IMPACTS OF CLIMATE CHANGE ON AGRICULTURE - A CONCEPTUAL ANALYSIS

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Abstract

Human emissions of carbon dioxide and climate change have a considerable impact on agricultural productivity, but the full impact has never been adequately assessed. Water availability is critical, yet rainfall is erratic, and the Palmer Drought Index of severity fails to compensate for every factor. Climate change in other parts of the world could have an impact on agriculture, whereas enhanced water utilization could contribute to preventing droughts. Because of fertilization with carbon dioxide and O3 destruction, agricultural output estimates are unreliable, and a comprehensive investigation of the repercussions of climate change on diseases and pests has not yet been achievable. Climate change has a consequential effect on infestations and conditions, yet it has no effect on productivity in agriculture globally.

As well as decreasing agricultural production and a rise in insect and weed infestations, climate change can result in soil deterioration, saltwater intrusion, landslides, increasing desertification, water damage, and loss of topsoil. In India, agriculture yield and output are suffering as a consequence of droughts, hurricanes, extremely high temperatures, rising seas, glaciers thawing, and warming oceans brought on by climate change. The temperatures in India are expected to rise by 3–4 °C by the end of the century, contributing to a 3-26% decrease in overall agricultural revenues. Climate change has a considerable impact on agricultural production worldwide, based on Met Office Hadley Center estimations for 2020 and 2050. The paper presents an overview of the numerous aspects of climate change that impact the productivity of agriculture. In consideration of the aforementioned, the main objective of this research article is to conduct a conceptual investigation into the theoretical impact of climate change on agriculture. This point of view considers the issue at present as urgently necessary, as well as socially and historically significant.

Keywords: **Human, Carbon Dioxide, Climate Change, Agricultural Productivity, Rainfall, Soil deterioration, Landslides, Warming and Agricultural Revenues.**

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Theme of the article

The environment and its conditions have a significant impact on agriculture. Even while farmers are frequently adaptable in their approach to weather and compared to the previous variations, there is still a significant amount of local adaptation to climate change in the form of entrenched infrastructures regional agricultural procedures, and personal experiences. In light of this, it is reasonable to anticipate that climate change will have an effect on agriculture, possibly posing a threat to certain current farming practices while also offering possibilities for advancement. In this article, recent research on how many mechanisms affect the efficiency of the worldwide agriculture as a result of climate change is reviewed. Instead of concentrating on particular places or processes, the objective is to present a world-scale perspective of all pertinent impacts because the purpose of this research is to contribute to an overall evaluation of the hazards to the worldwide availability of food.

There are many studies that concentrate on the effects of a certain component of climate change in a given area, but there are very few that offer a worldwide analysis. Furthermore, these studies frequently ignore changes in extremes or indirect consequences of climate change, such as rising sea levels or pests and diseases, in favor of concentrating on the direct impact of changes in the mean climate state on the development of crops.The prospective both direct and indirect effects of global warming on productivity in agriculture are yet to be subjected to a thorough, independently verified assessment. We report anticipated changes in pertinent climate-related parameters from the Met Office Hadley Centre models at each stage of our examination of the research as a first step toward such a comprehensive system assessment. This enables an overview of the various aspects of climate change that are pertinent to agricultural productivity, allowing for an evaluation of the relative significance of the various probable causes and implications. Both future research directions and some context for decision-making in a very unclear domain are provided by this.

The overwhelming majority of earlier analyses of the effects of climate change on agriculture, as well as other industries, have concentrated on time horizons approaching the end of the 21st century, emphasizing the consequences of human-caused climate change that may be prevented through decreased emissions of greenhouse gases.Because to the momentum of the natural climate system and the time scales over which significant change regarding human economic, social, and political impact on emissions of greenhouse gases could be brought about, it is also important to assess the impacts of climate change over the coming decades.Considering the climate system is sluggish to adapt to impose changes, even if greenhouse gas emissions started to decline right away, there would still be some degree of continued warming for decades and some sea level rise continuing for centuries. We give Met Office Hadley Centre for Climate estimates for roughly 2020 and 2050 in order to put the existing material in context on these time scales because there is relatively limited information on the effects of climate change accessible in the existing literature. Although the focus of this article is on impacts on productivity of crops, numerous of the procedures and consequences discussed below are additionally relevant to animals for consumption. The subject appears in some depth in the digital additional information.

