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Assessment of farmers' tree needs and traditional practices on seasonal frost management in degraded frost affected highlands of Northeastern Ethiopia

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Report summary

Ethiopia has strong initiations to rehabilitate or restore degraded lands but the success has been hindered by low soil fertility and extreme environmental events such as seasonal frost. Reports show that frost is one of the major causes of seedling mortality in the highlands. The main objective of the study was to investigate farmers' tree need and traditional seasonal frost management practices in degraded frost affected central highlands of Ethiopia. The study was conducted in purposively selected frost-prone areas in four woredas (districts), namely, Dessie Zuria, Legambo, Menz Gera and Menz Mama in Amhara regional state. A total of 202 households were sampled following simple random sampling technique by using the list of taxpayer households available in each site. Primary data were collected through a survey of individual households using a structured questionnaire, and focus group discussions (FGDs). The major tree species grown by farmers were *E. globulus* (55.0%), *Cytisus proliferus* (20.0%) and *Cupressus lusitanica* (9.4%). The major attributes and products of trees that were preferred by farmers were multipurpose use and fast growth nature (43.5%) and pole and construction material (68.5%) respectively. Seasonal frost is the major causes of seedling mortality for most of the farmers (59.4%) followed by drought (10.7%) and free grazing (8.5%). The farmers commonly practiced mulching (33.5%) followed by hoeing and watering (24.1%) and plant cover (21.5%) for frost management. The management practice of farmers should be optimized, and new alternative management practices should be examined, introduced and scale out in different frost-prone areas.

1. Introduction

The highlands of eastern Africa have seen rapid population growth and unprecedented land-use changes (Zhou et al., 2004), heightening the challenge of sustaining the resource base while providing for a growing population is heavily dependent on natural resources.

The Ethiopian highlands once covered with natural vegetation, but today the percentage of forest cover is less than 4%. The alarming rate of population growth and its resultant effect of agricultural land expansion and the high dependence on biomass energy are the most important direct drivers of deforestation and forest degradation in the areas (Yerdaw et al., 2014; Teketay, 2001; Hurni, 2010;). Deforestation and forest degradation together with unbalanced crop and livestock production and severe soil loss (Girma 2001) in turn are underlying causes of land degradation in the Ethiopian highland (Badege, 2001). Topography, soil types and agro-ecological parameters are also additional factors playing significant role in the degradation processes (Paulos 2001). Deforestation and land degradation are reducing the capacity of forests and the land to contribute to food security, and to provide other benefits, such as fuel wood and fodder (Girma, 2001).

Furthermore, extreme environmental conditions such as high temperature, frost, low humidity and desiccating winds are the main causes of failures in afforestation and reforestation activities in the country (Mulugeta and Demel, 2004). Plants growing in the field are habitually exposed to several environmental stresses (William, 1953) especially those affecting water availability and temperature, determine their growth and development (Janska, et al 2010). The ability to withstand environmental stresses, therefore, becomes the limiting factor for plant growth, survival and geographical distribution. Woody plants in the alpine life zone and in the tree line ecotone frequently exposed to conditions that can result in frost damage (Gilbert, 2014). Even though plant injury from freezing temperatures is common in temperate and arctic regions, tropical plants injured by temperatures as low as 10 °C. This kind of damage to tropical plants is called "chilling injury" (Stanhill et al, 1992).

Restoration of degraded forest/land in Ethiopia follows different types of strategies such as various forms of agro-forestry, reforestation/afforestation, area ex-closure, and woodlot development (Yerdaw et al., 2014; Limeneh and Hailemariam, 2014). However, due to infertility of soil and environmental stress (drought and frost) coupled with improper tree establishment and management techniques, the success of afforestation and reforestation has been at stake. Hence, to make the afforestation/reforestation effort successful, improving seedling establishment and management techniques in degraded frost affected highlands is a crucial task. Also, before examining different management practices at the field level assessing, documenting and incorporating the traditional farmers' practice on frost management is very important. Therefore, the objective of this study was to assess and investigate farmers' tree needs and traditional seasonal frost management practices in frost affected degraded highlands of Northeastern Ethiopia.

