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Floristic Composition and Diversity of Sacred Site and Challenges towards sustainable Forest Management: the Case of Remnant Forest Patch of Debrelibanos Monastery, Ethiopia

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Abstract

The flora and fauna diversity of Ethiopia is experiencing a great challenge due to interacting and complex factors. There have been efforts made by government and community to reverse such problems. However, the role of sacred in forest conservation and challenges they are experiencing was not fully studied. Hence, the aim of this study is to determine the composition, diversity and challenges of sacred forest of Debrelibanos monastery. Nested plot design (51 quadrats of 20 x 20 m and five sub-quadrats within each major plot) were used to collect all trees, shrubs and climbers with dbh and height greater than or equal to 2.5 and 2 meter. For social data collection, a total of 60 respondents were randomly selected and interviewed. Focus group discussion was also made. Shannon diversity index, Sorenson's similarity index and ANOVA test were conducted using SPSS of version 20.0.

In total 61 woody species belonging to 39 families and 59 genera were identified in the forest. Fabaceae were the dominant family followed by Euphorbiaceae, Moraceae, Loganiaceae and Verbenaceae. From the identified woody plants about 77.9% are tree, 14.4% are shrubs and 1.1% is climbers. The overall species diversity and evenness of sacred forest was 3.35 and 0.45 respectively. However, they varying among communities due to disturbances and hence the forest was shrinking from year to year as reiterated by 86.7% of the respondent. About 98% of the respondent identified that, it was result of disturbance (expansion of burial sites, increasing demand for firewood, illegal settlement) and weak forest management techniques. The study concludes that it is necessary to establish and expand modern funeral system, alternative source of income and other infrastructures. Once this is done, it is very likely to gear towards sustainable forest management within the study areas.

Key words: Sacred forest, composition, diversity, remnant, Debrelibanos

Introduction

Ethiopia is a biodiversity (flora and fauna diversity) rich country located in the Horn of Africa, stretching from 3° to 15° N latitude and 33° to 48° E longitude. This is the result of suitable climatic condition, geographical location (being tropical country) and geographical diversity (Zerihun Woldu et al., 1991; Haileab et al., 2010). However, currently both flora and fauna diversity of Ethiopia is experiencing a great challenge due to anthropogenic activities such as uncontrolled exploitation, expansion of agricultural land, grazing land, infrastructure, forest fire, industrialization and urbanization (Demel Teketay,2001; Gessesse Dessie,2007; Gessesse Dessie and Johan Kleman, 2007). The study of Gessesse Dessie (2007) and Laestadius et al. (2012) also identified that absence of dedicated forestry institution, institutional instability; weak budgetary allocation and low empowerment of local community as the drivers of forest decline in the earlier regime. These losses of forest resource had a negative effect on biological diversity and wildlife habitats (Birhane et al., 2006), plant genetic resources (Benitez-Malvido, 1998), water resources, human welfare, climatic conditions and economic growth of a given country.

There have been efforts by government (establishment of national park, sanctuaries, botanical garden, etc) to reverse the situation. The local community and their indigenous knowledge also contribute to forest resource use, management and conservation (Teklehaymanot et al., 2007; Mesfin, et al., 2009). Similarly, religious and/or cultural areas play a major role in maintaining sustainability of forest resources (Bonger, et al., 2006) and other biological and ecological conservation of different areas. Sacred groves and forests places can complement national parks and other protected areas established legally by the government. Despite there are various government protected areas (national park and sanctuaries) throughout the world, they are not sufficient to conserve the whole biodiversity and ecosystem. Sacred, religious, cultural areas and church forests are persistent and survived for centuries and still surviving and serve as refuge of wide range of wildlife and animals (Wassie et al., 2005; Wassie et al., 2010). Therefore, collaboration among religious, governmental, scientific, educational and/or conservation agencies was desirable for the protection and conservation of sacred sites and landscapes.

However, attention weren't given to the role of sacred site in forest conservation and challenges they are facing currently. Hence, the overall aim of the study is to determine the floristic composition and diversity of sacred sites; and assessing major factors influencing forest resources conservation within study area so as to protect and enhance the existing resources.

