

The Role of Agroforestry in Environmental Sustainability

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Abstract: *The increased pressure on the world natural resources which arises from population growth as well as economic pressure has resulted in unsustainable use of natural resources and environmental instability. The unstable nature of the world climate, attributed to human activities, depletion of forest cover due to increased hunger for forest and non-forest products has caused a lot of environmental problems such as, land erosion, flooding, frequent and severe storm, depletion of soil fertility, natural disaster as well as seasonal changes of world climate: These negative effect on the world ecosystem required a crucial attention. This paper reviews the importance of agroforestry and discusses various agroforestry practices that are capable of enhancing the sustainability of the environment. Agroforestry is a means of halting the vicious circle of deforestation, soil erosion and other environmental problems facing the country. Agroforestry refers to the combination of agriculture and forestry practices within a farming system. As a land-use system, it serves the diverse needs of individual farmers in harnessing the natural resources around them, as this cannot be reconciled by the traditional cropping system. It involves the combination of trees and crops that increase the medicinal, environmental, and economic value of land with the much-needed profit and food security. Hence Agroforestry systems such as live fence, home garden, shelterbelt, alley farming, taungya system, improved fallow and agrosilvopastoral are highly recommended as solution to environmental problems.*

Keywords: *Sustainability, Environment, Role, Agroforestry, Natural resources*

I. Introduction

Agroforestry is a multiple land-use system in which agricultural crops and woody perennials are grown on the same land management unit (Owunubi and Otegbeye 2012). Agroforestry practices encompass an entire spectrum of land use systems in which woody perennials are deliberately combined with agricultural crops and/or animals in some spatial or temporal arrangement (Lundgren and Raintree, 1982). Advocates have contended that soil conservation is one of its primary benefits. The presence of woody perennials in agroforestry systems may affect several bio-physical and bio-chemical processes that determine the health of the soil substrate (Nair, 1993). The less disputed of the effects of trees on soil include: amelioration of erosion, primarily through surface litter cover and under story vegetation; maintenance or increase of organic matter and diversity, through continuous degeneration of roots and decomposition of litter; nitrogen fixation; enhancement of physical properties such as soil structure, porosity, and moisture retention through the extensive root system and canopy cover; and enhanced efficiency of nutrient use because the-tree-root system can intercept, absorb and recycle nutrients in the soil that would otherwise be lost through leaching (Sanchez, 1987).

Nigeria is blessed with a large area of land and vegetations, but the use of this important resource has been abused, not sustainably used or managed. Ladipo (2010) pointed out that the forest has been treated in the past by many rural dwellers as inexhaustible. Recently everyone now realise that forest is at the verge of going to extinction if nothing is done to reverse the unsustainable use. Evans (1992) is of the view that the depletion of forest reserves in Nigeria is due to hunger for more agricultural land that could be used for food production, shifting cultivation, as well as urbanisation. It is a known fact that Agriculture, forestry and urban development remained the three major uses to which land is subjected. Unanaonwi and Bada (2004) maintained that these various uses to which land is subjected to are the consequence of environmental stress and degradation which invariably lead to reduction in the land area available for farming. Hence farmers have been restricted to consistent farming on the same land area for a long time, which has often resulted into decline in crop yield as well as environmental degradation.

Agro-forestry practices are being increasingly advocated as possible remedies. As it is a land use system that has the potential of improving agricultural land use while providing lasting benefits and alleviating adverse environmental effects at local and global levels. It has been known to have the capability of reducing emissions from deforestation and forest degradation; it promotes sustainable forest management as well as the conservation and sustainability of the environment. It is therefore imperative to employ, agroforestry, a land use system which encourage increase productivity as well as environmental stability.

