



## Impacts of Climate Change on Afghanistan's Horticulture Sector: A Review

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### Abstract

Afghanistan's horticultural sector faces significant challenges as a result of climate change, including rising temperatures, erratic rainfall, glacier retreat, and increased pressure from pests and diseases. Major fruit, vegetable and ornamental crops experience disruptions in flowering, fruiting, pollination, and postharvest quality due to these changes. Reduced chilling in temperate fruits, sunburn and cracking in apples, apricots, and grapes, heat-induced yield loss in vegetables, and climate-sensitive insect outbreaks are all indicated by global research and regional observations, despite the lack of direct and thorough investigations conducted in Afghanistan. Productivity is further threatened by water scarcity that is made worse by poor management. So as to highlight adaptation and mitigation options, such as climate-resilient cultivars, protected cultivation, precision irrigation, integrated pest management, enhanced soil management, and expanded research and policy support to improve resilience in Afghanistan's horticulture sector, this review synthesizes available Afghanistan-specific data and international findings.

**Keywords:** Climate change; Horticulture; Temperature; Water scarcity; Pests and diseases; Adaptation strategies

### په افغانستان کې د بڼوالۍ په سکتور باندې د اقلیم بدلون اغېزې: بیا کتنه

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### خلاصه

د افغانستان د بڼوالۍ سکتور د اقلیم بدلون له کبله له جدي ننگونو سره مخ دی او په دغه ننگونې کې د تودوخې زیاتوالی، نامنظم بارانونه، د یخچالونو کمېدل او د آفتونو او ناروغیو زیاتې پېښې شاملې دي. د مهمو مېوو، سبو او زیتني بوټو حاصلات د دغو بدلونونو له کبله د گل کولو، مېوه نیونې، گرده افشانی او حاصل له راټولولو وروسته د کیفیت له پلوه له ستونزو سره مخ کېږي. سره له دې چې په افغانستان کې د اقلیم بدلونونو په اړوند مستقیمې او هر اړخیزه څېړنې لږې ترسره شوې دي، اما د نړیوالو څېړنو او سیمه ییزو مشاهداتو له مخې، د معتدلو مېوو د یخۍ، د اړتیا کمښت، په مڼو، ناکو، انارو او انگورو کې د لمرسوځېدنې او چاودېدنې، په سبو کې د تودوخې په وسیله د حاصلاتو ضایع کېدل او د اقلیم بدلون له کبله د زیانمنو حشراتو زیاتېدل لیدل شوي دي. سربېره پر دې، د اوبو کمښت، چې د اوبو لگولو د کمزوري مدیریت له امله نور هم ډیر شوی، د مېوو دوامدار حاصل ته جدي ګواښ پېښوي. دا بیاکتنه د افغانستان اړوند موجودو معلوماتو او نړیوالو موندنو پر بنسټ د اقلیم بدلون د اغېزو د کمولو او له هغه سره د سازښت لارې چارې؛ لکه د اقلیم بدلون پر وړاندې مقاومت وراړتیا ګانو پېژندنه، په خوندي چاپیریال کې کرنه، د څاخکو اوبه لگونه، د آفتونو هر اړخیز مدیریت، د خاورې د حاصلخېزۍ مدیریت، په اړوند د څېړنو ترسره کول او د اقلیم بدلون د کمولو د پالیسیګانو جوړول، روښانه کوي، ترڅو د افغانستان د بڼوالۍ سکتور د اقلیم بدلون پر وړاندې د سازښت وړتیا لوړه او د پایداره حاصلاتو د تولید لامل شي.

**کلیدي کلمې:** اقلیم بدلون، بڼوالی، تودوخه، د اوبو کمښت، آفتونه او ناروغی، د سازښت ستراتیژي

## Introduction

One of the most significant challenges of the twenty-first century is climate change, which affects human communities, ecosystems, and agricultural systems worldwide. Since the 19th century, human activity mainly greenhouse gas emissions and changes in land use have raised Earth's average surface temperature by about 0.8 °C. (IPCC, 2013). Food production, water supplies, and environmental sustainability are all had a negative effect by these changes, which are characterized by rising temperatures, altered patterns of precipitation, and an increase in the frequency of extreme weather events (Pörtner et al., 2022).

