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Assessment of *Vitellaria paradoxa* population under different land use types in Northern Ghana

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ABSTRACT

There is a depletion of *Vitellaria paradoxa* populations mainly due to agricultural encroachment, seasonal fires and over exploitation notwithstanding its numerous benefits. This has affected natural regeneration and altered population structure of the species. The objectives of the study were 1) to determine the density of regenerations, saplings and mature *V. paradoxa* under different land use types 2) to determine stand structure of *V. paradoxa* under various land use types and 3) to compare the population structure of saplings and mature trees. Fifteen plots each of 20*20m were established using systematic sampling in the different land use types: Cultivated fields, fallow lands and virgin lands for the measurement of tree heights, diameters and number of individuals. Fallow lands recorded higher regenerations and saplings density compared to the other land uses. Mature *V. paradoxa* was dominant in cultivated fields. Fallow lands had more stable population with better regenerations compared to cultivated fields and virgin lands. Height of regeneration in cultivated fields was significantly different ($p<0.05$) compared to the other land use types. There was no significant difference between saplings stand structure. Mature *V. paradoxa* stand structure in cultivated fields was significantly different ($p<0.05$) compared to the other land use types. This study confirms that different land use types influence the population structure of *V. paradoxa* and there is anthropic selection.

Introduction

Indigenous trees are integral components of West African farming systems and in the Northern Savanna of Ghana. A number of trees species including *Vitellaria paradoxa, Parkia biglobosa, Adansonia digitata* and *Termarindus indica* have long supported the livelihood of rural people (Yaro, 2009). These indigenous species have multiple economic, nutritional, medicinal, cultural, and ecological benefits that provide invaluable livelihood security and environmental services to local communities and the nation's economy (Sanou *et al*. 2004; Teklehaimanot, 2004). The *Vitellaria paradoxa* (Shea) produces fruit which has multiple uses; on a local level is highly nutritious and is also a valuable commodity on local, national and international markets, making it the ideal candidate to research and investment. *V. paradoxa* butter products are increasingly becoming popular globally and it is envisaged that as the demand grows there will be need for sustainable management of the species (Teklehaimanot, 2004). It is a major component of the woody flora of Sudanian regional centre of endemism, contributing immensely to local livelihoods, amelioration of micro-climate and nutrient recycling through the decaying of its leaves and fine roots (White, 1983). *V. paradoxa* is the most prevalent woody species, commonly found in 'Agro-forestry parklands (Bonkoungou *et al*. 1994) and is widely spread across the savannah in Ghana. It is adapted to a wide variety of environmental conditions and thrives in wet and dry savannas where annual rainfall amounts between 400mm-1500mm per annum (MoFA, 2011). The *V. paradoxa* grows very well on a wide range of soils, including highly degraded, arid, semi-arid and rocky soil (Dogbevi, 2007).

Land-use practices in Northern Ghana includes; agriculture, forest reserves, protected areas (sacred grooves), harvesting of trees for charcoal production, livestock ranching and *V. paradoxa* fruit collection / processing are the major activities supporting the livelihoods of local communities. Farmers practice subsistence agriculture which is characterized by two land use practices namely continuous cultivation with annual crops such as sorghum (*Sorghum bicolor*), Millet (*Eleusine coracana*), Cowpea (*Vigna unguiculata*), Maize (*Zea mays*), Ground nuts (*Arachis hypogaea*) and agro-forestry (Okullo, 2004). Trees are deliberately associated with the agricultural environment because of specific uses such as soil stabilization and water conservation (Kessler and Breman, 1991). In each land use, *V. paradoxa* and other trees of economic importance are retained by farmers. The duration of the fallow period is based on size of land and household needs. Fallow periods of 1-5 and 5-15 years are common to farmers in villages of Northern Ghana, depending on how much land they possess, the needs of their household and the way they manage the lands. Short fallows are common in areas with high human population densities while long fallows in areas that are sparsely populated.

Human pressures including cutting of trees for fire wood, burning of the savanna vegetation, clearing forest for agriculture, and drought are the main threats to the species (Lovett and Haq, 2000) which have resulted in tree mortality and decreased regeneration (Gijsbers *et al.* 1994). Regeneration

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is hampered in agricultural areas, especially where cultivation is mechanized and the annual bush burning is equally destructive to shea juveniles. Strong winds at the beginning of the rainy season in March and April can destroy flowers and even topple trees, especially when root systems have been weakened by successive droughts. If climate change results in reduced rainfall, the destructive impact of strong winds may worsen in the future (Lovett and Haq, 2000). High temperature and smoke reduce bees' activity and periods of hot weather and late bush fires in March and April are blamed for reducing pollination and consequently affecting fruit production (Millogo, 1989). A plant parasite of the genus *Tapinanthus* (African mistletoe) is a major cause of tree mortality (Hall *et al.* 1996). In general, the parasite reduces the growth of the distal ends of the branches, affects wood quality and increases susceptibility to attack by pathogens. Infestation is also reported to affect fruit production. *Pestalotia heterospora* and *Fusicladium butryospermi* are microorganisms causing leaf-mosaic disease (Orwa *et al*. 2009). Bushfire also pose serious threats to the environment, most especially the juveniles of the species (Dwumfour, 1994).

