



The Role of Agroforestry in Climate Change Mitigation and Food Security in Afghanistan: A Narrative Review

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Abstract

Climate change poses a serious threat to food security in Afghanistan through drought, rain-fall variability, water scarcity, land degradation, and declining agricultural productivity. The review aimed is to assess the potential of agroforestry for enhancing climate resilience, food security, and rural livelihoods in Afghanistan. Agroforestry, which integrates trees with agricultural crops and/or livestock, is a climate-smart and multifunctional approach for addressing these challenges. By enhancing carbon sequestration and storage, soil and water conservation, biodiversity, food production diversity, and the resilience of rural livelihoods, agroforestry can help reduce the adverse impacts of climate change. This narrative review examined scientific, governmental, and institutional sources published between 2010 and 2025, including literature retrieved from Google Scholar, JSTOR, and PubMed. Of the initially identified publications, 49 relevant studies were analyzed in relation to agroforestry, climate change, food security, agricultural production, and economic sustainability. A qualitative thematic approach was employed to analyze the available evidence and identify major themes and findings. The findings indicate that agroforestry has substantial potential to improve food availability and diversity, soil fertility, water conservation, carbon storage, ecosystem resilience, and rural incomes. In Afghanistan, agroforestry systems based on species such as pistachio, wild almond, willow, mulberry, eucalyptus, and plane trees show considerable potential for expansion. However, their wider adoption remains constrained by limited scientific and field-based evidence, inadequate technical and institutional capacity, limited financial support, and uncertainties surrounding land ownership and use. Future research should focus on the long-term impacts of agroforestry across Afghanistan's diverse climatic regions, particularly its potential for carbon sequestration, soil and water conservation, agricultural productivity, economic benefits, and rural livelihood resilience. Such research is essential for developing effective, locally appropriate management approaches. Overall, agroforestry represents a promising climate-smart strategy that can simultaneously strengthen food security, climate resilience, ecosystem sustainability, and rural livelihoods in Afghanistan.

Keywords: Agroforestry, Afghanistan, carbon sequestration, climate change mitigation, climate resilience, food security

په افغانستان کې د اقلیم بدلون کمولو او د خوړو خوندیتوب په برخه کې د کرنیزې ځنګلولې رول: روایتی بیاکتنه