II. Importance Of Agroforestry

The importance of agroforestry cannot be overemphasised, as it has several advantages in the provision of food and other basic needs (i.e. fuel wood, staking materials, fibres, timber, medicinal concentrates, oils, fruits, and fodder for animals) for a large proportion of the rural population as well as its role in soil fertility restoration and the control of weeds in addition to amelioration of environmental degradation. Agro-forestry practices are being increasingly advocated as possible remedies and had been claimed, to have the potential of improving agricultural land use systems, providing lasting benefits and alleviating adverse environmental effects at local and global level. Adedire (2004); Adekunle (2005) and Oke (2008); agreed that agroforestry can provide new and useful solutions to many of the adverse consequences of human land use, including increased diversification of agricultural production system, increased yield of crops and livestock, reduction of non-point source pollution and increased rural development by contributing to an ecosystem-based management system, that guarantees sustainability and environmental quality. Agroforestry should therefore be seen as a system that addresses the declining quality of the environment, including the soil, while also increasing the variety of produce by the farmer. This will not only increase the farmers' income but also help ensure food security and balance. The retention of trees in farming systems has been recognized to increase crop output in the semi-arid region of Adamawa state (Amadi et al; 2003). Ajake (2012) also recognized the function of forest trees in term of income generation, good medicare, employment generation, raw materials, and provision of food among others. Agro forestry is increasingly promoted for restoring forest, degraded environment, reducing green house gases, and gaining other co-benefits, (Richard et al; 2009)

Richard et al; (2009) also pointed out some of the key benefits that agro-forestry puts into sustainable development programmes, these include: Biodiversity conservation, environmental (watershed) Protection, and Climate change mitigation and adaptation. It was therefore viewed as being useful in promoting afforestation /reforestation and in the unfurling mechanism for forestry development: "Reduction of Emissions from Deforestation and forest Degradation (REDD)" has also been recognized, as well as, meeting (inter)national climate change objectives. Agroforestry is also being known for, its role in traditional employment generation, thus it has the capability to deliver several benefits (e.g. income generation for poor farmers, environmental and ecosystem stabilization including control of desertification and deforestation).

III. Role Of Agroforestry In Environmental Sustainability

The contribution of agroforestry to the environmental sustainability is very significant through its environmental, economic and social functions. Not creating negative impact to the environment, while improving the production capacity of the soil. It is known for its ability to conserve natural resources at the same time as maintaining human activities.

The ever increasing world population has made the traditional system of African farming unsustainable. There is upsurge demand for food, leading to more pressure on forestlands and forest products has contributed greatly to unsustainable use of the nations natural resources In view of these, agroforestry as a technique is considered as one of the sustainable management system for land that increases production, ecological stability and supports sustainable environmental development (Wilson, 1990). Apart from providing wood, food and/or animal products, the integration of trees in the farming system could go a long way to help ameliorate environmental problems: specifically by creating microclimates favourable for crop growth, and enhancing the recycling of minerals to provide a more complete ground cover which could help to protect the soil from erosion and moderate extreme temperatures (Adedire, 2004). Evans (1992) also stated that the contribution of agroforestry to the sustainable development is very significant through its economical, environmental, and social functions. They further maintained that agroforestry has been proved to meet the criteria of sustainable development that has no negative impact on the environment.

IV. Role Of Agroforestry In Climate Change Mitigation

Climate change is a global phenomenon that imposes economic, social, and ecological challenges to the global community. Research has shown that climate change is attributed to human activities, which bring about CO₂ emissions, through the removal of forest cover (Owolabi, 2010). Deforestation, human induced conversion of forests to non forestland uses, is typically associated with large immediate reductions in forest carbon stock through land clearance. Poor forest management policies and illegal encroachment into forest reserves, urban development, road construction, fossil fuel combustion and excessive harvesting of fuel wood, contribute to the depletion of the ozone layer. Food and Agricultural Organisation of the United Nation FAO (2010), observed that deforestation account for approximately 18% of global carbon emissions. It was further reported by FAO (2001) that reduced deforestation, forest regeneratiuon, increased plantations development and agroforestry accounts for 12 to 15% of global sequestration of carbon emission from fossil fuels. Agroforestry has high potential to reduce atmospheric concentration of carbon dioxide (CO₂) and mitigate climate change. It is an established fact that planting of more trees, to increase the amount of forested land or to

