



## Effects of Climate Change on Vegetable Production

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### Abstract

The agriculture sector is highly sensitive to climate change, as the climate of a region determines the characteristics of its vegetation and crops. Global climate shifts are significantly impacting agriculture, affecting the world's food supply. Vegetable crops are particularly vulnerable to climatic changes, with temperature spikes and irregular precipitation at any growth stage leading to reduced growth and ultimately decreasing yields. In India, diverse climatic conditions allow the cultivation of various vegetables, making the country the second-largest producer globally. Vegetables are essential for food and nutritional security, but they are perishable, and climate change-driven price increases make them inaccessible to the poor. To combat these challenges, developing adaptation strategies is crucial. Focus should be on creating production systems with improved water use efficiency suited to hot and dry conditions. Crop management practices like mulching with crop residues or plastic can conserve soil moisture, while raised bed cultivation can counteract problems from excessive rainfall. Additionally, breeding techniques and biotechnology are essential for addressing these climate-related challenges.

**Keywords:** vegetation, vulnerable, combat, efficiency and addressing.

### Introduction

Climate change involves shifts in the climate caused directly or indirectly by human activities, which alter the global atmosphere beyond the natural variability observed over time. The Earth's atmosphere is primarily made up of nitrogen (78%), oxygen (21%), and argon (0.93%), gases that interact minimally with solar and infrared radiation. However, greenhouse gases (GHGs) in the atmosphere do interact with thermal radiation from the Earth's surface, trapping heat and leading to a warming effect known as the natural greenhouse effect. This natural process is crucial, as it helps maintain the Earth's average temperature, which would otherwise be around -20°C.

The natural greenhouse effect balances absorbed solar radiation with outgoing terrestrial radiation, ensuring the Earth remains habitable. Before the industrial revolution, human activities contributed only minor amounts of gases to the atmosphere. However, industrialization and the increase in GHG emissions have intensified the greenhouse effect, contributing to global warming and climate change.

These long-term climatic variations and sudden changes in weather patterns have raised concerns about the stability and profitability of the agricultural sector, particularly in the fruit industry. Climate change poses significant challenges for agriculture, including altered growing conditions, increased risks of crop failure, and fluctuating yields. To sustain farm incomes and ensure food and nutritional security, it is essential to understand the potential

impacts of climate change on various crops. By gaining a deeper understanding of these effects, farmers and policymakers can develop strategies to mitigate risks and adapt agricultural practices to a changing climate, ensuring the long-term sustainability of the agriculture sector. The phenology of agricultural plants is significantly influenced by maximum, minimum, and average temperatures. Rising global temperatures will necessitate the development of varieties that can better withstand higher temperatures. Climate change will impact the suitability and adaptability of existing cultivars by altering their growing seasons.

### **Impacts of climate change**

- Early glacier melting and flooding.
- Warmer, prolonged winters with unpredictable changes.
- Hotter and prolonged summers with low humidity and nearly zero precipitation.
- Inconsistent and decreased winter precipitation and snowfall.
- Groundwater depletion and water scarcity.
- Shifts in ecological zones.

All these changes will ultimately affect the vegetable production as a crop has a cardinal temperature range for proper growth and development and extremes of high and low temperatures affect the plant growth adversely.

### **Impacts of climate change on growth and development of vegetable crops**

Vegetable crops are highly sensitive to climate fluctuations, such as sudden temperature increases and irregular precipitation during any stage of growth. Vegetables are essential for food and nutritional security, but their perishability and rapid price increases during events like droughts or floods make them inaccessible to the poor. Climate change disproportionately affects small and marginal farmers, especially those who primarily rely on vegetable farming. In changing climatic conditions, issues like crop failures, reduced yields, lower quality, and increased pest and disease outbreaks are common, making vegetable farming unprofitable. Winter vegetables are particularly vulnerable to harsh weather compared to summer crops. Abiotic stresses such as extreme temperatures (both low and high), soil salinity, drought, and flooding are detrimental to vegetable production. High temperatures and limited soil moisture are key factors contributing to low vegetable yields. Different developmental stages, such as vegetative growth, flowering, and fruiting, are significantly impacted by climate variability. Elevated temperatures and unpredictable precipitation can disrupt normal plant growth and development, ultimately reducing crop productivity. Environmental stresses also negatively affect soil organic matter decomposition, nutrient recycling, and the availability of nutrients and water to plants. The severity and duration of these environmental extremes determine their overall impact on the crop growth cycle, biomass accumulation, and economic returns. Some major environmental effects affecting vegetable production are listed below:

- Early bolting in temperate crops.
- Chilling and frost injuries ultimately resulting in cell rupture and death.
- Increased incidence of insect-pest and diseases due to high temperatures and humidity.
- Improper pollination and fruit set ultimately affecting yield.
- Retarded plant growth due to extremes of both high and low temperatures.
- Improper colour development on crops like tomato and carrot.
- Physiological disorders like buttoning, bolting, sun-scald.