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لنډیز

اقلیمي بدلون په افغانستان کې د وچکالۍ، د اورښتونو د ډول او کچې بدلون، د اوبو د کمښت، د ځمکې د تخریب او د کرنیزې تولیدي وړتیا د کمېدو له لارې د خوړو خوندیتوب ته جدي ګواښ پېښوي. د دې څېړنې موخه په افغانستان کې د اقلیمي زغم، خوړو خوندیتوب او کلیوالي معیشتونو د پیاوړتیا لپاره د کرنیزې ځنګلولې د ظرفیت ارزونه ده، چې تمرکز یې پر هغو ونو-کرنیزو نباتات او ونو-مالدارۍ سیستمونو دی چې د اقلیم له بدلون سره د سازښت او د هغه د اغېزو د کمولو، د طبیعي سرچینو د ساتنې، د خوړو د تولید او د معیشتونو د مقاومت په پیاوړتیا کې رول لري. کرنیزه ځنګلولې د دغو ننگونو د حل لپاره د اقلیم-هوسیارې/سازښت لرونکې او څو اړخیزې تګلارې په توګه مطرح کېږي، چې د کاربن د جذب او زېرمه کولو، د خاورې او اوبو د ساتنې، بیولوژیکي تنوع، د خوړو د تولید د تنوع او د کلیوالي معیشتونو د زغم په پیاوړتیا سره کولای شي د اقلیمي بدلون ناوړه اغېزې راکمې کړي. په دې روایتی بیاکتنه کې د ۲۰۱۰ او ۲۰۲۵ کلونو ترمنځ خپرې شوې علمي، دولتي او بنسټیزې سرچینې، چې د JSTOR، Google Scholar او PubMed څخه ترلاسه شوې دي، څېړل شوې دي. له لومړني پېژندل شوو خپرونو څخه ۴۹ اړوندې څېړنیزې خپرونې د کرنیزې ځنګلولې، اقلیمي بدلون، خوړو خوندیتوب، کرنیز تولید او اقتصادي پابښت په تړاو تحلیل شوې دي. د شته شواهدو د تحلیل او د عمده موضوعاتو او موندنو د پېژندلو لپاره کیفي موضوعي تګلاره کارول شوې ده. موندنې ښيي چې کرنیزه ځنګلولې د خوړو د شتون او تنوع، د خاورې حاصلخېزۍ، د اوبو ساتنې، د کاربن زېرمه کولو، د ایکوسیستم د مقاومت او د کلیوالي عوایدو د ښه والي لپاره د پام وړ وړتیا لري. په افغانستان کې د پستې، وحشي بادام، بید، توت، یوکالیپتوس او چنار پر بنسټ د کرنیزې ځنګلولې سیستمونه د پراختیا لپاره د پام وړ وړتیا شتون لري. اما د دې سیستمونو پراخ پلې کیدل لا هم د علمي او ساحوي شواهدو د کمښت، د تخنیکي او بنسټیزې وړتیا د نه شتون، د مالي ملاتړ د محدودیت او د ځمکې د مالکیت او کارونې له ناڅرګندتیاوو سره مخ دی. راتلونکې څېړنې باید د افغانستان په بېلابېلو اقلیمي سیمو کې د کرنیزې ځنګلولې پر اوږدمهاله اغېزو تمرکز وکړي، په ځانګړې توګه د کاربن د جذب، د خاورې او اوبو د ساتنې، د کرنیز تولید، اقتصادي ګټو او د کلیوالي معیشتونو د زغم په برخه کې د هغې د وړتیا معلومولو لپاره ترسره شي. دا ډول څېړنې د اغېزمنو او له سیمه ییزو شرایطو سره مناسبو مدیریتي تګلارو د رامنځته کولو لپاره اړینې دي. په ټولیزه توګه، کرنیزه ځنګلولې یوه هیله بخښونکې اقلیمي-څیرکه تګلاره ده، چې کولای شي په هم مهاله توګه په افغانستان کې د خوړو خوندیتوب، اقلیمي مقاومت، د ایکوسیستم پابښت او کلیوالي معیشتونه پیاوړي کړي.

کلیمات کلیدی: افغانستان، اقلیم بدلون کمښت، اقلیم زغم، خوړو خوندیتوب، کاربن زېرمه کول، کرنیزه ځنګلولې

Introduction

Climate change is a major threat to food security, particularly in developing countries where livelihoods depend heavily on agriculture (Mutengw et al., 2023). It affects all four dimensions of food security—availability, access, utilization, and stability—through rising temperatures, changing precipitation patterns, and increasingly frequent extreme events such as droughts and floods (Yuan et al., 2024). These impacts reduce crop and livestock productivity and increase vulnerability within food systems. Forests and trees play an important role in addressing these challenges by regulating climate, supporting ecosystem services, and contributing to sustainable food production (Agrawal, 2014).

Forests regulate climate primarily through carbon sequestration and storage in biomass and soils, while also providing essential services such as biodiversity conservation, water regulation, soil protection, and nutrient cycling. They additionally provide food and other products, including fruits, nuts, honey, mushrooms, and medicinal plants (Mbow et al., 2014; Vinceti et al., 2024). These functions are particularly important for communities whose livelihoods depend on natural resources.

Agroforestry has emerged as a climate-smart land-use approach that integrates perennial woody plants with crops and/or livestock on the same land unit (Jung et al., 2024). It can enhance carbon sequestration and storage, supporting climate-change mitigation, while improving soil quality, conserving water, supporting biodiversity, and regulating microclimates, thereby strengthening adaptation and resilience. The diversification of agricultural and tree-based products can also improve food availability, income, and livelihood resilience. Through these interconnected functions, agroforestry contributes to food security and relevant Sustainable Development Goals (SDGs), particularly zero hunger, climate action, life on land, and poverty reduction (FAO, 2023; IPCC, 2022).

