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Impact of Climate Change on Agriculture in India

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A B S T R A C T

Climate change is projected to have a direct impact on food production around the globe. Climate change has the greatest known economic impact on agriculture due to its scale and sensitivity. Climate change could have a wide range of effects on agriculture, including crop quantity and quality in terms of productivity, growth rates, photosynthesis and transpiration rates, moisture availability, and so on. The consequences of agriculture's contribution to climate change, as well as climate change's negative impact on agriculture, are severe and are expected to have a significant impact on food production, potentially jeopardizing food security and livelihoods, necessitating special agricultural measures.

This paper conveys a review of various reports, articles, documents, and papers literature & analysis relating to climate change impacts on agriculture in India & food security.

Keywords: Climate Change; Agriculture; Food Security; Food Production.

1. Background

The complex relationship between agriculture and climate change is one of the most crucial challenges of our time. Understanding the complications of this interplay is vital for developing effective adaption and mitigation strategies to ensure food security and a sustainable future.

Agriculture output is dependent on a variety of elements in a country. Climate is one of the most important factors influencing agriculture not just in India, but also worldwide. Administrators are primarily concerned with the potential advantages and damages that may develop in the future from climate change as they affect the various policies at the national and international levels.

Farming is profoundly subordinate to climate conditions, and any changes in temperature, precipitation designs, and extraordinary climate occasions can have significant impacts on yields. Changes in temperature and precipitation designs can disturb the conventional timing of planting and gathering, influencing growth. E.g., rising temperatures can accelerate crop maturation, leading to reduced yields and lower quality produce. Additionally, changes in rainfall patterns can result in droughts or floods, both of which can devastate crops.

Another noteworthy effect of climate alteration on agriculture is the expanded recurrence and escalation of extraordinary climate occasions. Heatwaves, dry seasons, floods, and storms are getting to be more visited and extreme, posturing noteworthy challenges to rural frameworks. Extraordinary warmth can cause decreased crop yields, and increase the chance of rapidly spreading fires. Dry spells can lead to water shortage, influencing irrigation systems and diminishing crop productivity. Floods can devastate crops, contaminate water sources, and cause soil erosion.

Climate alter moreover influences the predominance and dissemination of bugs and infections, affecting agrarian efficiency. Hotter temperatures and modified precipitation designs can make more favorable conditions for bugs, permitting them to flourish and spread to unused regions. Essentially, climate changes can impact the geographic run of illnesses, influencing both crops and animals. This could result in expanded pesticide utilization, higher generation costs, and potential edit misfortunes.

Rising temperatures can moreover increment evaporation rates, assist in worsening water shortages. This could result in diminished trim yields, expanded competition for water assets, and potential clashes over water utilization. Moreover, climate alter poses challenges to water assets, which are significant for agriculture. Changes in precipitation designs can lead to water shortage, influencing water system frameworks and diminishing water accessibility for crops. Rising temperatures can moreover increment evaporation rates, assist in worsening water shortages. This could result in diminished crop yields, expanded competition for water assets, and potential clashes over water utilization.

Overall, the effect of climate alter on agriculture is multifaceted and complex. It threatens food security, livelihoods, and rural economies, especially in creating nations where farming plays a critical part.

2. Effects of climate change

'Climate change' is a defining issue right now. Significant long-term changes in the global climate system are observable worldwide. Green House Gases such as carbon dioxide, methane, nitrous oxide, and hydrofluorocarbons absorb solar radiation and raise atmospheric temperatures. CO2 levels have peaked at 410 ppm, contributing to the current warming effect. Geographical and phenological alterations occur as a result of changes in ecological structures caused by global climate change.

Increased temperature reduces crop duration, increases crop respiration rates, alters photosynthesis, affects pest population survival and distribution, resulting in the development of new crop-pest equilibrium, accelerates nutrient mineralization in soils, decreases fertilizer use efficiencies, and increases evaporate-transpiration.

Climate change has a significant indirect impact on agricultural land use in India due to the availability of irrigation water, the frequency and intensity of inter- and intra-seasonal droughts and floods, soil organic matter transformations, soil erosion, changes in pest profiles, decline in arable areas due to coastal land submergence, and energy availability. Although an increase in carbon dioxide is anticipated to benefit numerous crops, the resulting increase in temperature and increased variability in rainfall would have a significant impact on food supply. A few Indian research on the subject largely confirm an agricultural loss due to climate change. It also assumes that irrigation will be accessible in the future at current levels. Losses for other crops are yet uncertain, but they are projected to be very minimal, particularly for kharif crops.

