

REVIEW ARTICLES

FOOD SECURITY AND CLIMATE CHANGE: A CHALLENGE TO HUMANITY

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ABSTRACT

This review presents issues of food security and climate change comprehensively as a global challenge. It discusses on global and local situations of food security and its components such as food production, food availability, food access and food utilization. This paper discusses on impacts of climate change on agricultural production as well as food security and livelihoods both at the global and local levels. Suggestions are made for climate- and disaster- resilient future of humanity at local and global levels.

Key words: Resilience, impacts, food price, food production, agriculture

INTRODUCTION

Commonly, the concept of food security is defined as including both physical and economic access to food that meets people's dietary needs as well as their food preferences. The ability of individuals to obtain sufficient food on a daily basis ensures food security. As stated by FAO two decades ago (2004) "food security exists when all people, at all times, have physical and economic access to enough, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy lifestyle". United Nations has declared food security as a human right. It is therefore the responsibility of all member states of the UN to develop and implement policies, legislation and programmes to ensure food security of its citizens. Food security is indispensable in all parts of the globe. Discussion should therefore begin with an analysis of the food security at national level. There are four interlinked components of food security, i.e. food production, food availability, food access and food utilization. These components should be addressed while analyzing food security situation in a given location from the household to community and national levels.

Food insecurity and malnutrition are impacted by climate change. During the last three decades, climate change is estimated to have caused at least 160,000 deaths and 5 million disability-adjusted life years from four factors alone: malnutrition, malaria, diarrhea, and flooding (Cohen, 2008). The most recent trends in agricultural production loss have been attributed to disasters across all agricultural sectors as reported by FAO (2021). The report has covered 457 disasters in 109 countries across all regions and income categories. Income categories include, as mentioned by FAO (2021), the lower- middle- income countries (LMICs), upper-middle- income countries (UMICs) and the high-income countries (HICs). Of 457 disasters mentioned above, 389 disasters were reported to hamper agricultural production and consequently food security in LMICs.

1. FOOD SECURITY

1.1. Global scenario of food security

According to the World Resources Institute (WRI), global per capita food production has been increasing substantially for the past several decades. In 2019, an estimated two billion people in the world were food insecure, lacking regular access to safe, nutritious, and sufficient food (FAO, IFAD, UNICEF, WFP & WHO, 2020). Major drivers of food insecurity include economic conditions such as chronic poverty (Smith, El Obeid, & Jensen, 2000) and changes in food prices (Jolliffe, Seff, & De La Fuente, 2018), as well as non-economic factors such as rainfall instability, conflict, and disease (Hangoma et al., 2024).

In 2006, Microsoft National Broadcasting Company (MSNBC) reported that globally, the number of people who are overweight has surpassed the numbers who are undernourished – the world had more than one billion people who are overweight exceeded an estimated 800 million who were undernourished. According to a 2004 article from the BBC, China, the world's most populous country, is suffering from an obesity epidemic. Worldwide around 852 million people are chronically hungry due to extreme poverty, while up to 2 billion people lack food security irregularly due to varying degrees of poverty (FAO, 2003). According to the Food and Agriculture Organization approximately 868 million people were undernourished between 2010 and 2012 (FAO, 2012). About 852 million of these undernourished people lived in developing countries with over sixty per cent residing in South Asia and Sub-Saharan Africa (Cohen, 2008). These numbers were expected to increase as food yields potentially decline and production patterns shift as a result of climate change. In 2022, 2.5 billion adults were overweight, including 890 million who were living with obesity, while 390 million were underweight. Globally in 2022, 149 million children under 5 were estimated to be stunted (too short for age), 45 million were estimated to be wasted

(too thin for height), and 37 million were overweight or living with obesity. Nearly half of deaths among children under 5 years of age are linked to undernutrition. These mostly occur in low- and middle-income countries (WHO, 2024).

