



Food Security And Climate Change: Challenges And Adaptations

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The community of nations has adopted food security as one of the Sustainable Development Goals. Despite global commitment towards its achievement, food security remains elusive for a large section of humanity. One of the threats to food security comes from climate change. Rising sea levels reduce availability of land for cultivation, forcing people to move further inland. At the same time, water stress due to increased aridity will reduce productivity of farm agriculture, pastoral economies and inland and marine fisheries. Extreme weather events will cause crop losses and disrupt livelihoods, forcing large scale exodus of people from vulnerable areas. This paper discusses the impact of climate change on food security, and suggests certain strategies for adaptation.

Introduction And Background

Food consists of edible substances that are consumed by human beings. Not only does it fill the belly, it also provides energy needed to perform day-to-day activities, as well as nutrients that maintain and/or improve physical and mental health. Food is necessary not only for very survival, it also influences an individual's efficiency and productivity. Recognizing the importance of food, access to adequate food was included as a basic human right of an individual, and a collective responsibility by the United Nations when it adopted the Universal Declaration of Human Rights at its very inception in 1948. The importance of access to food was further emphasized as the world community included food security first in the Millennium Development Goals and then in the Sustainable Development Goals. It is important to attain food security for its own sake, and also for the attainment of several of the other development goals.

Food security is defined as the availability of food and the physical, social and economic access to sufficient, safe and nutritious food for all individuals at all times. Human history has seen a continuous struggle between human population and availability of food. Globally, regionally and locally, trends in the growth of human population have shown fluctuations coinciding with increase and decrease in the supply of food. In the late eighteenth century, Thomas Robert Malthus, in a seminal paper, identified famine as one of the major checks on human population growth. In more than two centuries after Malthus, humanity as a whole has averted a major food crisis, although hunger and starvation have accounted for large scale

deaths in many parts of the world and malnutrition has stunted the physical and mental growth of millions of children. Increase in food production has been possible because several less densely populated continents were colonized. In other cases, expansion of irrigation increased productivity and also allowed agriculture to expand into semi-arid areas. The twentieth century saw further increases in agriculture due to increased use of chemical fertilizers and crop protection compounds, mechanization of agriculture and evolution of high yielding varieties of crops through systematic plant breeding. However, an inequitable distribution of this increased production results in the continued and widespread prevalence of hunger and malnutrition. The UN World Food Programme's live Hunger Map (1) shows that 957 million people around the world do not receive adequate food.

Currently, threats to food security emanate from a variety of sources. World population continues to grow, albeit at a slower rate of just over 1%, adding roughly 80 million people to the total population every year. While population in most of the more developed countries is nearly stable, population in the least developed countries is growing at 2.3% per year. The least developed countries already have high levels of hunger and people living in them are highly vulnerable to changes in natural and human-made systems as they have lower adaptive capacity. The problem of world hunger was exacerbated by the outbreak of the COVID-19 pandemic. The economic downturn induced by this pandemic pushed a large number of people into the throes of hunger. The State of Food Security and Nutrition in the World (SOFI) Report of the Food and Agricultural Organisation (2) estimates that between 2019 and 2020, the number of people facing hunger increased by 46 million in Africa, 57 million in Asia, and 14 million in Latin America and the Caribbean as a consequence of the pandemic. Ironically, food security could also be endangered by growing affluence. It has been found that when foodgrains are consumed indirectly by human beings, by feeding them to animals in meat factories first and then consuming the meat of animals, it leads to a huge reduction in farm calories available for human consumption. As economic standards rise, people are known to increase the proportion of meat in their diets, thus reducing the amount of food grains available for the poor. Foodgrains are also diverted by farmers for the production of biofuels like ethanol, causing prices of foodgrains to rise (3). Agricultural production is also under threat from diversion of fertile agricultural land to non-agricultural uses like construction of residential units or setting up of industrial estates. However, the biggest threat to food security arises from climate change, the direct and indirect impacts of which are already being felt in different dimensions of the food system. This paper presents a detailed account of how climate change threatens food security by affecting the production of food as well as physical and economic access to affordable food for all.

Contrary to popular perception, climate is not constant. Through its geological history, the earth has experienced periods when the temperature has been significantly warmer or colder than what is observed today. These changes were brought about by variations in earth-sun relations and major geological processes that were far beyond human control. However, the current phase of climate change has the human imprint all over it. What is more, the billions of tons of carbon-di-oxide and other greenhouse gases that are released by human activity every year are contributing to global warming and inducing changes that previously happened over millions of years to happen within a human lifespan. The IPCC-AR5 (4) states that "the warming of the climate system is unequivocal as evidenced by observations of increases in global temperatures, widespread melting of snow and ice and rising sea level." By reducing

land available for cultivation, altering the physical conditions in which plant growth takes place, affecting the nutritional value of crops and causing damage to standing crops due to extreme weather events, climate change will have a pronounced negative impact on agricultural production. Simultaneously, disruption of livelihoods and rising prices will reduce economic access to food. Conflicts and natural disasters will further impact the distribution of food, causing hardship to producers as well as consumers of food. These are discussed in subsequent sections of this paper.