2. Materials and Methods

2.1 Description of the study area

This study was conducted in the central highlands of Ethiopia particularly in the highland areas of eastern Amhara, which is part of the North Central massif and dominated by undulating and

rugged topography. Two administrative zones in eastern Amhara, namely, South Wollo and North Shewa zones are first identified because of the prevalence of frost-prone degraded highlands in the areas. Similarly, two districts in each zone were selected for the study. Finally, four frost-prone kebeles (smallest administrative unit) were selected from the four districts, namely, Dessie Zuria, Legambo, Menz Gera and Menz Mama..

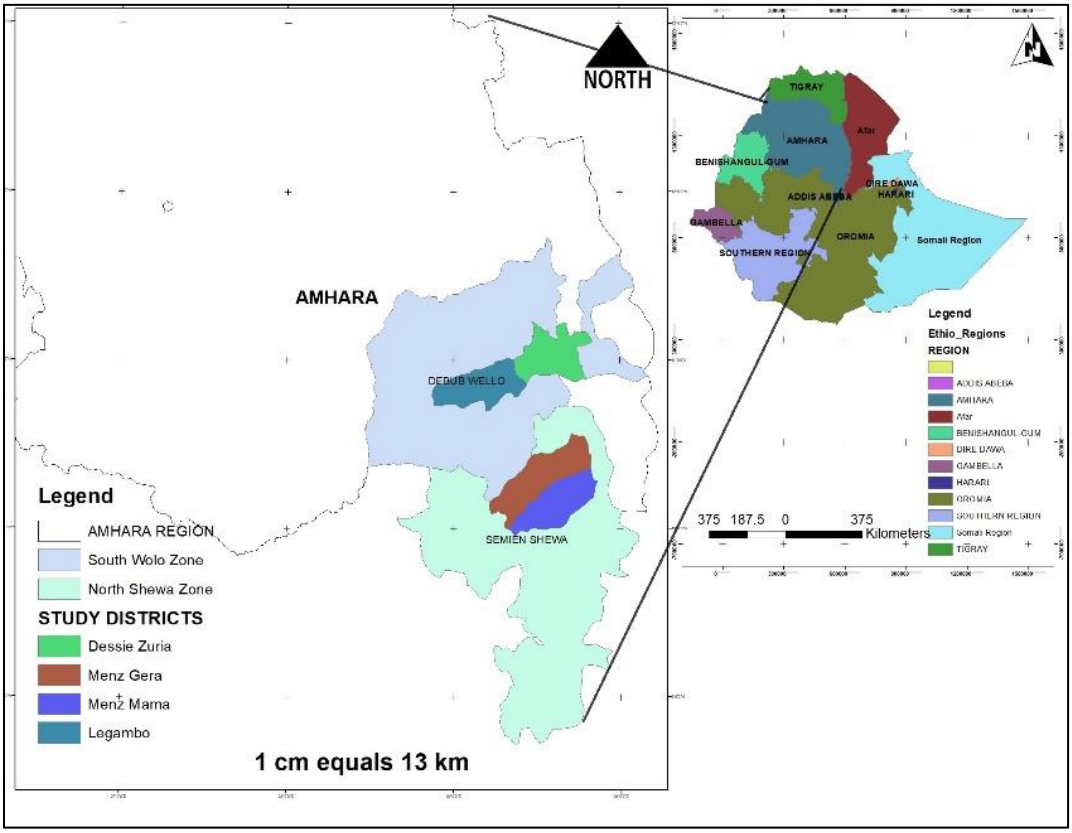

Figure 1. Map of the study area

2.2 Sampling design and data collection

A multistage sampling strategy was followed to identify administrative units (zones, woredas and kebeles) that are characterized by degraded and frost-prone highlands. To assess tree needs and traditional practice of farmers on seasonal frost management both primary and secondary data sources were used. The secondary data were collected from published and unpublished material (reports, scientific studies etc.) and primary data were collected through household survey with structured questioner, and focus group discussion (FGD).