Material and Methods

Description of Study Site

The study was conducted at Debrelibanos monastery (which is commonly called Abune Teklehaimanot monastery) at north Shewa, Ethiopia with geographical location of $09^0 43'$ 30" N longitudes and $38^0 51'0''$E latitudes (Fig. 1). It is found at104 km from Addis Ababa and 14km from Fiche town, the capital of North Shewa Zone, in the Oromiya Regional State. It has an altitudinal range of about 2400 m whilst the rim of the valley rises to over 2560 m. Its human population is estimated to be about 59,583(CSA, 2007). The area is characterized by bimodal rainfall season (June to September) and shorter rainy season (March to April). It has a mean minimum and maximum temperature of 5.7^0c and 22.90^0c respectively while the mean annual rainfall is about1037mm.The agricultural office of Debrelibanos reported that there are about three soils textural classes such as clay about 63%, sandy soil 10% and loam soil about 27% are found within the study area.

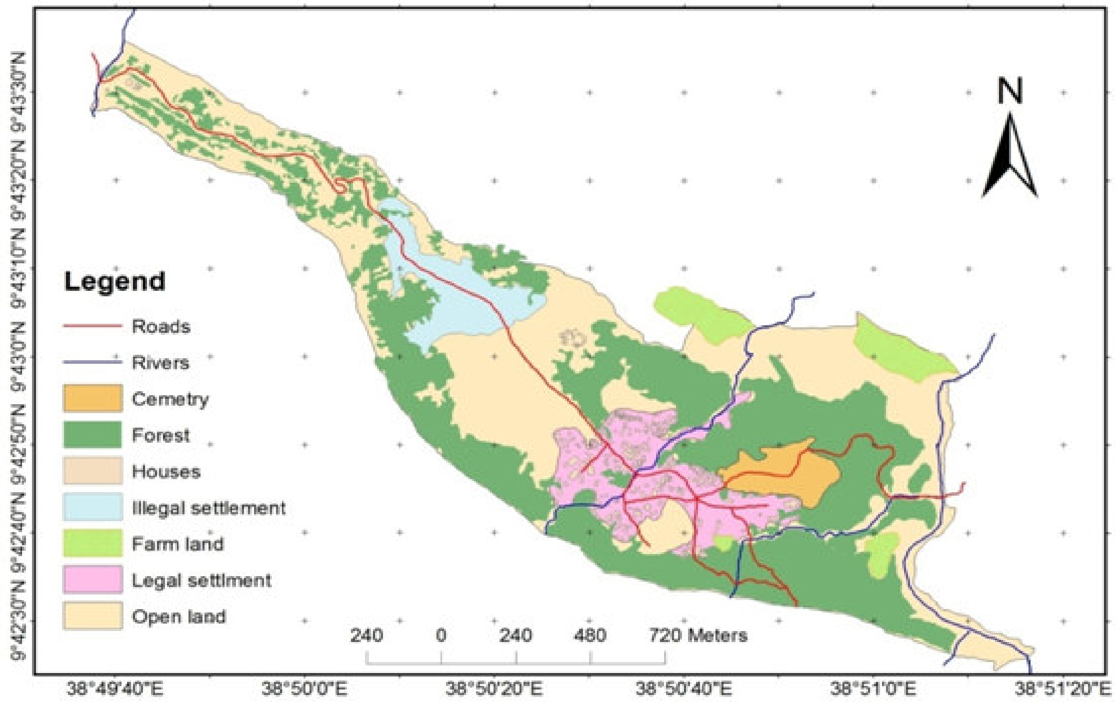

Figure 1: map of study area

The vegetation resources within the study area is one of the few remaining Dry Afromontane forests (has a total area of 85ha) and it serve as the home for diverse highland birds and other animal species. However, currently it encountered a great challenge and diminished from year to year.

Data collection methods

Reconnaissance survey was conducted before actual data collection to obtain information and general impression about vegetation pattern and to decide sampling methods. Followed by survey, the investigation of species diversity, composition and density was undertaken using transect survey. Accordingly, nested plot designs were developed and a total of 14 transect lines and 51 quadrates (20m x 20m = 400m2) were laid systematically across the forest following Kent and Cooker (1992) and Muller-Dombois and Ellenberg (1974). The distance between successive quadrate was about 100m whereas between successive transect lines were about 150m. To avoid the edge effect and biasness, the first transect line was laid purposively by entering 35m from the bottom side of the forest.

