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REVIEW ARTICLE

# Assessments on the Impacts of Climate Change on Food Production, Nutrition, Quality, and Resource Use Efficiency: A Review

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**Abstract**
Nowadays, climate change is a hot issue all over the world which mainly affects crop production and productivity. Thus, it causes food insecurity all over the globe mainly in Sub-Saharan African countries like Ethiopia. This paper provides a comprehensive overview bonded to the appraisal of climate change impacts on nutrition, quality, and resource use, effectiveness using climate, water, and crop yield models. The studies present that climate change models with advanced spatial resolution can be a way forward for coming climate protrusions. The variability of downfall and the adding temperature was a cause of frequent failure and shortage and had a disastrous impact on the livelihood of the people. Climate change exacerbates the enormous being burden of undernutrition. It affects food and nutrition security and undermines current sweats to reduce hunger and promote nutrition. Undernutrition in turn undermines climate adaptability and the managing strategies of vulnerable populations. Climate change is now a global miracle with growth, poverty, food security, and stability counteraccusations. Because of significant dependence on the agrarian sector for product, employment, and import earnings, Ethiopia is seriously hovered by climate change, which contributes to frequent failure, flooding, and rising average temperatures. The most vulnerable sectors to climate variability and change in the country are husbandry, water, and mortal health. Agricultural sectors are severely affected by Climate change; thus, it causes the production and productivity of animals and plants. To enhance productivity, biotechnology in breeding is therefore essential; nonetheless, optimization is needed for every crop and circumstance. While some newly released crop varieties can increase yield and improve resource use efficiency, others can produce crops on marginal land that are sufficient.

**Keywords**: Climate, Food security, Nutrition, Resource use efficiency, Temperature

## Introduction

Currently, climate change is the most the most factor affecting the environment globally, and also its effects will continue in the coming periods (Temesgen et al., 2014). The climate change is due to the various ways in which it

has destructive effects. Natural variables including volcanic eruptions, changes in the Earth's orbital components, and variations in solar output, as well as human-induced factors, namely the release of greenhouse gases, all contribute to global climate change. Although it is not a new phenomenon, the rate at which it is changing now is unparalleled. The average surface temperature of the Earth increased by 0.6–0.2$^0_C$ in the 20$^{th}$ century as reported by the IGP (Intergovernmental Panel) on Climate Change's 3$^{rd}$ Assessment Report (TAR). According to Parry et al. (2005), this trend is predicted to continue, with temperatures increasing by 1.4 - 5.8$^0_C$ by 2100.

On average, the Ethiopian's annual temperature increased by 1.3$^0_C$, or 0.28$^0_C$ between 1960 and 2006 in every decade. By the 2060s and 2090s, respectively, it is predicted that the mean annual temperature will rise by 1.1 to 3.1$^0_C$ and 1.5 to 5.1$^0_C$. As reported by McSweeney et al. (2007) reported that in many models, the expected changes under a single emissions scenario range up to 2.1$^0_C$. Moreover, climatic projections indicated that as a result of global warming, rainfall unpredictability will rise and extreme flooding and droughts will occur more frequently (World Bank, 2010).

The various reports showed that the most common cause of climate change is the emission of Greenhouse Gases. Similarly, the IPCC (Intergovernmental Panel on Climate Change's) (2007) evidence is now overwhelmingly persuasive that the change in the environment mainly the change in climate resulting due to greenhouse gases (GHGs) is real and that the most vulnerable and disadvantaged people will suffer the most. Moreover, the IPCC (2014a), reported that the global change temperature by 2100 on average may vary from 1.8-4.0$^0$c. In the case of plants and animals, about 20 to 30% of the species are forecasted to be under extinction due to the rise in temperature by 1.5-2.5$^0_C$ (FAO, 2010; IPCC, 2014a, b), which will have a significant impact on crop production and maintaining food security in underdeveloped nations as reported by Mekuriaw et al. (2014).