A total of 202 (171 male and 31 female) households, were sampled following simple random sampling technique by using the list of taxpayer households of the kebele, so that all sample household would have equal chance of being selected.

In addition, focus group discussions were held to verify and proof farmers' tree needs, and traditional frost management techniques.

2.3 Data analysis and interpretation

The qualitative and quantitative data were analyzed by employing descriptive statistics, such as such as mean, percentage, frequency and standard deviation in IBM SPSS statistical software version 25 (IBM, 2017).

3. Results and discussion

3.1 Demographic and socio-economic characteristics of the Household

Among the respondents, 84.7 % and 15.3 % were male and female household heads, respectively. The average family size of the respondent was five and the average age of the sampled household heads was about 44 years (Table 1.). Most of the respondents attended primary school (42.6%), and some were illiterate (23.8%) and had informal education (19.3%). The major economical occupation of the respondents was agriculture, with mixed farming system: growing crops, rearing animals and growing trees. Land was a major fixed asset for the farmers. The mean, maximum and minimum land holding of the respondents was 0.86 ha, 6.75 ha and zero, respectively. The other important asset of the households were domestic animals with mean, maximum and minimum number of 11, 66 and 0, respectively. Households owned domestic animals, including cattle, sheep, goats, chickens and others. The average livestock holding of the sampled households was 10.93 Tropical Livestock Units (TLUs).

Table 1. Household characteristics of sampled households

	N	Minimum	Maximum	Mean	Std. Deviation
Age of household head (year)	200	19	84	44.24	12.75
Family size	201	1	11	5.17	1.94
Size of land holdings (ha)	202	.00	6.75	.86	.64
Livestock number	202	0	66	10.93	8.96

3.2 Experience of farmers on tree planting activity

All the respondents were aware of on tree planting activity in their locality. However, 93.5, 75.2 and 73.3% of respondents had the hands-on experience on tree planting activity, grading seedling for frost and protecting plated seedling from frost respectively (Figure 2.).

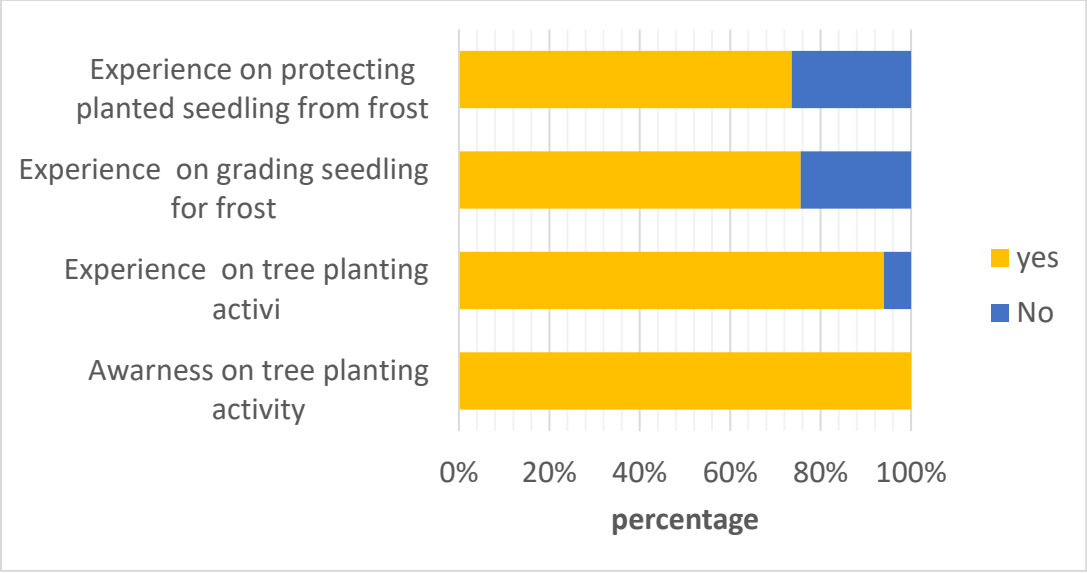

Figure 2. Awareness and experience of respondents on tree planting activity and frost management practices

