

7. Global Climate Change Impact on Crop Production

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Abstract:

Agriculture and climate change are deeply intertwined. Climate change has an adverse effect on crop production and farmer's lives. It reduces the crop yield and quality of the produce. Droughts and other extreme weather patterns have an influence on farmers as well as the consumption of food and nutrients. Extreme weather events such as cyclones, storms, and hailstorms are directly associated with climate change. These events have the potential to significantly damage infrastructure, livestock, and crops, which could result in lower yields and economic hardships for farmers. It poses challenges to agricultural pest management and reduced agricultural productivity. The efforts to combat climate change will have to focus on mitigation and adaptation efforts across all sectors. By adopting climate resilient agricultural practices, agroforestry, precision farming and climate smart water management methods, stakeholders can address the challenges faced by changing climate on crop production.

Keywords:

Climate change, Crop production, Agroforestry, Precision farming, Cyclones, Floods.

7.1 Introduction:

Climate change can be defined as the long-term shift in weather patterns and temperature over a large area. It has a profound impact on crop production leading to reduced crop yields, food insecurity and affect the livelihood of farmers. World Meteorological Organisation (WMO) and United Nations Environmental Programme (UNEP) have declared carbon dioxide as the major contributor to climate change. Across all examined scenarios, there is more than fifty per cent chance that the rise in global temperature would approach or exceed 1.5 degrees celsius between 2021 and 2040. In the case of a high-emissions trajectory, the globe may reach this barrier even sooner, between 2018 and 2037 (IPCC, 2021). The effects of climate change or global warming, include expanding deserts, altered precipitation patterns, increased frequency of extreme weather events, and rising sea levels. In recent times, the agriculture industry has experienced more significant impact from climate change. As a result of greenhouse gas (GHG) emissions agriculture industry is both directly and negatively influenced by climate change. India's agricultural

growth is also under threat from climate change as it experiences more frequent dry spells, heat waves, and irregular rains. In addition, the agricultural cycle and farm operations have been negatively impacted by the shifting rainfall patterns which include early withdrawal or delayed beginning of monsoon. The challenge of fulfilling the growing need for food production while managing and reducing the GHG emissions from agriculture must be addressed in light of the growing population and the need to improve food production. If adaptation measures are not taken, it is anticipated that the yields of rice that are rainfed in India will decrease by 20 per cent in 2050 and 47 per cent in 2080, while the yields of rice that are irrigated will decrease by 3.5 per cent in 2050 and 5 per cent in 2080 scenarios. Wheat yield is predicted to decrease by 19.3 per cent in 2050 and 40 per cent in 2080 scenarios due to climate change with notable regional and temporal variability by the end of the century (PIB, 2023). According to the IPCC Special Report on Climate Change and Land, the global food system may be responsible for the emission of 21- 37 percent of greenhouse gases. These result from food production, changes in land use, food processing, packaging, distribution and consumption as well as food loss and waste. There will likely be more heat waves, hot and dry days, and unpredictable rainfall patterns across Asia. Dust storms and tropical cyclones are also expected to become more frequent (Gouldson *et al.*, 2016). According to FAO (2015) natural disasters, such as extreme temperatures, storms and wildfires (23%), floods (37%), drought (19%), and pest and animal disease infestation (9%) are the primary cause of agricultural productivity losses in Asia (crops and livestock). These events have resulted in losses amounting to billions of dollars. India is a tropical nation that experiences heat waves, hailstorms, cyclones, droughts, floods, and coastal salinity, all of which pose hazards to sustainable development. Significant progress toward achieving the Sustainability Development Goals (SDGs) is anticipated in the agriculture and related sectors which employ around 70 per cent of India's workforce directly or indirectly. Due to the lack of natural resources rural population is especially susceptible to climate change. Ecologically sound agricultural practices and policy towards climate adaptation and mitigation are the need of the hour to mitigate the negative effects of climate change on crop production.

