



Review Article

CLIMATE CHANGE AND ITS SIGNIFICANCE IN AGRO-ECOSYSTEM – A REVIEW

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Abstract- Climate change is the most important factor for global agriculture as well as for Indian agriculture. The climate change in the form of increasing the temperature as well as increased rate of the precipitation. The change in the climate over the continent create the change in the agro- ecosystem by changing in the biogeochemical cycling of the natural resource. Because of change in the climatic conditions it will change by altering the forest productivity, plant physiology and the soil physical, chemical and biological processes. Indirectly affect the natural environment of the living organisms. These changes were affected the biodiversity of plant, animal and the soil biological properties, like reducing in the population of the soil bacteria, fungi, and many others. The effect of climate change on the composition and structure of soil microbes and it reducing the number of keystone species and their community structure. The importance of climate change phenomena in agro-ecosystem is well recognised and discussed, about the actual mechanism of change in the soil system and their response to the changing climate is vast and it is still beyond away from the understanding of research scientists. It is already argued that to understand impacts of climate change on the agro-ecosystem and the mechanisms coming under them and requirement of explicit consideration of linkages between the above and below ground biota. The overall effect of climate change mechanism on the function and structure of terrestrial agro-ecosystem is indirectly related to their effects on the soil biota and the processes. Here we are discussing about the impact of climate change on the agro-ecosystem *i.e.*, soil biota and their activities and how these changes are affect nutrient dynamics and their effects on the productivity and structure of agro-ecosystem.

Keywords- Agro-ecosystems, Climate change, Detrimental effects.

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Introduction

The pattern of climate change is the most significant and unique matter of concern in many area. It is a major threat for biodiversity and function of ecosystem. The increase in the concentration of the carbon di-oxide gas in the atmosphere is the clear cut signal of the human alteration of the earth system [1, 2]. Since the ancient times or after the beginning of the industrialisation, the levels of carbon di-oxide gas in the agro-ecosystem was increased from 250 ppm to 360 ppm. The increased level of CO₂ gas was almost 30 % of the initial level and this level is increasing with a very high speed due mostly to increasing in the burning of fossil fuels and clearance of the forest lands for agriculture purpose, especially in the hill region of the North-East India. If the process of industrialisation is continue like in the past, the level of atmospheric carbon di-oxide concentration in the end of 21st century will reach 500-900 ppm. According to the view of climatologists, that the rise in co₂ level has already sufficiently high to affects the world's climate and according to prediction in the third report on intergovernmental panel on climate change [3], this will further change in the climate due to increase in the average temperature and a very high abnormality in the extreme weather phenomena. The change in carbon di-oxide gas and temperature of the above eco-system will leads to change in the below ground system factors, most likely to change in the agro-ecosystem by changing in the soil biota and their relative performance in the soil system. The production or rising in the levels of greenhouse gases (GHGs) by the agriculture sector is very complex and having various wide composition, but proper management of agriculture system is a possible mean to mitigate [4].

Since climate is the most unique factor which determine the production and

productivity of the agro-ecosystem. The Change in the climate will changing in the global pattern of the precipitation over the globe especially in the rainfall distribution as well as in the intensity of the rainfall. The change in the rainfall pattern will influencing the environment such as soil properties like physical and chemical by changing in their property, for example, the heavy rainfall intensity increase the soil erosion, reduce the nutrient content of the soil, creating the anaerobic conditions which leads to increase or decrease in the nutrient availability to the plant and soil microbes. It also lead to reduce the rate of organic matter decomposition due to less number of soil bacterial species and bacterial diversity in the soil. Because in soil system there are so many functional group of bacteria's are present. If there is only one type of conditions prevail for a longer time of period then, a few species of microbes are dominant. But according to the basic principles more biodiversity is necessary to regulate the various bio-geochemical process of soils, which are totally depends upon the soil microbial population such as rate of mineralization and immobilization process, those are fully carried out by the various functional groups of the soil bacterial community. The availability of the necessary elements to the microbes as well as for crop plants is altered or reduced due to change in the soil environment by changing in the above ground climatic conditions. The climate change issue directly affect the eco-system productivity, which leads to increasing the threat for food security. In case of food security matter soils are the most important factor of production. It is necessary to understand the interaction between climate change and soil properties and how these changes in the above environment made change in below ground environment. Mostly those are play a key role *i.e.*, soil microbial

community functions and their community structure, and in what sense these are changing, and how we can control, to reduce, to maintain the agro ecosystem healthy and productive by study the below ground soil environment. Therefore, this paper will focus upon the climate change and its interactions with agro-ecosystem, and how climate change affects the soil properties and various microbial processes. The evaluation of impacts of climate change will be a huge task in developed and developing countries because there is a big relationship between the physical, biological and chemical processes are going in earth and the in environment.

