

WOODY TREE SPECIES DIVERSITY IN AGRICULTURAL LANDSCAPES OF A LOWLAND RAINFOREST ECOSYSTEM IN NIGERIA

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Abstract

Woody tree components of the agricultural landscape play diverse roles in the improvement of agricultural productivity, maintenance of the agro ecosystem stability and improvement of livelihood of the dwellers of the rural communities. An understanding of the diversity of woody tree species on agricultural landscapes is crucial to the landscape approach to woody tree species biodiversity conservation. This study was carried out to investigate the diversity of woody tree species in agricultural landscapes of Ijebu North Local government Area (LGA), Ogun State, Nigeria. Data was collected on 0.06ha for each of the identified agricultural landscapes using purposive and simple random sampling. All woody tree species with DBH \geq 2cm were identified. Shannon Weiner, Margalef and Pielou's indices and Sorensen's similarity coefficient (Ss) were used to measure the diversity of woody tree species in each farming landscape. Cash crop plantation has the highest Shannon index value (2.986) and Margalef value (7.016), farm fallow has the highest density of woody tree species (925 trees/ha) and evenness index (0.796). Woody tree species are significant component of agroecosystems in Ijebu North LGA and farmlands in the area have great potential for conservation of woody tree species diversity in the humid lowland zone of Southwestern Nigeria. It is recommended that the conservation potential of agricultural landscapes most especially the cash crop plantations of Ijebu North LGA should be harnessed and on-farm trees should be included in biodiversity conservation and sustainable management programmes.

Key Words: *Agroforestry, Biodiversity, On farm trees, Shannon Weiner index*

Introduction

The fragmentation of blocks of natural forest into small isolated patches of native vegetation surrounded by a matrix of agricultural and developed lands has been identified as one of the major causes of biodiversity loss (Hill and Curran, 2003 and Tripathi *et al.*, 2010). The decline in the surface area and vegetation quality of natural forests in recent times (Boffa *et al.*,

2008), can be ascribed to the increased demand for arable land and tree products with increasing demographic pressure (Boffa, 2000). This underlines the need to expand the horizon of forest conservation beyond the boundaries of protected forest areas in a landscape approach to sustainable forest management.

The rapid environmental degradation arising from increasing fragmentation of

landscapes due to population pressure and human activities (Nair, 2008), has positioned agroforestry system as one of the most common strategies proposed in recent years for addressing environmental degradation in the tropics (Oyewole *et al.*, 2015). Agroforestry is a dynamic ecologically based natural resource management system, which through the integration of trees on farms, diversifies agricultural landscapes and sustains production for increased social, economic, and environmental benefits (ICRAF, 1997). It is a system that has been used by many indigenous people as a traditional land use option, providing sustenance for early agriculturists while preserving forest resources and biodiversity (Oyewole *et al.*, 2015).

Agricultural landscapes are spatial network of agricultural, semi natural (traditional agricultural plots, agroforestry plots and fallow lands) and natural (pockets of forest lands) habitats (Bohan *et al.*, 2013). The landscapes often resemble a patchwork of rural villages, natural and semi natural habitats, and farms cultivating a diverse array of crops (agroecosystems) (Garbach *et al.*, 2014). Scattered trees are characteristics of agricultural landscapes in sub Saharan Africa (Bayala *et al.*, 2011). At the time of converting woodlands to farmlands, farmers remove most of the vegetation leaving behind selected multipurpose trees species for their diverse functions (Bayala *et al.*, 2011) such as products (revenue, food, wood, construction materials, fodder, medicine) climatic amelioration and soil fertility improvement (Faye *et al.*, 2010). A good understanding of the diversity of woody tree species on agricultural landscapes is crucial to landscape approach for woody tree species diversity conservation.

Although, there has been increased awareness on the contribution of agroforestry systems to overall tree canopy cover over the landscapes (Mustapha and Jimoh, 2012); the extent of woody tree species diversity in agricultural landscapes of Ijebu North Local Government Area of Ogun State, Nigeria is insufficiently documented.

Ijebu North Local Government Area is one of the areas in the tropical lowland rainforest of Nigeria with agricultural landscapes dominated by a mix of agricultural crops and woody tree species. In an earlier study, Mustapha and Jimoh (2012) identified 73 agroforestry tree species preferred by farmers as scattered trees on agroforestry systems in Ijebu North Local Government Area, but information on the species diversity of the woody component of the agricultural landscapes in the area is inadequate. Due to this fact, woody species conservation and sustainable management programmes in the area has often failed to take into account, the diversity of on-farm trees that co-habit with the agricultural components of farm landscapes. This has led to the destruction of many of these species. This study therefore seeks to investigate the diversity of woody tree species in agricultural landscapes of Ijebu North Local Government Area of Ogun State, Nigeria.

