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Changing Climate Scenarios: Strategies for Future Agriculture in Uttrakhand

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Abstract

Increasing concentration of green house gases in the atmosphere have already been documented and proved undoubtedly. Global Climate as a whole, is a phenomena which is affected or balanced by many interlinked processes of various systems in atmosphere, ocean etc. Considerable concerns have been made regarding human induced climate change as changed weather will certainly going to affect agriculture. Previous ice core samples and ocean sediments depicts climate change events in history also. Nevertheless, the present scenario of global warming is supposed to be due to escalating concentration in atmospheric green house gases, which change the heat balance of the earth surface. The recent trend includes in global sea level and northern hemisphere snow cover, rising global mean temperatures and increased extreme climatic events in India during last few decades.

Various General Circulation Models have projected the global warming could shift temperature zones, rainfall patterns and agricultural belts. Receding glaciers due to global warming are also reported in case of various studies on Dokriani glacier in Gangotri valley, Parbati glacier in Himachal's Beas basin and other different glaciers. The glaciers are also breaking. The warming may account for about 0.8 to 3 inches of the total expected sea level rise, while the retreat of glaciers and ice may account for about 0.8 to 2 inches. As predicted by the various climate models, by 2100 a rise of 1.8 to 4oC is expected in the average global temperature. Productivity of most cereals would drastically affected due to increase in temperature and decrease in water availability. Increased events of droughts and floods are likely to increase production variability.

To mitigate the adverse effect of climate change, conservation of the natural resources and their effective use, proper water conservation techniques and change in the priorities in research and technology should be ensured in future. Adoption of techniques like minimal tillage, residue management and increased production and use of biofules may be helpful in reducing the Green House Gases emission into the atmosphere.The strategies must include breeding of drought and water stress tolerant varieties,improvement in irrigation and water use efficiency of crop plants, reducing atmospheric concentration of greenhouse gases by adoption of various ecofriendly techniques, increase in productivity of existing farmed area and reduce deforestation and paddy plantation which contribute to CH4 emission and modification of microclimate for increasing productivity of crop.

Keywords: Changing climate scenarios; Global climate or in regional climates.

Introduction

Climate change is the variation in the global climate or in regional climates over time. It describes changes in the average state of the atmosphere that includes average weather over time scales for decades to millions of years. The changes in climate may be due to processes internal to the Earth or

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be driven by external forces. Most recently, they are mainly caused by human activities all over the globe. Now a days, the term "climate change" generally refers to the ongoing changes in modern climate, including the rise in average surface temperature widely known as global warming. The atmospheric blanket acts as Green House. The incomming short wave solar radiation heats up the earth and then the earth emits long wave radiation into the atmosphere. This green house effect or heat trapping in the atmosphere is very much necessary for sustaining life on the earth. Due to rapid industrilization in 19th century the concentration of many gases which can trap the long wave radiation emitted from earth is escalating and this results in the continuous rise in the global mean temperature in the atmosphere. Previous records show that the slight change in the globa mean temperature may have implications in many aspects of the various systems on the earth. IPCC has reconfirm that the increase in the concentration in the green house gases is a consequence of human activities since 1750 exceeding for the pre industrial values.[1]

Past climate records

Various geological records of carved mountain valleys, scratched bedrock, and glacial debris and moraines give evidence of the past several million years. In recent times, cores removed from the ice in Antarctica throw some light on the past climate. The longest cores are about 2000 meters, sampling layers of ice deposited as early as 160,000 years ago. The ice traps bubbles of air when it froze. The ratio of oxygen isotopes in this air is used to study the average air temperature at the time the bubble was trapped in ice including atmospheric greenhouse gases. Besides this fossil plants and the distribution of pollen show the change in vegetation, consistent with the changing climatic scenarios over the time scale. Various studies on air bubbles in ice cores correlate the higher temperature with more carbon dioxide.