Plant sample of different size were collected from the different size of the plots. In the main quadrat (400 m^2) all trees, shrubs and woody climbers with Diameter at Breast Height (DBH) greater than or equal to 2.5 cm and height ≥ 2 meter were recorded as mature tree (Alelign et al., 2007). Following the method of Tadesse Woldemariam(2003) within the major quadrat, five 3m x 3m sub-quadrats were laid to collect saplings of all trees, shrubs and climbers/lianas with height > 1 meter and seedlings of height ≤1 meters. After a complete list of trees, shrubs and lianas were collected following standard herbarium collection technique and they were taken to the National Herbarium of Ethiopia, Addis Ababa University, for identification. The identification of specimens was under taken with reference to authenticated specimens (Edwards et al., 1995; Hedberg and Edwards, 1989)

To undertake the socio-economic survey, a total of sixty households (thirty from within monastery boundary and thirty from outside monastery boundary) were randomly selected and interviewed using structured and semi-structured questionnaire. Focus group discussion was also made with representatives of monastery administration, development agents, kebele administration, woreda administration, local people, monks and youth representatives using close-ended questionnaire.

Data Analysis

Floristic diversity and evenness was quantified using Shannon-Wiener (Shannon–Wiener (H')) diversity index (Parthasarathy, 2001). Species richness of the study area was determined by addition of the number of species identified (Whittaker, 1972) (eqn.1).

$$H' = -\sum_{i=1}^{n} \mathrm{Pi} \ln \mathrm{Pi} \quad \text{.......... eqn 1}$$

The density of different plant species within the study area were determined by counting the numbers of individual species in each quadrat divided by the area of the plot (Kent and Coker, 1992) (eqn.2).

$$\text{Density} = \frac{\text{Number of above ground steams of species}}{\text{Sampled area in hectare}} \quad \text{.......... (eqn. 2)}$$

The ecological significance of plant species in the study area were calculated using relative frequency, relative density and relative dominance following Mueller-Dombois and Ellenberg, 1974):

$$IVI = R_D + R_F + R_{Dom} \quad \text{.......... eqn 3}$$

RD= Ni/Tn *100 …(eqn 4); RF = Fs/Ts * 100…(eqn5); RDom= As/Tc * 100 …(eqn6)

where RD is relative density; RF is relative frequency; RDom relative dominance/abundance; Ni is the number of individual of a species in the sample; Tn is total number of individual of a species in the sample; Fs is the frequency of species in the sample; Ts is the total frequency of all species in the sample; As is area occupied by the species in the sample (m^2) and Tc is total cover of all species in the sample (m^2)

Descriptive statistics and ANOVA test was used to analyze the overall data (vegetation as well as socio-economic data) with the help of SPSS version 20.0.

Result and Discussion

Floristic composition

A total of sixty one (61) species of woody plants belonging to fifty nine (59) genera and thirty nine (39) families were recorded within the study area. These plant species had the following growth form/habit: 77.9% are tree, 14.4% are shrubs and 1.1% are climbers or lianas.

Among the identified woody plant species, there was a number of plant species that are already nationally red listed (following the IUCN threat categories) as being threatened species. These include Hagenia abyssinica, Juniperous procera, Prunus africana and Podocarpus (Vivero et al., 2005). Olea europaea subsp.cuspidata, Podocarpus falcatus, Acacia abyssinica, Cordia africana, Ficus sur, Carissa edulis and Maytenus arbutifolia were also other trees and shrubs that are found within Debrelibanos monastery remnant dry Afromontane natural forest patch and listed as trees and shrubs of high national priority.

The most dominant family (families with the highest number of species) is Fabaceae which comprised about 4 genera (7.41%) and 5 species (8.77%). This is followed by Euphorbiaceae, Moraceae, Loganiaceae and Verbenaceae (21.04% of the total species recorded), Myrsinaceae, Apocynaceae, Myrtaceae, Oleaceae, Cupressaceae, and Solanaceae also had two species each (21.06%). On the other hand, the remaining family of the study area comprises one species (i.e. 49 % of total number of species) (Table 1).

