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Climate change and Soil Fertility: An issue of Food security Concern

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Abstract: Due to the rising concentration of greenhouse gases and changing precipitation patterns, the global mean temperature has increased by roughly 1.1°C since the preindustrial era. By the end of the 21st century, this increase could exceed 4°C. Water resources, agriculture, plant and animal life, and biodiversity are just a few of the areas where global warming may have unfavourable effects. Global climate change is predicted to have a potential impact on soil fertility through the physical, chemical, and biological properties of soil due to rise in temperature, alteration in precipitation pattern, increase in green house gas concentration in the atmosphere, and other factors because soils are related to climate system in a very complex way through nutrient and hydrologic cycles.

Keywords: Climate change, Greenhouse gases, Global warming, Soil properties.

Introduction

Long-term changes in a region's temperature and weather patterns are referred to as climate change. Despite the fact that these changes may be natural, over the past few decades, industrial and human activity have contributed to slowly increasing climate change, including an annual rise in the average surface temperature (IPCC, 2014). Humans have contributed to climate change since the Industrial Revolution (i.e., 1750) through the emissions of GHGs and aerosols as well as through changes in land use, which have led to an increase in global temperatures. Different effects of rising global temperatures include an increase in floods, storms, droughts, and sea levels as well as a reduction in ice sheets, sea ice, and glaciers. in the amount of greenhouse gases in the air, etc. Chen et al. (2021) evaluated the short- and long-term effects of climate change on Bangladesh's total fertility rate (TFR), as well as its direct and indirect effects on the production of main crops (e.g., temperature and precipitation).

The sun's radiation provides energy to the earth. GHGs are essential for retaining heat and keeping the earth's temperature at a level that supports life. The greenhouse effect is a natural occurrence that is required to sustain life on earth. The earth would be about 33°C colder now if not for the greenhouse effect. Due to growing fossil fuel use and deforestation, humans have recently contributed to an increase in atmospheric GHGs. The increase in GHGs over the past century has been the main factor contributing to global warming, which is typically attributed to greenhouse gases produced by human activity when fossil fuels like coal, oil, and natural gas are used (Brett 2009). Other greenhouse gases including (N_2O), (CH4), and (C.F.C.) have recently increased at a rate similar to that of carbon dioxide, which has increased the greenhouse impact. In total, water vapour contributed 60% of the green house effect shave, carbon dioxide contributed 26%, and other gases made up 14% of this contribution (Ahrens CD, 2014). Carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) atmospheric concentrations were all significantly raised by anthropogenic greenhouse gas emissions prior to the preindustrial era, and it was noted that about half of anthropogenic CO_2 emissions from the preindustrial era to 2011 occurred in the last 40 years (Butler JH, Montzka SA 2019).

Soil is one of the environments that is impacted by climate change (Brevik 2012). Due to the fact that the soil is responsible for supplying the world's growing population with food, it has the ability to jeopardise food security globally by altering soil processes and qualities (Brevik 2013). According to the IPCC's Fifth Assessment Report, human activity is most likely to blame for the global warming that has increased by about 1.0 °C above preindustrial levels, with a plausible range of 0.8 °C to 1.2 °C. If it continues to rise at the current rate, global warming may reach 1.5 °C between 2030 and 2052 (IPCC 2018), which is predicted to alter other local and global climate-related variables like rainfall, soil moisture, and sea level. The expected global climate change affects many soil physical, chemical, and biological aspects, as well as soil fertility and productivity. It involves a rise in temperature and atmospheric carbon dioxide (CO_2) levels, changes in rainfall pattern, and atmospheric nitrogen deposition. The availability of organic matter from biomass, the temperature pattern of the soil, the hydrology of the soil, and salt of the soil are all potential effects of climate change. Given all of these circumstances, the effects of climate change on soils have been examined.

The fact that cultivation in a majority of the overall cropped area—which is rain-fed—is dependent on monsoon uncertainties—indicates how dependent agriculture is on the climate. The stability of the food system can have a direct impact on food security due to climate change. In addition to producing the food that people consume, agriculture also serves as the main source of income for 36% of the global labour force. This percentage ranges from 40 to 50% in the densely populated nations of Asia and the Pacific, and in sub-Saharan Africa, 67% of the working population still relies on agriculture for their primary source of income. Both a cause and a victim of climate change are thought to exist in agriculture. Agriculture is both a sufferer and a contributor to climate change because it produces a huge amount of greenhouse gases and emits them into the atmosphere.

In addition to the likely drop in food production, a concern for nutritional security may arise due to a possible decline in food quality. Concerned about the potential impact of global climate change on human quality of life, efforts are being made to develop mitigation techniques. Ali et al. discovered that in Pakistan, maximum temperature had a negative correlation with wheat yield while minimum temperature had a positive and substantial correlation with all crops (wheat, rice, maize, and sugarcane). Furthermore, except for wheat, rainfall had a negative impact on crop yield [47].

Causes of Climate Change

The main reasons for this change can be divided into two groups, the changes caused by natural events and by anthropogenic activities (Ahrens CD, 2014)

Climate change due to natural events:

Studies have shown that the factors contributing climate change are : changes in incoming solar radiation, changes in the makeup of the atmosphere, and changes to the earth's surface.

