Sustainability Science and Resources, Vol. 8:1, 2025, pp. 1 - 14

Integrating Traditional Ecological Knowledge and Frost Management Strategies for Sustainable Tree Planting in Legambo District, Ethiopia

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Received: 1 November 2025 Accepted: 3 June 2025 Published: 5 June 2025

Abstract

This study examines traditional ecological knowledge and tree planting practices in Legambo District, Ethiopia, focusing on local farmers' preferred tree species and their frost management techniques. With only two percent forest cover and significant frost affecting seedling survival, understanding these practices is vital for sustainable land management. Using a multistage sampling method, data were gathered from 42 households through interviews, questionnaires, and observations. The findings indicate that Eucalyptus globulus is the most favored tree species, accounting for 52% of planted trees, primarily in woodlots. The research underscores the serious impact of frost on young seedlings, especially on degraded hillsides, where farmers report high mortality rates. Additionally, various traditional frost management strategies were identified, such as mulching, building protective barriers, and careful watering. These practices reflect a deep understanding of local ecological conditions and highlight the need to combine traditional knowledge with modern forestry techniques. The study's implications extend beyond Legambo, contributing to broader discussions on sustainable land management in frost-affected areas of Ethiopia. It emphasizes the critical relationship between ecological factors and local agricultural methods, illustrating how farmers address environmental challenges. By investigating tree species selection and frost resilience, the research calls for adaptive management strategies suited to the region's needs. To improve tree survival and rehabilitate degraded areas, the study offers key recommendations, including regular monitoring of seedlings under one year, targeted training for farmers on frost management, and fostering community engagement to share

successful practices. Ensuring access to quality planting materials is also essential. By encouraging collaboration among local communities, policymakers, and forestry practitioners, the study aims to bolster sustainable forestry efforts aligned with the region's ecological and socio-economic contexts.

Keywords: Traditional Ecological Knowledge, Frost Resilience, Tree Species Preference, Sustainable Forestry, Land Restoration, Community Engagement

Introduction

Traditional ecological knowledge, accumulated over many generations, is pivotal for the sustainable management of natural resources. In Ethiopia, a country with a varied topography of highlands and lowlands, environmental degradation is particularly severe. The highlands have suffered significant ecological damage due to deforestation, unsustainable farming practices, and soil erosion, resulting in a substantial reduction in natural forest cover (Tessema *et al.*, 2020; Dalle *et al.*, 2022).

To combat these environmental issues, Ethiopia began large-scale monoculture tree plantations in the mid-20th century, using both native and exotic species such as *Cupressus lusitanica*, *Eucalyptus globulus*, and *Juniperus procera* (Woldemariam *et al.*, 2021). These plantations, established primarily on lands that had been deforested, now cover approximately 800,000 hectares, a stark contrast to the remaining 2,720 hectares of natural forest (FAO, 2022). Reforestation and afforestation efforts, along with agroforestry practices like boundary planting and the use of scattered trees within agricultural fields, have been introduced. However, the success of these initiatives is often limited, especially in highland areas above 3,200 meters, where frost stress presents a significant obstacle (Haregeweyn *et al.*, 2021; Amare *et al.*, 2023).

The Legambo district in the Amhara region is a case in point, with only two percent forest cover and an uneven distribution of eucalyptus and indigenous trees among local farmers (Abebe *et al.*, 2022). Traditional methods for managing frost—such as protective coverings, regular irrigation, mulching, and strategic planting—reflect both adaptive strategies and existing shortcomings (Kebede *et al.*, 2022; Teferi *et al.*, 2024). This situation highlights the urgent need to enhance our understanding of tree planting practices and frost management strategies in this region.

Despite the important role of trees in maintaining ecological balance, supporting social structures, and contributing to economic development, the expansion of plantation forests has not fully met local needs. Recent studies indicate that *Eucalyptus* and *Cupressus* species dominate plantation areas, covering 58% and 29% respectively, while *Juniperus procera* and *Pinus* species are less common (FAO, 2023; Mulugeta *et al.*, 2023). The limited scope of community-led plantation projects further emphasizes the need for a detailed understanding of local tree planting preferences and related challenges.

