Plantation and Agroforestry Research Directorate

*Working Paper Series 03/2020*

Addis Ababa, September 2020

Ethiopian Environment and Forest Research Institute
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# Assessment of farmers' tree needs and their traditional knowledge on seasonal frost management in Bore woreda, Guji zone, Oromia region, Ethiopia

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**Report summary**

Frost occurs in some highlands of Ethiopia occasionally and affects tree establishment severely. The study was initiated to assess, and document farmers' tree needs, constraints and opportunities, and their traditional frost management techniques in frost affected highlands in Bore woreda, Oromia. The altitude of the woreda ranges from 1800 to 2900 meters above sea level. Two areas where seasonal frost is the major threats were purposively selected in the woreda. Boundary planting, home garden, and crop fields were among the niche of tree planting. Fuel wood, fodder, poles for construction, soil fertility improvement and erosion control, fruit production and medicinal value were the services and products farmers valued the most in the study area. Up to 12% of the interviewed farmers practice different frost management including the use of stone/wood fence, organic mulch, and smoke to protect their plants from possible damages. Farmers and interested tree growers in Bore districts should be aware of frost occurrence time, which is from September-January, and practice different frost management activities to reduce damage on their vegetation and seedlings.

**Key words**: frost, tree need, indigenous knowledge

## 1. Introduction

Ethiopia has a diverse biophysical environment and its land formations fall broadly into highlands and lowlands (Teklu, 2014). The highlands are highly degraded due to deforestation and forest degradation together with unbalanced crop and livestock production and severe soil loss (Girma 2001, Badege, 2001).

Furthermore, extreme environmental conditions such as high temperature, frost, low humidity and desiccating winds are the main causes to failure in afforestation and reforestation activities and too hostile for the natural regeneration in the country (Mulugeta and Demel, 2004). Plants growing in the field are habitually exposed to several environmental stresses, e.g. drought and frost. Low temperature is a key weather factor that places a limit on where trees and shrubs will survive. Frost damage occurs when ice forms inside the plant tissue and injures the plant cells. Frost damage may have a drastic effect upon the entire plant or affect only a small part of the plant tissue, which reduces yield, or merely product quality. Further the obvious low temperature limitations lead to killing of plant tissues by freezing through which most tissues can be suddenly destroyed during a period of rapid growth. Low temperature limitations can be manifested in temperature below freezing temperature resulting in the occurrence of frosts (FAO, 2005). Even though plant injury from freezing temperatures is common in temperate and arctic regions, tropical plants can be injured by temperatures as low as 10 °C. Such damage to tropical plants is referred to as "chilling injury". A wide range of techniques and methods exists for avoiding or reducing frost damage. They are divided into two groups: direct and indirect methods. Direct methods are aimed at improving the thermal regime of the air layer near the ground and at decreasing long wave radiation loss from soil and plants. Indirect methods are more preventive in nature and may be roughly subdivided into biological and ecological techniques (Stanhill et al, 1992). The ability of plant to withstand environmental stress (frost and drought) depends on the availability of essential nutrient in soil Consequently, good plant nutrition and sanitary status favors acclimatization and resistance to freezing (Alden and Hermann, 1971).

Land degradation in the form of soil fertility depletion and environmental stress (frost and drought) combined with improper tree establishment and management techniques can severely hamper afforestation and reforestation success. Therefore, this study was initiated to assess, and document farmers' tree needs, constraints and opportunities, and their traditional frost management techniques in frost affected and degraded highlands.

## 2 Materials and Methods

### 2.1 Description of the study area

Bore is one of the woredas (districts) in Guji Zone, Oromia, Ethiopia. The altitude of the woreda ranges from 1800 to 2900 meters above sea level. The land in this woreda is 29% crop land, 33% pasture, 30% forest, and the remaining 8% is considered swampy, degraded or otherwise unusable. The major crops in the woreda include barley, wheat, corn, teff, and horse bean . As the 2007 national census reported, a total population of this woreda was 210,179, of whom 105,726 were men and 104,453 women; 10,258 or 4.88% of its population were urban dwellers. With an estimated area of 1,296.88 square kilometers, Bore has an estimated population density of 128.6 people per square kilometer, which is greater than the Zone average of 21.1(CSA, 2005).

