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IMPACT OF CLIMATE CHANGE ON FOOD SECURITY IN INDIA

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Climate change is a phenomenon due to emission of green house gases (GHGs) from fuel combustion, deforestation, urbanization and industrialization resulting variation in solar energy, temperature and precipitation. It has been reported that the mean global surface temperature has increased by 0.76^{0}C over the past 100 years between (1906-2005). Change in climate on a global scale should influence local agriculture, and therefore affect the world's food supply. While climate change clearly affects agriculture which contributes 13.5 per cent of all human induced green house gas emissions globally. Indian agriculture is extremely vulnerable to weather and climate. Agriculture is one of the most vulnerable sectors to the anticipated climate change. In recent past there was substantial loss of crop in the country vulnerable due to extreme and unusual weather conditions. Several adaptation measures and mitigation strategies to reduce vulnerability to climate change by enhancing adaptative capacity, increasing resilience and also to offset the negative effect of climate change on Indian agriculture. Under changing climate, food security of the country might come under threat. Various studied showed that increase in temperature by 2.5^{0}C to 4.9^0 C, the rice yield will decrease by 15 per cent to 49 per cent and wheat yield will decrease by 25 per cent to 42 per cent without carbon dioxide fertilization. Despite the technological advances in the Green revolution during 1967-68 onwards, weather and climate are the basic factors in determining the agricultural productivity. To cope up with the climate change more effectively, integrated adaptation and mitigation options for a range of agro ecosystems, so as to enable a favorable policy environment for the implementation of the framework, have been identified. However, food security is aggravating day by day, resulting in more number of undernourished/malnourished persons in the world. Natural calamities (drought, flood, forest fire, fluctuation in rainfall pattern etc.) will be serious threat to human survival by way of availability of foods. The fundamental complexity of natural agricultural systems, and of the socioeconomic systems governing world food supply and demand. The ever increasing population in the developing and less developed countries is also major constraint. Moreover if food plants (Cultivated and wild species) are utilized for the production of renewable liquid biofuel, there would be enormous changes in agro ecosystems, destabilizing the natural balance and leading to lower productivity of food crops. The World Food Day celebrated ever year on 16th October gives an impetus to food security, but the major changes are to be surpassed for human welfare. Food security means an access by all people at all times to enough food for an active and healthy life. It is basic right of event to adequate diet. At present, food security in India is insecure and may probably collapse in future because food is not available with the recommended quality of nutrients and the number of malnourished/undernourished persons is increasing every year. During the last century, food production increased by about seven fold. This was achieved with modern farm technologies (hybrid seeds, synthetic fertilizers, chemical pesticides, farm machineries etc.). In India, by introducing the green revolution in the late sixties, the production of food grain could be increased fourfold. Similarly, eventhough the human population grew about fourfold, the amount of food supplied for each person was almost doubled. Therefore, adequate nourishment is possible if the food is distributed evenly across the whole world. In fact, this is not the reality, as about 10% of the population in the world is still undernourished. If this food is sufficiently is to be achieved, the world food production must be about 50 per cent greater than it was in 2000. This target seems to be difficult to achieve, as crop productivity is nearly stagnant or coming down or if continues to increase, it would be at much smaller rate of improvement due to several environmental changes and socio- economic situations. In fact, although human controlled factors such as soil, seed, fertilization and plant protection can be controlled, the weather is still key factor in agricultural productivity and reduction in the potential yield is likely to be caused by shortening of the growing period, decrease in water availability and poor vernilization. In India, agricultural productivity and farm economy should not be considered food commodities only, but other agricultural productions such as textile products, medicinal plants, horticulture, forest revenues, dairy by- products and internationally traded commodities. This is because sustainable high returns can only be generated from agricultural products that are valuable to customers. This means that there is an urgent need for transition from the agriculture to higher value foods.

Impact of climate change on crop productivity:

Climate change will affect crop productivity due to increases in CO_2 concentration and greenhouse gases, which indirectly depleted ozone layer in stratosphere. The increased amount of ultraviolet radiation due to depletion of stratospheric ozone layer will exert its deterious effect on crop growth and productivity by the destruction of chlorophyll and reducing photosynthetic rate. While increased CO_2 level could increase photosynthesis and water use efficiency. However, high temperature and green house gases will modify rainfall, evaporation, runoff and soil moisture storage will adversely affect crop growth and productivity. The IPCC contemplates a change in global surface temperature of 1.5 to 4.5°C by the year 2050, because of enhanced greenhouse gases. In India, the direct impact of climate change would effect plant growth, development and yield due to changes in rainfall and temperature. Increase in temperature would reduce crop duration, increase crop respiration rates, change the pattern of pest attack and new equilibrium between crops and pests hasten mineralization in soils and decrease fertilizer use efficiency. The rainfall over the period is expected to increase by 10-20 per cent in India. To cope up the regional climate change, agriculture may have to adopt some changes. These adjustments will depend on future development in technology, demand, price and national policy. Climate change presents crop production may be classified into two broad groups with prospects for both benefits and drawbacks, some of which are as follows:

Direct effects (Beneficial effect):

Understanding the potential impacts of global environmental change on this sequence of interlocking elements is a first step in modeling what will happen when any one of them is changed as a result of possible global warming, and a prerequisite for defining appropriate societal responses.