The Present Scenario

The increased concentration of the so-called atmospheric greenhouse gases, viz. carbon dioxide and methane, chlorofluorocarbons, Nitrogen dioxide, ozone affect the atmospheric temperature. Humans are putting the carbon dioxide into the air by burning fossil fuel or wood. Methane is the primary component of natural gas and it emits from garbage dumps. Chlorofluorocarbon compounds like Freon are used in refrigeration systems. CFC's are greenhouse gases as well as destroyers of ozone. It is established that GHG's are currently increasing, and it seems to be getting warmer the last few decades. Global warming is the increase in the average measured temperature of the Earth's near-surface air and oceans.The average global air temperature near the Earth's surface increased 0.74 ± 0.18 °C (1.33 ± 0.32 °F) during the 100 years ending in 2005.[1] The Intergovernmental Panel on Climate Change (IPCC) concludes "most of the observed increase in globally averaged temperatures since the mid-twentieth century is very likely due to the observed increase in anthropogenic (man-made) greenhouse gas concentrations"[1] via an enhanced greenhouse effect. Natural phenomena such as solar variation along with volcanoes had a small warming effect from pre-industrial times to 1950 and a small cooling effect from 1950 onward.[2,3] In the scenario of declining water resources and challenges to produce more to feed growing population productive use of water is of prime importance.[4] These basic conclusions have been endorsed by many scientific societies and academies of science. The overwhelming majority of scientists working on climate change agree with the IPCC's main conclusions.[5,6] The quantity of rainfall and its distribution has also become more uncertain. Extreme climatic extremes like droughts, floods, time and duration of rainfall and snowmelt have also increased. The sea level has risen by 10-20 cm with regional variations.[7] The total annual output of methane into the atmosphere from all sources in the world is estimated to be 535 Tg/year. Nitrous oxides, which are present in the atmosphere at a very low concentration (310 ppbv), are increasing at a rate of about 0.25% per year. N_2O is becoming important because of longer lifetime (150 years) and about 300 times global warming potential than CO_2.[7]

The Himalayan glaciers feed major rivers like Indus, Ganges and Bhramputra glaciers are highly sensitive, large scale indicators of energy balance in the polar and mountain regions. They are of enormous importance to local, regional and continental water resources. Receding glaciers due to global warming are also reported in case of various studies on Dokriani glacier in Gangotri valley, Parbati glacier in Himachal's Beas basin and other different glaciers. The glaciers are also breaking. There are evidences that glaciers are receding at rapid rate.[13]

Future predictions

It is estimated that by the end of 21st century an increase of 15-40% in the rainfall over India and in mean annual temperature of 3-6O C.[14] On the other hand a report of the IPCC entitled, "Climate change

2001: Impacts, Adaptation, and Vulnerability", released during 2001 projects that the global average temperature above the earth's surface would rise 1.4-5.8 degrees Celsius over the next 100 years.[15] More flooding, droughts and forest fires, decreases in agricultural productivity, displacement of tens of millions of coastal dwellers by sea level rise and intense tropical cyclones, and the degradation of mangroves and coral reef ecosystems are the likely consequences of climate change in Asia.

In general certain direct and indirect consequences on agriculture is expected due to future climatic change. Global ambient temperature increase may hasten maturity of different crops, increase respiration rate, quickening nutrient mineralization, increase water requirement of crops by increasing crop evapotranspiration.

The rising temperature and uncertainties in rainfall associated with global climate change may have serious direct and indirect consequences on crop production and hence food security.[8] General Circulation Models (GCMs) are widely used to throw light on future climate/Climate model projections summarized by the IPCC indicate that average global surface temperature will likely rise a further 1.1 to 6.4 °C (2.0 to 11.5 °F) during the twenty-first century.[1] Although most studies focus on the period up to 2100, warming and sea level rise are expected to continue for more than a thousand years even if greenhouse gas levels are stabilized. The delay in reaching equilibrium is a result of the large heat capacity of the oceans.[1]

Increasing global temperature is expected to cause sea levels to rise, an increase in the intensity of extreme weather events, and significant changes to the amount and pattern of precipitation, likely leading to an expanse of tropical areas and increased pace of desertification. Other expected effects of global warming include changes in agricultural yields, modifications of trade routes, glacier retreat, mass *species* extinctions and increases in the ranges of disease vectors, crop weed and crop pest interactions.

