

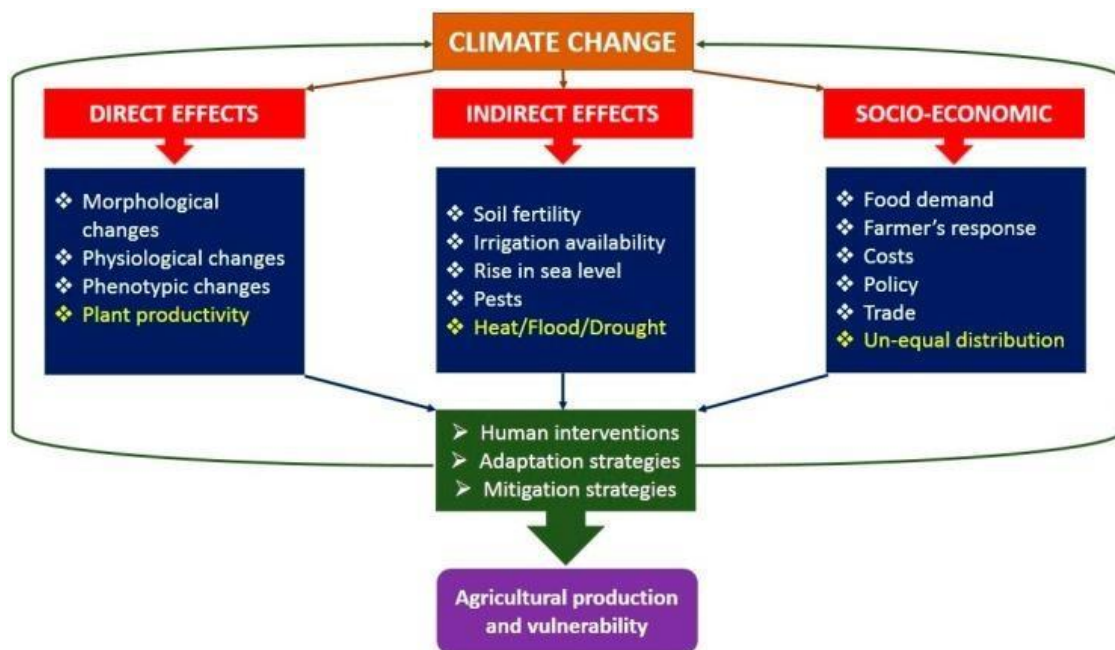
The Impact of Climate Change on Crop Yields

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Agriculture and climate change are internally correlated with each other in various aspects, as climate change is the main cause of biotic and abiotic stresses, which have adverse effects on the agriculture of a region. The land and its agriculture are being affected by climate changes in different ways, e.g., variations in annual rainfall, average temperature, heat waves, modifications in weeds, pests or

microbes, global change of atmospheric CO₂ or ozone level, and fluctuations in sea level. Plant growth and yield are greatly influenced by abiotic stresses. Under natural climate conditions, plants often experience numerous stresses like waterlogging, drought, heat, cold, and salinity. Living organisms such as plants, animals, fishes, and humans have been affected by the extreme environmental conditions around the globe. The danger to the world's climate conditions has triggered anxiety among everyone because crop yield might be compromised by fluctuations in various environmental factors that can risk food security. Recent studies reported that the developed countries have more vulnerability towards climatic changes (8–11%) than developing states. This article explores the various ways in which climate change affects crop production, the region's most at risk, and the strategies farmers are adopting to mitigate these impacts.

Rising Temperatures and Heat Stress on Crop Yield

Rising temperatures are a prominent consequence of climate change, with significant implications for agricultural productivity worldwide. Heat stress, resulting from elevated temperatures, can severely impact crop yields by affecting plant physiology and development. This article delves into how rising temperatures lead to heat stress, the physiological responses of crops, and the measures that can be taken to mitigate these effects.

Impact of Rising Temperatures on Crops

1. **Optimal Temperature Ranges:** Each crop species has a specific temperature range within which it thrives. Deviations from this range, particularly towards higher temperatures, can disrupt normal growth processes. For example, optimal growing temperatures for wheat range between 15-20°C (59-68°F). When temperatures exceed this range, wheat experiences reduced growth and yield.
2. **Heat Stress and Plant Physiology:** Heat stress occurs when temperatures are high enough to cause physiological damage to plants. This can manifest in various ways:
 - **Reduced Photosynthesis:** High temperatures can impair the photosynthetic machinery of plants, leading to reduced carbon assimilation and energy production.
 - **Accelerated Respiration:** Increased temperatures boost respiration rates, which can deplete the energy reserves of the plant and reduce biomass accumulation.
 - **Protein Denaturation:** Extreme heat can denature essential enzymes and proteins, disrupting cellular processes and leading to cell death.

2. Impact of Altered Precipitation Patterns on Crops

1. **Drought Conditions:**
 - **Water Stress:** Drought conditions lead to water stress, where crops do not receive sufficient moisture



for optimal growth. This affects various physiological processes, including photosynthesis, nutrient uptake, and transpiration.

- **Reduced Growth and Yield:** Prolonged drought periods can stunt plant growth, reduce leaf size, and ultimately decrease biomass and yield. For instance, maize (corn) is highly sensitive to water stress during its flowering and grain-filling stages, leading to significant yield reductions.
- **Soil Degradation:** Drought can also degrade soil health by reducing soil moisture, increasing erosion, and decreasing the activity of beneficial soil microorganisms.

