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Impact of climate change on agriculture and discussion on the impact of Agro metereological factors and its relation with crop growth

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ABSTRACT

Climate change poses significant challenges to agriculture worldwide, impacting crop growth, yield, and overall food security. This review paper explores the multifaceted impacts of climate change on agriculture, with a particular focus on the interplay between agro meteorological factors and crop growth. Through a comprehensive discussion, we examine how alterations in temperature, precipitation patterns, humidity, and extreme weather events influence various stages of crop development. Additionally, we investigate the role of agro meteorological factors in shaping plant physiology, penology, and susceptibility to pests and diseases. Furthermore, we analyze strategies for mitigating the adverse effects of climate change on agriculture through improved understanding and management of agro meteorological variables. By synthesizing existing research findings, this paper provides insights into the complex relationship between climate change, agro meteorology, and crop productivity, offering valuable guidance for policymakers, researchers, and agricultural practitioners.

Key words: *Climate change, Agriculture, Agro meteorological factors, Crop growth, Temperature, Precipitation, Penology, Food security, Mitigation strategies.*

Introduction

The most important weapon that can be used to tackle the global hunger is food security. The global food security is defined as both the sum of sufficient food production and food access. According to FAO, it is defined as a state when-

'All people, at all times, have physical and economic access to sufficient, safe, and nutritious food to meet their dietary needs and food preferences for an active and healthy life' (FAO, 1996) and Kumar *et al.* (2020)

Even after sufficient food is produced in the world to meet the needs of each individual, but still through studies it is found that more than 10% of global population is still under nourished. The statistics easily reflects that the only factor missing to satisfy the definition of food security is food access. The entire content can be summarised into the only reason, i.e. the fall on the level of production of food due to the global climate change. William R. cline (2007).

For production of crops, the list of important things that hits to our mind is quality seeds, chemi-

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cals, the irrigation system, the machinery, but the factor that may hit later is the agro meteorological factors which actually had contribution of roughly 67% in growth of the crops. The change in climate cannot be just understood through the change in air quality or the increase in temperature but also the fall in the water table, the contamination of the water, the change in the monsoon pattern and loss of the soil quality. Specially, if the effect of climate change is observed in India than it can be clearly understood that a lot of families will come into danger as nearly 58% of our population is highly depended on agriculture and are mostly low to middle income farmers. But according to the govt's data, even though a large number of people is following agrarian lifestyle Birthal *et al*. (2014)

GHGs from agriculture are a significant source of the climate change and greenhouse impact. However, the effects of climate change on agricultural production are far-reaching and could pose a future threat to food security. Wheeler and Braun (2013) A significant source of greenhouse gas emissions already comes from agriculture and the larger food production sector. These emissions could rise even further in the future if agriculture is intensified to make up for output declines (partly brought on by climate change) and rising demand for animal products. Between 2005 and 2050, the demand for livestock-related products is predicted to increase by 70%. Future food insecurity is projected to be significantly exacerbated by climate change, which will raise food prices and decrease food output. William (2007). As energy prices rise as a result of attempts to combat climate change, food may become more expensive. Due to drought and rising crop water demand, the amount of water needed for food production may become scarcer. As some regions become climatically unsuited for production, competition for land may increase. Extreme weather events linked to climate change may also cause abrupt drops in agricultural productivity, which would result in sharp price future climate change is anticipated to increase the frequency of heat waves, which will be extremely difficult for agriculture Kumar *et al.* (2020). Heat waves can lead to heat stress in both plants and animals, which has a detrimental effect on how much food is produced. When the plants are in the flowering stage, which is a single, crucial stage, extreme heat waves are very bad for crop output since they may result in no seeds at all. Heat stress in animals can reduce their fertility and productivity. It can also negatively impact their immune systems, increasing their susceptibility to certain diseases Birthal *et al*. (2014).

Relation Between Climate and Crops

Climate-related limitations will have an impact on the types of crops that can be grown and the livestock that can be kept. Plants that require a specific amount of water might not grow well in dry climates or places. It is possible to set up a sizable irrigation system, but doing so would be expensive. It makes more sense to choose a plant that is better suited to the local precipitation patterns. Areas with prolonged winters may not be suitable for crops that require an extended growing season. Mall *et al.* (2006) Again, it isn't very practical, but you could build a complex greenhouse and extend the growing season in this way. Planting crops that can withstand drought, such as some varieties of millet, five beans, and grapes, might be wise in a region that is prone to drought. Kumar *et al.* (2014b) Crop production is impacted by the climate and weather in many ways. If a weather event that is lethal to crops occurs during the growing season, an indicator of the influence of the fatal event may be more pertinent to explain variances in agricultural yield in that year than the growing-season mean climate. This category includes events like the 1993 Missouri floods in the United States, which destroyed a significant quantity of crops in the American Midwest (Rosenzweig *et al.,* 2002). If no catastrophic weather event occurred, the major variances in crop yield, as observed in various agricultural status reports, would be explained by the mean climate of the growing season Singh *et al.* (2019).

