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Coping with Climate Change Effects on Agriculture and Food Security: Building Resilience and Ensuring Sustainability

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Akhila Nand Dubey[1], Rakhi Mahto[2*]

[1]Assistant Professor -cum- Junior Scientist, Department of Soil Science and Agricultural Chemistry, Rabindra Nath Tagore Agriculture College, Deoghar (Jharkhand)

[2*]Assistant Professor -cum-Junior Scientist, Department of Agronomy, Rabindra Nath Tagore Agriculture College, Deoghar (Jharkhand)

Devastating environmental changes have left a significant impact on natural systems, human health, and agricultural production (Arunanondchai *et al.,* 2018). Climate change is defined as a long-term change in the expected patterns of typical weather in an area (or the entire Earth) over a prolonged period of time. It is concerned with unusual climate changes and how these fluctuations affect other parts of the earth. These changes may take tens, hundreds, or even millions of years to occur. However, increased anthropogenic activity, such as industrialization, urbanisation, deforestation, agriculture, and altered land use patterns, causes greenhouse gas emissions to rise and accelerate the rate of climate change. Climate change scenarios include temperature increases, precipitation fluctuations, and an increase in atmospheric CO_2 concentrations. Rising CO_2 concentrations in the atmosphere have a direct impact on the rate at which weeds and crop plants develop. The concentration of CO_2 in the atmosphere has increased from 280 μmol^{-1} to 400 μmol^{-1} as a result of continuing deforestation and excessive usage of fossil fuels. CO_2 concentrations are expected to double, reaching 800 μmol^{-1} by the end of the century. CO_2 is the most significant contributor to the greenhouse effect and rising world average temperatures (Vaughan *et al.,* 2018).

In the 21st century, the Earth's average temperature is expected to increase from 2 to 4.5 °C. According to IPCC-2014 (http://www.ipcc.ch/), the time-span between the 19th and the 21st centuries is considered to be the period which experienced the most warming.

Extreme precipitation events might well cause destructions due to floods whereas the scarcity or the total absence of rainfall for a longer period of time leads to drought stresses. The environment of the globe is continuously changing and industrialization is one of the main factors for temperature increase. Due to extreme weather events the frequency of global warming is expected to rise, which will ultimately disturb the ecosystem globally. Climate change influences food security in a very complicated manner. It hampers the agricultural yield directly by means of disturbing the agro-ecological environment and indirectly by putting pressure on growth and circulation of income and consequently increased the necessity of agricultural products.

The mitigation of greenhouse gases in conformity with international environmental treaties such as the Kyoto Protocol and the IPCC has been the primary focus of the global warming issue up to this point. However, given the assessment of the effects of climate change and vulnerability to it, the emphasis has shifted to adaptation and adaptability for agriculture. The IPCC emphasises the importance of agricultural adaptation to climate change. This is because greenhouse gases that have already been released into the atmosphere will cause global warming to persist for several decades even if greenhouse gas emissions drop (Kim, 2012).

The major approaches to addressing the problem of global warming include the reduction of greenhouse gas emissions and their absorption, the discovery of causal factors, and adaptation measures aiming at limiting the negative effects of climate change. Temperature, precipitation, and greenhouse gases, in particular, hampered plant metabolism, physiology, soil fertility, pest infestation, and irrigation supplies. Various adaptation and mitigation strategies have been developed to combat the negative effects of climate change on agricultural sustainability. Weather-smart activities (stress-tolerant varieties, ICT-based agrometeorological services), carbon-smart activities (zero tillage, legumes, crop residue management), knowledge-smart activities (agricultural extensions to improve capacity-building), water-smart practices (laser land levelling, rainwater harvesting, micro irrigation, crop diversification, raised-bed planting, direct-seeded rice), and nutrient-smart practices (Malhi *et al*., 2021).

These methods reduce the detrimental effects of climate change on crops and improve their climate adaptability by mitigating the negative repercussions. Climate change is expected to cause major economic losses on both a micro and macro scale, which these solutions can assist to mitigate. However, in order to maximise the impact of these interventions, they must be designed at the local or regional level. Adaptation and mitigation strategies are expected to increase farmer earnings without jeopardising agricultural output sustainability.

Climate Change: A Challenge for the Farming Community

- Climate change has disturbed traditional agricultural calendars, resulting in unpredictable growing seasons and crop harvests. Elevated temperatures have the potential to harm crop growth and reduce total output.
- Droughts, floods, and hurricanes are examples of more frequent and severe weather events that can

cause crop failures and disrupt supply chains, putting local and global food security at risk.

- A changing climate can encourage the spread of pests and illnesses, which can harm cattle and crops. If additional veterinary care and pesticides are required, production costs may rise.

Resilience and Sustainability Strategies

- The negative consequences of climate change can be lessened by the development and promotion of climate-resilient crop types. These cultivars are designed to endure harsh weather, pests, and illnesses, guaranteeing more consistent harvests.
- Crop rotation, no-till farming, and organic farming are examples of sustainable agricultural techniques that can enhance soil health and lessen agriculture's carbon footprint.
- In light of the changing climate, effective water management is vital. Drastic relief techniques such as rainwater gathering and drip irrigation can guarantee efficient water usage and prevent dry spells.
- Farmers can lessen the effects of extreme weather occurrences and make more informed decisions by having access to timely and accurate meteorological information.
- By lowering susceptibility to hazards associated with climate change and offering alternate sources of income, diversifying agricultural production and implementing agroforestry can improve resilience.
- Building resilience can be greatly aided by government initiatives that support agricultural research, encourage climate resilient and sustainable farming methods, and offer insurance to farmers.

Conclusion

Climate change influences on crop yield are frequently combined with its impact on water productivity and soil water balance. Temperature and rainfall will be affected by global warming, which will have a substantial effect on soil moisture and groundwater level. Crop productivity is affected by crop varieties and planting areas, soil degradation, growing environment, and water availability during the crop growth period. The availability of water and crop yield will decline in the future as temperatures rise and precipitation fluctuates.

Addressing this problem necessitates a multifaceted approach that encompasses the selection of crop varieties resilient to climate change, the implementation of sustainable farming techniques, efficient water resource management, and supportive regulatory measures. By integrating these strategies, we can enhance the resilience of agriculture, ensuring the security and sustainability of our food systems amidst the challenges posed by climate change. Beyond adapting to the current situation, our collaborative efforts seek to enhance the future by tackling the root causes of climate change.

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