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RESEARCH ARTICLE

WOODY SPECIES DIVERSITY, STRUCTURE, REGENERATION AND THEIR SIGNIFICANCE TO THE INHABITANTS IN SOUTHWESTERN ETHIOPIA

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ABSTRACT

Despite the significance of woody species in terms of economic and environmental benefits in Ethiopia, there have been either fragmented, or modified or completely destroyed and changed into other land use system as a result of a long history of dense human settlements, and intense farming and grazing. The overall objective of this study is to assess the status of woody species diversity, regeneration and structure and their contribution to the inhabitant in Masha and Andracha district of Sheka zone in Southwestern Ethiopia. Systematic sampling and simple random sampling techniques were employed to conduct survey of households. Furthermore, vegetation data were collected in a total of 160 plots (20m x 20m) in four Peasant Associations (PAs) following gradient of accessibility (village to deep forest). The vegetation data analysis revealed that there were a total of 20 woody plant families were recorded in the four PAs. Where 27 species were found in sample plots in Modi PA, 29 species were found in all three PAs. The Shannon index-(H) of each PA woody vegetation were 3.0862 in Beto, 3.1373 in Abelo, 3.0662 in Chegecha and 2.9402 in modi. The density of woody species were 3681/ha in Beto, 3190/ha in Abelo, 3312/ha in Chegecha and 2886/ha in Modi. The mean comparison shows significance difference for tree size classes 50-60, 70-80 and 80-90 cm in Beto and Abelo PAs. Survey result reviled that the livelihood strategies in the study area mainly depend on woody species and their products. As a result the inhabitants in the study district retain woody species for their various uses. However, woody species with more products play important role on local livelihoods; hence conservation of woody species is essential to sustain their livelihoods.

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INTRODUCTION

Ethiopia is a country with greatly varying landscapes ranging from high and rugged mountains, flat-topped plateaus, deep gorges, and incised rivers to valleys and rolling plains. These diverse physiographic features have contributed to the formation of diverse ecosystems characterized by great species diversity (Kamara, 1993; Badege and Zebene, 2010). The biological resources richness and diversity in Ethiopia, which are manifested in its wildlife and varied ecosystems. This varying ecosystem has given rise to a botanical treasure house containing 7000 different species of higher plants, flowering plants, conifers and ferns out of which 10-12% are probably endemic (IBC, 2008; Melaku, 2009). This entire diverse flora is found in the natural forests which once covered 35% of the country's total land area (EFAP, 1994, Reusing, 1998).

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At the 1992 United Nation Conference on environment development "Earth Summit" in Rio de Janeiro, Brazil, there was an important indication on growing international concern about diversity loss, and transformation from a scientific issue to popular, political and ultimately diplomatic issues (Abimbola *et al.,* 2011). The convention has its objectives as conservation of biological diversity, the sustainable use of its component and the fair and equitable distribution of benefits arising out of the utilization of genetic resources, thus covering the ecological, economical and social aspects of biodiversity.

However, nowadays, the vegetation cover on different landscape worldwide has declined considerably for several reasons. The biodiversity hot spot areas in Ethiopia are either fragmented, or modified or completely destroyed and changed into other land use system as a result of a long history of dense human settlements, and intense farming and grazing (Demel Teketay, 1992; EFAP, 1994; Demel Teketay, 2005; Schmitt *et al*., 2007). Even, the remnants of these areas are located in the South-West and other sacred groves in a matrix of agro-

forestry system in South-Central parts of the country (EFAP, 1994), have been subjected to many management influences. For example, clearing or thinning the indigenous tree species and replacing with fast growing trees, e.g. *Eucalyptus Spp* has become common activity in many areas which intern highly contributes to reduction in the extent, structure and composition of plant biodiversity.

Though, in a much better state compared to other lands, the plant biodiversity in southern Ethiopia are declining. The land managed under the natural forest system has been shrinking down the years due to different pressures. However, the natural forest in Sheka, Southern Ethiopia and elsewhere has still managed to retain minor portions of the plants.

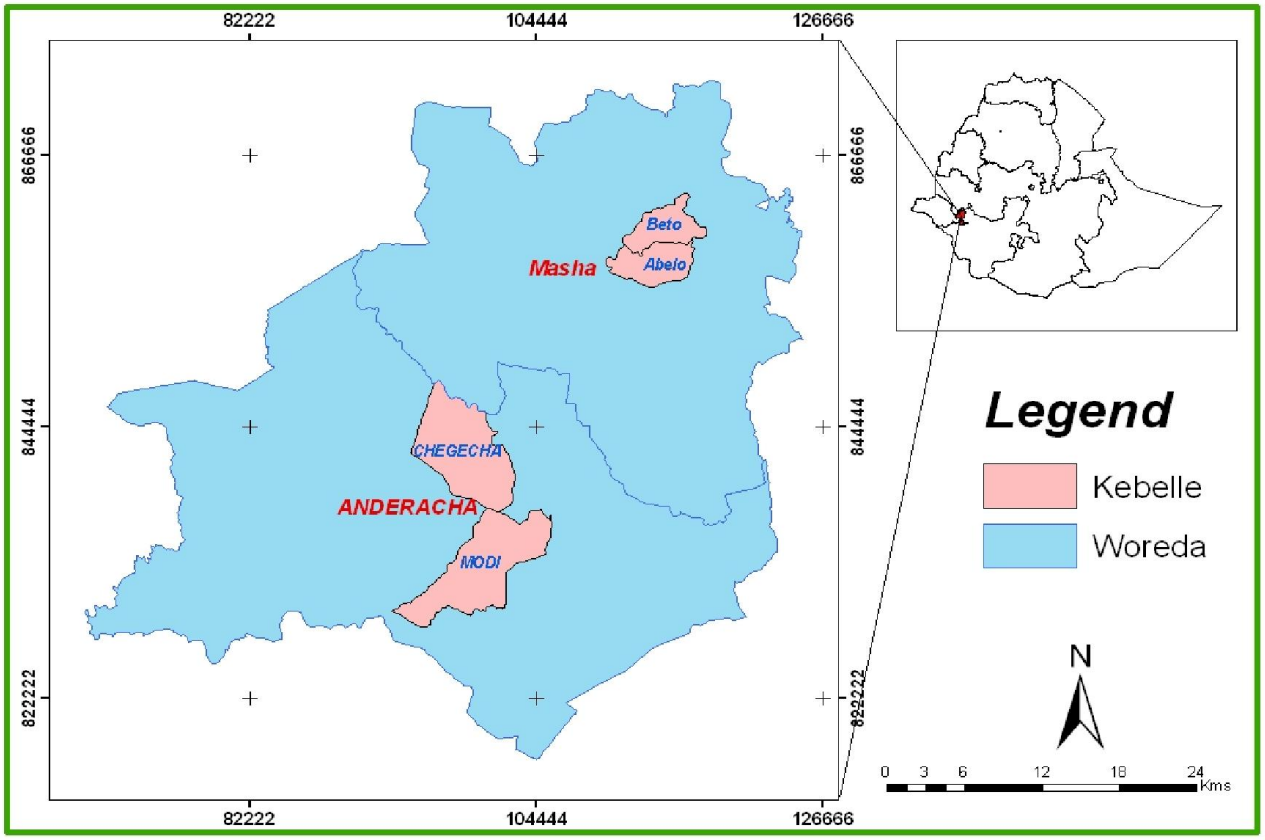
In another dimension, the conservation of plant biodiversity i.e. fauna and flora is of paramount importance for the conservation of Ethiopia's natural heritage, protection of the environment and maintenance of the resource base. Therefore, studying the woody species diversity, population structure and regeneration plays a significant role in that direction. The study would depict a general picture of the study area to assess their current condition and potential for further decision making on conservation and protection of woody species. Moreover, woody species in the study area provide a wide variety of economic products and environmental services. Thus studying diversity, population structure and regeneration of woody species and their contribution to the inhabitants is very important undertaking.

