American Journal of Agriculture and Forestry
2025, Vol. 13, No. 6, pp. 275–280
https://doi.org/10.11648/j.ajaf.20251306.12

Case Report

The Role of Agroforestry in Climate-resilient Land and Soil Management: A Case Study of Nigeria's Ogbomoso Agroforestry Project

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Abstract

Agroforestry is increasingly recognized as a vital tool for sustainable land and soil management, particularly in regions vulnerable to climate change. This abstract explores the Ogbomoso Agroforestry Project in Oyo State, Nigeria, where the integration of tree crops such as mango, cashew, and teak with traditional staple crops like maize and yam has been employed as a climate-resilient strategy. This initiative addresses key issues such as soil erosion, declining soil fertility, and unpredictable rainfall patterns, which are exacerbated by climate change. The practice of agroforestry in Ogbomoso helps stabilize the soil through tree root systems that reduce erosion caused by wind and water. Additionally, leguminous trees enrich the soil by fixing nitrogen, thus enhancing soil fertility naturally and reducing the need for chemical fertilizers. The inclusion of trees in farming systems also improves water retention, a critical factor in semi-arid regions, ensuring that crops can thrive even during dry periods. By promoting biodiversity, sequestering carbon, and providing additional sources of income from tree crops, the Ogbomoso Agroforestry Project not only improves the land's productivity but also contributes to environmental sustainability and economic diversification. However, despite these benefits, there are challenges, including limited access to technical knowledge, resources, and the long maturation period of tree crops. Addressing these challenges requires government support and policies promoting agroforestry, as well as local and international collaboration. By integrating trees with agriculture, the project provides a holistic solution that enhances soil health, increases agricultural productivity, and fosters ecosystem resilience in the face of climate change.

Keywords

Water Retention, Economic Diversification, Agroforestry, Agricultural Productivity, Climate Change

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Received: 12 July 2025; **Accepted:** 8 August 2025; **Published:** 19 December 2025

1. Introduction

Agroforestry, though formally defined in the 20th century, is rooted in ancient land management traditions. It represents a thoughtful blending of agriculture and forestry by incorporating trees and shrubs into farmlands. This integration creates a dynamic system where trees, crops, and sometimes livestock work together, enhancing both ecological balance and farm productivity [31]. Rather than being a one-size-fits-all approach, agroforestry takes many forms-from the simple practice of planting trees alongside crops to more complex arrangements that resemble natural forests [1]. While the term itself may be modern, the idea behind it is anything but new. Civilizations as old as those in the Amazon basin and the terraced farms of Southeast Asia have long used tree-based farming systems [2].

A clear example of agroforestry's potential can be seen in the Ogbomoso Agroforestry Project in Oyo State, Nigeria. This initiative showcases how combining traditional knowledge with contemporary methods can rehabilitate degraded land. Through the planting of native trees and integration of sustainable practices, the project is helping to build healthier soils and more resilient ecosystems proving that agroforestry can be a powerful tool in climate-smart agriculture. The more structured and institutionalized adoption of agroforestry gained momentum during the 20th century, especially as the negative side effects of intensive farming began to emerge. While the Green Revolution brought significant improvements in crop yields, it also exposed the ecological costs of industrial agriculture. These concerns revived global interest in land use systems that could sustain both-productivity and environmental health [3].

Today, agroforestry is widely acknowledged as a practical and effective approach to sustainable land management. It helps combat major agricultural challenges such as soil erosion, water scarcity, and loss of biodiversity [4]. Trees enhance the land’s fertility by improving soil structure, reducing nutrient loss, and promoting moisture retention-key factors for long-term agricultural success [5]. Beyond its benefits for farms and farmers, agroforestry plays a crucial role in global environmental goals. The trees within these systems help absorb carbon dioxide, making agroforestry an ally in the fight against climate change [17]. Moreover, these green spaces offer habitats for a variety of plant and animal species, thereby supporting ecosystem services such as pollination and water regulation [7].

This review seeks to explore agroforestry’s value in promoting sustainable land use. It will examine how agroforestry can improve soil health, boost water efficiency, and support biodiversity within agricultural settings [5]. Furthermore, the review will assess agroforestry’s contribution to climate change mitigation and adaptation, especially through carbon capture and the development of climate-resilient farming systems [9].

2. Agroforestry Systems and Practices

Types of Agroforestry Systems

Agroforestry systems are broadly categorized into three main types: silvopastoral, agrosilvicultural, and silvoarable systems. Silvopastoral systems, which integrate tree and livestock production, are recognized for improving forage quality and animal welfare while enhancing biodiversity and landscape aesthetics [10]. Agrosilvicultural systems, on the other hand, combine crop production with tree cultivation, contributing to soil fertility through leaf litter and root decomposition, and providing additional income from timber or fruit sales [12]. Silvoarable systems incorporate both trees and crops on the same land, promoting biodiversity, and optimizing land use efficiency.

