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Review Paper

IMPACT OF CLIMATE CHANGE ON AGRICULTURE

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Abstract: India is a diversified land with different types of climate and soils requiring different types of farming. When agriculture started on the planet Earth, the climate was remarkably stable. However, now the Earth's temperature is rising, possibly due to the green house effect – the warming that results from the rising concentration of heat trapping gases, mainly due to carbon dioxide present in the atmosphere. There are two reasons which are mainly attributing to the increase in carbon dioxide concentration, first the burning of fossil fuels and the second being deforestation. Excessive rise in the use of chemical inputs has also led to the adverse environmental and health impacts on farm workers and consumers.

Keywords: atmosphere, climate, green house gases, weather

INTRODUCTION

'Climate' when defined, is actually the average weather of a given region or area over a given period of time. It results due to the balance between sun, atmosphere, oceans, water systems, topography, plants and all living organisms. As per the IPCC (Inter governmental Panel on Climate Change, 2001), 'Climate Change' refers to any change in climate over time, either due to natural variability or as a result of human activity. The major causes to climate change has been accredited to the increased levels of greenhouse gases like carbon dioxide (CO_2), methane (CH_4), nitrous oxide (NO_2) and chlorofluorocarbons (CFCs). This is mainly due to the uncontrolled activities such as burning of fossil fuels, increased use of refrigerants and enhanced agricultural related practices.

Climate change is globally the most important environmental challenges of the present century. In developed and developing countries, the response to climate change varies greatly. The most visible impacts of climate change are the increased global mean surface temperature (projected to rise by 3.5 – 5^0C by 2100), CO_2 concentration is increasing by 1.9 ppm each year and is expected to reach 550 ppm by 2050 and 700 ppm by 2100; increased

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frequency and severity of drought, variations in precipitation and increased heavy precipitation events. All these manifestations have a significant impact on agriculture.

Global warming and climate change are often interchangeable used and understood. However, these terms are not identical. Climate change includes both warming and cooling conditions, while global warming pertains only to climatic changes related to increase in temperature (Grover, 2004).

Table 1: HISTORY OF CLIMATE CHANGE

Year	Event
1890	Scientist targeted carbon dioxide as a warming gas and said burning of fossil fuels like coal may lead to global warming
1927	Scientist Milankovic stated that changes in the earth's orbit causes climate change
1956	found that human activity raises temperature 1.1^0C every century
1983	threats of human emissions in the atmosphere including melting of ice caps
1992	At the climate change convention in Rio – de Janerio 154 nations signed an agreement for voluntary emission reduction
1997	Kyoto protocol sets emissions cut
2003	It became the hottest years on record

GREEN HOUSE EFFECT AND GREEN HOUSE GASES

The solar radiation from the Sun reaches the Earth's atmosphere. The surface of the Earth absorbs most of the short – rayed insolation and later releases this heat in the form of infrared radiation into the atmosphere. Some of the heat is absorbed by particles known as 'greenhouse gases'. The heat retained by the gases acts as a 'heat blanket'. The major green house gases include:

Water Vapour

The most abundant green house gas (GHG) in the atmosphere is water vapour but human activities have little direct impact on the atmosphere. It is expected that increased levels of other GHG may increase the H_2O vapour content in the atmosphere due to higher evaporative capacity of air resulting from global warming which may be viewed as a feedback.

Carbon Dioxide (CO_2)

Carbon dioxide is a colourless, odourless and non – flammable gas and it is the most prominent green house gas in the earth's atmosphere. Carbon dioxide is used by plant in

photosynthesis for making sugars. It is produced during respiration by plants, animals, fungi and microorganism that are dependent directly or indirectly on plants for food. Carbon dioxide is produced by burning of fossils fuels and deforestation. When we burn fossil fuels, we add carbon to the atmosphere. This carbon is in addition to the natural carbon cycle and comes from deposits far underground or under the ocean floor that otherwise would have remained stored for the foreseeable future. This creates a surplus of CO_2 that remains in the atmosphere for a long time.