Therefore, this study is initiated to enhance our understanding about the structure, diversity, and regeneration of woody species in Masha and Andracha district of Sheka zone in Southwestern Ethiopia.The output of this study will provide information for farmers (help them to better manage in a sustainable way), for development agents (use the recommendations as a tool to improve their extension delivery), planners (to plan appropriate technology that can improve sustainability of woody plants in agricultural landscape) and researchers (provide baseline information for conducting further research).

MATERIALS AND METHODS

Description of the study area

Sheka Zone is located at about 670Km from Addis Ababa, Ethiopia. Geographically, the Zone lies between 7°24'_7°52' N latitude and 35°31'_35°35'E longitude. It has three districts, namely: Masha, Andracha, and Yeki. Sheka zone has total population of 217,921, out of which 107,410 were female and 110,511 are male. The total population of Masha and Andracha districts is 36,716 and 26,449, respectively. Masha district has 18,038 male and 18,678 female and Andracha district has 13,291 male and 13,148 female (SZARDD, 2009). The study area receives maximum monthly rainfall of 348 mm in the month of July with minimum monthly rainfall in February. The maximum and minimum temperature of the study area is 18.4□ between February and April and of 15.7□ between Jun and august.



1kebele: the lower administrative unit in Ethiopian government structure, 2Woreda: Equivalent to District

Figure 1. Map of the study area

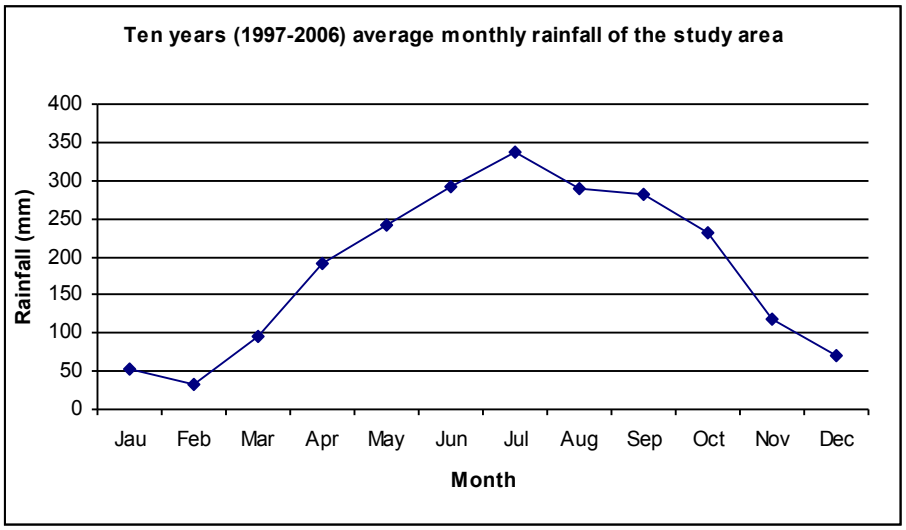


Figure 2. Ten Years (1997-2006) Average monthly Rainfall of the study Area

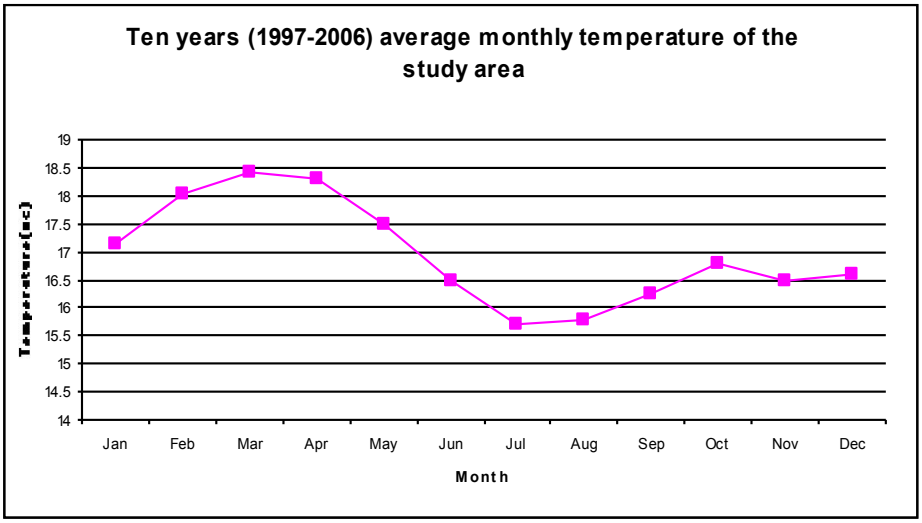


Figure 3. Ten Years (1997-2006) Average monthly Temperature of the study Area Source: NMA, 2010

With variation of altitude different forest types can be recognized in the study area. Accordingly, broad leaved Afro-mountain forest with coffee (*Coffea arabica*), broadleaved Afro-mountain forest without coffee and pure stands of highland bamboo (*Arundinaria alpina*) forests are found from lower to higher altitude. The soils of the study area differ in color from black to red. Regarding the types Nitosols, Vertisols, Fluvisol, Cambisols are the dominant soils types of the study area.

Data collection

In this research, stratified random sampling was used. Two districts, namely Masha and Andracha were selected based on the presence of woody species and inhabitants' dependency on woody species.

Using the same criteria, Beto and Abelo Peasant Associations (PAs) from Masha district, Chegecha and Modi PAs from Andracha district were selected.

Reconnaissance survey

Reconnaissance surveys (field visits of the study area) were made to get first impression on the status of woody species in the study area. Concurrently, discussions with natural resources management experts of the Masha and Andracha district Agricultural and Rural Development Office (ARDO) were held to create awareness on the objectives of the study and exchange ideas concerning woody species and their significance to the inhabitants.

Key informants interview

Key informants are defined as people who are most knowledgeable about woody species and who have been live continuously in the area for long period of time. Key informants are selected systematically with the help of local administration officers and development agents. They were interviewed to assess woody species that exist/lost in the study area.

Household survey

In each PAs 30 households were selected by using systematic sampling method. Systematic sampling involves drawing a sample by taking every K^{th} case from a list of the population. Ary *et al*. (2002) offer the following steps for conducting a systematic sample:

1. Decide how many subjects you want in the sample (*n*).
2. Divide N (the total number of members in the population) by n and determine the sampling interval (*K*) to apply to the list.
3. Select the first member randomly from the first K members of the list, and then select every K^{th} member of the population for the sample.

This was done by collecting the lists of the names of the entire households of each PAs. The total number of population in each PAs was divided by sample size (30), the quotients were used as sampling interval (K). Then the lottery method was used to have random start (the first household). Then every k^{th} household was selected from the list of households, the trend was continued until the 30^{th} household was selected.
Mathematically,

K = N/n

Where,
K= sampling interval
N= total households of the Kebele
n= sample size

Then the interview was conducted by using semi-structured questionnaire, and the interview focused on the significance of woody species for inhabitants in the study area.

Vegetation survey

In each selected four PAs woody species data were collected by laying 40 (20 m x 20 m) plots following transect lines, which were laid 300 m apart along forest. The interval between plots was 200 m. During data collection tree diameter at breast height (DBH) were measured using caliper and diameter tape. The later was used for tree diameter above 100 cm and tree heights were measured using clinometer. Individuals with DBH $\leq$ 2 cm and height $\leq$ 2 m were counted as follows: seedlings, height $\leq$ 1 m and saplings, height > 1 m and DBH $\leq$ 2 cm (Abayneh *et al.,* 2003). Saplings and seedlings were counted by laying 10mX10m plots within each plot. Altitudes, longitude and latitude were taken by GPS. Plant specimens were prepared and brought to Addis Ababa University in National Herbarium, where the identification were made by the help assistant and referring Flora of Ethiopia.