## Environmental factors that limit vegetable productivity

- 1) Temperature:** Consistently high temperatures lead to various morpho-anatomical changes in plants, impacting seed germination, plant growth, flower shedding, pollen viability, fertilization, fruit set, fruit size, fruit weight, and fruit quality. Several morphological traits aid in heat tolerance through conventional breeding approaches. These include long root length, which enhances water and nutrient uptake, a short life span to minimize temperature effects on the plant, and hairiness that provides partial shade to the cell wall and membrane, repelling sunlight and insects. Small leaf size reduces evaporation by minimizing stomata, while specific leaf orientation improves photosynthesis and enhances heat stress tolerance. Additionally, leaf glossiness and waxiness help reflect sunlight and deter insects. Low temperatures, such as chilling and freezing injuries, can affect all plants, but the mechanisms and types of damage vary significantly. Chilling injury occurs when plants are exposed to temperatures above 0°C (0°C-10°C), while freezing injury happens when plants are slightly exposed to temperatures below 0°C. Freezing injury in plants is caused by the formation of ice crystals from cytoplasmic water, leading to cell wall rupture and damage to cytoplasmic components. Tropical crop plants are highly susceptible to freezing injury, even with minor freezing conditions, whereas crops adapted to colder climates can often withstand mild freezing with minimal damage. In temperate climates, exposure to chilling temperatures can severely reduce yields or even lead to complete crop failure due to direct damage or delayed maturation. Even a slight temperature drop, without visible damage to chilling-sensitive plants, can result in up to a 50% reduction in productivity. Growth reduction has also been observed in muskmelon and watermelon. Seeds, particularly beans, are especially sensitive to low temperatures during imbibition and may fail to germinate under such conditions.
- 2) Soil Salinity:** Excessive soluble salts in soil, particularly in arid and semi-arid regions, limit the production of many crops, including vegetables (FAO 2002). Salt stress leads to several detrimental effects on plants, such as loss of turgor, stunted growth, wilting, leaf drop, decreased photosynthesis and respiration, loss of cellular integrity, tissue necrosis, and eventually plant death. In crops like cabbage, salinity significantly reduces germination percentage and rate, as well as root and shoot length and fresh weight. Salt stress also disrupts various metabolic processes. The problem of soil salinity is worsening, with salinized areas increasing by 10% annually due to factors like low precipitation, high surface evaporation, weathering of native rocks, irrigation with saline water, and poor agricultural practices. Young seedlings and plants during flowering are particularly sensitive to salinity stress, more so than at mature stages. Some crops, like onions, are highly sensitive to saline soils, while others, such as cucumbers, eggplants, peppers, beet, palak, and tomatoes, show moderate sensitivity. The response of plants to increased salt levels varies significantly among species, depending on their genetic tolerance to salinity.
- 3) Water Stress:** Drought stress occurs when soil water levels drop significantly, and atmospheric conditions accelerate water loss through processes like transpiration and evaporation. This stress is one of the most critical abiotic factors affecting plant growth and productivity, particularly in vegetable crops. While plants generally possess mechanisms to tolerate drought stress, the degree of tolerance varies widely among species and even among different varieties within a species. Drought stress manifests in various physiological changes, including reduced water content, decreased leaf water potential, loss of turgor pressure, stomatal closure, and a reduction in cell enlargement and growth. In vegetable crops, the effects of drought stress can be severe. The closure of stomata, which helps the plant conserve water, also limits the uptake of carbon dioxide,



leading to reduced photosynthetic activity. As photosynthesis declines, the plant's growth is stunted, and biomass accumulation decreases. The reduction in photosynthesis can also cause an imbalance in the production of chlorophyll, specifically altering the ratio of chlorophyll 'a' to chlorophyll 'b' and affecting carotenoid levels. These pigments are crucial for capturing light energy and protecting the plant from oxidative stress, so their disruption further impairs plant health. Drought stress can also have critical impacts on the reproductive stages of vegetable crops. For instance, in crops like onions and okra, persistent drought conditions can severely hinder seed germination. Similarly, in potatoes, drought stress can affect the sprouting of tubers, which is essential for crop establishment and yield. The overall result is a significant reduction in crop yield and quality, making drought one of the most challenging environmental factors for vegetable production.