As shown in Figure 2, about 93.5 % of respondents mentioned that they plant trees in different parts of their farm. The remaining 6.5% of the respondents did not plant tree on their farms due to shortage of land (66.7%), tenure insecurity (25%) and lack of planting material (8.3 %). Most people (55%) plant *Eucalyptus globulus* (55.0%) and some plant *Cytisus proliferus* (20.0%) and *Cupressus lusitanica* (9.4 %) (Table 2). Several studies reported that Eucalyptus tree species are the most preferred tree species in the world. It is due to its nature of establishment (Amare Getahun, 2010; Pohjonen and Pukkala, 1990; Selamyihun, 2004), wider adaptability and ecological range (Pohjonen and Pukkala, 1990; Jagger and Pender, 2003), good survival and growth rate (Getahun, 2002; Jagger and Pender, 2003), simple management requirement (Kebebew and Ayele, 2010; Getahun, 2002; Getahun, 2010) and multiple products, and associated market. In line with the present study Abiyu, et al (2015) reported that *Eucalyptus globulus* is the most widely planted tree species in Gonder Zuria district and accounts more than 90% of the total number of trees of the district.

Besides, as shown from the table below (Table 2), the most preferred niches for tree planting were home garden/ homestead (50.9%) followed by farmland boundary (23.4%) and others i.e. hillside, riverside and communal lands (19.7%). Different research reports have been revealed that home garden is confirmed as the common planting niches where the farmers need to manage woody species in combination with annual crops and vegetables (Gabiso and Abebe, 2017; Parihaar, et al., 2015; Tefera Jegora, et al., 2019). The implication of tree planting activity of the farmers restricted to home garden and farmland boundary is due to shortage of lands (Mesele Negash, 2007; Paembonan, et al., 2018) and to protect from free grazing (Tafere and Nigussie, 2018).

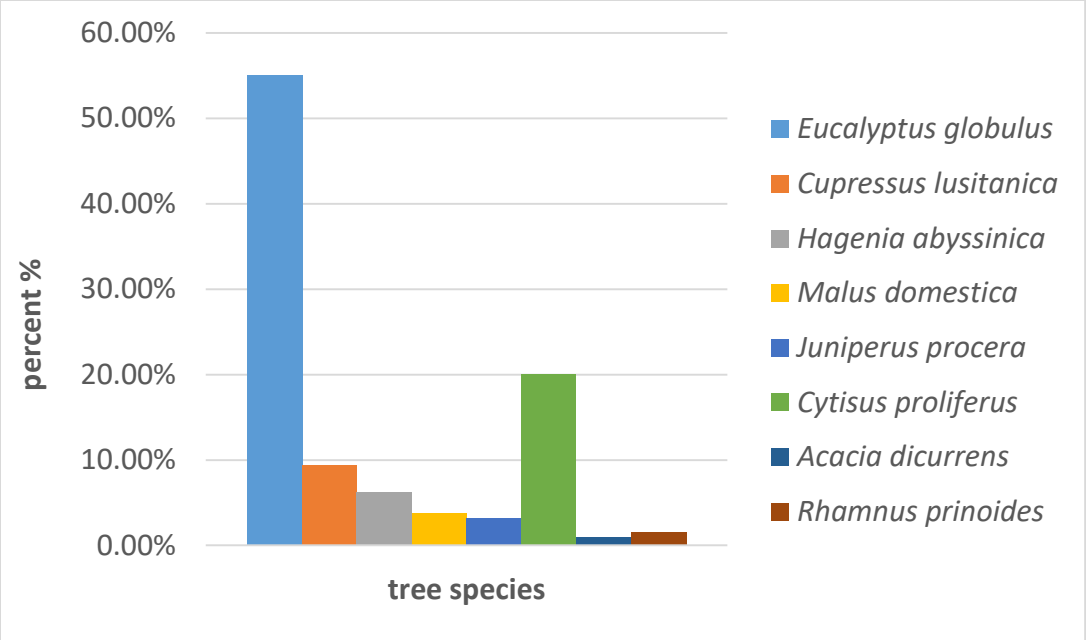

Figure 3. Tree species that commonly planted by farmers

Regarding the source of planting material, respondents explained that they got the planting material 50.8%, 9.2% and 40% of from government owned nursery, from private nursery and produced by themselves respectively (figure 4).

