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Regeneration Status of Acacia polyacantha and Boswellia Papyrifera Species in Shimelegir Forest, Jawi District, Ethiopia

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Abstract
The study focusing on regeneration status of "Gemarda Gerare"Acacia polyacantha and "Walia"Boswellia papyrifera (Del.)species which conducted in Shimelegir Forest, Jawi Woreda, Awi Administration Zone, Ethiopia from October, 2012 to February, 2014. The general objective of the study was to explore density and regeneration status of those species. A systematic sampling procedure was employed to generate the data like height and DBH of the tree. Accordingly, a total of 36 quadrants, each with the size of 25 m x 25 m at an interval of 350 m were laid out along the established transect line with between 500m apart. Two sub quadrants having size of 5 m x 2 m at two sides of every main quadrant to assess seedlings and saplings. Hipsometer and caliper were used to measure hight and DBH of the tree respectively. The data was processed and analysed by using Micriosoft excal 2008. The results show that the total density of Acacia polyacantha and Boswellia papyrifera was 24 and 56 Nha^{-1} respectively. The regeneration capacity of Acacia polyacantha displays an inverted "J" shape distribution with poor regeneration and good recruitment status and Boswellia papyrifera showed a bell shape population structure with poor regeneration and recruitment.
Keywords: Acacia polyacantha, Boswellia papyrifera, Density, Regeneration, Shimelegir state forest.

CHAPTER ONE: INTRODUCTION

Background and Justification

According to (Woody Biomass Inventory and Strategic Planning Project, 2002) woodlands can be defined as a continuous stand of trees with a crown density of between 20-80%. Maximum height of the canopy is generally not more than 20 meters. Ethiopia is estimated to have over 3.5 million hectare of woodland and shrub land with an estimated 300,000 tons of gums and resins production potential. Different studies indicate that ABC species, which are gum and resin producing tree species, are found in the low land sections of Amhara region which estimated to cover about 603,682 hectares and have the potential of producing 50 tons of gum and resin per year per hectare (Alemneh Dejene, 1997) among this Awi zone estimated to cover about 31,590 ha (5.23%).

An important feature of Ethiopia's dry forests is their richness in Acacia, Boswellia and Commiphora species. In Ethiopia, *B. papyrifera* and *Acacia polyacantha* grow in dry Combretum – Terminalia woodlands and wooded grass-lands in the north (Mulugeta Lemenih and Habtemariam Kassa, 2011). If the species forms the major crop (in density) along with its resources and the species is more or less uniformly distributed in its natural habitat, this species may be judged for the NTFP based enterprise (Mulugeta Lemenih and Habtemariam Kassa, 2011), which are the most important export commodities of the Ethiopian forestry sector.Their contribution to rural livelihoods, the national economy and ecosystem stability is significant, although not yet properly accounted for (Mulugeta Lemenih and Habtemariam Kassa, 2011).

Dry land forests also contain a wealth of unique biodiversity. However, they are shrinking and heavily disturbed mainly due to multiple natural and anthropogenic challenges (Mulugeta Lemenih and Habtemariam Kassa, 2011); (Tesema, 2011)). There are a number of driving forces which alleged to cause deforestation and these often vary across on types and extent of land use patterns (**Munton *et al.*, 1992**). The situation of the woodland in the Amhara region is deteriorating through time and calls for an immediate policy intervention and action (Tesema, 2011).

Statement of the Problem

The uncontrolled exploitation of forest areas by anthropogenic factor and depletion of vegetation by natural factor led to the threat as well as the decline in number and area of many plant species (B.Tesfaye, 2002). The combined information of population structure and demographic data can explain the potentials and/or constraints of the future population dynamics of a site (Peters, 1996). As a result, the ABC woodlands are increasingly being converted into farmlands (Dejene, 2008). The first problem to be addressed in this study is the ever growing pressure on ABC resources of the dry woodlands of Ethiopia which led to the decline of population of *B. papyrifera* (Groenendijk P, 2012); (Abeje Eshete, 2005) the problem may be attributed to over-tapping (Aberehame Abiyu *et al.*; 2010; Tefera Mengistu, 2011) which will have a negative consequence on most likely indicates depletion of the trees' carbon stock (Tefera Mengistu *et al.*; 2012). Most of the research work is directed towards gum Arabic and to a lesser extent towards gum talha. Unfortunately the *A. polyacantha* gum and all other gum resource from Acacia species received very little attention (Adam AA, 2008). *A. Polyacantha* comprises about 5% with relatively low quality gum contributed the total gum entering international trade (Getachew Desalegn and Wubalem Tadesse, 2004).

