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Original Paper

Plant Diversity Study on Kelekal Protected Forest in Debre Markos Town District, East Gojjam, Amhara Region, Ethiopia

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Abstract

This research was aimed to investigate floristic composition and structure of Kelekal protected forest established since 1999. For plant data collection, 33 different quadrats having 400 m^2 along seven different line transect were used. The structural data like Frequencies, Density, DBH, Hight, Relative dominance, Relative density and IVI values were calculated for each species and for the selectedwoody plants. The woody plant species having DBH≥2.5 cm and height greater than 2.5 m were measured. A hierarchical cluster analysis was performed to classify different plant communities. Shannon winner diversity indices and Sorensen's similarity indices were used to compare the identified plant communities. Endemic and economically important plants were identified from Flora of Ethiopia and Eritrea books. This research resulted 103 different vascular plants. Eight (7.77%) plants are endemic and the "K" partitioning in the R program using hierarchical cluster analysis resulted three-plant community types. The general distribution pattern of these woody plants at different DBH and height classes showed an inverted "J" shape pattern. Four different population patterns were investigated from the density of these species recorded at different DBH class. The result of the structural data provides pertinent information for future forest management techniques in Kelekal protected forest.

Keywords

protected forest, plant structure, kelekal, plant diversity

1. Introduction

The vegetation cover of a given area has a definite structure and composition because of the long-term interaction between biotic and abiotic factors. The pattern of distribution and vertical stratification of vegetation fluctuate due to different climatic zones, soil types, altitude and topography of the area.

These in turn influence the distribution and type of plants and animals in the forest (Mueller-Dombois & Ellenberg, 1974). The topography and diverse climatic conditions of Ethiopia led to the emergence of habitats that are suitable for evolution. These have led to the occurrence of some unique plant and animal species and their assemblages (Zerihun Woldu, 2008).

Over the last several decades, forest resources faced with different problems, which prevented them from realizing their potential contribution to economic and social development as well as environmental conservation. Among all, the growing human population and the demand for natural resources put great pressure on the biodiversity wealth of the world through deforestation, habitat fragmentation, and overexploitation of species (Terborgh & van Schaik, 1997; Noss, 1999). Habitat loss and change, over-harvesting, pollution, and climate change have been the direct causes of global biodiversity loss (Wood *et al.,* 2000), while population growth, changes in economic activities, socio-political factors, cultural factors, and technological change are indirect drivers (MEA, 2005).

Ethiopia as a country tried to conserve the forest resource supported by law to increase country forest cover and manage the existing primary and secondary forests. The first law was enacted in 1994 as the forest development, conservation and utilization proclamation No.94/1994. This law was repealed and replaced by another by amending it all-inclusive as forest development, conservation and utilization proclamation No. 542/2007 with the view to contributing to the economic development of the country, maintaining the ecological balance and conserving and enhancing our biodiversity through the sustainable utilization and development of forest resource by the regional state.

In this regard, the practice of establishing enclosures for forest development has emerged as a promising practice in different parts of Ethiopia. this activity historically practiced around Ethiopian Orthodox Church and now implemented here and there to increase forest cover and acquire benefit out of it (Bendz, 1986), namely in Tigray (Kindeya Gebrehiwot, 1997; Mitiku Haile & Kindeya Gebrehiwot, 2001; Emiru Birhane, 2002), Welo (Kebrom Tekle, 1998; Tefera Mengstu, 2001) and Shewa (Tefera Mengstu, 2001). Enclosures are areas selected for natural regeneration of the native flora as a means of land reclamation through protection of the areas from human and animal interference (Bendz, 1986; Alemneh Dejene, 1992).

The local people have reported that species that disappeared long time ago have been restored following establishment of enclosures. For instance, species that could not be observed for many years in some parts of eastern Tigray, namely *Olea europaea* subsp. *cuspidata* and *Juniperus procera,* reappeared, densities and diversities of the flora, particularly of grasses, and fauna increased, soil erosion decreased and even dead springs started to flow after different enclosures were established (Emiru Birhane, 2002). As a result, enclosures are becoming promising assets as sources of not only biomass energy, which accounts for about 80% of the total household energy supply in the country (EFAP, 1994), but also wood for construction, agricultural implements and several other purposes. Non-timber forest products, e.g., grass for feed and thatching, are becoming important outcomes of enclosures. Encouraged by these results, efforts are underway currently to replenish denuded areas of northern Ethiopia through the establishment of enclosures to promote conservation-based sustainable agriculture along with maintaining and enhancing the biodiversity of dry lands (Kindeya Gebrehiwot, 1997; Emiru Birhane, 2002).

Kelekal protected forest is protected 18 years back by private investor for forest development but this protected forest was not studied before and after establishment. Studies aimed at generating empirical information on history, diversity of the flora, if possible fauna and micro-organisms before and after establishment, rates and processes involved in recovery or dynamics of the vegetation, etc., which would ultimately assist to make informed decisions on the future fates of enclosures. In particular, such information from Kelekal protected forest is crucial for developing strategies, programs or technical guidelines for their conservation and sustainable utilization. Therefore this study specifically aimed to investigate the species composition, density and diversity of plants; to look the structure of the forest; to inspect the regeneration status of some selected woody species; to categorize the forest vegetation into plant community types; to elucidate the diversity of the different community types and to make some recommendations on the management and conservation of the forest.

2. Materials and Methods

2.1 Description of the Study Area

The Kelekal protected forest is located in Debre Marqos town district, East Gojjam Zone, Amhara National Regional State. Astronomically, the district is located at 10^0 16'- 10^0 22 “longitude to the north and 37^0 43'- 37^0 45” latitude to the East. The town district has given the land to investors for forest development for about 25 years since 1999 to protect, conserve and use the plant resource. From the information obtained through personal communication, we understood that, initially the investor planned to bring *Prunes africana* seedlings in the protected area for commercial purpose but he did not cover the land with what he planned due to different reasons. Rather he continues protecting the land by guard for the last 19 years. This phenomenon creates suitable condition for plants to grow and regenerate from seed bank. To see his contribution for forest development and evaluate the program, forest inventory conducted after 19 year of protection.

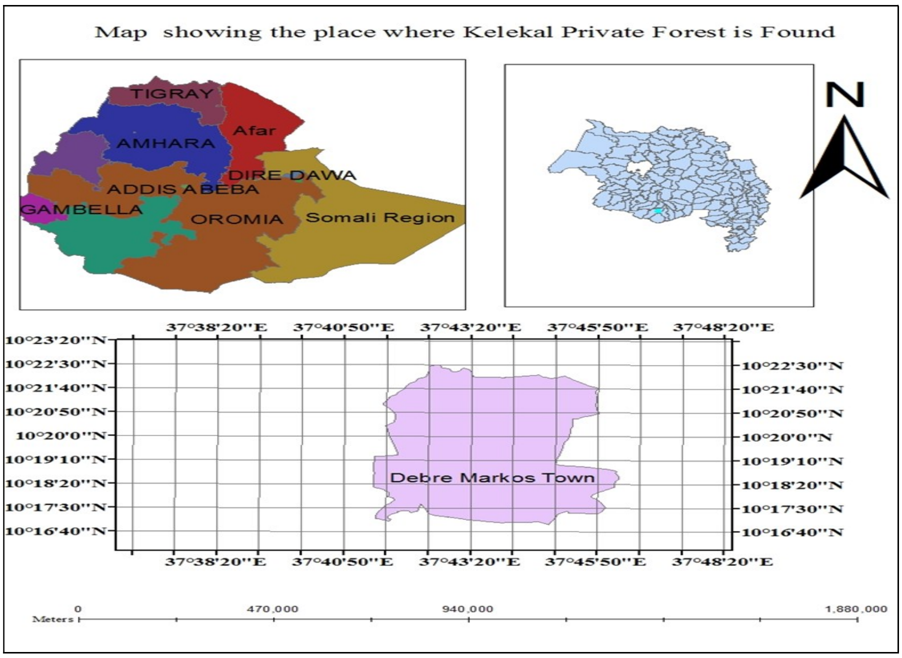

Figure 1. Study Area Map Showing KELEKAL Protected Forest

2.2 Methods

2.2.1 Sampling Design

Following reconnaissance survey, nine different transects following Kent and Coker (1992) and Muller-Dombois and Ellenberg (1974) were used for placing 33 different quadrats for the entire study. Sampling sites were arranged on these transect lines along gradient from top to dawn in 25 m elevation difference/drop. The distance between two transect line were 250 meter. Each of the nine transects contained different number of quadrats with size of 20m by 20 m determined by minimal area concept.

