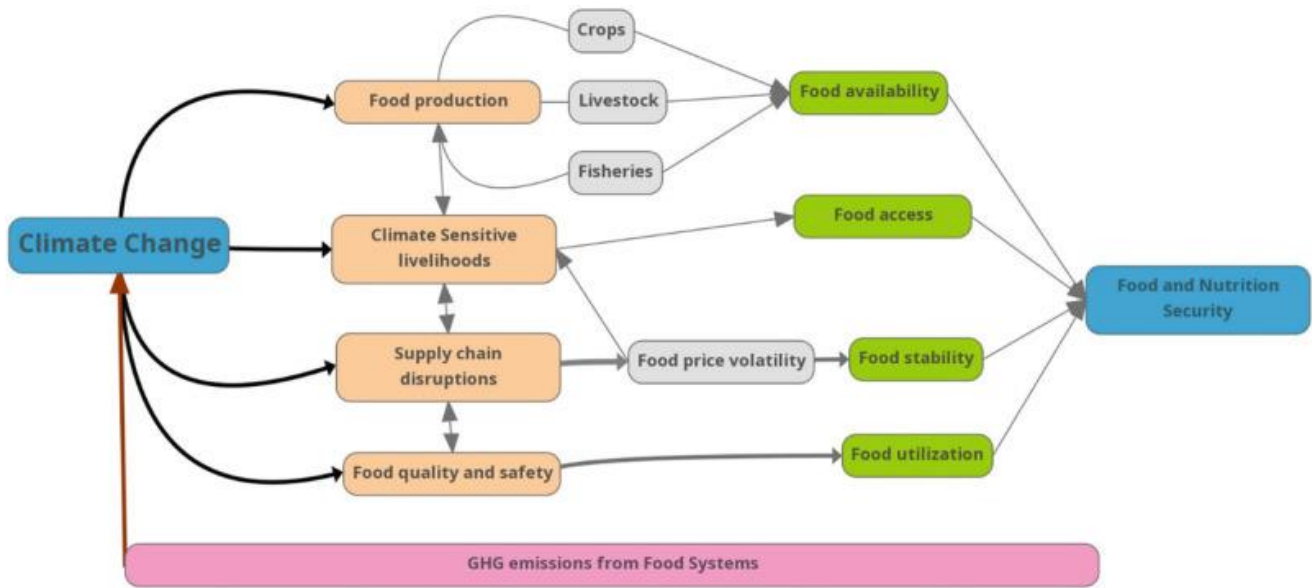
Abstract

Climate change has an effect on the functioning of all of the food systems, often in a way that worsens current problems and disparities among regions and groups in society. However, food systems contribute a third of all greenhouse gas (GHG) emissions to climate change. As a result, food systems can and should have a much greater influence on climate policies. In this research paper, some vacation points are highlighted for adaptation and mitigation of climate change in food systems. paper shows that many practices, technologies, knowledge, and social capital already exist for climate action in food systems. These practices work well with other important goals, like conservation of biodiversity, safe guarding ecosystem services, sustainable land management, and lowering social and gender disparities. Even though not at sufficient levels, many of these solutions are currently being used at local scales worldwide Thus, the massive endeavor to realize their full potential would necessitate overcoming various technical, political, economic, and structural obstacles in order to enable their much broader utilization.

Currently, additional solutions require additional funding for research and development. However, in the second half of this century, when most existing food production practices will face unprecedented challenges, our focus will be on helping us meet the longer-term challenges of climate change in regard to food systems. These pro-poor policy changes and support systems can immediately have positive effects on a wide range of things outside of food systems. In the long run, investments in research will help ensure food security and ecosystem stability for future generations.

1. Introduction

All of the components of food systems are affected by climate change (IPCC 2019). These include all of the actors and their interconnected activities involved in the production, aggregation, processing, distribution, consumption, and recycling of food products that come from agriculture (including livestock), forestry, fisheries, and food industries, as well as the broader economic, societal, and natural environments in which they are embedded (IPCC 2019). However, food systems are a significant contributing factor to global warming. They account for about a third (21–37%) of all greenhouse gas emissions via agriculture and land use, storage, transport, packaging, processing, retail, and consumption (Mbow *et al.*, 2019) (Fig. 1)



Climate change will have different effects on food systems around the world. Tropical and subtropical areas around the world are expected to see changes that are harmful to food systems, but some places, like northern temperate areas, may even experience some short-term benefits. Food and nutrition security will be affected by these changes through a complex set of mechanisms (Fig. 1) Temperature increases, changes in precipitation patterns, and increasing frequency or severity of extreme weather events like heatwaves, droughts, and floods are important climate changes that affect food and nutrition security (Mbow *et al.*, 2019).

