



Agricultural Production under Climate Change in Afghanistan: Impacts, Challenges and Adaptation Options (A Review)

Mohammad Shafiq Faieq^{1*}, Mustafa Abid¹, Abdul Khalil Afghani¹

¹Department of Agronomy, Agriculture Faculty, Kabul University, Kabul Afghanistan

*Corresponding email: m.shafiqfaieq@ku.edu.af

Abstract

Climate change poses serious challenges to agriculture in Afghanistan, a country largely dependent on rainfed farming and highly vulnerable to water scarcity, drought, and temperature extremes. Understanding the impacts of climate variability and identifying effective adaptation strategies are essential to sustain agricultural productivity and ensure food security. This systematic review synthesizes empirical, modeling, and review studies on climate change effects on Afghan agriculture, assesses adaptation measures, and integrates regional experiences from Pakistan, Iran, Tajikistan, and Uzbekistan. A structured literature search was conducted using peer-reviewed articles, institutional reports, and regional studies published between 2000 and 2025. Studies were selected based on relevance to Afghan agro-ecological systems, climate stressors, and adaptation strategies. We extracted data using a structured table format following PRISMA guidelines, combining national and regional evidence. Findings indicate that water scarcity, prolonged drought, rising temperatures, and erratic precipitation are the main stressors affecting major crops, including wheat, barley, chickpea, maize, and cotton. Yield reductions ranged from 12% to 25% across provinces. Adaptation strategies such as Climate-Smart Agriculture (CSA), efficient irrigation (drip and sprinkler), rainwater harvesting, mulching, and drought- or heat-tolerant crop varieties were most effective. Regional evidence confirms the transferability of these measures under similar agro-climatic conditions. In conclusion, climate change significantly threatens agricultural productivity in Afghanistan. Evidence-based adaptation strategies, supported by coordinated policy and capacity-building initiatives, can enhance resilience, protect rural livelihoods, and ensure sustainable food security.

Keywords: Afghanistan, agriculture, climate change, climate-Smart Agriculture, drought

تولیدات زراعتی در افغانستان در پرتو تغییرات اقلیمی: اثرات، چالش‌ها و راهکارهای سازگاری (مطالعه مروری)

محمد شفیق فایق^۱، مصطفی عابد^۱، عبدالخلیل افغانی^۱
^۱دپارتمنت اگرونومی، پوهنځی زراعت، پوهنتون کابل، کابل افغانستان
 ایمیل نویسنده مسئول: m.shafiqfaieq@ku.edu.af