Despite, the numerous economic, social and environmental benefits derived from *V. paradoxa*, there is rapid depletion of the resource which has affected natural regeneration and altered the population structure. Additionally, natural regeneration has declined as coppicing and pollarding have limited their ability to produce epicormic shoots that usually sustain the wild population. Hence, there are reports of the declining population of the species (Teklehaimanot, 2000; IUCN, 2012). In order to sustain *V. paradoxa* stands in the savanna woodland, there is the need to understand the stand structure and natural regeneration of the species under the different land use types such as cultivated fields, fallow lands and virgin lands.

Earlier studies compared *V. paradoxa* populations on cultivated land and fallow land previously disturbed by anthropogenic activities, as opposed to 'wild' populations in completely unmanaged areas (Boffa, 1995; Schreckenberg, 1996; Osei-Amaning, 1996). The lack of small diameter trees has also been given as evidence for the degradation of West African parklands (Gijsbers *et al.*, 1993). Lovett and Hag (2000) compared *V. Paradoxa* populations on sites with different intensities of landuse and concluded *Vitellaria* populations in farmed parklands being a direct result of anthropic selection following many centuries of traditional cultivation and fallow. Djossa *et al*. (2008) reported *V. paradoxa* trees as well preserved in Parklands where traditional farming activities foster the growth of young *V. paradoxa* trees and a random distribution pattern occurred for adult and juvenile trees with no association of juveniles to adults. Byakagaba *et al.* (2011) assessed the population structure and regeneration status of *V. paradoxa* under different management regimes concluding that land use management regimes influenced the population structure and regeneration status of *V. paradoxa* in East Africa. The main objective of this study was to estimate the population structure of *V. paradoxa* under different land use regimes in Northern Ghana. The specific objectives were; (1) to estimate density of regenerations, saplings and mature *V. paradoxa* under different land uses. (2) To determines stand structure of regenerations, saplings and mature *V. paradoxa* under different land uses. (3) To compare stand structure of saplings and mature *V. paradoxa* under different land uses.

Materials and Methods

Study area

The study was carried out in three communities namely Wambong, Aduyili and Toroyili in the Tolon District. Tolon District lies between latitude 9^0 15′ north and 10^0 02′ south and longitude 0^0 53′ east and 1^0 25′ west. The district shares boundaries to the north with West Mamprusi, West Gonja to the West and Central Gonja to the south whilst Tamale Metropolitan and Nanton districts share the eastern boundaries with it. The land is generally undulating with a number of scattered depressions with no marked high elevation. The district is drained by a number of rivers and streams; most prominent being the White Volta which almost divides the district into two equal halves. The rainfall begins in May and ends in the latter part of October. July to September is the peak period of the rainy season. The district experiences flood during rainy season, however the rest of the year is dry. Rainfall is unimodal, with an average annual rainfall of 1000mm. The vegetation cover is basically Guinea Savanna interspersed with short drought resistant trees and grasses. The soil is generally of sandy loam type except in the low lands where alluvial deposits are found. Major tree species include *V. paradoxa*, *Parkia biglobosa*, mango which are economic trees and form an integral part of livelihood of the people (TDA, 2012).

A preliminary inspection or survey was carried out in the three communities (Wambong, Toroyili and Aduyili). The aim of the survey was to identify areas with the presence of fallow land, virgin lands and cultivated fields that have good *V. paradoxa* stands. Some enquiries were made purposely to gather background information on the period of fallow.

Sampling design and data collection

Sites were selected in the three communities based on presence of uncultivated field and cultivated fields that have sizable area of *V. paradoxa* stands. These were the two most dominant land uses in the savanna farming system. Uncultivated fields were further categorized as virgin land and fallow land on the basis of length of fallow period. Virgin lands encompass sites which have not been tilled before, while fallow lands were 5 to 15years of no cultivation. Areas covered by annual crops or harvested formed the cultivated fields. Within each land use, 15 sampling plots of size 20m x 20m (0.6 hectare) were established using systematic sampling with distance of 10m separating plots following Chazdon *et al*.(2005).