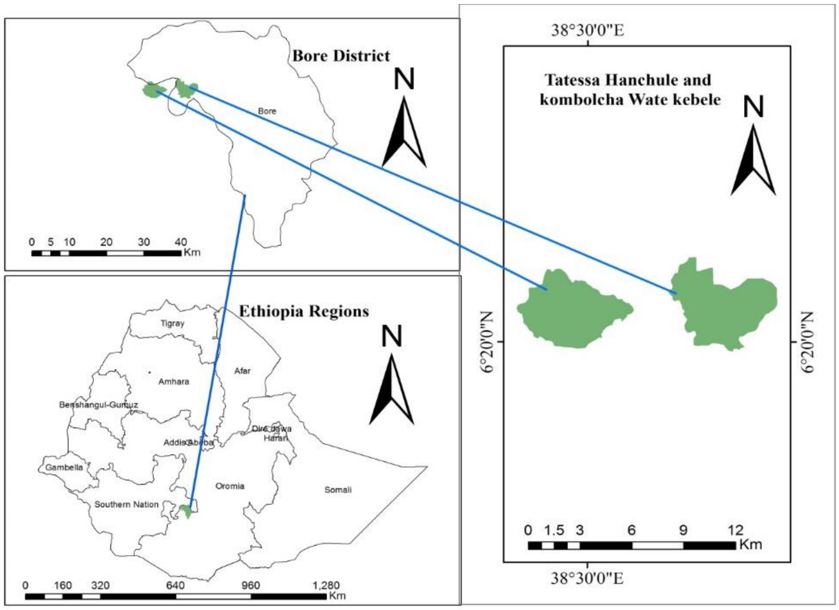


Figure 1 Map showing the locations of the two study areas in Bore woreda, Oromia, Ethiopia

## 2.2 Sampling procedure and sample size determination

The study woreda and two kebeles (the smallest administrative unit in Ethiopia (Tatessa Hancule & Kombolcha Wate) where seasonal frost is the major threats was purposively selected with the help of zonal and woreda natural resource experts. A total of 133 households were randomly selected for detailed interview on their tree need, constraints and opportunities and traditional seasonal frost management technique using Watson's (2001) formula:

$$n = \frac{\dfrac{P(1-P)}{\dfrac{A^2}{Z^2} + \dfrac{P(1-P)}{N}}}{R}$$

Where $n$ = sample size required, $N$ = total number of population (2150), $P$ = estimated variance in population, as a decimal: (0.1) for 90-10%, $A$ = precision desired expressed as decimal: (0.05 for 5%), $Z$ = based on confidence level: (1.96) for a 95% confidence level, $R$ = response rate: (0.99 for 99% response).

## 2.3 Data collection and analysis

To assess tree needs and traditional knowledge of farmers on seasonal frost management both primary and secondary data sources was used. The secondary data was collected from published and unpublished material (reports, scientific studies) and primary data source includes house hold survey with structured questionnaire, key informant interview (KI) and focus group discussion (FGD).

Questionnaire consisting of both closed and open ended questions were prepared to solicit information on the farmers tree need, traditional frost management technique. Both descriptive and inferential statistics were employed to analyze the data.

About 78.9% of the interviewed respondents were male headed and the rest 21.1% represent the female headed households. 40.6 % of the respondents never went to school; about 32.3 % had some schooling (1-8 class) while 16.5% were educated to grade 9-10 and about 4.5% of the respondent attended preparatory school (grade 11-12), 0.8% gained degree, while the rest 5.3% of respondents were grouped under informally educated community category.

In terms of societal status, about 91.7% of inspected household heads were ordinary residents, 4.5% were kebele administrative executive members, while the rest 3% and 0.8% were religious leaders and chief kebele administrator respectively,

On average family size per households was 8.37±3.68 in number in the study area. An average land holding size of households in the study area was 2.88±1.40 ha.

A great majority (96.2%) were farmers by occupation whereas, 2.3% of them participated on trade and the rest 1.5% of them were investors.