Table 1: The top ten dominant families with the highest number of general and species in the study area

No	Family name	Number of genera	percent	Number of species	Percent
1	Fabaceae	4	7.27	5	8.62
2	Euphorbiaceae	3	5.45	3	5.17
3	Loganiaceae	3	5.45	3	5.17
4	Rosaceae	3	5.45	2	3.45
5	Verbenaceae	3	5.45	3	5.17
6	Meliaceae	2	3.64	2	3.45
7	Myrsinaceae	2	3.64	2	3.45
8	Oleaceae	2	3.64	2	3.45
9	Solanaceae	2	3.64	2	3.45
10	Tiliaceae	2	3.64	2	3.45

Species Diversity

The overall species diversity and evenness of Debre libanos forest was 3.35 and 0.45 respectively. This implies that the forest resources have high diversity though the identified plant species (57) were distributed less evenly within the study area. The diversity, evenness and species richness was also varying among the three communities which were identified by author using R-software of versions 2.15.0 at 1.5 to 2.0 dissimilarity levels (Demie et al., 2013) in its previous studies (Table 2).

Table 2: Shannon-Wiener diversity index, evenness and species richness of the plant communities

Community type	Average altitude (m)	H' (diversity	J (evenness)	Richness
I	2488 - 2343	**2.92**	0.37	53
II	2529 - 2375	2.36	0.30	38
III	2497 - 2402	0.52	0.07	22

Where I= Carissa spinarum (C. edulis) - Olea europaea subsp.cuspidata (Olea africana; II= Acacia abyssinica subsp.abyssinica - Eucalyptus camaldulensis and III= Justicia schimperiana (Adhataoda schimperiana) – Crotona macrostachyus.

For instance, community I had the highest species diversity and evenness compared to community II and III, because it is found much closer to the monastery and in undisturbed (inaccessible due to topographic nature) area like below the mountain ranges which were inaccessible to domestic animals, browsers and grazers. Community II also had relatively good species diversity and evenness when compared to community III. However, community III had the least species diversity and evenness. According to the result obtained from questionnaire survey and personal observations, this was due to anthropogenic disturbance by domestic grazers, browsers, clearing for firewood and illegal settlement (expansion of residence houses) by the communities. Furthermore, absence of toilet, presence of holy water ('tsebel' in Amharic) widely dispersed within the forest and expansion of burial sites were other factors that contributed to low diversity, species evenness and richness within this community types. These is because most of the peoples that came for religious festivals and funeral move here and their within forest for searching toilet ,holy water-'tsebel' and other services which can in turn disturb and inhibit the growth and development of the plant species.

In terms of species richness/abundance, community-II had the highest number of species followed by community-I and community III. According to (Fattahi and Ildoromi, 2011) there is a direct positive relationships between species diversity, species evenness and species richness of a given forest ecosystems. The result from correlation analysis also confirms that they had strong positive relationships as indicated in table 3 below. These variables (i.e. species richness, diversity and evenness) are influenced by factors such as intensity of competition among plant species (Wilsey and Stirling, 2007), availability of seeds and chemical and physical properties of soil (Demel Teketay, 2005; Mulugeta Lemenih and Demel Teketay, 2006), ecological process within the forest and anthropogenic factors the envelope the area. Some of the community types of this particular study also exposed to these factors. Topographic factors are also other variables that influence species diversity, richness and evenness. For instance, the result obtained from correlation analysis (at $\alpha = 0.02$) shows that there is a negative correlation between topographic factors (particularly altitude and slope) and species richness, diversity and evenness of the forest. The study of Rahbek, (1995) also supported this idea and stated that the probability for many species to occupy the area generally follows a decreasing or hump-shaped pattern as altitude rapidly increases. However, in the case of this particular study, the community had more or less similar species richness and this might be due to absence of considerable altitudinal difference. For instance, community III though it is found in the middle altitude, it had comparatively lower number of species richness including lower species diversity and evenness where as community I which is found relatively at lower altitude had higher species richness, species diversity and evenness than community II (Table 2).