A very limited documented knowledge on the tree species as well as on the level of stock is a major constraint that needs to be addressed. In view of the limited scientific knowledge, less known quantity of resource that produce valuable NTFP. In Jawi district the forest contributes different non-timber forest products for people's livelihood but the resource has not utilized sustainably. So far, no study has been conducted to investigate as to why people's participation in PFM is less in the study area.

Therefore, this study tries to fulfill this gap by assessing the resources of *Acacia polyacantha* and *Boswellia papyrifera* species of the forest as they are the gum and resin bearing species.

Objectives of the Study

General objective

The general objective of the study is to explore density and regeneration status of *Acacia polyacantha* and *Boswellia papyrifera* species in Shimelegir state forest, Awi Zone, Northwest Ethiopia

Specific objectives

The specific objectives are:

- To assess the density of *Acacia polyacantha* (Willd.) and *Boswellia papyrifera* (Del.) Hochst. species.
- To examine the regeneration status of *Acacia polyacantha* (Willd.) and *Boswellia papyrifera* (Del.) species.

CHAPTER TWO: MATERIAL AND METHODS

Data Collection

Data for the study were collected from primary and secondary sources. The primary data were collected employing systematic stratified sampling method. Secondary sources mainly from published and unpublished works such as annual report of Agricultural Development Office of Jawi and annual plane of Environmental Protection, Land Administration and Utilization Office Jawi woreda

Vegetation data collection

Reconnaissance survey was made in November 25, 2012, in order to get a general impression on the intended to study forest (Shimelegir) site and to determine the sampling method to be used for vegetation data collection. The time for collection of both primary and secondary data was from December 1 to April 30, 2013.

Sampling technique used during data collection were laid the transect line in the forest with 500m interval, systematically, along the slope to collect the vegetation data. The first transect line was laid out randomly at one side of the forest along the gradient and the rest were taken parallel to it. Quadrants measuring 25 m ×25 m (625 m^2) laid down at every 350 m interval on the extended three transect lines. For tree assessment, the 625 m^2 quadrants were sampled. For seedling and sapling inventory, two sub-quadrants of 2 m ×5 m were sampled at the beginning and the end of the base line on opposite sides of the main quadrants for regeneration assessment (Figure3.2).

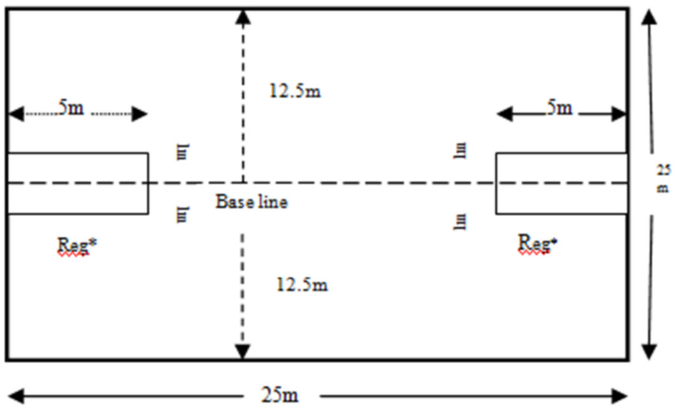

Figure 2-1 Sampling design for tree with regeneration sub-quadrants.

Selected plant species in all quadrants was recorded. For both trees height and diameter at breast height (DBH) was measured. To assess the regeneration status of woody plants, individual woody categorisation were made as height <0.5 m and dbh<2.5 cm seedling, h >0.5 m and dbh<5 cm sapling and h >0.5 m and dbh> 5 cm tree.