About 27.1% of surveyed households had a livestock number between 6-10, 19.5% had to have 11-15 and 16-20 livestock numbers while 9.0% of the respondents owned 21-25 livestock and 9.8% had less than five livestock.

## 3 Results and Discussions

### 3.1 Practice of farmers on tree establishment and management

All the surveyed households in the study area plant and manage different trees for different purposes. According to the respondents, *Eucalyptus globlus, Cupressus lusitanica, Hagenia abyssinica, Apple, Juniperus procera and Cytisus proliferus (tree lucerne)* were the tree species planted and managed on their farm. The list of uses mentioned by informants when compared with those reported in many other studies in Ethiopia (Hachoofwe, 2008; Adal, 2014; Tefera et al., 2014) and elsewhere (Gerique, 2006; Jose, 2009; Tabuti, 2012) revealed a similar result. This implies that the cognitive domains for on-farm woody species are similar in rural communities found in different parts of Ethiopia and other countries where livelihoods depend on plants (Adal,2015).

According to the respondents, the preferred tree species for planting on farms should have the following attributes: drought resistance, fast growth and ease of establishment, multiple use and frost resistance (Figure 2). Previous research results supported this argument in that to integrate trees on farms, farmers apply several criteria, including fast growth, utility, compatibility, multipurpose use-value, drought resistance, and access to seedlings (Adal, 2015).

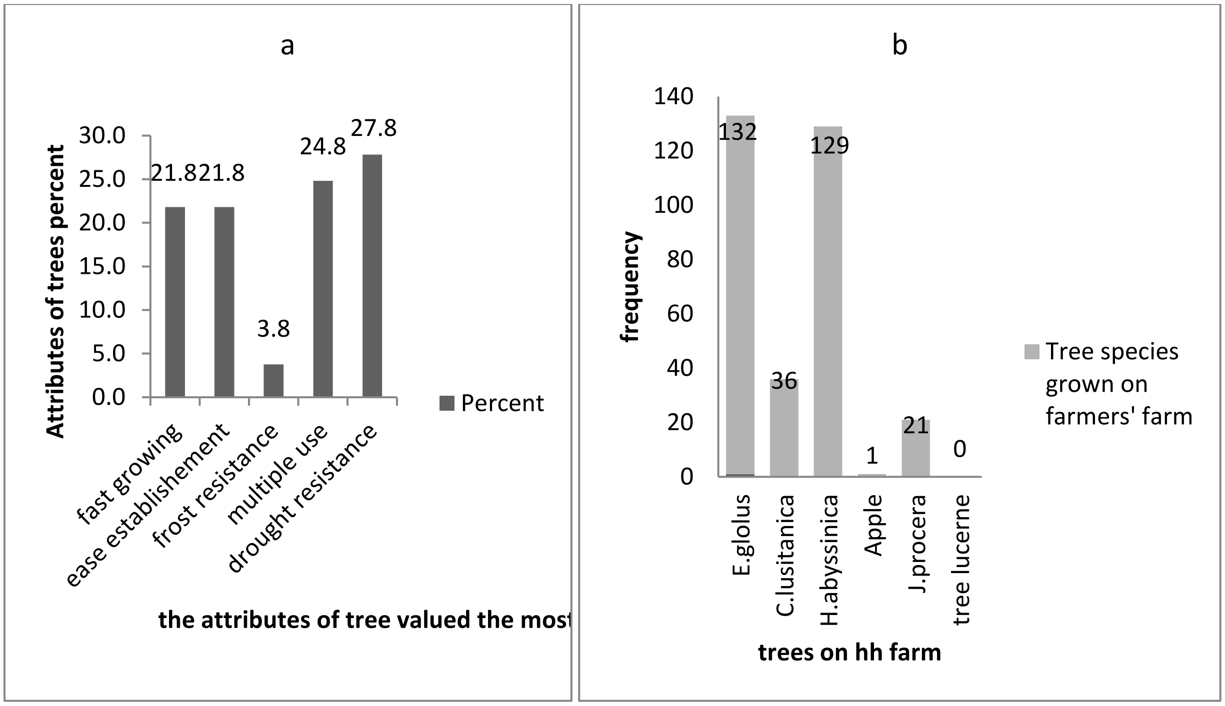


Figure2 Attributes of trees most valued by farmers (a) and commonly planted and grown trees (b) on farmers' fields in Bore woreda

