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Abundance and Diversity of Trees Species Under Different Land Uses in the Sudan Savannah Ecological Zone of Ghana, West Africa

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Abstract

Knowledge on tree species abundance and diversity is critical for sustainable land management and biodiversity conservation. The aim of the study was to assess tree species abundance and diversity across different land uses and sites in the Sudan savannah ecological zone of Ghana, a total of 64 plots of 3600 m2 (60 m x 60 m) were laid out in three land use types (Forest reserve, cropland and rangeland) in four sites (Bawku, Binduri, Garu and Pusiga).

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All standing trees and shrubs species encountered in the setting plot were recorded including dendrometry parameters. Alpha diversity was measured using Simpson, Shannon-Wiener and Evenness indices whereas similarity in species composition between land use types and sites were measured using Sorenson's index. The results showed that there were more species in the lower diameter classes (0 to 20 cm) than the higher diameter classes (>20 cm). the greatest value of tree diversity was recorded in forest land in the four sites compared to the other land use types. The highest similarity (53%) in tree species composition was recorded between cropland in Binduri and Garu. the current study revealed that forest land recorded the highest value of tree species richness in each site compared to the other two land use types (cropland and rangeland) in the same site.

Keywords: Abundance; Tree species diversity; Land use types; conservation; Sudan savannah ecological zone; Ghana.

1. Introduction

The natural resources in tropical regions are recognized for their high biological diversity and role in local climate patterns [1]. Biodiversity is necessary for human livelihoods [2,3] as the livelihoods of the population of many developing countries rely on these natural resources and biodiversity [4]. The rural poor often depend on biodiversity for a wide range of natural resources and ecosystem services essential for their well-being, and are therefore potentially affected by its degradation [5]. Biodiversity is the main backbone of the economy of most of developing countries including Ghana [6]. It affects the resilience of production systems or land uses and safeguard the rural population against future livelihood challenges. A recent study by [7] on West African and uses has shown a changing trend in their structure, composition and functions. To highlight the significance of biodiversity conservation, it is essential to estimate the worth of the species concerned particularly in multispecies agroecosystems where biodiversity is managed in integration [8]. These production systems provide numerous economic benefits for rural communities in the tropics and serve as intermediary for biodiversity conservation [9]. Ghana is recognized as one of the most advanced tropical African countries in terms of established forest policy and management planning [10]. Forest reservation date back to the early 1920s with the entire vegetation cover of the country categorized into 266 forest reserves and protected areas, covering 11 percent of the country [11] . The forest reservation system was one of the most extensive in sub-Saharan Africa to conserve the country's forest resources and protect biodiversity in the high forest, transition, and savannah zones. Police wise, the country's forest sector has witnessed o lot changes from 1948 policy which promoted maximum utilization of forest resources through to the implementation of 1944 forest and wildlife policy to the current (2012) policy. The 2012 Forest and Wildlife policy seek to address the current relevant issues confronting the forest sector such as illegal chainsaw activities resulting in the rapid depletion of Ghana's forest resources, and embrace emerging global issues like the Voluntary Partnership Agreement (VPA) and Reducing Emission from Deforestation and Degradation (REDD+) which have implications on the forestry sector and livelihoods [12]. These policies and management strategies are to ensure sustainable management and conservation of the country's natural resources. However, there is deficiency in forest protection from state authorities. For instance, between 1950 to the turn of 20th century, Ghana lost over 60% of its forest cover, about 2.7 million hectares [13]. Ghana's deforestation rate since the year 2000 has been approximately 3% per year (320,803 ha per year) but between 2013 to 2015 there was a market increase in deforestation to an average rate of 7.4% per year (794,214 ha per year) [14]. The major causes of forest degradation and deforestation are population growth, illegal logging, mismanagement and long history of sedentary agriculture which had affected the land use/land cover system and caused environmental degradation [15]. In addition, uneven distribution of rainfall in the country aggravated the deforestation process [16] in the savannah landscape. Deforestation leads to forest degradation, loss of biodiversity and exacerbates loss of vegetation and expansion of bare lands thereby making the country a net contributor to the global climate change. Economically, it poses a severe challenge to Ghana's economy as well as the capacity of forest ecosystems to sustainable supply critical goods and services for the country [17]. The major contributors to deforestation apart from illegal logging are forest clearance for agriculture expansion and unsustainable agriculture practices [18]. At the same time, agriculture continue to be the backbone of the nation's economy employing over 50 percent of the labor force and providing livelihood to majority of Ghanaians and unfavorable climate change impacts, it is expected that more natural landscapes will be converted into farmland. Thus, with population pressure and unfavorable climate change impacts, it is expected that more natural landscapes will be converted into farmlands to further worsen the current state of deforestation and erosion of biodiversity [19]. Rehabilitating these degraded landscapes and restoring the biodiversity and ecological integrity calls for an investigation among others into the abundance and diversity of tree species within the commonly occurring land uses such as forest land, cropland and rangeland in the savannah landscape. Besides land use types or farming systems and climate factors, the abundance and diversity of tree species may be affected by other factors such as household wealth status and the access to the market opportunities [20] .Unfortunately, to date, there is scanty data on abundance and diversity of tree species in different land management types in the savannah landscape. Therefore, it is necessary to understand the dynamics of trees species diversity in land use types in order to help in their restoration and better appreciate their contribution to the farmer's livelihood in the savannah landscape. In this study, our objective was to assess tree species abundance and diversity across different land use types, with the hypothesis that, the tree diversities vary with the land use types and sites in the Sudan savannah ecological zone.