Methodology

Study Area

Ijebu North local government is located between latitudes 6° 52' and 7° 10' N; and longitudes 3° 45' and 4° 12' E. The Local Government Area shares boundary with Remo North Local Government Area, Ijebu East Local Government Area, Odogbolu Local Government Area, Ogun State and Oluyole Local Government

Area, Oyo State. Apoje farm Settlement, an Ogun State Government Farm settlement and Area J1 Forest Reserve are located in the Local Government Area (Mustapha and Jimoh, 2012).

The area is in the humid lowland Region of the south-western part of Nigeria with the vegetation comprising dense evergreen tropical rainforest. The area has a mean annual rainfall of 1050 -

1280 mm, average temperature of 30°C throughout the year and relative humidity of about 50%. Agriculture is the main occupation of the people of this area. Subsistence and commercial crops production, livestock farming, scatter tree agroforestry, home gardens, agrisilviculture and arable and cash crop plantations are practiced by the farmers.

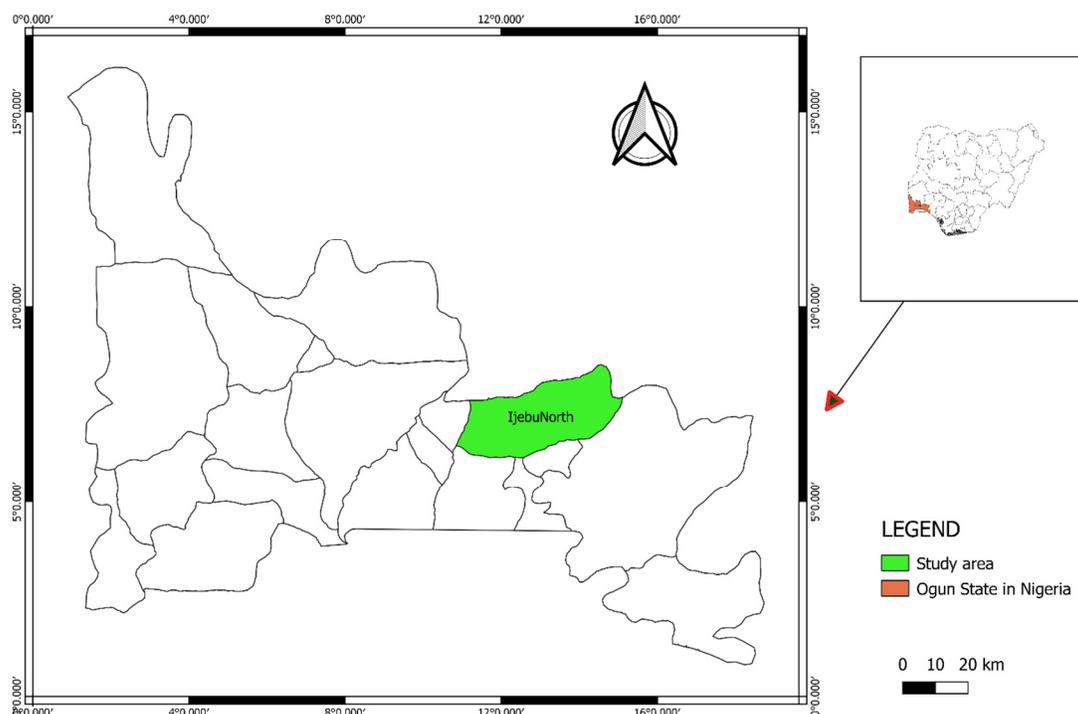


Fig. 1: Map of Ogun State showing study area

Data Collection and Analysis

A combination of purposive and simple random sampling was used. Four wards where agriculture is predominant were purposively selected. Six farms were selected purposively within each ward; two farms for each type of farming landscape (arable farmland, arable and cash crop plantation and farm fallow). On each farm, two 20 x30m plots were randomly laid. Thus, 48 sample plots (16 sample plots to each farming landscape) were surveyed.

All woody tree species with diameter ≥ 2 cm were identified to species level. Where species could not be identified by scientific names on the field, they were identified by their local names. The scientific names were later obtained from the book “*Vernacular names of Nigerian plants (Yoruba)*” (Gbile, 1984). The total number of each tree species encountered in the 16 (20m \times 30m) sample plots allotted to each agroecosystem was recorded to generate the frequency. On each sample plot, two 5m x 5m plots were

demarcated at alternate corners of the 20m x 30m for the enumeration of saplings and seedlings of woody tree species. The frequency generated on the 0.96ha for each agricultural landscape was used to calculate the density and the relative abundance of each identified species.