Impact Of Climate Change On Food Production And Productivity

Human-induced climate change has resulted in higher temperatures around the world. However, not all places are warming at the same rate. The polar areas are warming faster than the rest of the world, causing land-based polar ice sheets as well as sea ice to melt. Alpine glaciers too are retreating fast, releasing more and more water into the oceans. Simultaneously, rising temperatures are also causing thermal expansion of ocean waters. The cumulative effect of all these is a rise in sea level. Global mean sea level (GMSL) is estimated to have risen by about 16 to 21 cm since 1900. Nearly half of this rise has been registered since 1993 (5). The IPCC further projects that global sea level will rise at the rate of 15 mm per year, leading to a 1.1 metre rise by the year 2100, assuming that emission rates remain high. In the worst case scenario, sea levels could be 5 metres higher by 2300. Despite isostatic adjustments, rise in sea levels are changing coastlines around the world, leading to submergence of coastal lands, including highly fertile river deltas. By the year 2100, land that is currently occupied by 200 million people will be submerged, leading to a serious humanitarian crisis (6). The impact of rising sea levels is already being felt in small island countries. The results will be catastrophic for densely populated countries where a large number of people live only a few metres above sea level. Even more developed countries are at risk. In Netherlands, for instance, half the landmass is already at or below sea level. Kuttanad district in the Indian state of Kerala is famous for the Kuttanad Below Sea-level Farming System (KBSFS). In this unique system, rice is cultivated in farms reclaimed from delta swamps. Much of the land lies below sea level. In the last ten years, and especially after 2018, flooding has become a regular feature, and floodwaters do not recede. This has forced several farming families to abandon their lands and move either to towns or to other farming areas (7). Although the problem could be alleviated to an extent by adaptive measures to keep seawater out, ocean flooding will exact a high human, economic and political cost. The population displaced due to submergence will have to be rehabilitated in the remaining land, creating additional pressure on limited land resources. Some agricultural land will have to be diverted to residential use. Saline sea water is intruding into aquifers near the coast affecting the quality of water available for drinking as well as agriculture. Rice cultivators in coastal parts of Southeast Asia, especially Vietnam, are facing problems due to the incursion of sea water in inland areas. Rising sea level will expose newer areas to erosion by sea while intensifying erosion in areas already subject to wave action. The net result of all this will be a severe reduction in land available for agriculture. Food security will be acutely undermined in areas directly affected by the crisis, but its ripple effect will also be felt in other parts of the world.

Climate change does not only affect food security by reducing land available for cultivation. It also has a direct impact on the productivity of land as it alters the biophysical conditions under which agriculture is practised. Rising temperatures induce changes in atmospheric and oceanic circulations, altering the patterns of climate around the world. Climate change worsens the problem of land degradation and desertification in arid areas as higher temperatures increase the rate of evapotranspiration and reduce precipitation. This affects a large number of people, especially those living in South and East Asia and the circum-Saharan region (8). In other areas, late onset and early end of winter will require adjustments in cropping calendars. The spatial and temporal distribution of rainfall will be altered, necessitating further adaptation in traditional agricultural practices. Crop losses will be incurred due to unexpected weather changes. This was already witnessed when spring flooding in the corn and wheat growing belt of USA in 2009 ruined the crops of several farmers. Many other farmers lost the growing season as crops could not be sown in time. In countries like India, where a large percentage of population depends on agriculture, climate change poses a major challenge.

Food security will also be affected by an increase in extreme weather events. Rising ocean temperatures have increased the intensity and frequency of tropical cyclones. In 2020, the Atlantic witnessed 30 named cyclonic systems, as against the average of 12 per season (9). Increased intensity of rainfall increases flood related disasters while the concentration of rainfall in a few days increases the threat from prolonged drought. Disasters lead directly to crop losses, thereby reducing agricultural production. They also lead to loss of livelihoods. The FAO identified drought as the biggest cause of losses to agricultural output. The loss in plant and animal produce from agriculture due to drought is estimated to amount to US\$ 37 billion in Less Developed and Lower Middle Income countries. Repeated exposure to disasters further reduces the resilience of already vulnerable populations, threatening their survival. This can trigger off large scale national and international migrations. Environmental change and natural hazards have been identified by the IUCN as major causes of population displacement and refugees, surpassing even conflict as a cause of displacement. The UNHCR estimates that disasters resulting from extreme weather events cause more than 20 million people to become internally displaced while still more are forced to cross international borders (10).