2. Methodology and materials

2.1. Study area

The study was conducted in four Districts in the Upper East Region of Ghana. These are Bawku Municipality, Binduri, Garu and Pusiga Districts, all in the Sudan savannah ecological zone. The four areas lie between latitude 10°15' North and 11°15' North and longitude 0°03 East and -0°023' West. Its sites share boundaries with Burkina Faso to the north, the republic of Togo to the east, and Bawku West and East Mamprusi to the west and south, respectively (Figure 1). The vegetation is Sudan savannah characterised by grasses and scattered trees. As in other savannah zone in Upper East Region, fire has been used as an integrate part of the vegetation management and it contributes to expose bare soil to erosion [21]. The districts have a total population of (423,204 from GSS, 2019) and 62% are engaged in agriculture which is mainly for subsistence crop production. Bawku Municipality is the trading centre of the Upper East Region. The area experiences unimodal rainfall pattern with a short rainy season spanning May/June to September/October and a long dry season from November to April [21]. The mean rainfall varies between 25°C and 40°C [22]. From January to March, the Harmattan wind blows across the study site. The topography is characterized by gentle slope which can be described as a rolling land with isolated upland and slope ranging from 1 to 10% [21]. The soil is mainly "upland soil" developed from granite rocks. Soils are non-fertile due to the lack of organic matter. The area is drained by the White Volta river. The study area is characterized by the greatest population growth in the Upper East Region [21].

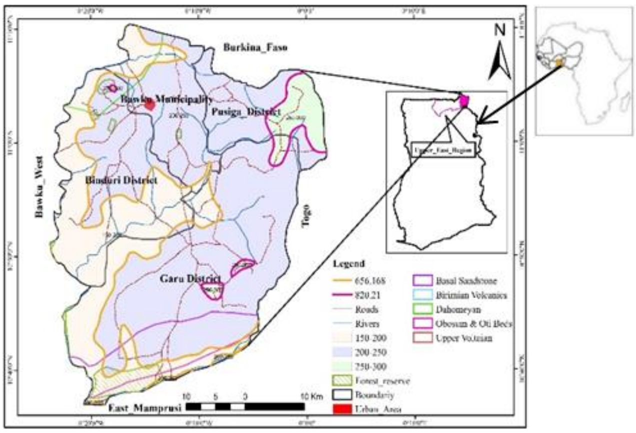

Figure 1: Location of the study area in Sudan savannah ecological zone of Ghana

2.2. Classification of land use types

To assess the extent of degradation of different types of land use and for different district, Landsat images were classified into three land use classes namely forest land, cropland and rangeland. The Random Forest (RF) algorithm was applied in "R" software (open source) to generate the land use maps. however, to generate a classification in RF, the number of trees and the number of variables are required [23]. In addition, to reduce error and the correlation between trees, the number of trees should be more than the number of split variables [23,24]. Thus, based on the knowledge of the study area, Landsat spectral bands and Google Earth images, training data were obtained by assigning pixels to the land use classes. Based on these training data, about two hundred trees were built for each RF and the number of variables used for splitting were set using the square root of total variables. Indicators such as Kappa statistics, overall accuracy, producer and user accuracy were calculated. Post classification comparison was applied to detect the change from one land use to another. The changes were estimated from 1986 to 1999, 1999 to 2006 and 2006 to 2016.

2.3. Sampling design and data collection

Systematic sampling method were employed to assess the diversity of tree species under different land use types. This sampling technique targeted three land use types (forest land, cropland and rangeland) in the four study sites (Bawku, Binduri, Garu and Pusiga). The forest land was a designated forest reserve which is a portion of state lands where commercial harvesting of wood products is excluded in order to capture elements of biodiversity that can be missing from sustainably harvested sites. Logging is not allowed in the forest reserves. On the other hand, cropland was a land use type specially used for agriculture purposes in the raising of crops or livestock while rangeland was an open area of land that is used for hunting or raising grasses, which is grazed by domestic or wild herbivores. The ecosystem under these two latter land-use types are more exposed to human pressure than the forest reserves where is restricted access to its resources. Five transect lines of 5 km long were aligned at an interval of 500 m from each other in each study site. For each site, a rectangular quadrat of 3600 m2 (60 m x 60 m) was laid out along transect in each land use type (forest reserve, cropland and rangeland) using compass and measuring tape (Figure 2). A total of 64 plots (16 plots per land use type) were set up for the tree species abundance and diversity assessment. All standing trees species (dbh > 10cm) encountered in the main plots (20 m x 20 m) and shrubs (girth ≥ 5cm & < 10) within the nested plots (10 m x 10 m) were enumerated and recorded in their local names and later converted into scientific names with the help of an expert in botany. Moreover, the diameter at breast height (1.30 m above the ground) of each tree species was measured with diameter tape and recorded whiles the girth (diameter at 40 cm above ground) of shrubs was measured using callipers. The heights of both trees and shrubs were measured using the hypsometer.