The CO_2 concentration in the atmosphere is now about 31^0c higher than 200 years ago. Burning of fossil fuels by automobiles, industries, power houses, clearing and burning of vegetation, extensive use of coal and cow dung cakes for domestic energy needs are the main causes of the increased levels of this gas.

Methane (CH_4)

Methane is the next biggest contributor to global warming due to intensive cultivation of agricultural crops especially rice. Methane is the second most important green house gas. Methane is colourless, odorless flammable gas. Natural sources of methane are tropical and northern wetlands and methane oxidizing bacteria that feed on organic material consumed by termites, Methane is also released by paddy field and livestock farms.

The concentration of CH_4 in the atmosphere has risen by about 151% over the last 200 years (IPCC, 2001). Digestive processes in ruminant animals (e.g. cattle, sheep, goats, deer), venting of natural gas and waste decomposition in landfills are also some of the sources of CH4 emissions.

Nitrous Oxide (N_2O)

Industrial emissions and the anaerobic conditions in agricultural soils due to water stagnation and increased use of inorganic fertilizers and addition of organic material under submerged conditions on soil are the major sources of nitrous oxide. Nitrous oxide levels in the atmosphere are estimated to have increased by 18^0 C in the last two hundred years mainly due to more intensive agricultural practices. The biological processes involved in nitrous oxide emissions from soil are not well understood and consequently there is considerable uncertainty with estimations of agricultural nitrous oxide emissions.

Halocarbons

Halocarbons of greenhouse significance include per fluorocarbons (PFCs), emitted primarily during aluminum production and hydro-fluorocarbons (HFCs) widely used in refrigeration units and in cosmetics sprays. Higher concentrations will have a direct bearing

on atmospheric ozone layer, which protects life from harmful ultraviolet radiations. It was estimated that this man made pollutant had resulted in 40% depletion of ozone in the northern hemisphere.

Table 2: Global CO_2 Emission and the Country Share

Country	CO_2 emission in Tonnes	% share in World	Per capita emission in Tonnes
Australia	377	1.42	18.50
Brazil	334	1.26	1.80
China	5060	19.06	3.90
India	**1149**	**4.33**	**1.10**
Japan	1214	4.57	9.50
Russia	1544	5.81	10.80
US	5841	22.00	19.70
EU	3271	12.32	8.50

(**Source:** World Development Indicator, 2010)

Facts to Know:

- India is the fifth largest emitter of green house gases, behind China, the United States, the European Union and Russia.
- Its annual carbon dioxide emission is in the range of 1.2 to 1.4 billion tonnes.
- Its annual green house gas emission CO_2 plus five other gases including methane is in the range of 1.6 to 1.8 billion tonnes.
- Between 1990 and 2004, India's carbon dioxide emissions grew by about 7% on an average.

CAUSES OF CLIMATE CHANGE

A. Natural Causes

- Continental drift
- Volcanoes
- Ocean currents
- Earth's tilt
- Comets meteorites and asteroids

B. Manmade Causes

- Burning of fossil fuel
- Change in land use pattern

- Industrialization
- Urbanization
- Deforestation
- Transportation

POTENTIAL IMPACT OF CLIMATE CHANGE ON AGRICULTURE

Agriculture is one sector, which is immediately affected by climate change, and it is expected that the impact on global agricultural production may be small. The potential effect of climate change on agriculture is the shifts in the sowing time and length of growing seasons geographically, which would alter planting and harvesting dates of crops and varieties currently used in a particular area. Seasonal precipitation distribution patterns and amounts could change due to climate change.

- Geographical shifts and yield changes in agriculture
- Reduction in the quantity of water available for irrigation
- Loss of land through sea level rise and associated salinization
- Changes in rainfall and temperature
- Changes in the frequency of extreme climatic events
- Shift in patterns of plant diseases and pests could lead to decreases in agriculture productivity

Water Requirement

The demand of water for irrigation is projected to rise in a warmer climate bringing increased competition between agriculture, already the largest consumer of water resources in semi-arid regions and urban as well as industrial users. Falling water tables and the resulting increase in the energy needed to pump water will make the practice of irrigation more expensive.