Table 3: Pearson's correlation among species richness, diversity, evenness(J), altitude and slope

		Species richness	H'	Altitude	Slope	J
Species richness	Correlation	1				
	P-value					
H	Correlation	0.982**	1			
	P-value	0.000				
Altitude	Correlation	**-0.501****	**-0.496****	1		
	P-value	0.000	0.000			
Slope	Correlation	**-0.190**	**-0.179**	0.729**	1	
	P-value	0.187	0.215	0.000		
J	Correlation	0.951**	0.970**	**-0.466****	-0.181	1
	P-value	0.000	0.000	0.001	0.208	

**. Correlation is significant at the 0.01 level (2-tailed). a. List wise N = 50

Even though the direct comparison of the species diversity of one forest with other forests is not feasible, the diversity of Debrelibanos remenant forest (H' = 3.35) is lower than Zegie church forest (H'= 3.72 and J= 0.84) (Alelign et al., 2007). This might be due to the difference in management practices, soil chemical and physical properties of the area.

Vegetation Similarity

The result from computation of Sorensen's similarity coefficient disclose that the distribution of woody plant species among communities in remnant forest patch were more or less similar. The similarity values in species composition between the three communities range from 0.53 to 0.67 (table 4). Community-I and community-II has higher species similarity value (Ss = 0.67). This might be due to the position of the two communities (have plots which are adjacent to each other) and environmental factors. As it was reported by Desalegn Wana and Zerihun Woldu (2005) and Dereje Denu (2007), in addition to altitudinal gradient, other environmental factors such as aspect, slope, soil, physical and chemical properties have sound effects on patterns of plants in communities. The lowest similarities (highest dissimilarity) (Ss = 0.53) were found between community-I and community III. The overall similarity coefficient ranges from 53-67% among all the communities. Thus, species composition dissimilarities account for 33% for the most similar communities (I and II) and the least similarity (47%) or highest dissimilarity (53%) was shared by communities I and III (Table 4).

Table 4: Sorensen's Similarity coefficient among the six communities

Community type	I	II	III
I	**1**	**0.67**	**0.53**
II	0.33	**1**	**0.56**
III	0.47	0.44	**1**

Values in bold refers to similarity among the communities where as the one in italics shows dissimilarities among the communities.

Importance Value index (IVI)

Species importance value index is the combined result of three parameters such as relative frequency, relative density and relative dominance (Kent and Coker, 1992). Accordingly, species importance value was calculated by adding these three parameters. There are five species IVI classes for woody plant species within sacred dry afromontane natural forest and the percentages of species in the IVI classes were 31.73%, 23.15%, 11.89%, 12.25% and 20.98% for classes 1, 2, 3, 4 and 5 respectively (Fig. 2). In other words, the majority of species importance value of woody plant species (about 31.73 %) of the study area fall within the first species importance value class (contain about 3 plant species) followed by the second (6 plant species-23.15 %), third (5 species-11.89%), fourth (9 species- 12.25%), and fifth (36 species- 20.984.68%). According to Curtis and McIntosh (1951), given species is said to be dominant if it had the highest importance value index compared to other plant species within area. Hence, Eucalyptus globulus, Olea europaea subsp. cuspidata (Olea africana), and Juniperus procera were the dominant and most important species that were categorized under the first SIV class and had high species importance value. According to Simon Shibru and Girma Balcha (2004), these plant species play great ecological importance in the forest patch. In line with Lamprecht (1989) and Tamrat Bekele (1994), the dominance and ecologically most importance of these species might be due to their good regeneration, pathogen resistance, growth in the shade and competition with other trees, least preference by browsing animals, attraction of pollinators and seed predators that facilitate seed dispersal within the existing environmental conditions of the study area.

The second class contains species such as Acacia abyssinica subsp.abyssinica, Prunus africana (Hook.f) Kalkam, Ficus sur (F.capensis) and Crotona macrostachyus which were the second most important ecologically (that is about 23.15 percent of the total species importance value). Cordia africana, Stereospermum kunthianum, Carissa spinarum (C.edulis), Schefflera abyssinica and Discopodium penninervum had species importance value index 2.97 – 2.09 (which had 11.89 %) and in general this trend decreased to species importance value class which form almost U - shape pattern. Dombeya torrida Subsp.torrida (D.goetzenii), Buddleia polystachya, Dracaena steudneri, Acokanthera schimperi, Dodonaea angustifolia, Rhus gultinosa, Bersama abyssinica subsp.abyssinica, Ekebergia capensis(E.rueppeliana) and Podocarpus falcatus (P.gracilior) are among species that had least importance value index; and least dominant species within the study area. The least importance value index may be due to adverse environmental conditions and selective disturbance by human on the available resource in the forest (Feyera Senbeta et al., 2007).

