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Research article

Plant diversity and community analysis of the vegetation around Tulu Korma project centre, Ethiopia

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Abstract: A study on plant diversity and community analysis was conducted between October 2014 to September 2015 with the objective of documenting plant species diversity together with the status and trends of biodiversity change. Common ecological methodologies and techniques were applied. Aerial photographs using Google earth and ground survey using GPS, compass and clinometers supported by ArcGIS based mapping was done to identify the clear distinction between vegetation and habitat heterogeneity before vegetation sampling. R statistical Software was used to run cluster analysis and ordination. Four plant community types were identified in the study. The Shannon-Weiner Diversity index was calculated to see the overall diversity of the study area. The area is with relatively high plant species diverse at H'= 3.37 with overall species evenness, J= 0.61 confirming the fact that Shewa floristic region is among the most species rich habitats. Ordination results showed that the major environmental variables structuring the floristic composition and plant community types and altitude was found to be the most influential factor at 95% confidence interval (P=0.005) using Canonical Correspondence Analysis. Comparison of historical records from literature and practical observation of the current status of the study area confirmed that there is an increasing trend of biodiversity and vegetation cover. This is justified by observing the positive impacts of the project centre for indigenous trees propagation and biodiversity development for Ethiopia located at Tulu Korma. The study showed that the area is rich in plant species and floristic composition, hence, experiences adopted by the Project Centre should be the lessons learned for the restoration and rehabilitation of similar environments.

Keywords: Cluster analysis - Ordination - Multipurpose plants - Indigenous species - Restoration.

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INTRODUCTION

Biodiversity is the variability among living organisms from all sources including *inter alia*, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species, and of ecosystems. In a broad sense it is to mean the abundance and distributions of and interactions between genotypes, species, communities, ecosystems and biomes. The term *inter alia* above is to mean among other things (Reynolds 2000, Gaston *et al*. 2004, Leadley *et al*. 2010, CBD 2011).

For countries like Ethiopia, it is important to learn the success histories from other countries as well as certain ongoing project trials in some parts of the country to rehabilitate degraded habitats, ecosystems and biodiversity loss. Ecological restoration is an attempt to return a system to some historical state, although the difficulty or impossibility of achieving the aim is widely recognized (Guyton 2001, Palmer *et al*. 2006, Naeem *et al*. 2009, Ferwerda 2012). A more realistic goal may be to move a damaged system to an ecological state that is within some acceptable limits relative to a less disturbed system. Ethnoecological approaches are among the key options in integrating academic disciplines and traditional ecological knowledge for sustainable environment (Albuquerque *et al*. 2014, Berkes *et al*. 1995, Berkes *et al*. 2000, Gómez-Baggethun *et al*. 2013).

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This research project focused on studying the status and trends of biodiversity change in Tulu Korma and its surrounding areas of Ejere District. Tulu Korma and its surrounding where the study was carried out is the Center for Indigenous Trees Propagation and Biodiversity Development in Ethiopia. The formerly known as "Center for Indigenous Trees Propagation and Biodiversity Development in Ethiopia" and currently named as "Center for the Restoration of Ethiopia's Biodiversity and Key Natural Resources" was founded by Professor Legesse Negash and established on 10 July 2004 with its primary objectives which envisages providing a platform for research and development on indigenous trees, shrubs, biodiversity, watersheds, and key natural resources including water and soils (Legesse Negash 2010).

MATERIALS AND METHODS

Location

Tulu Korma is located at 50–55 km West of Addis Ababa on the high way running from Addis Ababa to Ambo between 09°01.188' N and 038°21.570' E within altitude range of 2,163–2,267m. (Legesse Negash, 2010). Four neighboring kebeles bordering Tulu Korma are Chiri to the north, Kimoye to the west, Hora to the south and Endode to the east. Addis Alem is the nearest town about 3 kilometers from the center and it is with weather station from where the Ethiopian National Meteorological Service Agency (ENMSA) record weather data (Zewdie Kassa *et al*. 2016) (Fig. 1).

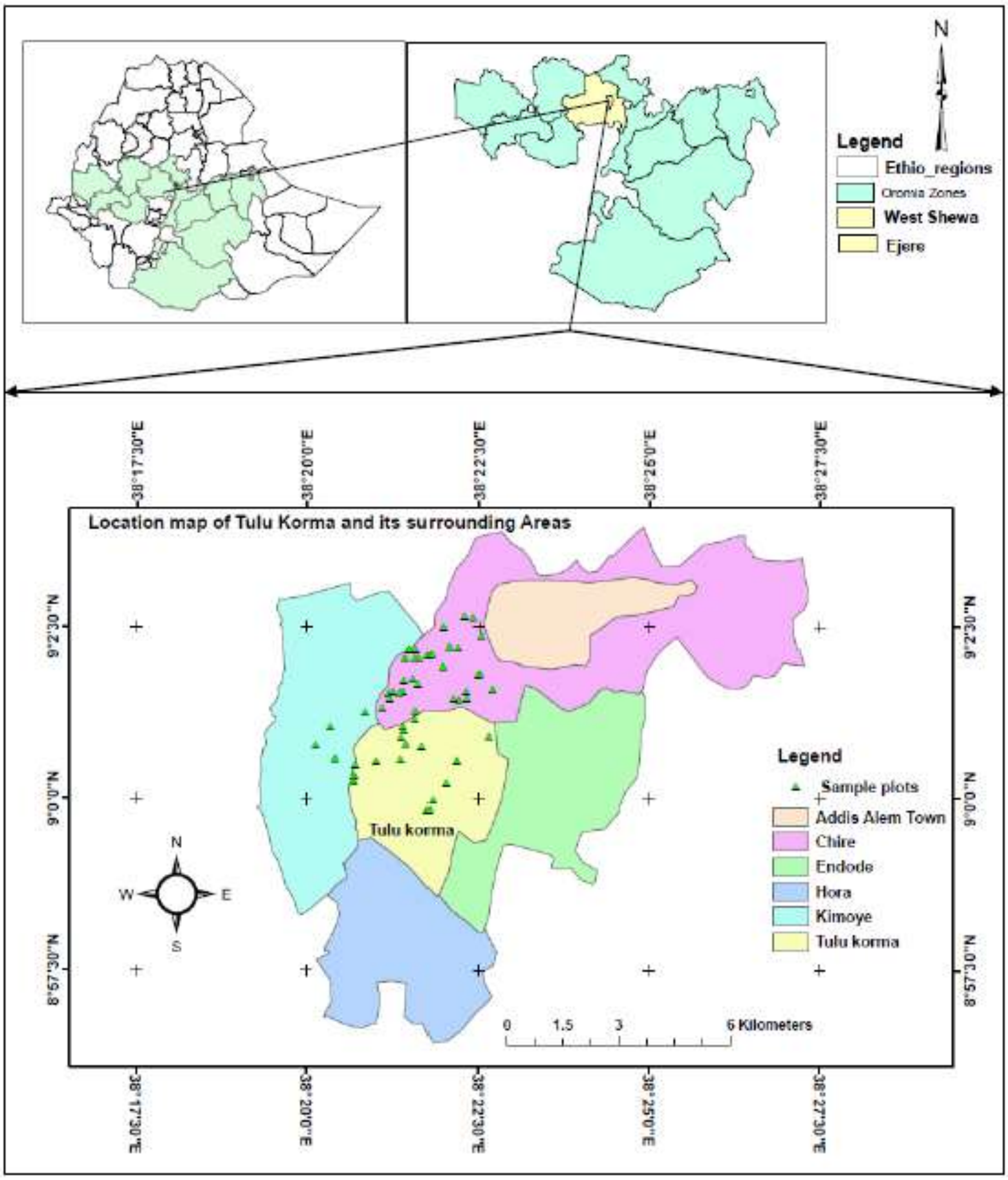


Figure 1. Location of the study area.

Climate

According to Zewdie Kassa *et al*. (2016), the annual average minimum and average maximum temperature for 16 years data is 7.4˚C and 26.2˚C respectively. The annual average temperature and average rainfall for the same years' data are 16.9˚C and 1099 mm respectively (Fig. 2).

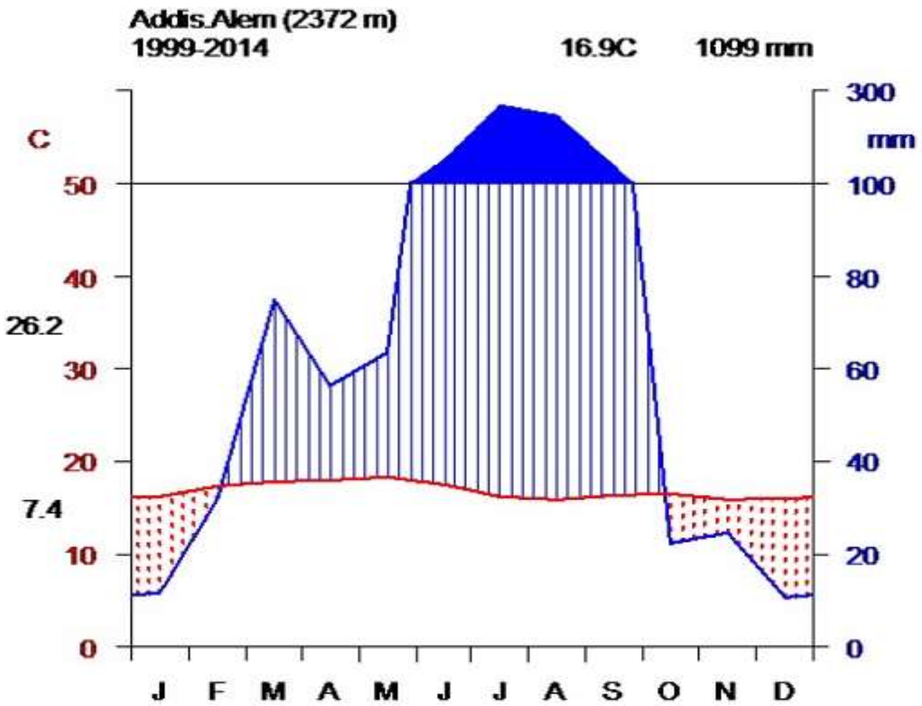


Figure 2. Climate diagram of the study area (data from ENMSA).

Vegetation

Areas between altitudes of 1800 and 3000 meters have been marked as the Dry evergreen Afromontane forest and grassland complex with the exception of high annual rainfall areas of 1700 millimeters and above (Friis *et al.* 2011). The vegetation of Tulu-korma and its surrounding belongs to such vegetation type and characterized by a canopy dominated by *Juniperus procera* (Cupressaceae), *Podocarpus falcatus* (Podocarpaceae), *Olea europaea subsp.Cuspidata* (Oleaceae), *Croton macrostachyus* (Euphorbiacea) and *Ficus spp.* (Moraceae). Shrubs and bush lands, woodlands and plantations are also available.

GIS data collection

It was noted that geographical information systems and models are among Computer-based Decision Support Tools integrating information (Mishra & Agarwal 2015). Hence, both aerial photographs using Google earth and ground survey using GPS, compass and clinometers supported by ArcGIS based mapping was done to identify the clear distinction between vegetation and habitat heterogeneity before vegetation sampling. Due to habitat heterogeneity, preferential sampling technique was used to collect vegetation and floristic data.

Vegetation and Ecological Data Collection

Vegetation data were collected using preferential sampling techniques and cover abundance values were calculated using presence/absence method (Kent & Cocker 1992). Cover was calculated as the area of the ground within a quadrate which is occupied by the above ground parts of each species when viewed from above (canopy cover) visually estimated as percentage. A 30m × 30m square quadrate was used to sample plant species. Sub-quadrates of 2m × 2m for grasses and sedges, 5m × 5m for herbs, 10m x 10m for shrubs were used to estimate the cover abundance values of different plant habits. The layouts of the quadrates were in such a way that one from each corner of the large quadrate and one at the center for the respective life forms. Species abundance values were converted following the Braun-Blanquet 1–9 scales (Van Der Maarel 2005) by calculating the Ordinal Transformed Values (OTV) as,

$$\text{OTV} = 1.415 \ln C + 2$$

Where, ln is the natural logarithm and C is the cover abundance value in percentage. The vegetation data were arranged in a three column format (sites, species and abundance) of creating ecological data tables for ease of analysis using R statistical software following (Zerihun Woldu 2012). The data were then carefully inspected in the three column table to check for possible errors before analysis.

Ecological data such as altitude, latitude, longitude, slope and aspect were collected by setting the GPS on the projected coordinate system format (UTM_Adindan_Zone 37). Aspect and slope were also carefully recorded by using SILVA compass and SILVA Ranger Clinometers instruments respectively right during specimen collection. Geophysical features, presence/absence and intensity of disturbance were recorded (Milgo 2011). Assessment of the type and levels of disturbance were determined by carefully observing the presence or absence of types of disturbance such as charcoal burning, fire, pole cutting, grazing, firewood collection, agriculture, construction, bee harvesting and any other. Then disturbance scales were set as: 0= no disturbance, 1= 0–20% of the quadrate disturbed, 2= 21–40% of the quadrate disturbed, 3= 41–60% of the quadrate disturbed, 4= 61–80% of the quadrate disturbed, 5= 81–100% of the quadrate disturbed.