The woody tree species diversity for each agricultural landscape was estimated using the Shannon Weiner diversity index (H). The diversity index (H) is the negative sum of all relative abundances (P) multiplied by the natural logarithm of the relative abundance (Ponce-Hernandez, 2004; Njoh *et al.*, 2013; Molla and Kewessa, 2015; and Nduwayezu *et al.*, 2015).

$$H = -\sum p_i \ln p_i \quad (1)$$

Where, $p_i = S/N$

S = number of individuals of one species
 N = total number of all individuals in the sample

Margalef Index was used as a simple measure of species richness for each agricultural landscape (Heip *et al.*, 1998; Aslam, 2009; Oke and Jamala, 2013; and Ikyaaagba *et al.*, 2015).

Margalef Index (D) is expressed as:

$$D = \frac{S-1}{\log_e N} \quad (2)$$

S = No. of species in the sample plot
 N = total number of individuals in the sample plot

The Pielou's Evenness Index (J) was used to calculate evenness of species in each agricultural landscape. It was calculated by dividing the diversity index by the maximum possible diversity (H_{max}) based on the number of species observed across the farming landscapes: (Pielou, 1966; Adekunle *et al.*, 2013; Tefera *et al.*, 2014).

$$J = \frac{H}{\ln S} \quad (3)$$

H = Shannon – Wiener diversity index
 S = total number of species in the sample

The variation in β diversity (the degree to which the different agricultural landscapes types share species) was estimated using the Sorenson similarity index (S_s). This is given by the formula (Aslam, 2009; Akinyemi and Oke, 2014 and Molla and Kewessa, 2015):

$$S_s = \frac{2a}{2a+b+c} \quad (4)$$

a= number of species common to both samples.

b= number of species distinct to landscape 1

c= number of species distinct to landscape 2

Results and Discussion

Farm fallow has the highest number of woody trees per hectare (925), followed by cash crop plantations and arable farmlands with 547 trees per hectare and 370 trees per hectare respectively (Table 1). Cash crop plantation has the highest Shannon diversity (H) Index value (2.986) and arable farmland has the least (2.408). Cash crop plantation has the highest Margalef Index value (7.016). Farm fallow has Margalef value of 5.449 and the highest equitability index (0.796). Arable farmland has the least evenness and richness values of 0.731 and 4.423 respectively (Figure 2). Cash crop has the least mean density (12.16 stems/ha) but the result of Shannon Weiner's index (H) indicates that cash crop plantation is the most diverse landscape in the study area with a Shannon diversity Index value of 2.936. It also has the highest species number (45). As expected, Arable farmland has the least Shannon value

(2.408), species number (27) and evenness value (0.731). The difference in the diversity index values may be due to the differences in the frequency and intensity of human disturbance on the landscapes and the original vegetation of the area. Bayala *et al.* (2011) observed that one of the determinants of the diversity of on-farm tree species is the original vegetation of the area. This result is an indication that cash crop plantation in Ijebu North LGA is a woody species diversity hotspot and it serves as habitat to various fauna and flora species outside the boundaries of protected forests.

The value of the Shannon Weiner's Diversity Index (H) of a diverse community usually falls between 1.5 and 3.5 and rarely exceeds 4.5 (Ponce-Hernandez, 2004). The Shannon index (H) values of the three selected agricultural landscapes of Ijebu North LGA range between 2.408 and 2.936 indicating a diverse ecosystem. These values are very close to the diversity index value of 2.9 obtained in *taungya* system in Shasha Forest Reserve, Southwest Nigeria (Akinyemi and Oke, 2014) and 2.71 obtained from cocoa agroforest in Ondo State (Oke and Odebiyi, 2007). It is also comparable to the diversity value (H) obtained from study of three reserves in tropical rainforest ecosystem of Southwestern Nigeria, 3.656 in *Shasha* Forest Reserve, 3.621 in Ala Forest Reserve and 3.342 in Omo Forest Reserve (Adekunle, 2006) and 3.75 in strict nature reserves of Akure Forest Reserve

(Adekunle *et al.*, 2013). The closeness of the H values of agricultural landscapes in Ijebu North LGA to that of forest reserve ecosystems of tropical humid lowland Region of Nigeria is an indication that agricultural landscapes have great potentials in the conservation of tree species diversity. This has implications for rural livelihood, ecosystem resilience and sustainability of agricultural ecosystems.

The result also shows that cash crop plantation has the highest species richness while arable farmland has the least species richness value. This conforms to the result of the Shannon Wiener's diversity index and species number. The low species richness value in arable farmland may be due to the loss of some species during land clearing and post planting operations carried out on arable farmland. The high similarity between the three farming landscapes is an indication of the relative homogeneity in the tree species composition of the landscapes.

Table 2 shows the similarity coefficient between the three agricultural landscapes types. Between arable farmlands and cash crop plantations, there is 61.1% similarity. The species in arable farmlands are 64.6% similar to the species in farm fallow and species in cash crop plantation are 66.7% similar to the species in farm fallow. Farm fallow and cash crop plantation have the highest similarity coefficient (0.667) and arable farmland and cash crop plantation have the lowest similarity coefficient (0.611).