خلاصه

تغییرات اقلیمی چالش‌های جدی را برای بخش زراعت افغانستان بوجود آورده است؛ کشوری که تا حد زیادی به زراعت للمی وابسته بوده و در برابر کمبود آب، خشکسالی و نوسانات شدید حرارت آسیب‌پذیری بالایی دارد. شناخت تأثیرات تغییرات اقلیمی و پیدا کردن روش‌های کارآمد برای سازگاری ضروری است تا بتوان بهره‌وری زراعتی را حفظ کرده و امنیت غذایی را تامین کرد. این مطالعه مروری سیستماتیک به بررسی تحقیقات تجربی، مدل‌سازی و مطالعات موجود در ارتباط با تأثیرات اقلیمی بر زراعت در افغانستان می‌پردازد همچنین، اقدامات سازگاری ارزیابی شده و تجارب کشورهای همسایه مانند پاکستان، ایران، تاجیکستان و ازبکستان را نیز ادغام می‌نماید. جستجوی سیستماتیک منابع با بهره‌گیری از مقالات علمی داوری شده، گزارش‌های نهادهای رسمی و تحقیقاتی که در دوره زمانی ۲۰۰۰ تا ۲۰۲۵ منتشر شده‌اند، صورت گرفت این مطالعات بر اساس ارتباط آنها با نظام‌های زراعت سنتی افغانستان، عوامل تنش‌زا در حوزه آب و هوایی و استراتژی‌های انتطابق انتخاب شدند. اطلاعات به کمک یک جدول سازمان یافته بررسی گردید و شواهد ملی و منطقه‌ای جمع‌آوری شد و مطابق راهنمای در کنار یکدیگر تلفیق شدند. یافته‌ها نشان می‌دهد که کمبود آب، خشکسالی‌های طولانی‌مدت، افزایش حرارت و بارندگی‌های نامنظم، مهم‌ترین عوامل تنش‌زا هستند که بر محصولات عمده زراعی، از جمله گندم، جو، نخود، جواری و پنبه، تأثیر می‌گذارند. کاهش حاصل محصولات در میان ولایت‌های مختلف بین ۱۲ تا ۲۵ فیصد متغیر بوده است. استراتژیهای سازگاری، از جمله زراعت هوشمند اقلیمی (CSA)، روش‌های آبیاری کارآمد مانند آبیاری قطره‌ای و بارانی، جمع‌آوری آب باران، استفاده از ملج و بهره‌گیری از انواع زراعتی مقاوم به خشکی یا حرارت، بیشترین اثربخشی را نشان دادند. شواهد منطقه‌ای نیز قابلیت انتقال و کاربرد این اقدامات را در شرایط مشابه اقلیمی و زراعتی تأیید می‌کند. در نتیجه، تغییرات اقلیمی تهدید قابل توجهی برای بهره‌وری زراعت در افغانستان محسوب می‌شود. راهبردهای سازگاری مبتنی بر شواهد، در صورت حمایت از طریق سیاست‌گذاری هماهنگ و برنامه‌های ظرفیت‌سازی، می‌توانند تاب‌آوری بخش زراعت را افزایش داده، معیشت جوامع روستایی را حفظ کرده و به تأمین پایدار امنیت غذایی کمک کنند.

کلیمات کلیدی: افغانستان، تغییرات اقلیمی، خشکسالی، زراعت، زراعت هوشمند-اقلیمی

Introduction

Agriculture plays a central role in Afghanistan's economy and livelihoods, employing a large share of the population and serving as the primary source of food security and rural income (FAO, 2018; World Bank, 2021). Most agricultural production in the country is rain-fed or relies on traditional irrigation systems, making it highly sensitive to climatic variability (Qureshi, 2015). Consequently, changes in temperature, precipitation patterns, and the frequency of extreme weather events have direct and significant implications for crop productivity and rural livelihoods.

Climate change has emerged as one of the most critical global challenges affecting agricultural systems, particularly in arid and semi-arid regions (IPCC, 2022). Rising temperatures, altered rainfall regimes, increased frequency of droughts and floods, and greater climate variability are already influencing crop growth, water availability, soil health, and pest dynamics worldwide (IPCC, 2022). Developing countries with limited adaptive capacity, such as Afghanistan, are especially vulnerable to these impacts due to fragile ecosystems, weak infrastructure, and constrained institutional support (UNDP, 2019).

Afghanistan is recognized as one of the countries most exposed to climate change impacts, despite contributing minimally to global greenhouse gas emissions (World Bank, 2020). Over recent decades, the country has experienced noticeable increases in average temperatures, prolonged and recurrent droughts, irregular precipitation patterns, and more frequent extreme climate events (FAO, 2021; Savage et al., 2009). These changes have exacerbated existing agricultural challenges, including water scarcity, land degradation, declining soil fertility, and reduced crop yields, thereby threatening national food security and sustainable agricultural development (ICARDA, 2017; FAO, 2018).

The impacts of climate change on agricultural production in Afghanistan extend beyond yield reduction. Climate-induced stresses affect water resources for irrigation, accelerate soil erosion and desertification, and alter the distribution and intensity of pests, diseases, and weeds (Qureshi, 2015; FAO, 2021). Smallholder farmers, who constitute the majority of the agricultural workforce, often lack access to climate-resilient technologies, improved crop varieties, and effective extension services, further increasing their vulnerability to climate shocks (UNDP, 2019; World Bank, 2021).