Species density was determined by counting the number of individuals in the sample plots and converting the count in to hectare.

$$\text{Density of all species} = \frac{\text{Total Number of all individuals of all species}}{\text{Sample in hectare}}$$

$$\text{Density of a species} = \frac{\text{Total Number of a species}}{\text{Sample in hectare}}$$

Data analysis

Data collected were checked, coded and encoded in a computer, which were then analyzed. The quantitative data acquired via household survey were analyzed by in Excel spread sheet and the results were presented in tables. DBH class distribution was used for analysis of vegetation structure. The purpose of using size class distributions in diameter at breast height (DBH) was to enable to investigate the regeneration status of the woody plant species (Peters, 1996). Vegetation data analysis was carried out in Excel spread sheet for density and tree size class distribution, the results were depicted in tables and bar-graphs. Shannon and Weaver (1949) index of species diversity was applied to quantify species diversity and richness. This method is one of the most widely used approaches in measuring the diversity of species. $H = -\Sigma (Pi \ln Pi)$, Where "H" is the Shannon and Weaver diversity index, "Pi" is the ratio of a species average to the total species average, "ln" the natural logarism to base e (log), $J = H/Hmax$, where "J" is the species evenness "H" Shannon and Weaver diversity index and "H max" is in S, where S is the number of species. Statistical Package for Social Sciences (SPSS) version 17 was used for mean comparison and significance test and the results were displayed by tables.

RESULTS AND DISCUSSION

Results

Woody species Composition and diversity

A total of 29 woody species categorized under 20 families were recorded in the study area (Table 1). Rubiaceae and Oleaceae family had the highest number of species (3 species each) followed by Araliaceae, Euphorbiaceae, Fabaceae and Meliaceae with 2 species each. The woody plants families recorded in the study area were similar in four PAs, but the woody plant families recorded in three PAs, namely: Beto, Abelo and Chegecha were 20 comprising 29 species. Whereas in Modi PA 18 families comprising 27 species were recorded, the two families Boraginaceae and Dracaenaceae were not recorded. In Beto, Abelo and Chegecha PAs families Oleaceae and Rubiaceae comprised (3)10.34%, where as families Araliaceae, Euphorbiaceae, Fabaceae, Meliaceae and Rutaceae comprised 2 species each 10% and the rest 13 family were represented with single species. On other hand, in Modi PA families Oleacae and Rubiaceae comprised 11.1% (3) species. Family Araliaceae, Euphorbiaceae, Fabaceae, Meliaceae and Rutaceae comprised 7.4% (2) species were recorded in Modi PA. There is no difference in composition of woody species between Beto and Abelo PAs as both have similar and equal woody plant families and species. The number of families and species of Chegecha has more than Modi, as the former has two more families and species, though the rests are identical. Both Beto and Abelo PAs had 29 identical wood species. On the other hand, the woody species in Chegecha and Modi were 29 and 27, where Chegecha has relatively higher species than Modi.

Table 1. Woody plant species in study area

No	Species Name		Family	Life form
	Local Name	Scintific Name		
1	Aemato	*Oxyanthus speciosus*	Rubiaceae	small tree
2	Boaro	*Dombeya torrida*	Sterculiaceae	tree
3	Boko	*Bersama abyssinica*	Melianthaceae	tree
4	Chato	*Albizia gummifera*	Fabaceae	tree
5	Dibo	*Rothmannia urcelliofomis*	Rubiaceae	small tree
6	Dido	*Galiniera coffeoides*	Rubiaceae	small tree
7	Ermicho	*Clausena anisata*	Rutaceae	small tree
8	Eto	*Ficus sur*	Moraceae	tree
9	Fishino	*Dracaena afromontana*	Dracaenaceae	tree
10	Karasho	*Polyscias fulva*	Araliaceae	tree
11	Keto	*Ilex mitis*	Aquifoliaceae	tree
12	Manjo	*Schefflera abyssinica*	Araliaceae	tree
13	Mergato	*Vepris dainellii*	Rutaceae	small tree
14	Omo	*Prunus africana*	Rosaceae	tree
15	Opo	*Schreberia alata*	Oleaceae	tree
16	Ororo	*Ekebergia capensis*	Meliaceae	tree
17	Shao	*Pouteria adolfifriederichi*	Sapotaceae	tree
18	Shawo	*Turraea holstii*	Meliaceae	shrub
19	Sheo	*Allophylus abyssinicus*	Sapindaceae	tree
20	Shigawo	*Chionanthus mildbraedii*	Oleaceae	tree
21	Shollo	*Pittosporum viridiflorum*	Pittosporaceae	tree
22	Shomo	*Croton macrostachyus*	Euphorbiaceae	tree
23	Wendabo	*Apodytes dimidiata*	Icacinaceae	tree
24	Werago	*Macaranga capensis*	Euphorbiaceae	tree
25	Weralo	*Cassipaurea malosana*	Rhizophoraceae	tree
26	Yago	*Millettia frruginea*	Fabaceae	tree
27	Yeho	*Olea capensis*	Oleaceae	tree
28	Yino	*Syzygium guineense*	Myrtaceae	tree
29	Yogamo	*Ehretia cymosa*	Boraginaceae	shrub

Table 2. The vegetation diversity indices of study area

Diversity indices	Masha District		Andracha District	
	Beto	Abelo	Chegecha	Modi
Shannon-(H)	3.0862	3.1373	3.0662	2.9402
Evenness (J)	0.36	0.37	0.36	0.35
Species in number	29	29	29	27

Table 3. Independent samples test for diversity of paired PAs forests

PAs	Sig	t	Df	Sig.(2-tailed)	Mean Difference	Std.Error Difference
Beto Vs Abelo	0.998	0.002	4	0.999	-0.02037	12.90009
Chegecha Vs Modi	0.851	0.057	4	0.957	0.712	12.46315

In order to get better picture on extent of woody species diversity in four PAs, several diversity indices were employed which include Shannon, Evenness and Simpson indices. The highest Shannon diversity index was recorded at Abelo followed by Beto, Chegecha and Modi (Table 2). The highest species evenness was recorded at Abelo PA. The Shannon diversity index of woody species exhibited certain variation between PAs.

The independent sample test for diversity of woody vegetations in Beto, Abelo, Chegecha and Modi PAs is shown in Table 3. Even though certain difference is observed on the calculated value of Shannon diversity indices between compared PAs, these differences were insignificant between each of paired PAs.

Woody species frequency

The woody species in the study area were not evenly distributed throughout the study PAs. For example, *Pouteria adolfifriederichi, Ilex mitis, Ficus sur* and Albizia *gummifera* were found to be the top four frequent species (Fig. 4). On the other hand *Schreberia alata*, *Rothmannia urcelliofomis and Pittosporum viridiflorum* were found to be the least frequent species in the study PAs.

In the study PA of Beto, *Macaranga capensis, Pouteria adolfifriederichi and Millettia frruginea* were the top three frequent tree species encountered in 39.7%, 33%, and 18.2% of the total sampled quadrates, respectively.

Woody Species density

The woody species density per hectare at Beto and Abelo PAs are indicated in Table 4.The stand density of all life forms of woody plants in Beto was 3681/ha of which 1879 (51%) were seedlings 1370 (37.2%) were saplings and 432 (11.8%) were trees. In Abelo1832 (58.5%) seedling, 990 (31%) sapling and 368 (11.5%) were tree, making the total density of 3190/ha.

