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Woody Species Diversity, Management and Contribution of Local Community in Protected Forest of Kuneba District, Afar Region Ethiopia

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ABSTRACT

Traditional forest management practices as adapted by local community are considered as ancient form of forest management systems and utilization in Ethiopia. The community protected forest as located in Kuneba wereda, Afar regional state (Ethiopia) is one of such forest where local community plays a vital role in its conservation and management. The present study was carried out to study the woody species diversity, the structural parameters (density, frequency, important value index and basal area) of woody species and contribution of local community to manage community protected forests at the study area. Both primary and secondary data were collected from the study area through household, key informants and woreda offices, respectively Field survey was also conducted to identify the present status of the forest. The data on structure, composition and woody species diversity in the study area were collected from 40 plots, which shown a total of 29 woody species in the study area. The composition, Shannon and Simpson diversity indices and evenness were also determined. *Acacia tortilis* (Eibito) was found as dominant woody species in the forest. It was learnt that the local communities manage the forest tree species in traditional ways for the benefits they derive from the forest. The continuous management practices in the forest and its consequences brought about the suppression of tree regeneration, reducing tree density eventually leading to the disappearance of some valuable forest species. Therefore, there is an urgent need to adapt conservation strategies in the forest of the Kuneba woreda area to save it from further deterioration, Moreover, it should be a priority issue for all concerned authorities to intervene immediately in the problem.

Key words: Woody species, *Acacia tortilis*, Kuneba forest

INTRODUCTION

The vegetation of Ethiopia is diverse in physiognomy and species composition that can be broadly classified into seven types (Friis, 1992). These are the lowland dry peripheral semi-deciduous Guineo-Congolian forest, transitional rainforest, Afromontane rainforest, undifferentiated Afromontane forest, dry single dominant Afromontane forest of the Ethiopian Highlands, dry single-dominant Afromontane forest of the escarpments and riverine forest. Although reliable information on the Ethiopian forest cover over time is lacking, there has been a growing concern regarding the status and use of the country's forest resources. All historical sources indicate that the forest cover in Ethiopia has been decreased rapidly in last few decades or so (EFAP., 1993, 1994; Reusing, 1998; Yirdaw, 2002; Birhanu, 2009).

The causes of forest loss in Ethiopia are many and interlinked. These include demand for agriculture land, uncontrolled grazing, high population growth, settlements, fires and unrestrained harvesting of forest products. The rapid forest depletion in high land areas is much more severe than the low lands as the highlands of Ethiopia, in contrast to most mountain systems outside Africa, are very suitable for human inhabitation (Yirdaw, 2002). For instance, the transformation of natural high forests into cultivated lands and grass lands has been most intensive in the northern and north eastern parts of Ethiopia over the last few centuries. Consequently, most of the remaining high forests are nowadays concentrated in the western, southern and south eastern parts of the country.

Assessments of forest structure are of fundamental importance to forest management, providing information on the size distribution of trees on which harvesting plans can be developed (Newton, 2007). Traditionally, indigenous people conserve forest resources found in their surroundings. Kuneba is one among the woredas conserving forest resources. The Kuneba woreda is located in North-East of Afar Regional State, Ethiopia. Even though, the woreda conserves forest resources, there is no documented data about the woody species diversity, the structural parameters, management and its contributions for local community of the woreda. In view of above perspectives, it was thought worthwhile to conduct a study aimed at woody species diversity, structural parameters, management and the contributions of local community in protecting forest of Kuneba woreda.

MATERIALS AND METHODS

Description of the study site: Kuneba is situated 588.5 km from Samara and covers 46960 ha area. The climatic condition of the area is categorized as 'Dega' 5%, 'Weyna dega'70 and kola 25% climatic zone. The minimum and maximum temperature of the Woreda is 23 and 38°C, respectively. There are seven kebeles in the study woreda and a total of 53043 population comprising of 30 and 70% to agro pastoral and pastoral community, respectively.

Vegetation survey: Prior to data collection, field reconnaissance survey was carried out. A systematic sampling design was used to locate sample plots in protected community forests of the site. The basic sampling unit was composed of two concentric circular plots each having 3 m (28.26 m^2) and 10 m (314 m^2) radius. Two set of vegetation data were collected within the basic sampling unit. Trees and shrubs defined as woody plants having a diameter at breast height (dbh) of at least 2.5 cm were recorded within 10 m circular plots (314 m^2). Seedling plants were recorded within 3 m circular plots (28.86 m^2). Seedlings are defined as woody plants having dbh of less than 2.5 cm. Accordingly, trees are considered to be woody plants that grows from single main trunk and don't branched at or near the base of the plant. Shrubs are considered to be self-supporting woody plants that have several stems at or near the base of the plant.