Climate change has a significant impact on agricultural systems, especially horticulture. Climate variability affects horticultural crops, such as fruits, vegetables, nuts, and ornamental plants, causing changes in phenology, increased pest and disease pressures, and their postharvest losses. According to recent studies, climate smart landscaping, precision orchard management, climate resilient cultivars, vertical farming, controlled environment cultivation and other adaptive practices can improve resilience (Jamal et al., 2024). The need for coordinated action among researchers, policymakers, and industry stakeholders is highlighted by the integration of cutting-edge technology, genomic breeding methods, and sustainable land use practices, which are backed by international agreements like the Paris Agreement.

Afghanistan is one of Asia's most climate vulnerable regions, with regular droughts and floods having negative effects on food security, agriculture sector, water resources, and health. Changing crop varieties, enhancing seed quality, altering irrigation techniques, and diversifying livelihoods are just a few of the adaption tactics that farmers employ. Despite these initiatives, rural populations are still very vulnerable to climate hazards, which worsen issues with poverty, food, and health, particularly in arid areas (Asim et al., 2024).

Afghanistan's agricultural sector heavily relies on horticulture. About 20–25% of the nation's GDP comes from agriculture, including horticulture which produces fruits, nuts, vegetables, and saffron playing a major part in export. Grapes, almonds, pistachio, fig, pomegranates, apples, apricots, and saffron are examples of high value crops that have a major impact on exports, employment, and domestic revenue. For example, in certain years, fruits and nuts can account for more than 40% of agricultural export revenue, with dried fruits and grapes being the main exports from Afghanistan (Jabari & Jabar, 2021).

This review attempts to critically analyze the effects of climate change on horticultural crops, identify adaptive strategies, and investigate opportunities to improve resilience and sustainability in Afghanistan's horticulture sector, given the significant challenges that climate change poses on horticultural productivity both globally and Afghanistan.

## Methodology

Relevant scientific literature published between 2000 and 2024 was reviewed using sources such as Google Scholar, Science Direct, ResearchGate, FAO publications, and country reports. Google Scholar, Science Direct, Research Gate, FAO publications, and country reports. We selected and compiled pertinent peer reviewed research on temperature rise, precipitation variations, water scarcity, pest and disease dynamics, and crop specific reactions. To detect general trends and local vulnerabilities, research conducted worldwide was compared with findings particular to Afghanistan. The applicability of adaptation and mitigation techniques suggested in the literature to Afghanistan's ecological circumstances was assessed. The data was then categorized into categories that addressed management alternatives, water resources, and effects on fruit, vegetable, and floriculture crops.

## Result and Discussion

### Effects of climate change on rising temperature

Horticultural crops' flowering, fruiting, and quality are severely disrupted by rising temperatures brought on by climate change. Even moderate temperature increases can change the hardness, ripening, and chemical composition of tropical fruits, such as mango, guava, and mandarin, where ideal production areas decrease (Haokip et al., 2020). Similar to that, inadequate chilling requirement and heat stress result in irregular bud break, poor fruit set, sunburn, cracking, and low yields in temperate fruits including apples, pears, plums, apricot, sweet cherry, and walnuts, forcing cultivation to higher altitudes. Therefore, adaptation techniques including low chill cultivars, rest breaking agents, and microclimate control are crucial (Rai et al., 2015).

Stress induced physiological challenges with horticultural crops that are relevant to Afghanistan are summarized in Table 1. The underlying stress responses such as heat, water deficiency, or high light intensity are probably applicable to Afghan agro-climatic conditions, even if many of the first observations originate from research conducted in India and other South Asian regions. These crops were chosen because they are important producers of fruits and vegetables in Afghanistan, supporting local markets and home consumption. Knowing these signs of stress aids in identifying crops that are susceptible, influences management techniques, and directs climate change adaptation plans. For instance, apple skin darkening and tomato sunburn indicate the need for temperature control and preventive measures in orchards and fields, while tipburn in lettuce and black heart in potatoes show the necessity of appropriate irrigation and soil management.