They affect crops, livestock, and fisheries productivity by changing water availability and quality, creating heat stress, and changing pests and disease environment, including by accelerating the spread of mycotoxins and pathogens. Increased floods and droughts can cause significant disruptions in food supply chains through harvest failures and infrastructure damage. When people are exposed to heatwaves, droughts, and floods, it can hurt their health and reduce their productivity, affecting their livelihoods and incomes, especially for people who work outside or live in climate-sensitive areas

In many lower-income nations, this exposure can have a significant impact on more vulnerable groups, such as women, children, smallholder farmers, and low-income households. Increased atmospheric CO₂ concentrations, land degradation, and a decrease in pollination services are further climate change-related issues that impact food systems. Crop yields and nutritional content are both impacted by variations in atmospheric CO₂ levels. According to Olsson *et al.* (2019) and Mirzabaev *et al.* (2019), climate change would worsen land degradation by increasing soil erosion, particularly in coastal and slope areas, increasing soil salinity in irrigated lands, and creating more arid and desertification-prone climates in some dryland areas.

Crop yields are also impacted by the possible loss or decline of pollination services. The number of people at risk of hunger could rise by 183 million by 2050 under high emission and low adaptation scenarios [i.e., under Shared Socioeconomic Pathway (SSP) 3] compared to low emission and high adaptation scenarios (SSP1), according to conservative estimates that only partially account for these climate change impacts. According to the higher emission scenario, an additional 150–600 million individuals are expected to

suffer from different types of micronutrient deficiencies by 2050 (Myers et al. 2017; Zhu et al. 2018; Medek *et al.* 2017).

All aspects of sustainable development are significantly impacted by the linkages between food systems and climate change. In reality, linkages between the food system and climate change are becoming more and more important in six of the seventeen Sustainable Development Goals (SDGs). These pertain to the four environmental goals of water resources (SDG 6), climate action (SDG 13), life below water (SDG 14), and life on land (SDG 15), as well as the social goals of gender equality (SDG 5) and zero hunger (SDG 2). In order to advance the 2030 Agenda for sustainable development well beyond the timeframe of the current SDGs, solutions addressing the difficulties presented by interactions between the food system and climate change can be a crucial starting point (Pradhan *et al.* 2017).

How Climate Change Interacts with Food Systems and Food Security

Food Accessibility

Crop production is already being significantly impacted by climate change in many parts of the world, according to a large body of information that has already surfaced (Kim *et al.* 2019; FAO 2018). According to estimates, the total factor productivity of agriculture worldwide has decreased by 21% since 1961 (Ortiz-Bobea *et al.* 2021). According to Iizumi *et al.* (2018), cereal yields have decreased by an average of 2–5% worldwide over the past four to five decades due to climate change.

Regional studies, such as those on wheat and barley in Europe (Moore and Lobell 2015), wheat in India (Gupta *et al.* 2017), and maize in Africa, Central and Eastern Asia (Ray *et al.* 2019), and Central and South America (Verón *et al.* 2015), also found this range of roughly 5% lower cereal yields due to climate change. According to Sultan *et al.* (2019), millet and sorghum yield in West Africa saw higher losses of roughly 5–20%, whereas maize yields in Eastern and Southern Europe were predicted to be lower by roughly 5–25% (Agnolucci and De Lipsis 2020).

The detrimental effects of climate change on fruit, vegetable, and legume yields in drylands, tropical, and subtropical regions are being documented in an increasing amount of research (Mbow *et al.* 2019; Scheelbeek *et al.* 2018). Following the use of coping and adapting measures, these yield losses have transpired (Mbow *et al.* 2019).

Climate change is increasing agricultural potential and crop production in temperate climatic zones, including northern China, parts of Russia, northern Europe, and parts of Canada (Moore and Lobell 2015; Ray *et al.* 2019; Potopová *et al.* 2017; Meng *et al.* 2014; Wang and Hijmans 2019; Bisbis *et al.* 2018). However, because of greater seasonal weather unpredictability, this increased production is often accompanied with weaker yield stability.