1.2. Local scenario of food security in Nepal

Nepal is a least developed country (LDC) having a population of more than 28 million people. While food security in Nepal has improved in recent years, 3.86 million people (13.2 %) are food-insecure, with 3 percent of households did not have enough food; among these 66.3 percent reported that the situation was due to increasing prices of food. Among all households, 78.2 percent listed increasing prices of food as a main concern (OCHA, 2022). Overall, households in rural areas of the country—where food prices tend to be higher—are more likely to be food-insecure than people living in urban areas, according to the survey.

Malnutrition remains a concern in Nepal. More than 40 percent of Nepalese children younger than five years of age are stunted and 10 percent suffer from wasting as a result of acute malnutrition, the UN World Food Program (WFP) reports. Pregnant and lactating women (PLW) also suffer from malnutrition, as well as micronutrient deficiencies. Approximately 1.4 million PLW are malnourished and 48 percent suffer from anemia, according to the UN agency (USAID, 2019).

Around 31 per cent people in the country live below poverty line. Around 49 per cent of under-five children are chronically malnourished. Globally, Nepal ranks 144th out of 182 countries in terms of its Human Development Index (UNDP, 2010). Annual population growth rate of the country is 2.2 per cent. It is estimated that the country's population in 2025 will reach 40.5 million; and will face difficulty to fulfill the food requirements. Looking at this scenario, Nepal will face serious food insecurity in future.

Nepal used to be a food exporting country before 1980 AD. Human Development Report has revealed that in the decades of seventies (NHDR, 1998) the rural communities in the Terai and Hills, particularly indigenous community had their dependency on forest products like food, fiber, utensil, medicine, fodder, mulch and so on in compliance of food security. However, forest coverage in the country is in declining trend, i.e. from 60 per cent in 1950s, 38 per cent in 1978/79 to 29 per cent in 2007.

In Nepal, mostly women are taking responsibilities of managing food security in their families. Recently, climate change has badly affected the agriculture

production system and biodiversity conservation. It has directly affected women and children in having access to food. When the family faces problem of food insecurity male members uses to migrate to cities or countries for income generation, while women, elderly members and children stay at home. In that situation, women shoulder the responsibility of taking care of children and elderly members of the household performing on-farm activities, income generation and household chores. Obviously, women are hardly hit by the climate change indirectly.

1.3. Impacts of disaster on food security and nutrition

Disasters extend beyond the economic realm having deleterious consequences for food security and nutrition. For the first time ever, this edition of the FAO report (2021) converts economic losses into caloric and nutrition equivalents. For instance, it estimates that crop and livestock production loss in LDCs and LMICs between 2008 and 2018 were equivalent to a loss of 6.9 trillion kilocalories per year. This equals the annual calorie intake of seven million adults.

Access to adequate food and nutrition are fundamental human requirements for using human capacity. Food insecurity and inadequate nutrition lead to multiple negative consequences to health including high morbidity, high susceptibility to diseases and higher mortality. It however depends upon various factors. Food security has been analyzed in terms of existing agriculture systems including new agricultural techniques, introducing improved and climate resilience crop varieties, access of people to bio-gas, income, agriculture labor, land ownership, land management, food availability, food storage and preservation, nature of works, livestock, poultry, aquaculture, food and taboos, feeding time and caste system.

2. CLIMATE CHANGE

The most general definition of climate change is a change in the statistical properties of the climate system when considered over long periods of time, regardless of its causes. The Inter-governmental Panel on Climate Change (IPCC) has defined climate change as a change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forces or persistent anthropogenic changes in the composition of the atmosphere or in land use system (IPCC, 2007).

Climate change is the variability in average weather and ultimately a state of the climate system over a specified time frame. This variability is normally evidenced by changes in the mean temperature, precipitation, rainfall levels and amount of CO₂ in the atmosphere. Changes in climate can be caused by natural factors such as sun light intensity and volcanic activity among others or anthropogenic factors such as burning fossil fuels, deforestation, green house farming and other human activities.

