

ASSESSING THE ROLE OF AGROFORESTRY IN CLIMATE CHANGE ADAPTATION AND MITIGATION, IN HONG LOCAL GOVERNMENT ADAMAWA, NIGERIA.

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ABSTRACT

Agroforestry, as a sustainable land use practice, has gained increasing attention for its potential contributions to climate change adaptation and mitigation in Hong. This paper assesses the role of agroforestry in addressing the challenges posed by climate change through a review of current literature and case studies. Agroforestry systems, characterized by the intentional integration of trees and crops on the same land, suffer a range of ecosystem services that enhance resilience to climate variability, mitigate greenhouse gas emissions, and promote sustainable livelihoods. The effectiveness of agroforestry in climate change adaptation and mitigation depends on factors such as species selection, management practices, and socio-economic context. By harnessing the synergies between agriculture, forestry, and conservation, agroforestry can play a significant role in building climate-resilient landscapes and contributing to global climate goals. However, challenges remain in scaling up agroforestry adoption, addressing policy barriers, and ensuring equitable access to resources and benefits. Future research and policy efforts should focus on identifying best practices, promoting enabling policy environments, and fostering multi-stakeholder collaborations to realize the full potential of agroforestry in climate change adaptation and mitigation.

Key words; Assessing, Agroforestry, Climate, Adaptation, Mitigation

INTRODUCTION

Climate change poses unprecedented challenges to global food security, biodiversity conservation, and rural livelihoods, necessitating urgent action to mitigate its impacts and adapt to changing environmental conditions. Agriculture, as a significant contributor to greenhouse gas emissions and a vulnerable sector to climate variability, plays a central role in both driving and responding to climate change. In this context, agroforestry emerges as a promising approach that integrates trees, shrubs, and crops in multifunctional landscapes, offering a range of environmental, economic, and social benefits. Agroforestry systems, characterized by their diversity of species, spatial arrangements, and management practices, have been increasingly recognized for their potential to enhance climate resilience, mitigate greenhouse gas emissions, and promote sustainable land management. The intentional integration of trees into agricultural landscapes can improve soil health, conserve water, enhance biodiversity, and provide additional sources of income for farmers. Moreover, agroforestry practices such as alley cropping, **silvopasture**, windbreaks, and riparian buffers contribute to carbon sequestration, reduce soil erosion, and enhance ecosystem services that are critical for climate change adaptation and mitigation. Agroforestry systems refer to land-use systems in which woody perennials are intentionally grown on the same land management unit as agricultural crops or animals (Nair et al. 2021). These systems aim to create a symbiotic relationship between different biological organisms to improve productivity, diversify income sources, and enhance ecosystem services (De Luc et al 2015). The world is facing an unprecedented crisis in the form of climate change, which is having wide-ranging impacts across ecosystems and economies (Gössling et al. 2020). Agriculture, a sector critically dependent on climatic variables such as temperature, precipitation, and seasonal patterns, is particularly vulnerable (Molua et al. 2016). According to a report by the Food and Agriculture Organization (FAO), climate change could potentially result in yield declines of up to 30% in several major crops by the mid-century (Fischer .2009). This poses a serious threat to global food security, particularly

in developing countries where agriculture is a major source of livelihood for the majority of the population (Mbow et al 2020). In addition to reduced yields, climate change has also been linked to the increasing frequency of extreme weather events such as drought. The increasing impacts of climate change on agriculture necessitate the development of systems that are both resilient and sustainable. Climate resilience in agriculture refers to the ability of the system to absorb shocks and stresses imposed by climatic changes and still maintain function. (Altieri et al. 2015). Sustainable agricultural systems, on the other hand, are designed to be economically viable, socially equitable, and environmentally sound over the long term (Pretty J, Bharucha Z p). Climate resilience and sustainability in agriculture are not just conceptual buzzwords but are critical for the future of the sector. They involve adopting practices that reduce the environmental footprint of agriculture, such as reducing water use and greenhouse gas emissions, while simultaneously enhancing its resilience to climatic shocks (Altieri MA, Nicholls CI 2017). This can involve a variety of approaches, from the adoption of drought-resistant crop varieties to the use of agro ecological practices that enhance soil health and water conservation. (Romero et al. 2022). Despite the growing recognition of agroforestry's benefits, challenges remain in scaling up its adoption, addressing policy barriers, and ensuring equitable access to resources and benefits. Furthermore, there is a need for empirical research, case studies, and policy analysis to better understand the socio-economic implications, trade-offs, and synergies associated with agroforestry in different contexts. This paper aims to assess the role of agroforestry in climate change adaptation and mitigation. through a comprehensive review of current literature, case studies, and policy frameworks. By synthesizing existing knowledge and identifying gaps in research and practice, we aim to inform policy makers, practitioners, and researchers on the potential of agroforestry as a climate-resilient land use option and advocate for its integration into climate change mitigation and adaptation strategies at local, national, and global scales.