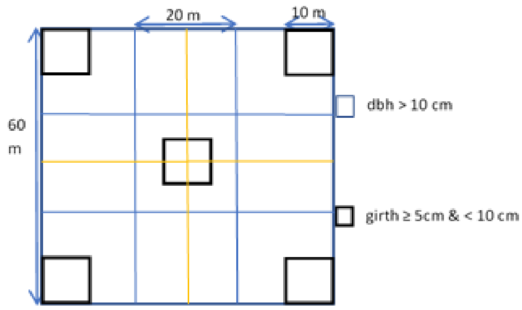

Figure 2: Plot layout along transects within the land use types

2.4. Data analysis

Data collected were analyzed to calculate the species richness index, alpha diversity indices (Shannon-Weiner index, Pielou index, Simpson's diversity index) and similarity index across the different land use types using software Estimate. The species richness is the number of different species present in an area and the species richness index is giving by:

$$\boldsymbol{S} = \sum \boldsymbol{n}$$

Where S is species richness and n is the number of individual species in a community [25]. The species diversity index (H') was determined by using the method given by [26] as cited by [27] :

$$\boldsymbol{H'} = -\sum_{i}^{s} \boldsymbol{p_i}^{\boldsymbol{lnp_i}}$$

Where, H' = Shannon Weiner diversity index, Pi is the proportion of individuals int the i species i.e. (ni/N); ni = importance value index of the species, and N = importance value index of the species. The value of Shannon Weiner diversity index usually ranges between 1.5 and 3.5, although, in exceptional cases, the value exceeds 4.5 [28]. The larger the H' value, the higher the diversity. The evenness index (E) was calculated following [29].

$$A = {}^{H'}/_{lnS}$$

Where, E is Pielou's evenness index, H' is Shannon Weiner diversity index and S is total number of species. The importance of this index may be explained by the fact that it estimated the homogenous distribution of tree species on land use types. Its value ranges between0 and 1 and 1 is the most even [27]. To estimate the most abundant species, the Simpson's diversity (D) was used. The Simpson's diversity index is divided from a probability theory and it is the probability of picking two different species at random [30]. Simpson's diversity is calculated by using the following equation as:

$$D = 1 - \sum P_i^2$$

Where D is Simpson's diversity index and Pi is the proportion of individuals founds in the species. The importance of this index is that it gives relatively little weight to the rare species and more weight to the most abundant species. Its value ranges from 0 to 1, where 1 represents complete diversity whereas 0 represents a low diversity [31]. The Sorensen coefficient of similarity index was used to calculate the species similarities between the different land use types in different sites. The importance of this index is that it measures the degree to which the species compositions of different systems are alike. Furthermore, it gives more weight to the species that are common to the sample rather than to those that only occur in either sample [30]. The Sorensen coefficient of similarity index (SS) is defined by:

$$S_s = \frac{2a}{2a + b + c}$$

Where, SS is Sorensen similarity coefficient, a is number of species common of both samples, b is number of species distinctive in sample 1, and c is number of species distinctive in sample 2. To obtain the size class distribution of tree species the diameters of all species enumerated were used to construct diameter size classes of 10 cm interval for the different land use types, using SPSS (Version 24.0).

3. Results

3.1. Land use dynamics in the four Districts

The land use change statistics illustrated in Figure 3 (a), (b), (c) and (d) showed an important trade-off between forest and cropland. In general, in the four study districts, there was a decrease in forest and rangeland areas, whereas an increase in cropland areas was observed. For instance, in Bawku, forest areas decreased from 21.94% in 1986 to 20.09% (1999), 18.01% (2006) and 15.24% in 2016. In Binduri, the forested area reduced from 5.06% in 1986 to 4.40%, 4.06% and 3.56% in 1999, 2006 and 2016, respectively. In Garu, the reduction of forest land was in the order 16.80% in 1986, 16.13% in 1999, 14.38% in 2006, and 13.70% in 2016. Similarly, in Pusiga, the forest showed a marked reduction from 1986 (15.32%), through 1999 (14.26%) and 2006 (13.26%) to 2016 (12.10%). Inversely, areas under cropland increased substantially in the entire study area. For Bawku Municipality, cropland increased by 37.19% in 1986, 43.26% (1999), 48.07% (2006) and 50.74% in

2016. In the Binduri District, the area of cropland expansion rose from 44.01% in 1986 to 46.02%, 47.09% and 48.42% in 1999, 2006 and 2016, respectively. For Garu District, cropland areas increased from 22.05% in 1986, 23.83%, 25.08 and 26.69% in 1999, 2006 and 2016, respectively.