Climate change is becoming the real threat to the lives in the world that largely affects water resources, agriculture, coastal regions, freshwater habitats, vegetation and forests, snow cover and melting and geological processes such as landslide, desertification and floods, and has long-term effects on food security as well as human health. According to FAO (2007) agriculture, forestry, and fisheries are highly sensitive to climate change; and climate change is very likely to have a serious impact on their productive functions. As a consequence, production of food, feed, fiber, energy, or industrial crops, livestock, poultry, fish and forest products may decrease.

2.1. Climate change patterns

- Changes in climatic events - rainfall, snowfall, temperature, attack of diseases, intensity of insects on crops are taking place all over the world.
- Changes are not similar in all places.
- Changes vary from one climatic zone to another.
- Weather events are changing in an unpredictable way.
- Sometimes, too much, too little, very early or very late, gaps in between, and so on.
- Seasonal pattern of weather events has been lost.
- Based on the broadest scale, the rate at which energy is received from the sun and the rate at which it is lost to space determine the equilibrium temperature and climate of the Earth. The energy is distributed around the globe by winds, ocean currents, and other mechanisms to affect the climates of different regions.

2.2. Impacts of climate change

Current conclusion of the IPCC (2007) regarding global climate change is as follows:

- Human activities are releasing greenhouse gases into the atmosphere.
- Rising levels of greenhouse gases are already changing the climate.
- Global temperature will likely rise by about 1.4 – 5.8°C by the year 2100

- Climate change is likely to have a significant impact on the global environment.
- Human society will face new risks and pressures on:
 - Food security
 - Water security
 - Physical infrastructures will be damaged.
 - Economic activities, human settlements, and human health will be impacted.
 - The poor and disadvantaged populations are the most vulnerable to these effects.
 - People and ecosystems will need to adapt to future climatic regimes.

Impact of climate change on livelihoods

a. Temperature increased

- Less moisture, less grass on grazing lands, less productive livestock in rangeland.
- Early harvesting of crops.
- Many new crops are possible but need other support.

b. Sea level raised

- Most affected are those whose houses are small.
- Service and working-class people are more vulnerable than others.

c. Snowfall – intensity, timing, and volume changed

- Glacier - rivers can be flooded at any time regardless of season.
- Settlements on riverbanks are more vulnerable.
- No or very less snow deposit on upland agriculture land results in less moisture on soil.
- Services from upland ecosystem reduced, possibility of desertification of upland higher.

2.3. Possible solutions of climate change

- Identification of complete solution is not possible.
- It is a global phenomenon with local implications.
- One country or one location alone cannot control the global phenomenon.

- a. **Mitigation:** Preclusions before the incidents – minimize greenhouse gases, resettlements, climate friendly planning, and support system.
- b. **Adaptation:** Long term thinking, planning, managing support system, changing practices permanently.
- c. **Coping strategy:** Immediate action after the incidents – changing crops, changing practices, find out immediate temporary solutions to natural calamities.

3. SCENARIO OF CLIMATE CHANGE

3.1. Global scenario of climate change

As already mentioned above, the mean global surface temperature increased 0.74° C during the 20th century. Since 1971 rates of land surface temperature have been increasing at an alarming rate between 0.23 and 0.28° C per decade. These continuing trends, coupled with changes in rainfall patterns and greater frequency of extreme weather events, are likely to have diverse effects on world population through declined agricultural and forest production and damaged wetland support systems. Glacier retreat and glacier Lake outburst flood (GLOF) are the most important and widely discussed issues as the potential risks. Compared to other sectors under impacts of climate change in Nepal, more studies have been carried out on glacier, their retreat and formation of glacial Lakes which are vulnerable to outburst. With melting of glaciers, risk of GLOF, water availability will rise and decrease sharply. It has effect on irrigation, power supply and aquatic ecosystem (IPCC, 2007). As global scenario of climate change, this situation is particularly applied in Nepal.