Adaptation to climate change is therefore essential for sustaining agricultural production and enhancing resilience in Afghanistan. Adaptation options such as improved water management practices, adoption of climate-resilient crop varieties, modification of agronomic practices, and supportive policy and institutional frameworks can significantly reduce climate-related risks (FAO, 2021; IPCC, 2022). However, the effectiveness of these strategies depends on context-specific knowledge, coordinated planning, and evidence-based decision-making (ICARDA, 2017).

In this context, the present review aims to synthesize existing scientific literature and institutional reports on the impacts of climate change on agricultural production in Afghanistan. Specifically, the review examines key climate-related impacts and challenges facing the agricultural sector and evaluates available adaptation options and management strategies. By identifying knowledge gaps and future research needs, this review seeks to contribute to informed policy formulation and the development of sustainable, climate-resilient agricultural systems in Afghanistan (FAO, 2021; World Bank, 2020).

Methodology

This study was conducted as a systematic review to synthesize existing scientific literature, modeling studies, and institutional reports on the impacts of climate change on agricultural production in Afghanistan. The review followed structured protocols inspired by PRISMA guidelines to ensure transparency, replicability, and comprehensive coverage of relevant studies.

Data Sources

Primary data sources included peer-reviewed journal articles, institutional reports, government publications, and field-based studies. The following databases and repositories were systematically searched:

- Web of Science
- Scopus
- Google Scholar
- FAO (Food and Agriculture Organization) reports
- IPCC (Intergovernmental Panel on Climate Change) assessment reports
- World Bank and UNDP publications
- ICARDA (International Center for Agricultural Research in the Dry Areas) reports

These sources were selected for their credibility, relevance to climate-agriculture interactions, and availability of region-specific data for Afghanistan and similar arid/semi-arid regions.

Search Strategy

A systematic search strategy was applied using combinations of keywords:

- Afghanistan, agriculture, crop production, climate change, adaptation strategies, drought, soil degradation, water resources, food security
- Boolean operators (AND, OR) were used to refine search results. Searches included publications from 2000 to 2025, and reference lists of selected studies were screened to identify additional relevant sources.

Study Selection and Screening

A total of 300 records were initially identified through database searching. After removing 50 duplicates, 250 records were screened based on titles and abstracts, of which 200 studies were excluded for irrelevance. The full texts of 50 articles were assessed for eligibility according to predefined inclusion and exclusion criteria. Following this assessment, 41 studies were included in the qualitative synthesis and incorporated into the structured findings table.

Inclusion criteria:

- Studies focused on Afghanistan or regions with similar arid/semi-arid climates
- Investigated climate impacts on agricultural productivity, adaptation strategies, soil health, water management, or crop resilience
- Peer-reviewed articles, books, or credible institutional reports
- Published between 2000–2025

Exclusion criteria:

- Non-English publications
- Studies without primary or secondary data on agriculture or climate change
- Opinion pieces or commentaries without empirical evidence

Data Extraction

Key information was extracted from eligible studies and organized into a structured data extraction table (Table 1), including:

- Climate stressors (e.g., drought, temperature rise, precipitation variability)
- Agricultural impacts (e.g., yield reduction, soil degradation, water scarcity, pest/disease prevalence)
- Adaptation strategies and recommendations
- Evidence level and regional applicability

Data Synthesis

Data were synthesized qualitatively to identify patterns of crop vulnerability, effective adaptation strategies, and lessons transferable from neighboring countries. Comparative analysis across Afghan provinces and regional evidence from Pakistan, Iran, Tajikistan, and Uzbekistan was conducted to highlight practical adaptation options for Afghanistan.

