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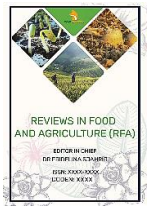

REVIEW ARTICLE

A REVIEW OF FOOD SECURITY CHALLENGES IN THE CONTEXT OF CLIMATE CHANGE: GLOBAL AND REGIONAL PERSPECTIVES

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ABSTRACT

This review integrates the data from academic research, case studies, and regional analysis to examine the effects of climate change on food security globally, emphasizing vulnerable areas like Nepal, South Asia, and Sub-Saharan Africa. It studies how agricultural productivity, food prices, livestock health, and rural livelihoods are affected by climate change, presenting a multi-faceted view of food security challenges. This paper clarifies the causes behind the decrease in food availability and the rise in food costs by establishing links between climate variability and agricultural yields. Shifts in precipitation cycles, unpredictable temperature trends, and extreme weather events' occurrence and severity fail crop production. This study highlights the core causes of the disruptions. It suggests solutions for adaptation and mitigation of the disruptions, including enhanced irrigation systems, climate-smart farming practices, and funding for agricultural research. Addressing these issues with targeted, regionally relevant solutions is crucial to strengthening resilience in an increasingly unpredictable environmental setting and ensuring food security.

KEYWORDS

Climate change, Food Security, Agricultural productivity, Extreme weather, Adaptation

1. INTRODUCTION

Climate change, driven mainly by human activities such as burning fossil fuels, threatens food security worldwide. Food security is a fundamental aspect of human development, as it is essential for leading a long and healthy life, achieving education, maintaining a decent standard of living, and participating in community life with dignity. (UNDP, 2017). Stability in the food supply, access and utilization, availability, and use are the Four key pillars that form the foundation of food security (Kotwal and Singh, 2024).

The primary causes of climate change include fossil fuel combustion, deforestation, and specific agricultural practices, contributing to greenhouse gas emissions and global warming. These changes disrupt agricultural productivity and threaten food security, particularly in less developed regions, by causing more frequent and severe weather events that impede crop production and disturb food supplies. Immediate actions and adaptation strategies are necessary to minimize these impacts and safeguard food security (Nations, n.d.).

The complex relationship between food security and climate change has been focused on in this case study, emphasizing how the change in temperatures, weather patterns, and increased frequency of weather events affect agricultural productivity and food availability. This study highlights the key drivers of climate change, such as burning fossil fuels and deforestation, and their direct impact on greenhouse gas emissions. This review also seeks to identify research gaps in the literature on climate change and food security, focusing on global patterns and regional-specific impacts.

2. METHODOLOGY

This review paper included a methodical analysis of reports, case studies, and scholarly publications from internationally recognized journals. Studies were selected for their relevance to climate change impacts on food security and the focus on regional agricultural disparities, specifically within Nepal, South Asia, and Sub-Saharan Africa. The selected case studies and data offer qualitative and quantitative insights into climate change impacts on agriculture—the investigation aimed to identify key challenges, obstacles, and potential solutions for enhancing resilience within the food system. Strategies discussed include adaptation and mitigation tactics, such as better irrigation systems, climate-smart farming, and funding for agricultural research to increase the resilience of food systems.

3. FINDINGS

3.1 Global Impacts of climate change on food security

Climate change significantly threatens global food security. According to the World Bank Organization, the number of people facing acute food insecurity has risen dramatically in recent years. Extreme weather events, such as droughts, floods, and heatwaves, are becoming more frequent due to climate change, disrupting agricultural productivity, especially in vulnerable regions like Sub-Saharan Africa and South Asia.

The rate of pests and insects is encouraged by the increasing global temperatures, which eventually have harmful impacts on crop yields and food productivity. Rising food prices and reduced crop outputs worsen malnutrition and hunger in these low-income regions (Kotwal and Singh, 2024). According to the World Bank, acute food insecurity increased sharply, from 135 million in 2019 to 345 million by mid-2022, intensified