– Increased atmospheric CO_2 concentration can have direct effect on growth rate of crop plants and weeds.

– Green house gas induced changes of climate alter level of temperature and moisture limit to agriculture.

Effect of CO_2 enrichment on crop growth:

It is estimated that even if man made emission of CO_2 could be kept at present rate, atmospheric CO_2 would increase (382ppm to about 450ppm by the year 2060 and 520ppm by the year 2100), which is the substance for photosynthesis. IPCC (1996) estimates that globally agriculture emits about 50 per cent of total methane, 70 per cent of nitrous oxide, and 20 per cent of carbon dioxide. Sources of methane emissions include rice, ruminant sand manure. Nitrous oxide emissions come from manure, legumes, and fertilizer use. Carbon dioxide emissions arise from fossil fuel usage, soil tillage, deforestation, biomass burning, and land degradation.

Greater atmospheric concentrations tend to increase the difference in partial pressure between the air outside and inside the plant leaves, and as a result more CO_2 is absorbed and converted to carbohydrates. Crop species vary in their response to CO_2. Wheat, rice, and soybeans belong to physiological classes (called C_3 plants) that respond readily to increased CO_2 levels. Corn, sorghum, sugarcane, and millet are C_4 plants that follow a different pathway.

Effect on plant growth:

Photosynthesis: Plant species with C_3 photosynthetic pathway tend to respond more positively to increase CO_2 because it suppresses the rate of photorespiration. C_4 plants (maize, sorghum, sugarcane and millets) are less responsive to increase CO_2 level since they are CO_2 saturated at current ambient levels and also have negligible photorespiration.

Increase leaf area : This allows greater interception of incident radiation which enhances the plant photosynthesis rate.

Increased number of branches and tillers per plant mainly in cereal crops.

Increased nitrogen fixation: The CO_2 concentration is an important controller of the symbiotic relationship between plants and nitrogen fixing organisms.

CO_2 enrichment enhances the plant root.

Effect on water use efficiency:

The increased evapotranspiration in plants will induce moisture stress. CO_2 enrichment crops may use less water due to decline in stomata conductance, which reduces transpiration, which will be minimize the moisture stress even while they produce more carbohydrates. Increased CO_2 has an effect on the closure of stomata and thus reduces water loss through transpiration and thereby improved water use efficiency.

Effect on salt tolerance:

Salt tolerance increases as CO_2 concentration goes up. There are two possible explanations:-

– Extra supply of photosynthetic may help to offset increased respiration demands

– Less water throughout in the transpiration stream could lessen the quantity of salt taken up.

Protection from air pollutants:

The narrowing of stomata by increased levels of CO_2 immediately infers the possibility from air pollutant that enters leaves by this route.

Effect on crop- weed competition:

C_3 crops in temperate and subtropical regions could also benefit from reduced weed infestation. Out of seventeen, fourteen most troublesome terrestrial weed species are C_4 plants in C_3 crops. The difference in response to increased CO_2 may make such weed less competitive. In contrast, C_3 weed in C_4 crops, particularly in tropical regions could become problem although the final outcome will depend on the relative response of crops and weeds to climate change as well.

Effect on crop-insect interaction:

Under increased CO_2 levels, nitrogen content of plants is likely to decrease while carbon content increase implying reduced protein level. This may reduce nutritional value of plants for insect- pests.

Effect on crop pathogen interaction:

Elevated CO_2 generally promotes plant growth and as plants structure is modified, the affected plants may sustain higher level of infestation without reduction in yield. Plants which are more vigorous are able to resist infection from weak pathogens such as facultative parasites, resulting in lower disease incidence and severity. However, large plants provide more surface area for infection and diseases (particularly those caused by obligate parasites) may increase in incidence and severity. Elevated CO_2 may benefit plant health and productivity by altering the morphology and physiology of plants to the detriment of pathogenic microbes**.** Crop-pest interactions may shift as the timing of development stages in both hosts and pests is altered.

Adverse effects (Due to increase temperature):

Effect on crop duration and phenology: In middle and high latitudes global warming will extend the length of the potential growing season, allowing earlier planting of crops in the spring, early maturation, harvesting and the possibility of completing two or more cropping cycle during the same season. Crop producing areas may expand pole ward in countries such as Canada, Russia, although yield in higher latitude will likely lower due to less fertile soils.

There may be about 6-8 per cent reduction in maturity duration for each 1^0C rise in temperature. Increased temperature during critical periods of crop development results in accelerated leaf senescence, decline in canopy photosynthesis and forced maturity in winter cereal crops.

