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10. Impact of Climate Change on Agriculture

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Abstract:

Climate change affects our world tremendously, Urbanization plays a key role in the climate change. The major cause of urbanization results from the increase in the population. Increase in population and their anthropogenic activities affect our climate in a greater scale. Increase in CO_2 emission is one of the major factors of climate change. Developed countries as well as undeveloped countries are equally responsible for CO_2 emission. USA contributes maximum in CO_2 emission. Climate change affects agriculture sector in negative way in the sense that weather affects the growth of many horticultural crops .Yield of many agriculturally important crops also decreases because of change in weather condition. Change in weather conditions affects the growth and development of many plant pathogens and their pathogenicity. Climate change can be mitigated through various ways. Mitigation and adaptation strategies are expected to increase farmers' income without compromising agricultural production sustainability. Climate change is quite unpredictable thus there is a need to mitigate the worsening impacts of climate change through several ways.

Keywords: *Climate change, urbanization, pathogenicity and mitigate.*

10.1 Introduction:

Climate change is one of the major problems across the world, modernization of lifestyle and ever increasing urbanization are the main factors. It is commonly defined as considerable changes in the average values of precipitation and temperature (meteorological elements) whose average has been calculated for a very long period (WMO, 1992). Increase in population and their tremendous increase of anthropogenic activities are also contributing on changes in Climate change. Sustainability of natural resources on our planet due to increase in human population is a major question (Arora, 2018). Almost all the parts of earth are touched and disturbed by human population and have put great constraint on the natural resources (Arora, 2018). Increase in the emission of various greenhouse gases showed greater impact on our planet and it has been estimated that this will result in rise in temperature by 02 °C by 2050 by various agencies such as United States Development Authority (USDA) and Organization for Economic Cooperation and Development (OECD)(Arora 2018 and IPCC,2007).Concentration of various greenhouse gases has been increased in a greater rate such as Methane (CH_4) by 150%, carbon dioxide (CO_2) by 40%, and nitrous oxide (N_2O) by 20% since 1750 (IPCC,2014). Carbon dioxide emissions, which is mainly due to the overuse of fuels rose in a tremendous rate 22.15 billion metric tons in 1990 to 36.14 billion metric tons in 2014 (Sathaye et al., 2006).It is one of the major greenhouse gases and these ultimately results in the increase of global temperature at an average rate of 0.15–0.20 ◦C per decade since 1975 (Abeydeera et al.,2019) and is expected to increase by 1.4–5.8 ◦C by 2021 (Arora, 2005).Increase in the greenhouse gases results in global warming which results in the melting of glaciers and polar ice by 2-3 times in comparison to last century. CO_2 was quite negligible in 1750 s, but as far as industrialization and urbanization increases, its rate also increases. World has emitted about 1.5 trillion metric tons of CO_2 since 1751. Developed countries as compared to less developing countries are responsible in emitting CO_2 .Out of all, Europe is the largest contributor of CO_2 having around 514 billion metric tons of CO_2 emissions, followed by Asia and the North American continent, which have recorded cumulative CO_2 emissions of 457 billion metric tons each(NOAA,2020)(Figure 1). The USA is the largest contributor to CO_2 emissions (399 billion metric tons), and has contributed 25% of total historical emissions since 1751, followed by China (200 billion metric tons). The European Union (EU-28), a union of 28 countries that sets collaborative targets, has contributed 22% of historical emissions of CO_2. India and Brazil contributes very less CO_2 emission (CDIAC, 2020).Climate changes occur due to the increase in the emission of greenhouse gases and it has resulted in the various changes in the fertilization of crops. In the 21st century, climate change will become a severe problem, and both rich and developing countries will face negative externalities (Tol, 2013).

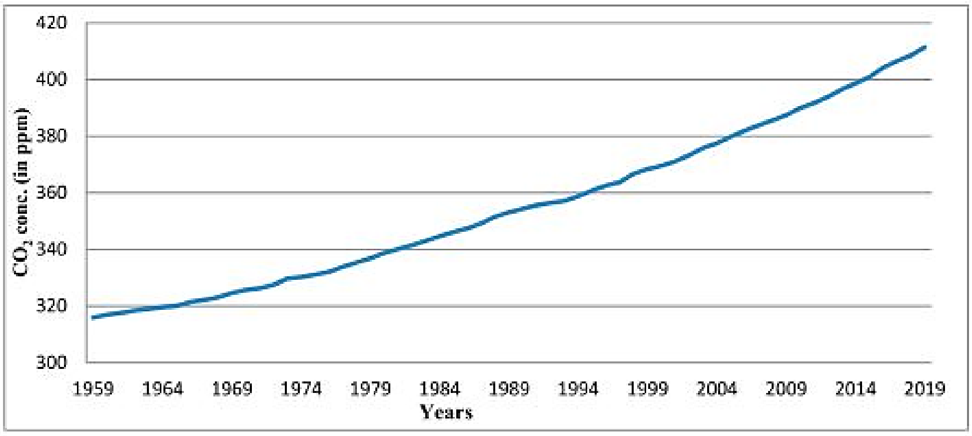

Figure 10.1: The Increase in CO_2 Concentration in the Atmosphere

(SOURCE- NOAA, 2020)