For complete collection of all plants (trees, shrubs, climbers, herbs, seedlings and saplings) five 1 m x 1 m sub plots, one at each corner and one at the center of the main plot were laid to sample herbaceous plants.Partition of the major quadrats (400 m^2) will be made into five one at the center and four at each corner, each 25 m^2 (5 m X 5 m) so as to make seedling counting easier. In each of these quadrats, the numbers of all seedlings that are less than 1 m in height were recorded. Individuals attaining 1 m and above with DBH less than 2.5 cm were considered as sapling and counted.

2.2.2 Vegetation Data Collection

A complete list of trees, shrubs, climbers and herbs including vascular epiphytes were made from each plot along each transect. Species occurring within 10 m distance from the plots boundaries were also recorded as present for floristic composition. Vernacular names of species were recorded during field work. In each plot, the following structural attributes were recorded for all woody plants. These are diameter and height. Diameter was measured for all individual trees and shrubs having DBH (Diameter at Breast Height) greater than 2.5 cm using a diameter tape. If the tree branched at breast height or below, the diameter were measured separately for the branches and averaged. Trees and shrubs with DBH less than 2.5 cm were counted. Height was measured for individual tree and shrub with DBH greater than 2.5 cm using calibrated stick. Where topographic features made difficult to measure height of trees and shrubs, it was estimated visually. The presence-absence and cover abundance data, defined here as the proportion of area in a quadrat covered by every species were recorded and gathered from each quadrat. Later on, cover abundance values were converted using the modified 1-9 Braun Blanquet scales (van der Maarel, 1979). Specimens of all vascular plant taxa were collected, pressed, dried and brought to the National Herbarium (ETH), Addis Ababa University for identification. The nomenclature of the taxa follows Flora of Ethiopia and Eritrea (FEE)

2.2.3 Vegetation Data Analysis

2.2.3.1 Forest Composition and Diversity

Species richness or alpha diversity, the Shannon-Wiener diversity index and evenness were calculated by importing the matrified abundance data into "vegan" package in R 3.2.1 (Oksanen *et al.*, 2014; R Core Team, 2014). The diversity index focuses on the relative species richness and abundance and/or the pattern of species distribution/evenness (Maguran, 1988; Krebs, 1999). The value usually falls between 1.5 and 3.5, rarely exceeding 4.5. Sorensen's similarity index used to determine the pattern of species turnover among successive communities and to compare the different communities with in the forest. It is described using the following formula (Kent & Coker, 1992). The value falls between 0 and 1 inclusive, meaning no similarity and perfect/absolute similarity, respectively.

2.2.3.2 Forest Structure

Species population structure, defined as the frequency distribution of individuals of a species in defined DBH and height classes was analyzed. The Importance Value Index (IVI) was determined from the summation of the relative values of density, frequency and dominance of each woody species whose DBH is greater than 2.5 cm (Kent & Coker, 1992). Basal Area (BA) (m^2ha^{-1}), measured as the cross-sectional area of a tree or shrub at breast height or stump height. It was computed from the measurement of DBH/DSH in spreadsheet programs as follows: BA=πd2/4, Where π 93.14, BA is basal area, and d is DBH (m). However, since DBH was measured in centimeters, the formula was modified in such a way that the Ba will be in square meters. Thus, $Ba=\pi d^2/40,000$ or $0.0000785d^2$, Where d is DBH in centimeters. The mean basal area of all investigated plots was converted to mean basal area per hectare.

2.2.3.3 Plant Community Classification

A hierarchical cluster analysis was performed to classify vegetation in Kelekal private forest (Kent & Coker, 1992; McCune & Grace, 2002). Quadrats were grouped into three clusters with the aid of Multivariate methods using R (Zerihun Woldu, 2012).

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3. Results and Discussion

3.1 Floristic Composition and Diversity

One hundred three plant species belonging to 94 genera and 53 different families were identified in Kelekal protected forest (Appendix 1). Among these 8 plants were found outside the quadrant. Thirty nine percent of the families were represented by more than one species. The highest number of species recorded for families Asteraceae (12.62 %), Fabaceae (8.74%) and Solanaceae (4.85 %). Twelve plants (11.65 %) were new records for Gojjam floristic region in the Flora of Ethiopia and Eritrea. Eight (7.77%) plants are endemic plant species. Accordingly, 16 species are trees, 47 species are shrubs, 12 species are climbers, and 28 species are herbs. In addition, of all the species collected 98.02% were dicots, 1.98 % were monocots. No fern were collected and one Gymnosperm was identified in the Forest.

3.2 Vegetation Structure of Kelekal Protected Forest

3.2.1 Diameter and Height Class Distribution of Kelekal Protected Forest

a. Height class distribution

Albizia gummifera (J.F.Gmel), *Croton macrostachyus* Del. and *Prunus africana* (Hook. F.) Kalkm, were the only tree species with heights above (26m) (Figure 2). Generally, the upper stratum of the forest consisted of *Croton macrostachyus* Del., *Albizia gummifera* (J.F.Gmel)., *Prunus africana* (Hook. F.) Kalkm,*Eucalyptus globulus* Labill. *Ficus sur* Forssk. *Acacia abyssinica* Hochst.ex Benth.*Croton macrostachyus* Del., *Eupohorbia abyssinica* Gmel and *Schefflera abyssinica* (Hochst. Ex. A. Rich.) Harms.

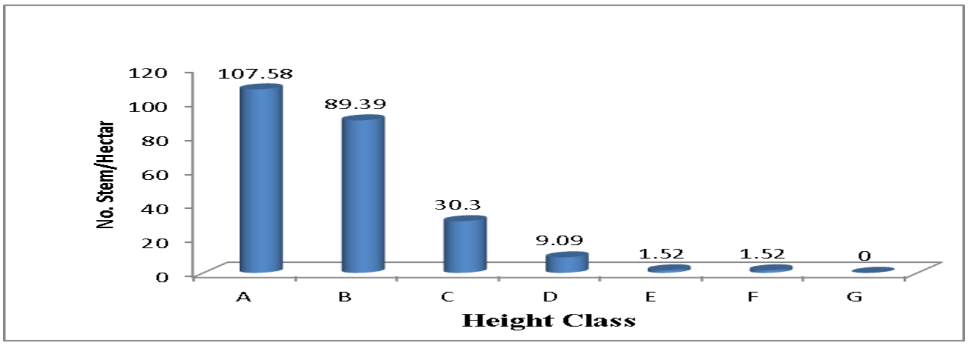


Figure 2. Distribution of Overall Woody Species Density in Height Classes (m)

Class A 2.5-5;B 5.1-10;C 10.1-15,D 15.1-20,E 20.1-25, F 25.1-30,G ≥30.1 meter.

The woody plant density has provided informations which support the assessment of individual trees is very important for future management. Thus, the ratio of density of trees with DBH greater than 10 cm to DBH greater than 20 cm in kelekal protected Forest was 0.62, indicating the dominance of large individuals over small individuals, which could be clearly attributed to forest destruction or the selective cutting of trees in the middle DBH classes. Different trends were reported elsewhere in Ethiopia (Tamrat Bekele 1993; Haile *et al.,* 2008; Tadele *et al.,* 2014). However, the selective cutting of plants in the middle DBH class is due to the high interest of the people used for different purposes like construction and farm tool preparation and farm field protection by putting it around the hedge or as fence. This was also confirmed by personal communication with the people around the forest.

b. Diameter at Breast Height (DBH)

The density of woody species with DBH≥10 cm was less than the density of woody species with DBH≥2.5 cm and DBH≥20 cm. The highest DBH was recorded for *Acacia abyssinica* Hochst. ex Benth (82.8cm). Followed by *Albizia gummifera* (J.F.Gmel) (66.87cm). *Acacia abyssinica* Hochst.ex Benth. and *Prunus africana* (Hook. F.) Kalkm were found in most DBH classes (Figure 3).