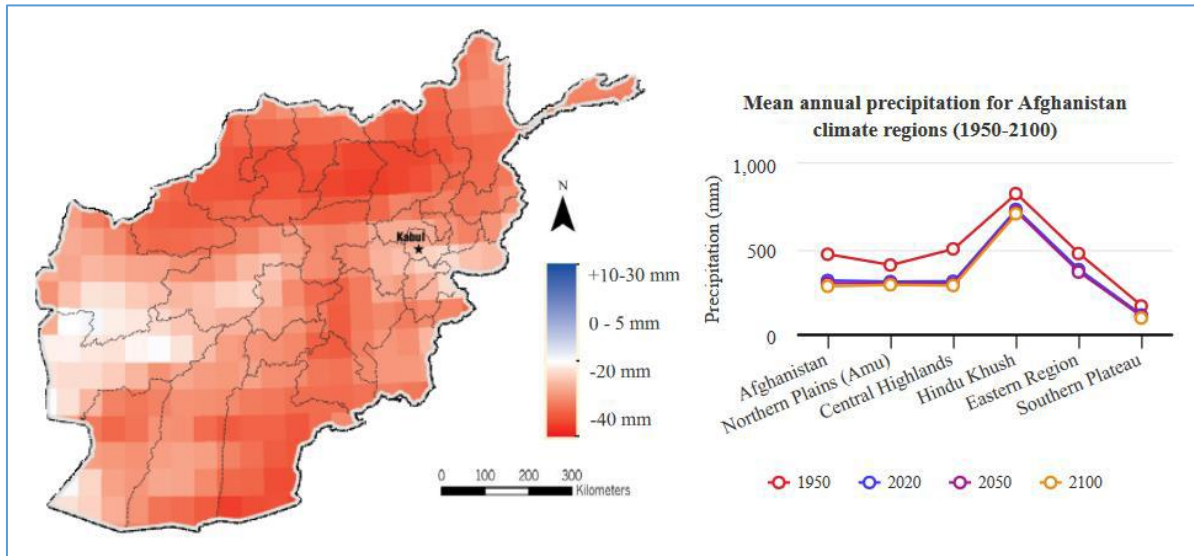
**Table-1.** Stress induced symptoms in key horticultural crops relevant to Afghanistan (adapted from Woolf and Ferguson (2000)).

Crop	Symptoms	Relevance/Interpretation for Afghanistan
Apple	Skin discoloration, pigment breakdown and water-soaked areas	Apples are a major fruit crop in Afghan orchards (e.g., Kabul, Panjshir, Nangarhar). High temperatures during fruit development can reduce marketable quality, making these disorders important for local cultivation.
Lime	Juice vesicle rupture: formation of brown spot-on fruit surface	Limes are grown in southern provinces. Heat stress or irregular irrigation may cause surface damage, affecting fruit quality for local consumption and markets
Cabbage	Outer leaves showing a bleached, papery appearance; damaged leaves are more susceptible to decay	Common in northern and central vegetable production zones. Heat stress and irregular watering can predispose cabbage to decay, reducing yield and shelf life
Lettuce	Damaged leaves assume papery aspect: affected areas more susceptible to decay; tipburn is a disorder normally associated with high temperature in the field; it causes soft rot development during postharvest	Lettuce is cultivated in cooler regions, but rising temperatures can induce tip burn and postharvest soft rot. Awareness of these disorders is critical for managing losses in Afghan fields.
Potato	Black heart; occur during excessively hot weather in saturated soil; symptoms usually occur in the center of the tuber as dark-gray to black discoloration	Potato is widely grown in highland regions. Excessive heat and poor drainage can cause black heart, reducing edible yield and storage quality.
Tomato	Sunburn; disruption of lycopene synthesis; appearance of yellow areas in the affected tissues	Tomatoes are grown across Afghanistan in summer. High sunlight and temperature stress can cause sunburn, affecting both yield and fruit marketability.

### Effect of climate change on reduced and irregular rainfall

Asia's rainfall patterns have changed due to climate change, resulting in decreased and erratic precipitation that negatively affects livelihoods and ecosystems. Climate processes like the Arctic Oscillation and the westward migration of the Indian summer monsoon have caused monsoon variability in Southeast Asia, which has resulted in rainfall drops of up to 70% below normal, causing droughts and floods (Loo et al., 2014). Similar to that, Afghanistan is experiencing more frequent floods, droughts,

and water shortages as a result of irregular precipitation patterns. These changes pose major obstacles to the nation's environmental sustainability by endangering food security, water resources, and agricultural output (Mehrad, 2020).



