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## Impact of climate change on agriculture

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### Abstract

Climate change refers to change in the series of events that includes rainfall, temperatures, snowfall and the winds which lasts for long time. Nowadays climate change has become a serious concern which is affecting many sectors. Change in climate will have a negative impact on yield, productivity of the crop and economy of the country. It also affects the disease cycle and pest out break and crop management practices and harvesting. Adoption of right practices and mitigation is the only way to cope up with climate change.

**Keywords:** Climate change, agriculture, rainfall

### Introduction

The term "climate change" refers to shifts that occur in the average temperature of an area and the patterns of its weather over long periods of time. These changes might be caused by a change in the solar cycle<sup>[8]</sup>. Climate change connects by natural processes.

Climate change has become a primary issue for human beings due to the frequent occurrence drought and floods effects on thousands of people who depend on the land their needs<sup>[14]</sup>. The world economy is impacted by the occurrence of natural disasters such as landslides, forest fires, cold waves, heat waves, floods, and droughts etc, and it has led to change in the chemical make-up of the atmosphere<sup>[12]</sup>.

Among different green house gasses [CO<sub>2</sub>, Co, N<sub>2</sub>O, CH<sub>4</sub>, O<sub>3</sub>, CFC] CO<sub>2</sub> plays a major role increase in the atmosphere temperature, as well as anthropogenic practice such as burning of fossil fuels which results in change in rainfall pattern<sup>[11]</sup>.

Agriculture is a major contributor and it is most affected by climate change<sup>[13]</sup>. In order to have food security, it is necessary to have awareness about the change in climatic pattern overtime and necessary adjustment to crop management procedures in order to have higher productivity in agriculture sector<sup>[9]</sup>.

### Causes of climate change

Climate change mainly caused human activities including deforestation and the combustion of fossil fuels, both of which contribute to an overall rise in the temperature of the world. Mostly these greenhouse gases (CH<sub>4</sub>, CO<sub>2</sub>, CFCs, N<sub>2</sub>O) occur naturally, but nowadays due to anthropogenic activities the gases concentration in the atmosphere are increasing<sup>[15]</sup>.

### Causes for rising emissions

- Nitrous oxide and Carbon dioxide are produced as a byproduct of the combustion of fossil fuels including coal, gas and oil.
- Trees have significant role to play in climate regulation by drawing carbon dioxide down from the air and storing it in their tissues. Cutting trees leads to lose of its beneficial effect.
- The CO<sub>2</sub> stored in the trunks of trees has been releasing into the atmosphere which results in greenhouse effect.
- Use of nitrogenous fertilizers leads to emission of nitrous oxide.
- Emissions of fluorinated gases, which may originate from appliances like air conditioners and freezers, have a warming effect up to 23,000 times stronger than that of CO<sub>2</sub>.
- In the case of livestock, after the digestion of the food in their stomach, cows and goats produce large amounts of methane, which later releases into atmosphere<sup>[10]</sup>.

### Climate change and how it impacts agriculture

Global climate and agricultural systems are interrelated. The Earth's temperature is rising because of unchecked rise of greenhouse gas emissions. In addition, the melting of glaciers will lead to more precipitation, more intense weather, and changing seasons. The stability of the global food supply is under threat as a consequence of climate change, as well as growing economic and population levels. Climate change has a negative impact on agriculture, reducing output. Increasing average atmospheric temperatures as a result of human-caused climate change has emerged as a major trend that has the potential to profoundly alter the course of human history.

### Impact of climate change in global context

Alarming impact of change in climate on the globe has now-a-days been in the priority topics all around the world. The global temperature has rose to about 1.1 degrees past 120 years but is expected to rise about 1.4 degree to about 5.2 degrees by 2100<sup>[16]</sup>. Due to more research on climate change, world is getting to know more about it thus lots of precautions are being taken to control it. Climate change is leading to an arise in sea level from an average of 1.7 mm/year in 20<sup>th</sup> century to 3.2 mm/year after 1993<sup>[17]</sup>. There is a rapid increase in melting down of glacier which has decreased >60 ft. after 1980. Due to climate change central, south, east and Southeast Asia large river basins are continuously decreasing. The Great Barrier Reef and Queensland Wet Tropics of Australia is suffering biodiversity losses. In Europe there is reduction in water availability; mountain's snow cover is reducing. In central and Eastern Europe water stress will increase due to reduced summer precipitation<sup>[18]</sup>.