Climate change also threatens the production of food from non-plant and non-land based sources. Livestock production will be affected as land currently used for grazing will face competition from expanding cropland. Additional threats will emanate from deterioration in quality of feed crops and forage, spread of diseases and reduced animal reproduction. Water stress will lead to further decrease in milk and meat production (11). Lower animal growth rates and reduced productivity have been observed in pastoral systems in Africa (8). Both marine and inland fisheries will be negatively impacted by climate change. In the case of marine fisheries, maximum catch potential from the world's exclusive economic zones will decline between 2.8% and 5.3% by 2050 according to greenhouse gas emission scenario RCP 2.6, and between 7.0 and 12.1% according to greenhouse gas emission scenario 8.5. Specific regions may be impacted to a greater extent. Largest declines are expected in tropical oceans, especially in the South Pacific region. Production from inland fisheries too is expected to decline as water becomes scarce. Declines are already evident in Pakistan, Morocco and Spain and the situation is expected to become worse (12). Apart from long term impacts of

climate change, fisheries will also suffer from short term impacts in the form of loss of production and infrastructure from extreme climate events like floods, cyclones, outbreak of diseases, parasites and algal blooms.

The human impact of the decline in fisheries can be quite severe. It is reported that over 10000 fishermen have moved out of their villages in Srikakulam district of Andhra Pradesh in India. They have migrated to other ports, mostly in Gujarat, as catches in their own area were dwindling steadily. Twenty varieties of fish that fetched higher prices in local markets had gone missing from the local coastal belt as rising temperatures of seawater had caused them to migrate to other areas. Fishermen with traditional boats could not venture beyond 5 nautical miles into the sea in search of preferred varieties of fish such as eel, catfish, flathead and milk fish. In 2016, scientists found a 'dead zone' across 60000 square kilometres in north Bay of Bengal at depths 70 metres and below. They have found that sea surface temperatures in the Bay of Bengal have risen by 0.2 and 0.3 degrees centigrade in 45 years. Temperatures are expected to further rise between 2 and 3.5 degrees centigrade by 2100. Marine ecosystems and their productivity have also been negatively impacted by increased acidity, deoxygenation and more intense cyclones, making 'fishing droughts' or failure of fishing seasons, more common (13).

Production of food will also decline due to land degradation and increasing aridity. An IPCC Special Report on Climate Change and Land states that climate change worsens the problem of land degradation. This is especially the case in low-lying coastal areas, river deltas, drylands and permafrost areas. The report further states that between 1961 and 2013, annual area of dryland in droughts has increased, on average by slightly over 1% per year, with large inter-annual variability.

In 2015, 500 million people were living in areas which experienced desertification between 1980 and 2000. Global warming at the current rate causes aridity, soil erosion, loss of vegetation, damage from wildfires, permafrost thawing, coastal degradation and reduction in yields from tropical crops. In drylands, crop and animal productivity are expected to decline because of climate change and desertification. The largest number of people vulnerable to increased desertification live in Asia and Africa. Crop yield declines are most likely to affect people living in tropical and sub-tropical areas. Among social groups, women, young and elderly persons and the poor are the most vulnerable (8). Global warming also affects the cycling of water within the earth system. Redistribution of precipitation over the earth will create water stress on some freshwater ecosystems (14). The relative proportion of salt water on earth is increasing as the amount of freshwater is reduced due to withdrawal of groundwater, melting of snow and ice and increasing aridity in continents (15).

Increased aridity in the atmosphere and soil will increase demand for irrigation water on the one hand. On the other hand, they will result in decline in freshwater supplies from surface and groundwater sources. The sustained retreat of glaciers in mountainous areas will lead to a dwindling in the flow of water in meltwater-dependent river systems. The Hindukush and Himalaya mountains, often referred to as the third pole, are home to over 10000 big and small glaciers, most of which are under severe threat from global warming. Ten mighty Asian rivers, namely the Amu Darya, Brahmaputra, Ganges, Indus, Irrawady, Mekong, Salween,

Tarim, Yangtze and Hwang Ho, and several other smaller ones, originate from these glaciers. Together, these rivers support a fifth of the world's population (16), meeting its needs for drinking water and irrigation throughout the year. The result of any reduction in the volume of water in these rivers will be catastrophic.