Data on the tree survey was gathered from each of the plots laid on the different land use systems. Individuals (saplings and mature trees) of *V. paradoxa* were measured for their stem diameter and heights. Diameters of saplings and mature trees were measured at breast height (1.3 m high) using diameter tape respectively. For multi stemmed trees, the diameters of the two boles were measured individually at breast height and the average of the two diameters was taken as the diameter of the tree. Any plant from germination to basal diameter (at ground level) less than 1cm was considered as regeneration. Individuals with stem diameters at breast height (DBH)> 9cm were considered mature trees, those with DBH between 1cm and 9cm or having height above 130cm was considered as saplings. Heights of mature trees and saplings height were measured using a Hagar clinometer. Height of seedlings was measured with a graduated pole.

Data analysis

V. paradoxa density under each land use was computed as the total number of trees per area in each size class including; regeneration (seedlings and coppices), saplings and mature trees

(Djossa *et al*. 2008*).* Density was calculated by the ratio of total number of individual *V. paradoxa* recorded per the sampled area.

$$\text{Density} = \frac{\text{Total number of trees}}{\text{Total area sampled}}$$

The diameter at breast height, size classes were grouped as 1- 2, 3-4, 5-6, 7-8, 9-10, 11-12, 13-15, 16-17, 18-19, 20-21, 21-22, 23-24, 36-39, 40-43, 44-47, 48-51,52-55, 56-59 cm this balances the samples across size classes, because the number of individuals generally declines with size (Condit *et al*. 1998*).* The average number of individuals (Ni) was used as an estimate for the class midpoint. Regression was calculated with class midpoint as the independent variable and average number of individuals in that class (Ni) as the dependent variable. Slopes of these regressions were henceforth simply referred to as Size Class Distribution slopes. The slope of the regression was used as indicator of the stand structure under each land use type (Obiri *et al.* 2002*).* Graphs of regression were plotted for individuals of regenerations, saplings and mature trees and their heights and diameters. The interpretation was made based on the slope of equations, where negative slope indicated good regeneration since there were more individuals in the small classes compared to the large classes and positive slope indicated poor regeneration with more trees found in larger classes than in smaller size classes of mature trees (Obiri *et al*., 2002*).* Also steepness was used to describe the regeneration status as the higher negative slope (steep slope) value indicated better regeneration than shallow negative slope (Lykke, 1998; Venter and Witkowski, 2010*).* Skewness of height and diameter classes' distribution were determined. The symmetry of the dbh and height distribution was used as a synthetic measure of the stand structure. A negative skewness value (if skew value < 0 severe left skewness) indicate a reverse J-shaped curve that is more individuals in the smaller height and diameter ranges. A positive skewness (if skew value > 0 severe right skewness) indicates a structure with more individuals in the large height and diameter class as compared to the smaller individuals. A skew value equal zero indicate normal distribution. Student's t-test in Genstat ($p< 0.05$) was used to determine whether land management regimes influenced the stand structure of regenerations, saplings and mature *V. paradoxa* under the different land use types. Results were shown in tables and graphs.

Result and Discussions

Densities of *V. paradoxa* in the land use types

A total number of 45 plots representing 1.8 hectares were laid, of which 15 plots were allocated to each land use type. The estimated total density of regeneration in the 1.8 hectares was 8,837 seedlings ha^{-1}. The fallow lands recorded the highest number of regenerations among the other land use types with a percentage of 55% as compared to 43% of the virgin lands and 2% to cultivated fields in the survey (Table 1). The estimated overall density of saplings in the 1.8 hectares was 455 saplings ha^{-1}. Generally the saplings density was low across the different land use types. Out of the total, cultivated fields recorded the lowest individuals of saplings as compared with the virgin lands and the fallow lands. The density of mature trees estimated in the land use types was calculated to be 475ha^{-1}. Mature trees density was relatively high under the different land management regimes. However considering all the land use types, cultivated fields recorded the highest density whereas the lowest density occurred in fallow lands.