Table 2. The main niche where the farmers grow trees

The main niches of tree planting	Responses	
	N	Percent
Home garden	137	50.9%
Crop field	16	5.9%
Boundary planting	63	23.4%
Other	53	19.7%
Total	269	100.0%

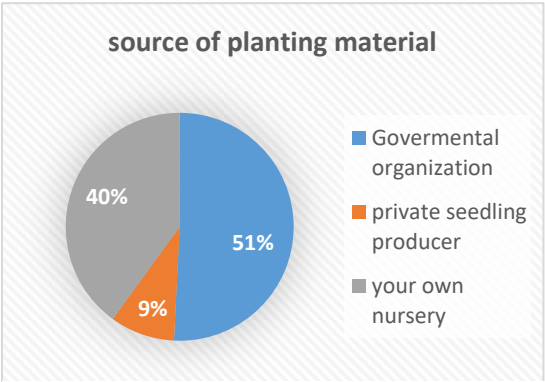

Figure 4. The main source of planting material

3.3 Farmers' preference of tree product and services

As shown from the following table (Table 3), multiple product and uses, fast growth and drought resistance were the most preferred attributes of tree in the study area. Among those tree attributes the tree that have multipurpose uses (43.5%) was the most preferred attributes followed by the tree having fast growth (41.4%) and drought resistant nature (14.0%).

Table 3. Farmers' preference of tree attributes products and services in the study area

Tree product and services	Frequency	Valid Percent (%)
Fuel wood	36	18.3
Fodder	14	7.1
Soil fertility and erosion control	8	4.1
Fruit	2	1.0
Poles for construction	135	68.5
Medicine	1	.5
Others	1	.5
Total	197	100
Attributes of tree	Frequency	Valid Percent (%)
Drought resistant	41	14.0
Fast growing	121	41.4
Easily established	3	1.0
Multiple use	127	43.5
Total	292	99.9

The results also indicated that about 68.5% of the household planted trees for production of poles for construction, 18.3 % for fuel wood production, and 7.1 % for fodder production (Table 3).

3.4 Causes of seedling mortality

All the households had awareness on tree planting activity in their locality. The result indicated that the major causes of seedling mortality in the study area included seasonal frost, drought (moisture stress), free grazing, inappropriate species site matching. About 59.4 % of the respondents indicated that seasonal frost is the major cause of seedling mortality followed by drought (10.7%) and free grazing (8.5 %).