However, the effectiveness of agroforestry depends on appropriate management and enabling conditions. Deforestation, land degradation, unsustainable land use, limited quantitative evidence, insecure land tenure, weak market access, and inadequate technical capacity can constrain its adoption and benefits (Psistaki et al., 2024). Supportive governance, community participation, farmer education, technical assistance, and appropriate incentives are therefore important for scaling sustainable agroforestry (Agrawal, 2014).

These challenges are particularly important in Afghanistan, where rural livelihoods depend heavily on agriculture and farming is vulnerable to rainfall variability, drought, water scarcity, rising temperatures, and land degradation (Ahmadzai et al., 2024). Agroforestry has potential to improve soil fertility and water-use efficiency, diversify production and income, and strengthen resilience to climate-related stresses. Evidence from Khost Province, for example, indicates its potential to support climate resilience and farmers' livelihoods (Raoufi, 2024).

Despite these potential benefits, empirical evidence on the long-term contribution of agroforestry to climate-change mitigation and food security remains limited in Afghanistan and other fragile, climate-vulnerable settings. This gap constrains evidence-based policy and sustainable land-management strategies (Agrawal, 2014; Sahar et al., 2025). Therefore, this narrative review synthesizes available evidence on the ecological, economic, and social contributions of agroforestry to climate-change mitigation, food security, and livelihood resilience, with particular attention to Afghanistan. It also identifies key knowledge gaps and implications for climate-resilient and sustainable land-use strategies.

Methodology

We conducted a narrative review in this study. In order to perform a comprehensive analysis of agroforestry and its impacts on climate change mitigation and food security, this study undertook an extensive assessment of journal articles, reports, case studies, and publications from research institutions, government administrative bodies, and non-governmental organizations (NGOs), as well as other credible academic and professional sources. The relevant existing literature was identified according to the objectives of this study through a critical review of studies published from 2010 to 2025. Scientific databases, including Google Scholar, JSTOR, and PubMed, were searched for relevant literature. Keywords such as “Afghanistan,” “climate change mitigation,” “food security,” “agroforestry,” “Carbon Sequestration,” and “agricultural production” were used to identify, filter, and review relevant studies.

Furthermore, a comprehensive evaluation of approximately 49 articles and reports was conducted to extract the necessary information. Specific areas of attention included the role of agroforestry in carbon sequestration, soil fertility improvement, water conservation, biodiversity enhancement, and its contribution to food security and economic sustainability. This study was designed to be broad and integrative in order to present a clear and comprehensive understanding of agroforestry’s role in mitigating climate change and enhancing food security. Both peer-reviewed and non-peer-reviewed articles and reports were included. The review focused on studies published in English that provide quantitative and historical insights; non-English publications were excluded. A study was considered eligible if it clearly addressed the key themes of agroforestry, climate change mitigation, food security, Carbon Sequestration, agriculture production or Afghanistan.

The research is based on secondary data covering the environmental and socio-economic impacts of agroforestry systems. Relevant information was extracted from the included studies and categorized into seven key themes: agroforestry in Afghanistan, enhancing household food security and livelihoods through agroforestry, effects of agroforestry systems on agricultural productivity and crop diversity, the role of agroforestry in climate change mitigation, impacts of climate change on agricultural production, climate change effects on Afghanistan’s natural resources, and food security in Afghanistan. The limitations of the study were acknowledged, and recommendations were proposed for future research, particularly in areas such as long-term productivity of agroforestry systems, economic evaluation, and policy frameworks aimed at strengthening food security and climate resilience.

Results

Effects of Agroforestry Systems on Agricultural Productivity and Crop Diversity

Compared to monocropping systems, agroforestry plays a crucial role in increasing yields because the integration of trees and crops enhances soil moisture and fertility while moderating temperature and microclimatic conditions. In some cases, mutual benefits among crops are amplified, such as shade provision and organic matter input, collectively leading to higher overall productivity. Previous studies indicate that agroforestry systems can increase yields per unit area by integrating perennial and annual crops, while also improving socio-economic conditions. However, the magnitude of these effects depends on management intensity, species selection, and climatic conditions (Castle et al., 2021; Omerkhil et al., 2024).