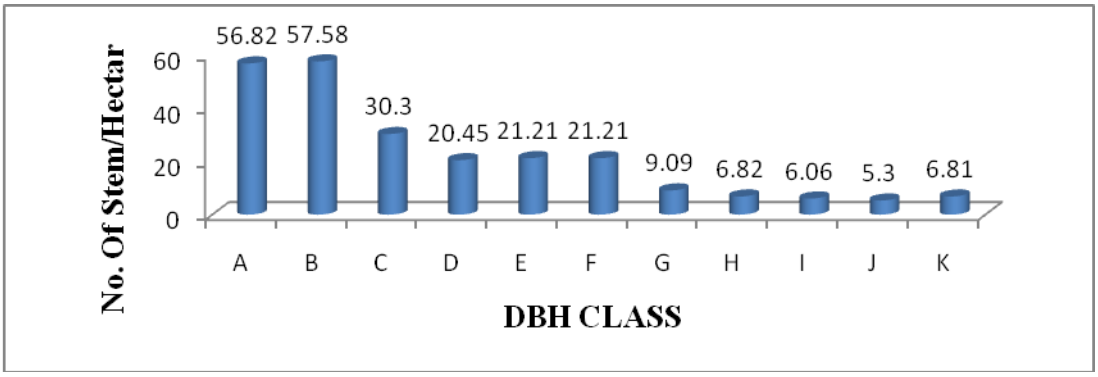


Figure 3. Distribution of Overall Woody Species Density among DBH Classes (cm)

Class A 2.5-7.5,B 7.6-12.5,C 12.6-17.5, D 17.6-22.5, E 22.6-27.5, F 27.6-32.5, G 32.6-37.5, H 37.6-42.5, I 42.6-47.5, J 47.6-52.5, K≥52.6 cm.

The general pattern of **DBH** and **Height** Class distribution of woody plant species in the kelekal forest was befitted an inverted J shape (Figures 2 & 3). An inverted "J" shape pattern of distribution could somehow indicate a healthy regeneration status of the forests (Demel Teketay, 1997). Similar overall population patterns were also reported for Kimphee Forest (Feyera Senbeta & Demel Teketay, 2003), Bale Mountain National Park forest (Haile *et al.,* 2008), Kuandisha afromontane forest (Abiyot *et al.,* 2017) and Kumuli Dry Evergreen Afromontane Forest (Gideon *et al.,* 2016).

But, this assertion was not guarantee that the different types of plants in the forest were shared this healthy nature of plant regeneration. When we look at the individual woody plant population structure, it deviates from the general pattern. This patter of species population structure suggests at least two major types of individual tree species: (1) species able to regenerate in the forest understory (*Acacia abyssinica* Hochst. ex Benth. *Prunus africana (Hook. F.) Kalkm*, *Bersama abyssinica* Fresen, *Dovyalis abyssinica* (A. Rich.) Warb, *Maesa lanceolata* Forssk.*Rhus glutinossa* A.Rich subsp. *Glutinosa* var.*glutinosa*) and (2) relatively large and probably old trees with difficulties to reproduce in the understory environment (*Acacia mearnsii* De Willd., *Croton macrostachyus Del.*, *Albizia gummifera* (J.F.Gmel), *Apodytes dimidiata* E. Mey. Ex Arn.Var. *acutifolia* and *Schefflera abyssinica* (Hochst. Ex. A. Rich.), *Juniperus procera* Hochst. Ex Endi.

3.2.2 Basal Area (BA) and Dominance

Albizia gummifera (J.F.Gmel), *Acacia abyssinica* Hochst.ex Benth., *Croton macrostachyus* Del., *Acacia mearnsii* De Willd., *Prunus africana* (Hook. F.) Kalkm, *Dombeya torrida* (J. F. Gmel.) P. Bamps., *Schefflera abyssinica* (Hochst. ex. A. Rich.) Harms with DBH values greater than 42 cm contributed 41.04 % of the total BA (Figure 4). In terms of species dominance, four species, namely, *Albizia gummifera* (J.F.Gmel), *Croton macrostachyus* Del., *Acacia abyssinica* Hochst. ex Benth. &*Prunus africana* (Hook. F.) Kalkm, ranked in the top four with dominance value (per ha) of 2.32, 1.62, 1.61, & 0.86 respectively**.** Woody plant species which were recorded and grouped in the higher DBH classes contributed most for the total BA. Accordingly, the total BA of woody species with DBH≥2.5 cm was 10.18 m^2 ha^{-1}. The BA of Kelekal Protected forest is considerably lower than in similar forest fragments such as Gedo Dry Evergreen Montane Forest (35.45 m^2 h^{-1}), Kuandisha afromontane forest (15.3 m^2 ha^{-1}), the Wof-Washa forest (102 m^2 ha^{-1}), Jibat forest (50 m^2 ha^{-1}), Denkoro forest (45 m^2 ha^{-1}) and Tara Gedam forest (115.4 m^2 ha^{-1}) (Birhanu Kebede 2010; Abiyot Berhanu *et al.,* 2017; Tamrat Bekele 1993; Abate Ayalew 2003; Zegeye *et al.,* 2011). The lower total BA is mainly attributed to lower DBH of woody species (Tamrat Bekele, 1993) and also kelekal protected forest is secondary forest with a few species protected by guards.

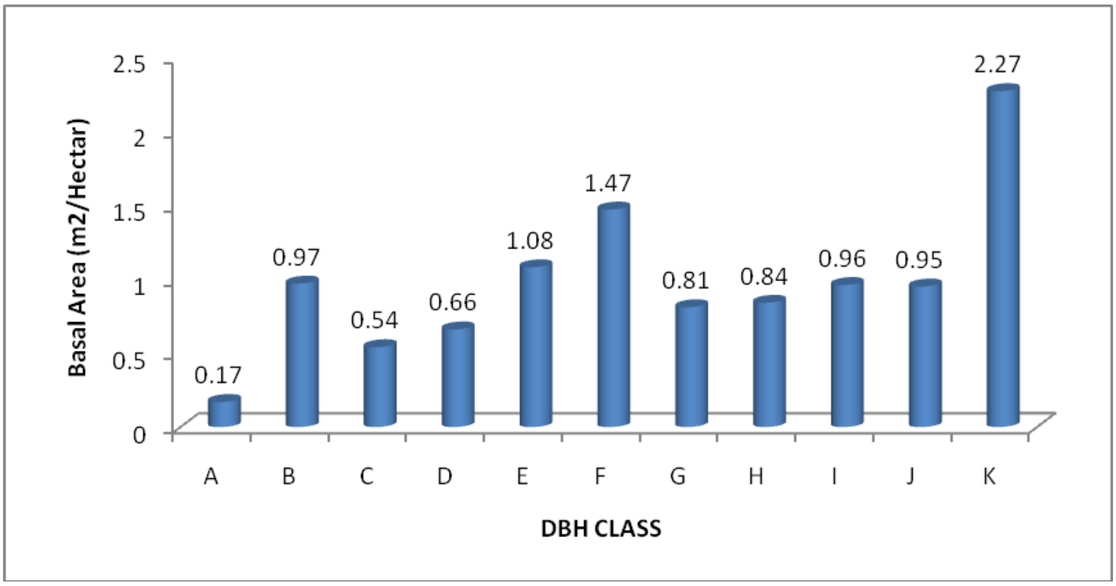


Figure 4. Distribution of Basal Area (m^2 ha^{-1}) in DBH Classes (cm)

Class A=2.5-7.5, B=7.6-12.5, C=12.6 17.5, D=17.6-22.5, E=22.6-27.5, F=27.6-32.5, G=32.6-37.5, H=37.6-42.5, I=42.6-47.5, J=47.6-52.5, K=≥ 52.6 cm.

3.2.3 Importance Value Index (IVI)

The importance Value Index (IVI) of species ranged from 3.44 to 83.27 (Appendix 2). Eight species, *Acacia abyssinica* Hochst.ex Benth, *Albizia gummifera* (J.F.Gmel), *Bersama abyssinica* Fresen, *Croton* *macrostachyus* Del., *Dovyalis abyssinica* (A. Rich.) Warb., *Gnidia glauca* (Fresen.) Gilg, *Pavetta abyssinica* Fresen.Var. *abyssinica*, *Vernonia myriantha* Hook.f.had IVI value greater than 40. These species contributed 51.72 % of the IVI value in this forest. Generally, 5 species have IVI of less than 5; 15 species IVI of 5.1-20 and 7 species IVI of 20-40. Other studies such as Abiyot Berhanu *et al.* (2017), Abate Zewdie (2007), Shambel Bantiwalu (2010) and Tadele *et al.* (2014) documented higher IVI for some tree species such as *Bersama abyssinica* Fresen and *Prunus africana* (Hook. F.) Kalkm than the current study in similar vegetation types. Some of the species with higher IVI values in this forest are among the characteristic species in the Dry evergreen Afromontane Forest (DAF) elsewhere (Fris *et al.,* 2010; Zerihun Woldu, 1999).