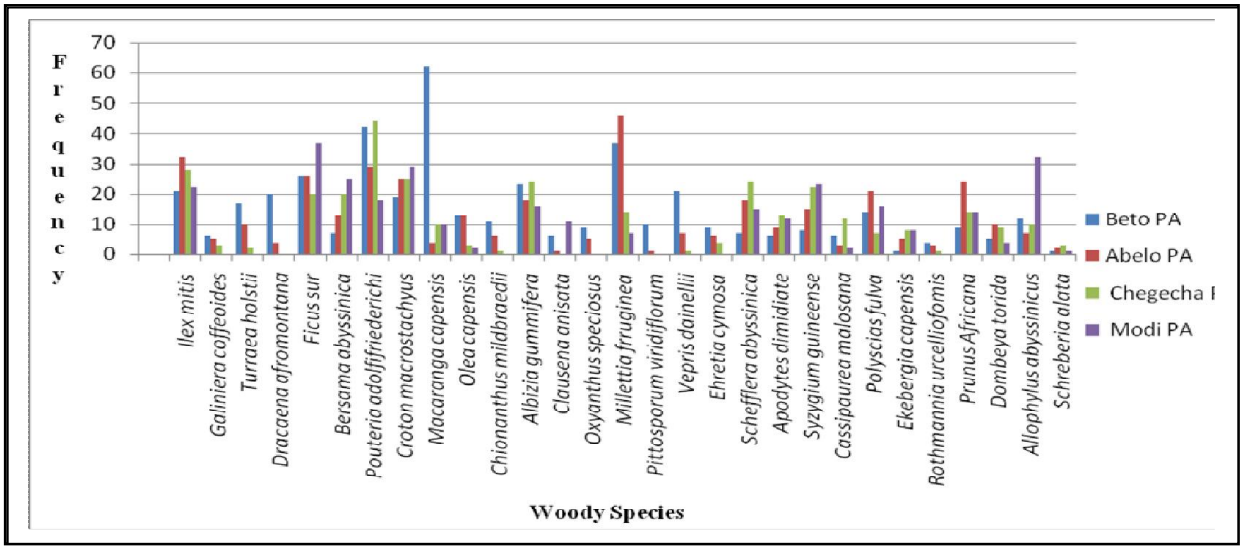


Figure 4. Frequency distribution of woody species in the study Pas

Table 4. Seedling, Sapling and Tree density /ha in Beto and Abelo PA

No	Species Name	Family name	Density/ha lie forms in PAs					
			Beto			Abelo		
			Se	Sa	Tr	Se	Sa	Tr
1	*Ilex mitis*	Aquifoliaceae	95	65	21	106	50	35
2	*Galiniera coffeoides*	Rubiaceae	14	20	6	32	25	4
3	*Turraea holstii*	Meliaceae	56	45	17	44	23	10
4	*Dracaena afromontana*	Dracaenaceae	43	28	20	1	1	3
5	*Ficus sur*	Moraceae	32	47	26	61	38	28
6	*Bersama abyssinica*	Melianthaceae	107	83	7	95	42	13
7	*Pouteria adolfifriederichi*	Sapotaceae	107	61	42	102	53	26
8	*Croton macrostachyus*	Euphorbiaceae	21	16	19	53	36	25
9	*Macaranga capensis*	Meliaceae	74	58	62	45	21	3
10	*Olea capensis*	Oleaceae	71	65	13	43	27	10
11	*Chionanthus mildbraedii*	Oleaceae	126	110	11	68	50	6
12	*Albizia gummifera*	Fabaceae	125	70	26	176	83	20
13	*Clausena anisata*	Rutaceae	83	43	6	64	29	1
14	*Oxyanthus speciosus*	Rubiaceae	110	86	9	85	69	5
15	*Millettia frruginea*	Fabaceae	112	92	37	102	54	47
16	*Pittosporum viridiflorum*	Pittosporaceae	21	20	10	13	4	1
17	*Vepris dainellii*	Rutaceae	119	85	21	70	50	8
18	*Ehretia cymosa*	Boraginaceae	23	13	9	25	16	6
19	*Schefflera abyssinica*	Araliaceae	0	0	7	0	0	17
20	*Apodytes dimidiata*	Icacinaceae	71	44	6	98	42	8
21	*Syzygium guineense*	Myrtaceae	61	43	8	119	46	14
22	*Cassipaurea malosana*	Rhizophoraceae	135	74	6	97	62	2
23	*Polyscias fulva*	Araliaceae	35	25	14	21	14	20
24	*Ekebergia capensis*	Meliaceae	6	8	1	49	26	5
25	*Rothmannia urcelliofomis*	Rubiaceae	88	65	4	20	10	3
26	*Prunus africana*	Rosaceae	51	15	9	104	54	21
27	*Dombeya torida*	Sterculiaceae	22	26	5	21	13	10
28	*Allophylus abyssinicus*	Sapindaceae	59	53	12	106	43	6
29	*Schreberia alata*	Oleaceae	0	0	1	0	0	2
Total			1789	1201	1879	1370	432	1832

Se= seedlings, Sa= saplings, Tr=trees

The mean comparison of Beto and Abelo vegetation as shown in (Table 5), the observed trend for lower size classes Beto has higher Mean ± SE, but for higher size classes Abelo PA has higher Mean ± SE values. Significance difference were observed only for tree size classes 50-60, 70-80 and 80-90 cm, in which Abelo PA has significantly higher than Beto.

Woody species density

The stand density of all life forms of woody plants in Chegecha was 3312/ha of which 1789 (54%) were seedling 1201 (36.3 %) were sapling and 322 (9.7 %) were tree (Table 6). In Modi seedling 1418(49%), sapling 1164(40.3%), and tree 304(10.7%) making a density of 2886/ha.

Table 5. Paired comparison woody species size between Beto and Abelo PAs

Woody species size	Beto	Abelo	Sig.	t	Mean difference
	Mean ± SE	Mean ± SE			
Seedling	64.379 ± 7.81662	62.7586 ± 7.89222	0.922	0.145	1.62069
Sapling	46.896 ± 5.51606	33.8276 ± 4.04137	0.083	1.911	13.06897
<10	4.1724 ± 0.62790	3.7586 ± 077468	0.84	0.415	0.414
10-20	5.1724 ± 1.11204	3 ± 0.73779	0.12	1.628	2.17241
20-30	2.5862 ± 0.85316	1.9310 ± 0.43246	0.139	0.685	0.65517
30-40	1.3793 ± 0.34887	1.2414 ± 0.27478	0.271	0.311	0.13793
40-50	0.5172 ± 0.15394	0.6552 ± 0.23424	0.219	-0.492	-0.13793
50-60	0.3793 ± 0.10427	0.5517 ± 0.16893	0.043	-0.869	-0.17241
60-70	0.2414 ± 0.11802	0.3793 ± 0.12569	0.198	-0.8	-0.13793
70-80	0.1034 ± 0.05755	0.3103 ± 0.12261	0.004	-1.528	-0.2069
80-90	0.0345 ± 0.3448	0.2069 ± 0.11511	0.005	-1.435	-0.17241
>90	0.3103 ± 0.13227	0.6552 ± 0.33761	0.065	-0.981	-0.34483

Table 6. Woody species density/ha in Chegecha and Modi PA

No	Species Name	Family name	Density/ha life forms in PAs					
			Chegecha			Modi		
			Se	Sa	Tr	Se	Sa	Tr
1	*Ilex mitis*	Aquifoliaceae	135	103	31	110	81	18
2	*Galiniera coffeoides*	Rubiaceae	46	29	2	33	38	0
3	*Turraea holstii*	Meliaceae	45	18	1	39	28	0
4	*Dracaena afromontana*	Dracaenaceae	20	17	0	0	0	0
5	*Ficus sur*	Moraceae	53	57	25	69	85	36
6	*Bersama abyssinica*	Melianthaceae	154	65	17	146	96	26
7	*Pouteria adolfifriederichi*	Sapotaceae	152	79	44	96	65	18
8	*Croton macrostachyus*	Euphorbiaceae	52	46	25	78	61	32
9	*Macaranga capensis*	Meliaceae	57	37	9	23	20	8
10	*Olea capensis*	Oleaceae	27	17	3	16	16	2
11	*Chionanthus mildbraedii*	Oleaceae	31	18	1	1	0	0
12	*Albizia gummifera*	Fabaceae	99	46	25	113	68	14
13	*Clausena anisata*	Rutaceae	65	55	0	95	78	8
14	*Oxyanthus speciosus*	Rubiaceae	30	16	0	1	1	0
15	*Millettia frruginea*	Fabaceae	62	36	15	60	58	6
16	*Pittosporum viridiflorum*	Pittosporaceae	5	5	0	7	10	1
17	*Vepris dainellii*	Rutaceae	53	31	1	29	16	0
18	*Ehretia cymosa*	Boraginaceae	1	0	0	0	0	0
19	*Schefflera abyssinica*	Araliaceae	0	0	25	0	0	21
20	*Apodytes dimidiata*	Icacinaceae	114	65	11	57	56	11
21	*Syzygium guineense*	Myrtaceae	139	75	21	93	71	21
22	*Cassipaurea malosana*	Rhizophoraceae	59	46	1	47	37	1
23	*Polyscias fulva*	Araliaceae	11	13	7	23	35	15
24	*Ekebergia capensis*	Meliaceae	85	51	6	51	37	6
25	*Rothmannia urcelliofcmis*	Rubiaceae	22	12	1	1	1	0
26	*Prunus africana*	Rosaceae	110	88	16	93	85	13
27	*Dombeya torida*	Sterculiaceae	32	93	8	28	23	3
28	*Allophylus abyssinicus*	Sapindaceae	118	73	17	96	85	35
29	*Schreberia alata*	Oleaceae	0	0	1	0	0	1
Total			1789	1201	322	1418	1164	304