Climate Change And Problems Of Access To And Distribution Of Food

The previous section discussed the adverse impact of climate change on the production of food. The availability of food grains is further reduced by spoilage and wastage in various stages. Wastage starts at the farm gate if food cannot be transported to the market in time, or if the cost of transportation exceeds the profit that accrue from sale of produce. Spoilage occurs if food is not stored properly in warehouses or there is failure in cold chains. Wastage can also happen if products remain on store shelves or in homes of consumers for too long. It is estimated that 25 to 30% of the total food production is either lost or wasted from farm to table (8). More than half the wastage (56%) happens in the industrialised countries (17). Rising temperatures will accelerate microbial action, increasing spoilage of food.

In addition to loss from wastage, food security is threatened by changes in consumption patterns. The availability of farm calories is reduced when they are fed to animals and then consumed as meat. Further reductions take place when food grains are diverted towards the production of biofuels. Any reduction in the supply of food pushes up the prices, making it more difficult for the poor to access food. While climate change affects economic accessibility to food due to rising prices of food, it simultaneously reduces the purchasing power of the poor by reducing their incomes. The role of climate change in reducing crop and livestock productivity has already been discussed. It also enhances risks to livelihoods, especially those that are based on the use of natural resources as it damages the health of all natural ecosystems. This includes people engaged in farming, nomadic herders, those dependent on forestry and fishing, as well as those associated with the tourism industry. Ironically, small farmers, herders and fisherfolk, who together account for nearly 70% of the world's food production, constitute the groups most vulnerable to food insecurity. Climate change also exacerbates economic hardships by inducing internal and international migrations. The cumulative effect of reduced productivity, destroyed livelihoods and forced displacements is reduction in income of affected groups. This further reduces their economic access to food.

In recent times, conflict emerged as a key driver of food crises around the world and was recognized as such by the Security Council in 2018. While conflicts arise due to social and political causes, climate-related crises can aggravate them. An example of a conflict fueled by climate change is being played out in the Lake Chad Basin. The Lake Chad basin lies across 4 countries, Nigeria, Niger, Chad and Cameroon. 17.4 million people live in the area, using the lake as a source of drinking water, water for irrigation and fish. The region has seen a rise in temperature 150% higher than the global average. Rainfall patterns too have been disrupted. Severe and prolonged droughts induced by climate change have afflicted the area since the 1970s. This has caused the lake to shrink by 90% in the last 60 years. Food insecurity induced by this crisis has led to the emergence of terrorist activity in the area. This

has undermined the ability of people to cope with the crisis. Their traditional adaptive strategy was to migrate to other areas. However, movement is now restricted by the military which is engaged in counter-insurgency operations. Depletion of resources has also triggered conflicts between different communities. Clashes between farmers and pastoralists in Nigeria resulted in the loss of 4000 lives from 2016 to 2019. In a vicious cycle, lack of employment opportunities push the youth to join the rebels (18). Prolonged conflicts disrupt the normal functioning of human systems, affecting supply chains, thereby reducing physical access to food.

Measures To Reduce Risk To Food Security From Climate Change

The gravity of the threat to food security from climate change cannot be overemphasized. It is obvious that humanity must respond with measures to reduce risk. These measures involve fundamental changes in how human-made economic, social and political systems operate. The most obvious solution to the problem would be to reduce the emission of greenhouse gases so that the rise in global temperatures can be limited. Efforts in this direction have been only partially successful, and it seems unlikely that the targets set to decarbonize economies will be achieved within the given time frame. We must therefore focus on strategies to build climate resilience.

We must invest heavily in building ecological infrastructure. Use of water harvesting technology will help in combating the twin problems of droughts and floods. Revival of wetlands and afforestation and reforestation will also bring similar benefits, while also contributing to reduced rates of soil erosion and desertification. This will also safeguard local economies by safeguarding them against natural hazards.

Agricultural scientists must focus on techniques that make agriculture proof against the vagaries of climate. Farmers must be encouraged to shift to alternate crops, breaking the rice-wheat dominance in agriculture. For instance, growing maize instead of wheat in the Indian state of Punjab can substantially reduce the need for water. Thus cultivation of water-frugal crops will help in overcoming the scarcity of water in arid areas. Crop diversification is also crucial in attaining sustainability while also contributing towards food and nutrition security.

Direct consumption of grain by humans can increase the availability of food for human consumption. Reducing the overconsumption of meat in some countries, especially when it is produced by feeding grain to animals, would free up a lot of grains. Availability of food can also be increased by reducing the wastage of food in different stages of production and consumption.

It is also necessary to check urban sprawl so that uncontrolled expansion of cities does not encroach upon fertile agricultural land. Vertical growth of cities may reduce pressure on

scarce land resources. Also, urban and per-urban agriculture can contribute towards food production.

Governments must take steps to control food prices in order to ensure that even the economically weaker sections of society have access to adequate food. At the same time, care must be taken to guarantee a fair price to farmers so that their livelihoods remain secure. Reduction of poverty and safeguarding livelihoods are essential steps towards meeting the goal of food security.

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