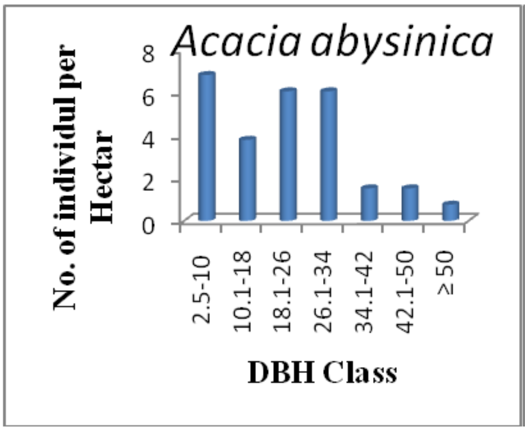
The highest IVI value of *Acacia abyssinica* Hochst.ex Benth, *Albizia gummifera* (J.F.Gmel), and *Croton macrostachyus* Del had arisen from its high frequency or distribution and high dominance values whereas the rest of the above mentioned species like *Bersama abyssinica* Fresen, *Dovyalis abyssinica* (A. Rich.) Warb., *Gnidia glauca* (Fresen.) Gilg, *Pavetta abyssinica* Fresen. Var. *abyssinica*, and *Vernonia myriantha* Hook.f are arise mainly from its frequency.

3.2.4 Species Population Structure

Accordingly, five general patterns of population structure were recognized in the three community types in kelekal protected forest.

The first pattern indicated a high number of individuals in the first DBH class followed by a progressive decline in the number of individuals with increasing DBH. This pattern of distribution is called an inverted J shape pattern of species distribution (Figure 5). This pattern is manifested on *Acacia abyssinica* Hochst. ex Benth. in the study area. Maximum values occurred in the first class and then reduced gradually.

The second pattern of population structure is indicated by the absence of plants in the lower DBH class and its presence in the subsequent DBH class including the Higher DBH classes. This can be shown by plants like *Albizia schimperi* and *Croton macrostachyus* (Figure 6). The complete absence of individuals in some diameter classes indicates that the regeneration of species was hampered during one or several phases of their life cycle. These might be caused by trampling by livestock, selective cutting for construction, timber or firewood purposes.



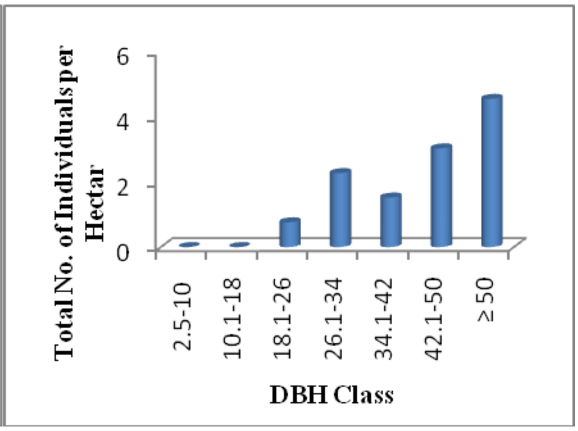


Figure 5. Population Pattern of *Acacia abyssinica* **Figure 6. Population Pattern of *Albizia schimperi***

The third pattern of population structure is represented by the absence of individuals in the first second or third DBH class and it can be present in the next two or three classes and absent in the last three or two classes. Such kind of pattern is indicated by different species like *Acacia mearnsii* De Willd., *Dombeya torrida* (J. F. Gmel.) P. Bamps., *Schefflera abyssinica* (Hochst. Ex. A. Rich.) Harms, *Ficus sur* Forssk., *Apodytes dimidiata* E. Mey. Ex Arn.Var. *acutifolia*, *Juniperus procera* Hochst.Ex Endi.This pattern indicates hampered regeneration caused by heavy human pressure on the species leading to scarcity of mature individuals that can serve as seed sources (Figure 7).

The forth pattern of population structure is indicated by the absence of plants in one or two Higher DBH clasees. This could be examplified by *Prunus africana*. This is due to selective cutting of plants in the forest due to different reasons. Such kind of pattern is a common phenomenon in protected forest (Figure 8).

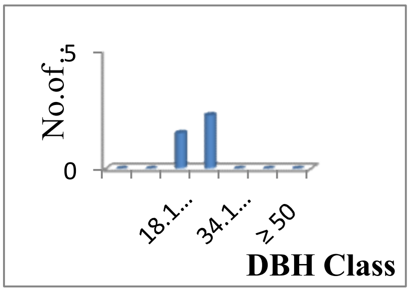


Figure 7. Population Pattern of *Apodytes dimidiata*

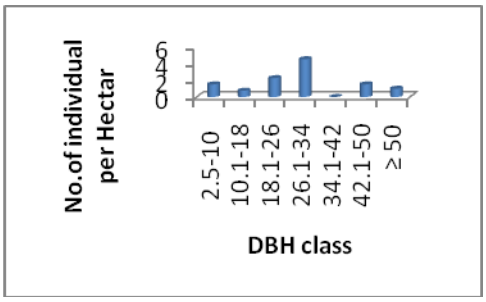


Figure 8. Population Pattern of *Prunus africana*

The fifth pattern of plant population structure was represented by the presence of plants in the first three DBH classes and the absence of plants in the rest of Higher DBH classes. Plants like *Bersama abyssinica* Fresen, *Dovyalis abyssinica* (A. Rich) Warb., *Maesa lanceolata* Forssk. and *Rhus glutinossa* indicate this pattern These plants show many large number of individuals of plants in the lower DBH class but these plants do not reach maturity that provide seeds in the next generation that indicates the phenomenon of secondary forest development or cutting of higher DBH classes (Figure 9 and Figure 10). Generally, absence of large sized individuals indicated that the forest has long history of anthropogenic disturbance.

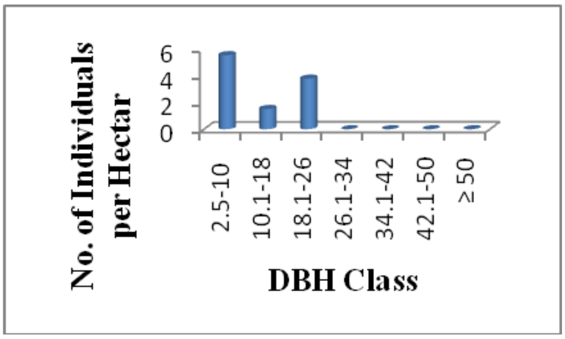


Figure 9. Population Pattern of *Rhus glutinossa*

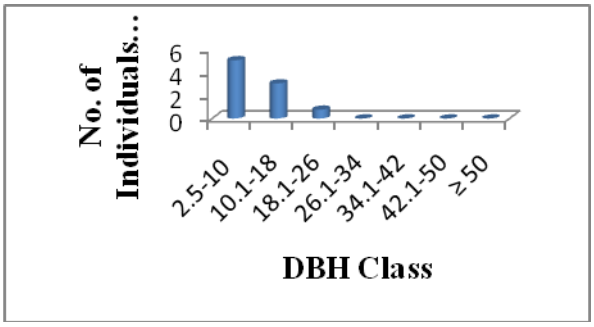


Figure 10. Population Pattern of *Maesa lanceolata*

The patterns of species population structure that emerges interpreted as an indication of variation in population dynamics in the forest (Popma *et al.,* 1988). Practically it can provide an estimate of the regeneration status of woody species (Demel Teketay, 2005a). Various studies have revealed various population structures of species in dry evergreen Afromontane forests of Ethiopia. For instance, Abiyot Berhanu et al. (2017), Demel Teketay (2005a), Alemnew et al. (2007), Haile et al. (2008), Shambel Bantiwalu (2010) and Tadele et al. (2014) reported various population patterns in similar forests in Ethiopia.