Approximately half of the global variability in food output can be attributed to climate change. Crop breeding, better agronomic management, adaptations based on indigenous and local knowledge, and other adaptive measures for raising crop yields are currently able to withstand, on average, the effects of climate change on such yields. However, this trend may eventually be overtaken by the pace of climate change, and many places are already feeling the effects. Due to rising drought-related food production losses brought on by climate change, 26 million people in southern Africa needed humanitarian aid in 2015–2016 (Funk *et al.* 2018). In addition to raising ocean temperatures and acidification, climate change is

decreasing the productivity of farmed fish and shellfish as well as wild fish harvests; in some areas, losses of 15% to 35% have been reported (Mbowetal.2019)

After the 2050s, it is anticipated that the effects of climate change on food production would get worse, especially under scenarios with larger emissions (Mbow *et al.* 2019). In agriculture, the regions that are already hot and dry—particularly the tropics and subtropics—as well as the worldwide drylands, where water scarcity is predicted to worsen, are anticipated to see the largest agricultural production declines as a result of climate change (Mirzabaev *et al.* 2019).

Access to Food

Climate change's effects on worker productivity, supply chains, and agricultural production in climate-sensitive industries will have an impact on food costs and incomes, which will have a significant impact on people's capacity to buy food (Baarsch *et al.* 2020). Depending on the Shared Socioeconomic Pathway taken into consideration, climate change is predicted to raise cereal prices globally by 1% to 29% (Mbow *et al.* 2019). Prices for fruits, vegetables, and legumes will also rise as a result of lower yields. It is difficult to determine how these price increases would affect food access. Higher food prices can help net food-selling farmers (Hertel *et al.* 2010). The urban poor and net food-buying farm producers will be the main victims of those same increased food costs (Mbow *et al.* 2019).

Higher temperatures and more frequent heatwaves will lower labour productivity when working outside or in enclosed spaces without air conditioning. Incomes and buying power will decline as a result of decreasing labour productivity.

Stability of food

Droughts, floods, hurricanes, and sea storms are examples of extreme water occurrences that will occur more frequently due to climate change. According to Mbow *et al.* (2019), inter-annual fluctuations in food production, the devastation of transportation infrastructures, and increased food price volatility can eventually result in more volatile regional and global food trade, compromising people's capacity to obtain food in a steady manner. Vulnerable social groups and landlocked nations with less infrastructure access to the global food trade may be more negatively impacted by these disruptions, particularly in areas without adequate or functional social protection programs (FAO 2018).

Food use and security

Climate change is expected to increase the number of disability-adjusted life years lost and have a negative influence on childhood undernutrition, stunting, and undernutrition-related childhood mortality. Africa and Asia are at the highest risk (Hasegawa *et al.* 2018a). Furthermore, it is projected that by 2050, 529,000 additional climate-related deaths will arise from changes in food availability and diet quality brought on by climate change, with a warming of roughly 2 °C (Springmann *et al.* 2016).

It is anticipated that South and East Asia would account for the majority of these deaths. Due to increases in food prices and decreased income, extreme weather events will even raise undernutrition risks on a regional level. Exposure to one risk factor for food insecurity, such as reduced yields, does not rule out exposure to other risk factors, such as decreased income. Increased atmospheric CO₂ concentrations lower

the protein and mineral content of cereals, lowering food quality and, consequently, food consumption (Mbow et al. 2019).

Rising temperatures are making it easier for viruses and mycotoxins to spread, endangering human health and increasing food loss and waste (Battilani 2016). Mycotoxins are expected to expand from tropical and subtropical regions to temperate zones due to climate change (Mbow et al. 2019). Food consumption would be adversely affected by the decline in water quality brought on by climate change.

Food systems effect on climate system:

One of the main causes of climate change is GHG emissions from food systems. Approximately 25% of the world's greenhouse gas emissions are caused by food systems, or as much as 37% if indirect effects on deforestation are taken into account (Mbow et al. 2019). According to recent estimates from the Food Climate Partnership (Rosenzweig et al. 2021b), the food system's overall GHG emissions in 2018 were around 16 CO₂ eq year⁻¹, or one-third of all anthropogenic GHG emissions worldwide.