The study revealed high regeneration in fallow lands as compared to the virgin lands and cultivated fields. This study agrees with findings by Djossa *et al*. (2008) and Byakagaba *et al*. (2011) where regeneration density of *V. paradoxa* in the cultivated fields was low compared to other land use types. The low density may be attributed to intense agriculture activities with the adoption of modern technology including ploughing fields with tractors, excessive application of agro-chemicals and rapid population increases (IUCN, 2012*).* The expansion of areas under agriculture coupled with a reduction in the fallow cycle is a more probable cause of tree cover decline (Laris and Wardell, 2006). It may also be due to excessive cultivation of land that has the effect of inhibiting seedling regeneration (Kelly *et al*., 2004). Also the excessive collection of *V. paradoxa* seeds by women from cultivated fields may account for the low density since cultivated fields are more accessible than virgin lands. Some farmers also lack knowledge of the significance of protecting regenerations of *V. paradoxa* when cultivating their fields. Seedlings density was low in the virgin lands compared to the fallow lands across the sites. This may be as a result of the dense stands of different trees and herbaceous flora cover which may impede the establishment of the regeneration of *V. paradoxa* through competition for growth resources (light, nutrient, and space) and also potentially predisposed to fire damage as a result of greater accumulation of dried flammable biomass (Dwumfour, 1994*).*

The generally low sapling density in all the land use types across the sites with the cultivated fields recording the lowest number among the other land use types is an indication that *V. paradoxa* populations risks degradation (Gijsber *et al*., 1994*).* This confirms the results of Byakayaba *et al*. (2011) who recorded similarly low sapling densities across land management regimes. However, this is contrary to studies by Lovett and Haq (2000) which stated that local people preferentially preserved significant sapling density of *V. paradoxa* in their lands as they cultivate. The savanna ecosystem is prone to frequent outbreak of wildfires which impede the establishment of regeneration into saplings in virgin land, this confirms the findings of Zida *et al*. (2007) and Peterson and Reich (2001*).* When farmers return to the fallows, they often cut the majority of *V. paradoxa* that are less than 3m in height preserving only the tallest ones (personal observations) because only those individuals could start fruit production in the near future. Although the juvenile trees are easily identified by the local population and although the socio-economic importance of this plant is known, the farmers cut some of the juvenile *V. paradoxa* trees together with other juveniles of undesired trees when cropping the vegetation cover. During the survey there was massive harvesting of fuel wood of which *V. paradoxa* saplings were in greater quantity. The villagers explain that the land is infertile and the only benefit to gain in the shorter period was the fuel wood.

The relatively high mature trees density of *V. paradoxa* under the different land management regimes across the studied communities confirms the results of Byakagaba *et al*. (2011) in Uganda. This is however contrary to result of studies done in Benin by Djossa *et al*. (2008) and Odebiyi *et al*. (2004) where the density of the mature *V. paradoxa* trees were highest in cultivated field than the other land use types. Hall *et al*. (1996) shows that, mature trees in the cultivated field produce greater quantities of fruits hence farmers tend to manage the few trees which are productive by employing some silvicultural practices like pruning to reduce shadow effect. These finding are supported by Lovett and Haq (2000) who found in the Gonja district of Northern Ghana that anthropic selection of *V. paradoxa* trees through elimination of other undesired trees as well as selecting *V. paradoxa* trees taking into account criteria such as spacing, growth, size, age, health, and productivity lead to an over representation of large trees on farmed lands in comparison to smaller trees. Augusseau *et al*. (2006) however, asserts that *V. paradoxa* are retained on farmlands as a result of traditional tenure restrictions that prevent cutting of these trees, such as by migrant farmers.

Stand parameters of *V. paradoxa*

Height of regenerating plants, saplings and mature *V. paradoxa*

A greater number of individuals were recorded in the regeneration height class range 0-29.99cm of the total across the different land use types (Fig. 1). As the height class increases the number of regenerating plants declined towards zero individuals. The height class distribution of regeneration of *V. paradoxa* under the different land use types showed negative skew values (Table 2) which depicts a reverse J-shape structure (Fig.1). As height class increases, regeneration height class in cultivated fields reduces eventually recording zero.

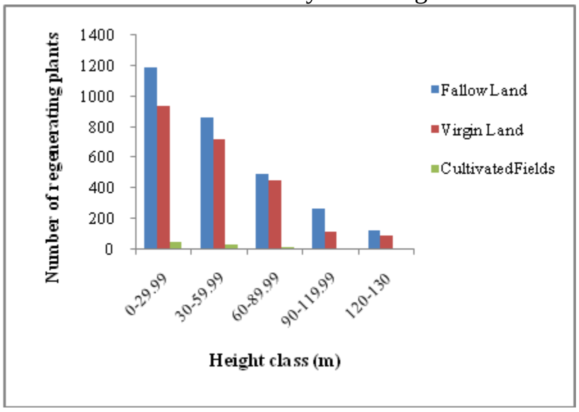

Fig 1: Regeneration in the different land use types

The survey recorded a total of 273 saplings in the 1.8 hectares, with height class ranging from 1.3-9m. The survey recorded 105 saplings in height class 1.3-2.99m across the three land use types, out of which fallow lands recorded 46.7%, 39.0% to virgin lands and 14.3% to cultivated fields. As the height class increases there is a decline in number of saplings. In the 6-9m class, a total of 94 saplings were recorded, the fallow lands recorded 46.8%, 40.4% to virgin lands and 12.8% to cultivated fields. The test for skewness of height class distribution in the three different land use types showed negative (Table 2), depicting reverse J-shape structure (Fig. 2).