The relationship between climate change and maintaining food security through the production of crops and animals has primarily focused on how it affects agricultural sectors ultimately causing the production of food crops. As an example, Gregory et al. (2002) reported that the wheat and rice crops, showed a reduction in crop length and consequently production of wheat crops as a result of heating and yield decreases of around 5% per $^0_C$ increase beyond 32$^0_C$ for rice. According to Cline's 2007 projection, agricultural productivity will decline globally by 15.9%, falling 19.7% more sharply in developing nations. Similarly, a simulation of maize output in Latin America and Africa for the year 2055 anticipated a 10% total decrease (Jones and Thornton, 2003, Addisu et al., 2020).

Unambiguous evidence of climate system warming includes rising global average sea levels, higher air and ocean temperatures on average, and resulted in extended snow and melting of ice (IPCC 2007). The seasonal mean temperature has risen in several parts of Ethiopia, according to the IPCC (2014a) study. By 2006, Ethiopia's average annual temperature had risen by 1.1–3.1$^0_C$, and likewise, McSweeney et al. (2007) explained that there were hotter days and also hot nights on average each year. Animal health and food production are both negatively impacted by this.

Currently, the concerns of crop production and being secure in food will be increased due to the effects of climate change, thus it will make more difficult conditions to produce more production of crops and livestock products to maintain food security in the world. Among these, the most powerful and frequently occurring one is natural disasters. Accordingly, Gregory et al. (2008) and UNFCCC (2009) explained that the consequences of natural disasters are profound for underdeveloped countries that are malnourished, impoverished, and still under food security. This paper's goal was to examine how climate change has affected possibilities for adaptation and mitigation as well as crop production, food security, nutrition, quality, and resource use efficiency.

**The Impacts of Climate Change**

## Impact of Climate Change on Nutrition

The influence of climate change on food security, undernourishment, and agricultural productivity in poor nations is the single greatest health risk, according to World Health Organization research, because so many people are affected (Confalonieri et al., 2007). Global hunger and malnutrition risks are increasing due to climate change, impacting food security, livelihoods, health, water, sanitation, and socioeconomic determinants, affecting food access, maternity care, and sanitation (Easterling et al., 2007).

Women, children, and marginalized populations are among those who are the poorest and most at risk of suffering from anticipated climate change effects (World Food Program 2009). They are highly vulnerable to natural disasters, directly depend on resources that are unstable due to climate change, and have limited capacity to adjust or mitigate its effects. Pastoralists, artisanal fishermen, and smallholder and subsistence farmers will be especially exposed to the intricate, regional consequences of climate change (Easterling et al., 2007).

According to the IPCC (2007), there will be 200–600 million more hungry people by 2080, and 24 million more people will be undernourished by 2050 as a result of developing nations' reduced access to calories. Furthermore, it has been projected that in 2050, there will be a relative increase in mild stunting of 1% to 29% due to climate change as opposed to a world without it. Climate change is expected to cause rates of severe stunting to increase by 23% in central sub-Saharan Africa and 62% in South Asia (Lloyd et al., 2011).

Climate change causes direct and indirect effects. It can cause direct effects on the production and productivity of crops and livestock, the food systems of the country, and its food security, whereas, the reduction and varying nutritional values of the products are the indirect effects of it. Many plant crops used by humans have lower protein concentrations as a result of increased carbon dioxide. The amount of atmospheric carbon dioxide that is expected in the next ($22^{nd}$) century will have a significant impact on plant physiology and growth, which is anticipated to have an impact on agricultural output and food quality. Under warmer and drier conditions, raised $Co_2$ is anticipated to have a stronger effect on the levels of grain protein (WHO, 2010 and 2013).

## Impacts of Climate Change on Health

Scientists have conjectured about the potential effects of climate change on human health due to the correlation between weather-related conditions and seasonality. Two recent studies are White and Hertz-Picciotto (1985) and Haile (1988). There is insufficient scientific evidence to conclusively demonstrate a link between human health and climate change. Human health is impacted by the climate both directly and indirectly. Heat stress, heart problems, preterm delivery, lung ailments including asthma and bronchitis, and infections spread by mosquitoes and ticks are examples of direct consequences. Premature birth, lung disorders associated with smog, and illnesses like pneumonia and influenza are examples of indirect consequences. For instance, Asthma, hay fever, pneumonia, influenza, and other illnesses are associated with particular climates and weather patterns, including winter, which impact the distribution and life cycles of fungi and plants.