### 3.2 Source of planting materials, planting niches and service/product of trees preferred for planting

Boundary planting is by far the most preferred tree planting niches in the study area followed by home gardens (Figure 3) A study conducted in southern Ethiopia by Negash (2007) showed that farmers' tree planting was limited to home gardens and boundary planting due to land shortage. The interviewed respondents also said that they match planting niches with the purpose of the planting. For example, for a species to be incorporated into farmlands, it should be one that sheds its leaves before the onset of rain and is easily decomposed to increase soil fertility. Evergreen species are kept around the residence (home garden), grazing land, and farm boundary to provide shade, fodder, and other functions (Adal,2015).

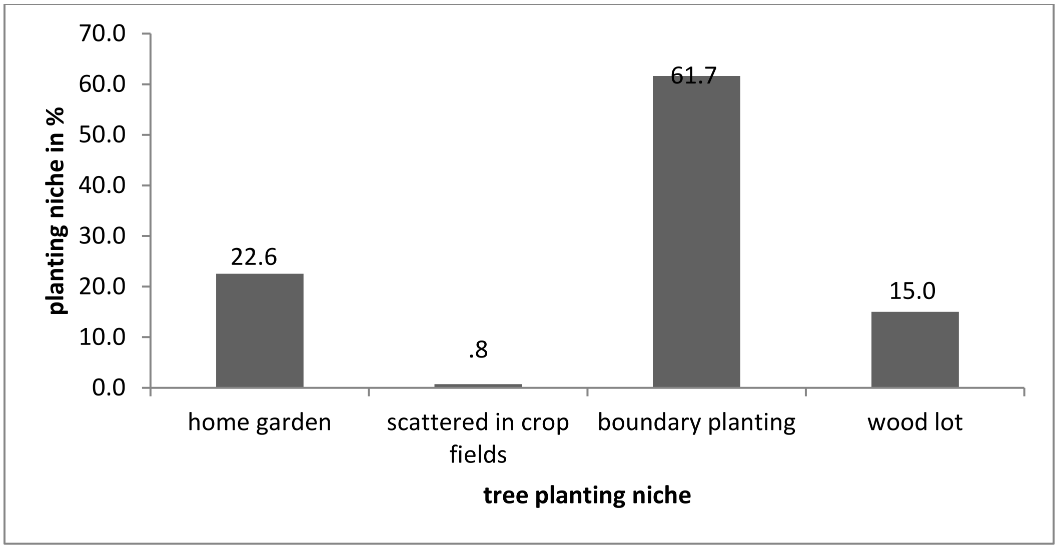


Figure 3. Planting niche of tree planted by households in Bore woreda

Regarding sources of planting materials, about 52.6% of the respondents said they get seedlings from state nurseries, 28.6% of them produce seedlings/planting materials in their own nurseries by broadcasting seeds on prepared planting site and latter thinning germinated seedlings, while 18.0% and 0.8% of the respondents get Seedling/planting materials from other privately-owned nurseries and NGO owned nurseries, respectively.