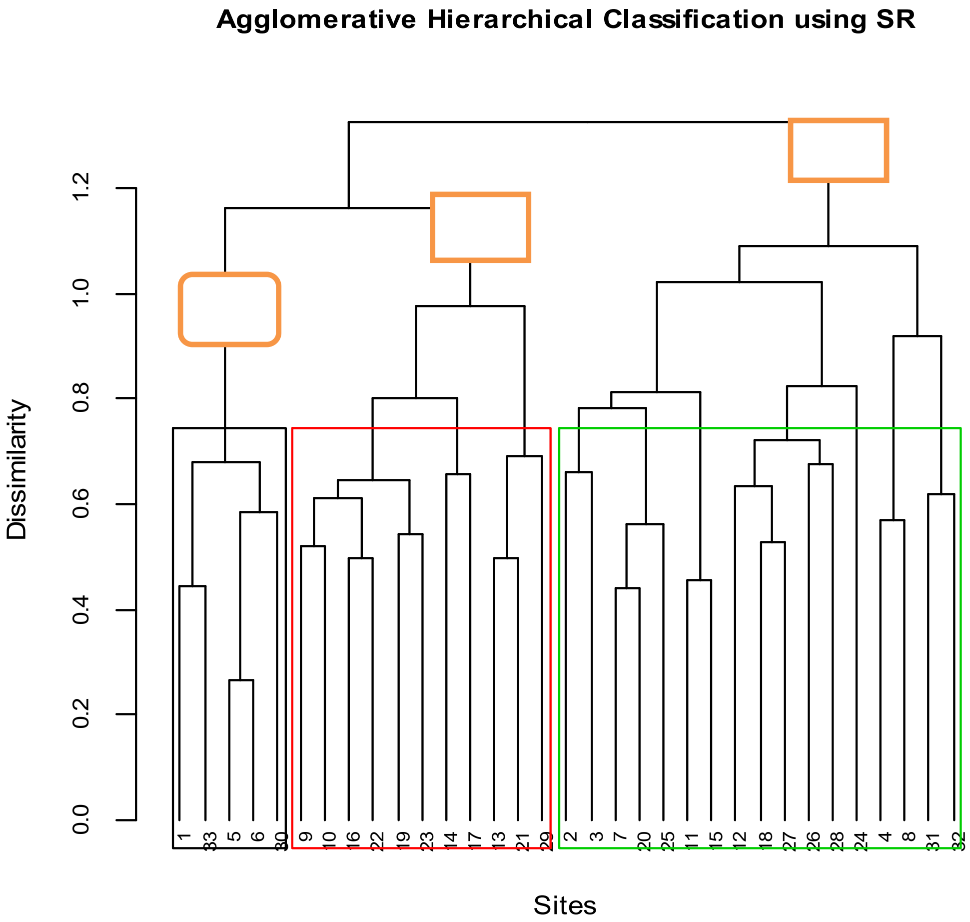
Examination of patterns of species population structures could provide valuable information about their regeneration and/or recruitment status as well as viability status of the population that could further be employed for devising evidence based conservation and management strategies (Demel Teketay, 2005a; Abrham Abiyu *et al.,* 2006). Various patterns of species population structures have been reported for different species in other Afromontane forests of the country (e.g., Demel Teketay, 1997; Abate Ayalew, 2003; Feyera Senbeta & Demel Teketay, 2003; Kumlachew Yeshitela and Taye Bekele, 2003; Simon Shibru and Girma Balcha, 2004; Ermias Lulekal, 2005; Haileab Zegeye *et al.,* 2006).

"J" population pattern represents good reproduction status and regeneration potential. This pattern of population growth is similar with study conducted by Abyot Birhanu *et al.,* 2017 in Kuandisha afromontane forest fragment in northwestern Ethiopia.

3.3 Plant Community Types in Kelekal Private Forest

3.3.1 Agglomerative Hierarchical Classification Using SR

The "K" partitioning in the R program was resulted three plant community types from the hierarchical cluster analysis (Figure 11).



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

Figure 11. Agglomerative Hierarchical Classification on Plants Found in Kelekal Protected Forest

3.3.2 Plant Community Types

A) Croton macrostachyus-Maytenus Arbutifolia Community Type

This community comprised of 5 quadrats and 36 species. The community is distributed in between the altitudinal ranges of 2400 and 2463 m a.s.l. This community has five plant species with highest mean values of the species cover abundance of Cluster groups (*Croton macrostachyus* Del., *Maytenus arbutifolia* (A. Rich.) Wilczek, *Acacia abyssinica* Hochst. Ex Benth, *Vernonia myriantha* Hook.f. and *Hypoestes triflora* (Forssk.) Roem & Schult). *Croton macrostachyus* Del., and *Prunus africana* (Hook. F.) Kalkmare the emergent trees of this community type. Other trees, shrubs and climbers associated with this community include, *Brucea antidysenetrica* J.F.Mill., *Capparis tomentosa* Lam., *Carissa spinarum* L. *Bersama abyssinica* Fresen. *Rosa abyssinica* Lindley, *Osyris quadripartita* Decn., *Pavetta abyssinica* Fresen. Var. *abyssinica*, *Phytolacca dodecandra* L Herit, *Pittosporum viridiflorum* Sims, *Prunus africana* (Hook.F.) Kalkm.

The herb layer is composed of *Hypoestes triflora* (Forssk.) Roem & Schult., *Laggera tomentosa* Sch.Bip .ex Arich.oliv. & Hiern, *Achyranthes aspera* L. var. sicula, *Cardus schimperi* ScIr. Hip. ex A. Rich., *Crepis rueppellii* Sch. Bip., *Kalanchoe densiflora* Rolfe Var. *densiflora.*

B) Hypoestes triflora-Embelia schimperi Community type

This community comprised of 11 quadrats and 90 species. The community is distributed in between the altitudinal ranges of 2381 and 2480 m a.s.l. This community has six indicator species (*Hypoestes triflora* (Forssk.) Roem & Schult., *Embelia schimperi* Vatke, *Acacia abyssinica* Hochst. Ex Benth, *Carissa spinarum* L., *Clausena anisata* (Willd.) Benth *Albizia gummifera* (J.F.Gmel), *Clutia abyssinica* Jaub & Spach. The emergent tree species in this community type are *Acacia abyssinica* Hochst. Ex Benth, *Albizia gummifera* (J.F.Gmel), *Schefflera abyssinica* (Hochst. Ex. A. Rich.) Harms, *Prunus africana* (Hook. F.) Kalkm, *Juniperus procera* Hochst. Ex Endi. And *Acacia mearnsii* De Willd Other trees, shrubs and climbers associated with this community include *Dregea schimperi* (Decne.) Bullock, *Lippia adoensis* var. *adoensis* Hochst. Ex Walp., *Pavetta abyssinica* Fresen. Var. *abyssinica, Ocimum lamiifolium* Hochst. Ex Benth.,*Osyris quadripartita* Decn**.**, *Apodytes dimidiata* E. Mey. Ex Arn.Var. *acutifolia, Dombeya torrida* (J. F. Gmel.) P. Bamps. *Dovyalis abyssinica* (A. Rich.) Warb., *Draceana steudneri* Engler, *Justicia schimperiana* (Hochst.ex Nees) T. Andres., *Phytolacca dodecandra* L Herit, *Pittosporum viridiflorum* Sims, *Rubus steudneri* Schweinf, *Vernonia amygdalina* Del., *Hippocratea africana* (wild.) Loes, *Solanecio gigas* (Vatke) C. Jeffrey.

The Herbaceous layer of this community is covered by the following plant species like *Achyranthes aspera* L. var. sicula , *Acanthus polystachis* Delile., *Carthamus lanatus* L., *Circium schimperi* (Vatke) C. Jeffrey ex Cufod, *Commelina benghalensis* L., *Crepis rueppellii* Sch. Bip.,*Cynoglossm lanceolatum* Forssk., *Tagetes minuta* L., *Foeniculum vulgare* Miller, *Hypoestes triflora* (Forssk.) Roem & Schult.*Kalanchoe densiflora* Rolfe Var. *densiflora*, *Lactuca serriola* L., *Rbia cordifolia* L., *Thalictrum rhychocarpum* Dill.& A. Rich

C) *Carissa spinarum - Acacia abyssinica* Community type

This community comprised of 17 different quadrats and 65 species. The community is distributed in between the altitudinal ranges of 2396 and 2481 m a.s.l. This community has five indicator species like *Carissa spinarum* L., *Acacia abyssinica* Hochst. Ex Benth, *Maytenus arbutifolia* (A. Rich.) Wilczek, *Osyris quadripartita* Decn., *Rosa abyssinica* Lindley. The emergent tree species in this community are *Acacia abyssinica* Hochst. Ex Benth, *Eucalyptus globulus* Labill.and *Ficus sur* Forssk. Other trees, shrubs and climbers associated with this community include *Ritchiea albersii* Gilg., *Gnidia glauca* (Fresen.) Gilg, *Pittosporum viridiflorum* Sims, *Pavetta abyssinica* Fresen.Var. *abyssinica*, *Hypericum quartinianum* A. Rich, *Hypericum revolutum* Vahl, *Gnidia glauca* (Fresen.) Gilg, *Maytnes senegalensis* (Lam.) Excell and *Heteromorpha arborescens* (Spreng.) Cham & Sch.

The Herbaceous layer of this community is covered by the following plant species like, *Verbascum sinaiticum* Benth., *Stephania abyssinica* Var. *abyssinica, Sida schimperiana* Hochst. Ex A. Riich.

Laggera crispata (Vah l) Hepper & Wood, *Kalanchoe densiflora* Rolfe Var. *densiflora* and *Orobanche minor* Smit.

3.4 Species Diversity, Evenness and Richness of the Plant Communities

The highest species richness and diversity were observed in community two and the others are presented in Table 1.