Three transects were established to examine the density and regeneration status of two species. At every 350m distance plot, of 25 m x 25 m (625m^2) was drop. Accordingly, 36 Quadrants (2.25ha) were surveyed.

Those are plant species; DBH of the mature tree, sapling and seedling using caliper; height of the mature tree were measured with hypsometer (ANSAB, 2010).

Data Analysis

Density and regeneration data analysis

Data compilation was a must as it was an important and preliminary work of analysis part to reduce the chances of missing data and entering the faulty data. Data was entered in the spreadsheets directly for in computer based calculation using MS Excel version 7 software program. Density (D) is the count of individuals per unit area. Counting was usually done in quadrants placed several times into vegetation under study. Afterwards, the sum of individuals per species was calculated in terms of species density per convenient area unit such as a hectare (Mueller-Dombois and Ellenberg, 1974).The following formula was used for the calculation of density (D).

$$\textbf{Density} = \frac{\textbf{Total no.of individual of species A}}{\textbf{Total no.of plots sampled x area of a plot (ha)}} \quad \text{.........Equation 2.1}$$

Data from all the study plots were pooled together for the analysis. The regeneration status of woody species was summarized based on the total count of seedlings and saplings of each species across all quadrants of their DBH and height. Diameter at Breast Height data were grouped and used into the following nine sited classes, seedling, sapling, 5_10, 11_15, 16_20, 21_25, 26_30, 31_35,>35. Similarly eleven height classes were designated as class 0 = 0-2, 2=2-4, 4 = 4 - 6, 6 = 6 - 8, 8= 8 - 10, 10 = 10 – 12, 12 = 12 – 14, 14 = 14 -16, 16 = 16 – 18, 18 =18 – 20, 20 = >20. Density of studied tree species of different size classes observed in the reserve indicated the level of regeneration of both tree species.

A graph of individuals per hectare (density) against size classes was plotted to show the regeneration status of trees species with individuals. With the objective of assessing regeneration status percentage of seedling and sapling of two studied species were calculated separately and represented in bar diagram. In this analysis (reverse *J*-shaped) imply stable populations that are naturally replacing themselves. While flat and *J*-shaped slopes are taken to mean poor recruitment and declining populations (Hall P, 1993); (Lykke, 1998); (Obiri J, 2002).

CHAPTER THREE: RESULT AND DISCUSSION

3.1 Density and regeneration status of A. polyacantha and B. papyrifera species

From the DBH class distributions of the species, two types of regeneration status were determined, i.e. good and poor regeneration.

3.1.1 Density of Acacia polyacantha and Boswellia papyrifera

The density of the gum-producing species *Acacia polyacantha* in *Shimelegir* state forest was 24 Nha^{-1} (figure 4.1). Approached lowest value of density (25 Nha^{-1}) of *Acacia polyacantha species* were reported from the study conducted in Beschillo and Blue Nile Riverine (Getaneh Belachew, 2006). Higher result also reported as density of (34.86 Nha^{-1}) in Makeni savanna forest, Zambia (Emmanuel, 2008).