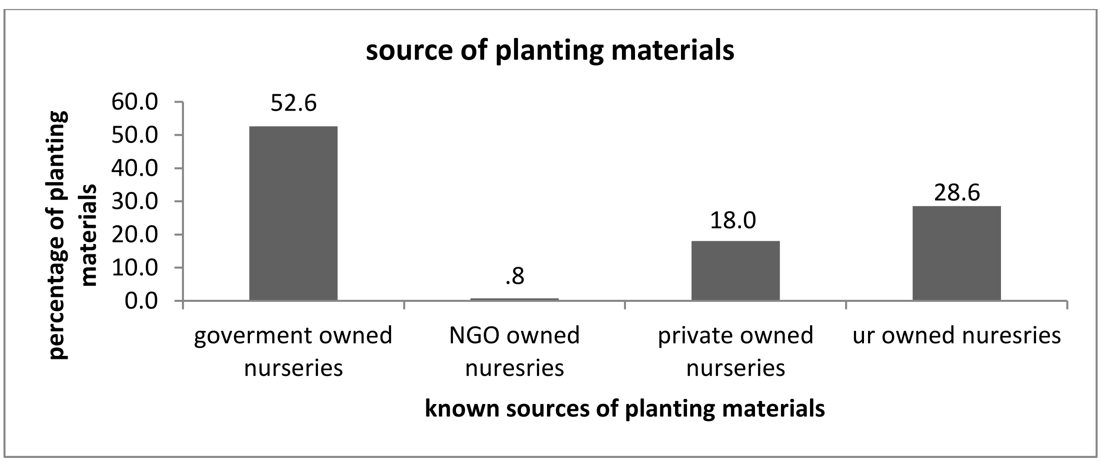


Figure4 Sources of planting materials in Bore woreda

About 54.9% of the respondents plant trees for production of poles for construction and 27.1% of the respondents plant trees for fuel wood production (Figure 5). Other tree planting objectives include fodder production, fruit production, soil fertility improvement and erosion control and medicinal value. Apart from providing the desperately needed wood products for construction and fuel, as well as twigs and pods for fodder, these on-farm trees improve crop yields by up to 56% (Negash, 2007). Such intensive land-use practices are claimed to make full use of limited space, save energy and to be an effective way of controlling erosion and leaching, and of maintaining soil fertility and land productivity (Negash 2007).

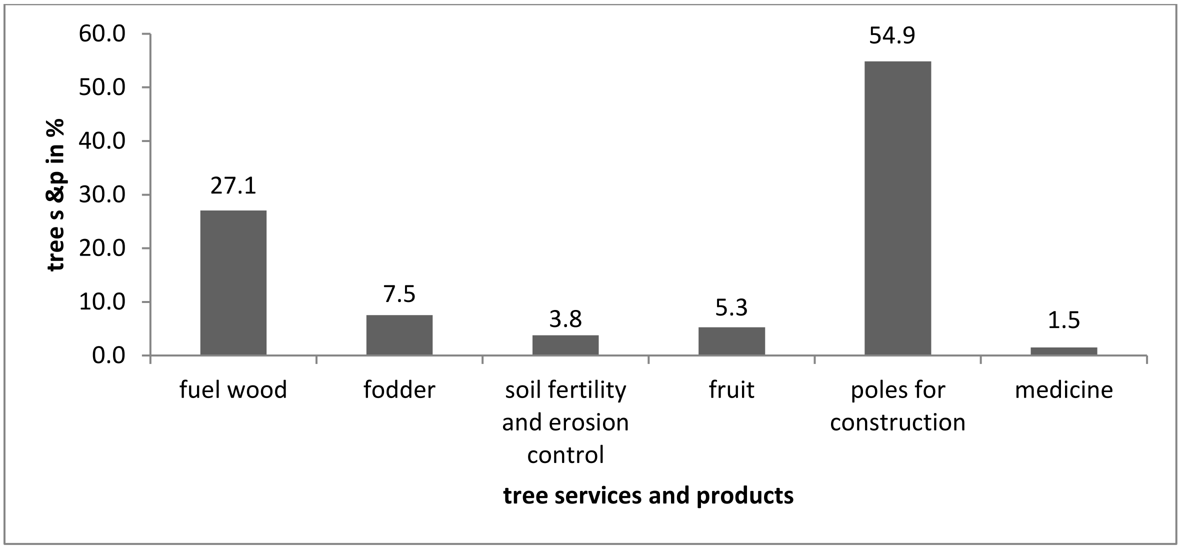


Figure 5 Tree services and products most preferred by respondents in Bore woreda

Respondents were asked whether they grade seedlings before out planting to the field or not considering frost problem, that 38.3 percent of them grade seedlings before out planting to field by using size-height, size-diameter and healthiness of the seedlings as a criterion, while 61.7 percent of the respondents did not grade seedlings before out planting to the field with any of above-mentioned criterion. From the respondents grading seedlings, 18.8% grade using size if seedlings good both with height and diameter withstand frost damage where as 11.3% of the respondents believe that seedlings with good height resist seasonal frost, and about 7.5% of them think that healthy seedlings with special height and diameter perform well even in the time of frost occurrence.

