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Climate change and food security

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Abstract
Climate change is a serious threat to our planet. Rising temperatures, erratic rainfall and extreme weather conditions have created havoc for many nations. The rate of global warming is higher than it has ever been. Variations in temperature are altering weather patterns and upsetting the natural balance of the ecosystem. Such climatic changes have adverse effect on the food security as well. Thus the current study explores the effects of climate change on food security. The results are based on the perspectives of different researchers. The effects were studied under food availability, food accessibility and food utilization in the face of climate change. Climate change adversely affects all the dimensions of food security. The current situation calls for a paradigm change regarding food systems and agriculture.

Keywords: Climate change, food security**,** food availability, food utilization

Introduction

Climate change is our planet's greatest existential threat and its effects can be seen worldwide. Climate change has a serious and pervasive effect on our ecology which can be harmful to human health and food production. Health issues can augment death rates, have an impact on the food supply, and lower labor output (NOAA, 2021) [42]. As global temperatures rise, changed weather patterns, catastrophic weather events, and other environmental disruptions make food production increasingly difficult and unpredictable. Increased frequency of pests and illnesses, increased frequency of extreme events like floods and severe storms, and diminished water resources are just a few of the negative effects that climate change will progressively have on agricultural productivity (FAO, 2015) [23].

The primary objectives of the Sustainable Development Goals (SDGs) are to eradicate hunger, attain food security, and enhance nutritional status. Climate change will undoubtedly increase the difficulty of this task. The number of individuals facing severe food insecurity amplified from 135 million in 2019 to 345 million in June 2022 across 82 countries. Food prices have increased to previously unheard-of levels as a result of supply chain disruptions, the COVID-19 pandemic's persistent effects on the economy, and the situation in Ukraine (World Bank, 2022) [55]. The World Food Summit defined food security as: "Food security exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food which meets their dietary needs and food preferences for an active and healthy life" (FAO, 2008) [22]. This definition divides food security into three primary categories. These categories are defined as "Availability*"* of enough and quality food, "Access*"* to nutritious and adequate food by individuals, and "Utilization" of food to meet all socio-physiological needs (Timmer, 2017) [52].

Future food security may be negatively impacted by frequent occurrences of water stress, a lack of water, and intensive farming practices that are unsustainable and erratic (Hameed *et al*., 2020) [27]. A third of Asia's greenhouse gas emissions are attributed to non-sustainable farming methods (Syed *et al*., 2022) [51]. Negative climate change have the greatest impact on the agricultural sector, which includes crop production, farm animals, fisheries, and forest farming (Awan and Yaseen, 2017) [5]. According to projections, changes in climatic components would amend cropping seasons, which will have an unfavorable effect on livelihoods depending on forest farming (Chisale *et al*., 2021) [12], and this could, at the regional level, finally put an end to the viability of a number of agriculture and forest species. This research reviews the existing literature in an effort to investigate how climate change affects food security while keeping in mind the scenario mentioned above.

Materials and Methods

A systematic review of literature was carried out. The database used in initial search strategy included Google scholar and research gate. Terms like "climate change and food availability," "climate change and food accessibility," and "climate change and food utilization" were included in

the search approach. After proper screening of articles with clear objectives, satisfying data collection methods and well described data analysis procedure, the literature was downloaded and final set of research papers, review papers and articles were reviewed.

Results and Discussion

Climate change and food availability

Crop losses exacerbate food insecurity in rural regions by lowering farm income in addition to plummeting food availability (Sam *et al*., 2019) [47]. The production of large farms that frequently grow the same crops every year while utilizing copious amounts of pesticides and fertilizers, which eventually deplete soils, pollute water, cause nutrient loss, reduce biodiversity, and exacerbate climate change has allowed for the achievement of current food security through intensive industrial agriculture (Pareek *et al*. 2020) [43]. As per Food and Agriculture Organization (FAO) 2016 [26], if the current situation of GHG emissions and climate change continue then by the year 2100 there will be decline in the production of major cereal crops (20-45% in maize yields, 5-50% in wheat and 20-30% in rice).