Se= seedlings, Sa= saplings, Tr=trees

Table 7. Paired comparison of woody species density

Size	Chegecha	Modi	Sig.	t	Mean difference
	Mean ± SE	Mean ± SE			
Seedling	61.275 ± 8.83844	48.4483 ± 7.92321	0.732	1.081	12.82759
Sapling	41.069 ± 5.57571	39.6897 ± 6.04766	0.432	0.168	1.37931
<10	2.2414 ± 0.45932	2.2759 ± 0.57642	0.395	0.047	-0.03448
10-20	2.2759 ± 0.39980	2.3793 ± 0.57539	0.276	-0.148	-0.10345
20-30	2.1034 ± 0.48966	2.2759 ± 0.63342	0.24	-0.218	-0.17241
30-40	1.5862 ± 0.38288	1.3448 ± 0.34483	0.401	0.468	0.24138
40-50	0.8276 ± 0.25340	0.7241 ± 0.23223	0.672	0.301	0.10345
50-60	0.5172 ± 0.18316	0.3103 ± 0.14974	0.241	0.875	0.2069
60-70	0.4828 ± 0.20233	0.4828 ± 0.18977	0.869	0	0
70-80	0.3448 ± 0.18083	0.3448 ± 0.13387	0.892	0	0
80-90	0.4138 ± 0.16843	0.1481 ± 0.08777	0.013	1.369	0.26564
>90	0.3103 ± 0.17266	0.2069 ± 0.07655	0.165	0.548	0.10345

The pair compassion between Chegecha and Modi PAs for seedlings, saplings and trees densities is shown in Table 7. Chegecha PA has higher Mean ± SE than Modi PA seedling, sapling and tree Mean ± SE values.

Even though total stand density of woody plants per hectare and Mean ± SE values in Chegecha PA is higher than that of Modi, significance difference is observed only in tree size class 80-90 cm, where Chegecha has the higher stand density than Modi PA.

Population structure and regeneration

The distribution of trees in Beto PA in different DBH classes is shown in figure 5.The number of stems in DBH ≥ 2cm class and less than 10cm was 121/ha (28%). The majority of individuals measured have DBH less than 30 cm were 80.6%, in size class of 30-70cm were 16.88%, and the size class > 70cm were 2.52%. The overall population structure shows there is healthy regeneration as depicted by the inverted J-curve (Figure 5).

The distribution of tree species in Abelo PA in different DBH classes is given in Figure 6. The majority of individuals measured have DBH less than 30 cm were 68.46%, size class of 30-70cm were 22.18%, and the size class > 70cm were 9.36%. The overall population structure shows there is healthy regeneration as depicted by the inverted J-curve in Figure 6.

Even though the density of all tree species in Beto PA is higher than that of Abelo PA, the distribution of trees by DBH classes in Abelo is relatively normal, in which the decreasing of number of individuals as diameter size class increases follows regular pattern. Whereas, in Beto the number of individual in the first diameter size class is less than second diameter size class, but the normal regeneration follows the opposite of this pattern. And the next thing is, there is rapid decreasing of number of individuals as diameter size increases, this is clearly observed in 50-60cm, 70-80cm and 80-90cm size classes in Beto PA.

The distribution of tree species in Chegecha PA in different DBH classes is given in Figure (7). The majority of individuals measured have DBH less than 30 cm were 60.65%, size class of 30-70cm were 30.72%, and the size class > 70cm were 8.63%. The overall population structure shows that there is healthy regeneration as depicted by the inverted J-curve. The majority of individuals measured have DBH less than 30 cm were 66.4%, size class of 30-70cm were 27.22%, and the size class > 70cm were 6.38%. The overall population structure shows there is healthy regeneration as depicted by the inverted J-curve in Figure 8.