Statement of the problem

Changes in the climate may make biodiversity in the soil loss, erosion, salinization, drop in organic matter, landslides, desertification, and flooding worse. Increased temperatures, altered precipitation patterns, and changing levels of greenhouse gases in the atmosphere can all have an impact on how much carbon is stored in soil. Poor quality forage and grain can affect how well pastures and wilderness can feed grazing animals. Crop growth may be hampered by greater precipitation and temperature extremes. Floods and droughts in particular can damage crops and decrease production. The agricultural sector in India is susceptible to climate change. Higher temperatures often lead to lower agricultural yields and an increase in the growth of weeds and pests.

Because of both an increase in temperatures as well as fluctuations in water supply, climate change can have a negative impact on the productivity of crops that require irrigation in all agriculture-ecological zones.The droughts that are becoming more frequent and extreme, hurricanes, extreme temperatures, higher seas, glaciers that are melting, and warmer seas can all adversely injure livestock, damage the habitats they rely on for survival, and have a disastrous impact on human way of life and societies.Both the productivity and output of agriculture of India are suffering as a result of global warming.

According to predictions made by the Intergovernmental Panel on Climate Change, India's temperatures is predicted to rise by 3–4°C by the end of the twenty-first century, which will result in a loss of 3–26% in net agriculture earnings. There are many ways that agriculture may be impacted by climate change. Warming tends to decrease production above a particular range of temperatures because crops grow more quickly and produce fewer grains as a result. Additionally, rising temperatures hinder plants' capacity to absorb and use precipitation. Taking into account the aforementioned facts, the overall objective of this research article is to present a thorough theoretical investigation into the impacts of climate change on agriculture in a conceptual analysis with the help of secondary sources of information and statistical data relevant to the article's subject matter. According to these points of view, the article's problem is one that is urgently needed and socially relevant.

Methodology of the article

The information and data utilized in this research obtained from secondary sources that related to the article's theme. It is a conceptual evidence-based descriptive and diagnostic review. Secondary research, also referred to as statistical analysis, uses data that has already been collected. In order to improve the effectiveness of the research overall, relevant data is obtained and organized carefully keeping the objective of the article in mind.

Secondary information can be gathered from an extensive variety of sources, including books, confidential journals, newspapers, websites, and official records. Primary data are regarded to be more difficult to obtain than secondary data. These sources of information can be used with comparatively little effort and investigation.

Objective of the article

The main objective of this article is to assess the impact of climate change on agriculture through a conceptual analysis using secondary sources of information as well as relevant statistical data.

Agriculture significantly influenced on climate change

The long-term mean climate state has a significant impact on the nature of agriculture and farming practices in any given location. Local farming communities typically have the infrastructure and experience necessary for specific farming practices and crop groups that are known to be productive in the given climate. If the mean climate shifts away from existing states, current practices may need to be modified in order to sustain production, and in some circumstances, the best form of farming may change.

Increased temperatures throughout the growing season can have a considerable influence on farm income, food security, and agricultural output. The suitability and productivity of crops are expected to rise and expand northward in mid- and high-latitudes, particularly for cereals and cool-season seed crops. Maize, sunflower, and soy beans, which are common crops in southern

Europe, might also be able to thrive further north and at higher altitudes. Depending on the crop, yields could rise by as much as 30% in this area by the 2050s. Due to longer planting windows and generally better growth conditions under warming, estimated huge gains in potential agricultural area for regions like the Russian Federation for the next century amount to a 64 percent increase over 245 million hectares by the 2080s. By the 2050s, however, technological advancement might exceed these disadvantages and lead to combined gains in wheat output of 37-101%. Without producer adaptation, even moderate levels of climate change may not necessarily have a positive impact on agriculture. For example, a rise in the mean seasonal temperature may cause many current crop varieties to be harvested earlier, resulting in lower yields overall than would otherwise be the case.

The higher temperatures may be quicker harmful, increasing the heat stress on crops and water loss by evaporation, in areas where temperatures are already close to the physiological maximum for crops, such as seasonally arid and tropical regions. In mid-latitudes, a 2°C local warming might boost wheat productivity by about 10%, whereas at low latitudes, a similar level of warming could reduce yields by almost the same percentage. Various crops have varying sensitivity levels to warming. The significant uncertainty in agricultural yield changes for a specific level of warming should be noted. We calculated the annual aggregate losses due to warming since 1981 by modeling statistical correlations between growing season temperature, precipitation, and global average yield for six key crops.