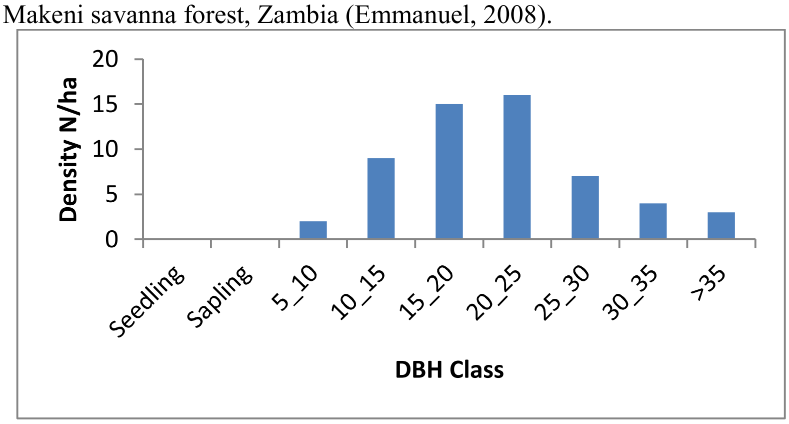

Figure 3-1. Density of *Acacia polyacantha* with DBH class distributions

The lowest density (56Nha^{-1}) of the *Boswellia papyrifera* tree species was observed in the stand. When compared to studies made in other woodlands harboring gum resin yielding species in the county, it had found that density ha^{-1} of gum and resin species in Shimelegir is more or less comparable (Figure 4.2).

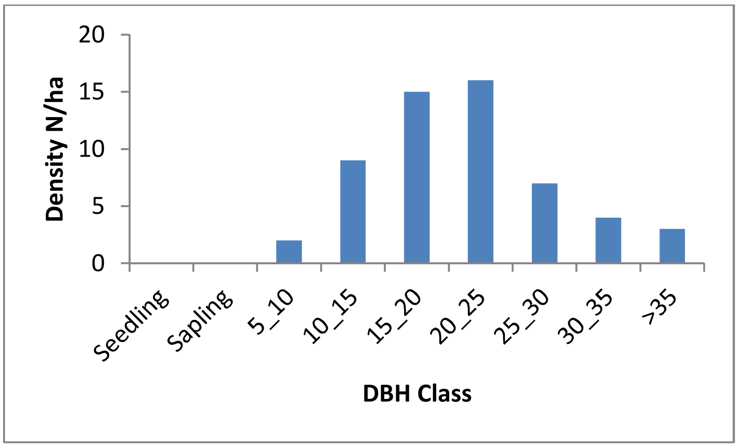

Figure 3-2. Density of *Boswellia papyrifera* with DBH class distributions

A similar population structure for *Boswellia papyrifera* has been reported in Eritrea (Ogbazghi, 2001; Ogbazghi *et al*.; 2006; Rijkers *et al*.; 2006) and Tigray, Ethiopia (Kindeya Gebrehiwot, 2003), (52 Nha^{-1}) were also registered from Tajmala forest and Dry woodlands of Nuba Mountains in Sudan (Asmamaw Alemu, 2007). But this figure is higher than the density of (Abuelgasim and Abdalla, 2008) findings (31.8Nha^{-1}) in Jebel Mrarra Area, Darfur; Sudan. Besides, these figures there were also lower density of *Boswellia papyrifera* in Jebel Marra, West Sudan (114 trees ha-1) reported by Khamis (2001), Eritrea (80-270 trees ha-1) (Ogbazghi *et al*.; 2006) and Ethiopia (64-225 ha^{-1}) (Mulugeta Lemenih *et al*.; 2007), Kindeya Gebrehiwot (2003) (100 and 254 ha^{-1}), (87 and 175ha^{-1}) in North Gonder (Abeje Eshet *et al.;* 2005). In this case, what makes Shimelegir woodland peculiar is the existence of less population of gum and resin bearing species along with their poor abundance.

Information on density ha^{-1} is in one way or the other related to the size of gum and resin going to be produced at a given area. The more the density of species, the better the opportunity to collect more, as it is only a small amount a single tree can yield per year, vies verses (Mulugeta Lemenih *et al.;* 2003; Abeje Eshete *et al.;* 2005). The study revealed the existence of variation in density among the gum resin yielding species, which points the need for care during plan for collection. At Jawi district for instance, the density in hectare of *B. papyrifera* and *A. polycantha* was very low, thus creating good opportunity to plan on restoration measures or hampered natural regeneration requiring attention rather planning for bulk production from these species.

3.1.2 Regeneration status of *Acacia polyacantha*

Diameter at breast height (DBH) is the most commonly used size measure in the analysis of plant population structure. However, several studies have used eight classes to include seedling and sapling in such studies (Demel Teketay, 1997; Getachew Tesefay *et al*.; 2002). The inclusion of seedlings and saplings in the plant population structure can provide information on species performances at the early stage of regeneration. *Acacia polyacantha* depicts not normal population structures in the study forest area, showing poor regeneration (Figure 4.3). Similarly Getaneh Belachew, (2006) found that *Acacia polyacantha* depicts gauss type structure with indicating poor regeneration and recruitment.