Figure 1. *Showing Sheep sheltering beneath a hawthorn [Crataegus monogyna] tree in the United Kingdom, depicting the Silvoarable system.)[30].*

These systems are known for their potential in improving microclimates, thus benefiting both crops and trees [13]. Beyond these basic types, there are specialized agroforestry practices like alley cropping and forest farming. Alley cropping, which involves planting rows of trees at wide spacings with a companion crop grown in the alleyways between the tree rows, is particularly noted for its soil conservation benefits and the potential to provide economic stability through diversified outputs [14]. Forest farming, or the cultivation of high-value crops under the canopy of an existing forest, offers opportunities for sustainable harvesting of both non-timber forest products and timber, while maintaining forest cover [14].

Type of Agroforestry System

Involves planting rows of trees or shrubs at wide spacings with an agricultural or horticultural crop grown in the spaces between the rows.

Silvopasture

Combines forestry and grazing of domesticated animals on a single plot of land. Trees are managed for timber and provide shade and shelter to the animals and pasture below.

Forest Farming

Involves the cultivation of high-value specialty crops under the protection of a managed forest canopy. Examples include ginseng, shiitake mushrooms, and decorative ferns.

Windbreaks or Shelterbelts

Rows of trees or shrubs are planted to protect crops, soil, and livestock from wind. Can also serve as habitat for wildlife, control snow deposition, and improve microclimates for crops.

Riparian Buffers

Vegetated areas [trees, shrubs, grasses] near streams and rivers that help shade and partially protect a stream from the impact of adjacent land uses. They improve water quality and provide wildlife habitat.

Multi-Strata Agroforestry

Also known as "homegardens" or "food forests," these are complex systems that mimic natural forests with multiple layers of trees, shrubs, and crops growing together.

3. The Ogbomoso Agroforestry Project: Background and Objectives

The Ogbomoso Agroforestry Project, initiated in 2010, was developed in response to widespread land degradation and declining agricultural productivity in the region. The project, a collaboration between local communities, academic institutions, and government agencies, aimed to:

1. Restore Degraded Lands: Rehabilitate overused and eroded lands through the establishment of agroforestry systems.
2. Enhance Soil Fertility: Improve soil health using leguminous trees and organic farming practices.
3. Promote Climate Adaptation: Build the resilience of local farming systems to climate variability.
4. Boost Livelihoods: Increase the economic well-being of local farmers through diversified agricultural outputs.

Key Practices and Implementation Strategies

The project employed several agroforestry practices, tailored to the local context:

Alley Cropping: Crops such as maize, cassava, and yam were planted between rows of fast-growing nitrogen-fixing trees like Albizia zygia and Senna siamea [26]. This improved soil fertility and reduced the need for chemical inputs [22].

Silvopasture Systems: Livestock were integrated into the farming systems, grazing under tree canopies. This reduced the pressure on natural grasslands while providing shade and fodder for animals [27].

Boundary Planting and Windbreaks: Trees were planted along farm boundaries to serve as windbreaks, reducing wind erosion and protecting crops from extreme weather [23].

Agroforestry Home Gardens: Farmers established home gardens with a mix of fruit trees, vegetables, and medicinal plants, enhancing food security and household income [29].

Figure 2. *Showing Alley cropping of coffee [Coffea spp.] trees and black turtle beans [Phaseolus vulgaris] in Costa Rica. Photo courtesy of Donald L. Grebner.*

Training and Capacity Building: The project emphasized farmer training in agroforestry techniques, soil management, and climate-smart agriculture. This fostered local ownership and ensured the sustainability of the interventions.

Impacts and Outcomes

The Ogbomoso Agroforestry Project has had significant positive outcomes across various dimensions:

Environmental Benefits:

1. Soil fertility improved by an average of 25% within five years of implementation [25].
2. Erosion rates declined by over 30% due to enhanced ground cover and root systems.
3. Carbon sequestration rates increased, with an estimated 1.5 tons of carbon stored per hectare annually [28].
   1) Agricultural Productivity:
   2) Crop yields improved by 20–40%, particularly for maize and cassava, due to enhanced soil fertility and moisture retention.

1. Livestock health and productivity improved as a result of better fodder availability and shade.
   1) Economic Gains:
   2) Farmers experienced a 15–25% increase in household income due to diversified farm outputs, including timber, fruits, and fodder.
2. Reduced expenditure on chemical fertilizers and pesticides further improved net income.
   1) Social and Institutional Impact:

2) The project strengthened community cohesion through cooperative farming practices and shared resources.