Describe two possible scenarios for how the mean temperature throughout the year will vary between 2020 and 2050 in comparison to today. All cropland is expected to warm to some extent, although the high latitudes are expected to undergo the greatest warming change. However, due to the existing marginal agriculture in some of these places, slight temperature rises in low latitudes may have a greater effect than in high latitudes. Variations in precipitation patterns have a big impact on agriculture because water is essential for plant growth. Projections of future precipitation changes frequently affect the magnitude and direction of climatic impacts on crop production because more than 80 percent of all agriculture is based on rainwater. Although there is growing confidence in projections of a general increase in high-latitude precipitation, especially in winter, and a general decrease in many parts of the tropics and sub- tropics, the impact of global warming on regional precipitation is difficult to predict due to strong dependencies on changes in atmospheric circulation. Even while there is agreement in some places regarding the direction of change, these uncertainties are represented in the two scenarios that are presented, which estimate differing signs of precipitation change averaged over all croplands. In one scenario, where precipitation is expected to increase generally, there are notable increases in the southern United States and India but also notable losses in the tropics and subtropics. In the alternate scenario, there are likewise declines in the low latitudes but no appreciable rises in India.

The vast range of precipitation change forecasts from several climate models is reflected in this. Numerous factors contribute to the variations in precipitation estimates. There are a variety of variables that can affect forecasts of precipitation change in a certain place, but one important one is the substantial dependency on changes in atmospheric circulation, which depends on the relative rates of warming in different regions. For instance, the difference between the expected weakening of the dynamical monsoon circulation, which would reduce Indian monsoon precipitation, and the rise in atmospheric water content brought on by global warming, which would increase Indian monsoon precipitation, accounts for some of the uncertainty in precipitation change over India.

Nevertheless, variations in the precipitation season might be of greater interest to agriculture than variations in annual mean. Climate models for India often predict a decline in precipitation during the dry season and an increase during the rest of the year, including the monsoon season, albeit with a significant inter-model variation. The availability of water is impacted by many factors in addition to precipitation. By the 2070s or 2080s, increased evaporative demand caused by warmer temperatures and longer growing seasons may increase crop irrigation needs worldwide by 5 to 20%, possibly more. However, due to significant regional differences, South-East Asian irrigation needs may rise by 15%. According to regional research, the need for irrigation will likely rise across the Middle East and North Africa and by up to 15% in Southeast Asia. However, it is anticipated that China will have fewer needs. These predictions obviously also rely on erratic variations in precipitation.

Weather emergencies and climate change

Though modifications to the average long-term climate will have an impact on the world's food supply and may necessitate continual adaptation, changes in the variation from year to year and severe thunderstorms may pose larger dangers to food security. Anomaly low precipitation episodes have historically been blamed for many of the biggest drops in crop yield. However, production can be affected by even little variations in the mean annual rainfall. In particular, the spatial and temporal distribution of monsoon rainfall has a significant influence on Indian agriculture. It was established that different geographical areas responded differently to extremes in precipitation. Because of the relatively brief growing season and relation to total precipitation, crop productivity in the upper Ganges basin is susceptible to drought. On the other hand, the Brahmaputra basin showed a rising impact of precipitation variability on crop productivity, particularly drought, while the lower Ganges basin was sensitive to pluvial flooding. Because of changes in precipitation patterns, these correlations have not remained constant over time. District variation suggested the significance of social variables and the development of irrigation technology.

Although specific incidents cannot be linked to climate change, the increase in the likelihood of heat waves over the twentieth century is suggested by meteorological data. The summer of 2003 brought extremely harsh weather to Europe, with 6°C on average above average temperatures and 300 mm of precipitation deficits. In Italy, where extraordinarily high temperatures predominated, corn cultivated in the Po valley saw a record crop output loss of 36%. According to estimates, manmade climate change has increased the likelihood of such summer temperatures in Europe by 50%.

