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Impacts of Climate Change on Agricultural Sector

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Abstract

Climate is the primary determinant of agricultural productivity and climate change is expected to influence crop and livestock production; hydrologic balance; input supply; type, frequency and intensity of pests and diseases; availability and timing of irrigation water application; severity of soil erosion etc. However, nature of these biophysical effects and human responses to them are complex and uncertain. Crop and livestock yields are directly affected by changes in climatic factors like temperature and precipitation and extreme events *viz*. droughts, floods, and wind storms. Additionally, carbon dioxide is fundamental for plant production; rising concentrations have the potential to enhance productivity of agro-ecosystems. Given the fundamental role of agriculture in human welfare, concerns have been expressed by federal agencies and others regarding the potential effects of climate change on agricultural productivity. Interests in this issue have motivated a substantial body of research on climate change and agriculture over the past decade.

Introduction

Agriculture is one of the most susceptible or vulnerable sectors to the effect of climate change because instead of several technological advancements through the introduction of Green Revolution in the second half of 20th century, weather as well as climatic situations are the key factors which still determine the crop productivity in majority of the areas throughout the globe. The potentiality of production obtained from the agrarian sector is affected excessively due to the anticipated shift in temperature and rainfall pattern and also their allied influences on water availability, pest and disease infestation, and immoderate or extreme weather hazards *etc*. Agriculture is considered to be a climate dependent bio-industry with remarkable regional characteristics as production continues depending upon the proper selection of crops according to the climatic condition of a particular region and appropriate cultivation practices.

Effects of Climate Change on Agriculture

- Climate change agitates or interrupts the agro-ecosystem, further impacting the arable, livestock, and hydrology sectors.
- Change in climatic elements influences the crops indirectly by increasing the infection and infestation of numerous insects, pests and diseases ultimately leading to population movement and change in biodiversity.
- Pathogen susceptibility and disease occurrence may be altered by climate change due to the effect of warming or moisture stress (drought) on crops' resistance power to diseases and enhanced pathogenicity by mutation induced by environmental stresses.

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• Ozone gas causes critical and apparent detriments to horticultural crops mainly reducing their market value.

• Ozone reduces the rate of photosynthesis and increases leaf senescence in turn impacting final productivity.

• While considering livestock sector, biological changes in case of fertilization and breeding and also growing pattern of pastures are affected.

• While considering hydrological sector, groundwater recharge as well as level of underground water table, water temperature, frequency of flood or drought, river or stream flow, and water quality of lakes and marshes are influenced through the impact of climate change on rainfall, evaporation, and soil moisture content.

• The increased amount of precipitation results into an enhanced rate of outflow; besides the rising temperature increases evaporation, leading to decline in outflow.

• Climate change possesses diversified effects on rural economy in terms of crop productivity, revenues of farm household, asset values and also infrastructure due to change in water resources accessible to agriculture.

• Developing countries situated on low latitudinal positions where most of the world's poor people dwell suffer expectedly more from adverse effects of global warming in the coming years due to their impoverished geographical location, higher share in economies and restricted capability of adaptation to rapid climate change; whereas agricultural production in high latitude countries customarily gets advantages.

• In a comprehensive estimate carried out in more than hundred countries, Cline (2007) predicted that the crop productivity throughout the globe would fall by 15.9 percent in the year 2080 if global warming proceeds with this persistent or incessant rate and developing countries would experience a disproportionately greater decline of 19.7 percent.

• Moderate to medium increase of approximately 1–3 °C in mean temperature including the linked increase in CO_2 concentration and change in rainfall pattern, give benefits to the crop yields in case of temperate countries but while considering the low latitude areas, moderate temperature increment of almost 1–2 °C favourably has negative effects on yield of major cereal crops.

• Besides, warming of more than 3 °C would create negative influences in all regions of the earth.

• The association of temperature increase and altering precipitation pattern can indicate the impression of climate change on soil moisture availability; agro-climatic situations; alteration of growing seasons, planting and harvesting calendars; insect pest, weed and other pathogen populations, *etc*.

• Evaporation and precipitation are anticipated to rise with escalating temperatures; moreover certain drought stricken regions would suffer from more severe dry periods.

• Climate change due to radiative forcing, increased CO_2 concentration in atmosphere would create a positive effect on yield through the stimulation of photosynthesis and reduction of water loss by transpiration from plant surfaces.

• Increased CO_2 concentrations in atmosphere can lead to a positive growth response for a number of staple crops under controlled conditions which is termed as 'carbon fertilization effect' and this effect is huge for C_3 crops like rice, wheat, soybean, fine grains, legumes and most of the trees having a lower rate of photosynthesis whereas in case of C_4 crops such as maize, millet, sorghum, sugarcane and many grasses, the effect is quite less.

• It is suggested by the reports of IPCC that yield would increase by 10–25 % in C_3 and up to 10% in C_4 crops when CO_2 levels reach approximately 550 ppm.

• Climatic variability and increased intensity and frequency of extreme weather events like droughts and floods can depress crop productivity.

• Crop evapotranspiration, photosynthesis, biomass production and land suitability are directly altered by climate change.