Specimen Collection and Identification

Voucher specimens were collected together with all the necessary information about the specimens carefully recorded at the spot. Specimen identification and deposition was made at the National Herbarium, Addis Ababa University using taxonomic keys, characters and published volumes of the flora of Ethiopia and Ertrea as well as other reference sources (Fitchl & Admasu Adi 1994, Hedberg & Edwards 1989 1995, Edwards *et al*. 1995, Edwards *et al*. 1997, Edwards *et al*. 2000, Judd *et al*. 2002, Hedberg *et al*. 2004, Hedberg *et al*. 2006, Azene Bekele 2007, Friis 2009).

Data Analysis

Vegetation data was analyzed using R statistical software (R Core Development Team 2013). The Shanon-Weiner diversity index was used to analyze vegetation data following Zerihun Woldu (2012). Hence the Shannon Diversity Index (H') is the average uncertainty per species in an infinite community made of S species with known proportional abundance and the Pi are the population parameters:

$$Shannon\ Diversity\ Index\ (H') = \sum_{i=1}^{s} PilnPi = \sum_{i=1}^{s} [\{\frac{\mathrm{ni}}{\mathrm{n}}\}\ln\{\frac{\mathrm{ni}}{\mathrm{n}}\}]$$

where n_i = the number of individuals belonging to the i^{th} of S species in the sample, n= the number of individuals in the sample, Pi = $\frac{\mathrm{ni}}{\mathrm{n}}$, the probability of sampling species i, $\ln\{\frac{\mathrm{ni}}{\mathrm{n}}\}$ = the natural logarithm of the probability of sampling species i. Shannon's equitability (J) was calculated to test species evenness as:

$$Equitability\ (J) = \frac{H}{Hmax} = \frac{H}{lnS}$$

where S is species richness, lnS is the natural logarithm of the species richness and J assumes the values between 0 and 1 with 1 being with complete evenness. Diversity, richness and evenness values were computed by running a data frame in R statistical software for diversity analysis. Sørensen's coefficient of similarity index was used to compare the general floras with respect to other flora areas in Ethiopia (Wildi 2010) and the output of the analysis interpreted. This, Sørensen's Similarity Index (I) calculated as:

$$Ss = \frac{2a}{(2a + b + c)}$$

Where, Ss is Sørensen's coefficient of similarity, "a" is the number of species common to both samples, 1 and 2, "b" is the number of species in sample 1 and "c" is the number of species in sample 2.

RESULTS

Plant Diversity and floristic composition

A total of 304 plant species belonging to 216 genera and 78 families were identified (Appendices 1, 2, 3). About four major life forms were identified of which 165 (54.28%) of the species were herbs, 80 (26.32%) were shrubs, 43 (14.14%) were trees and the remaining 16 (5.26%) were climbers. Top five plant families with the highest percentages of the total recorded were Asteraceae 50 (64.10%), Fabaceae 27(34.62%), Lamiaceae 25(32.05%), Poaceae 18(23.04%) and Solanaceae 15 (19.23%). About 47.44% of the families were represented by more than one species and 52.56% of the families were represented by single species each accounting 1.28% of the total (Appendix 2).

Visual classification of vegetation into sub sites was made to get homogenous representative groups for sampling. Five sub sites namely BERGA (BG), GAWO (GW), SAFARA (SF), SOROR (SR) and TECHISA (TC) localities were identified based on Google Earth images, their vegetation composition as well as visually observed ecological factors such as altitude, aspect slope, intensity of grazing and disturbance. Plot distribution among visually classified vegetation types and sub sites for sampling frame is indicated below (Table 1).

Table 1. Plot distribution among visually classified vegetation groups.

S.N.	Locality	Plots	Size	Percentage
1	BERGA	1,2,3,5,6,7,8,28,29,30,31,32	12	24
2	GAWO	9,10,11,22,38,39,40,41	8	16
3	SAFARA	34,35,36,37	4	8
4	SORORO	4,11,12,24,26,27,	6	12
5	TECHISA	13,14,15,16,17,18,19,20,21,23,33,42,43,44,45,46,47,48,49,50	20	40
		Total	50	100

Plant Community

The result of visual vegetation classification indicated five visually classified vegetation. Vegetation sampling and plots per the visual classification were taken proportionally (Fig. 3).

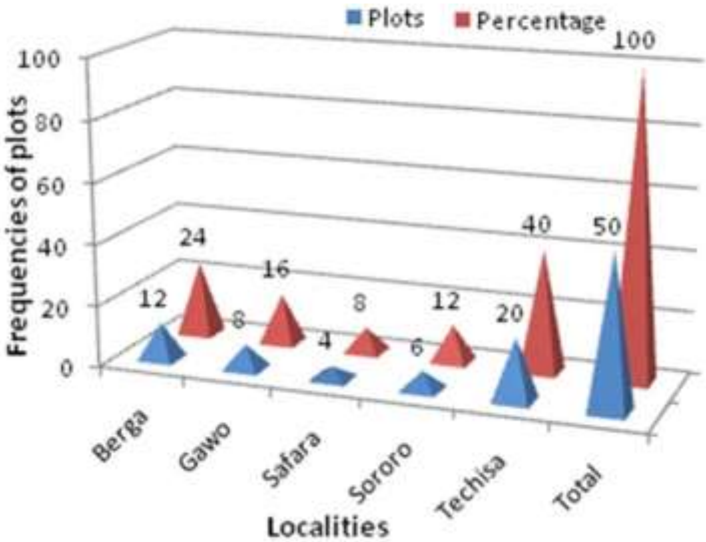


Figure 3. Frequencies of plots per visually classified vegetation.

Clustering along elevation range was also done and the result was compared with the dendrogrm output. The dendrogram output merged the five visually identified vegetations into four major clusters after proper inspection of the dendrogram structure and partitioning methods (Table 2).

Table 2. Cluster distribution along elevation range.

C	Cluster Groups/Sub sites/Plots	S	%	Ele. (m)	Diff. (m)
1	BG,BG,TC,TC,GW,GW,GW,BG,SF,SF,SF,TC,SF 5,6,13,18,22,9,41,32,34,37,36,33,35	13	26	2142–2269	127
2	BG,BG,SR,BG,TC,TC,TC,TC,TC,TC,TC,TC 3,7,27,28,19,20,21,23,47,45,46,43,	12	24	2121–2306	185
3	BG,TC,TC,SR,TC,TC,TC,BG,TC 1,16,49,12,44,14,15,2,48	9	18	2111–2237	126
4	SR,SR,BG,TC,TC,BG,GW,GW,SR,TC,BG,GW,SR,BG,GW,GW 4,26,29,42,50,8,10,38,25,17,31,39,24,30,11,40	16	32	2122–2338	216

Note: BG = Berga, GW = Gawo, SF = Safara, SR = Sororo, TC = Techisa; C = Cluster, S = Cluster size, % = Percentage, Ele. = Elevation, Diff. = Elevation difference.

Results of vegetation data analysis using R Statistical Software version 3.0.2 (R Core Development Team 2013) revealed four clusters that could be recognized as plant community types. Division of the dendrogram out put into specific number of cluster was done after inspection. The result of the inspection indicated that there are four numbers of possible clusters with K-value equal to 4 clusters. The K value was also confirmed for consistency by partitioning method which is obtained by plotting within groups' sum of squares versus number of clusters and observing where there is a sharp break in the graph. The value on the x-axis where there is sharp break of the graph represents the optimal number of clusters in the dendrogram (Fig. 4).

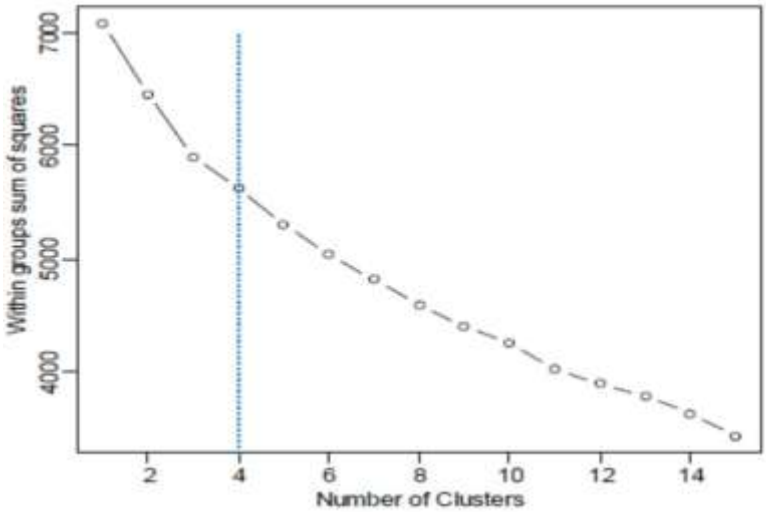
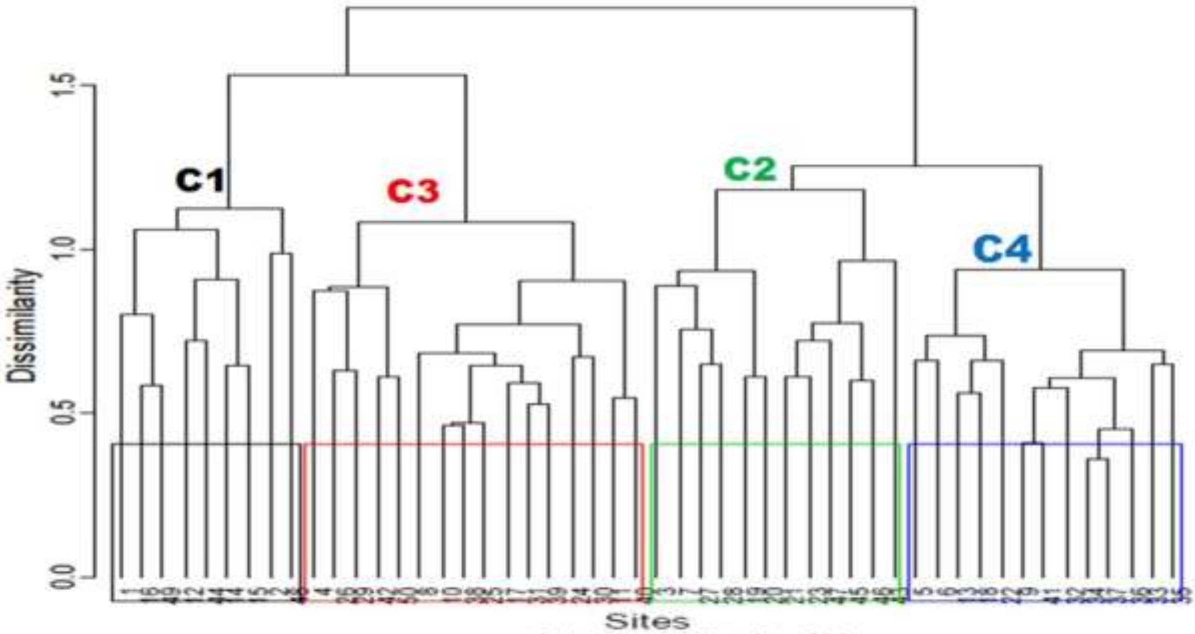


Figure 4. Optimal number of clusters.

The result was plotetted in the dendrogram as indicated below. From the dendrogram, the following sites belong to the respective cluster number and community type. The four community groups were indicated in the dendrogram output of agglomerative hierarchical cluster analysis using similarity ratio (SR) in R version 3.0.2 (R Core Development Team 2013) (Fig. 5).

uster1(C1)= Community1: 1,16,49,12,44,14,15,2,48 with cluster size = 9
Cluster2(C2)= Community2: 3,7,27,28,19,20,21,23,47,45,46,43 with custer size = 12
Custer3(C3)= Community3: 4,26,29,42,50,8,10,38,25,17,31,39,24,30,11,40 with cluster size =16.
Cluster4(C4)= Community4: 5,6,13,18,22,9,41,32,34,37,36,33,35 with cluster size = 13
Community 3 comprises about 32% of the clusters followed by community 4 about 26%, followed by community 2 about 24% followed by community 1 about 18% of the clusters.



$$SR = \frac{(\Sigma x(k,j)(\Sigma x(k,j)))}{(\Sigma x(k,i)^2 + \Sigma x(k,j)^2) - (\Sigma x(k,i)(x(k,j)))}$$

Figure 5. Agglomerative Hierarchical Cluster Analysis using similarity ratio (SR).

A combination of dominant or characteristic species with high synoptic values in each community types were used to name these plant community types (Table 3). A range of possible environmental variables such as altitude, aspect, slope, grazing and disturbance were analyzed and presumed to be structuring plant species composition and community types were indicated by ordination graph (Fig.6).