This study aims to address the knowledge gap concerning farmers' preferences for tree species and their traditional methods for managing frost in Legambo District. By evaluating current tree planting practices, identifying influencing factors, and examining traditional frost management techniques, this research seeks to refine tree planting strategies and support sustainable land management practices in the region.

Understanding these practices is vital for several reasons. First, it can help tailor tree planting strategies to better meet the needs of local communities who depend on forest products for fuelwood and charcoal (Gebrekidan *et al.*, 2023). Second, it can enhance the effectiveness of reforestation and afforestation projects by addressing specific challenges such as frost stress in highland areas. Lastly, this knowledge can contribute to broader efforts aimed at land restoration,

improving ecological resilience, and supporting sustainable land management across Ethiopia (Alemayehu *et al.*, 2023; Kidane *et al.*, 2024).

The findings from this study are expected to offer valuable insights for policymakers, forestry practitioners, and local communities. By integrating traditional knowledge with modern forest management practices, the research aims to promote more effective and sustainable approaches to tree planting and forest conservation in Ethiopia.

Material and Methods

Description of the study area

The study was conducted in Legambo District, located in the South Wollo Zone of the Amhara Region, Ethiopia. This district is bordered by Legahida and Kelala to the south, Wegde to the southwest, Borena to the west, Sayint to the northwest, Tenta to the north, Dessie Zuria to the northeast, and Were Ilu to the southeast. The administrative center of the district is the town of Akesta. The elevation in Legambo District ranges from 1,500 to 3,700 meters above sea level.

Population

According to the 2007 national census by the Central Statistical Agency of Ethiopia (CSA), Legambo District has a total population of 165,026, reflecting a 3.93% increase from the 1994 census. The population comprises 81,268 men and 83,758 women, with 7,327 individuals (4.44%) residing in urban areas. Covering an area of 1,017.35 square kilometers, Legambo District has a population density of 162.21 persons per square kilometer, surpassing the average for the zone, which is 147.58 persons per square kilometer. The district is home to 39,078 households, with an average household size of 4.22 persons and 37,384 housing units. The

predominant religion in the district is Islam, with 93.34% of the population identifying as Muslim, while 6.5% practice Ethiopian Orthodox Christianity.

Economic activities and livelihood

The economy of Legambo District is predominantly agricultural, with the majority of the population engaged in farming. The service sector also plays a significant role, contributing notably to the local economy. This sector includes various micro and small enterprises, such as hotels, service providers, and cooperatives, which are essential to the district's economic structure.

Sampling techniques

A multistage sampling technique was employed to select the study participants. First, Legambo District was chosen due to its relevance to the study. Second, kebeles (sub-districts) within the district were purposively selected. Third, three kebele administration offices were chosen from the selected kebeles. Finally, a total of 42 respondents were selected from these households using the Yamane formula for sample size determination.

Data collection methods

Data were collected from both primary and secondary sources. Primary data were gathered through household interviews, questionnaires, and direct observations in the study area. Secondary data were obtained from written documents provided by the woreda agricultural office, government reports, and online sources.

Data analysis

Data were analyzed using descriptive statistics and MS Excel 2010. The results were presented using various descriptive statistical tools, including averages, ratios, percentages, frequency tables, and graphical representations such as figures, graphs, pie charts, and bar charts.

Results and Discussions

Farm tree establishment and management

All surveyed households actively planted and managed a variety of tree species for multiple purposes, adapting to different ecological niches. Respondents highlighted **Eucalyptus globulus**, **Cupressus lusitanica**, **Hagenia abyssinica**, apple trees, **Juniperus procera**, and **Cytisus proliferus** (tree lucerne) as the primary species cultivated for uses such as boundary planting, woodlots, and around homes. The diversity of uses reported aligns with findings from various studies across Ethiopia, suggesting a shared understanding of on-farm woody species among rural communities (Mohammed, 2015; Jimoh, 2019; Kibru et al., 2020).