Agroforestry enhances household food diversity and seasonal food availability, as trees and shrubs often provide fruits, seeds, leafy vegetables, and other nutritious foods that fill die-

tary gaps. Several studies indicate that agroforestry improves access to diverse diets and helps reduce food shortages. These effects depend on household access, market conditions, and social factors. Overall, the findings are generally positive or neutral, with a prevailing trend toward increased food diversity (Ickowitz et al., 2022).

Previous research has demonstrated that there is no inherent trade-off between biodiversity conservation and crop yields. In some tropical agroforestry systems, when management practices such as shade regulation and structural diversity are properly implemented, both biodiversity conservation and high productivity can be achieved simultaneously. Furthermore, recent meta-analyses have shown that agroforestry enhances multiple ecosystem services, including soil conservation, carbon sequestration, and pollution control, which are critical for long-term yield stability and food production resilience. Nevertheless, local conditions, species selection, and management practices remain key determinants of these outcomes (Clough et al., 2011).

Enhancing Household Food Security and Livelihoods through Agroforestry

Agroforestry systems not only contribute to increased food production and higher yields, but also play a significant direct and indirect role in improving community food conditions and enhancing food security. Through the combined cultivation of perennial and agricultural crops, agroforestry can increase the availability of fruits, nuts, and other nutritious foods, thereby reducing malnutrition and food shortages. In addition, agroforestry methods such as intercropping and nitrogen-fixing practices between trees and crops improve soil fertility and contribute to the development of sustainable and resilient food production systems (Garrity et al., 2010).

Agroforestry is not only effective in improving the natural environment, but also provides economic benefits, particularly in regions where traditional agriculture is limited by climatic and environmental constraints. As noted by Roshetko (1999), agroforestry can generate additional income for farmers, directly supporting household food security. This additional income is especially important in areas where traditional farming is not economically sustainable or does not provide long-term benefits. Income generated through agroforestry serves as a safety net for households against food price fluctuations and uncertain market conditions. In regions where farmers rely solely on conventional agriculture, they are often exposed to external risks such as price volatility, extreme weather, and unstable markets (Kiptot & Franzel, 2012). By diversifying income sources, agroforestry enables farmers to avoid dependence on a single crop and reduce market-related risks. Moreover, agroforestry provides additional value-adding and income-generating opportunities. For example, tree products such as timber, fruits, nuts, and medicinal plants can be harvested and sold to generate extra income.

Agroforestry also creates employment opportunities through tree planting, pruning, timber harvesting, and crop collection, which ultimately raises rural living standards and contributes to economic development. The economic benefits of agroforestry are not limited to individual farmers but extend to community development and poverty reduction. Studies indicate that well-designed agroforestry systems improve the socio-economic conditions of rural communities, enhance household economic stability through diversified income sources, and improve access to basic livelihood resources (Franzel & Coe, 2001).

By supporting sustainable land management practices and promoting commercial activities, agroforestry directly contributes to poverty reduction and improved food security. Particularly in countries like Afghanistan, where malnutrition and food insecurity persist, the im-

plementation of agroforestry practices can play a fundamental role in strengthening food security and improving community nutrition. Through diversified cultivation of fruits, vegetables, and woody plants, agroforestry can reduce the root causes of food shortages and ultimately improve the quality of life and well-being of rural households.

The Role of Agroforestry in Climate Change Mitigation

Agroforestry involves combining agricultural crops, trees, and livestock on the same piece of land. These systems are important not only for producing food and timber but also for boosting resilience against climate change and its associated challenges. One major climate-related issue is drought. In dry areas, farming depends heavily on water availability, but climate change has reduced water supplies. Agroforestry helps tackle this problem by using deep-rooted trees that draw moisture from the soil to support nearby crops. Moreover, tree canopies help conserve surface soil moisture and lower evaporation rates, which is vital for drought resistance (Rolo et al., 2023).