Table 3. Synoptic table of species reaching value of ≥1 in at least one community type.

Cluster Number	**Cluster 1**	**Cluster 2**	**Cluster 3**	**Cluster 4**
Cluster Size	**13**	**12**	**9**	**16**
Acacia abyssinica	4.56	0	0	0
Cordia africana	2.11	0	0	0
Sesbania sesban	1.56	0	0	0
Acacia negrii	1.44	0	0	0
Andropogon abyssinicus	1.33	0	0	0
Caesalpinia decapetala	1.22	0	0	0
Xanthium spinosum	1	0	0	0
Olea europaea	0	3	0	0
Rhus glutinosa	0	2.42	0	0
Croton macrostachyus	0	2.25	0	0
Capparis tomentosa	0	2	0	0
Rhus vulgaris	0	1.92	0	0
Pittosporum viridiflorum	0	1.33	0	0
Clematis simensis	0	1.08	0	0
Podocarpus falcatus	0	0	5.38	0
Ficus sur	0	0	3.31	0
Calpurnia aurea	0	0	2.06	0
Phoenix reclinata	0	0	1.75	0
Vernonia amygdalina	0	0	1.63	0
Juniperus procera	0	0	1.25	0
Bersama abyssinica	0	0	1.19	0
Ficus palmata	0	0	1.13	0
Salix subserrata	0	0	1.06	0
Albizia schimperiana	0	0	0	5.38
Carissa spinarum	0	0	0	1.62
Dovyalis abyssinica	0	0	0	1.54
Pterolobium stellatum	0	0	0	1.31
Euclea divinorum	0	0	0	1.31
Premna schimperi	0	0	0	1.15

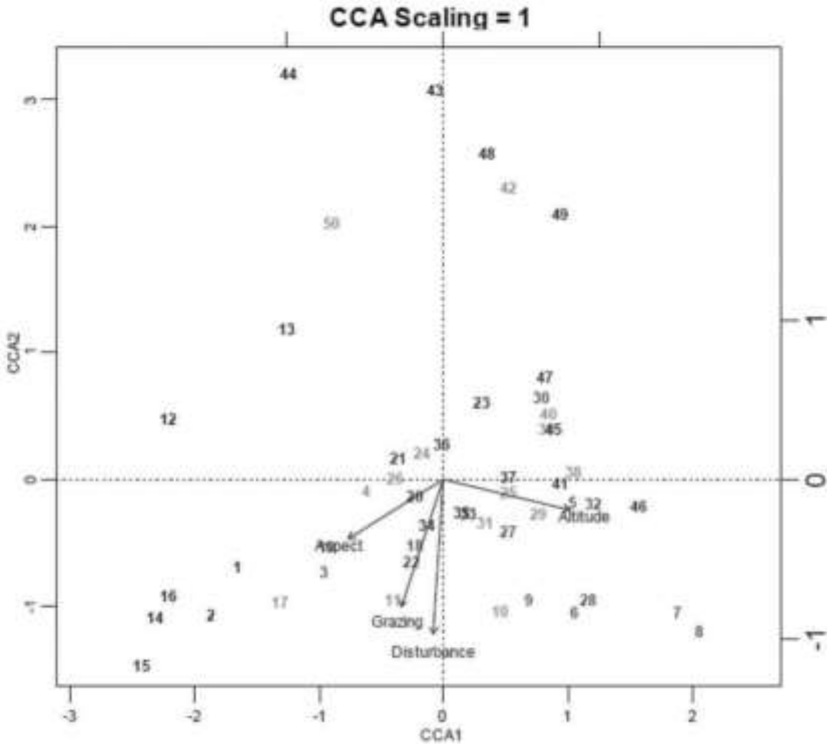


Figure 6. CCA: Displaying sites constrained by environmental factors using clusters.

However, analysis of soil as one of the possible environmental variables did not included in this study. The description of these plant community types is shown as follows. Therefore, it is worth considering soil as one of the variable structuring plant species composition thereby community type although the analysis is not included here.

Cordia africana-Acacia abyssinica type

This community type is found between elevation ranges of 2142–2269 m and dominated by *Acacia abyssinica and Cordia africana plant species. Sesbania sesban, Acacia negrii, Andropogon abyssinicus, Caesalpinia decapetala and Petrolobium stellatum* are also common species on this community type. Similarly, *Carissa spinarum, Croton macrostachyus, Pittosporum virdiflorum, Capparis tomentosa, Olea europaea, Salix subserrata*, *Juniperu procera*, *Podocarpus falcatus*, *Premna schimperi*, and *Pterolobium stellatum* are relatively rare species in this community type (Fig. 7).

Figure 7. A–B, *Cordia africana-Acacia abyssinica* community type.

Olea europaea- Rhus glutinosa type

This community type is found between elevation ranges of 2121–2306 m and dominated by *Olea europaea, Rhus glutinosa, Croton macrostachyus, Albizia schimperiana and Capparis tomentosa* plant species. Common

Figure 8. A–D, *Olea europaea-Rhus glutinosa* community type.

characteristic plant species belonging to this community include *Rhus vulgaris, Carissa spinarum, Pittosporum virdiflorum, Calpurnia aurea, Pterolobium stellatum, Caesalpinia decapetala* and *Clematis simensis*. Other relatively rare species belonging to this community include *Podocarpus falcatus, Bersama abyssinica, Euclea divinorum, Juniperus procera, Premna schimperi, Andropogon abyssinicus* and *Salix subserrata* (Fig. 8).

Podocarpus falcatus-Ficus sur type

The dominant species in this community type are *Acacia abyssinica, Podocarpus falcatus, Ficus sur* and *Croton macrostachyus* and it is found in the altitude ranges of 2111–2237 m. Other common characteristic species belonging to this community include *Calpurnia aurea, Phoenix reclinata, Olea europaea, Vernonia amygdalina, Carissa spinarum, Rhus vulgaris, Bersama abyssinica, Juniperus procera, Ficus palmate* and *Salix subserrata. Species such as Petrolobium stellatum, Premna schimperi, Dovyalis abyssinica, Pittosporum viridiflorum, Euclea divinorum, Acacia negrii, Andropogon abyssinicus, Caesalpinia decapetala, Capparis tomentosa, Clematis simensis* and *Rhus glutinosa* are relatively rare species of this community type (Fig. 9).

Figure 9. A–D, *Podocarpus falcatus-Ficus sur* community type.

Albizia schimperiana- Carissa spinarum

The dominant plant species of this community type are *Acacia abyssinica, Albizia schimperiana, Croton macrostachyus* and *Olea europaea*. The community is found in the altitude range of 2122__2338m. Relatively common species of this community type are *Rhus glutinosa, Calpurnia aurea, Capparis tomentosa, Carissa spinarum, Rhus vulgaris, Dovyalis abyssinica, Euclea divinorum, Premna schimperi* and *Pterolobium stellatum*. Species such as *Juniperus procera, Podocarpus falcatus, Vernonia amygdalina, Acacia negrii, Andropogon abyssinicus, Phoenix reclinata, Pittosporum viridiflorum, Bersama abyssinica* and *Clematis simensis* are relatively rare species of this community (Fig. 10).

Ordination

To see which environmental variables that were responsible for structuring the plant species composition and community types, the results/values of test for significance of environmental variables were obtained for Canonical Correspondence Analysis (CCA) by running the environmental data for the sites in R Statistical Software (Table 4).

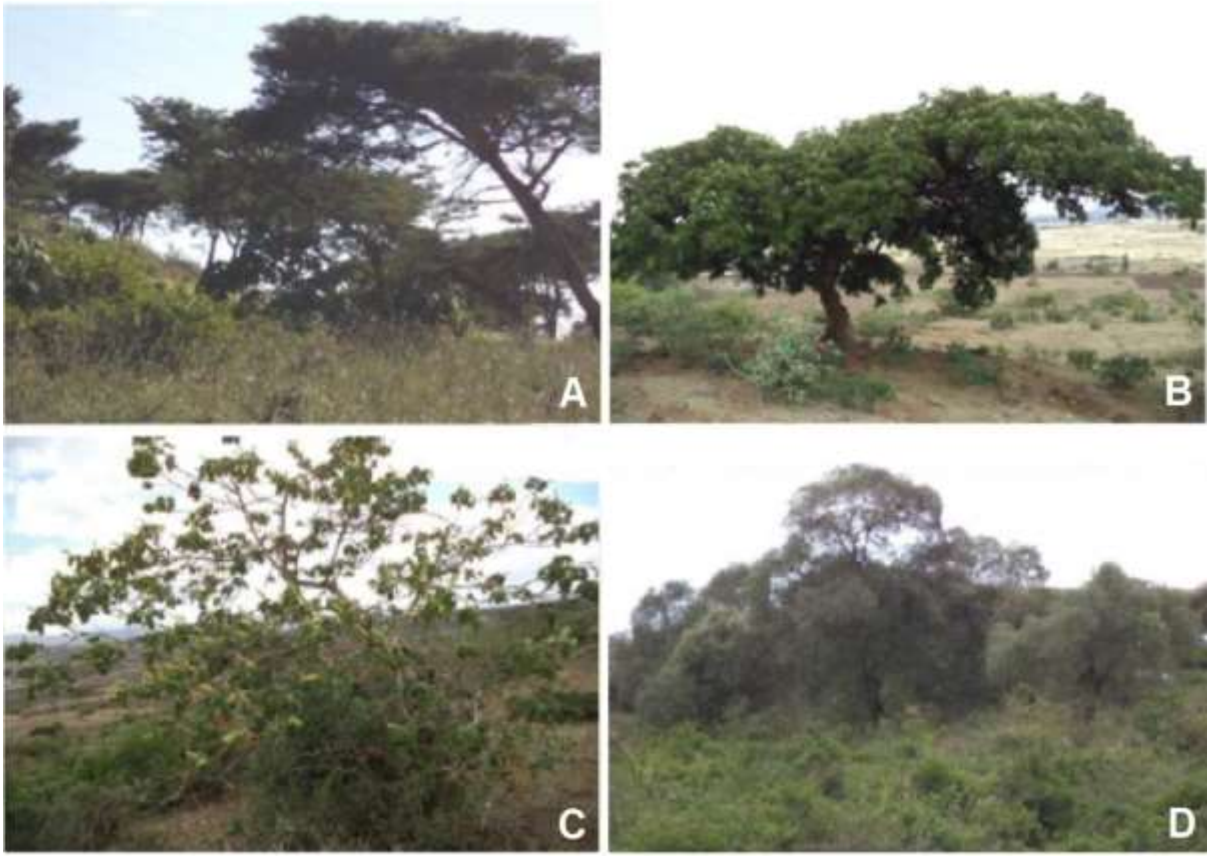


Figure 10. *Albizia schimperiana-Carissa spinarum* community type.

Environmental factors for constraint analysis: CCA and ANOVA

Results of backward and forward selection of environmental variables for constrained analysis based on their P-value and Akaike Information Criterion (AIC) where the variable with the lowest AIC value is the most influential (Table 4).

Table 4. Results of test for significance of environmental variables, CCA

Variables	Df	AIC	F_val.	N.per	Pr(>F)	Significance Codes	Significance
Altitude	1	307.10	1.6538	199	0.005	**	Yes
Disturbance	1	307.20	1.5529	199	0.005	**	Yes
Aspect	1	307.25	1.5055	199	0.010	**	Yes
Grazing	1	307.37	1.3910	199	0.010	**	Yes
Slope	1	307.51	1.2475	199	0.045	*	Yes

Results for ANOVA & CCA test for the significance of each environmental variable prior to analysis, sequential test for terms, test for axis and permutation test for CCA under reduced model marginal effects of terms are given below (Table 5).

Table 5. Results for ANOVA in conjunction with CCA to filter out environmental variables.

Variables	Df	Sum of Sqs	Mean Sqs	F. model	R2	Pr (>F)	Signi. codes	Significance
Slope	1	0.3941	0.39407	1.3522	0.02605	0.12		No
Aspect	1	0.4560	0.45598	1.5646	0.03107	0.03	*	Yes
Grazing	1	0.4700	0.4700	1.6127	0,04471	0.02	*	Yes
Altitude	1	0.6763	0.67628	1.3205	0.02028	0.01	**	Yes
Disturbance	1	0.3067	0.30671	1.0524	0.84775	0.32		No
Residuals	44	12.8282	0.29244		1.00000			No
Total	49	15.1262						

Results for permutation test sequentially for CCA under reduced model (Table 6); results of ANOVA.CCA test for availability of axes (Table 7); results for permutation test for cca under reduced model marginal effects of terms (Table 8) and the values of CCA (Table 9) to display sites constrained by some environmental factors using cluster groups have also been provided (Fig. 6).

Table 6. Results of sequential test for terms for significance environmental variables.

Variables	Df	Chisq	F	N.perm	Pr (>F)	Signi.codes	Significance
Slope	1	0.1738	1.2893	99	0.05	*	Yes
Aspect	1	0.1922	1.4262	99	0.02	*	Yes
Grazing	1	0.1807	1.3405	99	0.01	**	Yes
Altitude	1	0.2223	1.6489	99	0.01	**	Yes
Disturbance	1	0.1608	1.1929	99	0.09	.	Low
Residual	44	5.9309					

Table 7. Results of test for availability of axis CCA.

