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Review Article

Climate Change: Effects on Agriculture, Mitigation and Adaptation Strategies in India

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ABSTRACT

Climate change has emerged as a severe threat to the current agriculture system in the world, so crop production is declining, and booster factors of crop growth are deteriorating; thus, a challenge is developed to feed the population at stake. Climate change leads to cause various natural calamities, hazards to human health and animal health and creates socio-economic and political disturbances in the world. The adaptations and mitigation strategies focus on reducing the emissions and greenhouse gases that lead to climate change; also, protocols are made to deal with climate change. Climate change also has a significant impact on the livelihoods of the farming community. That should be checked to ensure better stability and sustainability in agriculture and other sectors for the growth of our country.

Keywords: *Climate, Agriculture, Mitigation, Adaptation.*

INTRODUCTION

Climate defines the constant weather pattern of an area over a long period. Climate change and agriculture, in particular, are linked with each other permanently. Weather factor has a fundamental impact on crop production and agricultural activities. Now, in particular, the climate change scenario has had a lot of negative impacts on agriculture because of its dependability and crop adaptability to that particular weather for its growth. Various climate change situations like drought, floods (IPCC, 2018), desertification and disrupted crop growing seasons have caused a lot of decline in world food production, which creates an alarming condition for agriculture to mitigate the food crisis in the world. The warnings are also given by FAO (Food and Agriculture Organizations) that an elevation in average global temperature of only two to four degrees Celsius can decrease the yields by near around 15-40 per cent in Africa and western Asian continents, along with 20-35 per cent in Middle East regions.

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Climate change is the sole responsible for the extinction of millions of organisms and other species on the earth. Agriculture only contributes 13.5 per cent of global greenhouse gas emissions, which was reported by the Intergovernmental Panel on Climate Change (IPCC, 2004). Climate change also continues to create challenges for the life and livelihoods of everyone on this globe. Changes such as elevated land and oceanic temperature, loss of snow covers, melting of glaciers, rising sea levels, more warm temperatures, more acidification of oceans, variable rainfall patterns, changes in water quality, water quantity, the shift in migrations, seasons, species abundances and their interactions with ecosystems in all regions are happening due to climate change conditions (IPCC, 2014). Elevated temperatures are expected to increase the limits of the water cycle, as a fact of which moisture content in the atmosphere increases, leading to saturation and nearly relative humidity in a constant manner (Hartmann et al., 2013). Due to the shifting of clouds and their circulation patterns in climate change scenarios, the changes are also noticed in photosynthetically active radiations (PAR), which are uncertain in nature.

Proper Chemical analysis of ice and sediment particles provides the fact that atmospheric carbon dioxide (CO2), methane (CH4), and nitrous oxide (N2O) concentrations have been at unparalleled levels for near about last 800000 years. Various anthropogenic activities and climate change have been the major possible reasons for global warming since the last mid-twentieth century (IPCC, 2014a). Continuous warming can increase the global warming temperature by about 1.5°C between 2030 and 2052 compared to the earth's initial temperatures in pre-industrial periods (IPCC, 2018). Climate change has affected various biological systems at different levels, starting from multiple levels to multiple ecosystem levels. Anthropogenic activity related to climate change has dismantled or disabled 82 per cent of about 94 major ecological processes identified by different biological scientists. In the ecosystem, new organisms will emerge, and existing resources like freshwater availability will be reduced in the rise of this climate change condition, creating situations for its extinction. Most organisms are unable to change their habitat and the geographical range quickly to keep them ready to combat climate change, and marine organisms will be exposed to higher acidification of seawater and low oxygen conditions. Food security is also at risk due to a decline in food grain production in tropical and subtropical regions and low fibre production, plant biosecurity risks, an increase in infectious diseases and pest attacks happening only for harmful impacts of climate change. Due to access to nutritious food, malnutrition and ill health components are arising due to so many climate change factors. Food shortages and a rise in price are the outcomings of these situations. In developing countries, especially import dependent countries, due to climate change, the price of the commodities increase and which lead to the food crisis, social instability, famine and migration related issues.