13 Gt CO₂ eq year⁻¹, or three-quarters of these emissions, were produced either on-farm or during pre- and post-production activities such as manufacturing, transportation, processing, and waste disposal. The remaining amount was produced by converting natural ecosystems into agricultural land. The findings also show that, between 1990 and 2018, land use change emissions declined while pre- and post-production emissions grew, and that pre- and post-production emissions were proportionately more significant in high-income countries than in low-income countries (Tubiello *et al.* 2021).

Adaptation and Mitigation Strategies for Climate Change in Food Systems

The following measures are suggested for adoption by governments, the commercial sector, and civil society based on the aforementioned evaluation and the most recent IPCC special report on Climate Change and Land (IPCC 2019). There are two kinds of these acts. First, food systems can adapt to and mitigate the effects of climate change using a variety of tried-and-true, practical solutions (Herrero et al. 2020) (Actions 1 to 7).

Many of these pre-existing solutions are well-known and are being used, if insufficiently, at local scales all over the world. Therefore, overcoming a number of structural and technical obstacles for their much wider implementation would be a tremendous endeavour to unlock their potential. In the second half of this century, when the majority of food production methods will confront previously unheard-of difficulties, the second category of action (8 and 9) focuses on important, potential ideas that can help us address the longer-term concerns of climate change within the context of food systems.

Increase your efforts to manage property sustainably:

Water is part of sustainable land management (SLM), which promotes and preserves ecosystem health, boosts agricultural output, and helps mitigate and adapt to climate change (Olsson et al. 2019; Mirzabaev et al. 2019). The use of land resources, such as soils, water, animals, and plants, to create goods that satisfy evolving human needs while concurrently guaranteeing these resources' long-term productive potential and the preservation of their environmental functions is known as SLM (UN 1992 Rio Earth Summit).

Encourage fair and transparent food commerce

The importance of international food trade as a crucial adaptation option to this unstable environment is highlighted by the extremely varied effects of climate change on food production globally and the rise in extreme weather events that disrupt local food production activities (Van Meijl *et al.* 2018; Stevanović *et al.* 2016).

A resilient food system can also be developed by bolstering local and regional food systems through initiatives and regulations that promote sustainable local production. Support for urban and peri-urban production, public procurement, and subsidies that promote the use of sustainable production techniques are a few examples of such policies.

Increased regional and local food trade as well as international food trade, which can serve as safety nets in the event of a climatic emergency, will be necessary to adapt to the changing climate. In order to achieve this goal, food systems' resilience can be strengthened by lowering the transaction costs of food commerce and upholding transparent and strictly enforced international food trade governance.

Encourage the growth and production of perennial crops:

Annual crops, primarily grains (cereals, oilseeds, and pulses), are grown on around 87% of the world's harvested land. These crops germinate [?] and are resown each year or season (Monfreda *et al.* 2008). A switch to perennial grain crops would dramatically reduce erosion and nutrient leakage, drastically reduce agricultural greenhouse gas emissions, and even make cropping a carbon sink. Our current cultivars are becoming more susceptible to stress due to ongoing climate change, which may eventually render them unsuitable for many parts of the world (Altieri *et al.* 2015).

By the second part of this century, cropping systems that are truly tailored to the climate could be developed thanks to new perennial cultivars. By reducing the demand for external inputs (seeds, fertilisers, pesticides, machinery, energy, and labour), perennial crops have the potential to significantly lower farming costs and produce social and economic benefits, especially for farmers and rural societies (Crews *et al.* 2018).

The growth of perennial polycultures, such as the intercropping of perennial grains and legumes, is equally significant since it makes the system more or less nitrogen self-sufficient. These findings provide evidence that high-yielding perpetual cultivars can be created in a matter of decades, but more research is desperately needed to fully understand this "perennial revolution."

Conclusion

There are two main takeaways from this chapter. The bad news is that food systems worldwide are expected to be greatly impacted by climate change, frequently in ways that worsen already-existing vulnerabilities and disparities between different parts of the world and social groups. The good news is that there are already a lot of methods, tools, knowledge bases, and social capital available to deal with climate change in a positive way, both in terms of adaptation and mitigation, as well as synergies and co-benefits with other crucial objectives like biodiversity conservation and other ecosystem services.

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