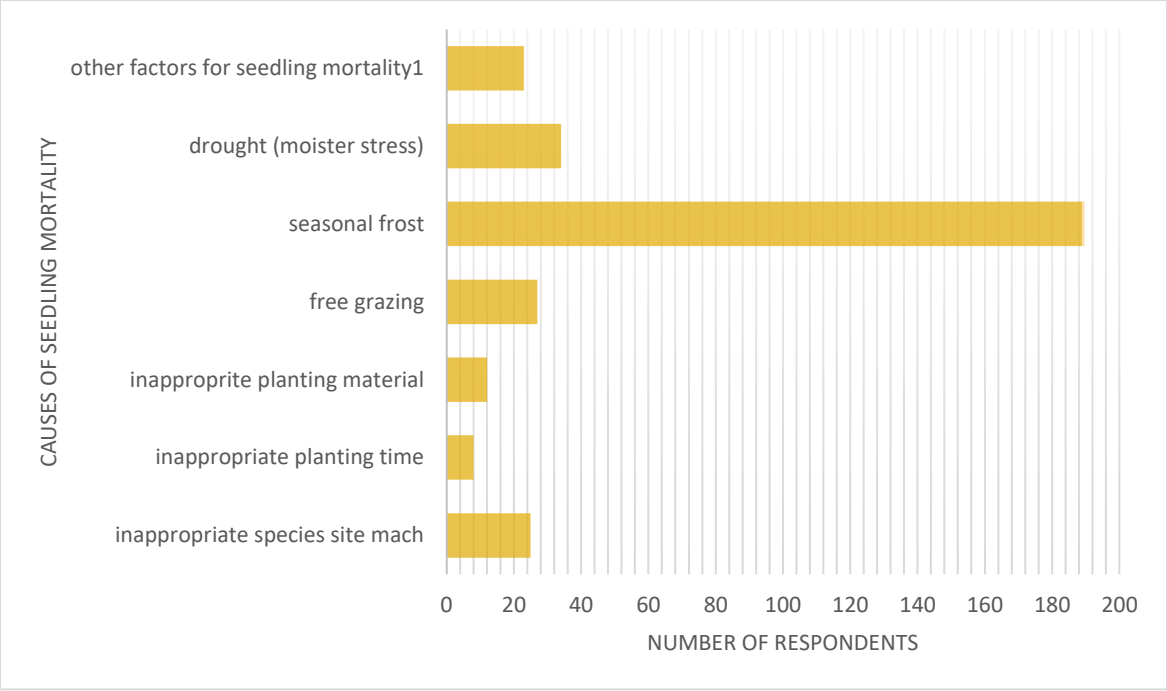

Figure 5. Major cause of seedling mortality in the study area (N, 318)

3.5 Seasonal frost occurrence, impact and its management

The present study indicated that in the study area frost was occurring in bimodal mode. According to 38.5 % of the respondents, frost occurred from October to December and from May to June, but 25.1% of the respondents mentioned that it occurred from September to January and 20.3% mentioned October and November as frost months.

As regards susceptibility of planted seedlings, most (52.4 %) of respondents (Table 4) pointed out that most planted tree seedlings were lost at the first six months after planting (Table 4). This implies that the highest care must be given to the planted seedlings in the first six months.

Table 4. The main stage of planted seedling susceptible to frost (N, 313)

Stage when planted seedlings are most susceptible to frost	Responses	
	N	Percent
In the first six months after planting	164	52.4%
In the first one year after planting	77	24.6%
In the first two years after planting	37	11.8%
In the first three years after planting	33	10.5%
When older than three years of age	2	0.6%
Total	313	100.0%

In addition to seedling stage, there is also susceptibility difference among specific planting sites (Table 5). The result of the study indicated that about 63.7 % respondents believed that tree

seedlings planted on degraded lands were most susceptible to frost damage followed by grazing/grass lands (16.2%) (Table 5).

Table 5. Planting area/sites most susceptible for frost damage

Planting areas most susceptible for frost damage	Responses	
	N	Percent
Around homestead	2	0.8%
Degraded hillside	165	63.7%
Cultivated land	5	1.9%
Grazing/grass land	42	16.2%
Other areas that are susceptible to frost	45	17.4%
Total	259	100.0%

As shown in Figure 7, mulching, stone/wood fence, plant cover and others like hoeing and watering were the major frost management practices of farmers in the study area. About 33.5 % of the respondents indicated that mulching was the most common frost management practice by farmers followed by other practices like hoeing and watering (24.1%) and plant cover (21.5%).

Figure 6. The major common farmers' frost management practices

Regarding planting time, management interventions employed to planted seedlings, and farmers' preference and their recommendation about frost tolerant tree species are presented in the following Figure 6. Most households (54 %) planted tree seedlings at the beginning of rainy season. Whereas, about 36.3% and 8.8 % respondents mentioned that tree planting activity was performed at the mid of rainy season and at the onset of the rainy season, respectively. Furthermore, the result shows that watering/irrigation, manuring and fertilization were the common management intervention for planted seedlings in the area (Figure 8b).