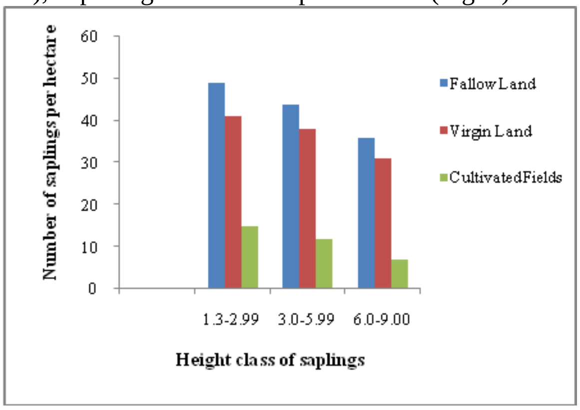

Fig 2: Height class distribution of saplings in the three land use types

Height of mature trees was relatively high in the different land use types of the study areas. A total of 285 mature trees were recorded, 38 in height class range 9.0-9.99m the lowest and 106 in height class 11-11.99m (Fig. 3) being the highest. Heights of mature trees in the cultivated fields as compared to the other land use types were far taller. Figure 3 shows a perfect J-shape across the different land use type with positive skewness (Table2).

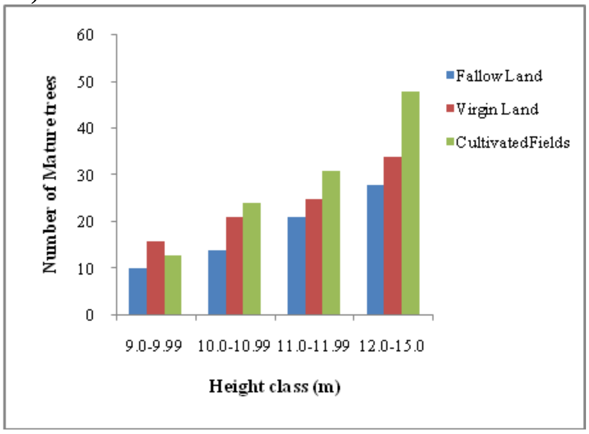

Fig 3: Height class distribution of mature *V. paradoxa* in the different land use types

Height class range 1-30cm of *V. paradoxa* regenerations under the different land use types across the study areas was more dominant in the fallow lands than the virgin lands and cultivated fields. As the height class increases, number of individuals in the height ranges decline under the land use types till the height class range 120-130cm where no individuals of *V. paradoxa* was recorded in the cultivated fields whereas lower numbers were recorded in the other land use types. This may be a result of the long period of mechanised agriculture which removes greater number of regenerations paving way for crop production hence hampering growth. The low individuals in height range 120-130cm in the virgin lands and fallow lands could also be due to wildfire, competition for growth resources with other tree species and tramping by animals which inhibit their growth. The shape of the regeneration height displayed a reverse J-shape structure indicating that more regeneration in the lower height class than the higher height class. As the height class increases there is a decline in individuals of the species across the study areas. Condit *et al.* (1998) indicated that population of species showing reverse J-shape structure in size and height class are an indication of healthy and stable stands which can maintain its population but as the slope become flat, it suggest there is no regeneration depicting unstable and degraded stands. In the case of the cultivated fields, as the slope become flat, zero regeneration occurred which could be the effect of cultivation on the species. As compared to the other land uses there were sharp decline but the slope was not too flat as occurred to the species under cultivated fields. Although some factors could have accounted for this decline in virgin lands and fallow lands but not as severe as agricultural activities couple with human population increases.

The height class distribution of *V. paradoxa* sapling across the study sites showed reverse J-shape structure which indicated that there were more individuals in the smaller height classes. The height of a tree is influenced by rapid growth, so when growth is interrupted increases in height are affected. In the case of height of saplings in the virgin land, dense canopy may suppress the growth of the light demanding species hence retards increase in height. This also increases the intensity of bushfires during the dry season. In Cultivated fields silvicultural practices like pruning and thinning are carried out by farmers as a way of reducing shadowing effect that hamper the increase in height of saplings because of interruption in translocation of photosynthates which impede growth in height. The poor state of nutrients in fallow lands does not allow rapid growth of the species therefore increase in height is negatively interrupted. This may account for more individuals in the shorter height ranges and since fallow lands were once cultivated; only the few regenerations will go on to become saplings.