According to a report by the European Academies' Science Advisory Council (EASAC), the frequency of extreme occurrences, such as floods, has grown by 50% in the previous ten years and is currently four times higher than it was twenty years ago. 2018's devastating floods in Kerala, India, provide a stark illustration of this. These floods have caused the top soil and nutrients in the soil to be washed out, which will lead to low productivity for a number of years unless proactive remediation techniques are implemented. Increasing sea levels or a propensity for severe rains may cause coastal agricultural fields to decrease. Additionally, this has caused the soils in coastal zones to become more salinized, which has stressed crops by reducing transpiration, respiration, and photosynthesis. This has ultimately put the availability and security of food in these areas at risk (EASAC, 2019) [19].

Water is essential for the cultivation of agricultural crops. In many regions of the world, water shortages are a major danger to crop productivity and food security because of insufficient or inconsistent rainfall and the depletion of groundwater supplies (Hussain *et al.*, 2019) [32]. In order to meet the world's food demand, crop yield must increase in situations where water supply is limited (Balyan *et al.*, 2017) [6]. Temperature increases brought on by climate change both locally and globally represent a serious hazard to crop productivity and plant growth (Priya *et al.*, 2019) [45]. According to the Intergovernmental Panel on Climate Change, global temperatures would rise by an additional 1.5 °C between 2030 and 2052 if current rates of global warming persevere (IPCC, 2018) [40]. Heat stress can hinder the plant development from germination to reproduction, which lowers the yield of important food crops (Hussain *et al.* 2019) [32]. Winter wheat yields were notably reduced as a result of carbon loss brought on by high temperatures at night (Impa *et al.* 2019) [33].

Plants encounter a variety of a-biotic stressors due to weather conditions, including salinity, drought, heat stress, cold stress, and others (Malhi *et al*., 2021) [38]. Reduced soil fertility, crop insect infestations, and limited water availability are the main unfavorable effects of climate change that will negatively affect agricultural output (Baul and McDonald, 2015) [7]. The rise in temperature is likely to reduce the yield of many crops by reducing their duration (Mahato, 2014) [37]. It is expected that the total yield of wheat, rice, and maize will decrease with every 2 °C increase in temperature in both the temperate and tropical zones (Challinor *et al*. 2014) [11].

Most parts of the world have anticipated increased frequency of droughts with an increase in the area impacted by drought from 15.4% to 44.0% by 2100. Africa is listed as the region most at risk. The yield losses in three cereal grains - rice, maize, and wheat - are predicted to worsen by 10 to 25% with every 1 °C increase in the global mean surface temperature (Deutsch *et al*. 2018) [15]. Since that insect populations are mostly dependent on a-biotic variables like temperature and humidity, climate change has the potential to increase pest populations and their movement, which might negatively affect agricultural productivity and even viability (Ghini *et al*. 2008) [25].

It has been predicted that yield decreases caused by winter grain stress from low temperatures frequently result in a 100% loss of production in some places of the world. Low temperature stress in the spring can reduce productivity by 10%, even with optimal management measures, resulting in significant financial losses (Collins and Chenu, 2021) [13]. Temperature variations, altered rainfall patterns, global warming brought on by higher greenhouse gas emissions, and soil a-biotic stress from various heavy metals all have an impact on major food crops. These factors also alter biological setups such as crop cycles, insect invasions, pest and disease invasions, and growth periods (Raza *et al*., 2022) [46].

In addition to having a significant negative influence on and reduction of vegetative cover, typhoons, wind storms, floods, and droughts can also cause excessive siltation and sedimentation, greater coastal tides, and storm surges on seaside areas. These catastrophes may also result in the buildup of various pollutants, water pollution, altered land topography, decreased precipitation, decreased soil fertility, and increased seawater intrusion (Akhtar *et al*., 2021) [2]. Changes in temperature and precipitation brought about by climate change can disrupt the growth phases of forest plants and crops in numerous ways (Davidson, 2018) [14]. Climate change has already led to an increase in the frequency of several developing plant diseases, and it is anticipated that pests and diseases will invade more frequently and with greater intensity as a result of changes in their geographic ranges (Bebber, 2019) [9].

