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## **The Role of Agroforestry in Enhancing Climate Resilience of Rural Landscapes in Azerbaijan**

### **Abstract**

Climate change poses increasing challenges for agricultural sustainability and rural livelihoods in Azerbaijan. While conventional adaptation strategies focus primarily on crop selection, irrigation management and land use policies, agroforestry offers a promising yet underexplored solution to enhance climate resilience. This paper investigates the potential of agroforestry systems as a nature-based approach to mitigate the adverse effects of climate variability, including drought, soil degradation, and biodiversity loss. Drawing on international case studies and regional data, the paper assesses the applicability of agroforestry practices such as windbreaks, silvopasture, and alley cropping in the context of Azerbaijan's semi-arid zones. By integrating trees into agricultural landscapes, agroforestry can improve soil moisture retention, increase carbon sequestration and diversify income for rural communities. The research highlights policy gaps and proposes practical recommendations for incorporating agroforestry into national climate adaptation strategies. The findings suggest that agroforestry can be a key component in building sustainable and climate-resilient rural environments in Azerbaijan.

**Keywords:** *agroforestry, climate change, sustainable agriculture, Azerbaijan, land degradation*

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## **Azərbaycanda kənd landşaftlarının iqlimə davamlılığının artırılmasında aqromezə təsərrüfatının rolu**

### **Xülasə**

İqlim dəyişikliyi Azərbaycanda kənd təsərrüfatının davamlılığı və kənd yaşayış vasitələri üçün artan problemlər yaradır. Ənənəvi uyğunlaşma strategiyaları ilk növbədə məhsul seçimi, suvarma idarəçiliyi və torpaqdan istifadə siyasətlərinə diqqət yetirsə də, aqromezəçilik iqlimə davamlılığı artırmaq üçün perspektivli, lakin hələ də öyrənilməmiş bir həll təklif edir. Bu sənəd iqlim dəyişkənliyinin, o cümlədən quraqlıq, torpağın degradasiyası və biomüxtəlifliyin itirilməsinin mənfi təsirlərini yumşaltmaq üçün təbiətə əsaslanan yanaşma kimi aqromezəçilik sistemlərinin potensialını araşdırır. Beynəlxalq nümunə araşdırmalarına və regional məlumatlara əsaslanaraq, məqalə Azərbaycanın yarı quraq zonaları kontekstində küləkdən qorunma, silvootlaq və xiyaban əkinləri kimi aqromezəçilik təcrübələrinin tətbiqini qiymətləndirir. Ağacları kənd təsərrüfatı landşaftlarına integrasiya etməklə, aqromezəçilik torpağın rütubətinin saxlanmasını yaxşılaşdırır, karbon sekestrini artırır və kənd icmalarının gəlirlərini şaxələndirə bilər. Tədqiqat siyasət boşluqlarını vurğulayır və aqromezəçiliyin milli iqlimə uyğunlaşma strategiyalarına daxil edilməsi üçün praktiki tövsiyələr təklif edir. Nəticələr göstərir ki, aqromezəçilik Azərbaycanda davamlı və iqlimə davamlı kənd mühitlərinin yaradılmasında əsas komponent ola bilər.

**Açar sözlər:** *aqromezəçilik, iqlim dəyişikliyi, davamlı kənd təsərrüfatı, Azərbaycan, torpaqların degradasiyası*

## Introduction

Agriculture remains a vital sector for Azerbaijan, contributing significantly to employment, food security, and rural development (Fao, 2020). However, the increasing impacts of climate change - manifested through rising temperatures, erratic precipitation patterns, frequent droughts, and land degradation- pose serious threats to agricultural productivity and the stability of rural livelihoods (IPCC, 2021). In response, researchers and policymakers have been exploring diverse adaptation strategies to mitigate these adverse effects. Among these, agroforestry has gained global attention as a nature-based solution that combines agricultural and forestry practices for enhanced ecological and economic benefits (Garrity, 2004; Mbow, Smith, Skole, Duguma, Bustamante, 2014). Agroforestry is defined as the intentional integration of trees and shrubs into crop and livestock systems to create more diverse, productive, and sustainable land-use systems (Nair, 1993). These practices have been shown to enhance biodiversity, regulate microclimates, improve water retention, reduce soil erosion, and sequester carbon (Jose, 2009).

Given the country's varying agro-ecological zones- from semi-arid lowlands to mountainous terrains- Azerbaijan presents a unique opportunity to assess the feasibility and benefits of agroforestry practices (Huseynov, Mammadova, Aslanov, 2021). Yet, little academic and policy-oriented research has been conducted to explore how such systems could be adapted to the local context. This study aims to fill this gap by evaluating the role of agroforestry in enhancing climate resilience in Azerbaijan's rural landscapes. The paper examines different agroforestry models, identifies the environmental and socio-economic benefits, and discusses potential barriers and policy interventions needed to promote these practices.

## Research

**Climate Change and Agricultural Vulnerability in Azerbaijan.** Azerbaijan's geographic and climatic diversity makes it particularly vulnerable to the adverse effects of climate change. The country comprises nine of the world's eleven climate zones, ranging from dry semi-deserts in the lowlands to humid subtropical areas along the Caspian Sea coast and alpine climates in the Greater Caucasus Mountains (MENR, 2021). This variability has historically supported diverse agricultural systems. However, changing climate patterns are now threatening the sustainability of these systems. According to national climate assessments, average annual temperatures in Azerbaijan have increased by approximately 1.3°C since the mid-20th century, with projections suggesting further rises of 2–4°C by the end of the 21st century under various emissions scenarios (IPCC, 2021). Rainfall patterns have become increasingly erratic, with certain regions experiencing frequent droughts, while others face sudden flooding events. These shifts are already disrupting planting and harvesting cycles, particularly in key agricultural regions such as the Kur-Araz Lowland, Ganja-Gazakh zone, and the Mil-Karabakh plain (World Bank, 2020).