Mature *V. paradoxa* in the cultivated fields recorded the maximum height as compared to the other land use types; whereas the virgin lands recorded the minimum height. The height in the cultivated fields could be the result of less intra and inter specific competition hence the trees get greater access to growth resources as a result of increase in growth which influence height of the species. The virgin lands and the fallow lands recorded lower heights probably because of high level of competition for light and nutrient between *V. paradoxa* and other tree species. Virgin lands probably also recorded lower heights as a result of poor soils since the pressure on land for agricultural purposes results in only infertile lands left uncultivated. The cultivated fields having taller trees than the fallow lands may just be a coincidence since the fallow lands were once farmlands and could have benefitted from all the advantages of cultivated fields. The height distribution across the study areas in the different land use types showed a perfectly J-shaped structure which indicated that there were more individual in the higher height class.

Diameter of Saplings and mature *V. paradoxa*

Out of the total of 273 saplings recorded in the study area, 115 saplings were recorded in the diameter class 0-2.99cm representing 42.1%, 100 saplings were recorded in the 3-5.99cm diameter class which represented 36.6% and in the size class 6-9cm, 58 saplings were recorded depicting 21.3%. The results of the survey indicated distribution of uneven aged stand. A higher number of saplings at lower diameters and a sharp decrease as the diameter increase giving a reserve J- shape structure (Fig. 4). Test for diameter distribution show negative skewness (Table 3) indicating more individuals in the small diameter ranges. From the graph the highest diameter distributions of the saplings fall within 0-2.99cm diameter classes in the fallow land and the lowest diameter was recorded in the cultivated fields.

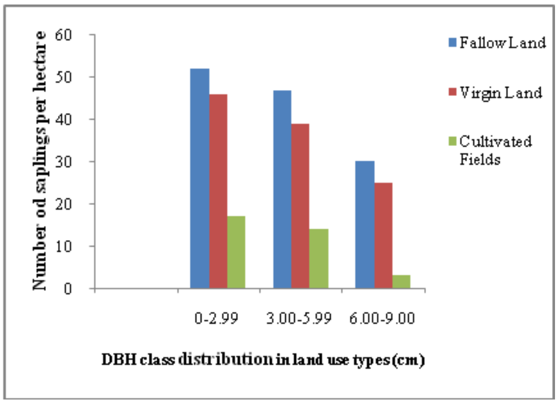

Fig 4: Size Class Distribution of sapling *V. paradoxa* in the different land use types

A total of 73 mature trees were recorded in the fallow land, 14 in 25-29.99cm diameter class representing 19.2% were the dominant with the least occurring at diameter class 40-45cm and above 45cm represented 8.2% and 0% respectively (Fig. 5). However, in the virgin lands the dominant diameter class was 35-39.99cm depicting 27.1%, with 0% recorded in size classes above 40cm. In the cultivated fields, the dominant size class (35-39.99cm) registered 24.1% whereas the least was recorded in size class 9-14.99cm depicting 2.6% (Fig. 5). In size class above 45cm cultivated fields recorded 10 mature trees represented by 8.62% as compared to the others with zero in size class above 45cm. The diameter class distribution of mature *V. paradoxa* in the cultivated fields showed normal distribution, positively skewed to the virgin lands and negatively to fallow lands (Table 3).

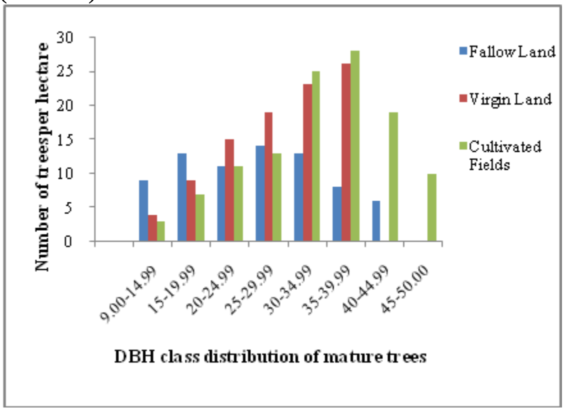

Fig 5: Size Class Distribution of mature *V. paradoxa* in the different land use types

The cultivated fields showed normal distribution (skew value 0.000) indicating equal individuals in both small and large size. The fallow lands showed a negative skewness (reverse J-shape) indicating more individual in smaller size class while the virgin land indicated positive skewness (J-shape) indicating long right tails (more individuals in large size classes).