Increased glacier melt in the Himalayas will disrupt irrigation supply, particularly in the Indo-Gangetic plains, with far-reaching effects for food production. Small variations in temperature and rainfall can have a considerable impact on the quality of grains, fruits, aromatic and medicinal plants, resulting in pricing and trade pattern changes. Rising sea levels, more frequent extreme weather conditions, changes in precipitation, and desert expansion are all implications of global warming or climate change. By 2100, the average worldwide sea level is expected to rise from 18 cm to 140 cm. The world has been dealing with environmental issues for the past 15 years. In 2019, various parts of Europe had the greatest temperatures in the last century. Climate change indicators include devastating floods, cyclones, droughts, storms, heat waves, glacier melting, changes in precipitation pattern and rate, diseases in agricultural productivity, a lack of fresh water, damage to ecosystems and the environment, and so on. South Asian countries have been negatively impacted in recent years.

Droughts, floods, tropical cyclones, heavy precipitation events, hot extremes, and heat waves have all been shown to have a negative influence on agricultural production and farmer livelihoods. The expected increase in these events would cause greater instability in food production and jeopardize farmers' livelihoods. Temperature and humidity have a significant impact on the populations of pathogens and insects. Increases in these factors alter their population density, resulting in a loss of yield.

Global warming may raise animal water, shelter, and energy requirements to satisfy expected increases in milk demand. Climate change is predicted to worsen heat stress in dairy cattle, reducing their productive and reproductive potential. According to preliminary estimates, global warming would reduce milk production in India by 1.6 million tons by 2020. Increased sea and river water temperatures are likely to have an impact on fish breeding, migration, and harvest.

Increasing climatic variability caused by global warming will, however, result in minor seasonal/annual changes in food output. Even now, all agricultural commodities are susceptible to such fluctuations.

Critical challenges that the agriculture sector would face in the event of climate change are:

- Water availability as a result of changing rainfall patterns, alteration in stream flow and increase in crop water demand
- Deterioration of water quality due to sea water intrusion, transport of salts from the deeper soil layers as a result of over-exploitation of aquifers and faulty irrigation practices
- Increased frequency and intensity of extreme weather events such as droughts, floods, and cyclones, which would have a greater impact on production levels than mean climate changes
- Heat stress caused by higher temperatures at critical stages of crop growth
- Unpredictable changes in pest and disease load.
- There is also the chance that minor pests will become big pests when climate conditions change.

3. Dataset on the impact of climate change on agriculture

Natural disasters are causing increasing economic losses around the world, and the agricultural sector is particularly vulnerable to them. According to the United Nations Office for Disaster Risk Reduction (UNISDR) (2018), disaster-hit countries suffered direct economic losses totaling US$ 2908 billion between 1998 and 2017. Climate-related calamities accounted for 77% of the overall losses. Climate change has had a greater impact on the agricultural

sector in recent years. According to the Government of India's economic survey (2018), the harmful effects of climate change cost the country $9-10 billion each year.

Agriculture is the primary occupation for 50% of India's people. Agriculture and associated sectors account for 15.4 percent of Indian GDP. Farming activities are carried out by selecting crops that are particular to the climate, soil type, resource availability, etc. As a result, farming production and productivity are entirely dependent on climatic circumstances. Weather disruptions such as temperature, precipitation, and sun radiation have an impact on the agriculture ecosystem, which includes the cattle, arable, and hydrological sectors. According to the global report, crop productivity is expected to decline by 10-40 percent by 2100. Enhancement of crop productivity is highly necessary for safeguarding the food and national security, particularly the resource-poor who would be the most affected, like small and marginal farmers.