Global economy is suffering a lot because of change in climate. It is having an impact on Infrastructure, Productivity, Agriculture market, ecosystem, tourism and many other sectors. The rise in global temperature by 0.03 degree C/year, will reduce world real GDP per capita by 7.22% by 2100<sup>[19]</sup>. According to a report by Swiss Re Institute, The largest impact of climate change is that it could harm 18% of GDP of worldwide economy by 2050 if the global temperature rises by 3.2 degree C<sup>[20]</sup>. Due to Sea level rise there is high risk of loss of trillions of dollars due to expected submergence of coastal cities into sea. The rapid increase in flood conditions every year across the world is also leading to massive damage of infrastructure, Agriculture, Connectivity etc.

### Impact of climate change in Indian context

India is facing problems in different sectors due to climate change. The unstable pattern of annual rainfall is leading to different drastic conditions. It is resulting in flood to some parts of India and also destruction of crops. Due to increase in temperature in northern India there is downfall in production of Rabi crops. Kharif crops are facing drought in some states like Jharkhand, Orissa, Chhattisgarh and north western India whereas at the same time some states faces flood situation like Bihar and Assam<sup>[21]</sup>. Overall result of these situations is leading to low annual production thus population has to suffer malnutrition. These atrocities also lead to Economic losses in different sectors. Due to increase in concentration of small dust particles in the lower atmosphere is resulting in reduction of monsoon in southern India. The early heat wave of 2022 has broken past 100 years record<sup>[22]</sup>.

Indian economy is said to be about 31% smaller due to impacts of global warming and climate change caused due to it<sup>[23]</sup>. Some sectors like energy, tourism, agriculture and

transport have suffered majorly in India and thus dealt with severe socio economic losses. According to World Bank report 7 of the 10 severe hotspot districts are in Vidarbha region of Maharashtra. Rests are in Chhattisgarh and Madhya Pradesh<sup>[24]</sup>. These hotspots suffer maximum GDP losses of around 9.8% in compare to country's average of 2.8%<sup>[25]</sup>. According to International Labour Organization there could be big loss of jobs in upcoming year due to increased heat stress.

### Impacts of Climate Change on Indian Agriculture

Because of climate change, India's agriculture is especially susceptible to the negative consequences of drought. This is due to the fact that more than two-thirds of India's land is rainfed, as well as the country's irrigation infrastructure is dependent on the monsoon rains. Flooding is a serious issue across the nation, but it is particularly prevalent in the eastern region, where it occurs on a regular basis. In addition, the northwestern cold, the central and northern heat waves, and the eastern coast cyclone all wreck havoc. These climatic extremes are occurring with more regularity recently as a consequence of the elevated temperature in the atmosphere. This has raised the possibility of severe losses in agricultural productivity as a result. Indirect and direct impacts on crops, soils, animals and pests may be caused by climate change. Crops having C3 photosynthetic pathways benefit from an increase in atmospheric carbon dioxide, which in turn boosts their growth and yield. The effects of climate change could include a reduction in crop duration, an increase in crop respiration, a change in the process of photosynthesis, a change in the survival and distribution of pest populations, a hastening of the mineralization of nutrients in the soil, a reduction in the efficiency with which fertilizer is used, and an increase in evapo-transpiration, among other things. The irrigation water's availability, severity and frequency of inter-seasonal droughts as well as flooding, the transformation of soil organic matter, changes in pest profiles, soil erosion, a reduction in arable regions due to the submergence of coastal land, and the availability of energy are all ways in which agriculture in India is indirectly affected by climate change. Climate change poses significant issues for the agricultural industry<sup>[3]</sup>.

1. Change rainfall patterns, changes in stream flow, and a rise in agricultural water demand are all factors that affect water availability.
2. Following to seawater intrusion, the movement of salts from deeper soil layers, and overexploitation of aquifers and poor irrigation techniques that cause the degradation of water quality.
3. An increase in the severity and frequency of severe weather effects like flooding along with hurricanes would have more of an effect on productivity than a change in the climate's average.
4. Higher temperatures at a vital point in the crop's development cause heat stress.
5. Disease and Pest populations may change unexpectedly. Changes in climate have the potential to elevate even small pests to the status of significant pests. Disease and Pest, livestock, water, and fisheries are all included in the following list of effects (Aggarwal *et al.* 2009)

### Climate change's effect on Crops

- Increase in CO<sub>2</sub> is helpful because it improves photosynthesis and reduces evaporative losses in a

variety of crops, notably those that use the C<sub>3</sub> photosynthesis mechanism, including rice and wheat. A rise in air temperature may diminish rainfall and irrigation water supplies, although this will not have a significant impact on the yield.