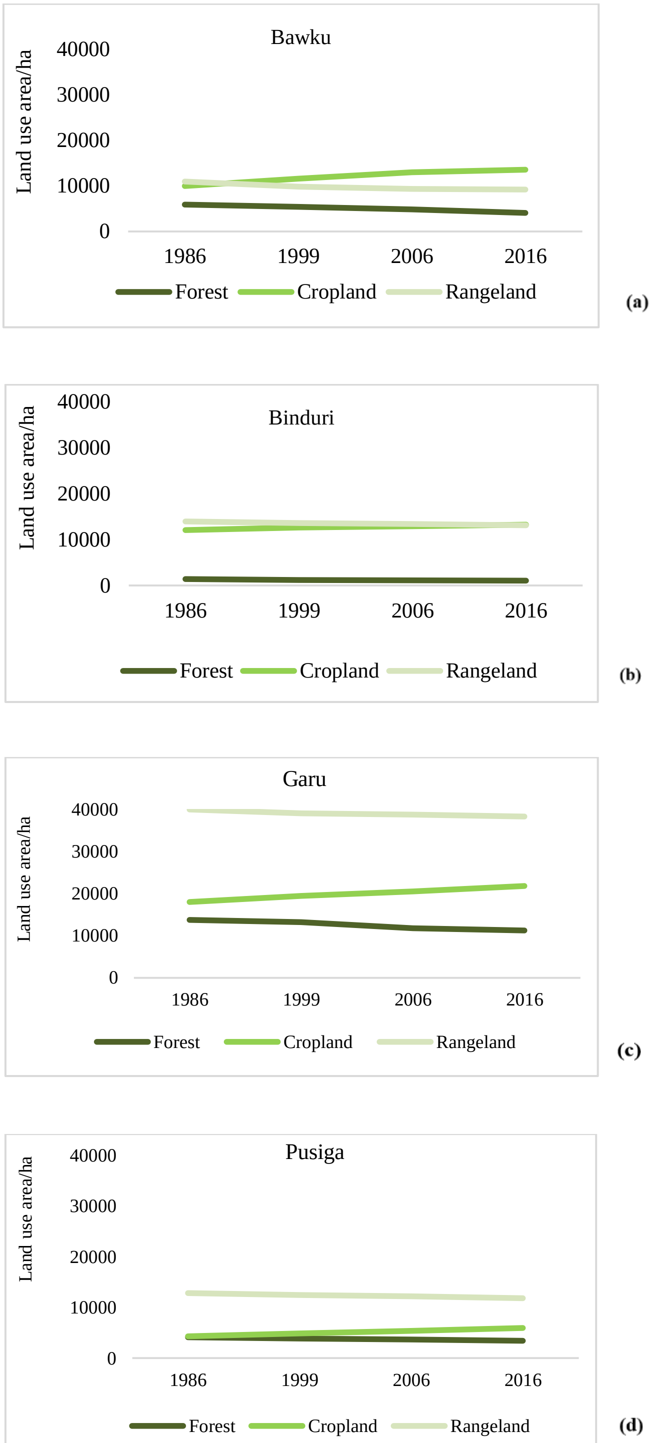

Figure 3: Land use change in Bawku (a), Binduri (b), Garu (c) and Pusiga (d) districts from 1986 to 2016

In Pusiga, the cropland increased from 21.39% in 1986 to 24.11% in 1999, 26.56% in 2006 and 29.37% in 2016. The land use classification accuracy indicators such as, Kappa statistics, overall accuracy, producer and user accuracy were determined and outcome shown as follows.