To undertake the conservation and management measures to these species, priority should be given to them on the basis of their respective SIV (i.e. the first priority should be given to species with the highest species importance value and least priority to species with the smaller species importance value). Accordingly, plant species contained in the first priority class requires immediate and continuous conservation and management action followed by the second, third, fourth and fifth classes.

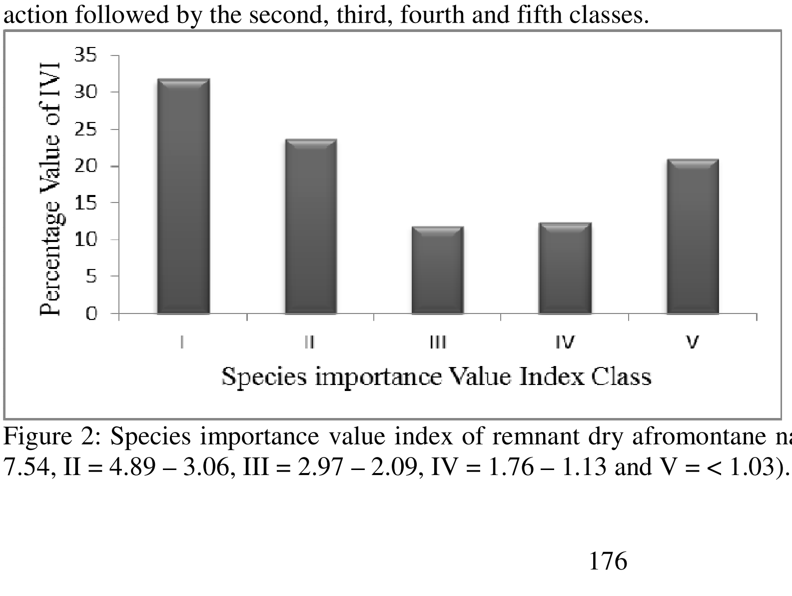

Figure 2: Species importance value index of remnant dry afromontane natural forest patch (Where class I = >= 7.54, II = 4.89 – 3.06, III = 2.97 – 2.09, IV = 1.76 – 1.13 and V = < 1.03).

Challenges against Forest Management

The coverage of forest resource in Ethiopia is reducing (particularly the northern part is currently devoid of forest resource) from year to year due to a set of interacting factors. Only remnant of natural forests around sacred church and lands of the Ethiopian Orthodox church have survived for many centuries, as islands of natural forest biodiversity, in the sea of deforested landscape across much of the Ethiopian highlands (Zewge Teklehaimanot et al., 2002). However, currently such areas are also seriously deforested particularly northern highlands of Ethiopia (Alemayehu Wassie, 2002). Debrelibanos monastery remnant dry afromontane natural forest patch is also one of the monasteries facing such challenges. About 86.7 % of respondents also confirmed that the forest of the monastery is degrading and shrinking compared to its past size and structure due to conflicting of interest among local communities. For instance, the result from questionnaire survey indicated that about 85% of the communities around and within the monastery territory use the forest for different purpose (Fig**.** 3) though it is claimed to be illegal as the monastery administration tried to explain during focus group discussion. Furthermore, as the study of Getaneh and Girma (2014); and Hordofa (2011) indicated the communities within and around the sacred forest was also use as the source of medicinal plant, food and shade during worship. Accordingly, different factors contributed for forest degradation have been identified by 98% of respondents; among which population growth (those reside within monastery territory as well as those coming for worships and religious festivals), expansion of burial site and increasing of fuel wood and construction demand account about 74.12 %.

