AGROFORESTRY: A VIABLE OPTION FOR CLIMATE CHANGE MITIGATION AND SUSTAINABLE ENVIRONMENT

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Abstract
African ecosystem comprises a variety of flora and fauna which constitute about 20 percent of all known species in the world. However, unsustainable land use practices and increased human pressure on natural resources have led to environmental degradation, climate change and loss of biodiversity. This has threatened and distorted ecological balance, resource conservation and management. This paper reviews and highlights the importance of agroforestry practices in all ramifications especially as they relate to climate change. To mitigate climatic challenges and maintain a healthy and sustainable environment, the adoption of sustainable agroforestry practices, therefore, becomes a viable option and strategy

Keywords: *Sustainability, Environment, Agroforestry, Ecosystem, Climate change*

Introduction

Climate change is a global phenomenon that imposes economic, social and ecological challenges on the global community. It is unarguably the most threatening environmental, social and economic threat facing sub-Saharan African countries today stimulating discourses with respect to the causes, long-term effects, as well as how to forestall its prolonged and frustrating impacts (Ozor *et al*, 2015). Climate change refers to a change in the state of the climate that can be identified by variability in the mean of its properties (average temperature, wind and rainfall patterns) that persists for an extended period (IPCC, 2007). Climate change distorts ecological balance and affects functional habitat networks of the natural environment. Its impacts such as rising temperature and declining rainfall in combination with other indicators could result in shifting of ecological zones and an overall reduction in ecological productivity in Africa.

The evidence of climate change manifests when there is an increase in ocean temperature due to excess carbon dioxide in the atmosphere, melting ice in the Arctic, and melting glaciers around the world; we equally experience irregular rainfall, flooding, and rising sea levels, intense drought and desertification. According to Oloyede (2008), the interaction of man with the environment through human-induced activities such as agriculture; deforestation; burning of fossil fuel etc. generates greenhouse gas emissions which builds up in the atmosphere and act like a blanket wrapped around the Earth, trapping the sun's heat and raising temperatures causing climate change. Its consequences are more pronounced in African societies because of its geography, its sole dependence on rain-fed agriculture, high level of poverty and its generalized incapacity to cope with the extremes of climate (Amonum *et al.*, 2009). Mitigating the impacts of climate change, however, becomes crucial for developing countries. Based on this, Kalu *et al.*, (2014) suggested the need to plant and grow more trees due to their numerous contributions to climate change, ecological balance, food production and medicine.

There is an increased concern at the highest international policy levels about the sustainability of the ecosystem in the light of the apparent rapid depletion of the natural resources base and this has brought agroforestry even further into the limelight (FAO, 2004). Agroforestry simply represents a combination and interrelationships between people, domestic animals, crops and trees, designed to rehabilitate land or to sustain and increase the production of certain desired social benefits. Thus, Agroforestry concerns the structure and functioning of the human ecosystem and not merely the biophysical system (Khot, 1999). This has been reported to contribute to climate change mitigation. Climate inconsistencies and ecological imbalances, however, can be restored and buffered by agroforestry practices. Even though agroforestry is not primarily designed for carbon sequestration, research has revealed that it is a unique and sustainable measure of maintaining ecological sustainability and increasing carbon stock in the terrestrial biosphere (Jacob *et al.*, 2013). Nair (2011) described agroforestry as a collective term for land use systems and technologies where woody perennials are deliberately planted on the same land management unit as crops and animals in some forms of spatial arrangements or temporal sequences with implied ecological and economic interactions between the different components including social and economic benefits. Agroforestry is a problem-solving land management system that accommodates the production of foods and forest products on the same piece of land. The application of Agroforestry science plays a potential role in achieving ecological balance and sustainability. It has been recognized as a mitigation and adaptation strategy for African smallholder farmers at risk of the impacts of climate change (Adekunle, 2009). Human activities that adversely affects the ecosystem and biodiversity are increasingly causing ecological shifts and degradation. Recognizing the potentials of agroforestry systems to address multiple ecological, social and economic challenges, this paper further review the importance of agroforestry systems in environmental sustainability and climate change mitigation.

Classification of Agroforestry Systems

Agroforestry can be classified into three main groups on the basis of components which can be combined in numerous spatial and temporal arrangements for different functions (Nair, 2011). The classes of the systems are described below:

- Agrisilviculture system: This is the integration of annual and perennial crops with woody perennials
- Silvopastoral system: This is the combination of trees with pastures/animals
- Agrosilvopastoral system: This is the integration of all the three elements namely- crops, trees and pastures/animal

Benefits of agroforestry systems

The deliberate incorporation of trees into the farming system has enormous potential to moderate the impact of climate, restore ecological balance and ameliorate environmental challenges. Agroforestry is increasingly promoted for restoring degraded environments, reducing greenhouse gases, enhancing food security, abating the impact of drought, preventing desertification, increasing soil organic matter and moderating micro-climate (Richards *et al.*, 2009). Agroforestry systems improve ecological resilience to climate change impacts through the following:

- **Regulation of micro-climatic condition**

There is the steady rapid depletion of natural resources through human activities that has a striking effect on the environment. This results in climate change. Trees are naturally equipped to sustain the health of the environment by regulating climate both at local, regional and global levels. Microclimatic improvement through the use of trees as shelterbelts and windbreaks controls high climatic temperatures. Trees produce atmospheric moisture, regulate the ecosystem and protect biodiversity. Trees reduce atmospheric carbon dioxide (CO_2) by sequestering carbon in the biomass of trees and reducing the concentration of the atmospheric greenhouse gases that induce global warming. Trees also provide green cover via shade which regulates the atmospheric temperature through evapotranspiration and breeze. Research has shown that climate change mitigation goals cannot be met without the incorporation of trees on farmlands and improved sustainable forest management (Federici *et al.*, 2017).