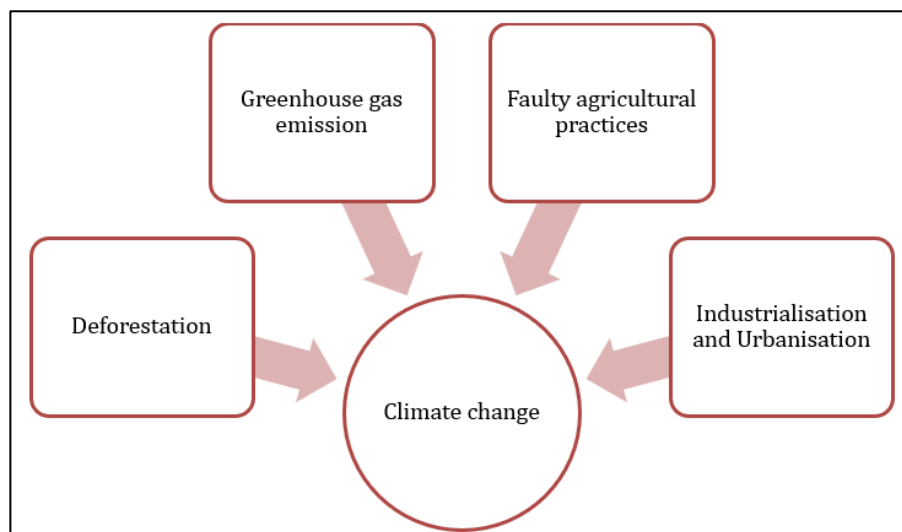


Figure 7.1: Causes of climate change

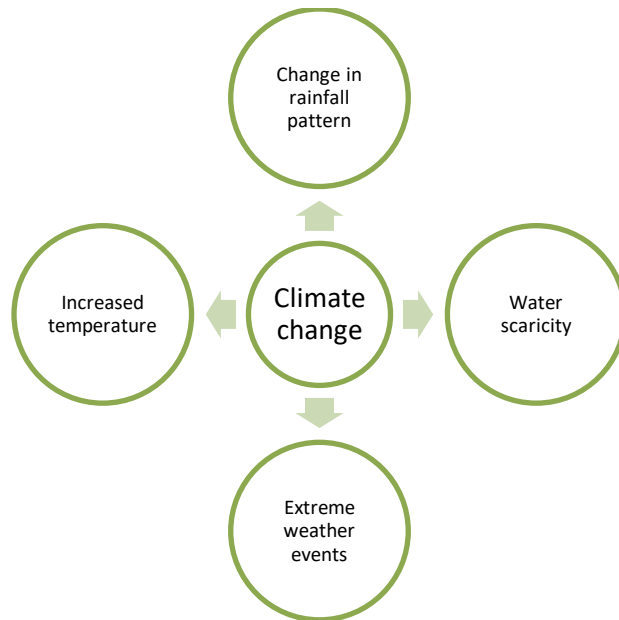


Figure. 7.2: Impact of climate change

A. Temperature Changes and Crop Production:

Increased temperatures are detrimental to the development and growth of crops. Elevated temperatures in the growing season have the potential to reduce crop yields and lower the nutrient content of crops. The productivity and health of cattle are also impacted by heat stress. Heat stress reduces the milk yield and working capacity of the cattles. Heat waves in India in recent years have impacted crop production especially for heat-sensitive crops like rice and wheat. Climate change poses major threat to the rice-wheat cropping system, a significant cropping system that provides half of Asia's food needs (Ghaffar *et al.*, 2022). The quantity and quality of wheat and rice crops are negatively impacted by climate change (Din *et al.*, 2022; Wasaya *et al.*, 2022). Crop evapotranspiration ultimately declined the wheat output since the growing season was shortened by rising temperatures (Azad *et al.*, 2018). Increased temperature also affects the quality traits of the crops. High temperatures and elevated carbon dioxide cause wheat grains to exhibit growth features while lowering their protein content (Asseng *et al.*, 2019). Likewise, wheat crop's soluble sugar content and protein content are also decreased by drought stress (Rakszegi *et al.*, 2019; Hussein *et al.*, 2022). In maize, plant height, leaf size, and stem girth were all considerably decreased in the water-limiting circumstances (Keenan, 2015). Agriculture and its allied sectors are negatively impacted by increasing frequency and intensity of heat waves in India. Shortage of drinking water for people and animals along with the drying out of the long-standing horticultural orchards are the consequences of heat waves induced by climate change. In 2019 India and its neighbouring nations had the worst and longest heat wave on record. Climate is the only factor that affects productivity and production (Srinivasarao *et al.*, 2016; Bal and Minhas, 2017). In addition to limiting the fruit setting in citrus fruits extreme temperatures can cause very large transpiration losses in vegetable crops.

Blossoms are burned or scorched by high temperatures especially on young trees. High temperatures during blooming have been found to have a significant impact on the fruit setting stage of navel oranges (Davies, 1986). Weather-related disturbances such as variations in temperature, precipitation and sun radiation have an impact on the cattle, arable and hydrological sectors of the agriculture ecosystem. According to the global report crop productivity is predicted to decline by 10–40 per cent by the year 2100.