Acacia polyacantha in the study forest area had higher number of individuals in the lowest classes since the regeneration might also correlate with abundant seed production and soil seed bank formation of species (Demel Teketay, 1997). In this case, as this species is able to form soil seed bank, this might also contribute to the good regeneration after rain. were shrubs or small trees or meight be cut by the local people for construction as well as charcoal preparation and fire hazard may resulting for less growth of to be a mature tree. Even though Mekuria Argaw *et al* (1999) and Getachew Eshete (1999) reported the thorny nature of these species helps the seedling to escape browsing by cattle, disturbances like fire can destroy trees but mature tree that have fire resistant characteristics e.g. thick bark may survive the fire, however seedlings, smaller trees and saplings are killed (Timo and Seppo, 2000). Inverted "J" shaped distribution is considered as an indication of poor regeneration status. Thus, the assessed species were put under poor regeneration (Figure 3-3).

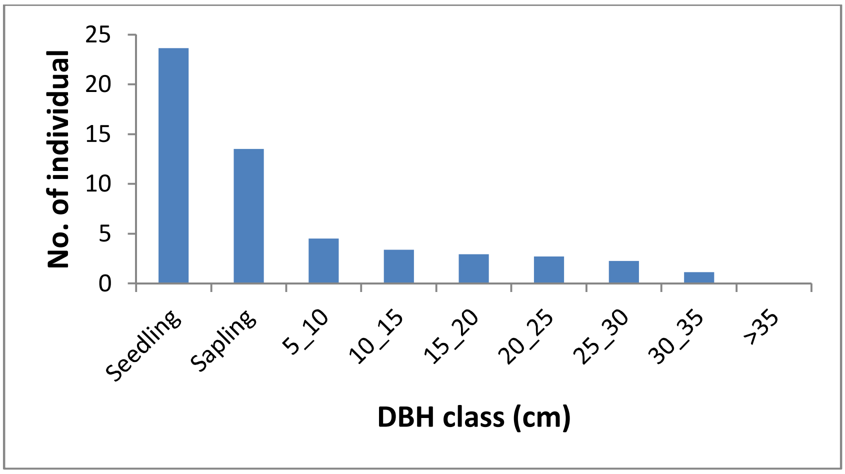

Figure 3-4. Regeneration status of Acacia polyacantha with DBH class base

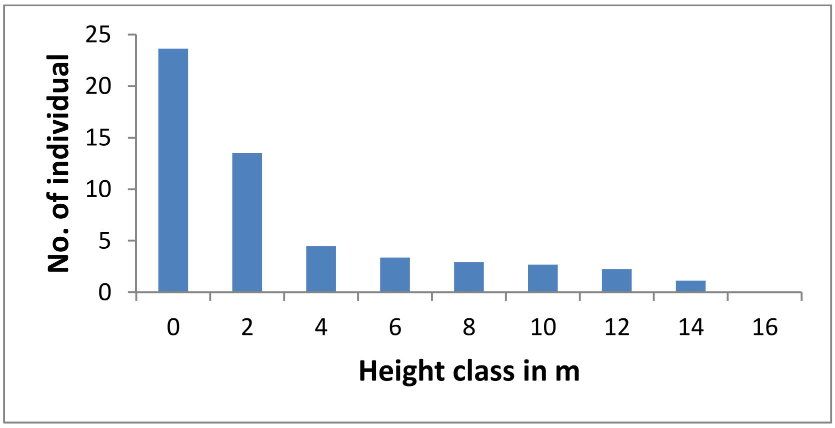

Figure 3-5.Regeneration status of *Acacia polyacantha* with height base

Study in Beschilo and Blue Nile river regeneration classify stories like upper storey of the tree individuals was 18 – 26 m, the middle storey 10 –15 m and the lower storey < 8 m (Getaneh Belachew, 2006).
The lower storey attain highest stem compared to the middle and upper stories. Under the middle and the upper strata storey *Acacia polyacantha* has less number of stem per plot and it was higher to lower storey (Figure 4-4).