The impact of weather and climate on the various crop production factors can vary and frequently occurs concurrently. Furthermore, different climate extremes can have varied effects on agricultural productivity. This makes it challenging to comprehend how the climate affects many aspects of agricultural production. For the sake of explanation, let's use an extreme hypothetical scenario in which a tropical cyclone-related landslide covers part of a cropland. In this situation, the harvested area would reduce, but the yield in the harvestable region would not necessarily decrease. In a more severe scenario, a growth season environment that is unfavorable—for example, reduced solar radiation caused by a modified monsoon—would reduce yield but not necessarily harvested area, Guiteras, (2009).

Major Reasons for Climate Change

Based on observations of Earth and scientific study conducted by a wide number of organizations and thousands of scientists from across the world, our understanding of the causes and effects of climate change is continually expanding in both breadth and depth. The latest research and observations from organizations like the Intergovernmental Panel on Climate Change (IPCC) and the World Meteorological Organization (WMO) serve as the foundation for all UNFCCC-r Due to human activity, notably the combustion of fossil fuels and changes in land use, the concentration of GHGs has been gradually rising since the Industrial Revolution, which has resulted in rising global temperatures. The amount of GHGs present in the atmosphere is directly correlated with the average global temperature on Earth. Small temperature increases have significant effects on weather and climate systems, which have negative effects on human existence and society. To prevent further emissions, lower the atmospheric concentration of GHGs, and prepare for the present and future effects of climate change, immediate action is required. Singh *et al.* (2019).

Natural phenomena that are not part of the climate system, such as variations in volcanic activity, solar output, and the Earth's orbit around the Sun, can have an impact on the climate of the planet. Changes in solar radiation and volcanic activity are the two of these that are important on the time scales of modern climate change. These variables primarily affect the quantity of incoming energy in terms of the energy balance of the Earth. Volcanic eruptions are irregular and have a very short impact on the climate. Over the past century, variations in solar irradiance have influenced climate patterns, but since the Industrial Revolution, the impact of additional greenhouse gases in the atmosphere has been more than 50 times greater than variations in the Sun's output Singh *et al.* (2006).

Anthropogenic Reasons

The main factor of climate change brought on by humans is carbon dioxide. It has been released in enormous amounts as a result of the burning of fossil fuels, and because it is a highly long-lived gas, it continues to have an impact on the climate system even after spending a very long period in the atmosphere. However, other chemicals are released by the burning of fossil fuels, industrial operations, agricultural, and forestry-related activities. Mall *et al.* (2006) some greenhouse gases, like carbon dioxide, are long-lived and contribute to long-term climate change. One example is nitrous oxide. Due to their fast removal from the atmosphere, some chemicals have shorter atmospheric lifetimes. They have a comparable transient impact on the climate system. Together, these transient climate forcing account for a sizable portion of the current human climate forcing. Positive climate forcers are those short-lived climatic forcing that warm the climate, whereas negative climate forcers cool it, Gupta *et al.* (2014).

If continued emissions keep the atmospheric reservoirs of short-lived climate forcers filled, they will continue to have an effect on the climate. However, lowering emissions will swiftly result in lower concentrations of such compounds in the atmosphere. After carbon dioxide, a variety of short-lived climate forcers have an impact on global warming and together they play a major role in how much the greenhouse effect is enhanced by humans. This comprises black carbon, a small solid particle produced by the incomplete combustion of carbon-based fuels (such as coal, oil, and wood), as well as methane and troposphere ozone, both of which are greenhouse gases. Singh *et al.* (2006).

Sulfate aerosols, among other transient climatic forcing, have a cooling effect on the climate. In addition to carbon dioxide, burning fossil fuels releases sculpture dioxide into the atmosphere, where it reacts with water vapor to generate aerosols, which are microscopic droplets that reflect sunlight. Sulphate aerosols do not have the same long-term impact as greenhouse gases since they are washed off in what is known as acid rain after only a few days in the sky. However, some of the warming from other substances has been countered by the cooling from sulfate aerosols in the atmosphere. That is, if it weren't for the high concentrations of sulfate aerosols in the atmosphere, the warming we have already seen would have been substantially greater Singh *et al.* (2006).