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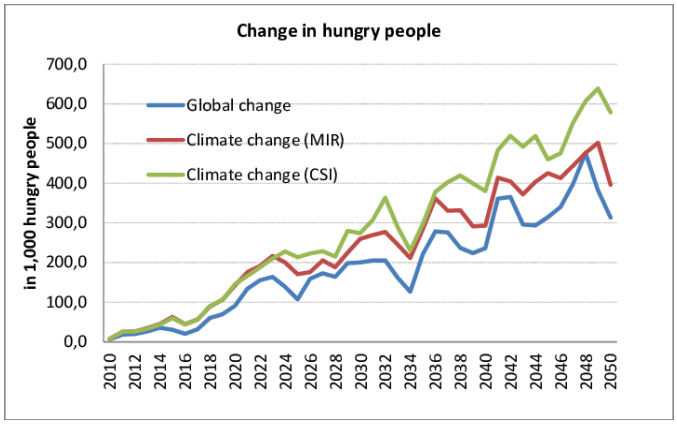
by the COVID-19 pandemic, supply chain problems, and geopolitical conflicts such as the conflict in Ukraine. As the graph illustrates, food insecurity is predicted to grow due to climate change, with a notable rise in hungry people by 2050, particularly in the most extreme climatic scenarios.



Source: (How to Mitigate the Effects of Climate Change on Global Food Security | PreventionWeb, n.d.)

Country	Weather/Climate Variable or Shock	Impact on Crop Production
Ethiopia	Rainfall-growing season Temperature-growing season	+ (7–8)% + (10–60)%
Malawi	Rainfall-growing season Dry spells-growing season	+ (16–20)% – (10)%
Niger	Rainfall-growing season Late onset of rains	+ (64–84)% – (42–51)%
United Republic of Tanzania	Within-season rainfall variation Too hot growing season (>30°C)	- (8–15)% - (14–25)%
Zambia	Rainfall-growing season Late/false onset of rains Too hot growing season (>28°C)	+ (5–10)% Decreases the impact of fertilizers by 50% Nullifies the effect of improved seed

Source: (Gitz et al., 2016)

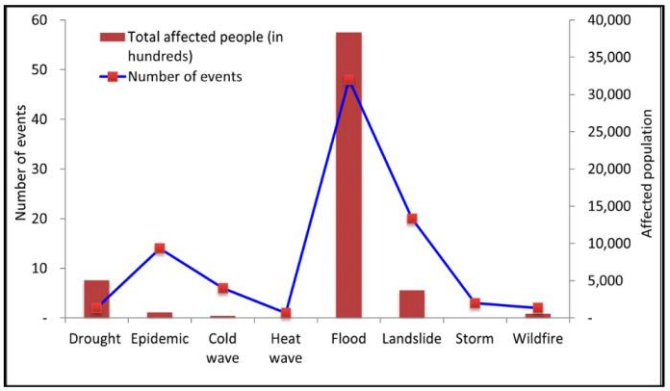
The table above illustrates that climatic factors affect agricultural output positively and negatively globally. For example, a rainy growing season in Ethiopia has the potential to increase agricultural yields by 7–8%, whereas a hotter growing season can increase yields by 10–60%. While on the other extreme, nations such as Niger have to face severe disadvantages; a late start to the rainy season can cause a 51% decrease in grain output. The benefits of better seeds are nullified in Zambia due to an overly hot growing season, illustrating a classic example of how climate change may counteract agricultural technology progress.

Besides, at the present moment, the global food system has become the main contributor to climate change, emitting a large share of greenhouse gases. To adapt, agriculture must become more resilient by improving water use, switching to less water-intensive crops, and enhancing soil health. These changes are vital to reducing emissions and ensuring food security, but they require substantial economic, social, and technological efforts, particularly in the most at-risk areas.

3.3 Regional focus: Nepal

In the case of Nepal, rice is the most important staple crop, constituting 45% of the national food supply; food security dramatically depends on domestic production. However, food sufficiency at the national level during years of good harvest does not ensure food security at the household or individual levels due to inconsistency in food availability, access, and utilization across different regions. Nepal's vulnerability to climate change impacts, such as droughts and floods, poses significant risks to food production, particularly for staple crops like rice and maize. Low-income countries like Nepal face heightened food insecurity risks as global food prices rise due to climate change and other factors. Nepal's dependence on imported food and susceptibility to climatic events like floods and droughts further complicate food security. This indicates a need for more refined understanding and strategies to address food security challenges at multiple levels, especially in the face of climate change. (Journal & Vol, 2012).