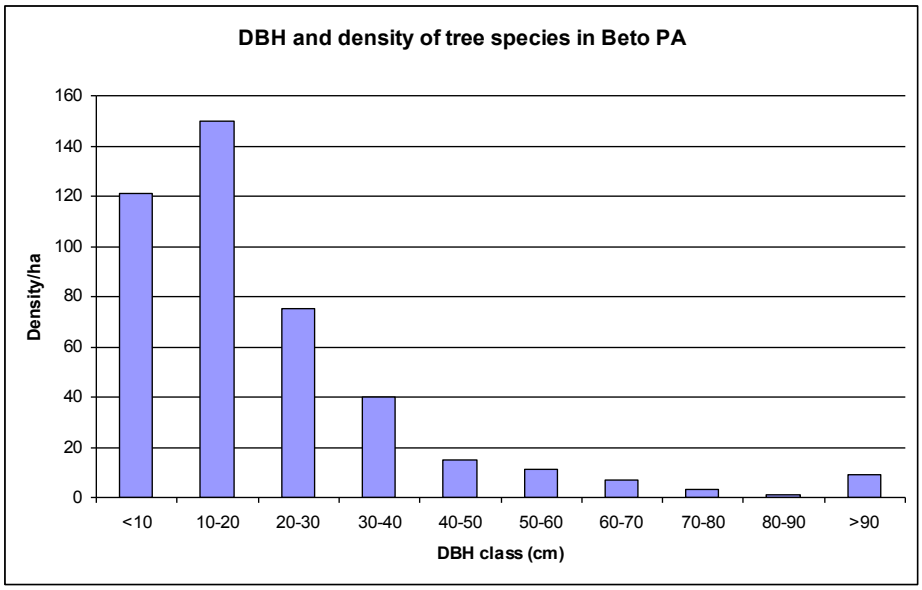


Figure 5. DBH Class and Density of woody species in Beto PA

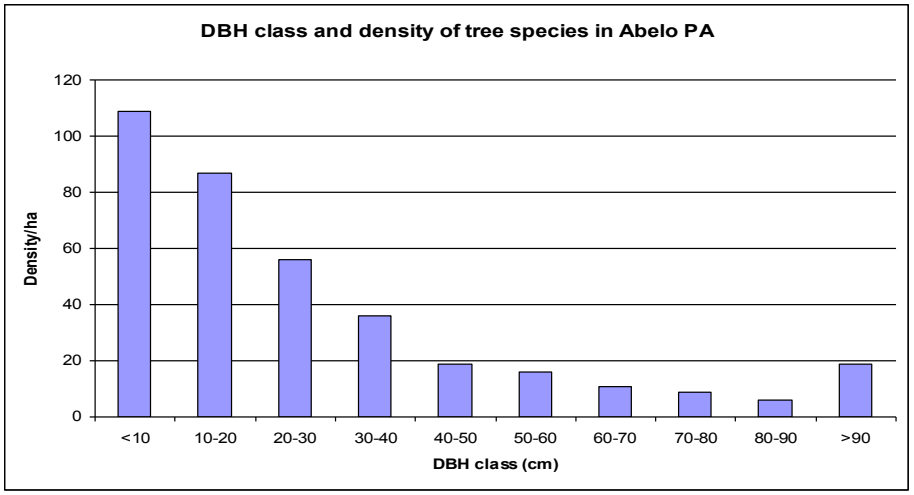


Figure 6. DBH Class and Density of woody species in Abelo PA

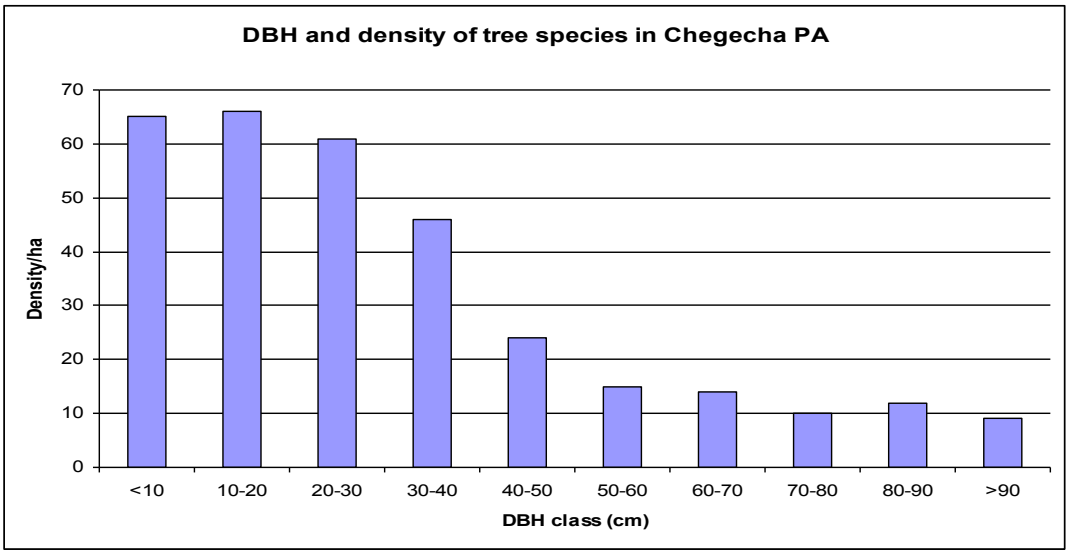


Figure 7. DBH Class and Density of woody species Chegecha in PA

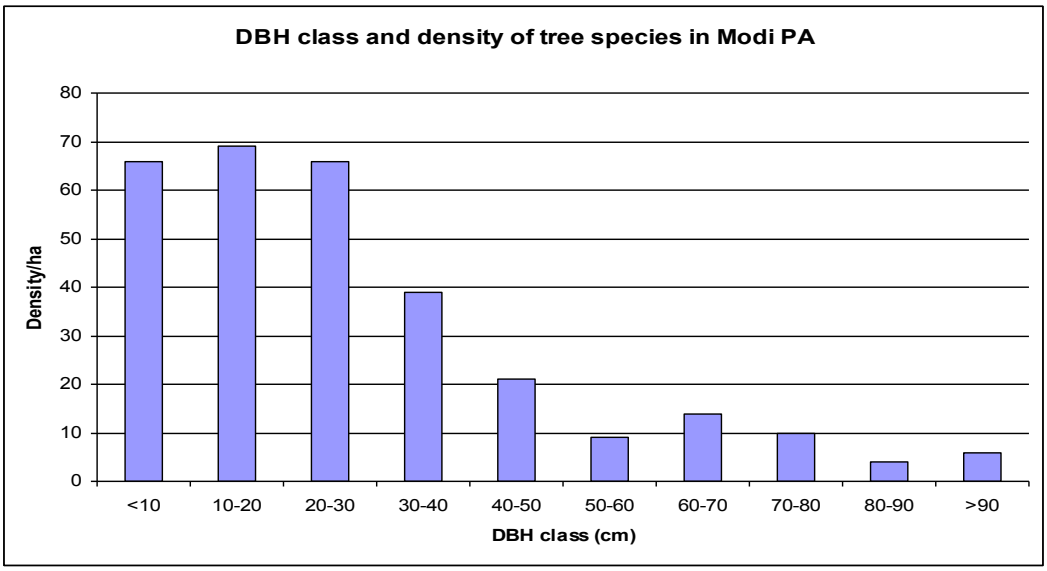


Figure 8. DBH Class and Density of woody species in Modi PA

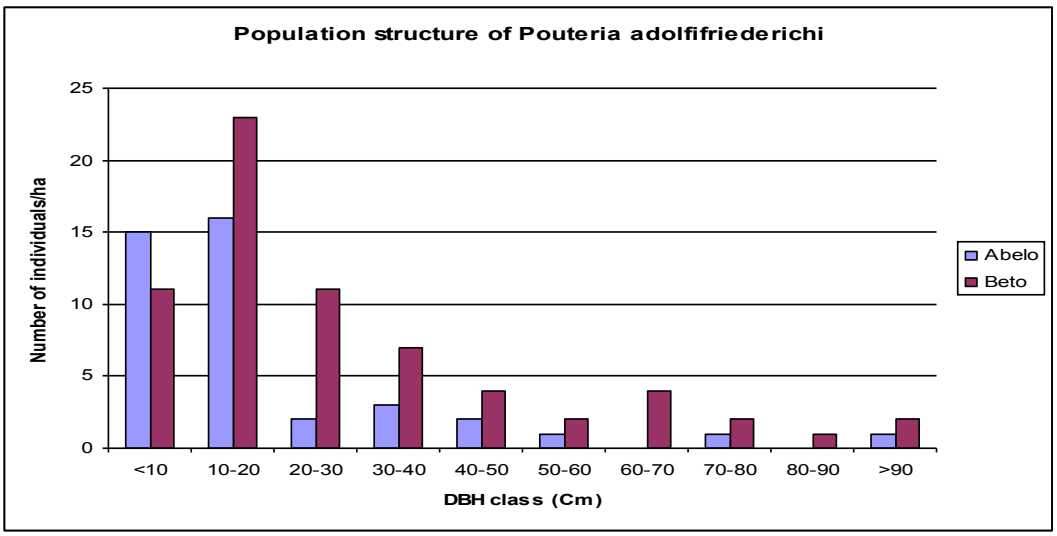


Figure 9. Population structure of *Pouteria adolfifriederichi* in Abelo and Beto PAs

Besides the above population structure of forest each PA, the following tree species population structure namely: *Pouteria adolfifriederichi*, *Allophylus abyssinicus* and *Bersama abyssinica* species were taken for comparison.

The population structure of *Pouteria adolfifriederichi* in Abelo and Beto PAs is shown in Figure 9. In all the size class DBH ≥ 10cm, except 60-70 and 80-90 cm Beto PA has higher number of individuals than Abelo PA. The population structure of *Pouteria adolfifriederichi* species in Beto PA shows there is healthy regeneration as depicted by inverted J-curve, but that of Abelo didn't show healthy regeneration (Figure 9), hence the diminish of the number of higher DBH trees might be more extraction of this tree species was done in Abelo than Beto relatively.

The Population structure of *Allophylus abyssinicus* in Abelo and Beto PAs is shown in Figure 11. In Beto PA the stand density of *Allophylus abyssinicus* in 10-20 cm DBH class is higher than in Abelo PA, while in 40-50 cm DBH class no stand for this tree species was not recorded. In both PAs the population structure of *Allophylus abyssinicus* species didn't show healthy regeneration.

The population structure of *Allophylus abyssinicus* in Chegecha and Modi PAs didn't show healthy regeneration as the stand density of first DBH class of these species are lower than stand density of second DBH class of this species in both PAs (Figure 12).