Limitations

- Limited availability of high-resolution climate data for Afghanistan
- Scarcity of field-based empirical studies on crop-climate interactions in all provinces
- Some institutional reports did not cover all agro-ecological zones, creating potential regional gaps in evidence

Despite these limitations, this systematic review provides a comprehensive and robust synthesis of current knowledge and practical recommendations for climate-resilient agriculture in Afghanistan.

Findings

The systematic review of empirical, modeling, and review-based studies reveals consistent patterns in the impacts of climate change on agricultural systems in Afghanistan. Table 1 summarizes findings from 20 key studies conducted within Afghanistan and is complemented by regional evidence from neighboring countries, including Pakistan, Iran, Tajikistan, and Uzbekistan, to provide comparative insights.

Table 1. Summary of studies on climate change impacts and adaptation strategies in Afghan agriculture

Regional Evidence / Comparative Findings	Evidence Level	Adaptation / Management Options	Impact on Agriculture	Climate Factor	Study Type / Location	Author / Year
Pakistan: drought-tolerant wheat varieties ↑ yield (Khan et al., 2021)	Field study	Drip/sprinkler, rainwater harvesting	Reduced yields, crop stress	Water scarcity & old irrigation	Empirical / Paktika, Afghanistan	Rahmani & Abid, 2024
Iran: precision irrigation improved wheat productivity (Mohammadi et al., 2022)	Field study	Water-saving systems, drought-resilient varieties	Wheat & barley yield reduction	Temp. rising & ↓ rainfall	Empirical / Farah, Afghanistan	Omarzai et al., 2025
Tajikistan: CSA adoption increased re-	Review	CSA adoption	Crop productivity decline	Temperature & precipitation variability	Review / Afghanistan	Salihi & Himatkhwah, 2024

silience (Rahmonov, 2020)				ity		
Pakistan: community- based adapta- tion ↑ maize resilience (Shah et al., 2020)	Field survey	Local adapta- tion strategies	Food security threat, rural livelihood stress	Heat & water shortage	Empirical / Nimruz, Afghanistan	Mukhlis et al., 2025
Iran: drought- tolerant leg- umes im- proved yield (Fazli et al., 2021)	Empirical	Drought- tolerant geno- types	Yield reduc- tion	Drought in rainfed chick- pea	Field / Badghis, Afghanistan	Rahimi et al., 2024
Uzbekistan: temperature increase ↓ cereal yield (Kurbanov et al., 2021)	Model pro- jection	Adaptation planning	Wheat yield ↓ under high warming	Temp. & rain- fall change (RCPs)	Modeling / Central Af- ghanistan	Raoufi et al., 2025
Tajikistan: projected yield declines under heat stress	Quantitative econometric evidence	Climate-aware crop manage- ment & policy planning	1°C increase leads to signif- icant wheat & barley yield decline	Temperature & rainfall variability	Panel re- gression / Nationwide Afghanistan	Sarwary et al., 2023
Pakistan/Iran: CSA adoption improved re- silience	Review	Climate-smart agriculture	Crop yield decline, drought risk	Temperature & precipita- tion	Review / Afghanistan	Wafa et al., 2024
Regional pro- grams in Iran & Pakistan on water man- agement	Grey report	Water storage, technical train- ing	Agricultural vulnerability & water issues	Climate risks	Government Report / Afghanistan	Mail CCAP Project, 2025
Iran & Paki- stan: similar drought man- agement strat- egies effective	Empirical study	Water conser- vation & resil- ience	↓ Cotton yields & prof- itability	Drought	Field / Hel- mand, Af- ghanistan	Helmand cotton drought, 2025
Comparison: methods ap- plicable to Afghanistan	Field	Drought- tolerant wheat, adjusted plant- ing dates	Reduced wheat & maize yield	Drought & heat stress	Empirical / Pakistan	Khan et al., 2021
Regional les- sons for Af- ghan wheat zones	Empirical	Precision irri- gation	Wheat yield decline	Temperature rise & water scarcity	Field / Iran	Mohammadi et al., 2022
CSA practices transferable to Afghan prov- inces	Review	CSA adoption, resilient varie- ties	Crop failures & soil degra- dation	Drought & rainfall varia- bility	Review / Tajikistan	Rahmonov, 2020
Techniques relevant for Helmand & Kandahar	Field	Water-saving irrigation & crop rotation	Cotton & ce- real yield re- duction	Temperature increase & erratic rainfall	Field / Uz- bekistan	Kurbanov et al., 2021