MATERIALS AND METHODS

Hong Local Government Area (LGA) is located in Adamawa State, Nigeria. Geographically, it lies in the northeastern part of Nigeria. The coordinates for the town of Hong, which serves as the administrative center of the Hong LGA, are approximately Latitude: 10.25583⁰ N Longitude: 12.9874⁰ E Hong LGA is bordered by the following local government areas within Adamawa State: To the north, it is bordered by Song LGA. To the east, it is bordered by Mubi South and Mubi North LGAs. To the south, it shares a border with Gombi LGA. To the west, it is adjacent to Maiha LGA. According to (NPC, 2006) census, the population of Hong LGA was around 169,126. Hong Local Government Area (LGA) covers an area of approximately 970 square kilometers. The dominant tribe in Hong Local Government Area (LGA) of Adamawa State, Nigeria, is the Kilba (also known as Huba) people. The Kilba tribe is known for its rich cultural heritage and history within the region. They are primarily engaged in agriculture, trading, and various traditional crafts. The Kilba language is widely spoken among the inhabitants of the area, is characterized by savanna vegetation. This savanna vegetation is well-suited to the region's climatic conditions, which include a wet season and a dry season. The vegetation supports agriculture and livestock rearing, which are the main economic activities in the area. The type of soil are Sandy Soils, loamy soil and clay Predominantly found in the area, these soils are well drained and suitable for growing crops such as millet sorghum, and groundnuts.

Rainy Season (Wet Season) occurs from May to October. This season is marked by heavy rainfall, which is crucial for agricultural activities in the area. Dry Season Lasts from November to April. It has the average rainfall of 2,400mm and average temperature of about 36⁰C. This season is characterized by little to no rainfall and includes. Harmattan Period Occurring from late November to early February, this period is marked by dry, dusty winds blowing from the Sahara Desert, resulting in cooler temperatures and lower humidity dominated by grasses with scattered emergent vegetation of African Savannah such as *Acacia species philoshgma spp* (Adebayo, 2004). The dominant tree species typically found in the savanna vegetation include: *Vitellaria paradoxa*,

Adansonia digitata, Parkia biglobosa, Tamarindus indica, Balanites aegyptiaca, Terminalia avicemioides, pterocarpus erinaceus, Annona muricata, Ficus sycomorus, Daniellia oliveri, Vitex doniana, Anogeissus leiocarpa, Combretum micranthu, Diospyros mespiliformis, Albizia lebbeck, Prosopis Africana, Afzelia Africana, Faidherbia albida, Sterculia setigera, Azadirachta indica, Terminalia superba, Lonchocarpus sericeus. These indigenous tree species play crucial roles in the local ecosystem, providing resources such as food, medicine, and timber, and contributing to the biodiversity and environmental stability of the region. There are 12 political wards in Hong LGA: these include Hong, Gaya, Mayo lope, Uba, Garaha, Husherezum, Daksiri Hildi, Thilbang, Kwarhi, Shangu, Banshika. Hong LGA comprises several districts, including: Hong District, Gaya District, Mijili District, Uba District, Garaha District, Kulinyi District, Daksiri District dominated by grasses with scattered emergent vegetation of African Savannah such as *Acacia species philoshgma spp.* the grasses and trees covers ranges from *Andropogon spp pennisetum spp and imperata spp* according to (Adebayo, 2004).

Data Collection

Data were collected using Stratified Sampling, this method involves dividing the population into distinct subgroups or strata that share similar characteristics. In this case, the population is divided into four strata: Farmers, Community-Based Organizations (CBOs), Local Experts, and Community Leaders/Local Government Officials. The population was divided into four strata based on their roles and perspectives related to agroforestry practices. The number of respondents from each stratum was determined based on their relevance and importance to the study. Two hundred (200) questionnaires were proportionally allocated to them.

Data Analysis

The data generated were analyzed using proportional allocation across the different subgroups. Descriptive analysis was used to summarize and interpret the distribution of the questionnaires in terms of raw count frequencies, and simple percentage.