B. Changes in Rainfall Patterns and Crop Production:

Rainfall patterns have changed as a result of climate change including variations in the amount, timing and distribution of rainfall. This may lead to unpredictable rains, floods and droughts, all of which could lower agricultural productivity. In India rice production decreases by 3 to 15 percent for every 1.5°C increase in temperature and 2 mm drop in precipitation (Ahluwalia and Malhotra, 2006). Most of the vegetable crops are severely affected by flooding, particularly tomato. Climate change has an impact on water availability especially in areas where irrigation relies on precipitation or snowfall. Water scarcity can result from melting glaciers and altered precipitation patterns particularly during crucial phases of agricultural growth. This may lead to higher competition for water supplies and reduces agricultural productivity. Flooding in many agricultural regions of the country have been witnessed and these floods have devastated crops and livestock, accelerated soil erosion and have polluted water. High rainfall leads to greater loss of top soil due to erosion and rise in sea level may lead to loss of farmland by inundation and increasing salinity of groundwater in coastal areas. About 60 per cent of croplands are under rain fed agriculture which will be the main targets of climate change effects. Poor and landless people would be more vulnerable as a result of all these changes. In many parts of India Farmers committed suicide from stress-related issues arising from the vagaries of monsoon. Erratic monsoons lead to depleting water availability due to changes in precipitation levels and falling groundwater tables.

C. Socio-Economic Impact and Climate Change:

There is general agreement that developing nations are more susceptible to climate change than developed nations due to the importance of agriculture in their economics events (Parry et al. 2001). Hence 800 million people lack access to adequate nutrition in the developing countries due to the repercussions of climate change.

Concerningly in the last 20 years domestic per capita food production in a group of over 40 "least-developed" countries mostly in sub-Saharan Africa has decreased by 10 per cent (UN Millennium Project 2005). Also increased production risks in many world regions widens the gap between rich and poor countries. Numerous socio-economic issues including poverty, economic expansion, development that is not sustainable and issues with health and safety might arise as a result of climate change (Swart *et al.*, 2003). The amount of state budgets (for floods, protecting forest areas, and controlling pollution), terms of trade (for changes in labour productivity and agricultural yield), economic growth rates (for changes in labour productivity and agricultural yield, depletion of natural resources) and social welfare (for increases in prices, floods, pollution, and health effects) will all be directly impacted by climate change (Cuervo and Gandhi, 1998).

D. Climate Change and Pest Incidence:

Climate change affects the abundance and spread of diseases and pests making agricultural pest management more difficult. Crop health may be impacted by variations in temperature and precipitation patterns which can encourage the spread of some pests and diseases. For example, the increased prevalence of pests such as the pink bollworm had an impact on cotton production in India while the unpredictable rains in the Somali region have caused locust swarms. Climate change has an impact on agricultural crops and their corresponding pests in both direct and indirect ways. Indirect effects of climate change are those on the associations that pests have with their surroundings and other insect species including natural enemies, rivals, vectors, and mutualists. Direct effects are those on the reproduction, development, survival, and dissemination of pests (Prakash *et al.*, 2014). Food security is threatened by the transnational spread of crop pests, a worldwide issue that affects all nations and areas. Global warming accelerates the growth of insect populations that leads to earlier infestation and cause agricultural damage. In the case of the Corn earworm (*Helicoverpa zea Boddie*) and the Cotton bollworm (*Helicoverpa armigera Hubner*) rising temperatures have led to range expansion and greater overwinter survival (Fand *et al.*, 2012).

E. Impact of Climate Change on Forest:

Climate change has profoundly affected the ecology, distribution and structure of forests (Keenan, 2015). Due to high temperatures and frequent dry spells forest trees have seen higher rates of tree mortality and die-off (Allen *et al.*, 2015; Greenwood *et al.*, 2017; Zhu *et al.*, 2021). For example, in South Asian countries drought, habitat modification and ongoing deforestation pose threat to trees like sal, pine, and gurjan (Wang *et al.*, 2019). Rising temperatures, increased carbon dioxide (CO₂) and erratic precipitation patterns cause insect pests to grow quickly which in turn causes more offspring to attack forest trees (Raza *et al.*, 2015). Therefore, in order to meet Asia's growing demand for food, fiber, and pharmaceuticals adaptation measures for forest restoration must be developed.