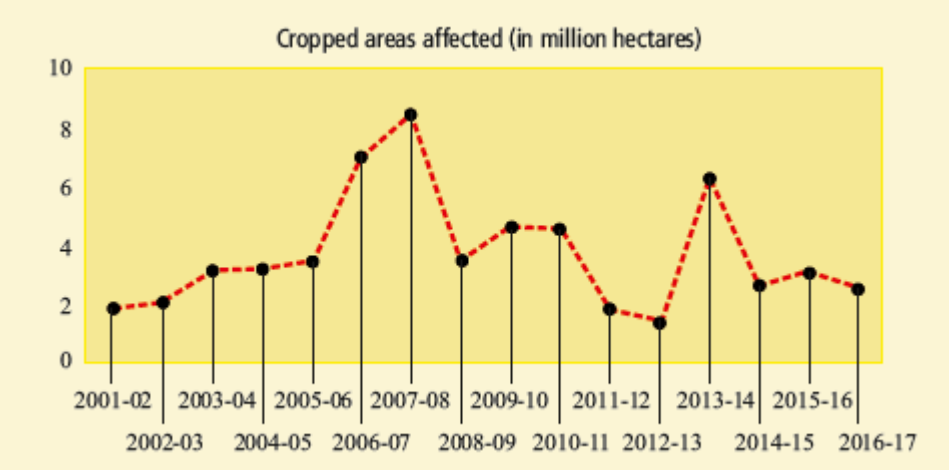

Fig. 1 - Year-wise damage due to natural extreme events in India

The Ministry of Agriculture and Farmers Welfare, India conducted a climate change effect assessment using crop simulation models that included forecasted climates for 2050 and 2080. In the absence of adaptation measures, rain fed rice yields in India are anticipated to fall by 20% in 2050 and 47% in 2080, while irrigated rice yields are projected to fall by 3.5% in 2050 and 5% in 2080 scenarios. Climate change is expected to cut wheat yield by 19.3% in 2050 and 40% in 2080 scenarios near the end of the century, with significant regional and temporal variability. Climate change is expected to diminish kharif maize yields by 18 and 23% in the 2050 and 2080 scenarios, respectively. Climate change diminishes crop production and lowers the nutritional content of produce. Droughts and other extreme weather events have an impact on food and nutrient intake, as well as on farmers.

4. Sector-wise effects of climate change in agriculture

Field crops: Crop yields in South Asian countries are anticipated to drop by 30 percent on average by the mid-21st century. North Indian states and Bangladesh are particularly vulnerable due to irregular rainfall and temperature variations (World Bank, 2008). For example, in India, a 1.5°C increase in temperature and a 2 mm decrease in precipitation diminish rice output by 3 to 15%. Climatic changes caused by rising greenhouse gas levels may have an impact on agricultural crop output and productivity across regions. Maize production in European countries is predicted to increase by 25% under optimal hydrological conditions. The drastic changes in climate alters the progressive stages of pathogens that eventually affect the growth and yields of crops severely, and also could lead to an increase in pest and insect population, ultimately devastating the overall productivity.

Horticulture: When exposed to extremely high temperatures, vegetable crops experience significant transpiration losses, which also affects fruit setting in citrus fruits. High temperatures cause burning or scorching of blooms, particularly on young plants. High temperatures during blooming appear to have a significant impact on the fruit setting stage of navel oranges. High temperatures cause moisture stress, resulting in sunburn and cracking symptoms on fruit trees such as apricots, cherries, and apples. The increase in temperature during the ripening period causes fruit burning and cracking in litchi plantations. The majority of food crops, particularly tomatoes, have been severely damaged by water. Another possibility for serious crop damage is the accumulation of endogenous ethylene. If the ozone concentration reaches to >50 ppb/day, yield of vegetable crops will be reduced by 5 to 15 percent.

Livestock, poultry, and fisheries sectors: Climate change, whether global, regional, or on a smaller scale, has a stronger impact on biological production, or the aggregate of these processes acts directly on individual organisms or species. The resilience and tolerance to environmental changes determine the growth and development of any species with specified traits. Global climate change has a wide-ranging impact on many aspects of animal production, reproduction, health, and adaptability. Higher temperatures cause dramatic changes in the animal's physiological physiology, including increased respiration rates (>70-80/min), blood flow, and body temperature (>102.5ºF). Dairy breeds are more prone to heat stress than meat varieties. An increase in temperature and temperature humidity index values above the crucial threshold level lowers dry matter intake and milk supply. It also disrupts the physiological processes of the animal's body. Poultries are highly vulnerable to temperature-related concerns, particularly heat stress. Heat stress affects poultry feed intake, resulting in lower body weight, egg production, and meat quality, as well as decreased eggshell thickness and increased egg breakage. Rising ambient temperatures may boost seasonal fish growth and development, but they also increase the hazards for populations living outside the thermal tolerance zone. A one-degree Celsius increase in temperature will have an impact on fish mortality and geographical distribution. Temperature

increases ranging from 0.37°C to 0.67°C modify the pattern of monsoon seasonal oscillations, finally moving the mating season of Indian main carps from June to March in West Bengal and Orissa fish hatcheries.

5. Impact of climate change on food security and livelihoods

There are four main characteristics of food security: availability, stability, access, and utilization. According to a research conducted by the Food and Agricultural Organization (FAO), climate change would have an impact on four dimensions of food security: food availability (production and trade), access to food, food supply stability, and food utilization. The significance of the various dimensions and the overall impact of climate change on food security will vary across regions and over time, and, most importantly, will be determined by a country's overall socioeconomic status as the effects of climate change are assessed to be detrimental to food security. Climate change may increase the country's dependence on imports, affecting its growth process.