**Fig-1:** Afghanistan precipitation pattern under different scenarios (Mehrad, 2020).

### Impact of climate change on water resources

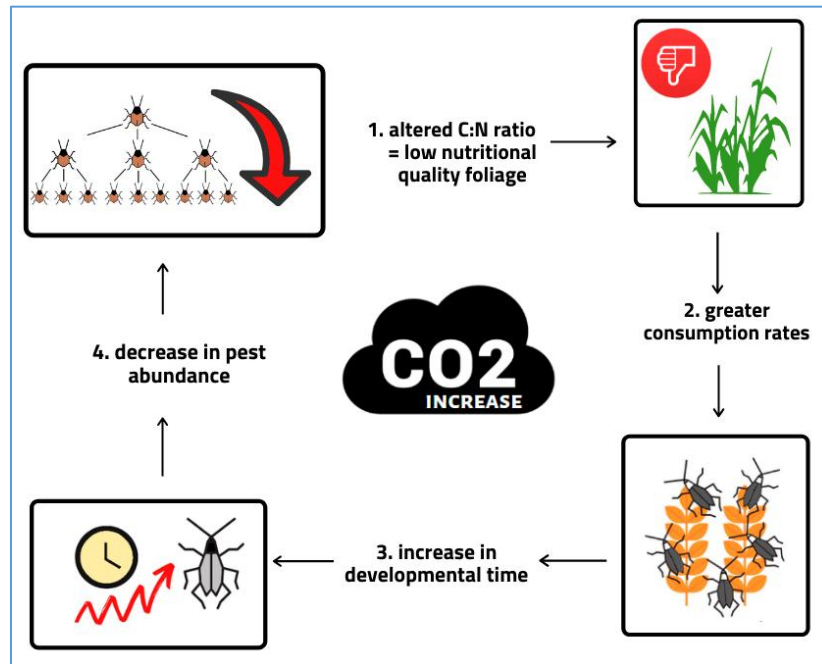
Rising temperatures, erratic or irregular rainfall, and glacier melting are some of the ways that climate change has impacted Afghanistan's water resources, causing variations in groundwater levels and river discharge. Losses surface run off and stream flow, especially in the Harirod-Murghab, Panj-Amu, and Helmand basins, resulted from a dip in average annual rainfall between 1957 and 2017. Groundwater depths fell from 60 m in 2005 to 90 m in 2017, while glacier volume dropped by 18.5% between 1994 and 2015. In certain places, increased glacier melts momentarily increased river flows, but long-term trends show water scarcity, which is made worse by protracted droughts, excessive groundwater extraction, and the drying out of ancient Karez systems.

Afghanistan's water crisis is mostly caused by ineffective irrigation (losing around 40% of water), poor water management, and trans boundary problems (with over 67% of surface water migrating to neighboring countries), while climate change also plays a role. Overall, governance and hydro-political issues are regarded as more important than climate-induced impacts, underscoring the necessity of coordinated policies for water management and climate adaptation (Rasouli, 2022; Nasimi et al., 2020; Baidar et al., 2024).

### Impact of climate change on the increase of diseases and pests

Pests and animal illnesses are severely affected by climate change, threatening global agriculture, ecosystems, and food security. The distribution, number, and behavior of pests and pathogens are changed by rising temperatures, increased CO<sub>2</sub> levels, and shifting rainfall patterns (Skendžić et al., 2021). Insects, fungus, bacteria, and viruses can live longer, proliferate more quickly, and spread to new areas at higher altitudes in warmer climates (Shrestha, 2019). This increases the frequency of pest outbreaks, the establishment of invasive species, and the spread of climate-sensitive illnesses like epizootic ulcerative syndrome in fish and bluetongue in animals (Peace, 2020). The quality of host plants is also affected by altered precipitation and increased CO<sub>2</sub>, which draw sugar loving insects and encourage the growth of pests (Shrestha, 2019). Crop loss and animal disease outbreaks are exacerbated by warmer winters, shorter insect life cycles, and excessive humidity (Skendžić et al., 2021; Peace, 2020). Additionally, natural pest host enemy balances are upset by climate change, which lowers the efficacy of biological management. Sustainable agricultural production requires adaptive, science

based tactics like predictive modeling, continuous monitoring, and updated Integrated Pest Management (IPM) (Skendžić et al., 2021).