Table 1. Shanon Wiener Diversity Index of Overall Species Richness, Diversity and Evenness Values of Plant Communities Identified in Kelekal Private Forest

Community type	Altitude range	Diversity index (H)	Species Richness (S)	Shannon's Evenness index (J)
Community one *Maytenus arbutifolia-Croton macrostachyus*	2400-2463	3.046733	36	0.850207
Community two *Hypoestes triflora-Embelia schimperi*	2381-2480	4.032953	90	0.89625
Community three *Carisa spinarum-Acacia abyssinica*	2396-2481	3.692061	65	0.884456

The possible reason for high species richness of community two may be associated with optimal conditions of environmental factors that favor vegetation growth and with the highest diversity because its species are evenly distributed and relatively high species were recorded. In contrast community one exhibited the least species richness and diversity. As the community lies along the margin of the forest (easily accessible), anthropogenic impacts such as selective removal of economically important trees, grazing by live stock and other environmental factors such as aspect, slop etc could contribute for low species richness and diversity. For example, Livestocks were observed in the forest margin during field study. Community type 3 was with intermediate richness and diversity

Based on the result of the data, it can be said that the second cluster or community type (cluster 2) relatively high diversity (H=4.03), and high Richness (=90), whereas the other two clusters are almost similar in diversity. The distributions of plants in cluster 2 are relatively evenly distributed than the other two clusters. i.e., the most diverse the community is the most richness the species are. Species richness represents the number of different species in a given area whereas evenness is a measure of equitability and it attempts to quantify the unequal representation of species in a community against a hypothetical community in which all species are equally common

3.5 Similarity among Plant Communities

Sorenson's similarity coefficient used to determine the similarities among plant communities (Table 2). More floristic similarity (0.68) was observed between community one and two than between any of the other community type. This could be associated to slope, aspect, the anthropogenic and other environmental factors such as soil type and properties not considered in this study. The list species similarity with any other community was recorded for community two and community three.

Table 2. Sorensen Similarity Coefficient among Community Types

Community type	1	2	3
1: *Maytenus arbutifolia-Croton macrostachyus*			
2: *Hypoestes triflora-Embelia schimperi*	0.68		
3: *Carisa spinarum* and *Acacia abyssinica*	0.57	0.53	

3.6 Regeneration Status of Keleka Protected Forest

The composition, distribution and density of seedlings and saplings are indicators of the future regeneration status of any forest. Based on the results of this study, 5 species (29.41 %) of the total were not represented by both seedling and sapling stages. These species were *Prunus africana* (Hook. F.) Kalkm, *Apodytes dimidiata* E. Mey. Ex Arn. Var. *acutifolia* , *Schefflera abyssinica* (Hochst. Ex. A. Rich.) *Pittosporum viridiflorum* Sims and *Ficus sur.* On the other hand, 5 species (29.41 %) of the total were not represented by sapling. These species were *Draceana steudneri* Engler, *Eupohorbia abyssinica* Gmel, and *Juniperus procera* Hochst. *Dombeya torrida* (J. F. Gmel.) and *Ekebergia capensis* Sparrm

Acacia abyssinica Hochst. Ex Benth., *Acacia nilotica* (L.) Willd.ex Del, *Albizia schimperiana* Oliv. *Bersama abyssinica* Fresen, *Croton macrostachyus* Del and P. Bamps.were represented by both seedling and sapling stages and hence, have relatively higher regeneration status.

Based on seedling sapling count, tree species of Kelekal protected Forest are grouped into 3 priority classes for conservation. These are class 1: those species with no seedling and sapling, Class 2: those with seedlings but no sapling, and Class 3: those with both seedlings and saplings >1 individual/ha (Table 3). The first and second priority classes, therefore, need due attention in order to save them from local extinction.

Table 3. List of Plants at Different Conservation Priority Clases

	Priority class one	Priority class two	Priority class three
1	*Prunus africana*	*Juniperus procera*	*Acacia abyssinica*
2	*Apodytes dimidiata*	*Ekebergia capensis*	*Acacia lahai*
3	*Schefflera abyssinica*	*Dombeya torrida*	*Albizia gummifera*

4	*Pittosporum viridiflorum*	*Draceana steudneri*	*Bersama abyssinica*
5	*Ficus sur.*	*Eupohorbia abyssinica*	*Croton macrostachyus*

4. Conclusion

In the present study, species diversity, plant community types, population structure and regeneration status were determined for the Kelekal protected forest in Debre Markos town District. The results of this study indicate the presence of relatively high species diversity. Asteraceae (12.62 %), was found to be the most dominant family followed by Fabaceae (8.74%), and Solanaceae (4.85 %). Shrubs and Herbs were the dominant growth forms while climbers scored the least proportion. In addition, of all the species collected 98.02 % were dicots and 1.98 % were monocot. No fern were collected and one Gymnosperm was identified in the Forest. From the total species recorded, *Rhus glutinossa* A.Rich subsp. *glutinosa* var.*glutinosa* listed in the IUCN red data list under the near threatened category.

From the DBH and Height distribution pattern and the density of total basal area, we understand that the presence of some large trees and the prevalence of small to medium sized individuals in the forest has indicated that the forest is in a late stage of secondary development.

IVI values of woody plants in this protected forest reveal the most economical and ecologically important woody species in the forests. Among the plants that have the highest IVI value, *Albizia gummifera* (J.F.Gmel) and *Croton macrostachyus* Del. (J.F.Gmel) was the most critically hampered species. Both the cumulative diameter and height class frequency distribution patterns of woody individuals had an inverted-J-shape, reflecting a more or less poor regeneration profile in the study area. Species with a low IVI: *Apodytes dimidiata* E. Mey. ex Arn. Var. *acutifolia*, *Dombeya torrida* (J. F. Gmel.) P. Bamps., *Schefflera abyssinica* (Hochst. Ex. A. Rich.) Harms, *Ficus sur* Forssk., *Juniperus procera* Hochst. Ex Endi need special attention to minimize depletion and priority for conservation. The cooperation and participation of the local communities at all stages are essential for the successful management of communal and locally available resources.

5. Recommendations

As privately owned protected forest, it is designed mainly for income generation. But when we assess it the owner did not get the benefits. The actual management used to achieve the objectives may need silvicultural treatments by stakeholders.

Efectivity of Forest development through different approaches like plantation, Area closure or protected forests must be cheeked by conducting phtososological study at different time scales for full management practices. The existing conditions of this forest (e.g., tree types, sizes, and ages) often dictate the opportunities to invest in forest management, as well as the specific practices like enrichment planting particularly in the open spaces is necessary and it encourages planting of indigenous and suitable exotic tree species.

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Appendix 1

1-List of Plants Found in Kelekal Protected Forest Including Family, Local Name Growth Form (H=herb, NWC=non Woody Cimber, WC=Woody Climber, S=Shrub, T=Tree), Vocher Noumber Endemis and Floristic Region (FR)

No	Scientific name	Family	Local name	Growth form	Voucher No.	Endemic to ethiopia	FR
1	*Abutilon cecilii* N. E. Br.	Malvaceae	Lut	S	KF-055	NON	GJ
2	*Acacia abyssinica* Hochst. ex Benth.	Fbaceae	Girrar	T	KF-004	NON	GJ
3	*Acacia lahai* steud & Hochst ex Benth	Fabaceae	Cheba	T	KF-089	NON	GJ
4	*Acacia mearnsii* De Willd.	Fabaceae	Yeferenge Girrar	T	KF-031	NON	GJ
5	*Acanthus polystachis* Delile.	Acanthaceae	Kosheshila	S	KF-002	NON	GJ
6	*Achyranthes aspera* L. var. sicula	Amaranthaceae	Key telenje	H	KF-005	NON	GJ
7	*Albizia gummifera* (J.F.Gmel)	Fabaceae	Sessa	T	KF-016	NON	GJ
8	*Alchemilla pedata* Rich	Rosaceae		H	KF-087	NON	GJ
9	*Apodytes dimidiate* E. Mey. Ex Arn. Var. acutifolia	Icacinaceae	Donga	T	KF-090	NON	GJ
10	*Argrolobium schimperianum* (hochst. ex A. Rich	Fabaceae		S	Kf-066	Endemic	GJ
11	*Asparagus africanus* Lam.	Asparagaceae	Yeset Kest	WC	KF-054	NON	GJ
12	*Bersama abyssinica* Fresen	Melianthaceae	Azamir	S	KF-017	NON	GJ
13	*Brucea antidysenetrica* J.F.Mill.	Simaroubaceae	Aballo	S	KF-091	NON	GJ
14	*Buddleja polystachya* Fresen.	Loganaceae	Anfar	S	KF-052	NON	GJ
15	*Calpurnia aurea* (Ait.) Benth.	Fabaceae	Digta	S	KF-013	NON	GJ
16	*Capparis tomentosa* Lam.	Capparidaceae	Gumero	S	KF-035	NON	NOTGJ
17	*Cardus schimperi* ScIr. Hip. exA. Rich.	Asteraceae	Kosheshila	H	KF-040	NON	NOT GJ
18	*Carissa spinarum* L.	Apocynaceae	Agam	S	KF-036	NON	GJ
19	*Carthamus lanatus* L.	Asteraceae	Yeahiya suff	H	KF-007	NON	GJ
20	*Circium schimperi* (Vatke) C. Jeffrey ex Cufod.	Asteraceae	Kosheshila	H	KF-078	Endemic	GJ
21	*Circium vulgare* (Savi) Ten	Asteraceae		H	KF-078	NON	GJ
22	*Clausena anisata* (Willd.) Benth.	Rutaceae	Limich	S	KF-001	NON	GJ
23	*Clematis simensis* Fresen.	Ranunuculaceae	Azohareg	WC	KF-065	NON	GJ
24	*Clerodendrum myricoids*(Hochst.) Vatke.	Lamiaceae	yemiserich	S	KF-051	NON	NOT GJ
25	*Clutia abyssinica* Jaub. & Spach	Euphorbiaceae	Feyelefeje	S	kf-077	Endemic	GJ
26	*Commelina benghalensis* L.	commelinaceae	Wuhaanqur	H	KF-021	NON	GJ
27	*Crepis rueppellii* Sch. Bip.	Asteraceae	Yefyel wotet	H	KF-020	NON	GJ
28	*Crotalaria quartiniana* A. Rich	Fabaceae		H	KF-084	NON	GJ
29	*Croton macrostachyus* Del.	Euphorbiaceae	Bissana	T	KF-049	NON	GJ
30	*Cynodon dactylon* (L.) pers.	Poaceae		H	KF-094	NON	GJ