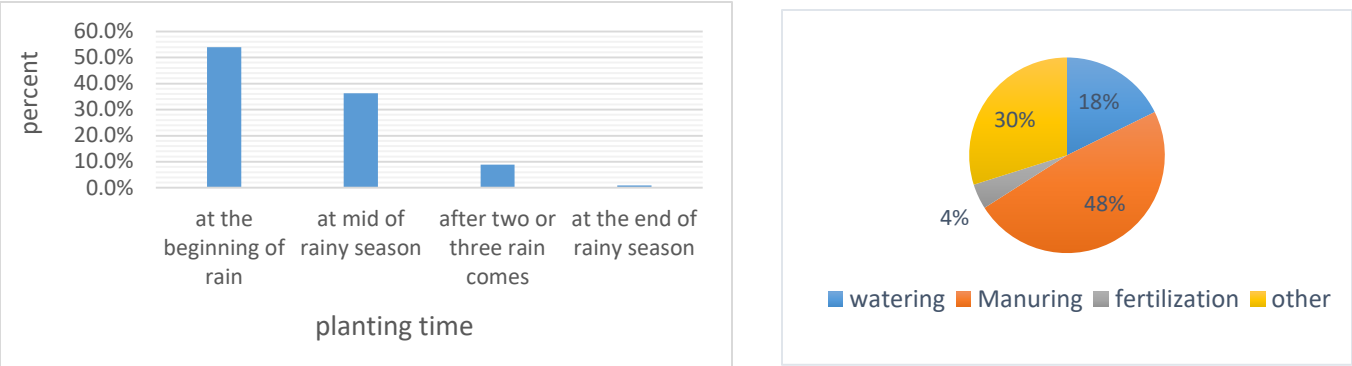

Figure 7. Time of tree planting (a) and the main management intervention (b)

The commonly applied action to enhance survival of planted seedlings was manuring (49.3%) followed by other management activities such as hoeing and weeding (29.9%) and watering (17.7 %). Moreover, the respondents mentioned that the best frost tolerant tree species in their locality were *E. globulus, Cupressus lusitanica and Acacia decurrens* as reflected by 40.3%, 32.8% and 17.9 % of the respondents, respectively (Table 6).

Table 6. Tree species that respondents recommended as frost tolerant species

Tree species recommended as frost tolerance	**Responses**	
	N	**Percent**
Eucalyptus globulus	27	40.3%
Cytisus proliferus	22	32.8%
Acacia decurrens	12	17.9%
Cupressus lusitanica	3	4.5%
Juniperus procera	2	3.0%
Hagenia abyssinica	1	1.5%
Total	67	100.0%

4. Conclusions and implications

The present study investigated farmers' tree needs and traditional seasonal frost management practices on 202 households in frost affected degraded highlands of Northeastern Ethiopia. We have identified that frost is the major cause of seedling mortality in the study areas and it affects more seedlings that are less than one year old, and its damage is severe on degraded lands. Hoeing and watering together, plant cover and stone/brush wood fence are among farmers' practice to protect seedling from frost. Besides, planting niches, tree species, and size and quality of planting material are possible determinants of frost damage in frost prone areas. It has an implications that the success of forest development and restoration of degraded land in general and tree planting activity in particular entails attentions to site selection and planting time. Although frost is frequently affect planted seedling under the age of one year, very importantly

intensive follow up of seedling at early stage is required. Moreover, optimization and up scaling of farmers' management practices in line with examination, introduction and adoptions of new management practices are very crucial.

5. References

Badege B (2001). Deforestation and land degradation in the Ethiopian highlands: A strategy for physical recovery. North east African Studies 8(1):7-26.

Beniston M. (2003). Climatic change in mountain regions: a review of possible impacts. Climate change 59: 5-31

Eshetu yerdaw, Mulualem Tigabu, Mulugeta Lemenih, Mesele Negash, and Demel Teketay, 2014, Rehabilitation of degraded forest and woodland ecosystems in Ethiopia for sustenance of livelihoods and ecosystem services. In: Katila, P.; Galloway, G.; de Jong, W.; Pacheco, P (Eds), Forests under Pressure: Local Responses to Global Issues, pp.

Gabiso G, Abebe T (2017) The Niche of Tree and Crop in Traditional Home garden Agro forestry system. In Case of Agro-biodiversity Conservation atFarm Level in Boricha and Wondo Genet, Sidama, SNNPRs Ethiopia'. J Biodivers Manage Forestry 6:4.