The diameter class distribution of saplings under the different land use types showed a reverse J-shaped structure revealing negative skewness. This structure is characterized by species with abundant and constant rejuvenation. The greater numbers of saplings fall within the diameter range 1-3cm which indicates healthy and stable regeneration. Obiri *et al*. (2002) spelt out negative skewness as indicating good regeneration since there are more individuals in the smaller size classes compared to the large classes. The size class distribution slope of the cultivated field indicates good regeneration where more saplings were found in smaller size class than the larger classes. This could be attributed to the fact that there is lesser competition in cultivated fields hence regenerations get full sunlight for photosynthesis which is pivotal to growth. In the fallow lands and virgin lands growth is retarded through competition hence more individuals in smaller size classes. Kelly *et al.* (2004) stated that *V. paradoxa* saplings were more abundant in the lower size classes in fallow lands as compared to cultivated fields.

In the different land use types, mature trees were more abundant in cultivated fields compared to the fallow and virgin lands. The difference in diameter distribution in the cultivated fields compared to the virgin and fallow lands may be explained by the fact that there is less competition and benefits from cultivation activities which may increase the growth. Field observation revealed that the main selection stage occurs when lands are cleared, as most immature individuals are removed and only productive large trees are maintained on the cultivated fields.

Table 1:Densities of seedlings, saplings and mature *V. paradoxa* under different land use types

		Seedling densities (ha^{-1})	
Land use	**Number per plot**	**Number of seedling per hectare**	**Percentage (%)**
Fallow land	2914	4857	55
Virgin land	2284	3807	43
Cultivated field	104	173	2
		Sapling densities (ha^{-1})	
Fallow land	129	215	47.3
Virgin land	110	183	40.2
Cultivated field	34	57	12.5
		Densities of mature plants (ha^{-1})	
Fallow land	96	122	25.7
Virgin land	73	160	33.7
Cultivated field	116	193	40.6

Table 2: Summary of means, standard errors of mean and skewness valves of height class of *V. paradoxa* in the different land use types. Values on the right are the skew values with the means, standard errors of means in the middle

	Height					
Land use type	**Seedlings**	**Skewness**	**Saplings**	**Skewness**	**Mature Trees**	**Skewness**
Fallow land	582.8±253.8	-0.870	43±3.8,	-0.274	18.3±5.5,	-0.057
Virgin land	456.8±213,	-0.896	36.7±4.9,	-0.201	24±6.6,	0.954
Cultivated field	20.8±14.0	- 1.191	11.3±3.5,	- 0.072	29±5.8,	0.620

Table 3: Summary of means, standard errors of mean and skewness values of *V. paradoxa* under different land use types. Values on the right are the skew values with the means, standard errors of means in the middle.

DIAMETER				
Land use type	**Saplings**	**Skewness**	**Mature trees**	**Skewness**
Fallow land	43±6.7	-0.561	9.1±1.8	-0.798
Virgin land	36.7±6.6	-0.053	11.5±3.1	0.666
Cultivated field	11.3±4.3	-0.578	12±3.1	0.000

Table 4: Summary of the means and standard deviation of density of Seedlings, Saplings and mature trees under different land use types

Land use type	Seedling	Saplings	Mature trees
Fallow land	485.7± 555.7	44.0±12.3	22.4± 4.4
Virgin land	380.7± 462.7	36.3 ±10.2	16.8± 3.8
Cultivated field	17.3± 29.2	13.0±9.2	19.4± 7.0

Table 5: Comparison of stand structure of *V. paradoxa* among land use types at $p < 0.05$ significance level

	Seedlings	Saplings		Mature trees	
Land use Type	**Height**	**Diameter**	**Height**	**Diameter**	**Height**
Virgin land and Fallow land	0.058	0.571	0.796	0.607	0.191
Virgin land and Cultivated field	0.015*	0.013*	0.123	0.012*	0.021*
Fallow land and Cultivated field	0.019*	0.027*	0.117	0.014*	0.047*

(*) asterisk indicates significant difference

This confirms Lovett and Haq (2000) assertion that larger diameter trees were dominant in cultivated fields. Overtime, this has led to significant changes in *V. paradoxa* size structure as compared to those on virgin lands. A smaller proportion of mature productive trees (dbh >45cm) were present on the cultivated fields than the unmanaged savanna woodlands. Generally light-demanding tropical tree species like *V. paradoxa* possess stand structure that are positively skewed in virgin lands. This is an indication of population with relatively high proportion of larger diameter size class individuals. Wright *et al*. (2003) indicated that gap-depending tree species are usually characterized by size distribution with many large individuals and long tail with small individuals. However, size distribution with relatively small number of young individuals can also be seen as population on the decline. The negative skewness for fallow lands showed more individuals in the smaller diameter class than larger size class. Majority of individuals in the small size class in the fallow lands indicates that tree species were good enough to regenerate naturally and they were faced with no dangers of extinction (Anonymous, 2005). Annual bushfire and the thick vegetation (forbes) may hinder regeneration on virgin lands. The intensity of bushfires will be low on fallow lands encouraging regeneration but on cultivated lands, deliberate removal of regeneration is the result observed. Contrarily to the above, Niekema (2005) attributes higher number of low diameter trees to bush fire and competition for nutrients while Chokkalingam and Dejong (2001) propose this as an indication of secondary or disturbed stands.