Table 3-1.Number of Acacia polyacantha under different DBH class and strata

DBH (cm)	Density ha $^{-1}$	Percentage	Storey Stem	Stem No per *2.25 A. polyacantha* ha^{-1}
Seedlings	12	50		
< 5	6	25	Lower	20
5- 10	2	8		
10 -15	1	4		
15 -20	1	4	Middle	3
20-25	1	4		
25_30	0.6	3		
30_35	0.4	2	Upper	1
>35	0	0		

Table 4.1 above shows that 83% of tree individuals were in < 10 cm DBH class. About 12% were within 10 < 25 cm DBH and 17 % > 25 cm DBH. There is a considerable decrease in number of individuals with increasing DBH. The State forest of *Shimelegir* forest was embraces of high proportion of lower sized *A. polyacantha* tree species.

3.1.3 Regeneration status of *Boswellia papyrifera*

Natural regeneration gives information on the regenerative capacity of a population (Shackleton, 1993; Obiri *et al.*; 2002). Density and regeneration status are commonly used indicators to evaluate impact of NTFP extraction from a given forest area (Silvertown, 1982; Shahabuddin & Prasad, 2004). No seedlings and saplings of the species were encountered in all the sample plots (Figure 4.5 and 4.6). The DBH class distribution of *Boswellia papyrifera* species in *Shimelegir* forest showed that zero number of individuals in the first and second classes with gradual increase towards the middle and slightly decrease to higher classes (Figure 4.5 and 4.6). In other words, sharply declining densities of individuals in successively larger size classes produces the J-shaped or bell shaped (Asmamaw Alemu., 2007) diameter class distribution for a species. In Eritrea and northern Ethiopia, natural regeneration of *B. papyrifera* is poor (Ogbazghi 2001; Kindeya Gebrehiwot, 2003; Abeje Eshete *et al*.; 2005; Abeje Eshete,*et al*.; 2005; Ogbazghi *et al*.; 2006; Mulugeta Lemeneh *et al*.; 2007; Abeje Eshete, 2011; Groenendijk *et al*.; 2012). Khamis (2001) also found that there was no regeneration of *Boswellia papyrifera* trees in Jebal Marra, West Sudan Nuba Mountain, South Kordofan State, Sudan showing that lack of regeneration and/or establishment of the species is a common problem in Sudan. Similar population structures of *B. papyrifera* were reported from Jebel Marra, West Sudan by Khamis (2001) and Adam (2003). In contrast, though there was inverted J-curve population, good regeneration was reported from the study conducted by Getaneh Belachew., 2006 in Beschillo and Blue Nile Riverine.