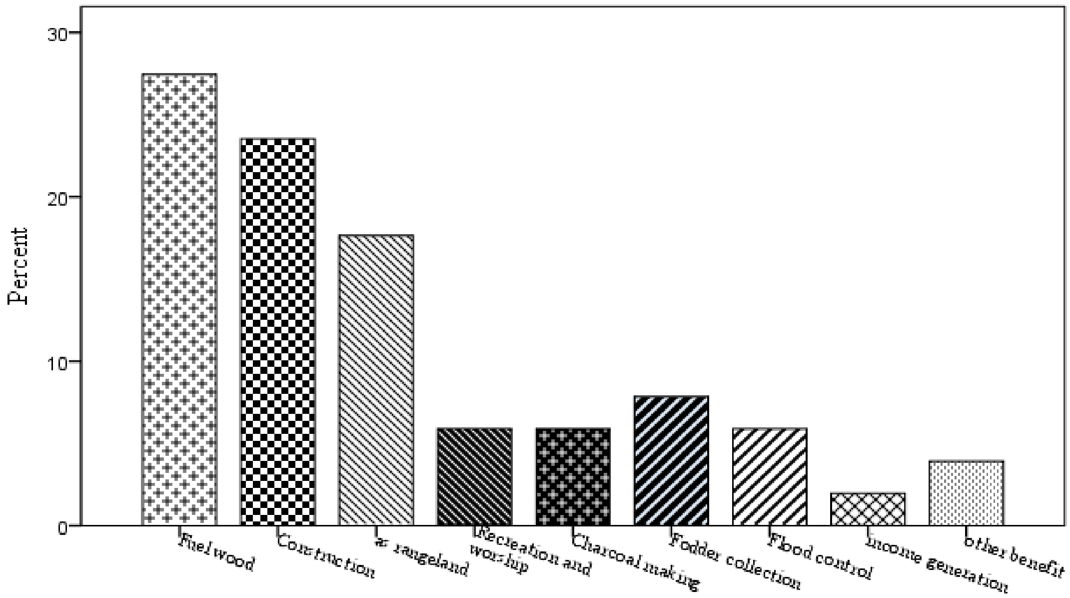

Figure 3: The different use pattern of Debrelibanos monastery remnant Dry Afromontane natural forest patch.

> "Deyaqon Lemma and Abiyot (among the respondent) stated that as population number (i.e. number of monk, those coming for religious festivals, visiting, etc) is increasing, their per capita demand and consumption of forest products could increases and these can result in forest degradation through clearing existing forest for expansion of residence house, fuelwood, religious purposes (crosses, religious sticks, drums, carvings), food and construction. In addition to these, expansion of burial site was also another factor that greatly influenced sustainability of the forest".

According to the response from respondents and personal observations, clearance of forest for burial land preparation and fuelwood heavily affected the forest (Plate 1). To undertake the burial ceremony the community clear the plant species both at seedling and sapling, however for mature plant particularly for Olea europaea subsp. Cuspidata (Olea africana) the monastery put restriction on cutting this plant species because they believe that it is the plant species that came with Abune Teklehaimanot and serves as a close of an area. However, the community can't give care for it and they cut its root while digging for burial activity. After long time, the area upon which burial system carried out may regenerate but repeated action of burial activity lead to instability for vegetation resources. Only those plant species that monastery put restriction upon their cutting and that withstand such disturbance can survive. The following Plate (1) is evidence that there were almost no mature tree and/or bare area/gaps that were developed for firewood and burial system.

Plate 1: Areas facing clearance for expansion of funeral system and obtaining fuelwood

The presence of high density of stumps within the study area was also evidence and the most frequently encountered cut stumps where Carissa spinarum (C. edulis), Olea europaea subsp.cuspidata (Olea africana), Juniperus procera and Acacia abyssinica.

The result from Eye witness and discussion held with the monastery administrator, monks and forest guards within the monastery also come up with the idea that illegal residents within the monastery were also another factor that contributed for the disturbance of the monastery forest. Those people that illegally reside within the monastery territory clear the forest for different purpose like for firewood, construction purpose and for grazing. In addition to this, the communities also clear the natural forest patches and replace by new plants species that fulfill their own needs, for instance Eucalyptus globulus and Camaldulensis for firewood, construction, etc. (Plate 2).

Plate 2: Areas occupied by illegal settlers and replaced by Eucalptus species. Photo by Getachew Demie (2013)

Forest Conservation/Management and Challenges

The forest resource of Debrelibanos is under great pressure. As the previous study of the author (2013) stated, the total density of mature tree was less than sapling and the saplings were greater than that of the seedling population which implies that the forest has poor regeneration and requires urgent conservation and management actions a point of view which was reiterated by nearly 73.34% of the respondent. The above identified problems not only contributed to poor regeneration of the forest but also influencing livelihood of the communities within and around the forest. The result from socio-economic analysis also reveals that about 91.7 % of the respondent stated that forest degradation hampered their livelihood both economically (Loss of income generated by selling forest product, cost incurred to undertake different management activity so as to adapt with the changed environment) and non-economically (loss of aesthetic value of an area, soil erosion, loss of forest products, lack of fresh air, shortage of rainfall and climate change).