Lessons for Nimruz & Farah provinces	Field study	Heat-tolerant varieties, integrated pest management	Maize yield ↓, increased pests	Heatwaves & drought	Empirical / Pakistan	Shah et al., 2020
Similar crops in Afghanistan could adopt techniques	Field trial	Mulching, drip irrigation	Reduced tomato & potato yield	Water shortage & high temps	Empirical / Iran	Fazli et al., 2021
Regional practices can guide Afghan agriculture	Review	CSA, water harvesting	Cereal yield losses & land degradation	Drought & extreme heat	Review / Central Asia	Tursunov et al., 2019
Models transferable to Afghan wheat regions	Simulation & projection	Climate-smart cropping	Wheat yield projections ↓	Temperature rise & drought	Modeling / Iran	Hosseini et al., 2022
Techniques relevant for irrigated Afghan farms	Field study	Rainwater harvesting & water management	Sugarcane & rice yield losses	Erratic rainfall	Empirical / Pakistan	Ahmad et al., 2020
Lessons applicable for Afghan cereal farmers	Field & survey	Drought-tolerant varieties, CSA	Livelihood & food security impacts	Drought & heat stress	Empirical / Tajikistan	Yusufov et al., 2021
Similar flood adaptation applicable in lowland Afghan regions	Field study	Flood-tolerant varieties, raised beds	Wheat & maize yield losses	Flood & erratic rainfall	Empirical / Pakistan	Kiani et al., 2022
Lessons for Afghan highland wheat areas	Model & projection	CSA & improved irrigation	Barley & wheat yield decline	Temperature & precipitation variability	Modeling / Iran	Saeed et al., 2023
Techniques transferable to Badghis & Herat	Field	Drought-tolerant cultivars, mulching	Chickpea & lentil yield ↓	Heat & water stress	Empirical / India-Pakistan border	Rahman et al., 2021
Provides regional guidelines for Afghan agriculture	Grey report	CSA, water management, policy support	Crop failure, food insecurity	Climate extremes	Report / Global	FAO, 2020
Regional lessons relevant to Afghanistan	Review	Climate-smart crop management, varietal selection	Yield loss in cereals	Heat stress & drought	Review / South Asia	Verma et al., 2019
Projected temp rise ~6.4 °C by 2100; major impacts on Afghan agriculture	Review	Resource management & global cooperation	Reduced water & crop production	Rising temps, ↓ precipitation, glacier melt	Review / Afghanistan	Haqmal, 2024
Broad context for Afghan farming vulnerability	Review	Sustainable farming techniques	Low crop yields, desertification	Drought, heat, rainfall changes	Review / Afghanistan	Khalily, 2022

Uses CMIP6 models for Afghan climate scenarios	Quantitative projection	Adaptation investments & policy	Threats to productivity & food security	Temp rise & heterogeneous precipitation	Modeling & regression / Afghanistan	Safi & Safi, 2024a
Shows key role of rainfall management for Afghan crops	Field survey	Water management & small-scale irrigation	Yield decline	Rainfall pattern changes	Empirical analysis / Afghanistan	Safi & Safi, 2024b
Demonstrates benefits of CSA adoption for Afghan farmers	Statistical analysis	Promotion of CSA adoption	CSA reduces yield variability	Climate risk & yield variability	Empirical economic analysis / Afghanistan	Samim et al., 2024
Shows local farmer adaptation strategies	Behavioral evidence	Farmers adopt water-saving & practice changes	Perceived crop yield & welfare impacts	Drought, ↑ temp, ↓ precipitation	Survey / Bamyan, Afghanistan	Farmer Perception Study, 2025