Climate change impacts the Himalayan region and adjoining plains as a result major rivers are in a verge of increased extinction rate of floral and faunal species, changing the rainfall pattern, changing the duration of vegetative growth and maturity period and overall growth of crop plants. Climate change could cause irreversible damage to unique forest ecosystems and biodiversity, rendering several species extinct. Forests ecosystems require a long response time to adapt to climate change. Climate is projected to change at a faster rate than the capacity of the forest ecosystems and plant species to adapt. Thus, it is necessary to develop and implement technologies and strategies to reduce the vulnerability of the forest ecosystems to changing climate, but there has been little research on this front. Warming in the Himalayan region indicate moderate to large-scale shifts in vegetation types, with implications for forest dieback and biodiversity (Ravindranath and Sukumar, 1998).

10.2 Climate Change and Agriculture:

Climate and agriculture are intensely interconnected with global processes. The impact of climate change on agriculture could result in problems with food security and may threaten the livelihood activities upon which much of the population depends. Even a small change in climate affects agriculture adversely decreasing the production rate. Climate change effect through global warming phenomenon increases the average atmospheric temperature, which has become a mega trend changing the global future significantly. In many regions of the world, such as Africa, Southern and Central America, and South and Southeast Asia, climates are extremely variable from year to year, and recurrent drought and flood problems often affect entire countries over multiyear periods (Li et al., 2017). There is increasing evidence that greenhouse gases have already begun to warm the planet (Intergovernmental Panel on Climate Change (IPCC), 2007).Climate change is resulting into a very high rate of land degradation causing enhanced desertification and nutrient deficient soils. The menace of land degradation is increasing by the day and has been characterized as a major global threat. According to Global Assessment of Land Degradation and Improvement (GLADA) a quarter of land area around the globe can now be marked as degraded (Kurylyk et al., 2014). Land degradation is supposed to influence lives of 1.5 billion people and 15 billion tons of fertile soil is lost every year due to anthropogenic activities and climate change. Land degradation is resulting in mass migrations and as per a report published by United Nations Environment Programme in 2017, 500 million hectares of farmland has been abandoned due to drought and desertification resulting in major social and environmental constraints. Extreme drought conditions, frequently occurring due to climate change, exacerbate the productivity of crops by causing nutrient immobilization and salt accumulation in soils making them dry, unhealthy, saline and finally infertile (Nazarenko, 2015). Such barren lands become non-arable with course of time and are eventually abandoned by farmers leading to economic losses and social issues.

10.2.1 Economic Impact of Climate Change and Agriculture:

The most important economic sector that is strongly reliant on the weather is agriculture without a doubt. The collecting of better information, the development of new tools and models, and the monitoring of real changes in climate and their consequences have all resulted in advancements in our knowledge of climate impacts. There are two types of studies on the influence of climate change on agricultural yields.

- The first category, which has just lately been formed, looks at statistical correlations between climate or weather and crop yields, which are often based on large-scale studies of crop growth in real-world field settings. For example, it has been statistically evidenced a reduction in wheat in the United States, increasing rainfall and temperatures increased the costs of insecticides for crops such as corn, potatoes, and soybeans(Chen et al.,2001).

- The second one is based on a mechanistic, bottom-up understanding of how plants develop and uses process-based crop models to replicate the biological mechanics of crop growth.