Table 1. Role of Sustainable Agricultural Practices in Environmental Benefit and Food Security

Sustainable Practice	Environmental Benefit	Contribution to Food Security	Source
Agroforestry	Carbon sequestration and soil conservation	Increased crop productivity and income diversification	Sahar et al. (2025)
Efficient irrigation	Water conservation	Improved crop stability during drought	Sahar et al. (2025)
Biodiversity conservation	Ecosystem resilience	Improved nutritional diversity	Sahar et al. (2025)
Climate-smart agriculture	Reduced greenhouse gas emissions	Enhanced resilience of farming communities	Sahar et al. (2025)

Source: Adapted from Sahar et al. (2025).

Impacts of Climate Change on Agricultural Production

Compared to previous decades, Afghanistan has experienced significant declines in the production of staple crops that form the foundation of food security. Studies on the impacts of climate change on food security in rural Afghanistan show that factors such as untimely and irregular rainfall, floods, and sudden temperature fluctuations have caused substantial reductions in crop production, particularly affecting rural food security. The table below presents the level of decline in the production of key food crops in Afghanistan before and after climate change (Yar et al., 2024).

Table 2. Changes in the Production of Major Agricultural Crops Due to Climate Change

Crop Type	Production Before Climate Change (1000 kg)	Production after Climate Change (1000 kg)	Percentage Decrease
Wheat	50	20	30
Barley	30	20	33
Rice	20	15	25
Corn	40	25	37.5

Source: (Yar et al., 2024)

Table 3. Afghanistan's Food Insecurity Situation by Phases From 2020 to 2022 (million)

Year	Total Population analyzed	Phase 1 Number of people	Phase 1 %	Phase 2 Number of people	Phase 2 %	Phase 3 Number of people	Phase 3 %	Phase 4 Number of people	Phase 4 %
2022	41.72	7.45	17.9	14.62	35.1	13.03	31.2	6.59	15.8
2021	40.41	7.95	19.7	13.61	33.7	11.98	29.7	6.85	17.0
2020	31.39	8.90	28.4	11.33	36.1	7.54	24.0	3.60	11.5

Source: Calculated by authors from IPC reports (Safi et al., 2024).

Climate Change and Its Effects on Afghanistan's Natural Resources

Climate change has increasingly contributed to severe environmental challenges in Afghanistan, with significant consequences for the country's agricultural sector and natural resources (Bove, 2021). In particular, forested areas such as Nuristan Province have experienced notable wildfire events in recent years. For example, in 2022, a major forest fire destroyed approximately 185 acres of woodland in Afghanistan, underscoring the growing vulnerability of the country's ecosystems to climate-induced stresses and environmental degradation (Xinhua, 2022).

Afghanistan Food Security

Climate change increases directly and indirectly the uncertainty and risk of food production and the supply chain (Palazzoli et al., 2015). Direct effects include modifications to precipitation, temperatures, and carbon dioxide availability. Indirect effects include impacts on water resource availability and seasonality, soil organic matter transformation, soil erosion, and decline in arable areas due to land degradation and desertification, changes in pest and disease profiles, and inflow of invasive species (Asian Development Bank, 2020; Ho et al., 2017; World Bank Group, 2020).

Climate change and the degradation of natural resources represent significant challenges for Afghanistan in achieving food security, alleviating poverty, and ensuring the sustainable management of environmental resources. As a country whose economy and livelihoods are predominantly dependent on agriculture, Afghanistan remains highly vulnerable to the adverse impacts of climate variability and environmental decline. These challenges not only threaten agricultural productivity and rural livelihoods but also intensify food insecurity, socioeconomic instability, and vulnerability among communities. Furthermore, the growing pressures associated with climate change and resource depletion have the potential to exacerbate social tensions and political instability, thereby hindering the country's long-term sustainable development and resilience (Safi et al., 2024).