- Extreme weather occurrences, including heat waves, droughts, floods, along with cyclones, are becoming more frequent and longer in duration.
- Increased agricultural water demand and variations in monsoon rainfall patterns have resulted in a reduction in yield in rainfed regions.
- The quality of medicinal plants, aromatic, coffee, tea, vegetables, and fruits, have decreased throughout the years.
- Increased vector and pathogen growth, quicker disease transmission, and enhanced host sensitivity are all contributing to changes in agricultural pests and diseases.
- Increased drought, storm, flood frequency and severity are major threat to agricultural biodiversity due to climate change and rising sea levels <sup>[5]</sup>.

#### Climate change's effect on water

- As temperature rises, the rate of evapotranspiration increases, leading to increase in irrigation requirements. Groundwater levels may be lowered in certain areas as a consequence of this.
- The melting of Himalayan glaciers may cause a rise in availability of water in the Brahmaputra, Ganges, along with their tributaries, but then in long term, the availability of water will decline significantly <sup>[7]</sup>.
- Runoff is expected to rise significantly during the rainy season, which might contribute to an increase in flood frequency and duration as well as soil erosion. The extra water, on the other hand, may be collected and stored for later use.
- The quality of groundwater along the coast of India is expected to be further influenced by the entry of sea water, which would disrupt the water balance in various sections of the country <sup>[6]</sup>.

#### Climate change's effect on soil

- Crop residues have a greater C:N ratio when CO<sub>2</sub> concentrations are raised, which may lower their decomposition rate and nutrient delivery in Indian soil, which is already relatively low.
- Increased soil temperature will lead to an increase in N mineralization; however the availability of this mineral may be reduced owing to processes like volatilization and denitrification.
- Changing rainfall amount and frequency, as well as wind strength, may affect soil erosion. It is possible that rising sea levels will make coastal areas less suited for traditional farming.

#### Climate change's effect on livestock

- The production of feed and the nutrition of cattle are directly impacted by climate change. The lignification of plant tissues is accelerated and the digestibility is decreased as a consequence of elevated temperatures. The production of food and fodder would be reduced as a result of reduced water availability.
- By increasing the number of vectors, climate change has a significant influence on vector-borne livestock diseases

in colder regions. Rainfall patterns may also impact how quickly vectors spread, which can lead to significant outbreaks of diseases.

- The need for water, housing, and energy for animals to satisfy predicted milk demand would grow because of climate change. In dairy cows, climate change is predicted to worsen the effects of heat stress, resulting in a decrease in reproductive efficiency <sup>[1]</sup>.

#### Climate change's effect on fisheries

- Fish spawning, migration, and harvest are anticipated to be affected by rising river and sea water temperatures.
- A rise in tropical cyclonic and temperature activity will have an effect on the cost of fishing, producing, and selling marine species.
- A rise in sea surface temperature is expected to exacerbate coral bleaching.

#### Climate change's effect on the horticultural industry

- Fruit setting in citrus fruits is hampered when plants are exposed to very high temperatures, owing to the large transpiration losses that result. Blossoms on young trees are more susceptible to being scorched or burned by high temperatures.
- Navel oranges have been shown to be significantly damaged by high temperatures during the flowering stage of their growth. Temperatures over 90 degrees Fahrenheit may cause fruit trees including apricots, cherries, and apples to develop sunburn and cracking signs.
- Flooding has wreaked havoc on the majority of food crops, notably tomatoes. The buildup of endogenous ethylene is another potential source of severe crop harm <sup>[2]</sup>.

#### Impact of climate change on pest and diseases incidence

- Expansion of geographic range by insects and pathogen.
- Changes in pest and pathogen growth rates and population.
- Quantity and biology of bio-control agent may change.
- Migrant infections as well as pests pose a significant risk due to the emergence of new disease/pest concerns <sup>[4]</sup>.

#### Mitigation and adaptation

There is an urgent need to adapt to life in a changing climate. Certain measures are necessary to be taken as soon as possible keeping in mind the upcoming consequences in near future possible due to climate change. The evaluation of risk due to changes in climate is necessary with the help of different research projects. These evaluations may help us in reducing the impacts that are possible in short or long term by controlling, lowering the impacts and making situation sustainable.

The integrated adaptation is the best way to tackle this atmospheric change. There is a necessity to raise awareness among people and government of different countries. Different organizations need to fulfill their roles and responsibilities in spreading awareness at local as well as national level. Collecting basic information and utilizing it in managing certain areas and sectors for planning adaptive measures. Promotion of technology in these areas may help in effective adaptation to improve societies. The mitigation efforts needed for the impact of climate change are not going to work with few changes; there is need for certain strict policies for success of these efforts <sup>[26]</sup>.