Our current understanding of climate change's impact on food security and livelihoods is limited, at least quantitatively. Multiple stressors, such as economic, political, and social conditions, as well as meteorological elements, all have an impact on food security in India. Despite this, there has been no systematic approach to operationalizing vulnerability in the context of various stressors. Climate variability is likely to have a significant impact on agricultural land-use and national food security due to snow melt, irrigation availability, the frequency and intensity of inter- and intra-seasonal droughts and floods, soil organic transformation matters, soil erosion, and energy availability as a result of global warming.

Climate change will exacerbate existing concerns to food security. By 2050, the probability of hunger is expected to increase by 10-20%, and child malnutrition would be 20% higher than in a no-climate change scenario. The other major worry is achieving food security in the face of changing climate conditions. It requires a significant increase in food production and greater access to enough and nutritious food, as well as the ability to deal with the dangers posed by climate change.

Community-based development processes must be supported so that the poorest and most vulnerable people can construct sustainable and climate-resilient livelihoods and escape chronic poverty and food insecurity.

6. Analysis

To face the challenges of food security and climate change, the country needs to reorient its land use and agriculture with state-of-the-art technologies and policy initiatives. The impact of climate change on gender is another area that needs to be concentrated. Cost on adaptation and economics need to be worked out for the future climate under business-as-usual conditions and for changed management situation for up-scaling adaptation options to larger regions. There is a need to develop a policy framework for implementing adaptation and mitigation options so that the farmers are saved from the adverse impacts of climate change.

There is a need to predict the future climate at finer resolution with low uncertainty for reliable impact assessment. Concerted efforts are required for the development of mitigation and adaptation strategies to climate change to increase resilience and reduce the vulnerability of Indian agriculture at local, regional, and national scales. As climate change impacts has no boundaries, research collaboration between developed and developing countries with funding support should be promoted and strengthened for developing and transferring climate-smart technologies. Development and operationalization of adaptation strategy necessitate socio-psychological empowerment of farmers besides developing competencies in acquiring knowledge and skills related to adaptation practices.

More study and data are needed on the complex and dynamic interaction between climate change and agriculture, as well as increased knowledge and capability among farmers and other stakeholders. To secure a sustainable and resilient future for Indian agriculture, a comprehensive and integrated approach encompassing multiple stakeholders, sectors, and disciplines is required.

In the context Sustainable Development Goals this topic aligns with multiple Sustainable Development Goals (SDGs), including SDG 2 (Zero Hunger), SDG 13 (Climate Action), and SDG 15 (Life on Land). To meet the challenges of sustaining domestic food production in the face of changing climate, the Indian Council of Agricultural Research (ICAR), Ministry of Agriculture and Farmers Welfare, Government of India launched a flagship network research project ‘National Innovations in Climate Resilient Agriculture’ (NICRA) in 2011. The project aims to develop and promote climate resilient technologies in agriculture, which addresses vulnerable areas of the country and the outputs of the project help the districts and regions prone to extreme weather conditions like droughts, floods, frost, heat waves, etc. to cope with such extreme events.

The National Mission for Sustainable Agriculture (NMSA) is the Indian government's flagship program that seeks to promote sustainable agriculture methods, increase production, and assure food security while conserving natural resources. The NMSA focuses on 10 essential aspects of sustainable agriculture, including improved crop seeds, water usage efficiency, pest and nutrient management, agricultural insurance, credit support, markets, access to information, and livelihood diversification. By implementing these measures, India can achieve the SDGs related to sustainable agriculture, food security, and climate action, and ensure a sustainable and resilient future for its agriculture sector.

7. Conclusion

Climate change, the result of "Global Warming," has begun to have an impact on the entire world. Agriculture is the most vulnerable sector to climate change because a region's or country's climate dictates the nature and qualities of vegetation and crops. Climate is the fundamental predictor of agricultural productivity, and it has a direct impact on global food production. Food production systems are particularly sensitive to climate variations such as temperature and precipitation, which can lead to pest and disease outbreaks, reducing harvest and impacting the country's food security.

To address the impact of climate change on agriculture and food production, India will need to take action at the global, regional, national, and local levels. This finding raises an essential question for future research and the welfare of Indian agriculture: how soon will Indian farmers be able to shift their farming practices to adapt to the changing climate, and what policies or technology will facilitate rapid adaptation to climate change.

In conclusion, the climate change has a direct impact on food production and food security in India, and that special agricultural measures and policies are needed to cope with the changing conditions and reduce greenhouse gas emissions.

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