- 4) Flooding:** Most vegetables are highly sensitive to flooding, particularly those with shallow root systems. Waterlogging poses a serious threat to crop growth and yield, especially in low-lying, rain-fed areas. When soil becomes waterlogged, the excess water displaces the air in the soil, leading to oxygen deprivation—a condition known as hypoxia. This lack of oxygen severely impairs the plant's ability to take up nutrients and water, causing symptoms like wilting, even when the soil is saturated with water. The primary cause of damage in waterlogged conditions is the shift in the plant's energy metabolism from an aerobic (oxygen-dependent) mode to an anaerobic (oxygen-independent) mode. Under anaerobic conditions, plants cannot produce sufficient energy to maintain normal physiological processes. This energy deficit leads to a buildup of toxic compounds, such as ethanol and lactic acid, which further damage plant cells and tissues. In vegetable crops, waterlogging can cause a range of detrimental effects. For instance, root systems may suffer from rot due to prolonged exposure to waterlogged conditions, which weakens the plant's overall structure and reduces its ability to absorb essential nutrients. Additionally, waterlogged soils often lead to nutrient leaching, particularly of nitrogen, which is vital for plant growth. This nutrient loss can result in poor plant vigor, chlorosis (yellowing of leaves), and stunted growth. Waterlogging also exacerbates disease problems in vegetable crops. The damp, anaerobic environment created by waterlogged conditions is ideal for the proliferation of soil-borne pathogens, such as *Pythium* and *Phytophthora*, which can cause root and stem rot. These diseases are often fatal, leading to significant yield losses. Moreover, waterlogging during critical growth stages, such as flowering and fruiting, can lead to poor pollination, reduced fruit set, and inferior fruit quality. This is particularly problematic in crops like tomatoes, peppers, and cucumbers, where consistent moisture levels are crucial for the development of high-quality fruits. Unfortunately, most vegetable crops have limited genetic variation for flood tolerance, making it challenging to breed varieties that can withstand prolonged waterlogged conditions. This lack of genetic diversity underscores the importance of adopting effective water management practices, such as improving drainage systems and using raised beds, to mitigate the risks associated with flooding in vegetable production.

## Conclusion

Addressing climate change's impact on vegetable production requires a multifaceted approach that integrates both short-term adaptation and long-term mitigation strategies. Farmers can adopt climate-resilient agricultural practices, such as the use of drought-resistant and flood-tolerant crop varieties, to reduce vulnerability to extreme weather events. Improved water management techniques, including drip irrigation and rainwater harvesting, can enhance water use efficiency and minimize the risk of waterlogging. Additionally, implementing soil conservation practices, such as mulching and cover cropping, can help maintain soil health and fertility, making crops more resilient to climate-induced stresses.

Precision agriculture technologies, like weather forecasting tools and sensors, enable farmers to monitor environmental conditions in real-time and make informed decisions about planting and harvesting. On a broader scale, investment in research and development is crucial for breeding new crop varieties that can thrive under changing climatic conditions. Policies that support sustainable farming practices, provide financial assistance, and promote climate-smart agriculture are essential to ensure the long-term viability of vegetable production in the face of climate change.

### References

1. Dhillon, W.S. and Gill, P.P.S. (2015). Climate change and fruit production. *Climate Dynamics in Horticulture Sciences*, 1: 23-31.
2. Kałużewicz, A., Gliszczyńska, A., Klimczak, I., Lisiecka, J., Tyrakowska, B., and Knaflewski, M. (2012). The influence of short-term storage on the content of flavonoids and vitamin C in broccoli. *European Journal of Horticultural Sciences*, 77(3): 137–143.
3. Kumar, L. (2013). To study the promotion of micro drip irrigation system and its impact on horticultural crop production in Ranchi district of Jharkhand. *Masters project*, pp 48.