Plant identification was carried out in the field and those could not identified in the field, were presented in local name. Nomenclature of species was done following the publications of the Flora of Ethiopia and Eritrea (Hedberg and Edwards, 1995; Hedberg *et al*., 2003, 2004, 2006).

Data analysis

Diversity measurement: The diversity of woody species was analyzed using the widely used Shannon-wiener index (H') (Jayaraman, 2000) expressed as:

$$H' = -\sum Pi \ln Pi$$

where, Pi = The proportion of individuals found in the ith species and ln = Indicates the natural logarithm, I =1, 2, 3.... and S = The number of species. Shannon evenness index was calculated by the formula:

$$\text{Equitability (evenness)}\, E = \frac{H'}{H'_{max}} = \frac{H'}{\ln s}$$

where, Hmax is the maximum level of diversity possible within a given population, H is Shannon diversity index, while s is the number of species (Jayaraman, 2000).

The Simpson's diversity index was derived from probability theory and it is the probability of picking two organisms at random which are of different species (Krebs, 1985; Magurran, 1988). We get Simpson's Diversity (D):

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

where, D = Simpson's diversity index, P_i = as described above. Simpson's diversity index gives relatively little weight to the rare species and more weight to the most abundant species. It ranges in value from 0 (low diversity) to a maximum of (1-1/S), where S is the number of species (Krebs, 1985). It is moderately affected by sample size (Magurran, 1988).

Density: The density of woody species is one of the most important structural parameters considered during data analysis. The density per hectare of woody seedlings, shrubs and trees were calculated by summing up all stems across all sample plots and converted into hectare basis.

Basal area: The other most important structural parameter considered is the basal area. It measures the relative dominance of a species in a forest. Basal area was calculated for each tree having a dbh >2.5 cm. It was calculated as:

$$BA = \frac{\pi * dbh^2}{4}$$

Where:
dbh = Diameter at breast height (cm)
π = 3.14

Frequency: Frequency is defined as the probability of chance of finding a species in a given sample area or quadrant (Kent and Coker, 1992). Thus, it shows the presence or absence of a given species within each sample plot. On the other hand, relative frequency shows the frequency of a species in relation to all other woody species constituting the forest under investigation.

Importance value index: The Importance value index is an important tool to compare the ecological significance of a species (Lamprecht, 1989). In this study, it was computed for all woody species encountered in the forest. It was calculated following Kent and Coker (1992) as:

IVI = Rel. density+Rel. frequency+Rel. dominance

Where,

$$\text{Rel. density} = \frac{\text{No. of a species}}{\text{Total No. all individuals of spedies}} \times 100$$

$$\text{Rel. dominance} = \frac{\text{Basalal of a species}}{\text{Basal area of all spedies}} \times 100$$

$$\text{Rel. frequency} = \frac{\text{Frequency of a species}}{\text{Frequemcy of all spedies}} \times 100$$

Population structure: Population structure was computed for woody plants species. For the purpose of studying the population structures in the community protected forest, the diameter of all individual woody plants was categorized into an arbitrary diameter classes. Accordingly, the woody species were grouped into seven dbh classes following Senbeta (2006). Histograms were drawn to show the relative distribution of individuals into different size classes.

Socio-economic survey: During socio-economic survey, data were collected from household interviews using a questionnaires to get back ground information about the contribution and the management practices carried out by local communities in the forest of study area. Key informants were selected through a village guided tour made with selected Peasant Association (PA) members and development agents. During a guided tour, farmers were randomly asked to give the names of key informants. A total of five key informants were selected. These key informants are individuals who lived in the area and who are assumed to have adequate knowledge of their locality. Households were selected randomly near to the forest to get information about the contribution and management practices. Secondary data was obtained at the local and district offices. The questionnaires was translated to the local language “Afarigna” to simplify for the enumerators. Three enumerators with Diploma qualifications were selected, trained and assigned for data collection. A total of 50 individuals were interviewed.

RESULTS AND DISCUSSION

Woody species diversity: A total of 29 woody species that belongs to tree, shrub and seedling were recorded in the community protected forest of the study site. This shows that the community protected forest was floristically rich as compared to studies made in other dryland areas of the country. For instance, Argaw *et al*. (1999) and Eshete (1999) made a study in the woodlands of the Upper Rift Valley and found only six woody species along the established quadrats. Likewise, studies conducted in the woodlands of the northern part of the country had also reported only 13 species (Kindeya, 2003) as compared to what was found in this particular case. This probably leads to the conclusion that, the selected study vegetations had diverse species composition compared to some other sites with more or less similar agro-ecology and vegetation formation in Ethiopia.