Axis	Df	Chisq	F	N.perm	Pr (>F)	Signi.codes	Significance
CCA1	1	0.2654	1.9688	99	0.01	**	Yes
CCA2	1	0.2221	1.6478	99	0.02	*	Yes
CCA3	1	0.1736	1.2878	99	0.04	*	Yes
CCA4	1	0.1507	1.1171	99	0.24		No
CCA5	1	0.1180	0.8757	99	0.85		No
Residuals	44	5.9309					

Table 8. Results of anova.cca values for marginal effects of environmental variables.

Variables	Df	Chisq	F	N.perm	Pr (>F)	Signi.codes	Significance
Slope	1	0.1581	1.1726	99	0.15000		No
Aspect	1	0.1671	1.2395	2699	0.06222	.	Low
Grazing	1	0.1361	1.0098	99	0.47000		No
Altitude	1	0.2221	1.6474	199	0.00500	**	Yes
Disturbance	1	0.1608	1.1929	99	0.13000		No
Residuals	44	5.9309					

Table 9. Biplot scores for constraining variables to show colored cluster groups.

Variables	Available axis					
	CCA1	CCA2	CCA3	CCA4	CA1	CA2
Altitude	0.807	-0.19	-0.516	-0.22	0	0
Grazing	-0.271	-0.80	-0.024	-0.54	0	0
Aspect	-0.607	-0.37	-0.667	0.22	0	0
Disturbance	-0.065	-0.97	0.188	-0.16	0	0

The Beta diversity of paired comparison of sites (Sørrensen index of dissimilarity) was found to be 0.79 indicating beta diversity indexes for the sample plots. The Shannon-Wiener diversity and the Simpson diversity indices were used to calculate alpha diversity. The result of the measures of combined information in multiple taxa of plant species and their respective abundance values per plot in the whole data frame was represented in (Appendix 4) and that of clusters is also indicated (Table 10).

Table 10. Shannon-Wiener and Simpson diversity indices for clusters. (H=Diversity)

Clusters	Richness	H (Shannon-Wiener)	H (Simpson)	ShannonEvenness	Simpson Evenness
1	194	4.74333312	55.39280314	0.900429164	0.285529913
2	161	4.520059437	58.50900307	0.889529569	0.363409957
3	183	4.456467679	42.39296476	0.855452447	0.231655545
4	87	3.727884826	25.0698853	0.83474284	0.288159601

DISCUSSION

Plant Diversity and floristic composition

The result of vegetation data analysis revealed that Tulu Korma and its surrounding area is very rich in plant species diversity and floristic composition. About 37 (47.44%) of the families recorded from the area were represented by two and more species while about 41 (52.56%) of the families were represented by only a single species (1.28%) each.

Top ten species rich families were *Asteraceae* (50, 64.10%), *Fabaceae* (27, 34.62%), *Lamiaceae* (25, 32.05%), *Poaceae* (18, 23.08%), *Solanaceae* (15, 19.23%), *Acanthaceae* (9, 11.34%), *Amaranthaceae* (8, 10.26%), *Cucurbitaceae* and *Rubiaceae* (7, 8.97%) each and *Brassicaceae* (6, 7.69%). The remaining families; *Apiaceae, Euphorbiaceae, Myrsinaceae, Polygonaceae, Ranunculaceae and Rosaceae* were (5, 6.41%) each; *Boraginaceae, Flacourtiaceae; Myrsinaceae* and *Oleaceae* (4, 5.13%) each; *Anacardiaceae, Asparagaceae,* *Buddlejaceae, Celastraceae, Cucurbitaceae, Malvaceae, Moraceae, Sapindaceae* and *Urticaceae* (3, 3.85%) each; *Asclepiadaceae, Balsaminaceae, Cactaceae, Cupressaceae, Rhmnaceae, Rutaceae, Tiliaceae* and *Verbenaceae* (2, 2.56%) each (Appendix 2).

The results also indicated that family *Asteraceae* (50, 64.10%) was represented by the largest number of species in the area confirming the fact that family *Asteraceae* is among the species rich families in the flora areas of the Flora of Ethiopia and Eritrea (Mesfin Tadesse 2004).

Environmental variables structuring the vegetation composition

Factors responsible for structuring the community types observed in this study will be best explained by the outputs of ordination analysis pining to five main environmental variables namely altitude, aspect, disturbance, grazing and slope of which only four of them were found to be significant variables. Moreover, stepwise selection of environmental factors for constrained analysis using Analysis of variance (ANOVA) in conjunction with Canonical Correspondence Analysis (CCA) based on their P-value and Akaike Information Criterion (AIC) where the variable with the lowest AIC value (Table 4) is the most influential indicated that altitude was found to be the most influential environmental variable at 95% confidence interval ($P = 0.005$) using CCA ordination (Table 4).

Analysis of diversity

Oksanen (2015) noted that species accumulation models and species pool models study collection of sites and their species richness. It was further noted that the exact method of calculating site based species accumulation curve yielded results that are very close to classical algorisms based on a random approach (Kindt & Coe 2005, Kindt *et a*l 2006, Oksanen 2015). The Beta diversity of paired comparison of sites (Sørrensen index of dissimilarity) for the vegetation of Tulu Korma and its surrounding areas was found to be 0.79 indicating beta diversity indexes for the sample plots. It was stated that beta diversity measures the change in diversity of species among sets of habitats (Zerihun Woldu 2012). According to (Whittaker 1960 1972), high beta diversity ($^{\beta}w > 5$) implies low level of similarity while low beta diversity ($^{\beta}w < 1$) implies high level of similarity among sets of habitats. Moreover, it was said that since species turn over between cluster groups is greater than species turnover between sample plots of the original data high species turnover will indicate high beta diversity (Whittaker 1972). Hence, for this particular study, since the value of beta diversity was found to be $^{\beta}w = 0.79$ and this value is less than one ($^{\beta}w < 1$), it indicates that there is low beta diversity with no species turnover and hence high level of similarity among the five sets of vegetation groups that were visually classified as discussed before.

Similarly, the overall Shannon-Wiener diversity and Simpson diversity indices were also computed to measure the average degree of uncertainty in predicting to what species an individual chosen from a random collection of S species and N individuals will belong. Hence, Shannon diversity (H) was found to be 3.37 with P value = 0.04, then Simpson = 1-P which is about 0.96 on average. In other words, this value is the overall diversity index of the study area which is relatively higher although it is lower than the diversity indices reported by other studies like Ermias Lulekal (2014) which was H' equal to 4.07 for Dense forest of Ankober District in North Shewa Zone of Amhara Regional State, Ethiopia. The Shannon-Wiener equitability $(J) = H/H_{max} = H/\log(S)$. The overall equitability for S=251 species found to be, equitability (J) =0.61 which is the average degree of equitability. It was emphasized that a larger Simpson Index will indicate lower diversity; hence it is better to analyze the reciprocal value of the Simpson Index. An alternative approach is to report 1-Simpson index (Kindt & Coe 2005). The overall Shannon-Wiener index (H'= 3.37) and over all species evenness (J = 0.61) indicate high species diversity. This high species diversity is in line with Friis (2009) that the Shewa floristic region is one of the most species rich areas of the flora regions. The values of the Shannon-Wiener diversity indices for the four clusters were also analyzed to show the diversity among cluster groups (Appendix 4; Table 10).

Major threats to vegetation

The major threats identified during the course of the study were agricultural intensification, high population pressure, charcoal making, firewood collection, grazing and demand of plant products for construction and tools. There are also warning signs of invasive alien species such as *Parthinium hystophorus*, *Argemone mexicana* and *Lantana trifolia* encroachment observed in the area although their distribution is very limited.

Eucalyptus plantations are also almost replacing the indigenous trees and other natural vegetation around the town margins of Addisalem Town.

Impact of centre for indigenous trees propagation project on the area

The Tulu Korma Centre for Indigenous Trees Propagation and Biodiversity Development project is an interesting trial from where lessons has to be learnt in restoration and rehabilitation activities of similar environments of other places. There is dramatic change in vegetation cover of the project area during the past decade. A good justification is that practical observation of the current status of the area and historical records that maintained by the founder of the centre before the project has centre has established. The centre's impact is not only restoring and rehabilitating the already dead habitat to its current living one but also has changed the minds and levels of understating of the local community of the surrounding areas towards vegetation conservation. Such positive impact was confirmed during individual as well as group discussion with local informants. Farmers, for instance, maintained remnant trees standing in their farmlands and tree cutting is not common practice in the area.

Moreover, in areas few kilometers away from the centre along the Berga River there are patches of vegetation in some pocket places with better conservation status. Information from the local informants showed that it is the farmers of the surrounding areas who kept the vegetation with the lowest possible disturbances. Therefore, it is good implication that the surrounding communities have learnt a lot from the project activities about vegetation conservation. The scenario also justifies the hypothesis that the Tulu Korma project centre for indigenous trees propagation and biodiversity developments has positive impact on local communities' understating of vegetation conservation to come to be true resulting in increasing trend of biodiversity of the area. That takes us to the conclusion that there is a need to knowledge integration from farmers' traditional ecological knowledge (FTEK) and scientific practices engaged in ecosystem conservation.

Floristic similarity

The Sørensen index of similarity with respect to nine floral areas; Masha= 20% (Abreham Assefa *et al*. 2013), Adisalem-Ginchi= 35% (Abdi Shentema 2012), Ginchi-Ambo= 38% (Belete Kebede 2012), Jeldu= 60% (Zewdie Kassa 2009), Bale Mountain= 15% (Haile Yinger *et al*. 2008), Cheliya= 33% (Endale Amenu 2007), Gimbi = 16% (Etana Tolasa 2007), Wonago = 45% (Fiseha Mesfin 2007), Borena = 4% (Gemedo Dalle *et al.* 2005) revealed that the vegetation of Tulu Korma and its surrounding areas most similar to Jeldu at 60% (Zewdie Kassa 2009) similarity and least similar to Borena at 4% (Gemedo Dalle *et al*. 2005) similarity. The highest similarity index with respect to Jeldu is pertaining to the fact that these two places are located in the same vegetation type, the Dry Evergreen Montane Forest and Grassland complex, (Friis *et al*. 2011) as well as the same sampling method followed during the study. Similarly, the least similarity with respect to Borena is pertaining to the fact that Borena lowland belongs to *Combretum-Terminalia* and *Acacia-Commiphora* woodlands which is different vegetation when compared to that of Tulu Korma and its surrounding (Appendix 5).

CONCLUSIONS

The current study revealed that Tulu Korma and its surrounding environs are very rich in plant species and floristic composition as well as indigenous traditional ethnobotanical knowledge systems. Comparison of historical records from literature and practical observation of the current status of the study area with regard to the trends of biodiversity changes in the area confirmed that there is an increasing trend of biodiversity and vegetation cover. The increasing trend is justified by observing the positive impacts of the project centre for indigenous trees propagation and biodiversity development located at Tulu Korma.

Although altitude, aspect, disturbance and grazing were found to be among the main environmental variables structuring the plant species composition as well as plant community types of the study area, altitude is the most influential environmental variable. This was justified by the ordination out puts of stepwise test for the significance levels of all the environmental variables presumed to be significant effects.

In Tulu Korma and its surrounding areas, despite the fact that there is better understanding of the local communities about vegetation conservation, there are also potential threats that need top priority for long-lasting and sustainable vegetation conservation of the area. This will come to be true by integrating and implementing effective natural resource management policies in connection with community based conservation projects at its grass root level. This can be come to truth through understanding the need to build on the existing resources of indigenous plant communities by improving on their management sustaining the resources as well as further domestication of highly valuable taxa.

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Supporting information

Appendix 1: List of species.
Appendix 2: List of Families.
Appendix 3: List of Genera.
Appendix 4: Values of the Shannon-Wiener diversity indices for each plot.
Appendix 5: Floristic similarity.