Table 1: Household Characteristics in the Study Area

Characteristic	N	Min	Max	Average
Age of house hold	42	18	55	37
Family size	42	1	10	6
Land size (hectares)	42	0	3	1.5
No. live stock	42	0	50	25

This data emphasizes the diverse agricultural practices and socio-economic conditions of the households in the study area, which can influence tree management strategies. Further

research could delve into the specific factors that impact tree species selection and management approaches among these communities.

Farmers' tree preference and niches

The study revealed that **Eucalyptus globulus** is the most preferred tree species, making up about 52% of the planted trees, followed by **Cytisus proliferus**, **Cupressus lusitanica**, **Hagenia abyssinica**, and **Juniperus procera**. This preference mirrors findings from other regions in Ethiopia (Sinclair et al., 2020).

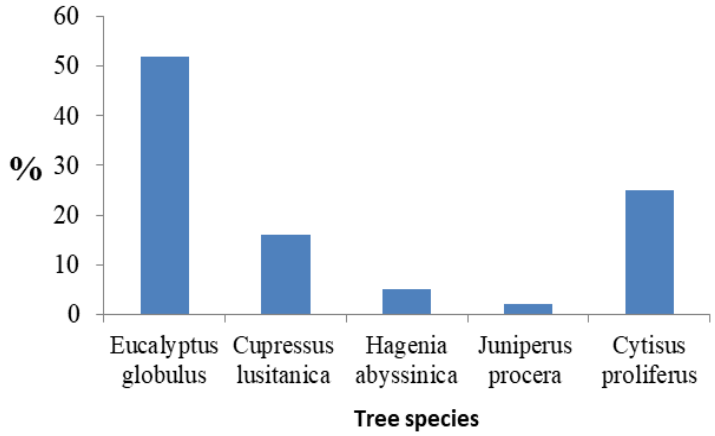

Figure 1: Tree Species Planted in the Study Area

The primary niches for tree planting identified were woodlots (57.14%), home gardens (14.29%), cropland (14.29%), and boundaries (11.9%). Consistent with previous research, woodlots are recognized as a common planting niche where farmers manage woody species effectively (Tesfaye et al., 2021).

Table 2: Main Niches Where Farmers Grow Trees

Main niche of tree planting	Response	
	N	Percentage
Homegarden	6	14.29
Wood lot	24	57.14
Crop land	6	14.29
Boundary planting	5	11.9
Other	1	2.38
Total	**42**	**100**

Table 3: Farmers' Preference of Tree Attributes, Products, and Services

Tree product and service	Frequency	Percentage
Firewood	12	28.57
fodder	6	14.29
Pole for construction	18	42.86
Medicine	1	2.38
Fruit	1	2.38
Environmental conservation	4	9.52
Total	**42**	**100**

Sources of seedlings and management

Respondents reported sourcing planting materials primarily from owned nurseries (65%), followed by government nurseries (34%) and private sources or self-production (1%) (Figure 3).

This indicates that while farmers utilize their own resources, government nurseries remain a critical source elsewhere in Ethiopia.