Human health may be impacted by climate-related changes in crop and animal production, surface and subsurface water, coastal resources, social and economic conditions, and more. Poorer diets could ensue from decreased food production, and decline of irrigation or agricultural drainage due to increasing the levels of the sea and altered patterns of precipitation could have serious negative effects on human health and the economy (Harrington et al. 1989). The ranges in topographical and vulnerability of humans to numerous factors like diseases may change as a result of increased human migration from one place to another. Human health will typically be negatively impacted by any situation that lowers standards of life (Chappie and Lave 1982).

Many problems still need to be rectified. Without reliable predictive information on the local temperatures, relative humidity, and precipitation amounts, it is impossible to anticipate the health effects. Confounding variables have an impact on human health, some much more so than the weather. Due to the complicated interrelationships between these components (both with weather and among themselves), global climate change may frequently have an impact on two or more factors at once. We lack the knowledge necessary to fully evaluate all the synergistic and compensating effects. Finally, we lack knowledge of the potential social and economic effects that variations in mortality and morbidity brought on by the climate or ozone might produce. We also don't know a lot about the social and financial consequences associated with such effects. It is difficult to find information, in particular, on the productivity losses and out-of-pocket medical expenses linked to rises in morbidity.

**Implications of Climate Change in Food Security**

The literature has a wealth of information about the negative effects of climate change on East Africa's agricultural industry. Climate change affects agriculture and food production in several ways. By influencing the rise and distribution of incomes, it indirectly impacts food production by influencing the demand for agricultural products (Gregory et al. 2008). Altering agroecological circumstances (e.g., variations in rainfall causing drought or flooding, or variations in temperature causing changes in the length of the growing season), directly impacts food production. In semi-arid and dry regions, the amplification of high temperatures and little precipitation will be the most noticeable effect of climate change on smallholder and subsistence farmers (Mendelson and Dinar, 2010). The fifth report from the IPCC warns that, particularly for farmers in semi-arid regions, climate change in East Africa could worsen food insecurity, cause people to lose their rural livelihoods, and lower agricultural production. The 2013 IPCC report noted that extreme weather events can be dangerous to critical infrastructure networks and services such as emergency response, water and power supply, and healthcare.

The yields of major cereal crops in the African region are expected to be considerably negatively impacted by climate change (Niang et al. 2014). Mild warming rates of 1 to $20^0_C$ are putting rare ecological systems in jeopardy and may have an impact on water supply, human health, and food production in some regions. According to "worst-case" projections, warming by $2^0_C$ by the middle of the century might result in losses of 27–32% for maize, sorghum, millet, and peanuts (Schlenker and Lobell, 2010). According to the IPCC, global warming of $4^0_C$ or more will raise the possibility of severe, all-encompassing, and permanent effects to which it will be challenging to adapt. Because of numerous factors, including land degradation or nutrient deficiency, quick growth of population, and unavailability of adequate technologies such as newly released crop species, plant nourishments, mechanization, and irrigation have sparked the development of agricultural sectors all over the world. These factors are in common in Ethiopia which makes it a great problem for the governments and other development organizations to maintain food security and alleviate the poverty (Mekuriaw et al. 2014). According to Gebreegziabher et al. (2016); Tadesse and Alemayehu (2019) and Tamirat (2019) reported that the agricultural sector plays a vital role by creating job opportunities for the people, as a result, in Ethiopia more than 85% of the populations are highly engaged in these activities, and also, it aids to GDF of the country approximately $40 billion; it earns 88% of export revenues, and fulfills 73% of the domestic industries depends on agricultural raw materials needs of the country. Therefore, the primary sector that contributes to food security is agriculture because it is a significant means of food and also, it is important in producing excess capital to hasten the social and economic growth of the nation. However, due to unpredictable and irregular rainfall, this sector is highly at risk in the degraded areas and semi-arid areas of the country. Moreover, Zenebe et al. (2011), reported that climate change has a detrimental effect on financial sectors through reducing revenues by worsening agricultural activities. As a result, if this trend continues in the world mainly in developing countries, there will be a decline in salaries by 2050. According to the World Economic

Forum in 2023, By 2050, unchecked climate change might force over 200 million people to migrate, resulting in poverty and undoing decades of development gains. According to the no-total factor productivity-growth scenario model, income is lost due to climate change by about 30% when compared to the no-climate-change baseline.