Effect on yield:

Increased temperature by 1 to 2^0C above mean of 17^0C temperature during grain filling period reduces yield due to increased rate of senescence of flag leaf and reduction in grain filling duration. Various studied showed that increase in temperature by 2.5^0C to 4.9^0C, the rice yield will decrease by 15 per cent to 49 per cent and wheat yield will decrease by 25 per cent to 42 per cent without carbon dioxide fertilization.

Effect on moisture availability to crops:

Climate change will modify rainfall, evaporation, run off and soil moisture storage. In general at mid latitudes, evaporation increase by about 5 per cent for each degree centigrade mean annual temperature rise. Increased evaporation from the soil and accelerated transpiration in the plant themselves will cause moisture stress. Vapour pressure deficit, one of the governing factors for ET will increase by 7 for each 1^0C rise in temperature.

Effect on drought, heat stress and other extremes:

– Hurricane intensities will increase with climate warming.

– Small increase in mean annual temperature in subtropical regions could sufficiently increase heat stress on temperate crops such as wheat so that these are no longer suited to such areas.

– In temperate mid latitudes, there will be reduction of winter chilling (vernalization). Many temperate crops require period of low temperature in winter to either initiate or accelerate the flowering process. Low vernalization results in low flower bud initiation and ultimately reduced yield.

– High rate of evapo transpiration would cause higher frequency of drought in tropics and sub-tropics

Effect on distribution of agriculture pests and diseases:

Temperature increase may extend the geographic range of some insect pests presently limited by low temperature. Longer growing seasons will enable insects such as grasshoppers to complete a greater number of reproductive cycles during the spring, summer, and autumn.

Effect on soil fertility and erosion:

Higher temperature is likely to speed the natural decomposition of organic matter and to increase the rate of other soil processes that affects fertility. The continual cycling of plant nutrients carbon, nitrogen, phosphorus, potassium and sulphur in the soil-plant atmospheric system is also likely to decline to accelerate in warmer conditions, enhancing CO_2 and N_2O gases emission.

Indirect effects :

Stratospheric ozone layer depletion and Increase in UV-B radiation: There is maximum concentration of ozone between 30 to 60 kilometers above the earth surface. This layer provides the living forms and other important biomolecules an umbrella of protection from the deterious effect of UV-B by absorbing heavily those UV-B wavelengths below 320nm. The major effects of this zone will be an increase in the amount of ultraviolet radiation reaching the biosphere. This increase will be completely contained within the UV-B zone (290nm-320nm). A 10 percent depletion of stratospheric ozone layer has been estimated at high latitudes over inhabited areas by the mid of 21st century. This depletion will result in 25 per cent increase in human non-melanoma skin cancer, 10 per cent decrease in certain UV sensitive crop yield. UV radiation exerts its deterious effect on crop growth and productivity by:

– Destruction of chlorophyll

– Reducing photosynthetic rate as it adversely affect hill reaction, PS-I and PS-II.

– Causing horomonal imbalance

– Breaking down IAA and its precursor

– Producing growth inhibitor.

Mitigation strategies:

Climate change over last few decades has endangered food security in India. Impacts are diversified and need to be addressed through public private partnership among communities, local government and states. There are two fold approaches to mitigate the climate stress-firstly by reducing greenhouse gas emissions, the main culprits of climate change and secondly, by adopting measures to mitigate adverse impacts of climate change. Water harvesting and conservation both in agriculture and domestic sectors has to be a national policy. Use of drip and sprinkler irrigation systems, mulching and bed plantation, construction of small tanks and check dams are some of the conventional measures for water conservation and harvesting. For example in Alwar region of Rajasthan, barren lands have been converted into lush fields by adopting these measures. Dried up rivers got rejuvenated by making "Johads"- small earthen check dams. Temperature and rainfall are the two major factors affecting crop productivity. Vertical drainage in the form of pumping groundwater is cost effective measure to lower the high water table. Also, the aquifer has storage properties and can be operated as inter-seasonal and multi-annual water storage facilitating supply of water in periods of scarcity. This further development of groundwater is an important strategy to achieve crop diversification.

Conclusion:

The changing temperature, rainfall patterns and carbon dioxide level will undoubtedly have important effects on global agriculture and thus on food security. Assessment of the effects of climate change on agriculture might help to properly anticipate and adapt farming to maximize agricultural production. IPCC and FAO are working on climate and food supply by integrating agriculture and socio-economic models, they may be able to predict whether there will be hunger and famine in the coming years. Geostatistical assessment based on crop simulation models have to be confirmed because though carbon dioxide enriches crop yields, there is less convincing evidence on the impact of warming temperature. Also, the interactive effect of temperature and plant nitrogen content on respiration is not fully understood. These studies are urgently needed as the balance between food supply and food demand is shifting abruptly from surplus to deficit. Therefore, though it is imperative to produce more food in volume. We should not forget its value addition and its impact on the environment. The choice between volume and value is to be spelt right now and should be translated into Government policies on agriculture in general and food crops in particular, to assure food security. According to IPCC, India can emerge as leader in solar energy within the next decade and show the world a way out of global warming. With these means, the country would be free from its costly imports and become energy independent. Other sources of bioenergy such as algae may also be available in future.