Climate change significantly impacts food security by influencing both crop and livestock production. Rising temperatures and increased frequency of extreme weather events, such as droughts, floods, and excessive rainfall, disrupt agricultural productivity (Downing, 1993). These changes affect soil quality through erosion, degradation of organic matter, and altered microbial activity, which diminishes soil fertility and productivity. Additionally, heat stress adversely affects livestock performance and well-being, further impacting food production. The combined effects of these changes pose a risk to global food security, especially as the need to produce more food grows with the increasing global population. Mitigation strategies, including monitoring soil organic carbon and implementing crop insurance, are essential to manage the economic impacts of these climate-induced disruptions on agriculture (Downing, 1993).



Source:(Poudel et al., 2017)

According to the graph, floods—caused by shifting precipitation patterns—are the most detrimental to Nepal's food security. As extreme weather events become more frequent due to climate change, droughts and heat waves become significant hazards. Given the importance of agriculture to Nepal's economy, the rise in these occurrences is expected to harm food costs, availability, and output, making food security a critical concern for the country.

The implications of climate change on food security are profound and globally significant. As extreme weather events become more frequent and intense, agricultural productivity declines, leading to higher food prices and reduced availability, particularly in vulnerable regions. This exacerbates hunger and malnutrition, undermining efforts to achieve global food security. The destabilization of food systems due to climate change threatens livelihoods, increases poverty, and can lead to social and political instability. Addressing this issue is crucial to ensuring a stable, healthy, and sustainable future for all.

3.4 Impact of Climate Change

3.4.1 Temperature Effects on Crop Yields

3.4.1.1 Wheat

According to a study, Research carried out in controlled settings, including open-top chambers, has demonstrated that wheat yields may grow by 8.6% with a 6.9°C increase in temperature and by 59.7% with a doubling of present CO2 levels to 800 ppm (Paudel et al., 2019). Under high CO2 and ambient temperature conditions, wheat production rose regionally by 41.5% in the Terai plain, 24.4% in the Hill, and 21.2% in the Mountain areas. On the other hand, wheat yield rose by 5.3% in the Hill and 33.3% in the Mountain areas but declined by 1.8% in the Terai, with a 4°C rise in temperature accompanied by irrigation. These findings imply that whereas wheat production at higher elevations may gain from climate change, the Terai region's lower regions may suffer unfavorable effects.

3.4.1.2 Rice and Barley

From the paper, we found that wheat, rice, and barley react differently to rising temperatures (Pant, 2013). The susceptibility of this significant crop to temperature rises is demonstrated by the fact that in Nepal, rice yields decline by around 365 kg per hectare for every 1°C increase in the average lowest temperature in September. Similarly, barley output decreases by

around 38 kilograms per hectare for every 1°C increase in the average lowest temperature in January. On the other hand, wheat responds favorably, increasing yields by around 233 kg per hectare for every 1°C increase in the lowest temperature in January. This suggests that although certain crops like wheat may profit from temperature variations, others like rice and barley may be affected, disrupting Nepal's food security.

3.4.2 Extreme Weather Events

Nepal has had a problem with recurrent droughts, intense floods, landslides, and various consequences on agricultural products due to climate change (Malla, 2009).

3.4.2.1 Droughts

Nepal frequently experiences droughts, which lead to reduced crop yields and increased food insecurity. Droughts worsen soil erosion and water shortages, which lowers agricultural yields and increases food poverty. It is more difficult for farmers to maintain steady crop output and support their livelihoods when monsoon patterns are unpredictable (Pant, 2013). A prolonged drought in the country's east caused around 10% of the land to become pasture, while excessive rainfall in the Terai area of the Midwest caused floods that reduced agricultural output by 30% (Regmi, 2009).

3.4.2.2 Floods

Climate change has increased the frequency of localized floods in Nepal, damaging agricultural fields and infrastructure, causing short-term losses in crop production, and disrupting food supplies. Due to an early monsoon, Eastern Terai experienced a rain deficit in 2005–06, and agricultural output nationwide fell by 12.5%. Due to a lack of rain, about 10% of agricultural land was left fallow, although the midwestern Terai had significant rain and flooding, which decreased productivity by thirty percent of the year (Malla, 2009).