Technological Impact on Farmers Decision Making

Farmers' access to agronomic technology can affect how the climate affects many production-related factors. To make up for the delayed seedbed preparation when the monsoon onset is late, for example, Northeast Thailand frequently uses direct seeding, which is a planting technique that saves more time and effort than transplanting (Sawano *et al.,* 2008).

Because of the photoperiod-sensitive rice varieties grown there, directly seeded rice always has a shorter growing season than transplanted rice, which results in a lower yield (Wheeler and Braun, 2013). Another illustration is how the type of rice used-floating or non-floating-affects the amount of land that can be harvested, the number of harvests, and the yield following floods, according to Kotera *et al.* (2014). Which aspect of crop output is influenced by the climate is also significantly influenced by farmer decisions. On the one hand, some farmers might only pick crop plants with the least amount of damage. The result of this choice would be a reduction in harvested area but not in yield. On the other hand, other farmers might harvest every plant, even those that are injured, and these results in a lower yield but not a smaller harvested area. Importantly, both choices can be considered legitimate in certain economic situations. When the crop price is high enough to make up for the decreased production, the former choice may be anticipated. The latter choice would be anticipated when crop production is supported by government subsidies or crop insurance, where insurance payouts are determined by deviations from a predetermined normal yield caused by yield anomalies The type of marketing channels, among other things, is a significant economic determinant. Producers who sell their goods directly to consumers postponed harvesting in order to assure full maturity because their customers place a higher importance on flavor than color William (2007).

To ensure the timing and requirements of the shipment, individuals who sell apple fruits through wholesale markets expedited the coloring by laying reflecting materials on the ground and/or removing leaves from around the fruits.

The choice of crops produced in response to water availability is another illustration of how decision-making and technology affect cropping area by Kumar *et al.* (2014b)

Extent of Crop Failure Due to Climate Change Shock

Although the extent of the harvestable area may be reduced as a result of severe weather events during the crop growth period (as well as insect outbreaks and other shocks) and the subsequent farmer response, temporal changes in the cropped area during crop growth from planting to harvest have not yet been well documented. Kumar *et al.* (2014b) For instance, the severity of tropical cyclones (a function of wind speed and accumulated rainfall) and the stage of rice growth when the cyclones hit can be used to explain the extent of rice area damaged as a result of tropical cyclones in Japan Additionally, depending on the growth stage at the time hailstorms struck and the producer's choice to replant, the yield and harvested area of maize in the United States are affected by hail (through lower stands and defoliation). Guiteras, R. (2009) However, due to a paucity of data, many economic models rely solely on the crop price from the previous year to estimate the harvested area in a given year (e.g., Furuya and Kobayashi, 2009). Even though it is somewhat true that pricing affects how much a farmer plants a crop, this method ignores the fact that severe weather occurrences reduce the amount of land that may be harvested William (2007)

Climate Change Had Lead to Shift in Cropping Areas

The significant impact of technology and decision-making on crop output makes it extremely difficult to identify, attribute, and comprehend historical cropping patterns' effects on climate change. For instance, many studies examining agro-climatic indices (such as growing-season degree-days with a certain base temperature) have long hypothesized and suggested that recent climate change may have contributed to the expansion of cropping area to higher latitudes and altitudes, but few studies have confirmed this hypothesis. For instance, the cropping area in central Siberia dropped after the fall of the Soviet Union in 1991, despite the fact that the thermal conditions there gradually improved, reaching their apex in the 1960s and 1980s as a result of increasing industrialization and urbanization, William (2008).

Although biophysical factors, such as climate, also contribute to the explanation of historical cropland trajectories in some biophysically marginal regions, the expansion of cropland in the continental United States between 1850 and 2000 is primarily attributed to changes in population density (Kumar *et al.,* 2012).

On the basis of a thorough field survey, Zhang *et al.* (2013)'s study is the only one we are aware of that shows cropland has expanded both vertically and horizontally throughout the Tibet Autonomous Region along the Brahmaputra River and its two tributaries. An agro-climatic index suggests that the observed cropland expansions are followed by improved thermal conditions, but it is more likely that they are the result of rising food demand in that area and farmer responses to enhance their income. Mall *et al.* (2006).