Climate change also threatens soil health. High temperatures, heavy rains, and extended droughts decrease soil organic matter, resulting in lower crop yields, food shortages, and a lack of fodder, which puts significant economic pressure on rural and farming communities. Agroforestry promotes crop diversification by providing fruits, timber, and fodder, thereby strengthening farmers' economic resilience. This diversification is particularly beneficial during times of climatic stress (Zouari & Hachicha, 2024). As global temperatures continue to rise, many crops suffer from heat stress. Tree shade helps reduce surface temperatures in farming areas, creating better conditions for crops to grow. Crops grown under tree cover are

shielded from yield losses caused by excessive heat. Research shows that tree shade can lower daytime temperatures by several degrees, which is essential for plant survival.

Rainfall patterns have become more unpredictable, with intense rainfalls followed by long dry periods. These changes pose serious risks to agriculture. Agroforestry systems improve rainwater absorption, enhance soil structure, and increase the soil's water-holding capacity. Trees also reduce soil erosion and lessen the severity of surface runoff. Studies indicate that agroforestry can protect crops from the effects of irregular and heavy rainfall (Quandt et al., 2023).

Agroforestry and climate-smart agricultural systems are increasingly recognized as effective approaches for improving water-use efficiency, strengthening ecosystem services, enhancing biodiversity conservation, and supporting sustainable food production under changing climatic conditions. These integrated systems help farming communities adapt to climate variability while contributing to long-term environmental sustainability and resilience (Sahar et al., 2025).

In summary, agroforestry is a powerful approach for adapting to and mitigating climate change. It helps lessen the impacts of drought, heat stress, and rainfall variability while preserving soil fertility, boosting food production and diversity, and improving farmers' economic well-being. Therefore, agroforestry should be incorporated as a fundamental part of agricultural policies and programs aimed at addressing climate change.

Agroforestry in Afghanistan

Agroforestry is a key strategy for supporting livelihoods, managing the environment, and conserving natural ecosystems. It promotes diverse production and sustainability by incorporating perennial woody plants into farming lands and systems, which enhances social, economic, and ecological advantages for farmers (Alao & Shuaibu, 2013; Khurram et al., 2026). As a rapidly evolving approach, agroforestry offers a long-term solution to help socio-ecological systems adapt to climate change (Gurung & Temphel, 2015). This advanced, sustainable system combines food production with nature conservation and is widely practiced in developing regions of South America, Central America, South Asia, and Southeast Asia.

Across Afghanistan, agroforestry remains in its early stages of development, characterized by incomplete policies, underdeveloped legal frameworks, and limited research and technical capacity. The Forest Department has initiated agroforestry programs aimed at reducing pressure on natural forests. Since 2013, pistachio and mountain almond seeds have been distributed across 17 provinces and planted near farmers' agricultural lands. Agri-silvicultural and agrosilvopastoral systems are commonly practiced. In the agrosilvopastoral system, perennial woody plants such as willow, mulberry, eucalyptus, and plane trees are cultivated alongside crops and livestock (Hossinni, 2015). Based on these sources, it is evident that agroforestry in Afghanistan is gradually progressing (Paudel & Shrestha, 2022).

Discussion

The agroforestry contributes to climate change mitigation and food security through carbon sequestration, soil fertility improvement, water conservation, and biodiversity enhancement, thereby supporting sustainable agricultural systems (Mbow et al., 2014; Garrity et al., 2010). These environmental benefits are closely linked with socio-economic outcomes, as agroforestry systems improve food availability and dietary diversity by providing nutrient-rich products such as fruits and nuts (Ickowitz et al., 2022), while also strengthening house-

hold resilience through income diversification (Franzel & Coe, 2001). Together, these studies present a converging view that agroforestry delivers integrated environmental and livelihood benefits.