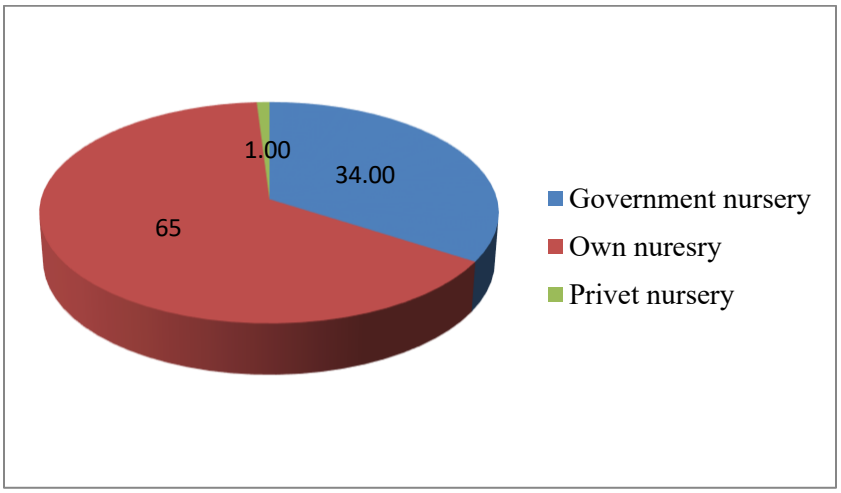

Figure 2: Source of Tree Seedlings

Causes of tree seedling mortality

The study identified woodlots (57.14%) as the most preferred niches for tree planting, followed by farmland boundaries (23.4%) and other areas. Research has consistently shown woodlots to be common planting niches for farmers managing woody species. In line with this, Bekele (2018) noted that homesteads are frequently preferred for tree planting among smallholder farmers (Haile, 2022). A significant concern raised by respondents was that various tree seedlings in the area are particularly susceptible to frost.

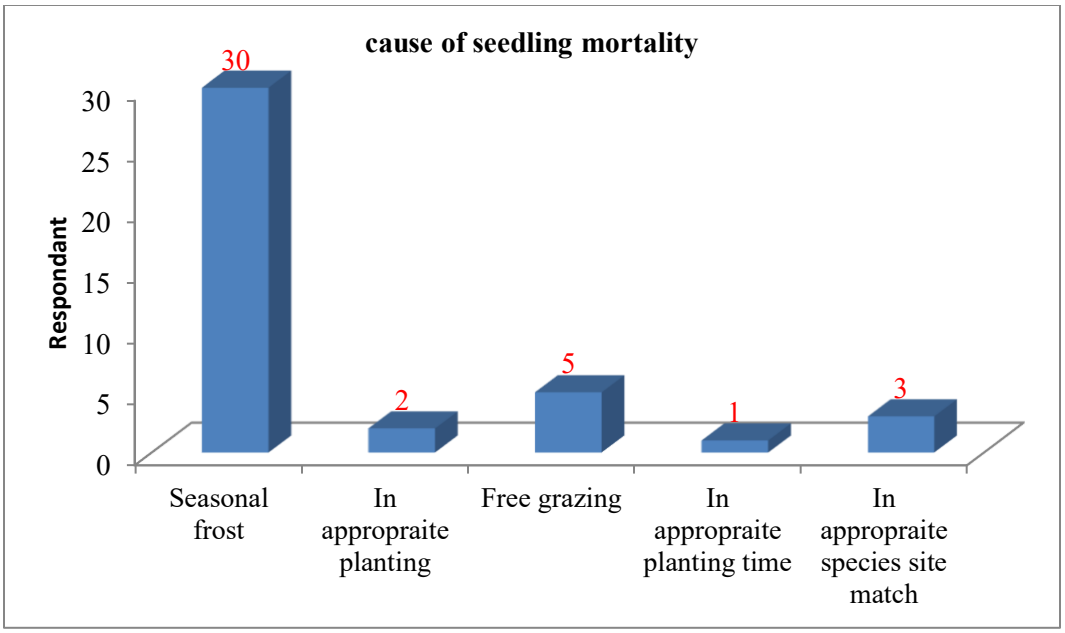

Figure 3: Causes of Tree Seedling Mortality

Seasonal frost and its management

The findings revealed that the most frost-susceptible planting areas included degraded hillsides (57.14%) and regions around homesteads and cultivated lands (14.29%). This is corroborated by Tesfaye et al. (2021), who emphasized that frost impacts all stages of plant growth, with seedlings being the most affected.

Table 4: Tree Planting Niches Susceptible to Frost Damage

Planting area most susceptible for frost damage	Response	
	N	Percentage
Around homestead	6	14.29
Degraded hillside	24	57.14
Cultivated land	6	14.29
Grazing land	5	11.9
Other	1	2.38
Total	**42**	**100**

Traditional practices for protecting trees from frost

As illustrated in Figure 4, farmers in the study area employ various frost management practices, including mulching, building stone/wood fences, and using plant cover. Approximately 47% of respondents identified cover as the most common practice, followed by hoeing and watering (24.1%) and plant cover (21.5%). This is consistent with findings from Tesfaye et al. (2021), which indicate that passive protection methods—such as soil and plant cover, along with managing cold air drainage—are typically implemented before frost events.