31	*Cynoglossm lanceolatum* Forssk.	Boraginaceae	Shingug	H	KF-056	NON	GJ
32	*Datura stramonium* L.	Solanaceae		H	KF-084	NON	GJ
33	*Dipsacus pinnatifidus* Steud. Ex A. Rich.	Dipsacaceae	Kelem	H	KF-069	NON	GJ
34	*Discopodium penninervium* Hochst.	Solanaceae	Aluma	S	KF-080	NON	GJ
35	*Dodonea angustifolia* L. f.	Sapindaceae	Kitkita	S	KF-009	NON	GJJ
36	*Dombeya torrida* (J. F. Gmel.) P. Bamps.	Sterculiaceae	Wolkfa	T	KF-029	NON	GJ
37	*Dovyalis abyssinica* (A. Rich.) Warb.	Flacortiaceae	Koshim	S	KF-015	NON	GJ
38	*Draceana steudneri* Engler	Draceannaceae	Merko	T		NON	GJ
39	*Dregea schimperi* (Decne.) Bullock	Asclepiadaceae	Yettota Kolet	WC	KF-048	NON	NOT GJ
40	*Echinops macrochaetus* Fresen.	Asteraceae	Kosheshila	H	KF-003	NON	GJ
41	*Ekebergia capensis* Sparrm.	Meliaceae	Lol	T	KF-062	NON	GJ
42	*Embelia schimperi* Vatke.	Myrsinaceae	Enkoko	WC	KF-014	NON	GJ
43	*Eucalyptus globulus* Labill.	Myrtaceae	Nech bahirzaf	T	KF-082	NON	GJ
44	*Euclea divinorum* Hiern	Ebenaceae	Dedeho	S	kf-072	NON	NOT GJ
45	*Euphorbia schimperiana* Scheele.	Euphorbiaceae	Antarfa	H	KF-050	NON	GJ
46	*Eupohorbia abyssinica* Gmel	Euphorbiaceae	Kulkual	T		NON	GJ
47	*Ficus sur* Forssk.	Moraceae	Sholla	T		NON	GJ
48	*Foeniculum vulgare* Miller	Appiaceae	Ensilal	H	KF-039	NON	GJ
49	*Gnidia glauca* (Fresen.) Gilg	Thymelaceae	Awra	S	KF-024	NON	GJ
50	*Gomphocarpus purpurascens* A.Rich.	Asclepiadaceae		H	KF-043	Endemic	GJ
51	*Heteromorpha arborescens* (Spreng.) Cham. & Sch	Appiaceae		S	KF-010	NON	GJ
52	*Hibiscus berberidifolius* A.Rich.	Malvaceae	Nacha	S	kf-075	NON	GJ
53	*Hippocratea africana* (wild.)Loes	Celasteraceae	Taro hareg	WC	KF-022	NON	NOT GJ
54	*Hypericum quartinianum* A. Rich	Guttifferae	Amja	S	kf-076	NON	GJ
55	*Hypericum revolutum* Vahl	Guttifferae	Amja	S	KF-061	NON	GJ
56	*Hypoestes triflora* (Forssk.) Roem & Schult.	Acanthaceae	Tikur Telenje	H	KF-073, kf 080	NON	GJ
57	*Jasminum abyssinicum* Hochst. Ex Dc.	Oleaceae	Tembelel	WC	KF-028	NON	GJ
58	*Juniperus procera* Hochst. Ex Endi	Cupressaceae	Yehabesha Tsid	T	KF-045	NON	GJ
59	*Justicia schimperiana* (Hochst. Ex Nees) T. Andres.	Acanthaceae	Simiza	S	kf-	NON	GJ
60	*Kalanchoe densiflora* Rolfe Var. subpilosa CuI	Crassulacea	Endehohula	H	KF-058	Endemic	NOT GJ
61	*Lactuca serriola* L.	Asteraceae	Wotet yemiwotaw	H	KF-059	NON	GJ

62	*Laggera crispate* (Vahl) Hepper & Wood	Asteraceae	Kessbudeje	H		NON	NOT GJ
63	*Laggera tomentosa* Sch.Bip .ex Arich.) oliv. & Hiern	Asteraceae	Keskesso	H	KF-047	Endemic	GJ
64	*Leonotis ocymifolia* var. raineriana (Burm. F.) Iwar	Lamiaceae	Yeferes zeng	S		NON	GJ
65	*Lippia adoensis* var. adoensis Hochst. Ex Walp.	Verbanaceae	Kesse	S	KF-064	Endemic ET&ER	GJ
66	*Maesa lanceolata* Forssk.	Myrsinaceae	Kilambo	S	KF-042	NON	GJ
67	*Maytenus arbutifolia* (A. Rich.) Wilczek	Celasteraceae	Atat	S	KF-038	NON	GJ
68	*Maytnes senegalensis* (Lam.) Excell	Celasteraceae	Koba	S	KF-082	NON	GJ
69	*Myrsine africana* (L.) R. Br.	Myrsinaceae	Kechemo	S	KF-041	NON	GJ
70	*Nuxia congesta* (R. Br. Ex Fresen.)	Loganaceae	-------	S	KF-071	NON	GJ
71	*Ocimum lamiifolium Hochst. Ex Benth. var. raineriana*	Lamiaceae	DamaKessie	S	KF-012	NON	GJ
72	*Orobanche minor* Smit	Orobanchaceae	Goshimta	H	KF-008	NON	GJ
73	*Osyris quadripartite* Decn.	Santalaceae	Keret	S	KF-037	NON	GJ
74	*Pavetta abyssinica* Fresen. Var. abyssinica	Rubiaceae	Dingay Seber	S	KF-034	NON	GJ
75	*Pavonia urens* Cav.	Malvaceae		S	KF-060	NON	GJ
76	*Periploca linearifolia* Quart. Dill. & A. Rich.	Asclepiadaceae	Moyder (wotet yemiwotaw hareg)	WC	KF-032	NON	NOT GJ
77	*Phytolacca dodecandra* L Herit	Phytolaccaceae	Endod	S	KF-085	NON	GJ
78	*Pittosporum viridiflorum* Sims	Pittosporaceae	Woyl	T	KF-027	NON	GJ
79	*Prunus africana* (Hook. F.) Kalkm	Rosaceae	Homma	T	KF-053	NON	GJ
80	*Pterolobium stellatum* (Forssk.] Brenan	Fabaceae	Konter	WC	KF-070	NON	GJ
82	*Rhamnus prinoides* L Herit.	Rhamnaceae	Gesho	S	KF-044	NON	GJ
83	*Rhus glutinossa* A.Rich subsp. Glutinosa var.glutinosa	Anacardiaceae	Tallo(Ashkamo)	S	KF-081	Endemic	GJ
84	*Ritchiea albersii* Gilg.	Capparidaceae	Chomye	S	KF-068	NON	GJ
85	*Rosa abyssinica* Lindley	Rosaceae	Kega	S	KF-033	NON	GJ
81	*Rubia cordifolia* L.	Rubiaceae		NWC	KF-025	NON	GJ
86	*Rubus steudneri* Schweinf	Rosaceae	Enjori	S		NON	NOT GJ
87	*Rumex abyssinicus* Jacq.	Polygonaceae	Mekmeqo	S	KF-081	NON	GJ
88	*Rumex nervosus* Vahl	Polygonaceae	Embacho	S	KF-046	NON	GJ
90	*Schefflera abyssinica* (Hochst. Ex. A. Rich.) Harms	Araliaceae	Getum	T	KF-023	NON	NOT GJ