### 3.3 Seasonal frost occurrence, cause and its management technique

Most of the respondents (99.2%) had the information about the causes of seedling mortality. From the respondents those who have information about seedling mortality and their causes, 92.5% of them said that seasonal frost occurrence was the main cause of seedling mortality in that particular area where as about 4.5% stated that inappropriate planting time as a cause of seedling mortality, 1.5% of them responded that inappropriate species site match was the cause of seedling mortality and other mentioned inappropriate planting materials and free grazing as possible causes of seedling mortality. Cold winds remove moisture from evergreen foliage more quickly than it can be replenished by the roots; this can cause leaf browning particularly at the tips and margins (Bouchet, R.J. 1965).

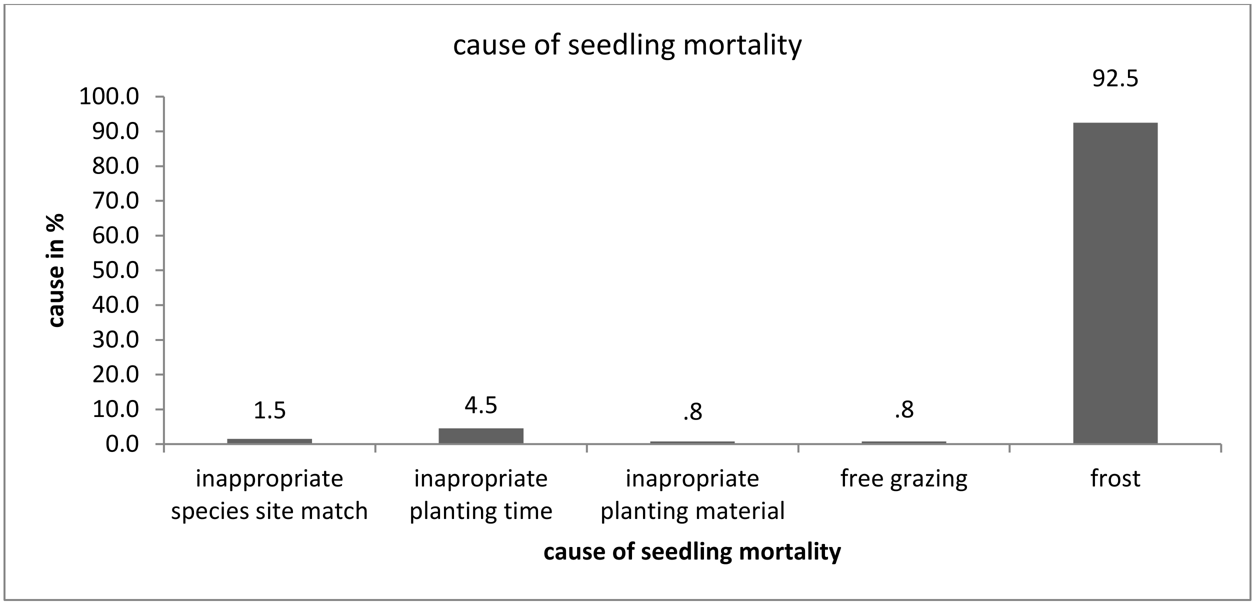

Figure 6 Causes of seedling mortality in Bore woreda

In terms of frost occurrence season, about 98.5% of the respondents support that seasonal frost occurs once in a year (between September- January) while the rest 1.5% of them think that frost occurs twice a year (between October-November and February-January). Frost damage was very serious during September to January because, this time was not rainy time where there was no fog and cloudy sky which reduces the net radiation losses through increased downward long wave radiation. On rare occasions, subzero temperatures occur during cloudy conditions associated with an advection frost. However, radiation frosts are considerably more common than advection frosts (FAO,1986). Regarding the stage when seedlings are more prone to frost damage,77.4% of the respondents agreed that seedlings at the first 6 month of their growth stage were prone to frost damage whereas 21.1% & 1.5% of the respondents said that the first and the second years of seedling growth stage were affected by frost damage, respectively. From this known time of frost occurrence and stage of planted seedlings affected by frost damage, farmers/tree growers need to have frost calendar to adjust their planting time to reduce damage from frost.