Getahun A. 2002. Eucalyptus farming in Ethiopia: the case for eucalyptus woodlots in the Amhara region. Ethiopian Society of Soil Science, 137-153.

Girma T (2001). Land Degradation: A Challenge to Ethiopia. International Livestock Research Institute, Addis Ababa, Ethiopia. Pp 815-823.

Hurni H, Solomon A, Amare B, Berhanu D, Ludi E, Portner B, Birru Y and Gete Z (2010). Land degradation and sustainable land management in the highlands of Ethiopia. In Hurni H, Wiesmann U (ed) with an international group of co-editors. Global change and sustainable development: A synthesis of regional experiences from research partnerships. GeoraphicaBernensia. 5:187-201

Janger P. and Pender J. 2003. The role of trees for sustainable Management of less favoured lands: the case of Eucalyptus in Ethiopia. Forest Policy economics, 5:83-95.

Janska, A., P. Mars, J. S. Zelenkova, and J. Ovesna . (2010). Cold stress and acclimation – what is important for metabolic adjustment? Plant Biology 12, pp 395–405

Kebebew Z. and Ayele G. 2010. Profitability and household income contribution of growing Eucalyptus globules (Labill.) to smallholder farmers: the case of central Highland of Oromia, Ethiopia. Eupean Journal of Applied science 2(1): 25-29.

Kidanu S. 2004. Nutrien Removal and Crop Productivity in Eucalyptus globules based rotational agro-forestry system on seasonally water logged highland vertisol of Ethiopia.

Mesele negash (2007). Trees management and livelihoods in Gedeo's agroforests, Ethiopia, forests, trees and livelihoods, 17:2, 157-168,

Mulugeta Limeneh and Hailemariam Kasa, (2014), Re-Greening Ethiopia: History, Challenges and Lessons, Forests 5:1887-1909

Paembonan, SA. Millang S., Dassir, M., and Ridwan, M. 2018. Species variation in homegarden agroforestry system in South Sulawesi, Indonesia and its contribution to farmers' income,
Earth and Environmental Science **157:** 012004 doi:10.1088/1755-1315/157/1/012004

Parihaar, RS., Bargali, K., and Bargali, SS. 2015. Status of an indigenous agroforestry system: A case study in Kumaun Himalaya, India, Indian Journal of Agricultural Sciences **85** (3): 442–7

Paulos D (2001). Soil and water resources and degradation factors affecting their productivity in the Ethiopian highland agro-ecosystems. Michigan State University Press. 8(1): 1-18

Pohjonen V and Pukkala T. 1990. Eucalyptus globulus in Ethiopia foretry. Forest ecology and Management 36: 19-31.

Solomon Mulu Tafere & Zebene Asfaw Nigussie. 2018. The adoption of introduced agroforestry innovations: determinants of a high adoption rate – a case-study from Ethiopia, Forests, Trees and Livelihoods, DOI: 10.1080/14728028.2018.1493954

Tefera Jagora, Zebene Asfaw and Agena Anjulo. 2019. Woody Species Diversity and Management in Home garden Agroforestry: The Case of Shashemene District, Ethiopia. Hindawi-International Journal of Forestry Research Volume 2019, https://doi.org/10.1155/2019/3697047

Teketay D. 2001. Deforestation, wood famine, and environmental degradation in Ethiopia's highland ecosystems: urgent need for action. NorthEastAfr Stud. 8:53–76.

Tesfaye Teklu, (2014), Environmental stress and increased vulnerability Impoverishment in rural Ethiopia: case studies evidence, International journal of African development 1:2

UNEP (2008), "Africa: Atlas of Our Changing Environment." Division of Early Warning and Assessment (DEWA) United Nations Environment Programme (UNEP), Nairobi, Kenya

William K Ferril1. (1953). Effect of Environmental Conditions on Survival and Growth of Forest Tree Seedlings under Field Conditions in the Piedmont Region of North Carolina. Ecology, Vol. 34(4), pp. 667-688

Zhou, G., N. Minakawa, A.K. Githeko, and G. Yan (2004), Association between climate variability and malaria epidemics in the East African highlands. PNAS 101(8): 2375–2380