Reason of climate change

The major reason of climate change is the production of some harmful gases, technically known as greenhouse gases (GHGs). The production of the GHGs was not the new thing for us, but increasing in their levels then before it is totally different *i.e.*, their concentration in the agro-ecosystem is crossing a certain levels and those increased levels of GHGs will leads to certain change in our environment it may be harmful or beneficial, it may be increase or decrease the productivity and it will reduce or enhance the microbial activity in the above ground system or in the below ground system *i.e.*, soil biological and biochemical environment, it is the most important concern for us nowadays. The major reason of climate change is the increase in the human activities related to consumption of natural resources for getting more profit due to greedy nature of human being. These activities includes: increased use of forest land for agriculture purpose, use of fossils fuels, deforestation, burning and decay of biomass, and increased industrialization. The increase in such activities of human being leads to emission of various gases like CO₂ from the various sector industries those are directly or indirectly involved in process of harmful gases emission, the methane (CH₄) gas emission is directly related to faulty modern agricultural practices specially from the rice-paddy fields as well as from the decomposition of the various animal bodies either above the ground surface or below the soil surface. The emission of sulphur dioxide (SO₂) and nitrous oxide (N₂O) is directly related to the use of different kinds of agro-chemicals in the modern agriculture. These agro-chemicals are more susceptible to losses in the environment by the various processes like mixing with surface flow of water *i.e.* runoff due to excess rainfall or because these chemicals are available in various forms like liquid or gases, and easily escape in the environment through the volatilisation process, photo decomposition susceptible etc. Some of them are easy to decompose and some may not be, those are hard to decompose by microbes remain in the soil for a longer period of time which made the change and affect the soil biodiversity, the easy ones escapes into the atmosphere through the activities of soil biota by various biochemical process. For example, the losses of nitrogenous fertilizers as denitrification process, ammonia volatilization in the alkaline soils. Some of the soil microbes also play a vital role in the process of denitrification those are anaerobic in nature *i.e.*, those living in the deeper layer of soil under the submerged soil conditions. For the production of methane gas some chemo-autotrophic bacterial genera are present in the bottom of the deep ocean are also responsible because they mostly rely for their energy upon the crystals form of methane (CH₄) present in the bottom of the deep ocean.

The levels of absorption, emission and spreading of the solar radiations in the atmosphere, ocean and the agro-ecosystem is most likely dependent upon the concentrations of the GHGs gases specially the carbon di-oxide concentrations due to their heat trapping nature which acts as a blanket to re-radiate the long wave radiations coming from the earth and cause the increase in the temperature of both below and above ground, mostly above ground *i.e.*, atmosphere. The heat trapping nature of GHGs is vary from gas to gas, the heat trapping potential of methane is 25 times more than the carbon dioxide. The contribution of GHGs in global climate change during the year 2004, is given on the basis of intergovernmental report on climate change [4]. CO₂ emission in the form of fossil fuels use 56.6 %, from deforestation and biomass burning 17.3 %, from others 2.8 % and the total sum of CO₂ production from anthropogenic sources GHGs emission CO₂ was about 77 %. The nitrous oxide produced from agriculture by human activities (use of ammonia based fertilizers) was about 7.9 % and the methane was 14.3 % from the wet rice field, livestock and various fermentation

processes of energy or waste organic materials.

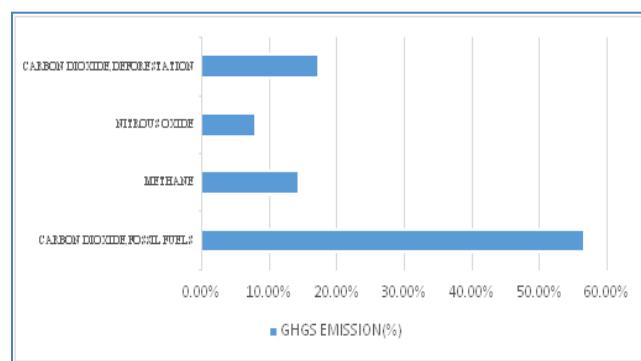


Fig-1 GHGs emission from various sources (IPCC, 2007).