The concept of adverse conditions varies by area because contemporary methods of agriculture are well adapted to local climates and produce adequate crops and types. For instance, temperatures that are extreme for grain farmers in the UK would be seen as average for farmers of cereals in central France. In many areas, agriculture may change to practices currently utilized in warmer climes, such as cultivating more tolerant crops, in order to adapt to increases in extreme temperature events. Increases in high heat or drought, however, may push the local climate into a state outside of what humans have historically experienced in areas where farming is practiced at the edge of critical thresholds. It can be challenging to predict how much adaptation will be feasible in certain situations.

- **Extremely high temperatures**

Since the middle of the 1980s, there may have been a connection between recent increases in climate variability and agricultural yields in nations around Europe, leading to increasing inter-annual variability in wheat yields. According to this analysis, wheat would become a high-risk crop in Spain due to such variations in yearly output variability. Without adaptation, crops even in mid-latitudes can suffer from extremely high temperatures. The former Soviet Union (USSR)'s abnormally high summertime average temperatures in 1972 played a significant role in the widespread disruptions of the global cereal market and food supply.

Short-term temperature fluctuations can have serious consequences, especially if they occur during important developmental periods. Many crops' yields can be significantly decreased by just a few days of high heat (more than 32°C) during the flowering period. Crop reactions to adjustments in growing circumstances can be nonlinear, exhibit threshold responses, and be affected by a variety of stresses that have an impact on their development, growth, and ultimate yield. Crop physiological activities that are involved in growth, such as photosynthesis and respiration, exhibit continuous and nonlinear responses to temperature, but rates of crop development frequently exhibit a linear response to temperature up to a certain point.

Nonetheless, environmental optimums are present in the processes of both growth and development. High temperatures have a short-term impact on gene expression and enzyme activity. These will have an effect on carbon assimilation, growth rates, and ultimate yield over the long term. The stage of crop development can affect how high temperatures affect the final yield. Showed that crucial temperatures of 35°C for a brief period around a thesis had substantial yield-reducing effects and that the plants experience warming episodes as independent events. High temperatures did not appear to have a substantial impact on growth and development, nevertheless, during the vegetative stage. Reviews of the literature indicate that temperature thresholds, particularly for processes like a thesis and grain filling, are clearly characterized and substantially conserved between species.

Despite the fact that groundnut is often produced in semi-arid regions with temperatures about 40°C, if the plants are exposed to temperatures above 42°C after flowering, even briefly, the yield may be significantly decreased. At temperatures above 36°C, maize shows decreased pollen viability. Mid-thirties degrees Celsius cause rice grains to become sterile, and wheat can experience the opposite of the vernalizing effects of cold temperatures at similar temperatures. Corn, soy beans, and cotton yields in the USA are negatively impacted by temperature increases above 29°C, 30°C, and 32°C, respectively. Future events would be less rare than those that are extreme today. It might be challenging to distinguish the effects of severe temperature events from those of drought. However, there are critical temperature limits over which crop physiology changes, potentially ruining harvests.

❖ **The drought**

Numerous interpretations of droughts exist, and they typically reflect various viewpoints. assert that "the significance of drought lies in its impacts." In order for definitions to be employed in an operational manner by decision-makers, they should be region-specific and impact- or application-specific. It is common to distinguish between different types of drought, including hydrological drought (reduced stream flow), agricultural drought (deficit in soil moisture, increased plant water stress), and socio-economic drought (balance of supply and demand of water in civilization). Since the 1960s, there has been an increase in the percentage of area affected by drought, as measured by the Palmer Drought Severity Index, in the areas sown for the major crops of barley, maize, rice, sorghum, soya bean, and wheat. This increase has ranged from around 5-10% to approximately 15-25%. A comparison of climate model simulations and observed data shows that the observed drying trend in PDSI has been caused by anthropogenic increases in greenhouse gas and aerosol concentrations. The global mean PDSI has likewise increased.

Drought is characterized in climate modeling studies as the 20th percentile of the PDSI distribution across time for pre-industrial conditions; this definition is hence region-specific. Therefore, at any given moment, 20% of the land surface will be considered to be in drought, yet the conditions in a location that is ordinarily wet during a drought may nevertheless be less dry than in another region that is dry during a drought. According to this definition, the MOHC climate model predicts that the percentage of land surface affected by drought increased from 20 to 28 percent throughout the course of the 20th century.