Appendix 1: List of plant species collected from Tulu Korma and its surrounding areas of Ejere District. (Key: T- Tree, Sh-Shrub, H- Herb, Li- Liana, Cl- Climber, W- Willd, HG- Homegarden, SW- Semi wild, Coll No.(ZKX)- Collection number, DSC_Code- Digital Scan_Code of fresh specimen during data collection)

SN	Species Name	Habit	Vernacular Name	Family	Coll. No.	Digital Scan code/ Photo	Range of Alt. (m) Distribution	Plant collected from
1	*Acacia abyssinica* Hocst. ex Benth	T	Laaftoo	Fabaceae	ZK038	DSC01539/540	1500-280	W
2	*Acacia albida* Del.	T	Garbii	Fabaceae	ZK275		~2600	W
3	*Acacia mearnsii* Del. Wild.	T	Amoozaa	Fabaceae	ZK136	DSC01922	elsewhere	HG
4	*Acacia melanoxylon* R.Br.	T	Omedla (Am)	Fabaceae	ZK276			HG
5	*Acacia negrii* Pic.Serm.	T	Dodota	Fabaceae	ZK277	DSC00384/385	2000-3100	W
6	*Acacia polyacantha* Willd.	T		Fabaceae	ZK278	DSC00430/431	500-1600	W
7	*Acacia seyal* Del.	T	Laaftoo	Fabaceae	ZK279			W
8	*Acanthes sennii* Chiov.	S	kosorruu	Acanthaceae	ZK225	DSC02419	1700-3200	W
9	*Achyranthes aspera* L.	H	Darguu	Amaranthaceae	ZK039	DSC01561-563	750-3050	W/HG
10	*Acmella caulirhiza* Del.	H	Gutichaa	Asteraceae	ZK047	DSC01572/573	550-2600	W
11	*Aeschynomene abyssinica* (A.Rich.) Vatke	S		Fabaceae	ZK280		1300-3300	W
12	*Agave sisalana* Perrine ex Engel	H	qaaca	Agavaceae	ZK281	DSC07178/179		HG
13	*Ageratum conyzoides* L.	H		Asteraceae	ZK089	DSC01408	1900-2400	W
14	*Ajuga integrifolia* Buch.-Ham. ex D. Don	H	Armaguusaa	Lamiaceae	ZK282	DSC00418	1500-3400	W
15	*Albizia schimperiana* Oliv.	T	Ambaltaa	Fabaceae	ZK092	DSC01571	1600-2600	W
16	*Alchemilla pedata* A.Rich.	H	Gurra hantuutaa	Rosaceae	ZK081	DSC01456/57	1800-4000	W
17	*Alisma plantago-aquatica* L.	H		Alismataceae	ZK283		1300-2500	W
18	*Allium sativum* L.	H	Qulubbii adii	Alliaceae	ZK284			HG
19	*Allophylus abyssinicus* (Hochst) Radlk	T	Sarara	Sapindaceae	ZK285		1450-3000	W
20	*Amaranthus caudatus* L.	H	Iyyaasuu	Amaranthaceae	ZK286	DSC00433	500-2500	HG
21	*Amaranthus dubius* Thell.	H	Laamoyii	Amaranthaceae	ZK073		150-2300	HG/SW
22	*Amaranthus hybridus* L.	H	Laamoyii	Amaranthaceae	ZK287	DSC01798	1500-2400	HG/SW
23	*Amaranthus spinosus* L.	H	Laamoyii	Amaranthaceae	ZK288	DSC01485	400-2400	HG/SW
24	*Amaranthus viridis* L.	H	Laamoyii	Amaranthaceae	ZK289		600-2300	W
25	*Andropogon abyssinicus* Fresen.	H	Baallamii	Poaceae	ZK029	DSC01719/720	1800-2400	W
26	*Apodytes dimidiata* E.Mey. ex Arn.	T	Calalaqaa	Icacinaceae	ZK0243	DSCO7749-757	1300-2600	W
27	*Argemone mexicana* L.	H		Paperaceae	ZK290	DSC00402/403	~2400	W
28	*Argyrolobium fischeri* Taub.	H	Atara hantuutaa	Fabaceae	ZK291		1600-2400	W
29	*Artemisia abyssinica* Sch. Bip. ex A. Rich	H	Arittaa jaldesaa	Asteraceae	ZK254	DSC07154	1800-3500	W/HG
30	*Artemisia afra* Jaq.	H	Arittaa	Asteraceae	ZK292			HG
31	*Arundo donax* L.	H	Shambaqoo	Poaceae	ZK293			HG
32	*Asparagus africanus* Lam.	S	Saritii	Asparagaceae	ZK294	DSC01869/870	700-3000	W
33	*Asparagus racemosus* Willd.	S	Saritii	Asparagaceae	ZK114		1350-3100	W

34	*Asparagus setaceus* (Kunth) Jassop	S	Saritii	Asparagaceae	ZK135	DSC02005	550-2400	W
35	*Astragalus astropilosulus* (Hochst.) Bunge	H		Fabaceae	ZK119	DSC02067-071	1500-2500	W
36	*Barleria grandis* Hochst. ex Nees	H		Acanthaceae	ZK018		900-1800	W
37	*Barleria parviflora* R. Br.ex T.Andres.	S		Acanthaceae	ZK169	DSC01440/441	700-2400	W
38	*Barleria ventricosa* Hochst. ex Nees	H		Acanthaceae	ZK165		500-2600	W
39	*Bersama abyssinica* Fresen.	S	Lolchisa	Melianthaceae	ZK021	DSC01875-877	1700-2715	W
40	*Bidens ghedoensis* Mesfin	H	Kelloo	Asteraceae	ZK002	DSC01402	1380-2600	W
41	*Bidens pilosa* L.	H	marfee seexana	Asteraceae	ZK037	DSC01987/988	750-2400	W
42	*Bothriocline schimperi* Oliv. & Hiern ex Benth	S		Asteraceae	ZK295		1300-2800	W
43	*Bougainvillea spectabilis* Willd	S		Nyctaginaceae	ZK260			W
44	*Brassica carinata* A.Br.	H	Raafuu	Brassicaceae	ZK296	DSC01644	1350-3000	HG
45	*Brassica nigra* (L.) Koch	H	Raafuu	Brassicaceae	ZK297		1600-2450	HG
46	*Brassica oleracea* L.	H	Raafuu	Brassicaceae	ZK298		100-3000	HG
47	*Brassica rapa* L.	H	tikilgomen	Brassicaceae	ZK299		~3000	HG
48	*Brucea antidysenterica* J.F. Mill.	S	Qabanyoo	Simaroubaceae	ZK198	DSC01950-952	1650-2800	W
49	*Buddeleja davidii* Franch.	S	Qawisa faranjii	Budlejacea	ZK193	DSC01775		HG
50	*Buddeleja polystachya* Fresen.	T	Qawwisa	Budlejacea	ZK137	DSC01892/893	200-3300	W/HG
51	*Caesalpinia decapetala* (Roth) Alston.	S	Arangamaa faranjii	Fabaceae	ZK214	DSC01533		W/HG
52	*Callistemon citrinus* (Curtis) Skeels	T		Myrtaceae	ZK300	DSC00441/442	1200-2500	HG
53	*Calpurnia aurea* (Ait.) Benth.	S	Ceekaa	Fabaceae	ZK009	DSC00378	1650-3000	W
54	*Capparis tomentosa* Lam.	S	Arangama guracha	Capparidaceae	ZK133	DSC01931-934	500-2200	W
55	*Cardiospermum halicacabum* L.	CL		Sapindaceae	ZK301			W
56	*Carduus nyassanus* (S. Moore) R. E. Fr.	H	Qoree harree	Asteraceae	ZK302	DSC01858/859	1200-3350	W
57	*Carissa spinarum* L.	S	Agamsa	Apocyanaceae	ZK040	DSC00361/364	550-2500	W
58	*Cassipourea malosana* (Baker) Alston	T	Warallo	Rhizophoraceae	ZK303			W
59	*Caylusea abyssinica* (Fresen) Fisch & Mey	H		Resedaceae	ZK304	DSC01786	1700-2750	W/HG
60	*Centella asiatiaca* (L.) Urban	H		Apiaceae	ZK245		1000-3200	W
61	*Chlorophytum tuberosum* (Roxb.) Baker	H		Anthericaceae	ZK027		550-1600	W
62	*Cicer arietinum* L.	H	shunburaa	Fabaceae	ZK048			HG/SW
63	*Cirsium englerianum* O.Heffm	H		Asteraceae	ZK054			W
64	*Cirsium schimperi* (atke) C.Jeffrey ex Cufod.	H	Qoree harree	Asteraceae	ZK057		1900-3000	W
65	*Clausena anisata* (Willd) Benth.	S	ulumaa	Myrsinaceae	ZK010	DSC01853/854	1500-2300	W
66	*Clematis simensis* Fresen.	Cl	Hidda fiitii	Ranunculaceae	ZK023	DSC01984-986	1500-3350	W
67	*Clerodendrum myricoides* (Hochst.) Vatke	S	maraasisaa	Lamiaceae	ZK094	DSC01618/619	700-2600	W
68	*Coffea arabica* L.	S	Buna	Rubiacea	ZK058			HG
69	*Commelina benghalensis* L.	H		Commelinaceae	ZKK003	DSC01403	400-2500	W
70	*Conyza steudelii* Sch. Bip. ex A. Rich.	H		Asteraceae	ZK061	DSC00365	2200-3000	W
71	*Cordia africana* Lam.	T	Wadeesa	Boraginaceae	ZK069		700-2550	W
72	*Cotula abyssinica* Sch. Bip. ex A. Rich.	H		Asteraceae	ZK077		1600-4600	W

73	*Crassocephalum macropappum* (Sch. Bip. ex A. Rich.)	H	Mandillo(Sh)	Asteraceae	ZK024	DCS01442	870-2700	W
74	*Crassocephalum rubens* (Juss. ex Jacq.) S.Moore	H		Asteraceae	ZK070		870-2700	W
75	*Crassocephalum viellinum* aut non (Bent) S.moore	H	Mandillo(Sh)	Asteraceae	ZK099	DSC01549/540	870-2700	W
76	*Crotalaria rosenii* (Pax) Milne-Redh. ex Polhill	S	atara qamalee	Fabaceae	ZK074		1350-2800	W
77	*Croton macrostachyus* Del.	T	Bakkaniisa	Euphorbiaceae	ZK011	DSC00407-409	500-2350	W
78	*Cucumis dipsaceus* Ehrenb. ex Spach	Cl	Hidda buqe seexana	Cucurbitaceae	ZK075		670-2000	W
79	*Cucumis ficifolius* A. Rich.	H	Hidii hooloo	Cucurbitaceae	ZK031	DSC01499	1300-2400	W
80	*Cucumis prophetarum* L.	H		Cucurbitaceae	ZK076		200-1950	W
81	*Cucurbita pepo* L.	Cl	dabaaqula	Cucurbitaceae	ZK079			HG
82	*Cupressus lusitanica* Mill.	T	gaatira faranjii	Cupressaceae	ZK083			HG
83	*Cyathula cylinderica* Moq.	H	Darguu/cogogiitii	Amaranthaceae	ZK086		900-3100	W
84	*Cyathula uncinulata* (Schrad.) Schinz	H	Darguu/cogogiitii	Amaranthaceae	ZK088		1300-2500	W
85	*Cymbogon citratus* (D.C.) Stapf.	H	Xajisaara	Poaceae	ZK090			HG
86	*Cynodon dactylon* (L.) Pers.	H	coqorsa	Poaceae	ZK091		1600-2700	W
87	*Cynoglossum amplifolium* Hochst. ex A.DC.	H	qoricha michii	Boraginaceae	ZK093		1500-3500	W
88	*Cynoglossum coeruleum* Hochst. ex A.DC.	H	qoricha michii	Boraginaceae	ZK195	DSC01473/75	1750-2250	W
89	*Cyphostemma adenocaule* Desc. ex Wild & R.B.Drumm.	Cl	hidda dololaa	Vitaceae	ZK063	DSC01629-631	600-2650	W
90	*Datura stramonium* L.	H	manjii	Solanaceae	ZK095	DSC00380/381	600-2800	W
91	*Datura suaveolens* Humb. & Bonpl. ex Willd.	S	Tsadaqii	Solanaceae	ZK105	DSC00434		W
92	*Delphinium wellbyi* Hemsl.	H		Ranunculaceae	ZK109	DSC01815/816	1520-3800	W
93	*Dicranopteris linearis* (Burn. f.) Underw.	H	kaarolee	Gleicheniaceae	ZK113			W
94	*Dicrocephalia integrifolia*	H	Q/Marzii	Asteraceae	ZK082		1750-3500	W
95	*Dicrostachys cinerea* (L.) Wight & Am.	S		Fabaceae	ZK118		450-2000	W
96	*Digitaria abyssinica* (Hochst. ex A. Rich)	H		Poaceae	ZK072		1400-2700	W
97	*Discopodium penninervium* Hochst.	T	coongii	Solanaceae	ZK122		1500-3500	W/HG
98	*Dodonea angustifolia* L. f.	S	ittacha	Sapindaceae	ZK244		500-2900	W
99	*Dovyalis abyssinica* (A. Rich.) Warb.	T	koshomii	Flacourtiaceae	ZK132	DSC01946-949	1700-3000	W
100	*Dovyalis caffra* (Hook. f. & Harv.) Hook. f.	S	koshomii	Flacourtiaceae	ZK123		1000-2700	W
101	*Dovyalis verucosa* (Hochst.) Warb.	S	mixmixaa	Flacourtiaceae	ZK168		1700-2200	W
102	*Dregea schimperi* (Becne.) Bullock	Cl	hidda gor'isaa	Asclepiadaceae	ZK111	DSC0220-022	1600-2400	W
103	*Echinops hispidus* Fresen.	H	shokolee	Asteraceae	ZK080		1700-3100	W
104	*Echinops kebericho* Mesfin	S	qabarichoo	Asteraceae	ZK126	DSC01606	2300-2600	W
105	*Echinops macrochaetus* Fresen.	H	shokolee	Asteraceae	ZK128	DSC01994/995	1350-3600	W
106	*Echinops spinosus* L.	S	shokolee	Asteraceae	ZK036	DSC01504	1350-2200	W
107	*Echium plantaginum* L.	H		Boraginaceae	ZK134	DSC01917-919	2200-2350	W
108	*Ekebergia capensis* Sparrm	T	somboo	Meliaceae	ZK112	DSC01822/823	1680-3000	W
109	*Eleusine floccifolia* (Forssk.) Spreng	H	Cangeedara	Poaceae	ZK026	DSC01491	1800-3200	W
110	*Embelia schimperi* Vatke	S	haanquu	Myrsinaceae	ZK129		1700-2800	W
111	*Ensete ventricosum* (Welw.) Cheesman	H	warqee	Musaceae	ZK130			HG