Direct Impact of Climate Change on Agriculture

Climate changes alter the atmospheric gas concentrations, and majorly atmospheric carbon dioxide concentration has essential effects on plant development, crop productivity and mortality. The direct impact of climate has both supportive and damaging impacts on significant farm levels. While accessing the supportive and damage effects of a farming system, it may be noted that C3 plants (Rice, Wheat, Potato and Peanut) show good response towards both rise in temperature and carbon dioxide than C4 plants (Maize, Sugarcane and Sorghum). The impact of climate change is more pronounced in tropical climate cropping systems also

fruits and vegetables rather than in subtropics, along with persistent unfavourable situations (Porter et al., 2014; Long et al., 2006; Tubiello et al., 2007a,b; Ainsworth et al., 2008; & Boote et al., 2010). The direct impact of climate change alters some of the mechanisms in plants, thus affecting crop production as extreme temperature increase causes the plant to reduce photosynthetic activities, with long term exposure to high temperature leading to the fall of leaves and crop failure (Asseng et al., 2015). In other cases high levels of carbon dioxide can reduce the nutrients such as Iron and Zinc, along with a decrease in protein (Müller et al., 2014; Myers et al., 2014; & Medek et al., 2017). The overall full benefits of carbon dioxide cannot be achieved for the plants in nitrogen stress situations. Climate change affects the crops and the soil environment associated with the particular crops, and it has been analyzed by various statistical analysis models and regression analysis (Lobell & Burke, 2008; & Schlenker & Roberts, 2009).

The loss of biodiversity affecting both the species individual and related ecosystems that support other dimensions are due to potential changes in climate. It is almost impossible to predict the actual impact of climate change on flora and fauna. Unable to perform quick migration strategies by certain organisms, they don't survive climate change. One survey in 2004 provided the fact that one in every three amphibian species was in severe danger of extinction due to the global warming scenario. The insects present in the temperate zone and polar zone experienced an increase in their number than tropical zone due to the direct impact of climate. Mountain ecosystems are the major hotspots of biodiversity. Elevated anthropogenic activities and increased temperature disturb the mountain diversity and cause fragmentation and destruction of mountain biodiversity. For example, in India, the Himalayan ecosystem is the most important lifeline not only to India but also to neighbouring countries as a source of all perennial rivers from the glaciers. Climate change is causing problems for the Himalayan glacier. It is estimated that Glacial Lake Outburst Floods (GLOFs) phenomena are going to happen due to climate change in the eastern and central Himalayas causing severe damage to forests, farms, life etc.

The rivers that arise from the Himalayan zone are interlinked with Indo-Gangetic regions, and it favours the growth of agriculture by providing water in a continuous order and provisions for fertile lands; nearly 65-70 % of farmers are associated with this farming community and climate change risk all these sectors at a large stake. The altered desert ecosystem due to climate change also hampers the organisms sustaining in that ecosystem.

Climate change has more significant threats to mankind's survival. It has bad impacts on human health, and each year, about 8-9 lakhs people die from the consequences of air pollution, 2 million from diarrhoea as access to clean water is denied, sanitation and not having proper hygienic, and a large number of people die from malnutrition and natural calamities. The variable climate with a warmer environment favours more for air pollutants to be present in the atmosphere, and emission of greenhouse gases have been the sole cause of the ozone layer depletion that leads to various skin cancer and eye-related diseases.

Indirect Impact of Climate Change on Agriculture

Climate change also has some impacts on other biological as well as physical systems rather than agricultural systems. The major effects include:

1. **Rise in Seawater level:** Due to elevated temperature, the glaciers start melting, and thermal expansion of the ocean surfaces thus helps in the rise of the water level of the sea and this rise may be one meter or more by the year

2100 (Church et al., 2013). This rise in sea level reaches the cultivated land, and the salt contents present in it are deposited when it is used for irrigation purposes in low lying coastland areas. The overall production of some lands is deteriorated by this situation.