**Impact of Climate Change on Quality and Resource Use Efficiency**

**Climate change impacts on water resources**

The hydrologic cycle is expected to quicken due to global warming, increasing precipitation and evaporation by 7 to 15% on a worldwide scale (Bolin et al. 1986). For many locations, climate models cannot agree on the direction of yearly precipitation change, hence the consequences on local water supplies are uncertain (Fredenck and Gleick 1989). In areas like northern California, where winter snowfall dominates precipitation and spring snowmelt dominates runoff, warmer temperatures may result in more winter rain, earlier spring melting, and seasonal runoff patterns (Gleick 1987a,b).

Water's relative values for alternate uses are likely to change. Variations in the seasonal and yearly availability of water can affect how water is used and reservoir capacity used for irrigation, fish habitat, flood control, and power generation. According to Frederick and Gleick (1989), hydroelectric power may become more appealing as a way to reduce the greenhouse effect while also coping with potential increases in energy needs. Water must be available at current or suitable new locations to produce more hydroelectric power, but water is running out in many parts of the world.

The building of dams, interbasin water transfers, desalination, waste recycling, and weather modification are examples of climate change adaptations that necessitate the development of non-conventional water sources. To increase performance, water managers might spend money on research and technology developments as well as infrastructure improvement plans, but they might not be able to justify these expenditures until climate change plays a major role (Frederick and Kneese, 1989). The possibility of future climate change could encourage further investment in these fields.

**Impacts of climate change on Forests, Unmanaged Ecosystems, and Biodiversity**

Within a few decades, the anticipated global warming might occur, possibly surpassing the millennium-scale natural rates of forest migration (Batie and Shugart, 1989). If this is the case, stressed-out existing woodlands become more susceptible to disease, pest infestation, and eventually fire (Clark, 1988). They will eventually replace the current forests with new forms of vegetation or forests that have a combination of species (Sedjo and Solomon 1989; Tamirat and Mekides, 2020).

In high latitudes, a lack of summer warmth and a lack of water limit tree development, while in the middle latitudes, heat and a lack of water limit growth. The consequences on forests would likely be negligible in the tropics, where temperature increases are predicted to be the least severe. As a result of climate change, the boreal forests will most likely migrate northward onto the tundra that is not now covered in trees, if there is enough precipitation and suitable soils. The biggest transitions, according to simulations, happen along the boundary between the boreal and cool temperate regions. Especially if higher $CO_2$ and better plant water use efficiency do not result in the predicted improvements in tree growth and moisture-saving benefits (Tamirat and Mekides, 2020), some mid-latitude forests may perish. According to Sedjo and Solomon (1989), species in mountainous areas would migrate to higher altitudes as temperatures rose.

Ecosystem biodiversity is at risk from rapid climate change, according to Batie and Shugart (1989). Certain extant plant and animal species would not be able to adapt because they are not mobile enough to migrate at the rate required for existence (Davis, 1989a, b). Although it is difficult to quantify, biodiversity has a significant economic worth. The forest industry must remove early species, try to salvage, thin, seed expensively, and actively plant trees in harvested stands to adapt to changing climates (Sedjo and Solomon, 1989).

In comparison to agriculture, the introduction of new types occurs much more slowly in forestry. Changes in the species mix may result from adaptation, at least in the early decades, and may necessitate expensive modifications to the logging and processing industries. Long tree growth cycles further increase the financial risk of selecting the wrong species for the changing climate, discouraging investment in trees and mills to process them. Production forestry will shift geographically, with some areas becoming more and more significant providers of wood products while others experience a loss. Only those locations where high-yield plantation forestry can still be carried out profitably will actively manage their woods.