One of the most pressing challenges is the increasing frequency and intensity of droughts. In 2020 and 2021, extended dry spells led to severe water shortages, reducing wheat yields by up to 40% in some areas (FAO, 2020). Groundwater reserves and irrigation infrastructure, already under strain from overuse and inefficiencies, are becoming insufficient to meet growing agricultural demands. At the same time, land degradation—accelerated by both climate factors and unsustainable farming practices—is contributing to the loss of fertile soils, especially in arid and semi-arid areas of central and southern Azerbaijan (UNCCD, 2021).

## Agroforestry as a Climate Adaptation Strategy: Global Perspectives and Lessons Learned

Globally, agroforestry has been successfully implemented in a variety of climates and socio-economic contexts. In Sub-Saharan Africa, farmer-managed natural regeneration (FMNR) has restored millions of hectares of degraded land, particularly in Niger and Ethiopia, leading to increased crop yields and improved food security (Garrity, 2004). As Azerbaijan seeks sustainable and climate-resilient agricultural models, these global lessons offer valuable guidance for designing and implementing agroforestry systems that suit the country's environmental and socio-economic realities.

**Opportunities and Challenges for Agroforestry in Azerbaijan.** Azerbaijan's diverse climatic zones and longstanding traditions in both agriculture and tree cultivation provide a solid foundation for the integration of agroforestry practices. Regions such as the Guba-Khachmaz, Shaki-Zaqatala, and Lankaran economic zones possess favorable conditions—moderate rainfall, fertile soils, and

existing orchard-based agriculture—that can be adapted into agroforestry systems. Additionally, semi-arid areas like Shirvan and the Kur-Araz lowlands, which face land degradation and drought risks, could benefit from agroforestry's capacity to restore soil health and reduce erosion (Ministry of Agriculture of Azerbaijan, 2020). Furthermore, agroforestry aligns well with Azerbaijan's broader environmental and climate goals. The country is committed to land degradation neutrality under the UNCCD and has pledged to reduce greenhouse gas emissions under its Nationally Determined Contributions (NDCs) to the Paris Agreement (MENR, 2021). Agroforestry systems contribute directly to these objectives by sequestering carbon, reducing pressure on forests, and supporting sustainable land management.

Infrastructural and financial constraints also pose barriers. Establishing agroforestry systems requires initial investment and patience, as trees take several years to mature. Smallholder farmers often lack access to affordable credit, seedlings, or reliable extension services that could support this transition (Guliyev, Aliyeva, Mammadov, 2019). To overcome these challenges, Azerbaijan can draw from successful experiences in other countries and invest in pilot projects, farmer training, and research programs focused on locally adapted agroforestry models. Collaboration between government agencies, universities, and international organizations could help create a supportive environment for innovation and long-term sustainability in the agricultural sector.

**Recommendations for Integrating Agroforestry into National Adaptation Strategies.** To effectively harness the benefits of agroforestry in the face of climate change, Azerbaijan must adopt a strategic and multi-level approach.

1. **Develop a National Agroforestry Strategy.** There is an urgent need for a dedicated policy framework that outlines the vision, goals, and implementation mechanisms for agroforestry. This strategy should define suitable agroforestry models for different ecological zones in Azerbaijan, establish targets for adoption, and integrate the approach within broader agricultural and environmental plans (FAO, 2017).

2. **Strengthen Institutional and Technical Capacity.** Capacity building is vital for scaling up agroforestry practices. Training programs should be developed for extension workers, agronomists, and local authorities to enhance their knowledge of agroforestry principles, species selection, land design, and long-term maintenance (Reij, Tappan, Smale, 2009).

3. **Provide Financial and Technical Incentives.** Establishing agroforestry systems requires initial investments that may be beyond the capacity of smallholder farmers. The government should consider providing subsidies, microloans, or tax breaks for farmers who adopt sustainable land use practices, including agroforestry. Additionally, support should be provided for nurseries that produce climate-resilient and locally adapted tree species (Jose, 2009).

4. **Incorporate Agroforestry into Climate and Land Use Planning.** Agroforestry should be fully integrated into Azerbaijan's Nationally Determined Contributions (NDCs), National Adaptation Plans (NAPs), and Land Degradation Neutrality (LDN) commitments. This alignment would not only strengthen the country's climate resilience but also attract international climate finance and technical assistance (Guliyev, Mammadova, 2018).

5. **Promote Research and Data Collection.** Local research is essential to identify the most effective and economically viable agroforestry systems for different regions. Universities and research centers should be supported to conduct studies on carbon sequestration, soil health, water retention, and yield improvement under various agroforestry models. Data gathered from these studies can guide evidence-based policymaking and extension services.

## **Conclusion**

Climate change presents a serious threat to the sustainability of agricultural systems in Azerbaijan. Rising temperatures, increased frequency of droughts, and land degradation have already begun to impact productivity, rural livelihoods, and food security. In this context, agroforestry offers a promising nature-based solution that aligns environmental restoration with economic resilience. This paper has explored the concept of agroforestry and its potential benefits in the context of Azerbaijan. Agroforestry systems enhance climate adaptation by stabilizing soils, increasing carbon sequestration, and supporting biodiversity. At the same time, they provide socio-economic advantages such as diversified income sources, improved crop yields, and better livestock

health. As Azerbaijan navigates a future of climate uncertainty, agroforestry stands as a viable and forward-looking approach. Its success, however, will depend on coordinated action among policymakers, scientists, farmers, and development partners.

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