112	*Epilobium hirsutum* L.	H	Ciraaroo/Ibsaa	Onagraceae	ZK120	DSC02125-129	1200-3000	W
113	*Equisetum ramosissimom* Derf.	H		Equisetaceae	ZK022	DSC01458-461		W
114	*Eragrostis* spp.	H	muriyyii	Poaceae	ZK071			W
115	*Eragrostis teff* (Zucc.) Trotter	H	xaafii	Poaceae	ZK210	DSC01595		HG/SW
116	*Erucastrum arabicum* Fisch & Mey	H	Jare seexanaa	Brassicaceae	ZK131		1350-2350	W
117	*Erythrina brucei* Schweinf.	T	waleenssuu	Fabaceae	ZK139	DSC01737/738	1400-2600	W
118	*Ethulia gracilis* Del.	S		Asteraceae	ZK143		300-2150	W
119	*Eucalyptus camaldunesis* Dehnh.	T	bargamoo	Myrtaceae	ZK060		1250-2800	HG
120	*Eucalyptus globulus* Labill	T	bargamoo	Myrtaceae	ZK052	DSC01557/558	1700-2800	HG/SW
121	*Eucalyptus terticornis* Smith.	T	bargamoo	Myrtaceae	ZK144	DSC01647-649	1450-2350	HG
122	*Euclea divinorum* Hiern.	S	mi'essaa	Ebenaceae	ZK045	DSC01992/993	1000-2400	W
123	*Euphorbia abyssinica* Gmel.	T	adaamii	Euphorbiaceae	ZK145	DSC00421	1900-2400	W/HG
124	*Euphorbia pulcherrima* Willd. ex Klotzsch	S		Euphorbiaceae	ZK146	DSC01722		HG
125	*Ficus Palmata* Forssk.	S	Luugoo	Moraceae	ZK148		100-2400	W
126	*Ficus sur* Forssk.	T	harbuu	Moraceae	ZK104	DSC02083/084	1400-2500	W
127	*Ficus vasta* Forssk.	T	qilxuu	Moraceae	ZK149		1000-2400	W
128	*Flacourtia indica* (Burn. f) Merr.	S		Flacourtiaceae	ZK241	DSC01873/874	1100-2350	W
129	*Foeninculum vulgare* Miller	H	insilaalee	Apiaceae	ZK142	DSC01978/979	1600-2300	HG/SW
130	*Galiniera saxifraga* (Hochst.) Bridson	S	buniitii	Rubiacea	ZK154		1350-3000	W
131	*Galinsoga paviflora* Cav.	H		Asteraceae	ZK025	DSC00365	950-2800	W
132	*Galium simense* Fresen.	H	saam'ee	Rubiacea	ZK234		1700-4000	W
133	*Girardinia bullosa* (Steudel) wedd.	H	Boobbii	Urticaceae	ZK155	DSC01905	1700-3000	W/HG
134	*Glycine wightii* (Wigh & Arn.) Verde	Cl	hidda hantuuta	Fabaceae	ZK216	DSC01711	380-2600	W
135	*Gnaphalium rubriflorum* Hilliard	H		Asteraceae	ZK078	DSC01464/65	2000-3600	W
136	*Grewia ferruginea* Hochst. ex A. Rich.	S	dhoqonuu	Tiliacea	ZK235		1350-2700	W
137	*Guizotia abyssinica* (L. f.) Cass.	H	nuugii	Asteraceae	ZK055	DSC00432	1500-2400	HG/SW
138	*Guizotia scabra* (Vis.) Chiov.	H	adaa	Asteraceae	ZK151	DSC01598	1300-3300	W
139	*Guizotia schimperi* Sch.Bip. ex Walp.	H	adaa	Asteraceae	ZK158	DSC01555	1300-3300	W
140	*Harpachne schimperi* (Hochst.ex Rich.)	H	Marga/Qunnii	Poaceae	ZK166		1000-2400	W
141	*Helminthotheca echioides* (L.) Holub	H		Asteraceae	ZK167	DSC00365	2000-2450	W
142	*Heracleum abyssinicum* (Boiss.) Norman	H	Ulululee	Apiaceae	ZK117		1800-3750	W
143	*Hibiscus ludwigii* Eckl. & Zeyh.	H		Malvaceae	ZK087		1400-2800	W
144	*Hygrophila shulli* (Hamilt.) M. R. & S. M.	H	kachoo	Acanthaceae	ZK046	DSC01554	550-2600	W
145	*Hyparrhenia anthistirioides* (Hochst. ex Arich.) Stapf	H		Poaceae	ZK170		1200-2400	W
146	*Hypericum quartinianum* A. Rich.	S	ulee foonii	Gutiferae	ZK150	DSC01817-819	1500-3000	W
147	*Hypoestes triflera* (Forssk.) Roem & Schult.	H		Acanthaceae	ZK013	DSC01431	1200-3200	W
148	*Impatiens rothii* Hook. f.	H	burii	Balsaminaceae	ZK173	DSC01930	1800-3500	W
149	*Impatiens* spp.	H	ansosila	Balsaminaceae	ZK172			W
150	*Ipomoea indica* (Burn.f.) Merrill	Cl		Convolvulaceae	ZK174			W

151	*Jasminum abyssinicum* Hochst. ex DC.	Cl	idda ichilbee	Oleaceae	ZK012	DCS01940/941	1700-2800	W
152	*Jasminum fluminense* Vell.	Cl		Oleaceae	ZK209		1300-2000	W
153	*Jasminum grandiflorum* L.	Cl	qamaxee	Oleaceae	ZK051	DSC01610-613	1600-2800	W
154	*Juniperus procera* Hochst. ex Endle.	T	gaatira habashaa	Cupressaceae	ZK125	DSC01920/921		W/HG
155	*Justicia ladanoides* La.	H		Acanthaceae	ZK014	DSC01434-436	500-2700	W
156	*Justicia schimperiana* (Hochst. ex Nees) T. Anders.	S	dhumugaa	Acanthaceae	ZK043	DSC01576/577	1300-2700	W/HG
159	*Kalanchoe densiflora* Rolfe	H	bosoqee	Crassulaceae	ZK177	DSC01507		W
157	*Kalanchoe marmorata* Bak.	H	bosoqee	Crassulaceae	ZK035		1340-2500	W
158	*Kalanchoe petitiana* A. Rich	H	bosoqee	Crassulaceae	ZK175	DSC01555/556	2000-3000	W
160	*Lactuca inermis* Forssk	H		Asteraceae	ZK176			W
161	*Laggera alata* (D.Don) Olive.	H		Asteraceae	ZK041	DSC01426	1400-2700	W
162	*Laggera crispata* (Vahl) Hepper & Wood	H		Asteraceae	ZK068	DSC01448	600-2650	W
163	*Laggera tomentosa* (Sch.Bip.ex A.Rich.) Oliv.& Heirn	S	Kaskasee	Asteraceae	ZK179			W
164	*Lantana trifolia* L.	S	Aqanciraa	Asteraceae	ZK180			W
165	*Leucas martinicensis* (Jacq.) R. Br.	H	bokkoluu adii	Lamiaceae	ZK050	DSC01488	~2500	W
166	*Linum usitatissimum* L.	H	talbaa	Liniaceae	ZK217	DSC01599/600		HG/SW
167	*Lippia adoensis* var. *adoensis* Hochst. ex Walp	S	kusaayee	Lamiaceae	ZK006	DSC01414	1600-3000	W/HG
168	*Lippia adoensis* var. *koseret*	S	shokonota	Lamiaceae	ZK147	DSC01546	1600-3000	W/HG
169	*Lycopersicon esculentum* Mill.	H	timatima	Solanaceae	ZK181		800-1800	HG
170	*Maesa lanceolata* Forssk.	T	abbayii	Myrsinaceae	ZK102	DSC01561-563	1350-3000	W
171	*Malva verticillata* L.	H	liitii	Malvaceae	ZK182		1600-4000	W/HG
172	*Maytenus arbutifolia* (A. Rich) Wiczek.	S	kombolcha	Celasteraceae	ZK067	DSC01557/558	1200-3000	W
173	*Maytenus gracilipes* (Welw. ex Olive.) Exell	S	kombolcha	Celasteraceae	ZK184	DSC01823-825	1250-2800	W
174	*Maytenus obscura* (A.Rich) Cuf.	S	kombolcha	Celasteraceae	ZK185	DSC01925	1700-3100	W
175	*Medicago polymorpha* L.	H		Fabaceae	ZK020	DSC01455	1400-3000	W
176	*Milletia ferruginea* (Hochst.) Bak.	T	birbirraa	Fabaceae	ZK186	DSC01899-901	1600-2500	W
177	*Momordica foetida* Shumach	Cl		Cucurbitaceae	ZK226		530-3450	W
178	*Myrica salicifolia* A. Rich.	T	baroodoo	Myricaceae	ZK255	DSC07156	1750-3300	W
179	*Myrsine africana* L.	S	qacama	Myrsinaceae	ZK098		1900-3800	W
180	*Nicandra physaloides* (L.) Gaertn	H		Solanaceae	ZK064	DSC00405/406	600-2100	W
181	*Nicotiana tabacum* L.	H	tamboo	Solanaceae	ZK053	DSC01640	300-2400	HG/SW
182	*Nuxia congesta* R. BT. ex Fresen.	T	qawwisa	Budlejacea	ZK249		110-3800	W
183	*Ocimum basilicum* L.	S	Bosobila	Lamiaceae	ZK187	DSC01980/981	~2400	HG
184	*Ocimum lamiifolium* Hochst. ex Benth.	S		Lamiaceae	ZK115	DSC02059/060	1200-2900	W/HG
185	*Ocimum uritcifolium* Roth	S		Lamiaceae	ZK033	DSC01878/879	600-2100	W
186	*Oenanthe palustris* (Chiov.) Norman	H	qoricha lagaa	Apiaceae	ZK124	DSC02110-012	1500-3000	W
187	*Olea europaea* subsp. *Cusp* (Wall. ex G. Don) Cif	T	ejersa	Oleaceae	ZK127	DSC01923/924	1250-3000	W/HG
188	*Opuntia cylinderica* (Lam.) D.C.	T	adaamii	Cactaceae	ZK188		2300-2450	W/HG
189	*Opuntia ficus-indica* (L.) Miller	T	adaamii	Cactaceae	ZK189		1400-2400	W/HG