**Fig-2:** Impact of atmospheric CO<sub>2</sub> increase on agricultural insect pests (Stiling and Cornelissen, 2007)

## Impacts of climate change on horticulture crops

### Fruit crops

Fruit crop cultivation depends on climate adaptation is significantly affected by climate change due to changes in temperature, precipitation, and the frequency of extreme weather events, all of which have an impact on plant physiology, yield, and quality. Research on grapes shows that harsh weather, fluctuating rainfall, and rising temperatures alter grape composition, including diseases evidence, sugar accumulation, acidity, and color development, making viticulture difficult (Aloy et al., 2024; Leeuwen et al., 2024; Arias et al., 2022). In a similar vine, the cultivation of apricots is extremely vulnerable to variations in the climate. The severity of *Monilinia laxa*-caused blossom and twig blight has changed due to warmer weather and altered precipitation patterns, which have caused flowering to advance by up to 50 days. In wetter, higher-altitude regions, some cultivars are less susceptible to the disease, while others are more susceptible (Tresson et al., 2020). Fruit crops suffer significant harm from extreme weather swings, such as heat and cold waves. The incidence of pests and diseases, especially fruit fly infestations, has significantly increased in guava, pomegranate and melon due to hot and humid circumstances (Hazarika, 2013). Fruits including apple, apricot, sweet cherry, pomegranate, citrus, litchi, and mango are also susceptible to sunburn, cracking, and early ripening due to temperature and moisture stress (Kumar and Kumar, 2007). Growth, yield, and fruit quality are further impacted by abiotic factors such drought, salt, flooding, and high CO<sub>2</sub> concentrations (Gora et al., 2019). Temperature has a significant impact on the development of red color in apples because anthocyanin accumulation peaks around 20–25 °C and decreases at higher temperatures (Pan et al., 2007). Extreme heat delays ripening and reduces fruit quality, while daytime and nighttime temperatures between 15 and 20 °C are ideal for anthocyanin production and fruit pigmentation in grapes (Reddy et al., 2017). Fruit set and pollination are similarly susceptible to shifting weather patterns. The ideal temperature range for pollination in temperate fruits, such as plum, apple, cherry, and pear, is between 20 and 25 °C. In contrast, low temperatures, fog, and rain have a detrimental effect on pollination, as demonstrated for sour cherries in the United States (Haokip et al., 2020). Low winter temperatures

also affect mandarin blooming and dormancy breaking, while navel oranges have a decrease in soluble solids and acidity. Fruit drop, cracking, and decreased fruit size are caused by cold temperatures below 15 °C during the early stages of longan (*Dimocarpus longan*) fruit growth (Reddy et al., 2017).

Overall, fruit production has numerous challenges due to climate change, including decreased vigor, yield, fruit size, and color intensity, increased vulnerability to pests, and decreased postharvest quality. To maintain fruit output in the face of shifting climatic circumstances, adaptive strategies such as the selection of tolerant cultivars, enhanced orchard management, and predictive modeling are crucial.

### Vegetable crops

The severity of environmental stresses on vegetable crops is significantly affected by climate change, and responses of the plants vary according to their developmental stage, the length of the stress, and its intensity (Bray, 2002). Similar morphological or biochemical strategies may be used by plants to deal with one or more stresses (Capiati et al., 2006). Interactions with the environment, however, may make these reactions more difficult or influence how climate change affects people. Table-3 lists a few types of vegetables that are susceptible to abiotic stress. By reducing fruit set and resulting in smaller, worse quality fruits, high temperatures can significantly reduce tomato pollination and yield. Heat stress prior to anthesis can cause abnormalities in the endothecium and epidermis, partial stomium opening, and inadequate pollen production (Sato et al., 2002). High temperatures prior to anthesis had little effect on pistil or stamen viability in peppers, but high temperatures after pollination prevent fruit set, suggesting that fertilization is especially vulnerable to heat stress (Erickson and Markhart, 2002). Furthermore, it has been demonstrated that air pollution dramatically lowers yields in crops including *Raphanus sativus*, *Lactuca sativa*, and *Brassica oleracea* by more than 50%. Numerous other vegetables are similarly susceptible to pollution-related harm, such as tomato, watermelon, potato, squash, soybeans, cantaloupe, peas, carrot, beet, and turnip. Vegetable yields can be lowered by 5–15% when daily ozone concentrations exceed 50 ppb (Raj Narayan, 2009).