3.2. Tree species abundance in different land use types and sites

The trees species decreased with an increasing level of habitat disturbance. In Bawku, a total of 212 tree species were recorded in forest land (FL); 53 in cropland (CL) and 31 in range land (RL) belonging to 16, 11 and 6 families respectively (Table 1). The most two abundance species found in FL were Diospyros mespiliformis and Azadirachta indica whiles families Ebenaceae (102; 48%), and Meliaceae (39; 18%) were the most abundant species observed in FL. In CL, Azadirachta indica and Vitellaria paradoxa were the most abundant tree species with Meliaceae (20; 37%) and Sapotaceae (7; 13%) being the two most abundant families encountered in CL in Bawku. The last land use type (RL) in Bawku was dominated by Vitellaria paradoxa and Diospyros mespiliformis with the following families: Sapotaceae (22; 70%) and Ebenaceae (6; 19%) being the most dominant families recorded. In Binduri, a total of 185 (FL), 42 (CL) and 108 (RL) tree species belonging to 12, 12 and 9 families respectively (Table 1) were recorded. The species Anogeissus leiocarpus and Eucalyptus tereticornis were the most two dominant tree species in FL whiles Combretaceae (103; 56%) and Fabaceae (23; 12%) were the most dominant families. In CL Vitellaria paradoxa and Terminalia macroptera were the most common tree species with Sapotaceae (20; 48%) and Combretaceae (5; 12%) being the two most abundant families. The tree species Combretum mole and Diospyros mespiliformis dominated the RL whiles Combretaceae (41; 38%) and Fabaceae (17; 16%) were the most commonly recorded families in RL in Binduri. In Garu were recorded 140 tree species in FL, 23 tree species in CL and 131 tree species in RL belonging to 6, 4 and 8 families respectively. In the FL of the same site, Anogeissus leiocarpus and Vitellaria paradoxa were the most common tree species whereas the most common families were Combretaceae (107; 76%) and Sapotaceae (23; 16%). In the CL, the dominant tree species were Vitellaria paradoxa and Eucalyptus tereticornis whereas Sapotaceae (10; 43%) and Myrtceae (9; 39%) were the largest families. Vitellaria paradoxa and parkia biglobosa and Sapotaceae (110; 84%) and Mimosaceae (6, 5%) were the most common tree species and families in the RL in Garu. In the last site (Pusiga), 159 tree species were recorded in FL, two (2) in CL and only one tree species was recorded in RL. The species in FL belong 6 families whiles the two and 1 tree species found in CL and RL belong 2 families and 1 family respectively. The FL was dominated by Mitragyna inermis and Anogeissus leiocarpus whiles Combretaceae (106; 67%) and Rubiaceae (30; 20%) were the most common families. The CL was dominated by Mangifera indica and Ficus capensis with the Anacardiaceae (1; 50%) and Moraceae (1, 50%) families being the most abundant families. The RL of Pusiga was very poor in species. It recorded only one species Faiderbia albida with belong to the Mimosaceae family (Table 1).

Table 1: Tree species within different land use types and sites in Ghana

Sites	Family	Species name	Overall number of species of individual in different land use types		
			Forest reserve	Cropland	Rangeland
Bawku	Meliaceae	Azadirachta indica	23	20	4
	Casuarinaceae	Casuarina equistefolia	1	0	0
	Bombacaceae	Ceiba pentandra	8	0	0
	Combretaceae	Combretum molle	8	0	0

	Ebenaceae	Diospyros mespiliformis	102	0	6
	Myrtaceae	Eucaliptus tereticornis	16	0	0
	Meliaceae	Khaya senegalensis	11	0	0
	Rhamnaceae	Ziziphus maritiania	11	0	0
	Fabaceae	Piliostigma thonningii	8	0	0
	Mimosaceae	Acacia dudgeoni	1	1	0
	Combretaceae	Anogeissus leiocarpus	14	0	0
	Malvaceae	Sterculia birrea	2	0	0
	Combretaceae	Terminalia albida	13	0	0
	Fabaceae	Acacia auriculiformis	65	0	0
	Fabaceae	Daniella oliveri	4	0	0
	Fabaceae	Gliricidia sepium	10	0	0
	Fabaceae	Senna siamea	22	0	0
	Fabaceae	Parkia biglobosa	4	1	0
	Bignoniaceae	Steresospermus kunthianum	0	1	0
	Anacardiaceae	Anacardium occidentale	0	6	0
	Verbenaceae	Vitex doniana	0	1	0
	Sapotaceae	Vitellaria paradoxa	0	7	22
	Asteraceae	Sclerocarpus erinaceus	0	1	0
	Bombacaceae	Andansonia digitata	0	1	0
	Myrtaceae	Eucalyptus camaldulensis	0	5	0
	Combretaceae	Terminalia avicennioides	0	5	0
	Anacardiaceae	Sclerocarya birrea	0	0	1
	Combretacea	Combretum glutinosum	0	0	1
	Sterculiaceae	Sterculia setigera	0	0	1
	Fabaceae	Acacia seyal	3	0	11
	Fabaceae	Afzelia africana	8	0	0
	Annonaceae		1	0	0
	Combretaceae	Annona senegalensis	16	0	20
	Combretaceae	Combretum molle	5	0	2
	Fabaceae	Detarium microcarpum	3	0	0
	Salicaceae	Oncabo spinoza	1	0	0
	Fabaceae	Prosopis africana	2	0	0
	Fabaceae	Pterocarpus erinaceus	1	0	0
	Apocynaceae	Strophanthus hispidus	1	0	0
	Loganiaceae	Strychnos spinoza	4	0	0
	Combretaceae	Terminalia avicennioides	10	0	0
	Combretaceae	Terminalia macroptera	1	5	0
	Sapotaceae	Vitellaria paradoxa	7	20	11
	Combretaceae	Combretum glutinosum	6	0	0
	Fabaceae	Erythrina senegalensis	3	0	0
	Anacardiaceae	Lannea acida	9	0	6
	Malvaceae	Sterculia setigera	2	0	0
Binduri	Myrtaceae	Eucalyptus	4	0	0