Construct a yield reduction rate (YRR), which analyzes historical yield trends with actual annual yields to determine a YRR due to climate variability (assumed to be owing to technology advancement and infrastructure improvement). It was claimed that 60-75% of observed YRRs can be explained by a linear relationship between YRR and a drought risk index based on the PDSI using national-scale data for the four key cereals (wheat, maize, rice, and barley). Current mean YRR values are estimated to be between 5.82 percent (for rice) and 11.98 percent (for maize). It is anticipated that drought-related yield reductions would rise by more than 50% if the linear link between the drought risk index and YRR holds in the future. The negative effects of drought may outweigh the positive effects of higher temperatures and longer seasons seen at mid- to high latitudes. It was proposed that lower agricultural production in some Russian regions may be offset by higher crop production in others, leading to relatively small average changes, using models of the world climate, crop productivity, and water resources. However, their findings suggest that in many of the major crop-growing regions in the 2020s and 2070s, the frequency of food production shortfalls might increase and triple, respectively. Despite an overall rise in water availability across Russia, the water resources model anticipated more frequent low run-off events in the South's already dry crop-growing regions and a markedly increased frequency of high run-off events over much of the country.

- **Flooding and significant rainfall**

A surplus of water might have an adverse effect on the production of food. Widespread crop destruction can result from heavy rainstorms that cause flooding, and too much water can also have additional negative effects such soil water logging, anaerobicity, and slowed plant growth. Farming operations being delayed is an indirect effect. It's possible that agricultural equipment isn't designed to operate in moist soil. In a study examining the effects of current climatic variability, it was found that August's significant rainfall was associated with poorer grain quality, which causes the grain to sprout in the ear and become infected with a fungal illness. This was demonstrated to have an impact on the subsequent goods' quality, which in turn affected the quantity of milling wheat shipped from the UK. As the climate continues to warm, the proportion of total rain that falls during severe rainfall events seems to be decreasing, and this tendency is anticipated to last. Over much of Europe, an increase in severe rainfall is predicted to result from a CO_2 doubling. In many locations crucial to agriculture, rainfall intensity increases by over 25% in the higher end estimates.

Agriculture production and indirect consequences of climate change

- **Parasites and ailments**

Through pests and disease, rising atmospheric CO_2 and climate change may potentially indirectly affect crops. The entire effects on crop yield are still unknown due to the complexity of these interactions. According to evidence, pests like aphids and weevil larvae respond favorably to increase CO_2. The overwintering mortality of aphids was also decreased by higher temperatures, allowing for an earlier and possibly more extensive dispersion. Evidence suggests that rainfall patterns in sub-Saharan Africa may affect locust movement patterns; as a result, there is a chance that climate change will affect how destructive this insect is. Climate change may also have an impact on pathogens and disease. This may be achieved by changes in climate or drought-related crop disease resistance as well as increased pathogenicity of organisms due to mutations brought on by environmental stress. Within its current distribution and into more northern areas where it is not yet present, the disease affecting oilseed rape could get worse over the course of the next 10 to 20 years. Changes in climate variability may also have a big impact on outbreaks' predictability and amplitude.

- **Water availability fluctuations brought on by distant climatic changes**

Climate changes outside of industrial zones could be quite important. Less than one-fifth of all farmed land is irrigated, but it generates 40 to 45 percent of the world's food. Water for irrigation is frequently taken from rivers, which depend on remote climatic conditions. For instance, rainfall in the upper levels of the Nile, such as the Ethiopian Highlands, is necessary for agriculture along the Nile in Egypt. Indicates the expected changes in monthly river flow for a selection of important rivers that are relevant in this context for the 2020s and 2050s. Climate change is causing some rivers, like the Nile, to flow more often year-round, which may be advantageous for agriculture. In contrast, the rise in run-off is accompanied by an increase in peak flow in other catchments, such as the Ganges, during the monsoon season. The river flow is still relatively low during the dry season. Despite general increases in annual water availability, water shortage may hinder agricultural output without adequate storage of peak-season flow. Flooding on croplands could result from increases during the peak flow.

These regions are primarily found in mid- to high-latitude regions, where warming is expected to be most pronounced. Less snow falls as a result of winter warming, and snow that does collect melts earlier in the year. Such systems' ability to store and release water is profoundly altered by shifting snow cover patterns. Changes in precipitation have an impact on runoff volume, especially as snowmelt begins to take hold at the end of the winter. The timing of runoff is mostly impacted by temperature variations, with earlier spring peak flows.