F. Adaptation Strategies Combating Climate Change:

Changes in the frequency and intensity of natural catastrophes have devastating effects on the agriculture sector endangering the lives of numerous people and their means of subsistence. In particular this sector is already in danger due to land degradation; declining water supplies and biodiversity losses and it is now even more susceptible to climate change. India is renowned for its wide range of agricultural techniques. Finding appropriate answers for the future requires bringing different points of view into a public conversation. Furthermore, precision farming which uses sensors and other scientific instruments to apply inputs precisely is becoming more and more popular in the advanced world. In India a calculated and astute transition to high-tech farming will lower average costs, increase farmer income and solve numerous other scalability issues.

Improved farming methods and techniques combined with adaptation techniques may lessen the likelihood of negative climate change effects. Water management is the critical factor for overall climate change adaptation in India. Since rain is essential to half of

India's agricultural production, rainwater conservation both in-situ and ex-situ through the construction of farm or community ponds is highly prioritized. Climate resilience in agriculture particularly in water stressed areas depends on effective water management. Farmers can increase their income using less water by putting climate-smart water management techniques into practice. It is possible to replenish groundwater and supply irrigation during dry spells by building ponds, check dams and farm ponds to collect and store rain water. The various in-situ soil conservation techniques are sub soiling, conservation furrows, trench-cum-bunding, broad bed furrows, ridges and furrows, zero tillage, plastic mulching and pani pipe technology etc. (Bhatta et al., 2015).

Other water saving techniques that can be deployed are SRI method of paddy cultivation which utilizes less water, seed and chemical fertilizers and pesticides. Drip irrigation method has high water use efficiency. Direct seeding of paddy with drum seeder conserves seed, moisture, and labour and helps to produce more tillers in paddy. Pusa hydrogel helps in absorption and retention of soil moisture which in turn results in slow release of moisture.