		camaldulensi			
	Myrtaceae	Eucalptus tereticornis	17	0	0
	Fabaceae	Senna siamea	1	0	0
	Fabaceae	Acacia sieberiana	2	0	3
	Combretaceae	Nogeissus leiocarpus	65	0	7
	Zygophyllaceae	Balanites aegyptiaca	5	0	3
	Ebenaceae	Diospyros mespiliformis	8	0	12
	Mimosaceae	Acacia dudgeoni	0	3	0
	Meliaceae	Azadirachta indica	0	1	0
	Sterculiaceae	Sterculia birrea	0	5	0
	Fabaceae	Faidherbia albida	0	1	0
	Bignoniaceae	Stereospermum	0	1	0
	Verbenaceae	Tectona grandis	0	1	0
	Bombacaceae	Adansonia digitata	0	1	0
	Anacadiceae	Mangifera indica	0	1	0
	Moraceae	Ficus capensis	0	1	0
	Caesalpiniaceae	Piliostigma thonningii	0	2	5
	Fabaceae	Tamarindus indica	0	0	2
	Combretaceae	Terminalia glaucescens	0	0	12
	Verbenaceae	Vitex doniana	0	0	3
	Fabaceae	Senna siamea	0	0	1
	Rhamnaceae	Ziziphus mauritiana	0	0	10
Garu	Mimosaceae	Acacia dudgeoni	1	2	0
	Meliaceae	Azadirachta indica	2	2	0
	Combretaceae	Anogeissus leiocarpus	92	0	0
	Sapotaceae	Vitellaria paradoxa	23	10	110
	Combretaceae	Combretum glutinosum	1	0	0
	Combretaceae	Combretum molle	1	0	0
	Fabaceae	Detarium microcarpum	5	0	0
	Sterculiaceae	Sterculia setigera	2	0	0
	Combretaceae	Terminalia macroptera	10	0	0
	Combretaceae	Terminalia avicennioides	3	0	0
	Combretaceae	Terminalia glauscesensis	0	0	1
	Rhamnaceae	Ziziphus mauritiana	0	0	3
	Myrtaceae	Eucalyptus tereticornis	0	9	0
	Caesalpinaceae	Piliostigma thonningii	0	0	2
	Fabaceae	Acacia gourmaensis	0	0	6
	Fabaceae	Acacia seyal	0	0	1
	Anacardiaceae	Lannea acida	0	0	1
	Mimosaceae	Parkia biglobosa	0	0	6
	Moraceae	Ficus gnaphalocarpa	0	0	1
Pusiga	Combretaceae	Anogeissus leiocarpus	106	0	0
	Rubiaceae	Mitragyna intermis	30	0	0
	Verbenaceae	Tectona grandis	2	0	0
	Fabaceae	Dalbergia sissoo	3	0	0
	Fabaceae	Acacia sieberiana	2	0	0
	Zygophyllaceae	Balanites aegyptiaca	5	0	0
	Fabaceae	Acacia seyal	2	0	0

Ebenaceae	Diospyros mespiliformis	9	0	0
Mimosaceae	Faidherbia albida	0	0	4
Anacardiaceae	Mangifera indica	1	0	1
Moraceae	Ficus capensis	0	1	0
Anacardiaceae	Mangifera indica	0	1	0
Moraceae	Ficus capensis	0	1	0

3.3. Diversity of tree species under different land use types and sites

The alpha diversity indices for all land use types and sites are shown in Table 2. In Bawku, all indices indicated that the Forest land (FL) is the most diverse, followed by the cropland (CL) and the rangeland (RL) respectively. A similar trend was recorded with the evenness index, which indicated that the highest homogeneity of tree species was found in Forest land compared to the other two land use types (cropland and rangeland) in Bawku (Table 2). In Binduri and Garu sites, the Shannon diversity and Simpson's diversity indices indicated that the FL is the most diverse followed by the rangeland while the cropland showed the lowest diversity of tree species. The Evenness index also showed a similar trend for the homogeneity of tree species (Table 2). The diversities were recorded on FL (Forest Land) and CL (Cropland) in Pusiga's site were based on the results of diversity index. The value of diversity indices of the rangeland is zero, which indicated no diversity in this land use type in the site of Pusiga (Table 2).