To reduce climate change, heat trapping of greenhouse gases in the atmosphere should be reduced. This can be done by reducing the source, from where these gases mostly come from. The soil, Ocean and Forests absorb these gases which is also needed to be enhanced as these works as sinks for these poisonous gases. Anthropogenic emission of gases can be reduced by improvement in energy generating units to lowering emission of carbon. Curbing the growth in energy demand may cost less in compare to adaptation. Promotion of Public transport, ecological industry, agriculture and livestock, Building of sustainable buildings, Afforestation etc. can help in mitigation. Crop diversification can help in adapting to climate change.

There is a need to plan energy efficient mobility of increasing population, also the infrastructural planning, Grazing or rearing of livestock leads directly or indirectly to deforestation, thus to reduction of livestock farming is an option which can eventually help in providing more land for cultivation. Increasing the Reuse method and replacing single use items can be helpful thus people can purchase less and share more.

Measures that may help to mitigate impact of climate change, Heat tolerant varieties can be developed, Water should be saved, Flood tolerant varieties can be developed, weather forecast needs to work at more accuracy in context of any sudden climate change, reuse of all the different sources of water, Conservation of forest is a must, prevention of groundwater from salinization. Erosion control facilities needs to be improved, assessment of disaster risks possible, control systems needs to be upgraded and new technologies needs to be developed for countermeasures<sup>[27]</sup>.

### Limiting factors of adaptation

Food is the most fundamental necessity of life for humans. An increase in agricultural output has been shown to reduce the number of absolute poor families by 0.6–1.2 percent for every 1 percent increase. Additionally, it is anticipated that in 2050 the world's population would increase to 9.7 billion, that would need an increase in agricultural produce of almost 70 percent. In the future decades, rainfed agriculture is expected to supply one-third or more of the additional food produced globally<sup>28</sup>. Crop yields are being harmed because of an increase in the severity and frequency of severe weather events. This means that factors such as temperature, air pollution, as well as water availability have a significant influence on agriculture<sup>[28]</sup>.

### Environmental factors

Abiotic and biotic restrictions are two categories of environmental influences on crop production. Environmental stressors may have a detrimental impact on a plant's growth and production. These changes can occur in the plant's structure and function, as well as in the plant's molecular and biochemical compositions. Other variables comprise useful organisms (such as beetle pollinators), pests (e.g., arthropod disease, parasitic nematodes), and human-induced evolution<sup>[29]</sup>.

### Abiotic constraints

#### Drought

Drought is a condition when the quantity of water available to a crop (via rainfall and/or irrigation) is inadequate to fulfil its evapotranspiration demands. Changing water availability (seasonal and volumes distribution), as well as water demand

for agriculture and other competing sectors, is a major factor in determining climate change.

### Heat stress

When the temperature rises over a certain threshold for an extended length of time, it is referred to as heat stress<sup>[29]</sup>. In plants, heat stress has detrimental effects on all phases of development, such as the growth and function of the reproductive organs.

### Cold stress

Plants that are exposed to cold or chilling stress at temperatures ranging from 0 °C to 15 °C suffer significant crop losses. Non-freezing low temperatures may harm or destroy tropical and subtropical crops, depending on the kind of crop.

### Soil properties

Weathering of rocks, humus production, and material transport all contribute to the creation of soils. Their origin, look, qualities, and capability for production all differ widely<sup>[29]</sup>. Defining soil fertility is the capacity of a soil to provide the nutrients necessary for a certain crop to thrive.

### Floods

Plants may experience a variety of stresses as a result of flooding, the majority of which are determined by the depth and length of the water. Rice, like many other wetland species, does well when plants are not entirely immersed in water and suffers less damage as a result from soil waterlogging than other crops.

### Biotic factor

#### Diseases and pests

Different types of microorganisms, including viruses, fungus, and bacteria, are responsible for the development of plant diseases. The productivity of crops is also negatively impacted by a wide variety of soil-borne and above-ground insect pests. Changes in the weather conditions often encourage the proliferation of diseases, while also having a detrimental impact on the production of plants and the fertility of the soil<sup>[29]</sup>.

### Conclusion

Climate change is real, and as a result, there is a need for a wide range of technological innovations in agriculture to maintain and improve the productivity. These innovations include agronomic and management practices, farm machinery, pesticides, adaptive microbial technology, fertilizer technology, genetic development of varieties. These innovations were achieved through research programs for understanding their implications in improving crop productivity as well as follows method to transform and reorient agricultural schemes for supporting food security under the novel climate change realities<sup>[30]</sup>.

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