**Table-3:** List of some abiotic stress vegetable crops. Source: Adapted from Rai & Yadav (2005)

Sl. No.	Tolerant	Crop
1.	Drought tolerant	Chill, melons, tomato, onion
2.	Heat tolerant	Peas, tomato, beans, capsicum
3.	Salinity tolerant	Melons, peas, onion
4.	Flooding/ excess moisture tolerant	Tomato, onion, chilli

### Effect of climate change on floriculture

Since it affects flowering patterns, reduces productivity, and lowers the market value of decorative crops, climate change presents serious difficulties to the floriculture sector. Temperature variations cause heat stress, floral bud abortion, and a reduction in bloom quality, especially in delicate crops like snapdragons (*Antirrhinum majus*) and roses (*Rosa hybrid*) (Murthy et al., 2024). However, they also hasten flowering in certain species. Drought and waterlogging are examples of altered precipitation patterns that further hinder floral development by altering the intake of water and nutrients. Elevated atmospheric CO<sub>2</sub> can improve water use efficiency and biomass production, but it does not always boost flower quality or yield. These effects are exacerbated by extreme weather, making floricultural crops more susceptible. Global floriculture's physiological performance, phenology, and economic stability are all at serious risk because to the combined effects of rising temperatures, erratic rainfall, CO<sub>2</sub> enrichment, and climatic extremes (Murthy et al., 2024).

### Comparison with regional trends

Afghanistan's horticultural climate change issues are in line with wider regional trends when compared to its neighbors, but its position is more insecure due to a number of structural weaknesses. For instance, irrigated agriculture in Pakistan is already severely affected by harsh weather, and many

farmers claim that increased heat and water scarcity make it difficult for them to adjust (Ali et al., 2024; Gillani et al., 2021). By 2050, the nation is expected to see temperature increases of up to 2.8 °C, which might further limit water supply and raise pest pressures (Khan et al., 2022). Due to high temperatures, minimal precipitation, and rising groundwater extraction, Iran is also dealing with a persistent water shortage (Rahmani & Abid, 2024). Despite similar climate pressures, adaptation is more challenging in Afghanistan due to these climate trends, weak institutional capability, and inadequate water management infrastructure. For example, local study reveals that many Afghan farmers continue to use antiquated irrigation systems and are ignorant of effective water-use techniques (Rahmani & Abid, 2024).

### **Adaptation strategies**

The goal of horticultural adaptation strategies is to increase productivity, sustainability, and resilience in the context of changing and unpredictable climate conditions. The development and dissemination of climate-resilient crop varieties that can withstand stresses like heat, drought, and salinity are important steps (Chachar et al., 2023; Kumar et al., 2024). Precision irrigation, rainwater collection, and effective drainage systems are examples of sustainable water management techniques that guarantee maximum water utilization and resource efficiency. By using agroforestry systems, one can enhance soil fertility, improve microclimates, and diversify revenue streams. Precision agriculture, remote sensing, and climate forecasting are examples of cutting-edge technology that facilitate data-driven adaptation and informed decision-making.

Local adaptive capacity is further strengthened and innovative approaches to addressing climate risks are encouraged through community-based initiatives and knowledge-sharing platforms. Furthermore, adaptation efforts should concentrate on strengthening the resilience and adaptability of long-term investments by creating "no-regret" strategies, encouraging reversible and flexible infrastructure designs, and adding safety margins to protect against extreme events in light of the growing uncertainty surrounding future climate conditions (Hallegatte, 2009). When combined, these strategies contribute to developing sustainable horticulture systems that may reduce risks, sustain yield productivity, and improve food security in an unpredictable and changing climate.