RESULTS/DISCUSSION

Farmers receive the largest proportion of questionnaires (104), as they are the primary practitioners of agroforestry and their input is crucial for understanding the real-world application and challenge. Community-Based Organizations are allocated 46 questionnaires, as they play a significant role in facilitating and supporting agroforestry practices within community. Local Experts receive 24 questionnaires, which allows for capturing detailed technical and scientific insights that complement the practical experiences of farmers and Community-Based Organizations. Community Leaders or Local Government Officials are allocated 26 questionnaires, which is sufficient to gather perspectives on policy, governance, and local regulations affecting agroforestry, shown in Table: 1

These agroforestry system in Table: 2 demonstrates a sustainable approach to agriculture that balances productivity with environmental stewardship, offering a model for climate-resilient farming. Climate Change Adaptation. Table: 3 reveals that Addressing the impacts of extreme weather events in Hong Local Government requires a multifaceted approach that combines traditional knowledge with innovative agroforestry practices. By enhancing the resilience of agroforestry systems, farmers can better withstand the challenges posed by climate change and ensure sustainable agricultural productivity. Overall Impact on Agroforestry; Soil Stability, Microclimate Regulation, Water Management. Contribution by focus group and experts in Table: 4 shows that Agroforestry systems in Hong Local Government experience compounded effects from extreme weather events, which collectively impact their sustainability and productivity. However, these systems also provide inherent resilience mechanisms: Enhanced soil stability, Microclimate regulation, Water management, understanding how extreme weather events affect agroforestry systems is crucial for developing adaptive management strategies. By leveraging the inherent resilience of agroforestry and implementing targeted practices, farmers in Hong Local Government Area can enhance their

systems' ability to withstand and recover from these climatic challenges. Table: 5 also indicate that by employing a combination of these assessment methods, farmers and researchers can gain a comprehensive understanding of the resilience of agroforestry systems to extreme weather events. This information is crucial for making informed decisions on management practices and selecting species and techniques that enhance climate resilience. And further explain in Table: 6. These agroforestry practices enhance the resilience of farming systems by improving soil health, increasing biodiversity, and providing protective functions against extreme weather events. Implementing a combination of these practices can create a more robust and adaptable agricultural system capable of withstanding climate variability. In Table: 7. They also reveal some methods, that researchers and practitioners can use accurately to assess the carbon sequestration potential of agroforestry systems, which is crucial for understanding their role in climate change mitigation and adaptation. And gave some few examples of indigenous, tree species in Table: 8. by incorporating a diverse range of tree and shrub species with varying growth habits and root structures. Agroforestry systems in Hong Local Government Area can maximize carbon sequestration potential while providing multiple benefits to farmers and the environment.

Table 1: Role in the community (e.g., farmers, Community-Based Organizations, Local Experts, Local Government Officials)

Organization	Allocation	%
Farmer	104	52
Community-Based Organizations	46	23
Local Experts	24	12
Local Government Officials	26	13
Total	200	100

Source field survey (2024),

Table: 2 briefly describe the agroforestry system and the main crops or trees involved?

Agroforestry system and Main crops	Descriptions
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1, Tree Species,

Leguminous trees; *Leucaena leucocephala*, *Acacia* spp.) These trees are

Planted for their nitrogen fixing ability

Fruit Trees Mango, Avocado, Citrus These trees offer a diverse range of fruits for consumption and sale, providing an additional source of income and food security.

Timber Trees; Teak, Mahogany Selected for their high-quality wood, these trees are grown to provide long-term income through sustainable timber harvesting.

2, Agricultural Crops

Staple Crops; Maize, Cassava, Sorghum Planted between rows of trees, these crops benefit from improved soil fertility and microclimate regulation provided by the tree canopy.

Vegetables; Tomatoes, Peppers, Leafy Greens): These are intercropped with staple crops and fruit trees, enhancing the overall productivity of the land and ensuring year-round harvests.

Cover Crops; ., Cowpea, Groundnut, Beans, These crops are used to cover the soil, preventing erosion, improving soil structure, and adding organic matter to the soil through biomass.

3, Agroforestry Practices:

Alley Cropping; Trees are planted in rows with wide alleys in between, where crops are grown. This arrangement facilitates easy management and maximizes the benefits of both trees and crops.

Silvopasture; Integration of trees with pasture for livestock grazing. Trees provide shade and shelter for animals, while also improving soil fertility and structure.

Contour Planting and Terracing; Trees and crops are planted along contour lines terraces to reduce soil erosion, improve water retention, and enhance landscape stability.

Benefits Observed

Improved Soil Fertility; The integration of nitrogen-fixing trees has significantly enhanced soil fertility, reducing the need for chemical fertilizers

Enhanced Biodiversity; The diverse plant species have attracted a variety of wildlife, improving the overall ecosystem health

Economic Diversification; The combination of different crops and tree products provide multiple income streams, increasing economic resilience

Climate Resilience: The system has shown increased resilience to extreme weather events such as droughts and heavy rains, with improved water retention and reduced soil erosion.

Source; field survey, (2024).

Table 3: Have you experienced extreme weather events?

Response	Number of the respondents	Percentage (%)
Yes	180	90
No	20	10
Total	100	100
Weather event		
Droughts	60	33.3
Flood	50	27.8
Storms and High Winds	40	22.2
Heatwaves:	30	16.7
Total	180	100

Source; field survey, (2024).