According to the respondents, 54.1% respond that grazing land was exposed to frost, 28.6% respond that agricultural land was exposed to frost and the rest 15% & 2.3% of the respondents agreed that degraded hillside and homestead were areas where frost damage was severe, respectively (Figure 7). Site selection is the single most important method of frost protection (Schereiber,1965). Factors to consider are cold air drainage, slope and aspect, and soil type. Most growers were aware of some spots that were more prone to damage than others. Typically, low spots in the local topography have colder temperatures and hence more damage (Schereiber, 1965).

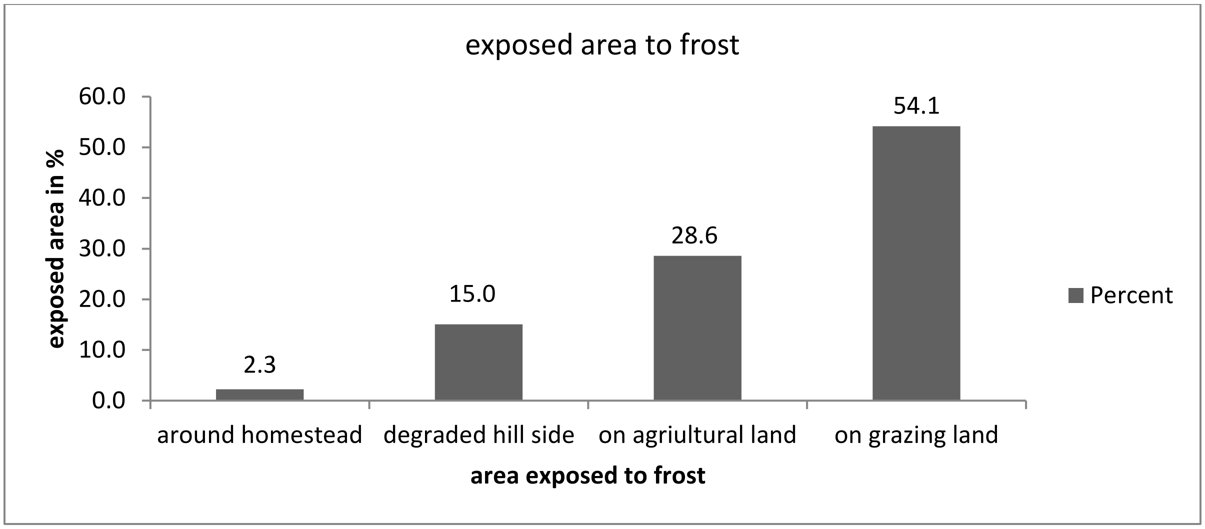


Figure 7 Area exposed to frost damage in Bore woreda

Respondents were asked if they apply any of the seasonal frost management that, 27.1% of them apply some management technique to reduce seasonal frost damage while 72.9% of the respondents didn't practice any of the seasonal frost management technique**.** From those respondents, who protect their plant through applying different frost management technique, 3.0% use stone/wood fence, 6.0% use organic mulch, 12.0% protect using plant cover while the rest 6.0% of the respondents use smoking to protect their plant against frost. Plant row covers increase downward long-wave radiation at night and reduce losses of heat to the air by heat convection (and advection) (Collomb, 1966). Covers must have a low coefficient of conduction and ideally would be opaque to long-wave radiation (Collomb, 1966). Dry soil has a lower thermal conductivity, so it is sometimes used to cover small plants to protect trunks of young trees during relatively short subzero periods (Blanc *et al.* 1963) The existence of organic mulch (e.g. straw, sawdust) reduces evaporation, but it decreases daily minimum air temperature. The mulch reduces heat flow from the ground to the surface, causing lower minimum surface temperatures, which leads to lower minimum air temperature as well (Bouchet, 1965). It is well known that the protection from heaters comes from the heat released by the fires and not from smoke production (Collomb, 1966). Consequently, smoke has little effect on upward or downward long-wave radiation at night and hence has little benefit for frost protection.