Table 2: Alpha diversity indices for the different land use types and sites in Ghana

Sites	Land use types	Diversity indices		
		Shannon Diversity (H')	Simpson's diversity	Evenness (H'E)
Bawku	Forest reserve	2.21	0.91	0.82
	Cropland	1.97	0.83	0.79
	Rangeland	1.48	0.82	0.76
Binduri	Forest reserve	2.48	0.90	0.84
	Cropland	1.82	0.73	0.73
	Rangeland	2.45	0.86	0.77
Garu	Forest reserve	1.19	0.68	0.72
	Cropland	0.72	0.53	0.45
	Rangeland	0.90	0.56	0.52
Pusiga	Forest reserve	1.09	0.51	0.52
	Cropland	0.69	0.50	1
	Rangeland	0	0	0

3.4. Species similarity between land use types and sites

The similarity of tree species maintained in the three different land use types and sites were summarized by Sorensen's similarity index (Table 3). Based on the presence or absence of tree species in the sampled plots, the highest similarity in tree species composition was recorded between cropland in Binduri and cropland in Garu (Table 3) while the lowest tree species similarity was recorded between cropland in Bawku and rangeland in Binduri and FL in Binduri shared 50% of tree species. Similar trend (50%) was recorded between FL in Garu and RL in Bawku. The RL in Garu and RL in Binduri share 50% of tree species. In addition, there was no similarity between the cropland of Pusiga with the other land use types except the cropland of Binduri (Table 3). Most of the majority of the different land use types shared less than 30% of the species while some land use such as the rangeland in Pusiga did not share any species

Table 3: Sorensen's similarity index (%) between different land use types in the studied sites un Ghana.

Sites	Land use type	Bawku			Binduri			Garu			Pusiga		
		FL	CL	RL	FL	CL	RL	FL	CL	RL	FL	CL	RL
Bawku	FL		20	17	14	20	30	29	9	22	15	0	0
	CL			22	16	33	7	36	40	19	0	0	0
	RL				26	11	19	50	44	13	14	0	0
Binduri	FL					11	50	40	14	18	30	0	0
	CL						7	36	53	19	20	29	0
	RL							24	11	50	43	0	0
Garu	FL								31	11	11	0	0
	CL									17	0	0	0
	RL										12	0	0
Pusiga	FL											0	0
	CL												0
	RL												

FL: forest reserve, CL: cropland, RL: rangeland

3.5. Tree species structure in different land use types and sites

Figure 4 shows the size distribution of tree species in the different land use types and sites. This (Figure 4) showed that there was unequal distribution of tree species in the different land use types and sites. The difference of shape from different land use types and sites is in general a sign of gradual increase in tree species with small diameter classes (0 – 10, 10 – 20 cm). indeed, species richness of tree species with large size classes of diameter (20 – 30; 30 – 40; 40 – 50; 50 – 60; 60 – 70; 70 – 80; 80 – 90 and > 90 cm) was quiet low in the different land use types and sites. Then, we considered as regeneration all individual dbh ranges between 0 to 20 cm. in addition, individual with dbh < 10 cm were considered as potential regeneration. However, within the different land use types, there were more species in the lower diameter classes (0 to 20 cm) than the higher diameter classes (>20 cm) suggesting successful regeneration. The species identified in Forest land for each site was more represented compared (Figure 4) to the other land use types in the same area. The large size of diameter classes especially from 80 – 90 and > 90 cm were less represented across site, except the site of Pusiga which was not recorded individual's tree for the mentioned diameter classes (Figure 3 d).

3.6. Tree density and species richness within the different land use types and sites

Tree density and species richness are shown in (Table 4). In the study area, the tree density per hectare (ha) varied according to land use types and sites. The forest land in the four sites (Bawku, Binduri, Garu and Pusiga) has the highest tree density per ha in comparison with other land use types (cropland and rangeland). In the sites of Binduri and Garu, the cropland recorded the lowest tree density/ha compared to the rangeland in the same site. Similar trend of the tree density per hectare in RL was recorded for the species richness in the four sites.

Table 4: Characteristics of the tree species within the different land use types in Ghana

Sites	Land use types	Tree density/ha	Species Richness (S)
Bawku	Forest reserve	218±21.52	18
	Cropland	36±4.00	12
	Rangeland	24±4.14	6
Binduri	Forest reserve	128±11.00	25
	Cropland	29±3.31	12
	Rangeland	75±5.00	15
Garu	Forest reserve	194±20.72	10
	Cropland	19±3.50	3
	Rangeland	90±24.42	9
Pusiga	Forest reserve	220±31.57	8
	Cropland	2±0.41	2
	Rangeland	4±1.21	1