190	*Oreoshimperella verrucosa* (A. Rich.) Rausder	H	Gosa dinbilaalaa	Apiaceae	ZK190		1900-3800	W
191	*Orobanche minor* Smith	H		Orobanchaceae	ZK056	DSC01620	1100-3000	W
192	*Osyris quadripartita* Decn.	S	waatoo	Santalaceae	ZK096	DSC01621	1600-2900	W
193	*Oteostegia tomentosa* subsp. *ambigiensis*	S		Lamiaceae	ZK191	DSC01820-822	1200-3000	W
194	*Parthenium hysterophorus* L.	H		Asteraceae	ZK246	DSC00404	900-1800	W
195	*Pavetta abyssinica* Fresen.	S		Rubiacea	ZK066	DSC01871/872	1350-2850	W
196	*Pavonia urens* Cav.	S		Malvaceae	ZK192	DSC01433	1500-3500	W
197	*Pelargonium multibracteatum* Hochst. ex A. Rich.	H		Geraniaceae	ZK242		1000-2700	W
198	*Pennisetum sphacelatum* (Nees) Th. Dur. & Schinz	H		Poaceae	ZK196		1900-2800	W
199	*Pennisetum thunbergii* Kunth.	H		Poaceae	ZK197		1700-3000	W
200	*Pennisetum vellosum* Fresen.	H		Poaceae	ZK199		1800-2800	W
201	*Pentas schimperiana* (A. Rich.) Vatke	H		Rubiacea	ZK247		1800-3200	W
202	*Persicaria setosula* (A. Rich) K.L. Wilson	H	kicuu	Polygonaceae	ZK201		500-2900	W
203	*Phaulosis imbricata* (Forssk.) Sweet	H		Acanthaceae	ZK202	DSC01601	600-2700	W
204	*Phoenix reclinata* Jacq.	T	meexii	Arecaceae	ZK097	DSC01557	500-2400	W
205	*Physalis peruviana* L.	H	Awuxii	Solanaceae	ZK203		1200-2600	W
206	*Phytolacca dodecandra* L. 'Hèrit.	S	handoodee	Phytolacacea	ZK204	DSC01990/991	1500-3000	W
207	*Pisum sativum* L.	H	atara	Fabaceae	ZK206			HG/SW
208	*Pittosporum viridiflorum* Sims	S	soolee	Pittosporacea	ZK205	DSC01799-803	1400-3000	W
209	*Plantago lanceolata* L.	H	qorxobbii	Plantaginaceae	ZK015	DSC01432	1200-3200	W
210	*Plectocephalus varians* (A. Rich) C,Jeffrey ex Cufod	H		Asteraceae	ZK108	DSC02034-036	1900-3600	W
211	*Plectranthes alpinus* (Baker) J.K. Morton	H		Lamiaceae	ZK194		1800-2800	W
212	*Plectranthes assurgens* Baker	H		Lamiaceae	ZK207		1800-2800	W
213	*Plectranthes barbatus* Andrews	H		Lamiaceae	ZK138		950-2750	W
214	*Plectranthes cylindraceus* Hochst. ex Benth.	H	dabasee	Lamiaceae	ZK274		1000-2600	W
215	*Plectranthes orantus* Codd	H		Lamiaceae	ZK222		1300-3500	W
216	*Plectranthes punctatus* (L.f.) L' Hèr.	H		Lamiaceae	ZK084	DSC01406/407	1350-3200	W
217	*Plectranthes schimperi* Chiov.	H		Lamiaceae	ZK116	DCS01582		W
218	*Plumbago zeylanica* L.	H		Plumbaginaceae	ZK208		700-2200	W/HG
219	*Podocarpus falcatus* (Thunb.) R. B. ex. Mirb	T	birbirsa	Podocarpaceae	ZK042	DSC00412-416		W
220	*Polygonium plebeium* R.Br.	H		Polygonaceae	ZK140	DSC01965/966	1000-2400	W
221	*Premna schimperi* Engl.	S	urgeessaa	Lamiaceae	ZK017	DSC01451	1350-2400	W
222	*Prunus africana* (Hook. f.) Kalkm.	T	gura'ee	Rosaceae	ZK212	DSC01906-911	1700-2500	W/HG
223	*Pterolobium stellatum* (Forssk.) Brenan	S	arangama diimaa	Fabaceae	ZK153	DSC01793/794		W
224	*Pycnostachys abyssinica* Fresen.	H		Lamiaceae	ZK213	DSC01847	1100-2700	W
225	*Pycnostachys eminii* Gürke	H		Lamiaceae	ZK215	DSC01847	1700-2200	W
226	*Ranunculus multifidus* Forssk.	H		Ranunculaceae	ZK106	DSC01943	1200-3800	W
227	*Raphanus raphanistrum* L.	H		Solanaceae	ZK062		1800-2400	W
228	*Rhamnus prinoides* Lyterit.	S	geeshoo	Rhamnaceae	ZK218	DSC00370	1175-3200	W/HG

229	*Rhamnus staddo* A.Rich	S	qadiidaa	Rhamnaceae	ZK110	DSC01614	1400-2900	W
230	*Rhus glotinosa* A. Rich	T	daboobesa	Anacardiacea	ZK159	DSC01535/536	1450-2700	W
231	*Rhus vulgaris* Meikle	T	Xaaxessaa	Anacardiacea	ZK059	DSC01466		W
232	*Ricinus communis* L.	S	qobbo	Euphorbiaceae	ZK121	DSC02117		W
233	*Rorippa nasturtium-aquaticum* (L.) Hayek	H		Brassicaceae	ZK219		2200-2600	W
234	*Rosa abyssinica* Lindley	S	hangooxoo	Rosaceae	ZK030	DSC01500/501	1900-3300	W
235	*Rosa x richardii* Rehd	S		Rosaceae	ZK220		1000-2100	HG
236	*Rosmerinus officinalis* L.	S		Lamiaceae	ZK221			HG
237	*Rubia cordifolia* L.	H		Rubiacea	ZK223			W
238	*Rubus steudneri* Schweinf	S	goraa	Rosaceae	ZK211		2300-3000	W
239	*Rumex abyssinicus* Jacq.	H	maqmaqoo	Polygonaceae	ZK101	DSC01547	1200-3300	W
240	*Rumex nepalensis* Spreng	H	shuultii	Polygonaceae	ZK001	DSC00368	1200-3900	W
241	*Rumex nervosus* Vahl	S	dhangaggoo	Polygonaceae	ZK224	DSC00395	400-3300	W
242	*Ruta chalepensis* L.	H		Rutaceae	ZK227			HG
243	*Rytigna neglecta* (Hiern) Robyns	S	mixoo	Rubiacea	ZK267			W
244	*Saccharum officinarum* L.	H	shankoora	Poaceae	ZK228	DSC02088/089		HG
245	*Salix subserrata* Willd.	S	alaltuu	Salicaceae	ZK005	DSC01411/412	1250-2850	W
246	*Salvia nilotica* Jacq.	H	qoricha michii	Lamiaceae	ZKO16	DSC01438/39	1300-3800	W
247	*Sapium elipticum* (Krauss) Pax	S		Euphorbiaceae	ZK229		1050-2100	W
248	*Satureja abyssinica* (Benth.) Briq.	H		Lamiaceae	ZK230	DSC01567/568	900-2700	W
249	*Satureja paradoxa* (Vatke) Engl. ex Seybold	H	duufaa loonii	Lamiaceae	ZK103	DSC01581	1350-3500	W
250	*Satureja punctata* (Benth.) Briq.	H	naddoo in Sheka	Lamiaceae	ZK231		600-3840	W
251	*Scadoxus multiflorus* (Martyn) Raf	H	kuukuu/arfaasee	Amaryllidaceae	ZK232			W
252	*Schefflera abyssinica* (Hochst. Ex A. Rich) Harmon	T	gatamaa	Araliaceae	ZK233		1450-2800	W
253	*Schinus molle* L.	T		Anacardiacea	ZK237			HG
254	*Senecio ochrocarpus* Oliv. & Hiern	H		Asteraceae	ZK238	DSC01564/566	2800-4300	W
255	*Senecio* spp.	H		Asteraceae	ZK164			W
256	*Senecio subsessilis*	H		Asteraceae	ZK239	DSC01505	2400-4310	W
257	*Senna didymobotrya* (Fresen.) Irwin & Bar	S	ceekaa guraacha	Fabaceae	ZK019	DSC00390/391	1450-2400	W
258	*Sesbania sesban* (L.) Merr.	T		Fabaceae	ZK236		300-2000	HG
259	*Setaria incrassata* (Hochst.) Hack.	H		Poaceae	ZK240			W
260	*Setaria pumela* (Poir.) Roem & Schult.	H		Poaceae	ZK085		500-2400	W
261	*Sida schimperiana* Hochst. ex A. Rich	S		Fabaceae	ZK028	DSC01495/496	1500-2600	W
262	*Sida tenuicarpa* L.	S		Fabaceae	ZK248		1550-2300	W
263	*Silybum marianum* (L.) Gaertn.	H		Asteraceae	ZK251		2200-2600	W
264	*Snowdenia polystachya* (Fresen.) Pilg.	H	mujjaa	Poaceae	ZK252		1500-2700	W/HG
266	*Solanacio gigas* (Vatke) C. Jeffrey	S	dilu arbaa	Asteraceae	ZK253			W
267	*Solanum anguivi* Lam.	H		Solanaceae	ZK163		500-2800	W
268	*Solanum incanum* L.	S		Solanaceae	ZK162	DSC00396	~2100	W

269	*Solanum indicum* L.	S	hidii waraabesa	Solanaceae	ZK256	DSC01583/584		W
270	*Solanum marginatum* L. f.	S		Solanaceae	ZK100	DSC00429	2000-3000	W
271	*Solanum nigrum* L.	H		Solanaceae	ZK032	DSC01479/80	700-2350	W
272	*Solanum tuberosum* L.	H	dinicha	Solanaceae	ZK257		1800-2600	HG
273	*Solanum vilosum* Mill.	H		Solanaceae	ZK258		1200-2600	W
274	*Sonchus asper* (L.) Hill	H		Asteraceae	ZK259	DSC00352	1050-2850	W
265	*Sorghum bicolor* (L.) Moench	H	misngaa	Poaceae	ZK261	DSC01597		HG/SW
275	*Sphaeranthus suaveolens* (Forssk.) DC.	H	Q/Marzii	Asteraceae	ZK107	DSC01593	1600-2100	W
276	*Spilanthes uliginosa* Jacq.	H	moxomoxaa	Asteraceae	ZK262			W
277	*Stephania abyssinica* (Dillon & A. Rich) Walp.	Cl	hidda kalaalaa	Menispermaceae	ZK044	DSC01579	1450-3400	W
278	*Syzygium guineense* (Wild.) DC.	S	badeessaa	Myrtaceae	ZK004	DSC01409/410	1200-2500	W
279	*Tacazzea conferta* N.E.Br.	Cl	hidda annannoo	Asclepiadaceae	ZK141	DSC01959-952		W
280	*Tagetes minuta L.*	S	bari fidee	Asteraceae	ZK049	DSC01645-646		W
281	*Teclea nobilis* Del.	S	hadheesa	Rutaceae	ZK250			W
282	*Thalictrum rhyncocarpum* Dill. A. Rich	H	siraabizuu	Ranunculaceae	ZK200	DSC01761-763	1600-3050	W
283	*Thalictrum schimperianum* Hochst. ex Schweinf.	H		Ranunculaceae	ZK263	DSC01826/827	1900-3800	W
284	*Thymus* spp.	H		Lamiaceae	ZK183			W
285	*Trifolium polystachyum* Fresen	H		Fabaceae	ZK008	DSC01416		W
286	*Triumfetta rhomboidea* Jaq.	S		Tiliacea	ZK264		400-2750	W
287	*Typha domingensis* Pers.	H	shanbaqoo jaldesa	Thyphaceae	ZK171	DSC02122-124		W
288	*Urera hypselodendron* (A. Rich) Wedd	H	laanqisaa	Urticaceae	ZK265		1700-2800	W
289	*Urtica simensis* Steudel	H	saamaa	Urticaceae	ZK266		1500-3400	W/HG
290	*Verbascum siniaticum* Benth.	H	guraa harree	Verbenaceae	ZK034	DSC00397		W
291	*Verbena officinalis* L.	H	q/albaatii	Verbenaceae	ZK268			W
292	*Vernonia adoensis* Sch. Bip.ex Wlp	H		Asteraceae	ZK269		500-2000	W
293	*Vernonia amygdalina* Del.	T	ebicha	Asteraceae	ZK152	DSC01541		W/HG
294	*Vernonia auriculifera* Hiern	S	reejii	Asteraceae	ZK161			W
295	*Vernonia myrantha* Hook. f.	S	reejii	Asteraceae	ZK156			W
296	*Vicia faba* L.	H	baqelaa	Fabaceae	ZK270			HG/SW
297	*Xanthium abyssinica* Walroth	H		Asteraceae	ZK271			W
298	*Xanthium spinosum* L.	H		Asteraceae	ZK272	DSC00428		W
299	*Xanthium strumarium* L.	H		Asteraceae	ZK65			W
300	*Ximenia americana* L.	S		Olacaceae	ZK273		500-2450	W
301	*Zanthodeschia aethiopica* (L.) K.P.J. Sprengel	H		Araceae	ZK305	DSC02041/042		W
302	*Zea mays* L.	H	boqoolloo	Poaceae	ZK306	DSC01549/540		HG/SW
303	*Zehneria scabra* (Linn. f.) Sond.	Cl	hidda adii	Cucurbitaceae	ZK160	DSC02023-027		W
304	Zehneria spp.	Cl	hida xixiixa	Cucurbitaceae	ZK307			W

Note: *Commercial in a sense is to mean that people depend on these species to make a living by selling them to generate income for their livelihood and not referring to large scale production. It is simply to mean marketability or how the poor people in the area depend on the species mentioned for their daily life

Appendix 2: List of Families.