- **Enhancement of Biodiversity**

Loss of biodiversity affects ecological quality and sustainability and makes the ecosystem vulnerable to the consequences of climate change. Traditional agroforestry systems conserve biodiversity through in-situ conservation of tree species on farmlands, provision of suitable habitat for plant and animal species on farmlands and protection of forest estates and forest resources. Agroforestry is recognized as a panacea for the conservation and enhancement of biodiversity globally, especially in tropical areas.

- **Restoration of degraded land**

Trees act as environmental buffers by absorbing and inhibiting the formation of secondary pollutants in the ecosystem and keeping the ozone concentration at a level that is not hazardous to a human thus, contributing to environmental sustainability and stability. Agroforestry systems play an intrinsic role in increasing soil organic matter through the decomposition of leaves and twigs litter. It improves soil structure, increases soil nitrogen content and enhances nutrient retention by making the soil suitable for arable crops. Oke and Kadeba (2001) observed that alley cropping on sloppy land strengthens soil physical properties, restores degraded lands, and reduces soil erosion and runoff. Agroforestry practices such as alley cropping and improved fallow yield more benefits for soil productivity.

Environmental sustainability and climate change mitigation through agroforestry practices

With the increasing effect of unsustainable land use practices and anthropogenic pressure on natural resources in the country, agroforestry, therefore, becomes a viable option and strategy for restoring ecological balance, mitigating climate change and maintaining biodiversity. To ameliorate environmental challenges, it is essential to adopt the under-listed sustainable agroforestry practices:

- **Taungya System:** This is a forest plantation establishment system in which forest trees are raised in combination with the temporary cultivation of crops. Many lands have been degraded due to economic development activities such as; mining, irrigation, agricultural activities etc. There is a need to restore ecological balance and improve the capacity of the environment to meet the needs of the people. Planting of trees can be used to repair these damages caused by human activities. Trees used in the Taungya system include *Tectona grandis, Gmelina arborea*, while crops like *Vigna unguiculata, Brassica spp, Gossypum spp* and others can be grown in conjunction with these forest trees.

Plate 1: Taungya System
(Source: Williams et al., 2022)

- **Improved Fallow**: Fallowing is defined as leaving a land that is normally cultivated temporarily uncultivated. An improved fallow is thus defined as the enrichment of a natural fallow with trees, shrubs or herbaceous legumes planted at high density to improve soil fertility, restore degraded lands, control soil erosion and reduce runoff (Jacob *et al.*, 2013). Examples of leguminous woody species that can be used include *Acacia* spp, *Gliricidia sepium, Parkia* biglobosa, *Prosopis africana*, *Pterocarpus angolensis*. Grain and forage legumes that can be planted in the understorey include *Sesbania sesban*, *Tephrosia vogelii*, *Pisum sativa*, *Vicia faba* etc.
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Plate 2: Improved Fallow
(Source: Williams et al., 2022)

- **Shelterbelt Establishment:** These are strips of trees, shrubs and vines planted closely together along the edges of croplands to shield crops from adverse weather like winds and storms. This system was described by Otegbeye and Famuyide (2005) as an important land use system commonly adopted by farmers in the arid and semiarid regions of Nigeria to control wind erosion, increase soil organic matter and strengthen soil physical properties. Examples of trees used for shelterbelt include *Azadirachta indica, Acacia senegal, Eucalyptus camadulensis, Acacia albida,* etc.

Plate 3: Shelterbelt Establishment
(Source: Williams et al., 2022)

- *Alley Cropping:* ***Alley cropping is also known as Hedge row intercropping. It is a simultaneous Agroforestry system where food crops are grown between hedge rows of planted shrubs and/or trees, preferably leguminous species. Rows of trees are planted at wide spacing with a companion crop grown in the alleyways between the rows. Species are periodically pruned to prevent shading of the companion crops and the pruning*** *is* ***applied as mulch to the crops to enhance the soil nutrient status and physical properties.***

Plate 4: Alley Farming/cropping
(Source: Williams et al., 2022)

- **Homestead Planting of Trees:** Different types of economic tree species are planted by the road sides and within the surrounding of a house. Trees help to purify the air by removing harmful substances and maintaining balanced levels of oxygen. Trees absorb pollutants like ammonia and sulphur dioxide and traps them in leaves and bark. These trees also provide green cover via shade which regulates the atmospheric temperature. Examples of trees used for homestead planting include *Moringa oleifera, Adansonia digitata, Tectona grandis, Gmelina arborea and Azadirachta indica.*

Conclusion

The roles of agroforestry systems in maintaining a sustainable environment and mitigating climate change cannot be over-emphasized. A sustainable and healthy environment is more resilient to negative environmental challenges than ecosystems under stress whose ecological process is impaired and unbalanced. Agroforestry, therefore is a major option and strategy for increasing environmental resilience because it can be used in enhancing biodiversity, regulating micro-climate, restoring degraded land and maintaining ecological balance to a healthy state.

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