Economic losses from natural disasters are rising globally, and agriculture sector is highly vulnerable to these disasters. According to the United Nations Office for Disaster Risk Reduction (UNISDR) (2018), disaster-hit countries experienced direct economic losses to the tune of US$ 2908 billion during 1998–2017. Of the total losses, 77 percent were due to climate related disasters. Climate change impacts are more pronounced on agriculture sector in the recent past. Government of India's economic survey (2018) estimated that the annual loss of US$ 9-10 billion was due to the adverse effects of climate change. Changing climate has also resulted in increased and sporadic incidences of foods in last few years. Report by European Academies' Science Advisory Council (EASAC) suggests that extreme events including foods have increased by 50% in last 10 years and are now occurring at rate of four times higher than in comparison to 20 years back (Arslan, 2014). Heavy foods in Kerala, India, in 2018 are a glaring example to showcase this. These foods have resulted in washout of top soil and nutrients from the soil, resulting in low productivity for several years to come, unless and until corrective and pro-active remediation strategies are not worked upon. Rise in sea levels or prevalence of heavy rainfall could result in decline of agricultural lands in coastal regions. This has also resulted in salinity of soils in coastal regions leading to stresses in crops such as decreased respiration, photosynthesis and transpiration, ultimately jeopardizing food availability and security in such regions. Due to extreme and unsuitable weather conditions in India, there exist high chances of soil infertility leading to a decline in the quantity and quality of the crop. Change in climate will affect the groundwater recharge, soil moisture, and frequency of drought or flood, and groundwater level in different areas (Allen et al. 2004, Eckhardt et al. 2003, Huntington 2003). Increased soil temperature may also lead to an increase in autotrophic CO2 losses from the soil caused by root respiration, root exudates, and fine-root turnover (Mahato, 2014).

According to the World Food Program (WFP) report (2018), there has been significant reduction in the rate of increase in the crops yield per hectare in comparison to the high rate in the increasing population. According to the recent IPCC report on Impacts and Adaptation, there will be a "marginal spike in the amount of people at risk of hunger owing to climate change" throughout the current century (Antle, 2008). It has been also estimated by Food and Agriculture Organization (FAO) that by 2100 there will be serious reduction in the production of major cereal crops as Maize, wheat and rice by 20-45%, 5-50%, 20-30% respectively, if the climate change and greenhouse gas emissions continues in this current trend. The impact of climate change-induced output shocks on more policy-relevant variables like food security, prices, economic welfare, and consumption, will be mediated by global agricultural commodity trade and would be dependent on concepts effects and the interaction of effects of climate change with current market distortions in the agricultural sector(Antle, 2008). Intensive agricultural practices, such as the enormous use of agro-chemicals, livestock generation, and the exploitation of water supplies, have resulted from the ever-increasing demand for food due to the ever-increasing population. Anomalies in precipitation have a negative impact on agriculture as it has a substantial impact on agricultural yields as well as cropland regions. According to evidence, nearly 9% rate of farmland growth in the developing world over the last two decades is attributable to dry anomalies, as farmers extend their land to compensate for yield losses (Zaveri et al., 2020).

Land degradation is accelerating as a result of climate change, resulting in increased desertification and nutrient-deficient soils. Droughts, which are becoming more often as a result of climate change, aggravate crop yield by generating nutrient immobilization and salt accumulation in soils, leaving them dry, unhealthy, saline, and ultimately sterile(Arora,2019). With time, such barren fields become unusable, and farmers abandon them, resulting in economic losses and social problems.

10.2.2 Mitigation and Adaptation:

Change in the climate affects farmers mostly thus voluntary mitigation practices is the motivational factor to deal with the climate change (Semenza et al., 2011). However mitigation strategies will not work efficiently as there will be a reduction in the number of people exposed to water stress thus others needed adaptation strategies due to their exposure to increased stress (Vuuren, 2010). Many traditional methods can be adopted by farmers to deal with the climate change such as various traditional management systems and agro ecological management like bio diversification, soil management, and water harvesting; which will ultimately help the framers to adopt climate –resilient practices (Alteri and Nicholls, 2017).

These methods are beneficial in the sense that it will ensure increased carbon sequestration, increased soil health, increased soil quality and reduced soil erosion, leading to resilient soils and cropping systems, ultimately ensuring food security during climate change (Lal et al., 2011). Some educational programs which mainly focus on climate resilient techniques can be arranged for creating awareness. These educational programs are the most successful ones in providing climate-change education for ecological development (Anderson 2012).

Some of the adaptation methods of mitigation can be broadly classified into resource-conservation technologies, cropping-system technologies, and socio-economic or policy interventions. These practices will help the farmers to deal with the change in the climate.

10.3 Conclusion:

Ever increasing population has put a lot of pressure on agriculture sector to meet with the food and nutritional security of the world, which got worsened with climate change. Although there is no certainty regarding the future climate scenario and its possible impacts however various studies report that climate change will decrease agricultural productivity in the next coming years. Various factors related to climate, such as temperature, precipitation, and greenhouse gases, significantly hampered pest infestation, soil fertility, irrigation resources, physiology, and plants' metabolic activities.

A number of mitigation and adaptation strategies have been developed to deal with the deleterious impact of climate change on agricultural sustainability. The future of climate change and its associated impacts is highly unpredictable, which makes planning for mitigation and adaptation a bit complex which necessitates the formulation of climate-resilient technologies involving an interdisciplinary approach according to the region and farmers are needed to be aware of these practices (Malhi et al., 2021).

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