Table 1: Diversity indices of woody species at Kuneba community protected forest

Parameters	Values
Shannon diversity index (H')	2.26
Simpson diversity index (D)	0.81
Evenness (E)	0.67

In order to get better picture on the extent of woody species diversity, several diversity indices were employed which include Shannon, Evenness and Simpson indices for the study area. The Shannon diversity index (H'), Simpson diversity index (D) and evenness (E) of woody species of the study community protected forest were calculated (Table 1). The diversity of a given forest area was determined by the value of diversity index.

Structural parameters of woody species

Abundance and density: A total of 232 individuals of woody species were encountered from the sampled quadrats of Kuneba community protected forests. Adidahara, Eibito (*Acacia tortilis*) and Sasakto (*Acacia etbaica*) were the most abundant woody species accounted for 66.38% of the whole woody species obtained from the sampled quadrats.

The total density (expressed as the number of stems per hectare) of all woody species was found to be 185 stems ha^{-1}. A few species of woody plants were found to predominate the density of the community protected forests of the study area. For instance, three species: Adidahara, Eibito (*Acacia tortilis*) and Sasakto (*Acacia etbaica*) were contributed to 65.9% of the total density at the study site. This result is five times lower than the study conducted by Birhan (2009), at South Wallo community forests with density of 881 individuals ha^{-1}.

Basal area: The total basal area (expressed as the basal area of stems per hectare) of community protected forests of Kuneba woreda woody species with dbh >2.5 cm were 6.81 m^{-2} ha^{-1}. This result is very low as compared to the study made by Birhan. (2009), at Tehuledere district of South Wallo community forests with Basal Area (BA) of 22.87 m^{-2} ha^{-1}. This great variation may come from the differences in agro-ecological zones of the study sites. Unlike the density of trees, basal area is a function of size of the trees stems than simple stem counts.

Frequency: The woody species in the protected community forests of the study site were not evenly distributed throughout the study quadrats. For example, Adidahara, Eibito (*Acacia tortilis*) and Sasakto (*Acacia etbaica*) were found to be the top three frequent species. These species were encountered in 78, 48 and 28% out of the whole sampled quadrats respectively (Fig. 1). On the other hand, Alaki, Alayito, Amdal, Andukto, Dawayito, Deherbu, Dokohita, Gabu, Hindile, Lehatto, Sola, Sulva, Ungule and Waranat were found to be the least frequent species in the study site.

Important value index: To determine the importance of woody species recorded in Kuneba woreda community protected forests, their Importance Value Index (IVI) was calculated and presented in Table 2. In this study, three species were recorded as the most important woody species in the study site. Eibito (*Acacia tortilis*) which frequently occurred in the area has got the highest importance value index (82.66%) followed by *Adidahara* (64.73%) and Sasakto (*Acacia etbaica*) (42.02). However, seven woody species were equally important in the study site.

Population structure of woody species: The pattern of size-class distribution (i.e., diameter) has often been used to represent the population structure of a forest (Khan *et al*., 1987). The comparative patterns of the population structure (stem diameter distribution) of the whole woody

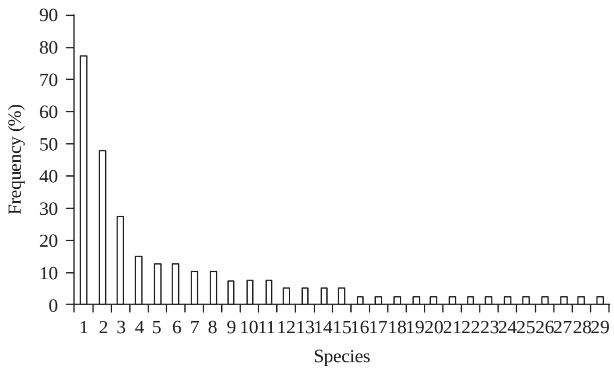

Fig. 1: Overall frequency distribution of woody species in sampled plots (n = 40) of the study site (1) *Adidhara*, (2) *Eibito*, (3) *Sasakta*, (4) *Atimikto*, (5) *Tatahala* (6), *Ulaga*, (7) *Kukura*, (8) *Susohoto*, (9) *Arga gudo*, (10) *Salaha*, (11) *Udayto*, (12) *Dama's salaha*, (13) *Hawahuto*, (14) *Hubukto*, (15) *Madarto*, (16) *Alaki*, (17) *Alayito*, (18) *Amdal*, (19) *Andukto*, (20) *Dawayito*, (21) *Deherbu*, (22) *Dokohita*, (23) *Dabu*, (24) *Hindile*, (25) *Lehatto*, (26) *Sola*, (27) *Sulva*, (28) *Ungule* and (29) Waranat