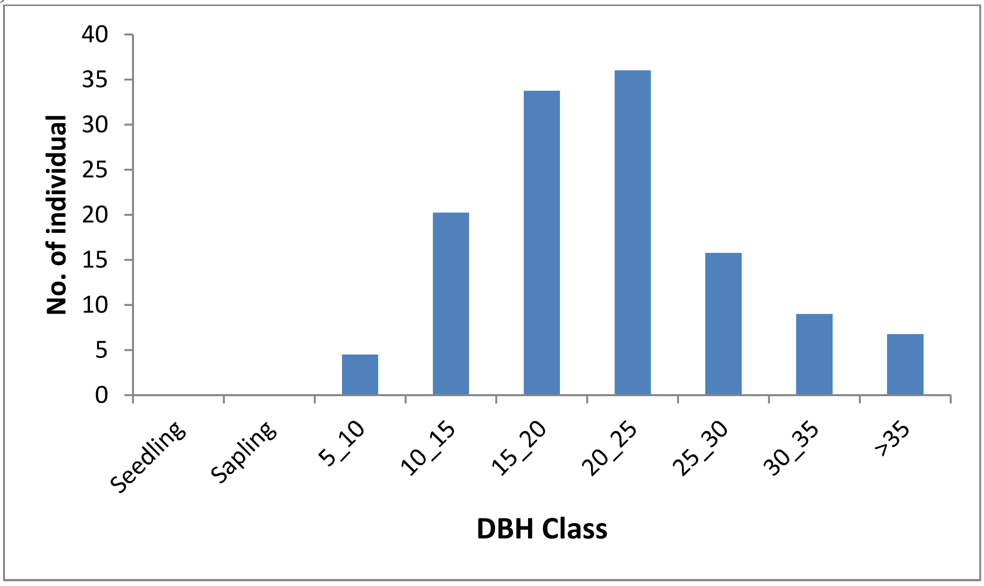

Figure 3-6. Regeneration statues of *B. papyrifera* species with DBH class

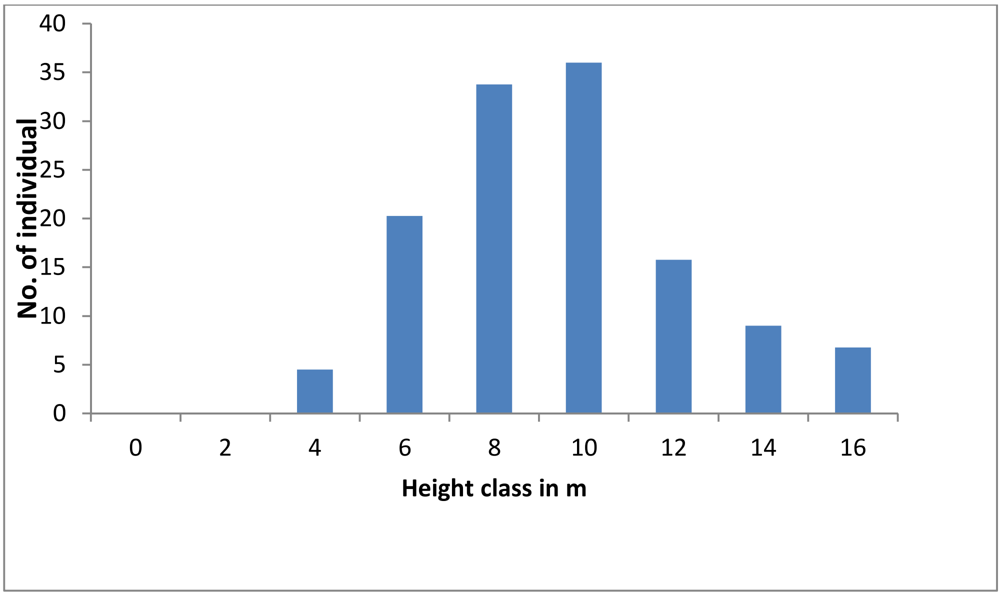

Figure 3-7. Regeneration statues of *B. papyrifera* species with Height class

This is an indication that the species is under threat not only in the study area but also in several geographical locations in the region of its distribution due to continuous tapping for incense production, human induced fire, overgrazing and climatic anomalies.

The local community blames the investors on frankincense production for the death of *Boswellia* trees that since they are not permanently invest in the area and they pay the money per kilogram for tappers so that they tend to maximize yield from trees by making many tapping spots per individual tree. From the observation those

CBO member's tappers makes also improper tapping.

Boswellia papyrifera was reached the upper strata. The middle storey was extremely denser than the lower storey. This indicates that over browsing, expansion of farm land and seasonal flood fire may have destroyed many of the seedlings and young trees as well (Table 4.2).