2. Excessive Rainfall:

- **Waterlogging:** Excessive rainfall can lead to waterlogged soils, which suffocate plant roots by depriving them of oxygen. This can cause root rot and other diseases, severely impacting crop health and yield.
- **Nutrient Leaching:** Heavy rains can wash away essential nutrients from the soil, leading to nutrient deficiencies that affect plant growth.
- **Delayed Planting and Harvesting:** Persistent heavy rains can delay planting and harvesting times, disrupting the agricultural calendar and potentially reducing the growing season.

3. Increased Incidence of Pests and Diseases on Crop Yield

Climate change is not only altering temperature and precipitation patterns but also increasing the incidence and spread of agricultural pests and diseases. This phenomenon poses a significant threat to crop yields and global food security. This article examines how climate change is driving these changes, the specific impacts on crop health and productivity, and strategies to mitigate these effects.

How Climate Change Increases Pests and Diseases

1. Warmer Temperatures:

- **Extended Growing Seasons:** Warmer temperatures can extend the growing seasons of both crops and pests. This allows pests multiple life cycles within a single season, increasing their populations.
- **Expanded Ranges:** Higher temperatures enable pests and pathogens to expand their geographical ranges into regions previously too cold for their survival. For example, the European corn borer and the Colorado potato beetle are extending their habitats northward.

2. Altered Precipitation Patterns:

- **Humidity and Disease:** Many plant pathogens, such as fungi and bacteria, thrive in warm and humid conditions. Increased humidity and frequent rainfall can create ideal conditions for diseases like rusts, blights, and mildews.
- **Drought and Pest Resilience:** Some pests, such as locusts and aphids, can survive and even thrive in



drought conditions, exacerbating their impact on already stressed crops.

3. Increased CO₂ Levels:

- **Enhanced Pest Survival:** Elevated CO₂ levels can improve the food quality for some pests, increasing their survival and reproduction rates. For instance, higher CO₂ levels can lead to increased nitrogen in plant tissues, making them more nutritious for pests.

Examples of Pests and Diseases Influenced by Climate Change

1. Insects:

- **Fall Armyworm (*Spodoptera frugiperda*):** Originally confined to the Americas, this pest has spread to Africa and Asia, devastating maize and other crops.
- **Colorado Potato Beetle (*Leptinotarsa decemlineata*):** Warmer temperatures have enabled this pest to move northwards, affecting potato crops in regions previously safe from infestations.

2. Fungal Diseases:

- **Wheat Rusts (*Puccinia* spp.):** Rust diseases thrive in warm, humid conditions and can cause significant yield losses in wheat. New, more virulent strains like Ug99 are spreading due to climate change.
- **Late Blight (*Phytophthora infestans*):** This pathogen, which affects potatoes and tomatoes, thrives in wet and humid conditions. Climate change-induced changes in precipitation are increasing its prevalence.

3. Bacterial Diseases:

- **Xanthomonas Wilt:** Affects bananas and other crops, with outbreaks linked to wetter conditions brought about by climate change.
- **Bacterial Blight (*Xanthomonas oryzae*):** This disease affects rice and is becoming more prevalent in changing climatic conditions.

4. CO₂ Concentration and Crop Yield

The rising concentration of atmospheric CO₂, largely due to human activities like fossil fuel burning and deforestation, plays a significant role in climate change. CO₂ is a critical component of photosynthesis, the process by which plants convert light energy into chemical energy. Elevated levels of CO₂ can influence crop growth and yield in various ways, presenting both opportunities and challenges for agriculture. This article explores the effects of increased CO₂ on crop yields, including potential benefits, negative impacts, and the complex interactions with other climate change factors.

Positive Impacts of Elevated CO₂ on Crop Yields

1. Enhanced Photosynthesis and Growth:

- **C₃ Plants:** Plants that use the C₃ photosynthetic pathway, such as wheat, rice, soybeans, and most



other crops, can benefit from increased CO₂ levels. Elevated CO₂ enhances the efficiency of the enzyme RuBisCO, which catalyzes the first major step of carbon fixation. This can lead to higher rates of photosynthesis, greater biomass accumulation, and potentially increased crop yields.

- **C4 Plants:** C4 plants, including maize (corn), sugarcane, and sorghum, are less responsive to elevated CO₂ because they already have a mechanism to concentrate CO₂ around RuBisCO. However, these plants may still see some improvement in water-use efficiency and growth under certain conditions.

2. Improved Water-Use Efficiency:

- Higher CO₂ levels can cause stomata (tiny openings on leaf surfaces) to partially close, reducing water loss through transpiration. This improved water-use efficiency can be particularly beneficial in water-limited environments, potentially sustaining crop yields during periods of drought.

Negative Impacts and Limitations of Elevated CO₂

1. Nutrient Dilution:

- While elevated CO₂ can enhance growth and yield, it can also dilute the nutrient content of crops. For instance, increased CO₂ levels often lead to lower concentrations of essential nutrients such as proteins, iron, and zinc in crops like wheat and rice. This nutrient dilution poses a significant challenge for food quality and human nutrition, especially in regions where these crops are dietary staples.

2. Interaction with Other Climate Factors:

- **Temperature:** Higher CO₂ levels are often accompanied by rising temperatures. While CO₂ can boost crop growth, excessive heat can counteract these benefits by causing heat stress, reducing yields, and affecting crop development and reproductive success.
- **Water Availability:** Improved water-use efficiency under elevated CO₂ is beneficial, but the overall impact on yields depends on water availability. In regions experiencing severe drought, the benefits of higher CO₂ may be limited if water remains a major limiting factor for crop growth.

3. Increased Pest and Disease Pressure:

Elevated CO₂ can alter plant physiology and chemistry, potentially making crops more susceptible to pests and diseases. For example, changes in plant tissue composition under higher CO₂ levels can improve the nutritional quality of plants for pests, leading to increased pest populations and damage. Additionally, some pathogens thrive under the altered environmental conditions associated with climate change.

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