Table 1: Species density on agro ecosystems in study area

	Species number	Density (/ha)
Arable farmland	27	370
Cash crop plantation	45	547
Farm fallow	38	925

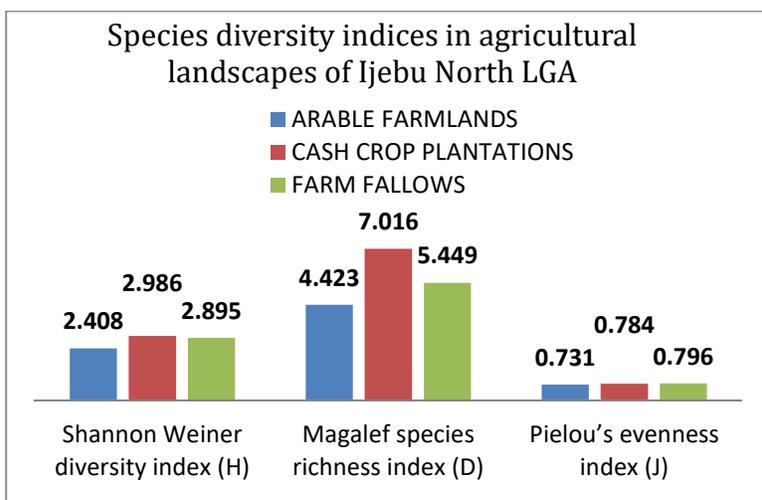


Fig. 2: Species diversity indices in agricultural landscapes of Ijebu North LGA

Table 2: Sorensen's similarity coefficient (Ss) of the farming landscapes of Ijebu North LGA

Agricultural landscapes	Arable farmlands	Cash crop plantations	Farm fallows
Arable farmlands	1.000 (0.000)	0.611 (0.389)	0.646 (0.354)
Cash-crop plantations	-	1.000(0.000)	0.667 (0.333)
Farm fallows	-	-	1.000(0.000)

Sorensen's index is highest between cash crop and farm fallow and lowest between arable farmland and cash crop plantation. This may be due to the difference in the permanence of the crops within the landscapes. The low similarity between arable farmland and cash crop plantation may be due to the difference in management intensity and method of land preparation (Jimoh *et al.*, 2012). According to the farmers in the area, cash crop plantations are left more or less undisturbed with less weeding once the cash crops planted are established; whereas there is always a continuous array of farming activities (land clearing, weeding, bush burning etc.) on arable farmlands. The chances of regeneration and survival of woody tree species in the relatively undisturbed farming system of cash crop plantation is higher than in arable farmland where there is constant human interference; seedlings and saplings and even the lower branches of

trees may be cleared off during weeding to make room for arable crop component of the farming landscape. Also cash crops are perennial. This implies that they remain on the landscapes for years (in the study area there are cash crop plantations that have been in existence for over 50years) with little or no replanting or brushing thus allowing the agro-ecosystem to recover from earlier disturbance.

The high similarity between cash crop plantation and farm fallow (a recuperating ecosystem) could be linked to the reduced human interference in both landscapes. As mentioned earlier, farm fallows in Ijebu North LGA are arable farmlands left undisturbed for some years (4 – 15years) in order for it to regain its fertility. The reduced human interference and disturbance from agricultural activities give room for regeneration and survival of woody species; it also encourages succession

and gradual movement towards ecosystem stability. This implies that arable farming which usually involves slash and burn agriculture is least suitable for woody species conservation.

Conclusion

Agricultural landscapes of Ijebu North Local Government Area of Ogun State is home to diverse woody tree species with the cash crop plantations of Ijebu North LGA having the highest diversity and farm fallows having the highest density. Woody tree species diversity in agricultural landscapes of Ijebu North LGA is comparable to those observed in natural forests reserves in the tropical rainforest ecosystem of South-western Nigeria. If managed sustainably, agricultural landscapes have the potential to contribute immensely to ecosystem stability, agroecosystems sustainability, food security and rural livelihood, and the conservation of woody tree species diversity in the humid lowland region of Nigeria.

Recommendation

It is recommended that the conservation potential of agricultural landscapes most especially the cash crop plantations of Ijebu North LGA should be harnessed and on-farm trees should be included in biodiversity conservation and sustainable management programmes. More efforts should be directed towards educating farmers on the diverse roles of on-farm trees and creating awareness on the contribution of agricultural landscapes to environmental stability and biodiversity conservation. Also, tree planting and sensitization programmes should not be limited to the urban areas but should be extended to include rural communities to enlighten and train farmers on various

tree planting and management practices in order to ensure the sustainable management of the diverse woody tree species on agricultural landscapes in the area.

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