### **Mitigation strategies for climate change in horticultural crops**

Enhancing carbon sequestration, using sustainable farming methods, and increasing resource efficiency are all essential for horticultural systems to effectively mitigate climate change. The development and implementation of stress-tolerant and climate-resilient crop varieties, effective water management methods like mulching, rainwater collection, and drip and sprinkler irrigation, and integrated nutrient and production management with organic manures, compost, and biofertilizers to lessen reliance on synthetic fertilizers and cut greenhouse gas emissions are some of the key tactics (Rashid et al., 2020). Improving agricultural machinery's energy efficiency, utilizing renewable energy sources, controlling fertilizers and organic amendments to reduce nitrous oxide emissions through slow-release fertilizers and nitrification inhibitors like dicyandiamide or neem-based products, and carrying out soil management techniques like reduced or no tillage, biochar application, cover crops, intercropping, and agroforestry systems to increase soil organic carbon and ecosystem resilience are all part of orchard crops (Rajatiya et al., 2018). Greenhouses, shade nets, and plastic tunnels are examples of protected cultivation technologies that offer regulated settings to reduce temperature extremes and assure continuous and off-season production. However, mitigation efforts may occasionally fail or have unexpected negative impacts, underscoring the significance of comprehending mitigation risk, which results from uncertainty in reaching mitigation goals. In order to address these risks, it is necessary to determine the concerns of stakeholders, examine how decision-making is influenced by risk percep-

tion and acceptance, and take power imbalances among agents participating in mitigation into account (Cardenas, 2024).

**Table-4:** List of vegetables having tolerance to abiotic stresses. Adopted from Kanaujia et al. (2020)

Crop	Variety	Abiotic stress
Tomato	Arka Vikas and Arka Meghali	Drought
	Thar Anant, Pusa Sadabahar	Heat
	Pusa Sheetal	Fruit set up to 8°C
	Pusa Hybrid 1	Fruit set up to 28 °C
Eggplant	Pragati and Pusa Bindu	Salinity
Chilli	G4, Arka Lohit and LCA334	Drought
Okra	Pusa Sawani	Salinity
Cucumber	Pusa Barkha	High temperature
Onion	Arka Kalyan	Excess soil moisture
Radish	Pusa Chetki	High temperature
Potato	Kufri Surya	Heat

**Table-5:** Drought resistant fruit crop cultivars for dry and semi-dry areas. Source: Adopted from Singh et al. (2009) and Singh (2010)

Crop	Varieties suitable for arid and semi-arid ecosystem
Pomegranate	Ganesh, Dholka, Jalore Seedless, Mirdula, Phule Arakta, Basin Seedless
Ber	Gola, Seb, Umran, Banarasi Karaka, Goma Kirti, Narendra Ber Sel-1 and 2
Fig	Poona Fig, Dinkar, Dianna, Conardia, Excel

**Table-6:** Resistant rootstock and varieties of fruit crops against biotic and abiotic stress. Source: Adopted from Singh et al. (2009) and Singh (2010)

Crop	Root stock	Crop Shoot Stock Traits
Guava	<i>P. cujavillis</i>	Tolerant to drought, Sodic soil
Grape	Dogridge, 110 R, SO-4	Drought, Salinity tolerant
Citrus	Rangpur Lime	Drought, Phytophthora tolerant
Lime	Rangpur lime and Cleopatra mandarin	Salinity tolerant
Fig	<i>Ficus glomerata</i>	Nematode and salinity tolerant
Pomegranate	<i>Punica granatum</i> (variety: Ruby)	Drought tolerant

## Conclusion

Climate change poses significant threats to Afghanistan's horticultural sector, particularly through rising temperatures, erratic rainfall, water scarcity, and increasing pest and disease outbreaks. Apples, citrus, vegetables, and ornamental crops are most vulnerable, with projected impacts on yield, quality, and economic stability. Despite some insights from regional and international studies, there is a clear evidence gap regarding locally observed impacts on specific crops and agro-ecological zones. To enhance resilience, priority adaptation strategies include the development and promotion of climate resilient cultivars, efficient irrigation and water management, soil fertility optimization, protected cultivation, and robust pest monitoring systems. Long term adaptation also requires strengthening agricultural research, farmer education, and supportive national policies. Coordinated efforts addressing these priorities can help sustain productivity, reduce climate risks, and secure rural livelihoods in Afghanistan.

## Recommendations

Adopting climate-smart agricultural techniques, such as effective irrigation systems, soil moisture conservation, balanced fertilizer management, and the adoption of stress-tolerant crop varieties, is advised in order to reduce and adapt to the effects of climate change in horticulture. Resilience will be further improved by increasing early-warning systems, expanding access to climate-resilient technology, and strengthening farmers' technical skills through training. To decrease climate-related risks and ensure sustainable horticulture output, supportive government policies, research innovation, and enhanced market infrastructure are also crucial.

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