Other unmanaged terrestrial and freshwater ecosystems have nonmarket value to humans because of their rarity (they might be protected in national parks, for example), significance in maintaining genetic and biotic diversity (Peters and Darling 1985; Graham 1988; Wilson 1988), and general ecological context they provide for natural resources that humans exploit. Research has indicated that the distribution of biotic communities and vegetative life zones, such as grasslands and tundra (Emanuel et al. 1985), arid communities (Neilson, 1986, 1987), and forests (Pickett and White 1985, Overpeck et al. 1990, Tamirat and Mekides, 2020), may be affected by global warming. Mainly the arid regions are particularly vulnerable (Adam et al. 1978; Dregne, 1893). Changes in former climates have been found to have a significant impact on vegetal patterns in pale ecological studies (Davis and Botkin 1985; Webb, 1986; Woodward 1987; Davis, 1989a, b). Concern is growing over how global warming may affect arctic and alpine communities, highly specialized terrestrial species, and species with weak dispersion systems (Peters and Darling 1985). Since aquatic communities are intimately linked to their terrestrial environments through energy, nutrients, and water, changes in terrestrial vegetation could have a substantial impact on freshwater systems, even though the effects of global warming on aquatic communities are still unknown (Minshall et al. 1985; Tamirat, 2019).

**Climate Change Adaptation and Mitigation Measures**

According to FAO (2010), the most important strategy to maintain food security and reduce the impacts on the environment is Biotechnology. In the meanwhile, modified crop types that can withstand extreme weather conditions including drought, waterlogging, salt, and climate change might increase the area that can be planted with crops, like in eroded soils, to improve the availability of foods for the future.

There is a great deal of worry that the rising levels of greenhouse gases in particular, carbon dioxide contribute to global warming by absorbing long-wave radiation reflected off the earth's surface. Carbon in the atmosphere has increased by 30% over the previous 150 years. According to Stavins and Richards (2005), the majority of scientists concur that elevated atmospheric carbon dioxide concentrations and increasing global temperatures are causally linked.

Increasing the worldwide storage of carbon in soils is one strategy suggested for lowering atmospheric carbon dioxide. However, storing carbon in soil benefits everyone. According to Kumar et al. (2009), Adesodun and Odejim (2010), and others, it boosts soil quality, improves agronomic production, advances food security, and mitigates climate change by offsetting anthropogenic emissions. Programs for conservation and reforestation have been implemented in this scenario throughout the past three decades (Tamirat and Mekides, 2020). To adapt to climate change, smallholder farmers must manage agricultural risk through climate-smart agriculture, enhance

climate information services, and accelerate adaptation over decadal time scales using integrated technology, agronomy, and policy alternatives.

## Conclusion

Numerous studies have established the validity of climate change, the likelihood that it will worsen, and the likelihood that the most vulnerable and disadvantaged people will suffer the most. The security of food and nutrition is directly impacted by climate change, undermining present initiatives to combat food insecurity, the vitally important yet less addressed social, economic, and human health-related issues in the world. Human health may be impacted by climate-related changes in agricultural production mainly crop production, aquaculture, water and coastal resources, social and economic conditions, and more. The variability of climate such as the presence of unpredictable rainfall, floods, and droughts; and the variation in temperature, and precipitation can cause an impact on agricultural sectors. To achieve the necessary scale and rate of climate change, the following points should be considered; a) the integration of climate change policies and their implementation, b) the policies and implementations should be evidence-based, c) to maintain food security at all levels of the nations, the usage of climate-smart approach should be mandatory. The major effects of climate change on the yield of crops and livestock feeds, the availability of water, the occurrence of pandemics and unexpected diseases, and flood damage will result from variations in rainfall and rise in temperature. Improved rotation systems, reduced tillage carbon-sequestration practices, and higher crop cover including agroforestry, are just a few of the CSA strategies for climate change adaptation and mitigation that should be strengthened. Construction of additional dams and reservoirs, inter-basin water transfers, and the creation of "unconventional" sources of water, such as desalination, reutilizing of various waste materials from the industry, municipal sectors, and agricultural sectors, as well as weather modification, could all be considered adaptations to climate change.

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