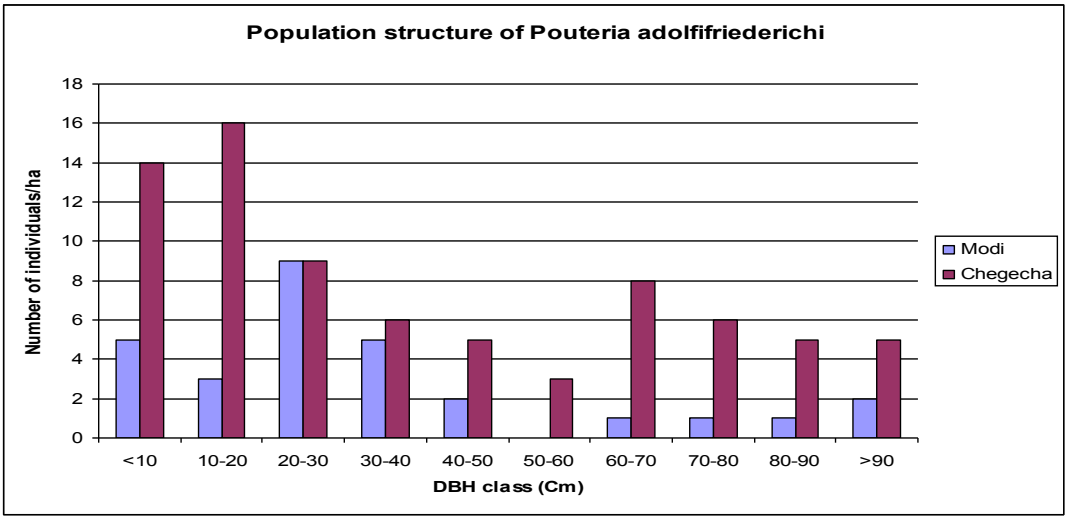


Figure 10. Population structure of *Pouteria adolfifriederichi* in Modi and Chegecha PAs

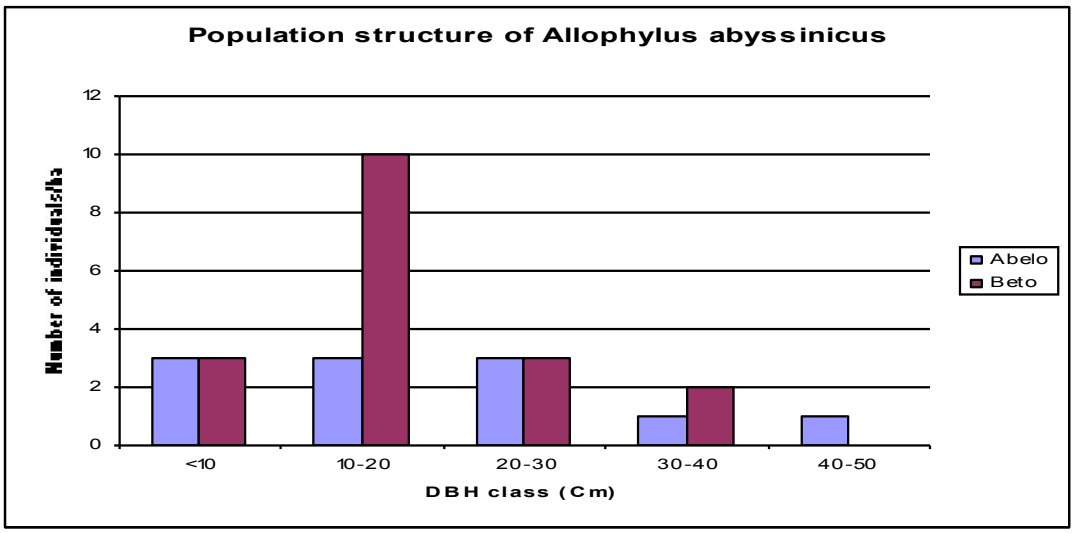


Figure 11. Population structure of *Allophylus abyssinicus* in Abelo and Beto PAs

The population structure of *Pouteria adolfifriederichi* in Modi and Chegecha PAs is shown in Figure 9. In Modi and Chegecha healthy regeneration is not observed for this species, as it didn't depict inverted J-curve (Figure 10). Particularly, in Modi PA the absence of tree stand in 50-60 cm and the diminishing of higher DBH class might be resulted from more extraction than in Chegecha PA.

The population structure of *Bersama abyssinica* didn't show healthy regeneration as in some of DBH class thee stands were not recorded for both PAs (Figure 13).

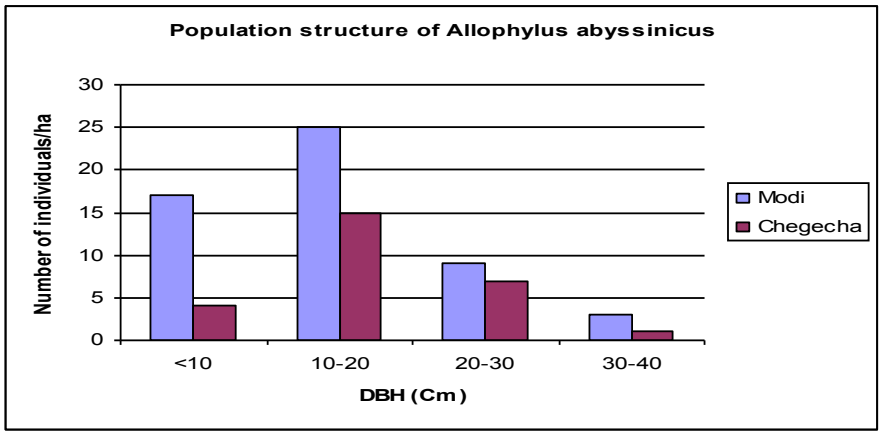


Figure 12. Population structure of *Allophylus abyssinicus* in Modi and Chegecha Pas

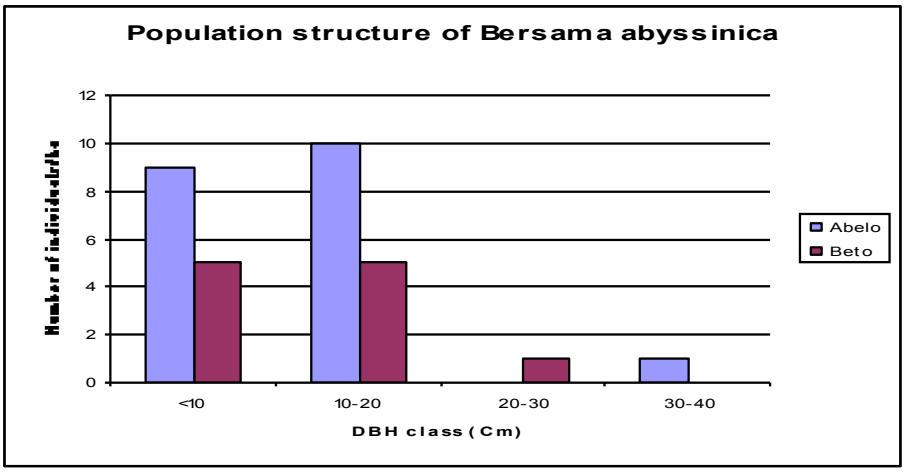


Figure 13. Population structure of *Bersama abyssinica* in Abelo and Beto Pas

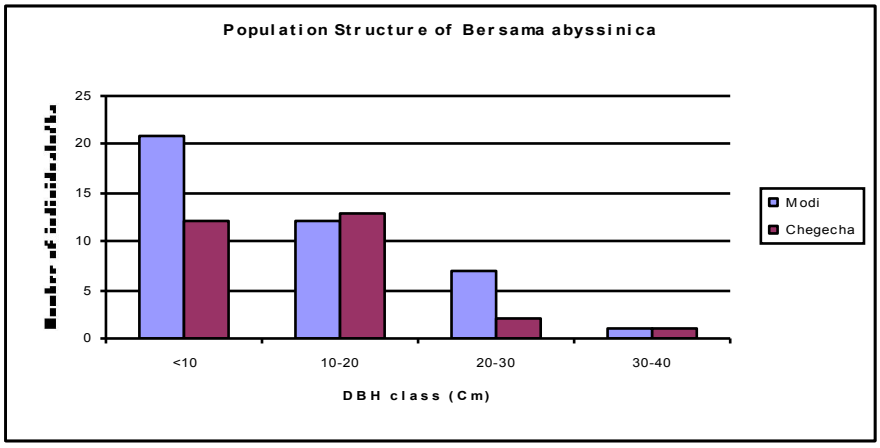


Figure 14. Population structure of *Bersama abyssinica* in Modi and Chegecha PAs

The population structure of *Bersama abyssinica* in Modi PA showed relatively normal trends of the number of individuals decrement as the size class increases, hence there is healthy regeration in Modi which is not observed in Chegecha (Figure 14).