89	*Sesbania sesban* (L.) Merr.Var. nubica	Fabaceae	Saspania	S	KF-079	NON	GJ
91	*Sida schimperiana* Hochst. Ex A. Riich.	Malvaceae	Chifrg	H	KF-026	NON	GJ
92	*Solanecio gigas* (Vatke) C. Jeffrey.	Asteraceae	Boze	S	KF-086	Endemic	GJ
93	*Solanum anguivi* Lam.	Solanaceae		S	KF-063	NON	GJ
94	*Solanum incanum* L.	Solanaceae		S		NON	NOT
95	*Solanum villosum* Mill.	Solanaceae		H	Kf-092	NON	NOT
96	*Stephania abyssinica* Var. abyssinica	Menispermaceae	Aytehareg	WC	KF-019	NON	GJ
97	*Tagetes minuta* L.	Asteraceae	Yekintarot Medhanit	H	KF-067	NON	NOT GJ
98	*Thalictrum rhychocarpum* Dill. & A. Rich	Ranunuculaceae	Sire Bizu	H	KF-011	NON	GJ
99	*Urera hypselodendron*(A. Rich.) Wedd.	Urticaceae	Lenquato	WC	KF-074	NON	GJ
100	*Verbascum sinaiticum* Benth.	Scrophulariaceae	Ketetina	H	KF-030	NON	GJ
101	*Vernonia amygdalina* Del.	Asteraceae	Girawa	S	KF-006	NON	GJ
102	*Vernonia myriantha* Hook.f.	Asteraceae	Gengereta	S	KF-057	NON	GJ
103	*Zehneria scabra*(Linn. F.) Sond.	Cucurbitaceae	Huregressa	NWC	KF-018	NON	GJ

Where GJ=Gojjam floristic Region, NOTGJ=Not found in Gojjam Floristic Region, NON=Not Endemic.

Appendix 2

Frequency (F), Relative Frequence (RF), Dominance (D), Relative Dominance (RDO) and Density (DE), Relative Desity (RDE), IVI (Importance Value Index) of Woody Species of Kelekal protected Forest Whose DBH Is ≥ 2.5 cm

No	Local name	Scientific name	Family	H	F	RFR	DO	RDO	DE	RDE	IVI
1	Girrar	*Acacia abyssinica* Hochst. ex Benth.	Fbaceae	T	19	57.6	1.61	14.7	26.51	11	83.27
2	Yeferenge Girrar	*Acacia mearnsii* De Willd.	Fabaceae	T	6	18.2	0.57	5.2	4.55	1.89	25.27
3	Sessa	*Albizia gummifera*(J.F.Gmel)	Fabaceae	T	8	24.2	2.32	21.2	12.12	5.03	50.44
4	Donga	*Apodytes dimidiate* E. Mey. Ex Arn. Var. acutifolia	Icacinaceae	T	4	12.1	0.32	2.92	3.79	1.57	16.61
5	Azamir	*Bersama abyssinica* Fresen	Melianthaceae	S	16	48.5	0.27	2.46	20.45	8.49	59.44
6	Anfar	*Buddleja polystachya* Fresen.	Loganaceae	S	3	9.09	0.002	0.02	3.03	1.26	10.37
7	Digta	*Calpurnia aurea* (Ait.) Benth.	Fabaceae	S	3	9.09	0.16	1.46	4.55	1.89	12.44
8	Agam	*Carissa spinarum* L.	Apocynaceae	S	1	3.03	0.06	0.55	0.75	0.31	3.89
9	Limich	*Clausena anisata* (Willd.) Benth.	Rutaceae	S	4	12.1	0.01	0.09	3.03	1.26	13.47

10	Yemiserich	*Clerodendrum myricoids*(Hochst.) Vatke.	Lamiaceae	S	2	6.06	0.004	0.04	1.52	0.63	6.73
11	Bissana	*Croton macrostachyus* Del.	Euphorbiaceae	T	11	33.3	1.62	14.8	15.15	6.29	54.41
12	Kitkita	*Dodonea angustifolia* L. f.	Sapindaceae	S	2	6.06	0.002	0.02	1.52	0.63	6.71
13	Wolkfa	*Dombeya torrida* (J. F. Gmel.) P. Bamps.	Sterculiaceae	T	3	9.09	0.36	3.29	3.03	1.26	13.63
14	Koshim	*Dovyalis abyssinica* (A. Rich.) Warb.	Flacortiaceae	S	12	36.4	0.2	1.83	11.36	4.72	42.9
15	Merko	*Draceana steudneri* Engler	Draceannaceae	T	1	3.03	0.03	0.27	0.76	0.32	3.62
16	Lol	*Ekebergia capensis* Sparrm	Meliaceae	T	7	21.2	0.27	2.46	8.33	3.46	27.13
17	Key bahirzaf	*Eucalyptus globulus* Labill.	Myrtaceae	T	7	21.2	0.48	4.38	12.88	5.35	30.94
18	Dedeho	*Euclea divinorum* Hiern	Ebenaceae	S	1	3.03	0.002	0.02	0.76	0.32	3.36
19	Kulkual	*Eupohorbia abyssinica* Gmel	Euphorbiaceae	T	2	6.06	0.06	0.55	3.03	1.26	7.87
20	Sholla	*Ficus sur* Forssk.	Moraceae	T	2	6.06	0.09	0.82	1.52	0.63	7.51
21	Awra	*Gnidia glauca* (Fresen.) Gilg	Thymelaceae	S	14	42.4	0.08	0.73	12.88	5.35	48.5
22	Dinblal mesay	*Heteromorpha arborescens* (Spreng.) Cham. & Sch	Appiaceae	S	1	3.03	0.01	0.09	0.76	0.32	3.44
23	Amja(sefi)	*Hypericum quartinianum* A. Rich	Guttifferae	S	3	9.09	0.003	0.03	2.27	0.94	10.06
24	Yehabesha Tsid	Juniperus procera Hochst. Ex Endi	Cupressaceae	T	2	6.06	4E-04	0	0.004	0.002	6.07
25	Kilambo	*Maesa lanceolata* Forssk.	Myrsinaceae	S	7	21.2	0.1	0.91	9.09	3.77	25.9
26	-------	Nuxia congesta (R. Br. Ex Fresen.)	Loganaceae	S	4	12.1	0.1	0.91	3.03	1.26	14.29
27	Keret	*Osyris quadripartite* Decn.	Santalaceae	S	4	12.1	0.03	0.27	6.06	2.52	14.91
28	Dingay Seber	*Pavetta abyssinica* Fresen. Var. abyssinica	Rubiaceae	S	14	42.4	0.03	0.27	13.64	5.66	48.36
29	Woyl	*Pittosporum viridiflorum* Sims	Pittosporaceae	T	9	27.3	0.17	1.55	9.09	3.78	32.6
30	Homma	*Prunus africana* (Hook. F.) Kalkm	Rosaceae	T	9	27.3	0.86	7.85	10.61	4.4	39.52
31	Tallo(Ashkamo)	*Rhus glutinossa* A.Rich subsp. Glutinosa var.glutinosa	Anacardiaceae	S	10	30.3	0.2	1.83	9.85	4.1	36.22
32	Chomye	*Ritchiea albersii* Gilg.	Caparidaceae	S	3	9.09	0.05	0.46	2.27	0.94	10.49
33	Kega	*Rosa abyssinica* Lindley	Rosaceae	S	1	3.03	0.005	0.05	0.76	0.31	3.39

34	Getum	*Schefflera abyssinica* (Hochst. Ex. A. Rich.) Harms	Araliaceae	T	2	6.06	0.21	1.92	1.52	0.63	8.61
35	Girawa	*Vernonia amygdalina* Del.	Asteraceae	S	3	9.09	0.07	0.64	6.06	2.52	12.25
36	Gengereta	*Vernonia myriantha* Hook.f.	Asteraceae	S	14	42.4	0.06	0.55	14.39	5.97	48.94