4. Discussion

The main results from this study indicated that cropland expanded contrary to other land use classes between 1986 to 2016. Meanwhile, considerable area decreased in forested area. Such observation could be explained through the increase of land demand due to population growth and loss of soil organic matter. These explanatory factors have been mentioned by several studies [32–35] as the most important causes of cropland area expansion. Moreover, as indicated by [15], local population depend on the forest resources for firewood, building material, livestock as well as income generation which aggravated deforestation and forest degradation. Similar observation was made in the Lake Bosomtwe Basin of Ghana from 1986 to 2008, where the overall annual lost occurred in forest was 7782.62 ha [36]. In terms of cropland expansion similar results were found in Wa municipality in the Upper West Region [37] and in the Lake Bosomtwe Basin of Ghana where, cropland areas increased was 16224 ha [36]. Within the different land use types, there were more species in the lower diameter class (0 – 20 cm) than the higher diameter classes (>20 cm) suggesting successful regeneration. Similarly, results were reported by [38] in the Sudan Savannah of Ghana. The higher tree species richness as well as the tree density was found in FL compared to the other land use types (CL and RL) this was largely due to the high restrictions of human access to the forest reserves while the other both land use types are exposed to human pressure. In addition, the tree species richness was higher in the Biodiversity Conservation Area (forest reserve) than each of an unprotected area (FL and RL). The evidence is that all the tree species grow naturally in cropland are not reach adult stage due to the fact farmer prioritized only the edible tree species while unwanted species are removed from the FL. However, the current study tree species richness was close to those obtained in a similar study conducted in the Sudan Savannah of Ghana [38] and in a Nigerian montane forest reserve by [39]. In each site the diversity indices indicated that the Forest land (FL) is the most diverse followed by the cropland (CL) and the rangeland (RL) respectively. The present study corroborated the previous study reported by [40] in the Sudanian zone of Burkina Faso, which started that the Sudanian eco-zone, was less diversified than the protected forest. A similar trend was recorded with the evenness index, which indicated that the highest homogeneity of tree species was found in Forest land compared to the other two land use types. The highest diversity in forest explained the level of protection of that area while the lower diversity of the RL and CL explained the level of exploitation of this biodiversity for human being. Shannon diversity was zero for the rangeland in Pusiga due to the fact that all the individuals tree recorded on this land use type was the same (belong to the same species). Therefore, there is a need for conservation strategy of tree species over cropland and rangeland in each site. Our results support the initial hypothesis that, the tree diversity varied with the land use types and sites. A great dissimilarity was observed in the species composition between the different land use types and sites. Only the RL in Binduri and FL in Binduri shared 50% of tree species. Similar trend (50%) was recorded between FL in Garu and RL in Bawku. The RL in Garu and RL in Binduri share also 50% of tree species. However, most of the majority of the different land use types shared less than 30% of the species. This dissimilarity may be explained by the utilization of the land use types, which can impact the tree species conservation. For instance, the forest species are naturally grown and protected by the forest code while in the FL area, farmers are selective in the choice of species retained in their field and this contribute to decrease the tree species diversities. The RL in Pusiga did not share any species that may explained by the lower species recorded in the land use types compared to the others. Similar results were reported by [41] in North in Riparian forest in Burkina Faso. The families encountered in land use types varied between land and site. In Bawku, Ebenaceae, Meliaceae and Sapotaceae were the most abundance families registered in the three land use types. The most abundant families registered in FL were the Ebenaceae family (48%), and the Meliaceae family (18%), FL was dominated with Meliaceae (37%) and Sapotaceae whereas, the RL was dominated by the Sapotaceae (70%) and the Ebenaceae family (19%). In Binduri the most three dominated families were the Combretaceae, Fabaceae and Sapotaceae family. Combretaceae (56%) and Fabaceae (12%) were the most dominated families in FL whereas Sapotaceae (48%) and Combretaceae (12%) were the most dominated families in the FL. In return, Combretaceae (38%) and Fabaceae (16%) were the most dominated families in RL in Binduri. In Garu, the following families: Combretaceae, Sapotaceae, Mimosaceae and Myrtaceae were the most four dominated. Combretaceae (76%) and Sapotaceae (16%) recorded the higher value in FL whereas the most dominated families in the FL were Sapotaceae (43%) and Myrtaceae (39%). Sapotaceae (84%) and Mimosaceae (5%) were the dominated families tree species in RL in Garu. The common family abundant found in the three sites and land use types were the Sapotaceae families. This may explain by the fact that the species of vitellaria paradoxa belong to the Sapotaceae is protected by the forest code and also due to the ecosystem services provided by this species it is save even in case of clearing a new field. Combretaceae, Rubiaceae, Anacardiaceae, Moraceae and Mimosaceae were the most dominated families in Pusiga. The Combretaceae (67%) and Rubiaceae (20%) was the most recorded in FL whereas Anacardiaceae (50%) and Moraceae (50%) were the most in FL. The RL of Pusiga site was very poor in species as well as in families. Our results support the initial hypothesis that, the tree diversities varied with the land use types and sites and that land use changes and type of land management at the sites drive the abundance and diversity of tree species in Sudan Savannah ecological zone.

5. Conclusion and recommendations

The study showed that tree density, richness and species diversity decrease with and increasing level of habitat disturbance. However, the forest land recorded the highest value of tree density and species richness in each site compared to the other two land use types (cropland and rangeland) in the same site. The diversity indices (Shannon diversity and Simpson diversity) revealed that the forest land is more diversified compared to any other land use types in each site. Agroforestry practices should be an alternative for the re-introduction of tree species in the cropland as well as in the rangeland, which are more degraded. Sorensen's similarity index revealed that most of the different land use types shared less than 30% of the species while the rangeland in Pusiga did not share any species. The current study focused on the assessment of all tree species diversity in different land use types; however, in-depth assessment focused only on indigenous tree species diversity is required to quantify the status of native tree species in the context of climate change impacts in savannah ecological zone of Ghana.

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