Whereas more river flow may be advantageous to agriculture, this is only the case if there is a way to store extra run-off for use later in the growing season. Few rivers presently have enough storage to handle significant changes in run-off's seasonality on a global scale. A large portion of the winter runoff will quickly be lost to the oceans when storage facilities are insufficient. Demonstrates the Volga catchment's monthly river flow in Russia. It demonstrates an earlier and higher peak flow during snowmelt, followed by a reduced flow throughout the remainder of the course of the year. One-sixth of the world's population today resides in river basins that are fed by mountain glaciers, including the Indus and Ganges, two significant rivers. key population growth is anticipated in key glacier-fed river basins like the Indo-Gangetic plain. As a result, adjustments to remote precipitation as well as the volume and seasonality of glacial melt waters may have an effect on global food supply.

The vast majority of glaciers that have been seen around the world are shrinking. It was previously impossible to link this retreat to recent warming. Although changes in atmospheric moisture, particularly in the tropics, may be playing a role, there is broad agreement that warming is the primary cause of retreat. River flow will be initially augmented by glacier melting, but as the flow becomes more seasonal, the risk of flooding will rise. Long-term glacial retreat is anticipated to be further accelerated, eventually resulting in a drop in run-off, though the timing of this decline is uncertain. With around 15,000 glaciers in the Himalayas, the Chinese Glacier Inventory recorded 46 377 glaciers in western China. These glaciers hold about 12,000 km3 of fresh water in total. There is evidence of glacial weakening in the western Himalayas, and radioactive bomb deposits from one high-altitude glacier show no net accumulation since 1950. A glacier retreat in the Himalayas is also supported by the low number of firsthand observations. Large rivers like the Indus, Ganges, and Brahmaputra receive water from these glaciers, and although the precise amount is unknown, it is expected to contribute significantly to seasonal river flow. These rivers currently supply household and agricultural water to close to 500 million people. The Indus and Ganges rivers could become more cyclical due to climate change and stop flowing during the dry season. This indicates that water shortages in the area will likely worsen in the future, especially given the region's growing population.

- **Normal sea level rise**

Because of a combination of the thermal expansion of the ocean's already-existing water mass and the addition of new water from the melting of land ice, sea level rise is an unavoidable result of a warmer climate. In particular, when the capability for the introduction or modification of sea defenses is relatively poor or nonexistent, this can be predicted to eventually result in the inundation of coastal territory. With regard to crop yield, it is obvious that areas with low-lying coastal agriculture and significant sea level rise are most vulnerable. In recognition of the fertility of fluvial soils, many large river deltas offer significant agricultural area, and many small island nations are likewise low-lying. In the coming decades and centuries, rises in mean sea level pose a threat to submerge agricultural lands and saline groundwater, while the most severe effects might not be felt for many centuries due to the time needed to melt sizable ice sheets and for warmth to reach the deep ocean. The West Antarctic Ice Sheet (WAIS), the East Antarctic Ice Sheet (EAIS), and the Greenland Ice Sheet (GIS), which are both thought to be fragile, would each have a potential sea-level rise associated with it of 5 meters, 60 meters, and seven meters, respectively. A maximum eustatic sea-level rise of roughly 2 m by 2100 is thought to be physically achievable but extremely unlikely due to the potential pace of discharge of these ice sheets and past maximum sea-level rise (under similar climatic conditions). Even if land is not permanently destroyed, storm surges that last only a short while can still be extremely destructive. There hasn't been a lot of research done on the effects of storm surges or mean sea level rise on agriculture.

Aspects of changes in atmospheric composition, which are not connected to climate, as a consequence of emissions of greenhouse gases

- **Fertilizing with CO2**

Increasing atmospheric CO2 concentrations can directly alter plant physiological processes like photosynthesis and transpiration in addition to having an impact on climate through radiative forcing. Therefore, any evaluation of how CO2-induced climate change affects agricultural productivity must take into consideration how the physiological effects of CO2 influence the climate impact. various photosynthetic mechanisms (known as C3 and C4) that have evolved affect how various species respond to CO2. These routes also affect how different species respond physiologically to CO2. The distinction is whether or not the plant cells' ribulose-1,5-bisphosphate carboxylase-oxygenase (RuBisCO) is saturated by CO2. Because RuBisCO in C3 plants is not CO2-saturated under the current atmospheric circumstances, increasing CO2 concentrations promote net carbon intake and consequent growth. Since the RuBisCO enzyme is highly conserved in plants, it is anticipated that all C3 crops, including wheat and soy beans, will exhibit similar reactions. According to theoretical calculations, boosting atmospheric CO2 concentrations to 550 ppm might result in a nearly 40% increase in photosynthesis in these C3 crops.