• Precipitation maintains a direct relationship with monsoon in India originating from Indian and Arabian seas; warmer climate may accelerate the balance of hydrological or water cycle through alteration of magnitude and timing of rainfall and runoff.

• Warm air holds more amount of moisture resulting in an increase in evaporation; additionally, an inevitable consequence of warming *i.e.* sea level rise would increase the detrimental effect of permanent or seasonal saline intrusion into groundwater and rivers which would create a potential influence on water quality and its effective utilization in domestic, agricultural and industrial sectors.

• Besides, the rise in mean sea water level in the long run causes inundation of coastal lands; agricultural lands as well as can salinize groundwater.

• The pattern of production of various crops is largely affected by the shift in temperature and precipitation and moreover, the productivity is hampered because of escalating atmospheric CO_2 content leading to the increase in vulnerability of landless and the poor.

• Increase in the growing season temperature or mean seasonal temperature can considerably affect crop productivity, farm incomes and food security; besides reducing the duration of many crops and hence final yield.

• In seasonally arid and tropical regions having temperature range already close to the physiological maxima for crops, higher temperature would be more disadvantageous as it increases heat stress on crops and water loss by evaporation.

• Increased evaporative demand due to escalating temperature and longer growing season would enhance irrigation requirement of crops by 5-20 % or more by 2070 or 2080.

• Temperature extremes on short term basis may be crucial, more specifically at key developmental stages; besides, a few days of extreme temperature of more than 32 °C at flowering stage can extremely reduce yield.

• Physiological processes like photosynthesis and respiration linked with crop growth show continuous and non-linear response to temperature but developmental rates show a linear response up to a definite level.

• Higher temperature range may affect enzymatic reactions and gene expressions on short term basis whereas carbon assimilation hence crop growth rate and finally yield are hampered on long term basis.

• Heavy rainfall occurrences leading to floods or excess water can destroy crops entirely over broad regions due to waterlogging, anaerobic situation and reduced plant growth ultimately impacting food grains production.

• On the other hand, excess water causes indirect impacts like delayed farming operations and moreover agricultural machineries are not adapted to wet soil conditions.

• Global mean sea level is projected to rise by 0.18 to 0.59 m by the end of the century.

Indian Scenario of Climate Change

• India's agriculture is more dependent on monsoon from the ancient periods.

• Any change in monsoon can excessively affect agricultural sector in our country.

• Increasing temperature is also detrimental for food production.

• Rising CO_2 concentration up to 550 ppm may increase the yields of several crops like rice, wheat, legumes and oilseeds by 10-20 %.

• Research studies indicated that even 1°C rise in temperature can reduce the productivity of wheat, soybean, mustard, groundnut, and potato by 3-7 %.

• Enhancement in temperature, variability in precipitation and decline in availability of irrigation water would decrease the yield of majority of the crops only marginally by the year 2020 but up to 10-40 % by the end of the year 2100.

• Climate change would particularly possess huge influence on rainfed crops, cultivated on approximately 60% of crop lands.

• Increased frequency of droughts and floods favourably increases variability in production.

• The adverse effect of global warming is anticipated to be more pronounced in northern regions of India.

• Extremes of maximum and minimum temperature would increase under altered climatic conditions; few places receive heavier rainfall whereas some places remain dry.

• Gross per capita availability of water in our country will reduce from 1820 m^3/yr in 2001 to 1140 m^3/yr by the end of 2050.

• Corals found in Indian Ocean will be soon exposed to summer temperature exceeding the thermal threshold levels observed over last 20 years and the annual bleaching of corals will become almost a certainty from the year 2050.

• According to the former surveillance on mean sea level along the Indian coast depicted that a long term rising trend of 100 years of about 1.0 mm/year was observed.

• According to the current information, a rising trend of almost 2.5 mm/year in sea level along Indian coastline was observed.

• The sea surface temperature generally warms up by 1.5–2.0 °C and 2.5–3.5 °C by the mid and end of this century respectively.

• A 1 meter rise in sea level may displace about 7.1 million people in our country and almost 5764 sq. km of lands will be lost in addition to 4200 km of roads.

• More than 50 percent of forests may experience shift, extremely influencing the biodiversity, regional dynamics in climatic elements along with the livelihoods depending upon the forest products.

• Majority of the biomass produced in the forests is greatly susceptible to the projected climatic alterations within 50 years.

• Last but not the least, 77% and 68% of the forested grids may alter in forest types by the end of the year 2085.

Conclusion

Climate change is caused by the change in each component of the climatic system such as atmosphere, hydrosphere, biosphere, cryosphere and lithosphere or by complicated interactions among those components. Considering all of these scenarios, agriculture must require better management practices of natural resources such as land, water and genetic resources to have more resilience to climate change. It takes at least 5 to 10 years to assess the impacts of climate change and the vulnerability to it and prepare proper countermeasures against it. Especially, as agriculture is climate dependent and thus susceptible to climate change, it is very urgent to prepare adaptation measures against climate change.

Reference

Cline, W., 2007. Global Warming and Agriculture: Impact Estimates by Country. Center for Global Development and Peterson Institute for International Economics: Washington DC.