Climate variability

Climate variability can be a preamble to the expected long-term changes in climate. In southern Asia region, where certain varieties of crops are grown near other limits of maximum temperature tolerance, such as rice, heat spells can be particularly detrimental. Similarly, increased drought frequency can not only reduce water supplies but also increase the amount of water needed for plant transpiration.

Soil fertility and erosion

The soil fertility status is also influenced significantly by higher air temperatures. Warmer conditions are likely to either enhance or reduce the natural decomposition of organic matter depending on the moisture availability. Higher temperatures can also increase the rates of other soil processes that effect fertility. Increase in CO_2 concentration can lower pH which directly affects the nutrient availability.

Pests and diseases

Conditions are more favourable for the proliferation of insect pests in warmer climates. Longer growing seasons helps insects such as grasshoppers to complete a greater number of reproductive cycles during the spring, summer and autumn. Warmer winter temperatures also allow larvae to grow in winter, thus causing greater infestation during the following crop season with altered climatic conditions. Livestock diseases may also be affected in the same way.

Weeds

Similar to crops, weeds will also be directly affected by changes in climate and in CO_2 and thermal regime levels. Insects and diseases are not likely to be directly affected by CO_2 changes, but may be affected indirectly because of altered host-plant metabolism, development and morphology. The C_3 weeds will show better response to elevated CO_2 than C_4 weeds but as compared to crop plants both will show better response to elevated CO_2.

If the photosynthetic pathway is same for crop and weed, then weed growth is favoured when CO_2 is increased. Weeds that are reproduced by vegetative means may show strong response to atmospheric CO_2. Canada thistle (*Cirsium arvense)* and quack grass (*Elytrigia repens)* became more resistant to herbicides when grown in higher concentrations of CO_2. The CO_2 enrichment reduced the effects of water stress, increased leaf area and total dry weight of the three C4 grasses *viz., Echinochloa crusgalli, Eleusine indica and Digitaria ciliaris*.

River system

Climate change is also expected to increase both evaporation and precipitation in some regions. However, if the rate of evaporation exceeds the rate of precipitation, soil will become drier, lake levels will drop and rivers will carry less water. Warm water will likely increase Blue Green Algae and other unproductive algae that can reduce the levels of dissolved oxygen.

As temperature increases many fishes try to look out for the cooler regions. Either they may try to move upstream of river or into greater depths which is not possible in smaller rivers and lakes.

EFFECT OF CLIMATE CHANGE ON CROP YIELD

The change in crop yield is dependent on changes in rainfall and CO_2 concentration. Photosynthesis is enhanced when additional carbon is available for assimilation and yield will generally rise. In middle and higher latitudes, global warming will extend the length of growing period allowing early planting of crops in the spring, earlier maturation and harvesting and the possibility of completing two or more cropping cycles during the same year. Most commercial crops including wheat, rice, barley, oats, potatoes and most vegetable crops tends to respond favourably to increase CO_2, with a doubling of atmospheric CO_2 concentration leading to yield increase in the range of 15 – 20^0C. Other crops include corn, sorghum, sugarcane and many tropical grasses which are less responsive to increase in CO_2.

EVIDENCE OF GLOBAL WARMING

The climate is changing. The main reason of climate change is the increase in the concentration of green house gases in the atmosphere due to several natural and anthropogenic activities. There are both physical and biological evidence of climate change which are discussed below:

A. Physical evidence

- Rise in atmospheric temperature and CO_2 level
- Uneven distribution of rainfall
- Shifting and shrinking of cooling period
- Changing pattern of monsoon
- Occurrence of natural disasters like earthquakes, volcanoes, forest fire etc.

B. Biological evidence

- Early blossoming of trees
- Appearance of grasses in Antarctica
- Changing cropping pattern

Adaptation options to climatic change

To combat with the changing climate, certain rules may be followed which are as follows:

- Changing varieties / crops

- Altering fertilizer rates to maintain grain or fruit quality and be more suited to the prevailing climate
- Altering amount and timing of irrigation
- Water harvesting
- Conserve soil moisture (e.g., crop residue retention)
- Use water more efficiently
- Altering the timing or location of cropping activities
- Diversified income including livestock raising

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