Empirical evidence further supports the critical role of forests and sustainable land-use practices in climate change mitigation. A study conducted that using advanced econometric modeling (ARDL approach), examined the relationship between renewable energy consumption, agricultural production, forest cover, and CO₂ emissions. The findings revealed that both renewable energy use and forest area significantly contribute to reducing CO₂ emissions, while agricultural production was identified as a major source of emissions. The study particularly emphasized that afforestation and forest expansion are among the most effective strategies for carbon reduction. These results highlight the importance of integrating forest-based solutions and sustainable agricultural practices into climate mitigation strategies, especially in developing countries where agriculture remains a dominant economic sector (Sahar et al., 2026).

Contemporary studies suggest that climate-smart agricultural systems, including agroforestry practices, play a significant role in enhancing resilience against climate variability while supporting food security and environmental sustainability. Sustainable agricultural strategies such as efficient water management, biodiversity conservation, and climate adaptation mechanisms are increasingly recognized as essential tools for mitigating the adverse impacts of climate change on agricultural productivity and rural livelihoods. Furthermore, integrated land-use systems contribute to ecosystem stability, reduce greenhouse gas emissions, and strengthen the adaptive capacity of farming communities under changing climatic conditions (Sahar et al., 2025).

However, the extent of these benefits is not uniform across studies. While some research reports clear increases in crop yields under agroforestry systems, other studies indicate that yield outcomes are highly context-dependent and may remain neutral where management practices or species selection are suboptimal (Castle et al., 2021). Similarly, although certain studies demonstrate that biodiversity conservation and agricultural productivity can be achieved simultaneously, others suggest that this balance is conditional and influenced by system design and management intensity (Clough et al., 2011). These contrasting findings indicate that agroforestry performance is shaped by local ecological conditions, technical implementation, and socio-economic factors rather than representing a universally consistent outcome.

The strength of existing evidence is further constrained by methodological limitations. More literature relies on short-term or qualitative assessments, with limited availability of long-term quantitative data on carbon storage, economic returns, and broader socio-economic impacts (Quandt et al., 2023). Differences in research design, scale, and measurement indicators further complicate cross-study comparisons and reduce the generalizability of findings. As a result, the overall direction of evidence is positive, the magnitude and consistency of agroforestry outcomes remain insufficiently quantified.

The findings of this review are consistent with global research demonstrating that agroforestry systems can significantly contribute to sustainable agricultural transformation under changing climatic conditions. In many developing countries, agroforestry has enhanced adaptive capacity by reducing dependency on monocropping systems and increasing resilience to climate-induced shocks. Furthermore, the integration of trees within agricultural landscapes supports ecological restoration while simultaneously improving household nutrition and rural

incomes. These multifunctional benefits make agroforestry a practical strategy for balancing environmental conservation with agricultural productivity (Mbow et al., 2014; Garrity et al., 2010).

Recent studies in Afghanistan have revealed that human-induced activities such as illegal timber harvesting, excessive fuelwood collection, overgrazing, and the expansion of agricultural land have substantially reduced forest regeneration and weakened ecosystem resilience. These pressures have adversely affected biodiversity, soil conservation, carbon storage, and the sustainable management of natural resources. Nevertheless, sustainable forest management strategies, including agroforestry practices, reforestation, assisted natural regeneration, and community-based forest management, have demonstrated considerable potential to rehabilitate degraded ecosystems, enhance environmental resilience, and support climate change mitigation and sustainable food production in vulnerable rural communities of Afghanistan. (Iqbal & Khurram, 2025).

And also, sustainable forest management in Afghanistan emphasize that adaptive silvicultural strategies, assisted natural regeneration, retention forestry, and community-based forest management significantly contribute to improving ecosystem resilience, biodiversity conservation, and carbon sequestration under changing climatic conditions. These approaches strengthen forest structural complexity, reduce environmental degradation, and enhance the adaptive capacity of rural landscapes against droughts, land degradation, and climate-related disturbances. Furthermore, integrated forest and agroforestry management systems support sustainable land use, improve ecosystem services, and contribute to long-term food security and climate change mitigation in vulnerable regions of Afghanistan (Iqbal & Saadat, 2026).