Climate change and food accessibility

According to Schmidhuber and Tubiello (2007) [49], a country's, a community's, or an individual's ability to afford enough nutritious food is referred to as their access to food. Swinburn *et al*. (2011) [48] attributed food accessibility whether foods are available in a form and location that facilitate their consumption. Households' physical access to food is impacted by climate change in ways that include transportation systems, road infrastructure, and physical luck (Tol, 2018) [54]. Climate change-related crop failures have a harmful impact on poor nations because they lack the knowledge and resources indispensable for disaster preparedness (Islam and Wong, 2017) [34].

The distribution system and infrastructure are impacted by the high frequency and intensity of precipitation brought on by climate change in nations with poor road networks (Hendrix and Salehyan, 2012) [29].

Allocating funds for food purchases by households becomes difficult when income sources are impacted by climate change (Campbell *et al*., 2016) [10]. Severe weather conditions may also have an impact on the supply of agricultural products, which could lead to increases in food prices and a negative impact on the incomes of the impoverished, particularly in low-income nations. As a result, the people's purchasing power will be greatly impacted as they devote a larger portion of their income on food supplies (Hertel and Rosch, 2010) [30]. Some food items become costly due to rising pricing, which has an influence on people's social well-being and exacerbates inequality (Ivanic and Martin, 2008) [35].

The effects of climate change on agricultural goods have an impact on consumer ability to purchase certain popularly chosen food varieties as well as food availability. Households may change their food basket to preserve purchasing power when a preferred food item's price rises, or they may drastically cut back on their disposable income to keep the same food basket (Ziervogel and Ericksen, 2010) [56]. For instance, up to a certain point, an increase in temperature or precipitation has a favorable effect on wheat output in Nepal; however, when temperature or precipitation climbs exponentially, wheat yield drastically drops (Thapa-Parajuli and Devkota, 2016) [53]. Typhoons, wind storms, floods, and droughts occur frequently, which raises the overall cost of agricultural and agro-forestry production.

At the same time, agricultural productivity falls which leads to a decrease in the availability of food and a rise in food costs (Kumar *et al*., 2022) [36]. Extreme weather phenomena brought on by climate change, like windstorms, floods, and droughts, have a detrimental effect on infrastructure, destroy market access, submerge transportation channels, and create significant health risks for those trying to access markets (Nissen and Ulbrich, 2017) [41]. Adverse local, regional, and global climate change impacts can alter the production of food products. These effects ultimately affect biomass output, which includes the production of fiber, feed, food, and fuels (Peña-Lévano *et al*., 2019) [44]. Unfavorable climatic conditions can adversely affect the resources and infrastructure thus affecting the nutritional security in the long run.

Climate change and food utilization

The use of healthy, hygienic, and wide-ranging food will become more difficult for populations with restricted resources as a result of depressing effects on cattle, crops, and forests brought on by climate change and extreme occurrences (Hammond *et al*., 2015) [28]. According to projections, there will be an increase in the frequency and intensity of extreme events and natural catastrophes, which poses significant risks to the availability of a diverse and hygienic food supply, particularly for populations with few resources and a higher likelihood of socioeconomic disputes. This would worsen dietary and health restrictions, which would affect food security as a whole (Hoekstra *et al*., 2018) [31].

Increased atmospheric CO_2 reduces the synthesis of amino acids, which lowers the amount of protein in crops that are edible and lowers the dietary content of vegetables (Dong *et al*., 2018) [18].

Comparative studies of a number of cereal and legume crops revealed that the former had lower protein levels than the latter due to increased CO2 concentrations between 7 and 10%, but the difference was negligible (Dietterich *et al*., 2015) [16]. Should these changes in plant protein composition persist, 200 million people worldwide could experience protein shortages, which could exacerbate and put the health of impoverished populations at risk (Smith and Myers, 2019) [11]. In addition to deficiency in protein, high CO2 also results in important food crops having fewer vital minerals. When CO2 concentration reaches 550 ppm zinc (Zn) and iron (Fe) content in cereals and legumes decrease by 3-11%. Globally, more than 1 billion people are zinc deficient, and 200 million more will become zinc deficient if CO2 enrichment in the atmosphere persists (Beach *et al*., 2019) [8].