Effects of climate change on agriculture are particularly sensitive as the agriculture produces food and provides the primary source of livelihood for large portions of the society. Climate change influences crop and livestock production, hydrological balances, input supplies and other components of agricultural systems (Moench *et al.*, 2003). Agriculture, forestry, fisheries and wetlands are highly sensitive to climate change; and climate change is very likely to have serious impact on their productive functions. As a consequence, production of food, feed, fiber, energy, or industrial crops, livestock, poultry, fish, forest products and wetland services may decrease. Climate change has been affecting all dimensions of food security, namely food production, food availability, accessibility to food and food utilization. Climate change has also created risks to the food security of the large number of populations particularly in the least developed and developing countries in Africa, Asia and Latin America, where

forest, wetlands, river, lake / sea and agriculture (including fishery) are the primary sources of food and nutrition as well as livelihoods.

Wetlands influence the climate as integral parts of river basins through their impact on the hydrological cycles at both global and regional scales, and through regulating the atmospheric chemistry to a disproportionate extent in terms of their area. Some wetlands sequester large amounts of carbon (mostly as peat but also in biomass) over very long periods (from centuries to millennia), whereas others produce significant amounts of methane and nitrous oxide. Thus, wetlands can both mitigate climate change and act as its drivers.

Climate change and its impacts on wetlands are poorly understood. Climate change has widespread impact on wetlands: small wetlands are drying up and disappearing. Obviously, climate change has direct impact on water resource. Permanent wetlands are getting transformed into seasonal ones due to greater variation in the water levels. Ultimately, biodiversity within the affected wetlands has been perished.

Higher maximum temperature, more hot days and heat waves could lead to increased heat stress and increased incidence of pest and diseases in many wetlands' plants and animals. Wetlands biodiversity and the wetland ecosystem services, which people depend on, are indeed under threat from the impacts of climate change. Though wetlands are the "victim" of climate change, the wetlands are at the same time crucial to mitigate climate change by reducing greenhouse gases. They have an important and underestimated role in both carbon storage and greenhouse gas regulation. The enhanced capability of wetlands to store carbon is largely a result of their productivity. Excluding peat lands, wetlands are among the most productive ecosystems in the world. Wetlands are often anaerobic, which greatly reduces the rate of decomposition relative to aerobic systems. Due to these facts, production usually exceeds decomposition in the wetlands, and results in the net accumulation of organic matter and carbon. Wetland ecosystems are essential and offer natural infrastructure for strengthening climate change adaptation. Wetlands can reduce adverse effects of climate change, such as food shortage, by providing vital biodiversity resources. Conversion of wetlands for other purposes, over exploitation of resources, pollution of water, excessive use of agrochemicals, invasion of alien species, encroachment for settlement and farming and sedimentation of the water bodies are some of the reasons behind the loss of wetlands. Climate change is becoming an added stress for wetlands in particular.

3.2. Scenario of climate change in Nepal

Climate change causes poverty, depletion of natural resources, and unsustainable management practices. There is a big gap in protected areas management with impact in ecosystem management. The nature of impacts however is complex because ecosystem components are interlinked. It is also very specific in local context. Nepal is one of the richest countries in terms of bio-diversity and unique geographical position in the world but it is one of the five most affected countries by climate change. With 5833 species of flowering plants, including about 248 species of endemic plants and 700 species of medicinal plants, Nepal's landmass is home to 26 species of mammals, 9 species of birds and 3 species of reptiles that are declared endangered; and are being protected by Nepalese laws (Dahal, 2008). Millions of people in Nepal are at risk from the impacts of climate change including reductions in agricultural production, food insecurity, strained water resources, loss of forests and biodiversity as well as damaged infrastructure (WBG, 2021). Therefore, these valuable species and resources need to be protected keeping in view the effects of climate change on landscape ecosystem and natural resources.