Table 3-1.Number of Boswellia papyrifera under different DBH class and strata

DBH (cm)	Density ha $^{-1}$	Percentage	Storey Stem	Stem N<u>o</u> per *2.25 B. Papyrifera* ha^{-1}
Seedling	0	0		
Sapling	0	0	Lower	3
5 -10	3	5.4		
10_15	6	10.7		
15_20	13	23.2	Middle	36
20_25	17	30.4		
25_30	8	14.2		
30 -35	5	9	Upper	17
>35	4	7.1		

Table 4.2 above shows that 5.4% of tree individuals were in < 10 cm DBH class. About 64.3 % were within 11 < 25 cm DBH and 30.3% > 30 cm DBH. There is a considerable increase in number of individuals with increasing DBH and decrease when the tree DBH was farther increase in DBH. It might be resulting from environmental and anthropogenic disturbances on the species. The State forest of *Shimelegir* forest were composed of high proportion of middle sized *Boswellia papyrifera* trees species.

The middle storey attains highest stem of *Boswellia papyrifera* species compared to the lower and upper stories. The lower storey has no stem. *Boswellia papyrifera* species were limited to the upper and the lower strata. Only it reached the middle strata. The middle storey was two times denser than the upper storey. This indicates that over browsing, expansion of farm land, seasonal flood, fire hazard and resettlements may have destroyed many of the seedlings and young trees as well.

Boswellia papyrifera has the ability to produce ample quantities of seedlings. However, a low number of seedlings may not necessarily imply low regeneration. This is because the number of seedling observed at any given time depends on mortality rate and carrying capacity of the specific site (Condit *et al*.; 1995). In most of the study sites, plant mortality is far higher for individuals in smallest size classes than in larger size classes. Vulnerability of seedlings to hazards from environmental and biotic factors is higher at the early stages of seedling establishment (Fenner 1987; Whitmore 1996).

Adam and El Tayeb, (2008), Khamis, (2001) reported that they encountered quite high number of seedlings of the species in the same area, the possible reason for the discrepancies could be the season of the regeneration survey that Adam and El Tayeb (2008) conducted that the regeneration survey immediately after the rainy season and the survey was conducted during the dry season in case of the present study.

The lack of regeneration of the species could be attributed to intensive tapping, continuous tapping of the trees, fire, over grazing and migration. Local people suggested that since it has edible leaves and its seedling has full of leaves. Even when protected against grazing and fire, the seedlings fail to exhibit good survival (Sisay Asfaw, 2006; Aklilu Negussie *et al*.; 2008). One of the major driving forces for the degradation of the woodlands and the frankincense trees is assumed to be immigration both sponsored (resettlement) and spontaneous (Kindeya Gebrehiwot, 2003; Mulugeta Lemenih *et al*.; 2007).

Conclusion

The study was aimed at providing useful information on the present condition of the density and regeneration statues of *Acacia polyacantha* and *Boswellia papyrifera* and willingness of the people to participate in Participatory Forest Management inShimelegir State Forest which can be used as an input for future development intervention. The findings of the study revealed that less density of *Acacia polyacantha* and *Boswellia papyrifera* populations.

The total density of tree stems per hectare of *Acacia polyacantha* was lower (24 Nha^{-1}) relative to other study findings and *Boswellia papyrifera* was also lower in its density (56 Nha^{-1}), indicating that both species of *Shimelegir* state forest has been found to possess scattered tree individuals.

The regeneration capacity of *Acacia polyacantha* and *Boswellia papyrifera* tree species were found to be different. Accordingly, *Acacia polyacantha* has inverted "J" shaped distribution with poor regeneration and good recruitment status and *Boswellia papyrifera* has shows bell shaped population structure with poor regeneration.

Recommendations

Generally, as Shimelegir forest is important in different goods and services, PFM in Shimelegir is established in 2011 with the objective of conserving the unique biodiversity of the region and improving livelihood of the community. Hence the following recommendations are forwarded to reduce the existing distraction pressure on both species and on how peoples can improve their willingness to participate in PFM.

- Create favorable conditions for the regeneration of native species through promoting matured trees as seed sources, plantation forests, fire protection and minimization of livestock pressure.
- Boswellia species are classified as an endangered and economically important tree species, the establishment of a special Boswellia research and development unit is strongly recommended with considering mycorohozoa assocition.
- Creating integrated awareness programs that could promote economical, social and ecological importance of dry forests trees and their severity deforestation particularly in the study area.

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