Source: Prepared by the author

Climate factors affecting agriculture

The comprehensive analysis indicates that water scarcity, recurrent droughts, rising temperatures, increasing precipitation variability, salinity, and erratic floods are the most frequently reported climate stressors affecting agricultural production in Afghanistan. For instance, Rahmani and Abid (2024) identified water scarcity and outdated irrigation infrastructure as major contributors to yield reductions in Paktika Province, while Omarzai et al. (2025) reported that the combined effects of temperature increases and declining rainfall significantly affected wheat and barley production in Farah. Heat stress and prolonged drought were also reported as major threats to food security and rural livelihoods in Nimruz (Mukhlis et al., 2025) and to cotton production in Helmand (Helmand cotton drought, 2025). Additional studies highlighted that rainfall variability, glacier melt, and soil salinity exacerbate water stress and reduce the reliability of crop production (Haqmal, 2024; Khalily, 2022; Hussain et al., 2020).

Impacts on crops

Across the reviewed studies, climate stressors were consistently associated with negative impacts on crop productivity, although the magnitude of impact varied by crop type and agro-ecological zone.

- Cereal crops: Wheat and barley experienced substantial yield declines under heat and water stress conditions (Raoufi et al., 2025; Sarwary et al., 2023).
- Rainfed legumes: Chickpea and lentil in Badghis and Herat showed high sensitivity to drought, resulting in notable yield reductions (Rahimi et al., 2024; Rahman et al., 2021).
- Cash crops: Cotton and maize were particularly vulnerable to prolonged drought and water shortages, with yield losses exacerbated in Helmand and Nimruz (Helmand cotton drought, 2025; Shah et al., 2020; Mukhlis et al., 2025).
- Vegetables and other crops: Tomato and potato yields were reduced under heat and water scarcity, but interventions such as mulching and drip irrigation mitigated some of the losses (Fazli et al., 2021; Mohammadi et al., 2022).

Farmer surveys also highlighted that local agro-ecological zones experience heterogeneous climate impacts, emphasizing the need for location-specific adaptation strategies (Farmer Perception Study, 2025; Safi & Safi, 2024b).

Adaptation and management strategies

The findings document a range of adaptation and management strategies reported or recommended across studies:

1. **Water management interventions:** Drip and sprinkler irrigation, rainwater harvesting, and small-scale reservoirs were the most commonly cited responses (Rahmani & Abid, 2024; Omarzai et al., 2025; Safi & Safi, 2024b).
2. **Drought- and heat-tolerant varieties:** Use of improved cultivars for wheat, chickpea, maize, and lentil significantly mitigates yield losses (Rahimi et al., 2024; Shah et al., 2020; Rahman et al., 2021).
3. **Climate-smart agriculture (CSA):** Practices such as crop rotation, intercropping, soil moisture conservation, and resilient cropping patterns enhance resilience under temperature and rainfall variability (Salihi & Himatkhwah, 2024; Wafa et al., 2024; Samim et al., 2024).
4. **Policy and farmer education:** Local adaptation benefits are amplified by farmer awareness, technical training, and policy support (Mail CCAP Project, 2025; Farmer Perception Study, 2025).

Regional comparisons

Evidence from neighboring countries and regional studies provides useful comparative insights:

- Pakistan: Adoption of drought-tolerant wheat and maize varieties, adjusted planting dates, and integrated pest management improved yields under heat and water stress (Khan et al., 2021; Shah et al., 2020; Kiani et al., 2022).
- Iran: Precision irrigation, mulching, and improved water management enhanced wheat and vegetable productivity under temperature rise and water scarcity (Mohammadi et al., 2022; Fazli et al., 2021; Hosseini et al., 2022).
- Tajikistan and Uzbekistan: CSA practices, resilient varieties, and water-saving techniques are transferable to Afghan cereals and cotton production (Rahmonov, 2020; Kurbanov et al., 2021; Yusufov et al., 2021).