Table 2: Importance value index of woody species of Kuneba community protected forest

Species names	RF (%)	RA (%)	RD (%)	IVI
Eibito	16.38	16.38	49.90	82.66
Adidahara	26.72	37.93	0.08	64.73
Sasakto	9.48	12.07	20.47	42.02
Udayto	2.59	3.45	9.16	15.19
Sukohoto	3.45	6.03	2.91	12.39
Salaha	2.59	2.16	4.92	9.66
Atimito	5.17	3.02	1.02	9.21
Kukura	3.45	1.72	3.43	8.60
Ulaga	4.31	2.59	0.83	7.72
Tatahala	4.31	2.16	0.90	7.36
Other remain species (19)	21.55	12.50	6.41	40.46
Total	100.00	100.00	100.00	300.00

RF: Relative frequency, RA: Relative dominance, RD: Relative density and IVI: Importance value index

species in the studied community protected forest are presented in Fig. 2. Abundance of stems, in general, was very high at lower diameter classes and it drastically decreased as the diameter classes increased. For instance, 53% of the individual in the studied forest area was found in the dbh class less than 5 cm, whereas the higher dbh classes were comparatively represented by few individuals (Fig. 2). The number of individuals within the largest diameter class (>30 cm) accounted for only six percent. The main reason for decreasing percentage of the number of individual woody species within the largest diameter class (>30 cm) is due to cut and carry system used by the local people for construction materials and fuel wood consumption. This study is in line with the study made by Getaneh (2006), who revealed that woody species with dbh>30 cm harvested by the local people for construction and charcoal preparation.

Contributions of woody species

Ecological contribution: According to respondents, the forest is important contributing factor to the ecology of area in minimizing flood hazard in the lower stream, reduces soil erosion and minimizing desertification. According to their explanation, prior to the forest conservation efforts by local community, flood was a frequent phenomenon affecting the residential areas and farm lands of lower stream. Now, the occurrence of flood is minimized due to the involvement of the local communities by managing the forest resources judiciously.

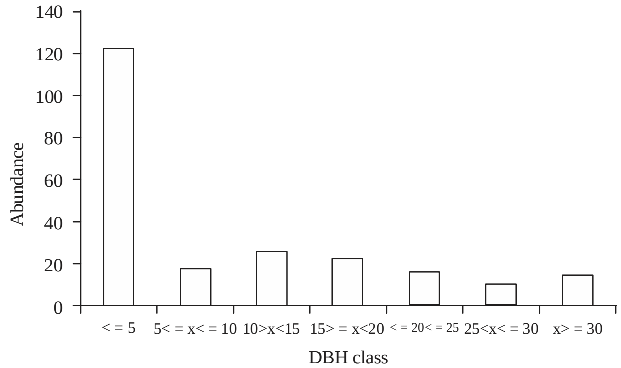

Fig. 2: Diameter class frequency distribution of all woody species in the study site

Management of woody species: Based on their own indigenous knowledge, people living near the protected community forest site developed their own management practices. That is, through their own initiation. Currently, the forest area is prohibited for unauthorized entry and seems to be free from human and livestock interferences. According to the information obtained from the group discussion made with the respondents, local communities of the study site developed a law which governs the whole beneficiaries on how to use the resources (the forest and its component resources). The present study is in line with the study made by Byron and Arnold (1999), which revealed that depending on the cultural background and the management objectives, local communities developed different traditional management practices and perception on forests resources. For some communities, forests are important not only for subsistence, but also for their spiritual life, which may influence the way they manage the forest.

CONCLUSION

On the basis of this study, it may be clearly stated that the forest resources substantially contribute and affect the socio economic and ecological well being of society. Fodder for animals, fruits, construction material and fuel wood are the main socio-economic contributions whereas flood reduction, stabilizing micro-climate and erosion control are among the ecological contributions of the forest resources. To assure suitable use of woody species, farmers employ a wide range of management practices. Guarding and fencing to prevent the interferences of human and livestock are the most commonly used system to manage community forests in the study area. The number of woody species in the community protected forests should be increased which may improve the productive as well as protective values of the forests. Moreover, it should be a priority issue for all concerned authorities including governmental agencies to intervene immediately in the problem.

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