Interestingly, the region's cropping intensity rose both horizontally and vertically in the 2000s compared to the 1970s, mostly as a result of temperature increases. A second crop, rapeseed, can be grown for the remainder of the growing season to increase soil fertility and income since farmers can plant the first crop, winter barley, earlier than they would have otherwise been able to. The availability of water and fertile soil (soil deposition is driven by water transportation) is another element that restricts the spread of agriculture in the area, and as a result, agricultural expansion and intensification are currently restricted to a specific distance from main river systems. William (2007).

Adaptation Shown by Crops Under Climatic Stress

The climate changes drastically when the Earth's temperature rises and becomes idiotically harsh. Environmental changes can be exceedingly harmful and put naturally occurring crop species in danger in many different ways. In field conditions, heat and drought are the most common stresses and have a big impact on plants. According to reports, plants need a specific temperature to grow and blossom normally. The physiology of plants is greatly impacted by temperature changes. The production and yield of grains are negatively impacted by heat stress, sterility is caused by cold stress, and the morpho-physiology of plants is negatively impacted by drought stress. These climatic issues seriously hinder plant growth and yield and cause massive reactions that include molecular, biochemical, physiological, and morphological changes Kumar *et al.* (2020).

In order to create plants that are resistant to stress, it has become clear that understanding the mechanisms underlying plant stress-resistance is a highly challenging undertaking. To supply the demand for food each day, major cereal crops including maize, rice, and wheat are essential. The most widely grown of these was wheat, which topped the list of staple crops. Wheat delivers a far higher concentration of proteins than maize or rice, which only supply 2 to 3% per gram and is grown on 38.8% of all agricultural land in the globe William (2007).

The Ways to Tackle the Impact of Climate Change on Agriculture

Changes in sowing timing, the use of cultivars resistant to drought, and the development of novel crops are some crucial methods for reducing the threat posed by climatic unpredictability and improving crop plants' capacity for adaptation. Through the use of crop-management strategies that can improve crop development under a variety of environmental challenges, we can also help plants adapt to their environment. To combat weather pressures, it's important to choose the right sowing time, planting density, and watering procedures. Kumar et *al.* (2020)

Plant breeding demonstrates dynamic approaches for crop development and improvement under varied environmental challenges. By creating stress-resistant cultivars, it provides a technique to potentially ensure food security and safety under extreme weather fluctuations and assist plants in escaping from various pressures during a vital stage of plant growth (Kumar *et al.*, 2020). One of the key components for determining accomplished inbreeding is genetic divergence analysis, which is used for polymorphism, inbreeding, assessment, assortment, and recombination to achieve plant perfection. The production of novel cultivars based on genetic distance and similarity is thought to benefit greatly from genetic divergence studies, Wheeler and Braun (2013).

Omics approaches offer helpful tools to clarify the biological roles of any genetic information for crop development and improvement Wheeler and Braun (2013). In population genomics, many molecular markers are investigated across the environment in a large number of individuals to discover novel variation patterns and assist in determining if the genes play roles in major ecological features (Wheeler and Braun, 2013). In order to attain the highest levels of molecular breeding and to screen elite germless with multi-trait assembly, the breeding program is often combined with genomic techniques in various crops Kumar *et al.* (2020). Genetics and transcriptase analysis are employed to identify phenotypes under various environmental variation correlations Wheeler and Braun (2013). Investigating the molecular pathways underlying the resistance to abiotic stress is also made possible by genomics Wheeler and Braun (2013)

A powerful method for genetically altering the

DNA for the benefit of humans is biotechnology. A potent tactic is genetic alteration using biotechnology. Genetics has gathered encouraging information that can be used to considerably mitigate a variety of biotic and abiotic challenges, including salt, drought, heat, and cold. Findings into stress-responsive transcription factors (TFs) can be used to create agricultural cultivars that are resistant to stress. In genetically modified crops, these TFs can regulate the phenotypes of genes linked to diverse stressors, Government of India. (1989) and Wheeler and Braun (2013).

Conclusion

The world is alarmed by climate change because it affects agriculture and the goods produced by it. Global warming is a result of industrialization and toxic gas emissions, which ultimately damages the environment. Plant development and yield are severely hampered by climate change. The most common sort of stress that plants experience is abiotic stress. The most urgent requirement right now is to investigate the genetic underpinnings of these systems in order to comprehend how plants respond to various abiotic situations. For greater plant adaptation to abiotic circumstances, several bottleneck molecular and physiological hurdles must be overcome. A particularly important sign of environmental stress is changes in temperature and rainfall patterns. Collectively, weather changes have both beneficial and negative effects, but the latter are more thought-provoking.

Conflict of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Conflict of Interest -None

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