3.4.3 Pests and diseases

Insect pests are impacted by climate change since it raises CO2 levels and temperature. Warmer weather can hasten pests' metabolism, reproduction, and spread, resulting in early and worse infestations. Food security is put at risk as a result of increased crop damage. However, various insects have varying temperature tolerances; the impact varies depending on the pest type. In general, pest intensity tends to rise with climate change, resulting in more frequent and severe crop losses (Subedi et al., 2023). Numerous pests and diseases previously only found in warmer climates and at lower altitudes are now thriving at higher altitudes, indicating that climate change has created the environmental conditions necessary for these pests and diseases to flourish at higher altitudes. (Neupane et al., 2022).

3.4.4 Socio-economic impacts and Nutritional impacts

The farming communities of Nepal are adversely affected by climate change, especially the vulnerable populations such as women and smallholder farmers. Unpredictable weather patterns, such as droughts and floods, lower agricultural output, which increases poverty and causes revenue loss. These consequences exacerbate already-existing socioeconomic disparities since they are more noticeable for people without access to resources and technology. According to the World Food Programme (WFP), these climatic shocks seriously threaten the financial stability of Nepal's most vulnerable populations. (Nepal Country Strategic Plan (2019-2023) | World Food Programme, n.d.)

Climate change's disruption of Nepal's food production impacts food security and nutrition, which raises costs and decreases availability. An increase in the frequency of extreme weather events, such as droughts and floods, leads to crop failures and a reduction in the variety of foods consumed, primarily affecting low-income households and raising the risk of malnutrition. According to the Food and Agriculture Organization (FAO), these modifications worsen Nepal's food insecurity and nutritional outcomes (Gitz et al., 2016).

4. Results And Discussion

The study shows significant gaps in region-specific adaptation techniques, especially in susceptible regions like South Asia and Sub-Saharan Africa. Higher CO2 concentrations may temporarily boost agricultural yields in some areas, but an increase in insect infestations and harsh weather frequently offsets these gains. Global food security is seriously threatened by climate change, as seen by the sharp rise in acute food insecurity from 135 million in 2019 to 345 million by mid-2022. Droughts, floods, and heat waves are extreme weather phenomena that progressively interfere with global agricultural productivity.

While crop yields have significantly decreased, and food costs have risen substantially. Regional analyses reveal a variation of impacts: extreme conditions of weather in Niger and Tanzania drastically shrink agricultural production, whereas the countries like Zambia and Ethiopia have been facing reductions in crop yields due to the fluctuations in temperature and rainfall. Frequent floods and droughts in Nepal worsen food poverty and underline how vulnerable nations are that depend on their agricultural output.

As climate change affects regions variably, the study enlightens the significance of region-specific solutions. Legal solid frameworks and improved assistance for vulnerable communities are essential to mitigate the consequences of climate change on food security and ensure sustainable, resilient agricultural systems in the future.

5. Conclusion

Global food security is seriously risked by climate change, especially in vulnerable areas. According to the research, agricultural output is considerably disrupted due to rising temperatures, extreme weather events, and changing weather patterns. This results in reduced crop yields, increased food costs, and heightened risks to the health of animals. Malnutrition and food poverty are made worse by these interruptions, especially in low-income communities.

Resilient food systems require adaptation and mitigation methods, such as enhanced irrigation systems, climate-smart farming practices, and funding for agricultural research. Customized and area-specific solutions are needed to address every region's unique problems. In light of the growing threats associated with climate change, immediate action is necessary to protect food security and provide a stable, sustainable. In a future where everyone can access food, immediate action is needed.

Suggestions

- To increase yields and lessen reliance on the climate, cultivate and disperse crop types that are heat- and drought-tolerant.
- In places with limited irrigation, install effective irrigation systems to increase water-use efficiency.
- To improve soil health and crop resilience, implement sustainable farming techniques such as conservation tillage and agroforestry.
- Install early warning systems to assist farmers in anticipating and lessening the effects of extreme weather occurrences.
- Invest in improved storage facilities to reduce losses after harvest and preserve food quality.
- Boost agricultural research funding to hasten the creation of climate-smart technology.
- Encourage using resilient methods and increase farmer education on climate adaptation techniques.
- To increase production and lower greenhouse gas emissions, policies supporting climatesmart agriculture should be established.

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