To reverse the problems the sacred forest patch is facing, the monastery also undertaken different management actions such as forest guarding and planting of different species within the gaps developed due to clearing of the

Deyaqon Zenebe Tsige and Fantu (development agent) pinpointed this as

> *" there is no openness between monastery and woreda administration on the issues of forest resource conservation and management. The monastery doesn't need to participate the woreda since it fear that the right of ownership may raise one day".*

forest for fire wood, etc. However, the degree of management action undertaken by monastery though rated as good (43.3%) and very good (36.7) respectively it is not good (Fig. 4). As a researcher and from eye wittiness, the response of those respondents (about 13.3 %) that said the management action was fair was supported. This was because of the presence of huge gaps/space that were developed due to different factors such as clearing for firewood, illegal cutting by illegal residents within and around forest area, burial activity, etc. (plate 1 and 2). Furthermore, as the result of questionnaire survey indicated, conflict/disagreement among the monastery administration and illegal residents within the monastery territory, lack of commitment in forest protection, lack of technical knowledge and land for nursery development and lack of variety of plant seedlings were the major driver for the weakness of the forest conservation and management activities carried out by monastery administration. Absence of coordination among woreda and monastery administration (on the issues of forest management) was also another contributing factor for the weakness of forest management.

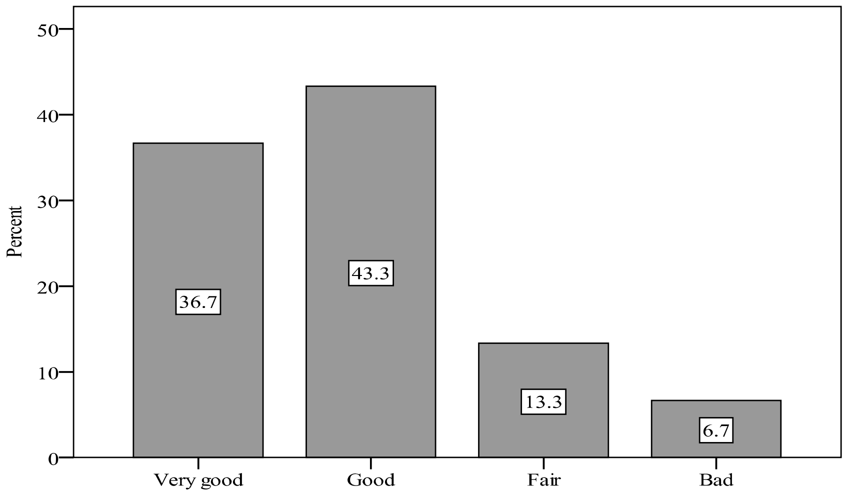

Figure 4: The degree of management action undertaken by monastery to reverse the problem the forest was facing.

Conclusion and Recommendation

The forest patch of Debrelibanos monastery is one of the sacred church forests with high species diversity and richness of 3.35 and 0.45 respectively. The highest percentage of species composition is tree followed by shrubs and climbers. However, currently the forest patch was facing a great challenge which makes its sustainability under question mark. The study indentified expansion of burial site, illegal settlers, interference by browser and grazers, poor infrastructures and widespread presence of holy water-'tsebel' within forest patch as detrimental factors leading to forest degradation and hampering its sustainability. Hence, the following recommendations were suggested:

1. To minimize the risk, urgent mobilization of the illegal settlers and building a sense of ownership and conservation through discussion and consultation with various stakeholders is vital.

2. Infrastructures like toilet, road and other sacred resources like 'tsebel'-holy water would be constructed and placed at specific place to avoid the movement of those peoples coming for religious purpose here and there within the forest for finding these resources. This would also include the local communities.

3. Training with regard to forest resource management and conservation, nursery site development, purpose of planting diversified plant species within gaps developed due to different actors, etc should be given for the community and monastery administration to enhance the status of the forest.

4. Alternative energy sources like biogas, stoves and other resource saving technology should be expanded within the study area to reduce threats on the forest.

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