Climate change dimension:

The understanding of the climate change dimension is necessary to understand the various problems creating nowadays. In the study of climate change we have been seen so many changes and it will continue if we don't look in this matter. These dimensions are

Long term dimension of GHGs

The long term dimension of GHGs includes various gases most likely those having a heat trapping capacity *i.e.*, carbon dioxide. These gases remaining in the atmosphere for a longer time. It will cause so many consequences for the future generation. The rise in sea water level and anthropogenic warming would continue even if we stabilized the GHGs emission.

Feedback

There is a need to take action against the changing climate, because it will increasing the average temperature and emission of GHGs gases, if we will not take action the temperature in the near future will be very high then we are expecting.

Global climate change

This is the most significant dimension of climate change because the emission of GHGs gases may not different from country wise in the sense of quantity, for example one tonnes GHGs emission from china will not different from India as the emission of same quantity. It mean it will affect global climate not the particular place or one region of a country. The increasing risk and vulnerability due to change in climate are the outcomes of physical processes [5]. The non-compliance in the carbon reduction is also triggered protectionist sentiments. The European Union is threatening unilateral trade measure that can affect the import trade as a part of its ambitious drive to reduce carbon emission at least 20 % by 2020 [6].

Effect of climate change

The effect of climate change is a results of long term changed in the outer environment due to various physical, biological and chemical changes in the agro-ecosystem by the activities of human being.

Effect on eco-system

The ecosystem is dynamic complex of the plant, animals and the micro-organisms, and the non-living eco-system working with each other as a functional unit. In order to get good ecosystem, there should be a mechanism to maintain quality and quantity of nutrient cycle, production, soil formation etc. The agro-ecosystem includes all living and non-living things. Because of changing climate it will mostly affect the precipitation, temperature. So there are things to fix such as water purification, protection of coastal area, recycling of waste nutrients, the removal of carbon from the atmosphere. A basic variation between the past and future ecosystem is the dominating influence of human activity and intervention in ecosystem such as desertification increase due to over grazing in semiarid lands

and in subtropics.

Rise in temperature:

The change in climate increase in the warming of the ecosystem due to rise in temperature will not be equally distributed over the globe. The increase in temperature will have very different impacts upon the vegetation, ecosystem productivity, structure and composition depending upon the actual temperature value at the location. Global temperature has increased 0.2 °C per decade in past 30 years. The greatest extinction risk from global warming may be in tropics, where biological diversity is also greatest.

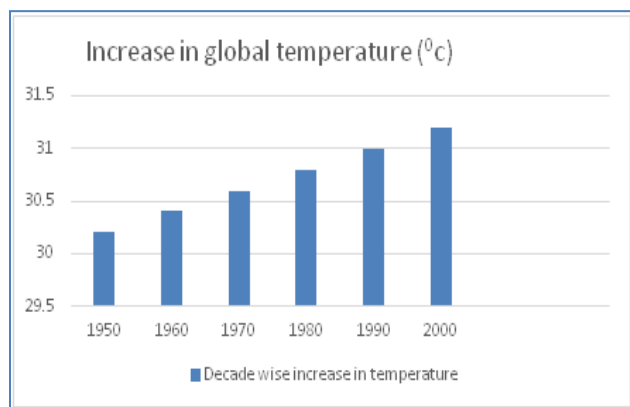


Fig-2 Global temperature increased in past years (IPCC, 2007).

Change in precipitation

The climate change increased the average temperature in the past and it will be continue in future also. The severe soil moisture deficit and frequency of short term drought is expected to double at end of 21st century. The increase in temperature increase the rate of evaporation and it will leads to increased rate of precipitation, but a large increase in precipitation is not expected. It will be high at some places and lower at another. More rain expected at equatorial belt and at higher- latitudes .

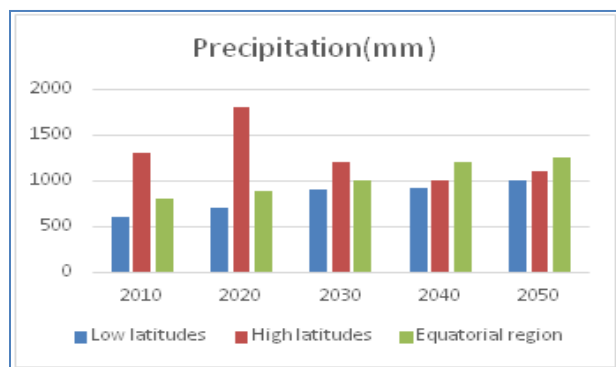


Fig-3 Expected precipitation at different latitudes (IPCC, 2007)

Impact on soil properties

Soil is the most important part of the agro-ecosystem which provides the habitat and food for all living organisms. It also known as the "nutrient reserves" for plant, animals and soil microbes. The impact of climate change on soil properties is slow and complex. Because soils not only be affected directly by rising temperature and precipitation but also can acts as a source of GHGs gases and thus contribute in GHGs gases responsible for climate change. The change in the soil properties especially biological changes are difficult to measure both in quantity and quality.