As mentioned above Glacier retreat and glacier Lake outburst flood (GLOF) are the most important and widely discussed issues as the potential risks. Compared to other sectors under impacts of climate change in Nepal, more studies have been done on glacier, their retreat and formation of glacial Lakes vulnerable to outburst. With melting of glaciers, risk of GLOF, water availability will rise and then decrease sharply, which will have effect on irrigation, power generation and aquatic ecosystem. This scenario of the impact of climate change is widely visible in Nepal. Nepal has observed the trend of annual increase in temperature per decade by 0.41°C which is higher than the global average increase of 0.23 to 0.28°C per decade. The maximum temperature records from 1971-1994 in Nepal show a warming trend after 1977. Maximum temperature increased from 0.06°C to $0.12^{\circ}\text{C}/\text{year}$ in most of the Middle Mountain and Himalayan regions whereas in the Siwalik and Terai regions, temperature seemed to be increasing by less than $0.03^{\circ}\text{C}/\text{yr}$. (Shrestha, *et al.*, 1999). Significant variability in precipitation was observed on annual and decadal time scales in Nepal but distinct long-term trends were not found (Shrestha, *et al.*, 2000). The Ijma Glacial Lake, second largest glacial lake in Nepal Himalayas lying at the height of 5000 m above average sea level, is one of the potentially dangerous glacial lakes. The size of Ijma Lake recorded in the year 2002 showed that the size of the lake expanded by 28 per cent as compared to its extent in the year 1992 (Rai, 2007). The effects of global warming and climate change are more vulnerable in the Himalayan region of the globe with melting of ice, glacier, and worst of the entire incidence if glacial lake

outburst floods take place having devastating impact on eco-system. The effect of climate change is more acute in poor developing counties like Nepal.

Changes in rainfall patterns and occurrence of erratic monsoon precipitation, drought, and floods in the hills and serve cold winters in the terai have already been experienced and widely reported by farmers in Nepal (Rajbhandari and Shrestha, 2013b, Namita, 2014; Selvaraju, 2014). Agriculture is the source of income or livelihoods of two third population in Nepal (MoAD, 2022). Agriculture in Nepal is dependent on weather and climatic conditions. So, the economy of the country is more sensitive to climate change. Today rainfall starts earlier and ends late, as a result paddy planting month has been dry and late planting has resulted in reduced paddy yield. Farmers have been trying to adapt to the changing climate to maintain the yield of rice, the main staple food in Nepal. Nepali farmers have adopted measures such as conservation of local cultivars, alternative practices to reduce water stress, soil erosion, changes in cropping pattern and crop adjustments (Rajbhandari and Shrestha, 2014). Thus, it has become obligatory to find out and implement some effective adaptation strategies at the local level to cope with the climate variability and change as provisioned in agricultural development strategy (ADS) document (ADB 7762-NEP, 2013).

Climate change affects green sectors more than other sectors of the economy. Agriculture production depends on nature or rainfall and gets affected by the change in the climatic parameters such as extreme weather events. Geographic distribution of rainfall and snowfall and increased frequency, duration and intensity of droughts are also visible (FAO, 2004). Rajbhandari and Shrestha (2014) reported that the local climate at Rupa Lake area had changed over the past few decades; and as a direct consequence farming communities across the area were affected negatively. Similar results were reported by studies carried out in other parts of the country (Regi and Adhikari, 2007; Regi *et al.*, 2008; Gentle and Mareseni, 2012; Rai and Rajbhandari, 2013; Namita, 2014; Silvaraju, 2014). Vulnerability of the farming system in Nepal is very high to climate fluctuations. Droughts in 2006 resulted in an estimated reduction of 21 per cent in rice area planting due to low and uneven rainfall distribution during rice planting and early crop growth (Gumma, *et al.*, 2011). The 2008/09 winter drought in Nepal was one of the worst on record when rain monitoring stations across the country received less than 50 per cent of average precipitation during the period of November 2008 to February 2009 (MoAC; WFP; FAO, 2009). The drought resulted in a significant decrease in wheat and barley production, the two major winter crops, in the country with a decrease of 14.5 and 17.3 per cent, respectively compared to the previous year (MoAC; WFP; FAO, 2009). The interactions with local farmers in Makawanpur and Kaski districts revealed similar situation that productivity in

the area was declining corresponding to extreme and unreliable weather conditions (Nepal, 2014; Rajbhandari and Shrestha, 2013).