S.N.	Families	Number	Percentage
1	Acanthaceae	9	11.34
2	Agavaceae	1	1.28
3	Alismataceae	1	1.28
4	Alliaceae	1	1.28
5	Amaranthaceae	8	10.26
6	Amaryllidaceae	1	1.28
7	Anacardiacea	3	3.85
8	Anthericaceae	1	1.28
9	Apiaceae	5	6.41
10	Apocyanaceae	1	1.28
11	Araceae	1	1.28
12	Araliaceae	1	1.28
13	Arecaceae	1	1.28
14	Asclepiadaceae	2	2.56
15	Asparagaceae	3	3.85
16	Asteraceae	50	64.1
17	Balsaminaceae	2	2.56
18	Boraginaceae	4	5.13
19	Brassicaceae	6	7.69
20	Budlejacea	3	3.85
21	Cactaceae	2	2.56
22	Capparidaceae	1	1.28
23	Celasteraceae	3	3.85
24	Commelinaceae	1	1.28
25	Convolvulaceae	1	1.28
26	Crassulaceae	3	3.85
27	Cucurbitaceae	7	8.97
28	Cupressaceae	2	2.56
29	Ebenaceae	1	1.28
30	Equisetaceae	1	1.28
31	Euphorbiaceae	5	6.41
32	Fabaceae	27	34.62
33	Gleicheniaceae	1	1.28
34	Flacourtiaceae	4	5.13
35	Geraniaceae	1	1.28
36	Gutiferae	1	1.28
37	Icacinaceae	1	1.28
38	Lamiaceae	25	32.05
39	Liniaceae	1	1.28
40	Malvaceae	3	3.85
41	Meliaceae	1	1.28
42	Melianthaceae	1	1.28
43	Menispermaceae	1	1.28
44	Moraceae	3	3.85
45	Musaceae	1	1.28
46	Myricaceae	1	1.28
47	Myrsinaceae	4	5.13
48	Myrtaceae	5	6.41
49	Nyctaginaceae	1	1.28
50	Olacaceae	1	1.28
51	Oleaceae	4	5.13
52	Onagraceae	1	1.28
53	Orobanchaceae	1	1.28
54	Paperaceae	1	1.28
55	Phytolacacea	1	1.28
56	Pittosporacea	1	1.28
57	Plantaginaceae	1	1.28
58	Plumbaginaceae	1	1.28
59	Poaceae	18	23.08
60	Podocarpaceae	1	1.28
61	Polygonaceae	5	6.41
62	Ranunculaceae	5	6.41
63	Resedaceae	1	1.28
64	Rhamnaceae	2	2.56
65	Rhizophoraceae	1	1.28
66	Rosaceae	5	6.41
67	Rubiacea	7	8.97
68	Rutaceae	2	2.56
69	Salicaceae	1	1.28
70	Santalaceae	1	1.28
71	Sapindaceae	3	3.85
72	Simaroubaceae	1	1.28
73	Solanaceae	15	19.23
74	Thyphaceae	1	1.28
75	Tiliacea	2	2.56
76	Urticaceae	3	3.85
77	Verbenaceae	2	2.56
78	Vitaceae	1	1.28

Appendix 3: List of Genera.

S.N.	Genera	Number	Percentage
1	Acacia	6	2.78
2	Acanthes	1	0.46
3	Achyranthes	1	0.46
4	Acmella	1	0.46
5	Aeschynomene	1	0.46
6	Agave	1	0.46
7	Ageratum	1	0.46
8	Ajuga	1	0.46
9	Albizia	1	0.46
10	Alchemilla	1	0.46
11	Alisma	1	0.46
12	Allium	1	0.46
13	Allophylus	1	0.46
14	Amaranthes	4	1.85
15	Andropogon	1	0.46
16	Apodytes	1	0.46
17	Argemone	1	0.46
18	Argyrolobium	1	0.46
19	Artimesia	2	0.93
20	Arundo	1	0.46
21	Asparagus	3	1.39
22	Astralagus	1	0.46
23	Barlerial	3	1.39
24	Bersama	1	0.46
25	Bidens	2	0.93
26	Bothriocline	1	0.46
27	Bougainvillia	1	0.46
28	Brassica	4	1.85
29	Brucea	1	0.46
30	Budeleja	2	0.93
31	Caesalpinia	1	0.46
32	Callistemon	1	0.46
33	Calpurnia	1	0.46
34	Capparis	1	0.46
35	Cardiospermum	1	0.46
36	Carduus	1	0.46
37	Carissa	1	0.46
38	Cassipourea	1	0.46
39	Caylusea	1	0.46
40	Centella	1	0.46
41	Chlorophytum	1	0.46
42	Cicer	1	0.46
43	Cirsium	3	1.39
44	Clausena	1	0.46
45	Clematis	1	0.46
46	Clerodendrum	1	0.46
47	Coffea	1	0.46
48	Commelina	1	0.46
49	Conyza	1	0.46
50	Cordia	1	0.46
51	Cotula	1	0.46
52	Crassocephalum	3	1.39
53	Crotalaria	1	0.46
54	Croton	1	0.46
55	Cucumis	3	1.39
56	Cucurbita	1	0.46
57	Cupressus	1	0.46
58	Cyathula	2	0.93
59	Cymbogon	1	0.46
60	Cynodon	1	0.46
61	Cynoglossum	2	0.93
62	Cyphostemma	1	0.46
63	Datura	2	0.93
64	Delphinium	1	0.46
65	Dicranopteris	1	0.46
66	Dicrocephalia	1	0.46
67	Dicrostachys	1	0.46
68	Digitaria	1	0.46
69	Discopodium	1	0.46
70	Dodonea	1	0.46
71	Dovyalis	3	1.39
72	Dregea	1	0.46
73	Echinops	4	1.85
74	Echium	1	0.46
75	Ekebergia	1	0.46
76	Eleusine	1	0.46
77	Embelia	1	0.46
78	Ensete	1	0.46
79	Epilobium	1	0.46
80	Equisetum	1	0.46
81	Eragrostis	2	0.93
82	Erucastrum	1	0.46
83	Erythrina	1	0.46
84	Ethulia	1	0.46
85	Eucalyptus	3	1.39
86	Euclea	1	0.46
87	Euphorbia	2	0.93
88	Ficus	3	1.39
89	Flacourtia	1	0.46
90	Foeninculum	1	0.46
91	Galiniera	1	0.46
92	Galinsoga	1	0.46
93	Galium	1	0.46
94	Girardinia	1	0.46
95	Glycine	1	0.46
96	Gnaphalium	1	0.46
97	Grewia	1	0.46
98	Guizotia	3	1.39
99	Harpachne	1	0.46
100	Helminthotheca	1	0.46
101	Heracleum	1	0.46
102	Hibiscus	1	0.46
103	Hygrophila	1	0.46
104	Hyparrhenia	1	0.46
105	Hypericum	1	0.46
106	Hypoestes	1	0.46
107	Impatiens	2	0.93
108	Ipomoea	1	0.46
109	Jasminum	3	1.39
110	Juniperus	1	0.46
111	Justicia	2	0.93
112	Kalanchoe	3	1.39
113	Lactuca	1	0.46

114	Laggera	3	1.39
115	Lantana	1	0.46
116	Leucas	1	0.46
117	Linum	1	0.46
118	Lippia	2	0.93
119	Lycopersicon	1	0.46
120	Maesa	1	0.46
121	Malva	1	0.46
122	Maytenus	3	1.39
123	Medicago	1	0.46
124	Milletia	1	0.46
125	Momordica	1	0.46
126	Myrica	1	0.46
127	Myrsine	1	0.46
128	Nicandra	1	0.46
129	Nicotiana	1	0.46
130	Nuxia	1	0.46
131	Ocimum	3	1.39
132	Oenanthe	1	0.46
133	Olea	1	0.46
134	Opuntia	2	0.93
135	Oreoshimperella	1	0.46
136	Orobanche	1	0.46
137	Osyris	1	0.46
138	Oteostegia	1	0.46
139	Parthenium	1	0.46
140	Pavetta	1	0.46
141	Pavonia	1	0.46
142	Pelargonium	1	0.46
143	Pennisetum	3	1.39
144	Pentas	1	0.46
145	Persicaria	1	0.46
146	Phaulosis	1	0.46
147	Phoenix	1	0.46
148	Physalis	1	0.46
149	Phytolacca	1	0.46
150	Pisum	1	0.46
151	Pittosporum	1	0.46
152	Plantago	1	0.46
153	Plectocephalus	1	0.46
154	Plectranthes	7	3.24
155	Plumbago	1	0.46
156	Podocarpus	1	0.46
157	Polygonium	1	0.46
158	Premna	1	0.46
159	Prunus	1	0.46
160	Pterolobium	1	0.46
161	Pycnostachys	2	0.93
162	Ranunculus	1	0.46
163	Raphanus	1	0.46
164	Rhamnus	2	0.93
165	Rhus	2	0.93
166	Ricinus	1	0.46
167	Rorippa	1	0.46
168	Rosa	2	0.93
169	Rosmerinus	1	0.46
170	Rubia	1	0.46
171	Rubus	1	0.46
172	Rumex	3	1.39
173	Ruta	1	0.46
174	Rytigna	1	0.46
175	Saccharum	1	0.46
176	Salix	1	0.46
177	Salvia	1	0.46
178	Sapium	1	0.46
179	Satureja	3	1.39
180	Scadoxus	1	0.46
181	Schefflera	1	0.46
182	Schinus	1	0.46
183	Senecio	3	1.39
184	Senna	1	0.46
185	Sesbania	1	0.46
186	Setaria	1	0.46
187	Sida	2	0.93
188	Silybum	1	0.46
189	Snowdenia	1	0.46
190	Soghum	1	0.46
191	Solanacio	1	0.46
192	Solanum	7	3.24
193	Sonchus	1	0.46
194	Sphaeranthus	1	0.46
195	Spilanthes	1	0.46
196	Stephania	1	0.46
197	Syzygium	1	0.46
198	Tacazzea	1	0.46
199	Tagetes	1	0.46
200	Teclea	1	0.46
201	Thalictrum	2	0.93
202	Thymus	1	0.46
203	Trifolium	1	0.46
204	Triumfetta	1	0.46
205	Typha	1	0.46
206	Urera	1	0.46
207	Urtica	1	0.46
208	Verbascum	1	0.46
209	Verbena	1	0.46
210	Vernonia	4	1.85
211	Vicia	1	0.46
212	Xanthium	3	1.39
213	Ximenia	1	0.46
214	Zanthodeschia	1	0.46
215	Zea	1	0.46
216	Zehneria	2	0.93

Appendix 4: Values of the Shannon-Wiener diversity indices for each plot.

PID	H'(Diversity)	Richness	Evenness
P1	3.329631	32	0.960729
P2	3.253272	28	0.976312
P3	3.389128	32	0.977896
P4	3.581226	41	0.964361
P5	3.370436	36	0.940538
P6	3.533461	41	0.951499
P7	3.295591	31	0.959698
P8	3.321857	34	0.942007
P9	3.260078	32	0.94066
P10	3.362857	37	0.931302
P11	3.288576	33	0.940532
P12	3.347116	34	0.94917
P13	3.504579	40	0.950039
P14	3.539896	45	0.929921
P15	3.616323	46	0.944545
P16	3.143009	30	0.924089
P17	3.060292	27	0.928533
P18	3.142136	29	0.933133
P19	3.184894	29	0.945831
P20	2.999674	25	0.931901
P21	3.092242	26	0.949095
P22	3.107949	28	0.932701
P23	2.74415	19	0.931977
P24	3.09061	24	0.972485
P25	3.144701	27	0.954143
P26	3.088121	28	0.92675
P27	3.122136	28	0.936958
P28	3.017692	24	0.949541
P29	3.165204	30	0.930615
P30	3.113305	26	0.95556
P31	3.005245	27	0.911831
P32	3.059186	26	0.938949
P33	2.689051	17	0.949117
P34	2.899514	22	0.938038
P35	3.054263	25	0.94886
P36	3.054912	26	0.937637
P37	2.813805	21	0.924219
P38	3.251435	31	0.94684
P39	3.271425	32	0.943934
P40	3.218976	28	0.96602
P41	3.091012	25	0.960277
P42	3.238892	30	0.95228
P43	3.504557	37	0.970545
P44	3.20823	31	0.934258
P45	2.796782	18	0.96762
P46	2.902043	21	0.953201
P47	2.797547	19	0.950112
P48	2.614161	15	0.96533
P49	2.653067	18	0.917898
P50	3.209445	28	0.96315

Appendix 5: Floristic similarity.

Locality	Elevation	Author	Year	a	b	c	Ss	%
Tulu Korma	2111-2338	Zewdie Kassa	2015	-	-	-	-	-
Masha	1700-3000	Abreham Assefa	2013	43	261	87	0.198	7.424
Addisalem-Ginchi	2137-2289	Abdi Shentema	2012	71	233	30	0.351	13.161
Ginchi-Ambo	2101-2200	Belete Kebede	2012	78	226	32	0.377	14.136
Jeldu	1200-3100	Zewdie Kassa	2009	165	139	77	0.604	**22.647**
Bale mountain	3010-3410	Haile Yinger *et al.*	2008	41	263	189	0.154	5.774
Cheliya	1300-3060	Endale Amenu	2007	82	222	106	0.333	12.486
Gimbi	1310-2100	Etana Tolasa	2007	42	262	169	0.163	6.112
Wonago	1350-2875	Fiseha Mesfin	2007	112	192	86	0.446	16.723
Borena	1252-1777	Gemedo Dalle	2005	13	291	314	0.041	**1.537**