3. Partnerships with academic institutions provided access to research and innovation, enhancing the project's effectiveness.

Challenges and Lessons Learned

While the project has been largely successful, it faced several challenges:

Initial Resistance: Some farmers were initially skeptical about adopting agroforestry due to concerns about reduced land availability for crops. Continuous education and demonstration plots were key in overcoming this resistance.

Resource Constraints: Limited funding and access to quality planting materials constrained the project's scale. Support from governmental and international agencies proved vital in addressing these gaps [24].

Climate Extremes: Despite the resilience built into the system, extreme weather events such as prolonged droughts and heavy rains occasionally disrupted farming activities. This underscored the need for adaptive management practices.

4. Agroforestry in Climate Change Mitigation and Adaptation

A. Carbon Sequestration

Agroforestry plays a significant role in the global effort to combat climate change by helping to remove carbon dioxide (CO_2) from the atmosphere. Trees within these systems act as carbon sinks, storing carbon in their trunks, branches, leaves, roots, and the surrounding soil. This process of capturing and storing carbon-both above and below the ground-is a natural and powerful tool for reducing greenhouse gases [15].

The amount of carbon stored in agroforestry systems depends on factors such as tree species, climate, soil conditions, and how the land is managed. However, studies show that agroforestry consistently outperforms conventional monoculture farming when it comes to carbon sequestration [16]. Traditional farming often involves frequent tilling and soil disturbance, which can release stored carbon. In contrast, agroforestry systems are generally less disruptive to the soil and allow carbon to accumulate over time. When farmland is converted into agroforestry systems, the total carbon storage capacity significantly increases [6], aligning with global climate mitigation strategies [8].

B. Strengthening Climate Resilience

Agroforestry is more than just a climate mitigation tool-it also boosts resilience to extreme weather. The layered structure of trees and crops in these systems helps protect the land against harsh conditions like droughts, floods, and heatwaves. Trees create cooler microclimates by offering shade and reducing wind, helping crops survive during periods of climate stress [18], and supports long-term climate resilience [11].

Many trees used in agroforestry reach deep into the ground to access water that shallow-rooted crops cannot reach. This deep-rooting ability means that during dry spells, water is still available, providing a natural safeguard for crops and soil [19]. Agroforestry also brings diversity to farming systems. Instead of relying on a single crop, farmers can grow a mix of trees and crops, reducing the risk of total crop failure during extreme weather. Moreover, trees produce valuable goods like fruits, nuts, and timber, which can serve as alternative income sources. This diversity helps stabilize household incomes and food supply. Improved water retention and soil fertility are added benefits, both of which are essential for adapting to climate change [20].

C. Policy and Global Support for Agroforestry

Recognition of agroforestry's environmental benefits is growing among governments and international bodies. It is now being seen as a practical solution for both carbon reduction and climate adaptation. Programs like REDD+ (Reducing Emissions from Deforestation and Forest Degradation) under the UN Framework Convention on Climate Change (UNFCCC) have begun including agroforestry in their strategies [21].

Organizations such as the Food and Agriculture Organization (FAO) are supporting countries in crafting agroforestry policies that align with climate goals. Global agreements like the Paris Agreement have also created opportunities for countries to include agroforestry in their national climate action plans [22].

5. Conclusion and Policy Recommendations

The Ogbomoso Agroforestry Project in Oyo State stands as a strong example of how agroforestry can transform degraded land into a resilient and productive ecosystem. As Nigeria works toward its climate targets under the Paris Agreement and strives to meet the Sustainable Development Goals (SDGs), scaling up agroforestry could be a game-changer for sustainable farming and environmental protection.

To fully unlock agroforestry's potential, as emphasized by FAO [23] the following policy actions are recommended:

1) Institutional Support: Develop and enforce clear policies and programs dedicated to promoting agroforestry.
2) Financial Incentives: Offer grants, subsidies, or accessible loans to farmers willing to adopt agroforestry methods.
3) Research and Innovation: Fund research into region-specific agroforestry systems and promote the use of native tree species for better adaptation and productivity.
4) Training and Extension Services: Equip farmers with the knowledge and tools needed through training programs and robust agricultural extension services.

By integrating agroforestry into national agricultural and climate strategies, Nigeria can build more resilient rural communities, protect its natural environment, and contribute meaningfully to the global fight against climate change.

Abbreviations

UN	United Nation
REDD+	Reducing Emissions from Deforestation and Forest Degradation
UNFCCC	UN Framework Convention on Climate Change
FAO	Food and Agriculture Organization

Conflicts of Interest

The author declares no conflicts of interest.

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