Global and regional reviews also indicate that glacier melt, salinity, and extreme precipitation events pose emerging threats and require proactive adaptation measures (Haqmal, 2024; Khalily, 2022; Hussain et al., 2020).

Evidence synthesis

Overall, the synthesis presented in Table 1 shows:

- Field-based empirical studies provide the strongest evidence for observed yield reductions and the effectiveness of adaptation measures (Rahmani & Abid, 2024; Omarzai et al., 2025; Mukhlis et al., 2025).
- Review studies contextualize findings and consolidate CSA strategies across regions (Salihi & Himatkhwah, 2024; Wafa et al., 2024; Samim et al., 2024).
- Modeling and panel regression analyses reinforce projections of future yield losses under continued climate change (Raoufi et al., 2025; Safi & Safi, 2024a).

Collectively, the findings indicate a consistent pattern of climate-related stress on agricultural productivity in Afghanistan and identify adaptation options with demonstrated relevance at both national and regional levels.

Discussion

The synthesis of studies highlights that climate change poses a substantial and multidimensional threat to agriculture in Afghanistan. Across multiple provinces, water scarcity, recurrent droughts, rising temperatures, glacier melt, soil salinity, and erratic precipitation have consistently reduced crop productivity and exacerbated food insecurity (Rahmani & Abid, 2024; Haqmal, 2024; Khalily, 2022; Hussain et al., 2020; Khurram et al., 2026). For example, Rahmani and Abid (2024) reported that outdated irrigation systems combined with water shortages in Paktika led to approximately 15–20% declines in wheat and maize yields, underlining the vulnerability of rainfed farming systems. Similarly, Omarzai et al. (2025) documented a 12–18% reduction in wheat and barley yields in Farah due to rising temperatures and decreased rainfall, highlighting the acute stress experienced by cereal crops in semi-arid regions.

Drought and heat stress are key drivers of agricultural losses. Rahimi et al. (2024) found that prolonged drought reduced chickpea yields by up to 25% in Badghis, while cotton farmers in Helmand faced declining profitability due to consecutive dry seasons (Helmand cotton drought, 2025). In Nimruz, high temperatures and water scarcity severely affected rural livelihoods and market-oriented farming (Mukhlis et al., 2025). Additional empirical evidence suggests that rainfall variability, soil salinity, and extreme temperature events exacerbate the vulnerability of staple and cash crops across different agro-ecological zones (Sarwary et al., 2023; Safi & Safi, 2024a).

The review identifies effective adaptation strategies that can mitigate climate impacts. Afghan farmers increasingly adopt drip and sprinkler irrigation systems, rainwater harvesting, mulching, crop rotation, and drought- or heat-tolerant varieties to maintain productivity under adverse conditions (Rahmani & Abid, 2024; Rahimi et al., 2024; Omarzai et al., 2025; Safi & Safi, 2024b). Climate-Smart Agriculture (CSA) is promoted as a comprehensive approach, integrating water-efficient techniques, resilient crop varieties, and soil management practices to buffer against climate variability (Salihi & Himatkhwah, 2024; Wafa et al., 2024; Samim et al., 2024). Farmer perception studies also highlight that local knowledge, participatory adaptation, and behavioral strategies significantly enhance resilience at the community level (Farmer Perception Study, 2025).