These limitations are especially significant in the Afghanistan setting, where empirical evidence remains scarce and fragmented (Paudel & Shrestha, 2022). Existing studies provide limited guidance for large-scale implementation across diverse agro-ecological zones. Structural constraints, including weak institutional frameworks, limited financial and technical support, and unclear land tenure systems, further restrict adoption (Agrawal et al., 2014). In addition, low levels of technical knowledge among farmers limit effective implementation, reducing the potential benefits observed in other regions. The absence of context-specific models and long-term field-based evidence constrains the ability to evaluate system performance under local climatic and socio-economic conditions. Consequently, although the broader literature supports agroforestry as an effective strategy, its applicability and effectiveness in Afghanistan remain insufficiently demonstrated, highlighting the need for context-driven research and implementation.

Conclusion

The reviewed evidence indicates that agroforestry is a sustainable approach for addressing climate change impacts while strengthening food security and rural livelihoods. Integrating trees with crops and other agricultural activities can support carbon sequestration, soil and water conservation, erosion control, and diversified production. These functions, together with tree-based products such as fruits, nuts, and honey, can improve food availability, household income, and resilience to climate-related stresses. The literature also indicates that agroforestry can contribute to the four dimensions of food security—availability, access, utilization, and stability—particularly in climate-vulnerable regions such as Afghanistan.

In Afghanistan, however, wider adoption remains constrained by limited technical capacity, inadequate institutional and policy support, restricted market access, and insecure land

tenure. Based on these findings, the authors recommend strengthening institutional support, farmer capacity building, research, and community-based implementation to enhance the contribution of agroforestry to climate resilience, food security, and sustainable rural development.

Recommendations

Despite the increasing impacts of climate change on agriculture and natural resources, limited attention has been given to sustainable climate adaptation strategies in Afghanistan. However, the growing threats of land degradation, water scarcity, declining crop productivity, and food insecurity highlight the urgent need for effective environmental interventions. In this regard, agroforestry presents a promising climate-smart approach that can support climate change mitigation, enhance ecosystem resilience, and improve food security. Therefore, greater emphasis should be placed on assessing and promoting agroforestry practices to strengthen sustainable agricultural development, reduce environmental degradation, and enhance the resilience of rural communities in Afghanistan (Safi et al., 2024).

Agroforestry not only contributes to climate change mitigation through carbon sequestration but also enhances soil fertility, water conservation, and biodiversity. Furthermore, it supports sustainable livelihoods by improving agricultural productivity and increasing the resilience of farming communities against climate-related shocks.

Based on the above findings, the following recommendations are proposed for policymakers, development practitioners, researchers, and local stakeholders to promote effective agroforestry implementation in Afghanistan:

- i. Policymakers should integrate agroforestry into national agricultural plans and provide incentives, financial assistance, and technical support to farmers for the implementation of agroforestry systems.
- ii. Strong monitoring mechanisms should be established to assess the impacts of agroforestry implementation on climate change mitigation, food security, and livelihood improvement. Monitoring indicators should include carbon sequestration, crop yields, soil fertility, biodiversity, and household income.
- iii. Efforts should be made to build the capacity of farmers and other stakeholders. Training programs, farmer field schools, and extension services should be implemented to disseminate knowledge and empower farmers.
- iv. Local communities should be actively involved in planning, decision-making, and implementation processes to ensure that agroforestry practices align with their needs and priorities.
- v. Continuous research and innovation are necessary to develop and apply agroforestry methods suitable for Afghanistan's diverse climatic zones and agricultural systems. Research institutions, universities, and agricultural development agencies should collaborate on studies, pilot projects, and field-based research to promote agroforestry expansion.
- vi. Collaboration among government agencies, non-governmental organizations, research institutions, and development partners is essential to share resources, exchange knowledge, and scale up successful projects. Public-private partnerships can facilitate investment in agroforestry projects and strengthen sustainable value chains for agroforestry products.

- vii. Successful agroforestry systems should be expanded and replicated across regions with different climatic conditions, as lessons learned from implementation provide a foundation for designing and executing future projects.

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