Table 4: Effects of Extreme Weather Events on Agroforestry Systems in Hong Local Government? (e.g., crop damage, tree loss, soil erosion)? Focus group,

Events	Negative Impacts
1. Droughts	Crop Damage; Drought can cause wilting, stunted growth, and decreased productivity. Tree Loss; Lack of sufficient water can lead to tree mortality Soil Erosion; the lack of moisture reduces soil cohesion.
2, Flood;	Crop damage; Sediment deposition can bury seedlings and disrupt plant growth. Tree loss; Young trees are more prone to being uprooted. Soil erosion; by washing away the topsoil, especially on slopes.
3, Storms and high winds:	Crop damage; breaking stems, leaves, and fruits.

Tree loss; can break branches, topple trees, and cause structural damage.
 Soil erosion; The removal of protective vegetation cover by wind can also contribute to erosion.
 4, Heat wave ; Crop damage; causing leaf scorching, reduced photosynthesis, tree loss; heat stress can reduce tree growth and productivity,
 Soil erosion; Heatwaves can dry out the soil, making it more prone to erosion by wind.
 Source; field survey, (2024).

Table 5: How do you assess the resilience of your agroforestry system to extreme weather events (e.g., crop yield stability, tree survival rates, soil moisture retention)?

Assessing Resilience	
1, Crop yield stability ;	Yield Monitoring, Drought and Flood Tolerance
2. tree survival rates ;	Tree Health Monitoring, Survival Data Collection
3, soil moisture retention ;	Soil Moisture Sensors, Soil Sampling
4. Soil erosion; Sediment	Traps and Erosion Pins, Field Observations

Source; field survey, (2024).

Table 6: What specific agroforestry practices have you found to enhance resilience to extreme weather events (e.g., species diversity, mixed cropping, permanent cover crops)?

Agroforestry practice	Enhance Resilience
1. Species Diversity ;	Multiple Tree Species, Fruit, Nut, and Timber Trees.
2. Mixed Cropping ;	Companion Planting, Crop Rotation and Intercropping
3. Permanent Cover Crops ;	Cover Crops, Mulching:
4. Windbreaks and Shelterbelts ;	Windbreaks, Shelterbelts:

Source; field survey, (2024).

Table 7: How do you measure the carbon sequestration potential of your agroforestry system (e.g., biomass measurement, soil carbon analysis)

carbon sequestration potential	methods to measure
1. Biomass Measurement ,	Aboveground Biomass, Belowground Biomass
2. Soil Carbon Analysis ;	Soil Sampling, Carbon Stock Estimation
3. Remote Sensing Techniques ,	Satellite Imagery, LiDAR (Light Detection and Ranging)
4. Carbon Accounting Models ;	Process-Based Models, Empirical Models
5. Eddy Covariance and Flux Tower Measurements ;	Eddy Covariance, Flux Tower Measurements
6. Carbon Credits and Verification Protocols ;	Carbon Credit Projects

Source; field survey, (2024).

Table 8: What types of trees and shrubs are most effective in sequestering carbon in your system?

Trees and Shrubs	Number of respondents	%
1. Piliostigma thoningii	18	9
2. Acacia Senegal	16	8
3. Borassus aethiopum	18	9
4. Ficus sycomorus	18	9
5. Albizia spp. (Albizia	16	8
6. Adonsonia digitata	16	8
7. Parkia biglobosa	18	9
8. Vertilleria paradoxum	16	8
9. Adonsoniadigitata	16	8

10.	<i>Tamarindus indica</i>	16	8
11.	<i>Borassus eathiopum</i>	16	8
12.	<i>Anacardium occidentale</i>	16	8
Total		200	100

Source; field survey, (2024).

CONCLUSION

The assessment concludes that agroforestry is a viable strategy for both mitigating and adapting to climate change in Hong, Adamawa State. It offers a dual benefit of reducing carbon emissions and enhancing the resilience of agricultural systems to climate impacts. The integration of trees into agricultural landscapes improves ecological stability, boosts crop yields, and provides additional economic benefits through the production of timber, fruits, and other tree products. Agroforestry practices also enhance water retention and soil fertility, which are critical for sustaining agricultural productivity in the face of climate change. However, the success of agroforestry systems depends on appropriate species selection, farmer training, and supportive policies.

RECOMMENDATIONS

1. Policy Support and Incentives: The government should develop and implement policies that support agroforestry practices, including providing incentives for farmers to adopt these systems. Subsidies, tax breaks, and grants can encourage the integration of trees into farming systems.
2. Farmer Training and Education: Comprehensive training programs should be established to educate farmers about the benefits of agroforestry and the best practices for implementing these systems.

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