increase the density of the existing forest in Nigeria would help mitigate climate change impacts in the country and at global level. Morgan et al (2001) also supported the fact that rising level of atmospheric carbon dioxide and associated global warming can only be addressed by adopting CO₂ reduction strategies. Agroforestry, as a system that combines trees and/or shrubs (perennial) with agronomic crops (annual or perennial), offers great promise to sequester Carbon, both above and below-ground. Agroforestry systems even though not primarily designed for carbon sequestration have been reported to present a unique opportunity to increase carbon stock in terrestrial biosphere (Jacob et al; 2013)

V. Role Of Agroforestry In Economic Sustainability

Nuga and Iheanacho (2011), recognised soil erosion as another long time serious environmental problem that has adverse effect on the economy of Nigeria. This has several environmental and economic impacts, especially in West Africa where the resilience ability of soil is limited. Hence an agroforestry practice through the incorporation of woody perennial has the potentials of mitigating the impact of soil erosion, through the incorporation of both the above and below tree biomass. Bamigbade et al; (2011) stated that when the system of agroforestry is properly enhanced and place in the right perspectives by all environmental stakeholders, this will help in addressing some issues of economic instability in the country. Trees in agroforestry system are known to provide fuel wood, food, shelter, drugs, income, raw materials and improvement of soil fertility for crop growth. As well as wide range of environmental protection, the products and services forest product provides are essential to every aspect of life. Asinwa et al; (2012) conducted a survey on the economics of some forest fruit trees and found out that harvesting, processing and marketing of products from economic forest trees plays an important role in food security, employment and income generation.

VI. Variety Of Agroforestry Systems For Environmental Sustainability

Taungya Farming: This system has been used as a method of establishing forestry plantation. This consists of growing annual agricultural crops along with the forestry species during the early years of establishment of the forestry plantation. Usually the land belongs to the forestry department or their large scale leases, who allow the subsistence farmers to raise their crops. The farmers are required to tend the forestry seedlings and, in return, retain a part or all of the agricultural produce. It is an agreement that will last for two or three years, during which time the forestry species would grow and expand its canopy (Adekunle and Bakare, 2004). It was described as a way of completely utilisation of forest soil for increase agricultural production in developing nations. It is an avenue for farmers to participate in tree planting and be directly involved in afforestation project of the government. Otegbeye and Famuyide (2005) also indicated that, taungya farming was widely adopted in the arid and semi-arid land of Nigeria, as a method of reforestation.

Improved Fallow: This is a rotational system that uses preferred tree species as the fallow species in rotation with cultivated crops as in traditional shifting cultivation. The reason for such trees is production of an economic product, or improvement of the rate of soil amelioration, or both. The potential of improved fallow systems was tested by the world agroforestry centre for controlling soil erosion using fast growing shrubs such as *Crotalaria* spp and *Tephrosia* spp. In addition a significant improvement in soil moisture content has been observed in improved fallow system (Jacob et al; 2013). An ideal fallow species would be one that grows fast and efficiently take up and recycles available nutrients within the system, thus shortening the time required to restore fertility. Examples of such species are *Gliricidia sepium*, *Leucaena leucocephala*, *Fardherbia albida*

Live fence: This is an agroforestry system which involves fencing of farmlands with living plants to prevent animals from entering or serve as boundary demarcation. In this system, various fodder trees and hedges are planted as live fence to protect the property from stray animals or other biotic influences. Usually, species used for live fencing must be species that produce very little shade on farmlands; tolerant of animal browsing or are not browsed by animal at all. Such examples are: *Gliricidia sepium* (Plate 1), *Sesbania grandiflora*, *Erythrina* sp, *Acacia* sp. This system is commonly adopted among farmers as the woody species, apart from serving as boundary demarcation, it also enhance fuel wood supplies of the family (Adedire,1992)