2. **Economic balance disruption:** The natural calamities due to climate change lead to a decrease in production, preservation, and transportation to other parts of countries. The rise in price for that particular commodities is extremely bad for the poor, and this spike lea to economic balance disruption.
3. **Water Resources:** The water sources face certain unfavourable situations that lead to a decline in water level in reservoirs and future water stress conditions. The river basin's natural reservoir capacity for irrigation is decreasing, thus creating a problematic situation for semi-arid zone irrigation (Döll, 2002; & Mote et al., 2005).
4. **Inland flooding:** The heavy rainfall in some areas leads to the flooding conditions that cover the entire land for agriculture and low lying areas. This prolonged waterlogging condition in agriculture fields creates a problem for the crop establishment as well as loss of fertilizers applied on the soil, along with difficulties for agricultural farm equipment running on the field.
5. **Pests and weeds insurgence:** The Change in climate affects agro-ecological zones and also affects the crop microclimates, thus altering the growth and survival of various damaging pests, their extent and timing of crop attack, diseases, and weed competition with crop plants (Ziska & Runion, 2006; & Rosenzweig & Tubiello, 2007).

The direct and indirect climatic effects are either long-term or time-based in nature. The long-term effects are more pronounced and cause severe damage for a long duration, and time-based effects cause damage in one-time frame. Climate change cause not only economic stress but also some political stress situations.

Mitigation And Adaptations

In India, various responses have been taken to mitigate or combat the climate change scenario as follows:

1. **National Clean Energy Fund:** National Clean Energy Fund was created in 2010 by The Government of India to support promoting and financing clean energy initiatives and funding research, particularly in the area of clean energy for future sustainability.
2. **National Action Plan on Climate Change (NAPCC):** The national action plan has eight identified core missions operating such as Solar Energy; Enhanced Energy Efficiency; Sustainable Habitat; Water; Sustaining the Himalayan Ecosystem; Green India; Sustainable Agriculture; and Strategic Knowledge for Climate Change. The mission mainly focuses on adaptive measures.
3. **International Solar Alliance (ISA):** ISA was launched on 30th November 2015 at the United Nations Climate Conference held in Paris by India and France. Ban Ki Moon, former Secretary General of United Nations.
4. **Paris Agreement:** India has made three commitments under the Paris agreement. By 2030 India's greenhouse gas emissions to be reduced by 2005 levels and its GDP intensity by 33-35%. Apart from this 40% of India’s power capacity would be from non-fossil fuel sources. In the mean time, an additional carbon sink of 2.5 to 3 billion tonnes of carbon dioxide equivalent through coverage by forests and trees in additional by 2030 will be accomplished by India.
5. **Bharat Stage Emission Norms:** Bharat stage emission norms are associated with controlling emissions from

vehicles to reduce air pollution and were introduced in April 2000 and initiated Bharat Stage 1, followed by BS-II in 2005. The BS-III was adopted nationwide in 2010, and BS-V and VI were planned to be adopted from 2016 onwards to mitigate the climate changes.

Worldwide Protocols Related to Climate Change:

1. **Montreal Protocol:** Montreal protocol was signed in the year 1987 and came into force in January 1989. India became a member in 1992. This protocol gives provisions to reduce the ozone layer depleting situations.
2. **Kyoto Protocol:** The Kyoto Protocol was formed on 11th December 1997 and came into force on 16th February 2005. At present, there are 192 parties with this protocol. This protocol deals with different ways to reduce the emissions of greenhouse gases in industrialized countries and advises them to adopt measures to mitigate the issue.

CONCLUSIONS

Climate change is now emerging as the greatest challenge to the sustainable development of agriculture and other sectors. Thus, all countries should address this issue with a broad and shared perspective for getting a solution to it. While doing so, the developed countries should help the underdeveloped countries with suitable strategies to fight back against this crisis. The adaptability and different methods should be able to utilize the resources such as air, water, land etc., to its higher efficiencies; thus, proper development can be achieved, and we can save our planet from the verge of climatic disasters.

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