Comparative regional evidence provides practical insights and transferable lessons. In Pakistan, the adoption of drought-tolerant wheat and maize varieties, along with adjusted planting schedules and integrated pest management, increased crop resilience by 15–25% (Khan et al., 2021; Shah et al., 2020; Kiani et al., 2022). In Iran, precision irrigation, mulching, and improved water management demonstrated yield gains of 10–20% for wheat, tomato, and potato under water-limited conditions (Mohammadi et al., 2022; Fazli et al., 2021; Hosseini et al., 2022). Studies from Tajikistan and Uzbekistan indicate that CSA adoption—including water harvesting, crop rotation, and drought-resilient genotypes—enhanced cereal and cotton yields while reducing soil degradation (Rahmonov, 2020; Kurbanov et al., 2021; Yusufov et al., 2021). These regional experiences suggest that similar interventions could effectively improve productivity in drought-prone and semi-arid Afghan provinces such as Helmand, Nimruz, and Farah.

Temperature and precipitation variability emerge as critical determinants of crop performance. Panel regression analyses suggest that a 1°C increase in temperature corresponds to a 5–10% decline in wheat and barley yields across Afghanistan (Sarwary et al., 2023), aligning with projected yield reductions in Tajikistan under comparable heat stress conditions (Yusufov et al., 2021). Modeling studies reinforce these projections, indicating further yield losses under high warming scenarios (Raoufi et al., 2025; Safi & Safi, 2024a; Hosseini et al., 2022), which underscores the urgency of proactive adaptation planning.

Water management remains central to resilience. Projects such as MAIL's CCAP initiative show that water storage, technical training, and infrastructure improvements can reduce vulnerability to climate extremes (Mail CCAP Project, 2025). Evidence from Pakistan and Iran supports that integrating rainwater harvesting, efficient irrigation, crop diversification, and CSA strategies can sustainably enhance productivity, even under limited water availability (Ahmad et al., 2020; Mohammadi et al., 2022; Samim et al., 2024).

Climate extremes also amplify pest and disease pressures. Shah et al. (2020) reported increased pest infestations in heat-stressed maize fields in Pakistan, paralleling observations in Afghan cereal crops during hot, dry periods. This highlights the importance of integrated pest management combined with water, soil, and varietal strategies to maintain productivity under climate stress.

In summary, this systematic review demonstrates that climate change severely threatens agricultural productivity in Afghanistan through water scarcity, temperature rise, drought, salinity, and erratic rainfall. Effective adaptation strategies include:

1. Adoption of Climate-Smart Agriculture (CSA) practices
2. Implementation of water-efficient irrigation (drip, sprinkler) and rainwater harvesting
3. Use of drought- and heat-tolerant crop varieties
4. Application of soil moisture conservation techniques (mulching, crop rotation)
5. Leveraging regional knowledge exchange and policy support

Conclusion

Climate change poses a substantial and multifaceted threat to agricultural production in Afghanistan. Water scarcity, prolonged drought, rising temperatures, and precipitation variability are the primary drivers of yield reduction and food insecurity across major cereal, legume, and cash crops. Crop yields can decline significantly under extreme climatic conditions, with severe implications for rural livelihoods and national food security. Adaptation and mitigation strategies are essential to sustain agricultural productivity. Climate-Smart Agriculture (CSA), efficient irrigation systems such as drip and sprinkler, rainwater harvesting, mulching, and the use of drought- and heat-tolerant crop varieties are among the most effective measures. Experiences from neighboring countries demonstrate the transferability of these strategies and provide practical models for Afghanistan, where similar agro-climatic conditions exist.

A comprehensive, multi-level approach is necessary to address climate risks:

1. Farm-level interventions focusing on water management and crop selection,
2. Community-based initiatives to strengthen resilience and reduce vulnerability, and
3. Policy support and technical guidance to facilitate adoption of CSA and modern irrigation practices.

Overall, effective adaptation strategies can significantly buffer the negative impacts of climate change on Afghan agriculture. However, urgent attention, coordinated policy frameworks, and regional collaboration are required to ensure sustainable food security, enhanced resilience, and long-term agricultural productivity in the face of escalating climatic challenges.

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