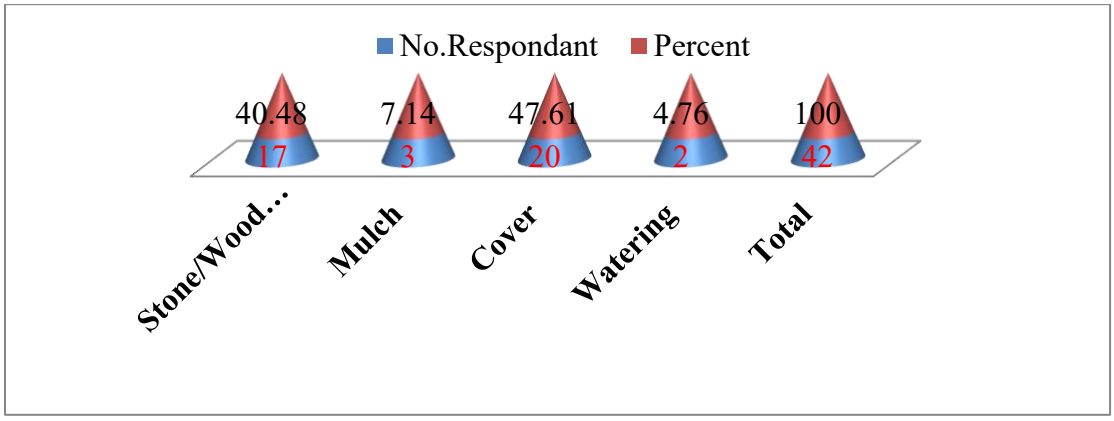

Figure 4: Traditional Practices of Farmers to Prevent Frost Damage on Trees

Conclusion and Recommendations

This study examined farmers' tree preferences and traditional frost management strategies among 42 households in the frost-affected, degraded highlands of South Wollo, Ethiopia. Our findings highlight that frost significantly threatens seedling survival, particularly impacting those younger than one year, with an especially severe effect observed on degraded lands. Farmers employ various protective measures, such as hoeing, watering, using plant cover, and constructing stone or brushwood fences, to mitigate frost damage. These practices are crucial

in maintaining soil temperature and moisture levels while providing physical barriers against harsh conditions.

Key factors influencing frost damage include the selection of planting niches, the choice of tree species, and the size and quality of planting materials. These insights underscore the necessity for tailored agricultural practices that enhance seedling resilience in challenging environments.

To effectively address the challenges posed by frost, we propose several recommendations:

1. **Enhanced Monitoring**: Establish a structured monitoring program for seedlings, particularly those under one year of age. Regular assessments will help identify early signs of frost damage, enabling timely interventions to reduce losses and improve seedling survival rates.
2. **Training Programs**: Develop comprehensive training initiatives focused on effective frost management techniques. These programs should emphasize the importance of selecting appropriate planting niches and resilient tree species, equipping farmers with the knowledge and skills necessary to navigate frost-related challenges.
3. **Resource Accessibility**: Ensure access to high-quality planting materials, such as improved seed varieties sourced from reliable suppliers. This accessibility will empower farmers to make informed planting decisions, bolstering the resilience of their seedlings against frost.
4. **Community Engagement**: Facilitate community forums to encourage the sharing of successful traditional practices and innovative frost management strategies. Engaging local knowledge and experiences can lead to more effective and culturally relevant solutions, strengthening community bonds in the process.

5. **Research and Development**: Promote ongoing research into the effects of climate variations on tree species in frost-prone areas. This research should explore innovative management practices that enhance frost resilience, allowing for better adaptation to changing climate conditions.
6. **Policy Support**: Advocate for policies that support the rehabilitation of degraded lands and promote sustainable tree planting practices in frost-prone areas. Policymakers should prioritize initiatives that balance environmental sustainability with community needs, ensuring long-term benefits for the region.

By implementing these recommendations, stakeholders can significantly improve tree survival rates and contribute to the successful restoration of degraded landscapes in South Wollo and similar regions. Through collaborative efforts and targeted strategies, we can enhance resilience against frost and promote sustainable agricultural practices, ultimately fostering a more sustainable and productive environment for local communities.

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