Plate 1: *Gliricidia sepium* used as life fence for boundary demarcation

Home Garden: This represents land use systems involving deliberate management of multipurpose trees and shrubs in intimate association with annual and perennial agricultural crops and livestock within the compounds of individual houses. The whole tree-crop-animal units are being intensively managed by family labour. Home gardens can also be called as **Multitier system** or **Multitier cropping**. Home gardens are highly productive, sustainable and very practicable (Plate 2). Food production is the primary function of most home gardens. Many species of trees, bushes, vegetables and other herbaceous plants are grown in dense and in random or spatial and temporal arrangements. Most home gardens also support a variety of animals. Fodder grass and legumes are also grown to meet the fodder requirement of livestock. In a research conducted by Edmund (2005), he discovered that one of the agroforestry practices used in the South-eastern State of Abia includes multi-storey home gardening and border planting. He highlighted some of the reasons why the method is used more, such as the security it provides in food production, the variety of crops obtained, the capacity to boost soil fertility, and the much-needed income.



Plate 2: Typical example of Home garden

Alley farming or Hedgerow intercropping: Alley cropping is the planting of trees or shrubs in two or more sets of single or multiple rows with agronomic, horticultural, or forage crops cultivated in the alleys between the rows of woody plants. (plate 3) Trees or shrubs are generally planted in a single- or multiple-row set or series. All traditional crops can be grown with alley cropping. The primary factors determining which crops can be

grown are the canopy density and sunlight requirement for the agronomic, horticultural, or forage crop. The improvement in vegetative cover through agroforestry in the form of contour hedgerows is reported to be an appropriate innovation for reducing soil erosion on sloping lands. Improvement in soil physical and chemical properties has been reported with long term effect of alley cropping with various hedgerows species by Hulugalle and Kang (1990), likewise in a research conducted by Oke and Kadeba (2001), they discovered that *Cajanus cajan* fallow and alley cropping had positive effect on soil Nitrate. Adekunle (2006) added that the tree litters in alley cropping facilitate nutrient cycling, help in suppression of weed as well as control of soil erosion.



Plate 3: Hedgerow intercropping/Alley farming

Shelterbelts: These are windbreaks designed to protect farmsteads and livestock from wind. In this system, one or more rows of trees/shrubs, are planted against wind direction to reduce wind speed which could cause damage to farmland, as well as serve as control to wind erosion. This system was described by Otegbeye and Famuyide (2005) as an important land use system commonly adopted by farmers in the arid and semiarid region of Nigeria. It was observed to that it increases farmers' gross yields of crops, when compared to those grown outside it. This confirm early report by Adegbeyin (1986) that increases of 183-363% in maize and millet occurred in some parts of Jigawa state compared to 114-189% in unsheltered area. Tree species such as *Azadirachta indica*, *Eucalyptus camaldulensis*, *Acacia nilotica* are suitable for this system.

Agrosilvopastoral: The production of woody perennials combined with annual crop and pastures is referred to as agrisilvopastoral system (Plate 4). There are two forms of this system (a) Home gardens (b) Woody hedgerows for browse, Mulch, Green manure and soil conservation, reason why the method is used more, is the security it provides in food production, the variety of crops obtained and the capacity to boost soil fertility.



Plate 4: Agrisilvopastoral system

VII. Conclusion

The problem of environmental instability brought about by mounting pressure on the available land resources as a result of persistent rise in population, has probe lot of disturbance on the existing natural ecosystems. These human disturbances and unsustainable use of natural ecosystem which posed a lot threat to local biodiversity; leading to environmental degradation need to be addressed. Therefore there is need to embrace agroforestry a promising land use system that involves the integration of variety of trees species with herbaceous crops and / animal in some form of spacial arrangement or temporal sequence. These systems have the ability to increase the biodiversity and increase the overall productivity consumed by household. It also reduces soil loss and improves the physical, chemical properties of soil and at the same time helps in climate change mitigation for the sustainability of the environment. In order to exploit the full potential of agroforestry system and practices, suitable model has to be appropriated towards the sustainability of the environment.

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