Woody species uses for the inhabitant

Woody species identified at both study districts have a wide range of uses. The inhabitant collect different woody species for income generation and households' consumption, and this activity is the integral part of their livelihood strategies. Based on respondents, a total of thirteen different use types were recorded. Some of the major uses obtained from woody species at the study sites include, fuel wood, shade, soil fertility improvement, fodder, construction and others.

Almost all the identified parkland woody species provide more than one use.

Table 8. Woody species uses

No.	Use type	Masha District		Andracha District	
		Beto PA HH No	Abelo PA HH No	Chegecha PA HH No	Modi PA HH No
1	Fuel wood	23	26	24	25
2	Construction	17	23	22	28
3	Cash generation	12	27	24	27
4	Food	20	23	21	22
5	Medicine	21	24	23	27
6	Farm tool	29	30	29	28
7	Shade	26	27	27	24
8	Bee keeping	24	21	22	27
9	Soil fertility	30	29	29	30
10	Fodder	24	26	27	22
11	Amenity	3	6	3	0
12	Timber	23	22	21	30
13	Charcoal	7	12	13	19

Table 9. The amount forest products and income gained in the study area

District	PA	Forest product	No HH	Amount/year (Kg)	Income/Year (in ETB)	Cover %
Masha	Beto	Beehive honey	30	3864	61824	76.4
		Cardamom	26	492	13776	17.00
		Lianas	8	nk	2859	3.6
		Wild honey	17	103	1648	2.00
		Wild coffee	1	6	96	0.12
		Timiz	4	29	145	0.14
		Wild gesho	1	nk	84	0.10
		Medicinal plants	2	nk	35	0.04
		Cultivated coffee	1	31	496	0.60
	Abelo	Beehive honey	30	1063	17008	85.20
		Cardamom	3	36	692	3.50
		Lianas	3	nk	450	2.20
		Timiz	2	17	85	0.40
		Medicinal plants	6	nk	250	1.30
		Cultivated coffee	2	92	1472	7.40
Andracha	Chegecha	Beehive honey	29	4127	66032	80.60
		Cardamom	24	396	11088	13.53
		Wild honey	24	79	1264	1.54
		Wild coffee	2	17	272	0.33
		Timiz	6	63	315	0.40
		Wild gesho	3	nk	678	0.84
		Medicinal plants	1	nk	100	0.12
		Cultivated coffee	2	134	2144	2.64
	Modi	Beehive honey	29	1330	21280	98.00
		Medicinal plants	4	nk	450	2.00

ETB= Ethiopian Birr (1 ETB = $20.78) nk = not known

The study conducted by Sutcliffe 2009, in the same Masha and Andracha district also demonstrated that woody products contributed to household income generation and household consumption. The contribution of woody species diversity to rural communities was studied in different areas, which showed the contribution of woody species to household income is indispensable. For instance, Cavendish (2000) in Zimbabwe reported 35 %, and Gunatilake (1998) in Srilanka reported 24%. Research done in six communities in Tanzania also found that farmers were deriving up to 58% of their cash income from the sale of charcoal, fuel wood, wild fruits and vegetables (CIFOR, 1999). Similarly, many studies in Ethiopia reported for instance, Arsema (2008) showed that on average 47% of the annual income of households is derived from bamboo sale in Shedem PA of Goba district.

Livelihood strategies in the study area mainly depend on woody species and their products. Additionally non woody products collected from the natural forest, crop production, livestock production, and off-farm activities (petty trading and daily labor) also contribute to the livelihood of the inhabitants. Among these livelihood strategies of local people, income from off- farm is relatively small in case of all PAs. In Beto and Chegecha PAs woody species products contribute the highest share, but woody species contribute lower average percentage share in Abelo and Modi PAs, where animal production supports highest average percentage share. Woody species contribute higher to the livelihood of peoples in Beto and Chegecha, and lower in Abelo and Modi PAs. In this study the highest and the lowest contribution to households' annual income are 74.6% and 22.1%, respectively.

DISCUSSION

Woody species composition and arrangement in landscape can be diverse in various ecosystems. The result of the present study showed no variations in species composition between the study PAs. On the other hand woody species diversity showed a slight variation among the study PAs. The highest Shannon

diversity index was recorded at Abelo followed by Beto, Chegecha and Modi. The highest species evenness was recorded at Abelo PA. The Shannon diversity index (H') of woody species exhibited certain variation between PAs. The Shannon diversity indices showed slightly higher value in Masha district as compared to the Andracha district. This is because the woody species in Masha district at both study PAs Beto and Abelo are remnants from the clearance of natural forest and the level of forest extraction lower.

Out of 29 woody species recorded in the study area 27 of the woody species were common to both districts and categorized under 21 families. The families recorded in the study area were similar in four PAs. The frequency distributions of woody species showed variations between the study PAs at both districts. For example, *Pouteria adolfifriederichi, Ilex mitis, Ficus sur* and Albizia *gummifera* were found to be the top four frequent species.

The result of this study showed that in Beto PA 80.6% of individuals measured have DBH less than 30cm. This might be attributed to the extraction of large size class woody species for various uses. However, the overall population structure in the study area shows a healthy regeneration as depicted by the inverted J-curve in all PAs. Which resulted from the gradual decrement of stand density as the size classes increase .The total number of trees/shrubs in each DBH classes decreased with an increased in DBH classes. This relation also was observed in Dedessa forest by Gebremedhin (2000); in Chilmo and Menagesha forests (Tamrat, 1993) and the tropical lowland rain forest of Los Tuxtlas, Mexico (Bongers *et al.,* 1988).

The selected three tree species, namely: *Pouteria adolfifriederichi*, *Allophylus abyssinicus* and *Bersama abyssinica* population structure showed irregular pattern of decrease as size class increase even in some DBH classes in higher diameter classes no individuals were recorded, this may be extraction of these tree for various purposes. The previous studies demonstrated the occurrence of this kind of results. According to Demel (1996,1997), the low number of trees in the natural forest can be attributed mainly to human disturbances such as cutting of trees for different uses.

Conclusion

The woody species inventory at the study districts were provided information on exiting situations of species richness, diversity, evenness, frequency, population structure, density, and woody species uses. There were no significant differences in the diversity, composition and density of woody species between the study PAs. In the present study, a total of 20 families comprising 29 woody species were recorded. Both Beto and Abelo PAs had 29 identical wood species. On the other hand, the woody species in Chegecha was relatively higher species than Modi. The study district had displayed such features as dominance of a few species in population structural parameters, density, and frequency. In the different PAs, different woody species dominated all the structural parameters. Estimation of wood resources in terms of regeneration, difference is observed between tree size class 80-90 cm of Chegecha and Modi, where the higher is recorded in chegecha which has more extractive forest products than Modi PA. The population structure of the woody species was generally found to have a pattern that is expected of any natural population characterized by the presence of most of its individuals in the lower size classes rather than the opposite. That is, the population displayed for most of the prominent species an inverted J–shape.

About 13 different use types were identified, of which fuel wood accounted for the largest number of species, followed by construction purposes. Many woody species such as *Macaranga capensis, Pouteria adolfifriederichi and Millettia frruginea*, *etc*., are grown widely in the study districts because of their roles in providing shade and soil fertility, wood and other products.

Recommendation

Based on the present findings, the following points are recommended.

- To increase the number of woody species in the study districts, extension efforts should be made. This could be by promoting, introducing and expansion of multipurpose woody species that help in improving the productivity as well as protective values of the woody species. Hence, diversification of woody species with the aim of enhancing livelihood of the inhabitants needs to be an important priority.
- Woody species contribute large share of local community livelihoods. The conservation of forests is thus very essential to sustain local people livelihoods.
- Farmers' indigenous knowledge and experiences should be considered in the process of woody species development plans and they should be participated from the beginning to the implementation activities.

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