Due to rising CO2 levels, millions of individuals are predicted to be at risk of protein, iron, and zinc shortages, and the situation will worsen in cultures where these deficiencies are already a problem. Heat stress has a detrimental effect on the nutritional content of milk, which has a significant impact on the milk byproducts sector (Summer *et al*., 2019) [50]. In general, temperature stresses both high and low is likely to decrease the food safety of essential goods, particularly fruits, vegetables, and fisheries. This is because altered environmental circumstances lead to higher rates of microbial activity (Alegbeleye *et al*., 2022) [3]. Due to the water-related effects of climate change, such as reduced supply of sterilized water, food safety is affected and human and cattle health is jeopardized (Djekic *et al*., 2016) [17].

The loss of jobs and other means of subsistence, migration, and disruption of public health services are some of the indirect effects of climate change on human health. These effects disproportionately affect poor and indigenous populations and have a detrimental impact on food security (Ebi and Hess, 2020) [20]. Elevated food prices were associated with the decline in food consumption across all communities, according to analyses about the relationship between food price flexibility and food demand in developing nations. These analyses led to the conclusion that higher food prices are likely to result in a decrease in nutrient consumption (Afshin *et al*., 2017) [1].

Recommendations

Several actions are needed to reduce vulnerabilities and increase resilience of food security in the face of climate change. These interventions range from risk management and agricultural practices to social protection. Due to the agriculture and food security sectors' sensitivity to climate change, national climate-related instruments such as adaptation plans needs to better recognize the significance and unique characteristics of these sectors, and food security and agricultural policies needs to incorporate climate change concerns (Gitz *et al*. 2016) [26]. The plausible strategies could be reducing greenhouse gas emissions from agriculture while raising crop yields, keeping farmers unaffected by additional costs or restrictions, and promoting

social inclusion by concentrating on those who are most at risk from climate change (Campbell *et al*. 2016) [10].

Political, economic, and social factors should be considered in order to fill in the knowledge gaps on the effects of climate change on food production as well as availability, access and utilization (Farooq *et al*. 2022) [24]. Rather than focusing only on ensuring food availability globally, it will be beneficial to approach the food system in its entirety to provide societies with healthy nutrition on a local level (El Bilali, 2019) [21]. Information systems that are tailored to a farmer's needs and specific regions are essential for enhancing their ability to adapt by supporting fundamental decision-making.

The assessment of how climate change affects food security requires information, expertise, and awareness. It should be considered one of the main media subjects and included into regular, thoughtful conversations in print and electronic media (Asrat and Simane, 2018) [4]. Farmers must have simple access to reliable, timely, and relevant information through the multi-collaboration of relevant government agencies and stakeholders, as well as innovative information and communication technology technologies. In addition, a few tactics deserving of government attention include timely announcement of stressful days, conferences, training sessions, awareness seminars, and talk shows on electronic media. Other strategies include incorporating the effects of climate change on food security into traditional education curricula and organizing grassroots campaigns.

It has taken many years to recognize the ecological effects of techno-centric approaches to food production, but it has only been recently that the detrimental effects of agriculture on the environment have come into sharp relief. Approximately 25% of greenhouse gas emissions worldwide are attributed to agriculture (carbon dioxide, methane, and nitrous oxides), especially in systems related to cattle production. Burning fossil fuels has a similar substantial climate footprint to that of food production.

Conclusion

Achieving food security, reducing hunger, and enhancing nutrition are the main objectives of the sustainable development goals. Simultaneously, climate change is already having an effect on food security and agriculture, and it will make the fight against hunger and malnutrition even more challenging. Our ecosystems are already severely and widely impacted by climate change. One of humanity's biggest difficulties is ensuring food security in the face of climate change. Even though some of the issues brought on by climate change are just now becoming apparent, immediate action is required to give agricultural production systems the time to become resilient. Organizations that make global decisions should give priority to those areas where food security is already compromised by extreme weather fluctuations. Thus, to conclude there is a link between food security and climate change. Neglecting the uncertainties around climate change will result in increasingly unfavorable circumstances.

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