Climate change due to human activities (anthropogenic):

Climate change caused by human activities, which has increased especially in the last two centuries, includes: Release of aerosols in to the bottom part of the atmosphere., Greenhousegas, Changes in Land use, etc.

Climate Change impact on Soi:

Since the earth's creation, there has been a constant state of global climate change. To meet the global demands for food and fibre for an expanding population from limited soil resources, soil appears to be more crucial for modern human cultures than ever before. Food security is being threatened worldwide by climate change. Due to their tropical environment and the inadequate adaptability of its small and marginal farmers, countries like India are particularly vulnerable. According to projections, both direct and indirect effects of climate change on crops, soils, livestock, and pests will have a considerable impact on agriculture. It is anticipated that changes in soil moisture conditions and a rise in soil temperature and CO_2 levels will be the main effects of climate change on soils. On soil processes and qualities crucial for recovering soil fertility and productivity, the consequences of the global climate change are predicted to vary. The main effects of climate change are anticipated to be a rise in temperature and CO_2 levels. Table 1 provides an illustration of the negative consequences of climate change on soil characteristics.

Table1. Climate change effects on soil

Climatic factors	**Effects**
Rise in temperature	Salinization of soil, Soil organic matter decomposition increases, Loss of soil organic matter, Decreases soil porosity, Increases soil compactness, Reduction of soil CEC, Reduction of soil fertility, Deterioration of soil structure, Increases risk of soil erosion, Reduction of water retention capacity, Increases CO_2 release from soil, Reduction of soil organic C, Increases ammonia volatilization, Increases rhizospheric temperature, Stimulation of nutrient acquisition, Enhances soil microbial activity, Increases bio availability of N and P from organic matter.
Heavy and intensive rainfall	Destruction of soil aggregate Increases risk of soil erosion Increases leaching of basic cations Soil acidification Reduces soil CEC Loss of soil nutrients, especially N Development of hypoxic condition in poorly drained soil ToxicitiesofFe,Mn,Al,and B Loss of N through denitrification
Decreased rainfall	Increases salt content Soil moisture deficit Decreases diffusion and mass flow of water-soluble nutrients Possibility of occurring drought

	Loss of nutrient from rooting zone through erosion Reduces nutrient acquisition capacity of root system Reduces N-fixation in legumes
	Increases soil C availability Increases soil microbial activity Increase soil fungal population

Adaptation and Mitigation of Climate Change

By implementing both adaptation and mitigation strategies, the negative effects of climate change, such as an increase or reduction in temperature and rainfall, or other extreme weather events, can be reduced. The ability to modify and build resilience to a varied and unfavourable shift in the climate is attributed to adaptation measures. This can be done by using conservation agriculture methods, such as zero-tillage, mulching, crop rotation, avoiding monoculture, altering the timing of farming activities, and applying the right amounts of inputs, such as irrigation, fertiliser, pesticides, etc., at the right time. On the other side, mitigating efforts aim to lessen the consequences of climate change by lowering the atmospheric concentration of greenhouse gases.

By managing C and N in an agricultural system properly, it is possible to lessen the emissions of GHGs, which in turn can help to combat climate change. By improving agricultural management practises, such as minimising soil disturbance and optimising grazing management, greenhouse gas emissions (GHGs) due to soil organic carbon volatilization can be decreased. By maintaining the proper rate and timing of fertiliser application, which decreases both leaching and volatilization losses by enhancing fertiliser usage efficiency, emissions can be lowered by adhering to integrated nutrient management. Since rice cultivation, enteric fermentation in ruminants, and storing livestock manure are the main sources of methane emission in agriculture, improving the management of animal waste, covering dung heaps, and irrigation in paddy cultivation can reduce its emission. By maintaining the proper rate, manner, and type of N fertiliser application and soil management, as well as by employing nitrification inhibitors such as nitropyrin, dicyandiamide, neem cake, neem oil, karanj cake, etc., nitrous oxide emission can be controlled.

Maintaining a shallow water table and avoiding extensive ploughing unless it might result in the drainage of organic soil are other ways to limit GHG emissions. Reducing emissions can also be aided by stopping deforestation and maintaining the current forest cover. Carbon dioxide emissions can be reduced by storing carbon in soil by lowering biomass burning, managing soil temperature and moisture better, and reintroducing carbon to damaged land's soils.

Conclusion

Global climate change influences are anticipated to alter soil physical parameters such as texture, structure, bulk density, porosity, nutrient retention, etc., affecting the soil fertility through which it may result in soil salinization, reduce nutrient and water availability, alter C and N dynamics, and reduce soil biodiversity. Climate change's negative effects are primarily felt in the soil's chemical characteristics, such as pH, salinity, cation exchange capacity, nutrient cycle, and acquisition. Physical, chemical, and biological characteristics of the soil are closely tied to its nutrient and carbon cycles, which in turn balance soil fertility. Since the majority of soil functions, including pH, cation exchange capacity, water and nutrient retention, as well as soil structure, depend on soil organic matter, the fluctuation in its rate of decomposition as a result of global warming has a negative impact on the soil fertility. So, by implementing some adaptation and mitigation strategies like conservation agriculture, residue management, integrated nutrient management practises, etc., the negative effects of climate change on soil fertility can be reduced.

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