Respondents were asked to list out tree species that they believe can resist/withstand frost damage and *Hagenia abyssinica* was pointed out by many as frost tolerant (Figure 14).

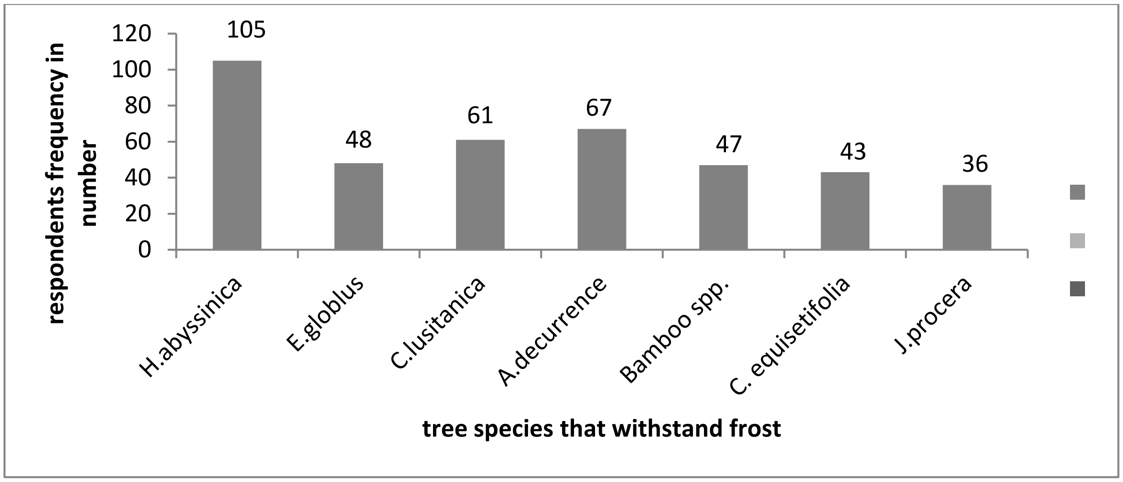


Figure 8 Tree species with stand frost damage in Bore woreda

Strong wind (19.5%), free grazing (50.4%), moisture stress (2.3%), site condition/degraded (26.3%) and human disturbance (1.5%) were amongst factors that aggravates frost according to the inspected respondents. In Southern California, very rapid thawing, a strong wind, topography was among factors aggravating frost according to (Sakai, 1968).

The management interventions made against frost were manuring (57.9% of the respondents), and 18.0% of the respondents intervene with watering/irrigation management, 15.8% with plant cover, 3.8% smoking and only 1 respondent believed fencing helps protect against frost. According to Angus, (1962), species selection, avoiding frost pocket'-position selection, covering plants with double layer /suitable protection when frost is forecast. Mulch the root area with a thick layer of organic matter can be used to protect young trees from frost.

About 78.9% of the respondents plant out seedlings at the beginning of the rain season and 20.3% of them plant out seedlings at the mid of rain season while the rest 0.8% of them were planted seedlings after two/three rain comes. Farmers were aware of seasonal frost occurrence time that they have calendar of planting out seedlings**.** According to (Susan Patterson,1976), frost can cause damage to tree blossoms and young plants. Since rain season start in study area early April and frost occur during September-January and the first 6 month of seedling stage were damaged, farmers preferred planting out their seedlings at the beginning of rain season to escape from frost damage.

### 3.4 Conclusion and recommendation.

The study revealed that boundary planting and home garden, were the most important tree planting niches in the study area. State nursery is by far the most important source of tree germplasm in the study area. Production of poles for construction and fuelwood are the most important tree planting purposes in the area. From those who protect their plant through applying different frost management technique, most of the respondents apply plant cover to protect seedlings from frost damage. Frost is a very important sources of tree mortality in the study area. It mainly occurs from September-January. *Frost tolerant tree species in the area include H. abyssinica*, *A. decurrence*, *C. lusitanica*, *E. globulus*, *highland bamboo*, *C. equisetifolia* and *J. procera*. Because smoking has little effect in protecting seedlings from frost, its application as one of the frost protection tools needs to be discouraged. Proper species selection and the application of plant cover should be encouraged and scaled up successfully establish trees in the area.

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