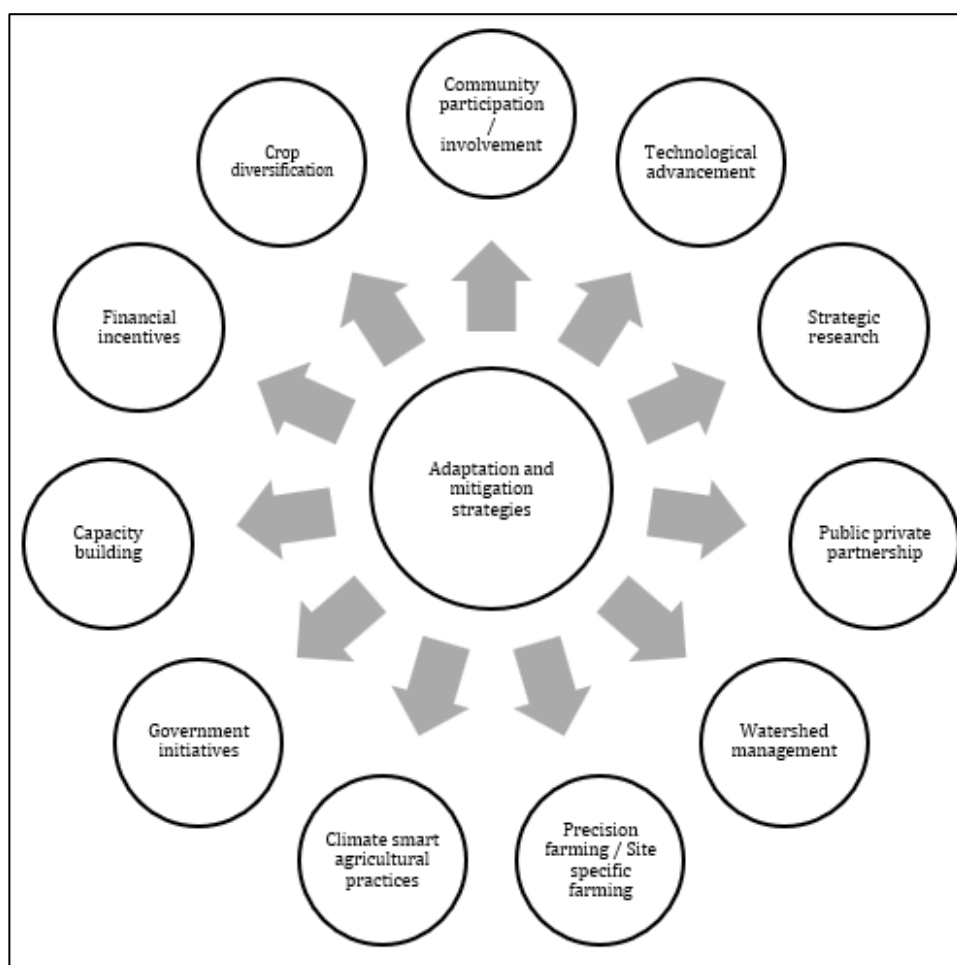


Figure 7.3: Adaptation and Mitigation Strategies in Crop Production

Growing different crops together in the same field or integrating trees with crops can enhance biodiversity, reduce soil erosion, and increase climate resilience. For instance, intercropping legumes with cereals not only provides additional income but also improves soil fertility through nitrogen fixation. Also, encouraging the cultivation of non-traditional crops that are more resilient to climate extremes can reduce dependence on a single crop and mitigate risks. For example, promoting drought-tolerant millets can help farmers cope with changing climatic conditions. India has a rich tradition of consumption of millets. Millets are also known as Mota anaj. They are climate resilient staple food crops that are drought tolerant and less inputs for the growth and development. FAO has declared 2023 as the international year of millets.

Agroforestry is the sustainable land use management system that increases the overall productivity by combining agricultural crops, tree crops and animal husbandry either simultaneously or sequentially and adopting and accepting all crop management practices that are compatible with the socio-economic practices of the local people. Additionally various practices like Zero Budget Natural Farming (ZBNF) can be adopted. It is a method of chemical-free agriculture drawing from traditional Indian practices. An Early warning system should be put in place to monitor changes in pest and disease outbreaks. Capacity building of different stakeholders for greater awareness and community action should be done. Site specific management should be adopted which make uses drones, Artificial intelligence and Internet of things (IoT) for efficient crop production and management activities. To offset yield loss from heat-induced reduction in growing periods, use genotypes in crops with higher potential daily yield. Crop diversification can be adopted in Indian condition to ensure financial security.

7.1.2 Government of India Initiatives to Climate Change Adaptation:

The Indian government has taken a number of steps to create the most effective missions to fight global warming and adapt for climate change. Some of the missions are covered below (MoA and FW, 2018)

- a. National Mission on Sustainable Agriculture (NMSA):
- b. The National Action Plan on Climate Change (NAPCC) served as the framework for this mission, and it was launched in the year 2014–2015. The goal was to improve productivity by combining resource conservation with the enhancement or restoration of soil fertility. It specifically targets dryland or rainfed agriculture areas focusing on soil health management, Integrated Farming System (IFS), integrated animal component and water use efficiency (WUE).
- c. National Adaptation Fund for Climate Change (NAFCC):
- d. This scheme was launched in 2015–16, primarily to assist with concrete adaptation efforts aimed at lessening the negative consequences of climate change in industries including water, forestry, agriculture, animal husbandry, tourism, etc.
- e. Pradhan Mantri Krishi Sinchayee Yojna (PMSKY):
- f. The main motto of this Scheme is 'Har Khet Ko Paani' to improve water use efficiency and 'More crop per drop' to provide end-to-end solutions in water source creation, distribution channels and its management.
- g. Pradhan Mantri Fasal Bima Yojna (PMFBY):

- h. The purpose of this scheme was to provide full insurance coverage for crop losses and lessen agricultural hardship and to maintain farmer's welfare.
- i. Soil Health Card (SHC):
- j. Soil Health Cards (SHC) program aims to provide farmers with comprehensive information on the soil nutrient status of their land based on tests, as well as the recommended dosage of fertilizers to enhance productivity through smart input use.
- k. Green India Mission (GIM):
- l. The main objective of this Mission is to protect, restore and enhance the diminishing forest cover in India, and to fight climate change with adaptation and mitigation measures.
- m. Paramparagat Krishi Vikas Yojna (PKVY):
- n. The main objective is to encourage and support organic farming by using cluster technique to create an organic community which ultimately improves the health of the soil.
- o. National Action Plan on Climate Change (NAPCC) and State Action Plan on Climate Change (SAPCC):
- p. It was launched to create awareness among public, Govt. agencies, industries, scientists and the society on the risks posed by global climate changes and steps to encounter the same.

7.2 Conclusion:

Climate change possess significant threat to global and Indian agriculture. Climate change is the result of rising global temperatures brought on by massive emissions of greenhouse gases from a variety of sources.

Severe heat waves and their unpredictable occurrences cause significant harm or loss to every living thing on the earth. A comprehensive approach encompassing mitigation, adaptation, and stakeholder collaboration is essential to ensure improved crop production, food security and sustainable future in tropical countries like India.

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