An analysis of the mean annual surface air temperature over India for the period 1901-1988 based on 73 stations shows a significant warming of about 0.4 °C per 100 years.[9] The Inter–Governmental Panel on climate change has compiled the magnitude of change in temperature, rainfall and carbon dioxide for different parts of the world[10] according to which, by 2010, CO_2 level will increase to 397-416 ppm and to 605–755 ppm by 2070.

Future Implications on agriculture

IPCC has projected slight increase in crop productivity in temperate regions in response to increase in temperature of 1-3 OC , while the decrease in cereal yields in dry and tropical regions in response to even small increase of 1-2 OC in temperature.[13]

The increased concentration of CO_2 will benefit crops like rice , wheat and pulses[19] whilst some studies indicate a probability of loss of crop production in India due to increased temperature for the period of 2080-2100 of 5-30%.[16,17]

The increased run off all over the world is predicted.[13] This will increase water flow in wet season and its unavailability in dry season. The receding glaciers owing to global warming would further aggravate the future run off situation.

There will be decrease in fertilizer use efficiency with increase in temperature. This is expected to promote high fertilizer use in future in turn further aggravate the green house gases emission from agricultural fields. in agro ecosystems having low input would be the least affected systems due to low fertilizer use efficiency.[19]

Major Strategies to Mitigate climate change

Efficient rainwater harvesting and water conservation techniques

Extreme climatic events are expected to be on rise due to climate change. Various palaeoclimatological evidences indicate the 'climate change-rain water harvest' hypothesis. The heightened historical human efforts for construction of rain water harvesting structure in the history of India in response to abrupt climatic fluctuations like aridity and drought have been worked out.[11] In India, it is a practice for at least 8000 years. Local studies on risk management and decision-making can compliment global climate modeling exercise in order to cope with the realities of future climatic scenarios.

Capturing methane and nitrous oxide emission from agricultural fields:

Low fertilizer nitrogen-use efficiency in agricultural crops is caused by large nitrogen losses due to leaching and gaseous emissions (ammonia, nitrous oxide, nitric oxide, nitrogen In general, nitrogen oxide emissions from mineral and organic nitrogen can be decreased by management practices that optimize the crop's natural ability to compete with processes where plant-available nitrogen is lost from the soil-plant system, and/or by directly lowering the rate and duration of the loss processes..

Precision farming, that includes, global-positioning systems and in situ sensors for soil, crop, and microclimate monitoring may be helpful in efficient use of nitrogen applied. It also includes variable rate water, fertilizer, and pesticide application

temporally and spatially. Biological and chemical methods for manipulating soil microbial processes to increase efficiency of nutrient uptake, suppress N_2O emissions, and reduce leaching may also be effective in this regard. Capturing soil erosion, and leaching, soil-conservation practices are also to be emphasized.[12] For reducing the methane emission from paddy fields direct seeding of paddy crop is an option to minimize production cost, while reducing CH_4 emission. Intermittent irrigation also minimizes CH_4 emission. In comparison to fresh organic matter, compost addition is very effective in reducing CH_4 emissions for irrigated rice fields.

Adoption of minimum tillage techniques in crops

A large amount of carbon is stored in soil and is relatively labile. Organic carbon sequestration levels may be increased with silt and clay content and the maximum level is achieved when soils are most highly aggregated, i.e. when they are not tilled. Tillage breaks aggregates and exposes soil organic carbon to biological decomposition and its Loss is proportional to the intensity of tillage. Less tillage results in more soil carbon accumulation. Less tillage operations also helps in better soil conservation and sustainable crop production. It also helps in better water infiltration, greater soil aggregates stability and less effect of drought to crops. Animal manure contributes relatively a small amount of N_2O, CH_4 and CO_2.