The physiology of C4 crops such as maize, millet, sorghum, and sugarcane differs. Because CO2 concentrations in these plants are three to six times higher than in the atmosphere, RuBisCO is already saturated. As a result, higher CO2 concentrations provide no further physiological benefits. These crops may become more water-efficient at higher CO2 concentrations because stomata do not need to stay open as long for the plant to receive the requisite CO2. As a result, yields may rise modestly. Increased CO2 concentration in the atmosphere increases photosynthesis by 30-50% in C3 plant species and 10-25% in C4 plant species, resulting in a smaller crop yield gain.

Increased carbon dioxide (CO2) has the ability to increase production amounts while decreasing yield quality. Global-scale comparisons of CO2 fertilization impacts with those of mean climate change demonstrate that the degree of CO2 fertilization effects is a significant component in deciding whether global-scale yields are anticipated to rise or decrease. Without CO2 fertilization, all regions are expected to lose production due to climate change by 2050. By the end of the century, stabilizing CO2 levels at 550 ppm would reduce output losses, and pressures from drought might be lessened by improved water use efficiency and increased root densities. This could change the correlation between meteorological drought and agricultural or hydrological dryness and partially counteract the anticipated rise in evaporative demand caused by global warming.

In order to determine how much water is actually accessible for agricultural use, soil moisture and run-off are crucial factors. These quantities are simulated in climate models as being essential to the hydrological cycle. Forecasted variations in soil moisture and runoff are shown in two scenarios, with increases in certain areas and decreases in others. Extreme temperature changes are crucial, and dryness can be more dangerous than the yearly mean soil moisture availability.

- **The ozone**

Ozone is a significant secondary air pollutant that has been found to have detrimental effects on agricultural yields at current concentrations. While ozone precursor emissions are down in North America and Europe, they are fast rising in other parts of the world, particularly Asia. Ozone decreases agricultural production in a number of ways. First, immediate and obvious damage to goods, like horticultural crops, lowers their market worth. In addition, ozone lowers photosynthetic rates and speeds up leaf senescence, both of which have an effect on the final yield. Numerous studies looking into such yield reductions have been conducted in Europe and North America. However, there is now minimal evidence in other regions, such as Asia. We therefore have a limited understanding of the effects in these areas.

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Conclusions

Although there are many impacts caused by human emissions of greenhouse gases and climate change on agricultural output, their overall influence is not yet recognized. In fact, many of these effects and their interactions have not yet been accurately quantified, especially at the global level. Although a rise in the average temperature may be confidently predicted, the effects on production may be more influenced by the frequency and severity of high temperatures. Agricultural land may eventually be lost due to persistent inundation caused by mean sea-level rise, but the effects of brief flooding from storm surges may be significant even though they are less predicted.

Groundwater supply is crucial, yet precipitation predictability is extremely unpredictable, and there is also the additional issue of a lack of clarity over the pertinent drought indicator. The Palmer Drought Severity Index is one measure used in some research, including those by the IPCC; however it does not take into account all essential variables. Due to the reliance on rivers nourished by precipitation, snowfall, and glaciers located far away, agricultural impacts in some places may result from climate changes in other regions. Increased water usage efficiency by plants under increasing CO_2 concentrations may also partially alleviate drought, while the effect is still unclear, particularly on enormous scales. Although most agricultural areas are anticipated to see an increase in the amount of time spent in drought as measured by soil moisture, the climate models employed here project an increase in annual mean soil moisture availability and runoff in many locations.

Furthermore the direction of crop production estimates is unknown because it heavily depends on the potency of CO_2 fertilization as well as O_3 damage. Modeling predictions are inadequately limited as a result of the paucity of studies evaluating crop yield responses to CO_2 fertilization and O_3 pollution under actual growing circumstances. A global study of the indirect effects of climate change on pests and illnesses has not yet been done, but local studies have been done. Overall, a thorough evaluation of the effects of human climate change on global agricultural productivity does not seem to be achievable at this time.

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