Even a small variability in the climatic parameters like rainfall and temperature for a short period of few weeks or months could largely affect food production and thereby food security in most parts of the country. Local- level impacts such as loss of local land races, plant and animal species, changes in cropping patterns, scarcity of water due to drying up of wells/ decrease in natural water tables, decrease in agricultural productivity have been widely reported in Nepal. Moreover, during the last few years it has been observed that due to recurrent incidence of drought, flood, epidemic of disease and pests, and lack of adequate knowledge of coping mechanism among farmers, especially marginalized community and women; sometimes they lost their total crop production which they relied upon (Rajbhandari and Shrestha, 2013). The situation is becoming more alarming due to the insufficient research, documentation, early warning system, gaps in policies, weak implementation of existing policies and poor support mechanism like crop/livestock insurance policies and subsidies. Though Nepali farmers play a minor role in increasing GHGs globally, climate change has significantly affected their livelihoods and local natural resources available in their communities. Owing to this, farmers have followed some mitigation measures based on their indigenous local knowledge and traditional practices (Rajbhandari and Shrestha, 2014). They however lack strong climate change adaptation and mitigation strategies, which have further added to a range of factors that contribute to increased vulnerability and poverty.

Climate change is posing a threat at present and for future generation of our society. It has further threatened the food insecurity status of low-income strata people of Nepal. It has worsened the living conditions of especially resource-poor households dependent on subsistence farming, fisheries and forest resources. All of these factors have increased food insecurity. Rural communities, particularly those living in already fragile environments, have been facing an immediate and ever-growing risk of increased crop failure. It has caused loss of livestock, and reduced availability of forest products. Frequently more intense and extreme weather conditions have had adverse impacts on food production, availability, accessibility and supply in rural areas. That ultimately has magnified food insecurity.

CONCLUSION

The underlying causes of hunger, poverty and malnutrition in Nepal include low agricultural productivity, weak market connections and coordination, poor infrastructure and inadequate government resources. Gender, ethnicity and caste relationships also play an important role in food security as a majority of women

and many marginalized group members, who often do not have access to their own land, cash or other assets, work in agriculture.

Despite many difficulties for agricultural production and value chain development, there are many opportunities for agriculture-led growth in Nepal to ensure food security. A climate smart multi-sector integrated and sustainable public-private partnership (PPP) approach should be implemented efficiently with people-the-first (PTP) policies to build and strengthen agri-business and market systems in Nepal.

LOOKING FORWARD: A DISASTER-RESILIENT FUTURE

Investing in resilience and disaster risk reduction, especially data gathering and analysis for evidence-informed action, is of pivotal importance for ensuring crucial role of agriculture in achieving a sustainable future with ensured food and nutrition security. Holistic responses and cross-sectoral collaboration are key in the disaster response. Countries must adopt a multi-hazard and multi-sectoral systemic risk management approach to anticipate, prevent, prepare for and respond to disaster risk in agriculture. Strategies need to integrate not only natural hazards, but also anthropogenic and biological threats, such as the COVID-19 pandemic, and must be based on an understanding the systemic nature and interdependencies of risks.

Innovations such as remote sensing, geospatial information gathering, drones and disaster robotics, and machine learning are powerful new assessment and data gathering tools that have much to offer in the quest to reduce disaster risks in agriculture. Moreover, there is a need of appropriate and effective GEDSI policies and programmes in each country to effectively address the impacts of climate change and food / nutrition security on women, and other disadvantaged groups of people.

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