Comparison of stand structure parameters between land-use types

The study revealed high regeneration in fallow lands as compared to the virgin lands and cultivated fields. Comparison of mean densities of the three land use types also revealed that the regeneration in fallow lands was greater with a factor of 28.08 greater than those on cultivated fields and 1.28 greater than those on virgin lands (Table 4*)*. Lowest numbers of regenerations were recorded in cultivated fields in all the study areas.

Generally *V. paradoxa* sapling density was low in all the land use types across the sites but the cultivated fields recorded the lowest number among the other land use types. The comparison of the mean densities of the saplings among the different land use types was negligible variable and there was no significant difference. The mean and standard deviation also showed variation in terms of influence of the different land use types on the species density (Table 4*)*. Saplings in cultivated fields and fallow lands were negatively affected by land use activities hence affect their existence.

Mature trees density of *V. paradoxa* was relatively high under the different land management regimes across the studied communities. Comparison of the mean densities of mature trees, showed slight differences under the different land use types. However the cultivated fields recorded the highest number of mature *V. paradoxa* as compared to the other land uses across all the studied area (Table 4).

Student t-test was used to compare the stand structure of the various land use types (Table 5). Comparison of regenerated plant height in cultivated fields and other land use types showed significant difference (p= 0.015 and 0.019) but no significant difference between virgin lands and fallow lands (p=0.058). For the sapling diameter in cultivated fields and other land uses show significant difference (p= 0.013 and 0.027) but no significant difference between virgin lands and fallow lands (p=0.571). There was no significant difference in sapling diameter in all the land use types. There was a similar trend in mature trees showing significant differences in both height and diameter comparing cultivated fields to other land uses (Table 5).

The comparison of regeneration height in cultivated fields to the other land use types showed significant difference ($p<0.05$) which illustrated influence of anthropogenic disturbance on the species in cultivated fields. No significant difference between regeneration height in fallow lands and the virgin lands portray less impact of land use on the species. However, there was no significant difference between saplings height on the various land use types, therefore may be concluded that land use types had no or less influence on saplings height.

The comparison of diameters of saplings in the cultivated fields with the other land use types showed a significant difference indicating that land use had influence on saplings size, but there was no significant difference between fallow lands and virgin lands in terms of saplings size. Also analysis showed no significant difference between heights of mature *V. paradoxa* under different land use types. Therefore it could be concluded that the land use has no or less influence on mature *V. paradoxa.* However, there was significant difference in diameter of mature *V. paradoxa* under the different land uses when diameters of mature trees were compared. This showed influence of land use on the diameter of species on different land use types. This finding confirms the research finding made by (IUCN, 2012) that population of *V. paradoxa* was under a threat as a result of different anthropogenic activities such intense agriculture activities, and excessive exploitation of the resource.

Conclusions

The study confirms land use systems influence the population structure and regeneration status of *V. paradoxa*. The research revealed that the regenerations density of the species was high in fallow lands as compared to virgin and cultivated fields. Sapling density was low under all land use types, with most saplings falling within the lower and upper diameter classes giving a reverse J-shaped graphs. Fallow lands recorded more stable population with better regeneration compared to cultivated fields and virgin lands. The study revealed a decline in individuals as the height of regeneration increases, where cultivated fields recorded zero in height range 120-130cm. The tallest of mature trees was recorded in the cultivated fields in the height class range 12-15m, with the lowest height in class range 9-9.99m recorded in fallow lands. Most mature *V. paradoxa* fall within height range of 11-15m and diameter size 25-40cm, giving a perfect J-shaped structure. The study showed that the largest diameters size (above 35cm) of mature *V. paradoxa* trees were dominant in cultivated fields as compared to the virgin and fallow lands. This study concludes that the different land use types significantly influenced the stand structure (height, diameter and density) and regeneration density of *V. paradoxa* in the surveyed communities. It is therefore recommended that traditional bye laws on conservation be reinforced and education of farmers/tractor operators on ways of protecting seedlings during land preparation for farming.

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