Carbon Sequestration

Carbon sequestration is the term describing processes that remove carbon from the atmosphere. To help mitigate global warming, a variety of means of artificially capturing and storing carbon as well as of enhancing natural sequestration processes are being explored.the natural carbon sinks are forests, oceans and soil. Forests are carbon stores, and they are carbon dioxide sinks when they are increasing in density or area. Thus, reforestation can mitigate global warming until all available land has been reforested with mature forests. Enhanced adoption of improved agriculture technology as well as improved infrastructure in the future is expected to raise gross agricultural production which will result in higher CO_2 fixation. Alternatively, agricultural residues may be ploughed in to increase soil carbon. Information on carbon sequestration especially in fruit trees and agro-forestry needs to be quantified.[7] The atmospheric conditions could not be modified easily in the marginal farmer's field on very large basis as it is very expansive. However, efforts are now being made to improve the microclimatic conditions through agroforestry. Agrofoestry can tackle this problem up to some extent by increasing the forest cover of the country. Trees can provide better microclimatic conditions for growth of intercrops .. Therefore, under Shallow water table conditions trees can be introduced in monocultue for providing better microclimatic conditions for wheat. Thus agroforestry is found to influence the microclimatic conditions and ensures the optimum use of natural resources to increase agricultural production . Studies on Nelder design reveals that, for more PAR availability to intercrop either deciduous trees or evergreen trees at wider spacing should be planted in Nelder design however there is ample future scope to explore on these aspects of microclimatic modification as per the need of various crops.[22]

Enhancement of Water Productivity in Horticultural crops

As predicted by various agro climatic models for future scenario of the world water would be a scares of natural resource in future. Horticultural crops line vegetables, spices, flowers, medicinal plants and other plantation crops may have more efficient use of water than cereals and cash crops .irrigation system at present needs 2000 tones (t) water to produce 1t cereal grains. With the use of efficient irrigation system, the same may need 500-700 t water for said production. However most of the horticultural crops, need less than 300 t water for production of 1t of horticultural produce.[4] Water productivity may be enhanced by manipulation of geometry of crop, scientific irrigation scheduling and application methods and proper crop growth duration adjustment. Development of drought tolerant traits in cultivars and traits for reducing transpiration not at the cost of productivity may be helpful in this direction.

Efficient Climatic Risk Management

Weather consciousness among farmers should be enhanced. There should be a change in land use pattern and various cultural practices like alteration in planting dates, spacing, new cultivars as per new climatic conditions, input management. There should be change in the farming system as per need of any particular area. Breeding of drought and water stress tolerant short duration varieties should be emphasized. Forecasting of extreme climatic events drought, flood etc. should be refined so that the exact forecast well in advance may be done to escape the after effect of the events.[20]

Management of Natural Resources through Remote Sensing

Last but not the least important, remote sensing techniques prove to be very useful in planning natural resource management in a sustainable manner. In agricultural resource planning this technology helps in crop acreage estimation, its condition assessment, yield prediction, water resources, soil, and land use management. The recent satellite have an edge over the old technology of remote sensing in helping accurate meteorological studies and fine tuning of weather forecasting science. The role of GIS (Geographic Information System) in precision agriculture is immense. Precision agriculture involves variability management and its evaluation. The GIS technology ensures the optimum use of inputs in agriculture with maximum output in many ways like diseases and pest management, irrigation scheduling, stress detection and its management and yield estimation. It would be a promising approach in reducing overuse of chemicals in agriculture, thereby reducing the degradation of natural resources if appropriately utilized.[21]

Conclusion

The goal of effective ways to cope with climate change events is to adopt agricultural management technologies and policy changes between hazard events such that the crop/animal production risk associated with the next event is reduced through the adoption of well-formulated land use plans and mitigation actions that have been adopted by the stake holders.

Productivity of most cereals would drastically affected due to increase in temperature and decrease in water availability. Increased events of droughts and floods are likely to increase production variability.

Adoption of techniques like minimal tillage, residue management and increased production and use of biofules may be helpful in reducing the Green House Gases emission into the atmosphere. The strategies must include breeding of drought and water stress tolerant varieties,improvement in irrigation and water use efficiency of crop plants, reducing atmospheric concentration of greenhouse gases by adoption of various ecofriendly techniques, increase in productivity of existing farmed area and reduce deforestation and paddy plantation which contribute to CH4 emission and modification of microclimate for increasing productivity of crop. Soils in drylands are not only thirsty but also hungry. Wide spread deficiencies of macro and micro nutrients occur due to loss of nutrients through surface soil erosion and inadequate nutrient application. The replenishment of the nutrients in cropping cycles is not adequately done due to poor resource base of farmers.

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