Direct impact on soil system function

Climate change will be able to change in the soil function by changing in the physical, Biological and chemical processes that carried out by soil microbes. For example increase in the losses of soil carbon content due to higher rainfall according to a soil-climate model. Also the increased loss of soil carbon is

augmented by high temperature. The expected changes in soil by climate change are given as: (a) increased losses of CO₂ from organic and mineral soils. (b) Poorer soil structure, stability and water holding capacity due to loss of soil carbon (c). Poor nutrient availability and erosion. (d) Increased rainfall increase in the peat formation process and emission of methane (CH₄) gas from the soil. (e) The area experiencing with low rainfall undergo peat, CO₂ losses and increased moisture deficit condition for arable crops and forest soils, thereby affecting the pattern of grasslands or foraging area, reproduction and survive ability of soil invertebrate, of the food web. (f) Increased frequency of drought will increase the swell-shrink properties of the soils (ex. Clay soils).

Indirect impacts on soil system

Climate change have both positive and negative impacts on soils. The combined effect of climate change increased in the productivity of some arable crops, for example winter wheat, sunflower, sugar beet. The increased productivity generally leads to increased input level of carbon to the soils due to increased soil organic matter (SOM). It is expected to be increased in the rate of photosynthesis and higher availability of plant nutrients in the soil.

Impact on soil biota

The climate change effects the soil biota in many ways. The soil biota includes both the fauna and flora, which play a vital role in breakdown and decomposition of organic waste material in the soil. The changed climate having the higher concentration of many gases in the atmosphere especially carbon dioxide and GHGs. Here we are discussing about the impact of elevated CO₂ on soil biota. The elevated concentration of the CO₂ affect the soil biota and their processes indirectly via. Change in the composition and productivity of plant community which, indirectly affect the biota community and structure. This changed conditions bring the change in soil biota species distribution and their rare species too (key stone spp.). The elevated CO₂ influence the carbon inputs to soil in both quality and quantity which leads to change in biota species. In many studies it is shown that increased CO₂ concentration in the atmosphere increased the productivity of plants by increased rate of photosynthesis [7]. The positive effect of increased CO₂ on plant biomass was mostly seen on nutrient rich soils especially when nitrogen is not the limiting factor. The response of various natural and semi-natural agro-ecosystems to elevated CO₂ are very less due to nitrogen element deficiency [9]. It has been shown that the increases in carbon supply to soils through roots, will increase in the growth as well as in the activity of soil microbes [10]. According to some studies, the effects of elevated CO₂ on microbial community structure has shown very complex and some are showing no response [11-15].

Conclusion

Climate change is the most important issue for the developed and developing countries. We have to think about climate change, its impacts either it is positive or negative. It's the time to take action against the changing climate otherwise after 30 or 40 years later, it will be beyond our control. It is the greatest challenge for agro-ecosystem especially for soil biota and their relative processes. The changing climate mostly increasing temperature and CO₂ concentration in the atmosphere affect the soil microbes i.e. the key stone species or rare species of microbes at the threat due to changing in the soil climate above and below ground both chemically and biologically, those are specific to a particular soil system. It is clear that soils and their biota are substantially changed by changing climate. The overall effects of changing climate changes the agro-ecosystem and their relative sub-systems.

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Authors contributions

Ganesh Narayan Gurjar is the main author for his review paper work. Narendr Kumar Meena and Rajesh Kumar are my coauthors.

Abbreviations

CO₂ = carbon dioxide
 CH₄ = methane gas
 SOM = soil organic matter
 GHG = greenhouse gases
 IPCC = intergovernmental panel on climate change
 % = percent
 °C = degree Celsius
 SO₂ = Sulphur dioxide
 N₂O = nitrous oxide
 PPM = part per million
 MM = millimeter
 UNDP = United Nations development program

Ethical approval

This article does not contain any studies with human participants or animals performed by any of the authors.

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