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Selecting Adaptive Tree and Shrub Species for Rehabilitating Degraded Drylands in Northeastern Ethiopia

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Agro-ecology; Adaptive capacity; Degraded Lands; Rehabilitation; Survival rate

Abstract

Climate change threatens forests and ecosystems. Introducing adaptable trees and shrubs can mitigate impacts. This study aimed to assess and evaluate different native and exotic species for rehabilitating degraded, moisture-stressed areas in Northeastern Ethiopia. Data were collected quarterly over four years to investigate the rehabilitation and moisture stress conditions in the study areas. The results of the study showed that the root collar diameter, height, DBH, and survival rates were measured to evaluate species suitability for restoration. There were significant differences between the species in terms of height, root collar diameter, and survival. In the low-altitude at $P<0.05$ level. Acacia saligna and Leucaena glabrata recorded the highest heights and root collar diameters, respectively, while L. glabrata (95.5%), Dodonea angustifolia (91.6%), and Ziziphus spina christii (75%) showed the highest survival rates. Cordia Africana (85.4%) and A. saligna (73.1%) had the highest mid-altitude survival rates. Top-performing species in diameter and height growth showed higher survival rates. Poor performers included C. equisetifolia, J. curcas, and S. sesban (low altitude) and H. abyssinica and O. africana (high altitude). The study found no significant differences in performance between native and exotic species. Instead, the adaptive capacity of the species varied based on drought tolerance during dry seasons. Species with the highest growth and survival metrics in each agroecology are recommended for the study areas and similar regions. Sustainable forest restoration requires continuous selection of resilient trees and shrubs.

1 Introduction

The world's forests are attracting international attention due to various environmental issues, including the serious effects of climate change, which threaten many lives and resources (Reynolds et al., 2007; White et al., 2019). According to the FAO (2005a) and Rashid (2004), the world's forests cover approximately 3.9 billion hectares, or 29.8% of the Earth's land surface. Out of this total, about 1,751 million hectares, or 44.9%, are found in developed countries, while 2,149 million hectares, or 55.1%, are in developing countries. Roughly 95% of these forests are natural, while 5% are plantation forests. Forest resources are continuously declining due to various natural and human-made reasons, and they are currently facing rapid degradation (UNEP, 2018).

Widespread deforestation in tropical regions has led to large areas of degraded vegetation, which support significantly reduced biodiversity. For instance, since 2000, millions of hectares of forest have been cleared each year worldwide, with most of the deforestation occurring in the tropics (FAO, 2015). Tropical deforestation is often followed by converting forestlands to agricultural uses, mainly to replace land that has lost productivity due to poor farming practices (Harwood, 1993). These degraded lands are often abandoned

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as wastelands that could potentially regenerate to forests. However, in areas affected by intense human activities, the natural processes of recovery are often very slow due to soil degradation, repeated disturbances, and isolation from intact forests.

Many studies show that establishing tree plantations on degraded lands can help overcome physical and biological barriers to forest recovery and support the regrowth of native forest communities (Lugo, 1997; Parrotta et al., 1997). Most reforestation projects aim to restore the forest's productivity for future timber products, but combining short-term economic goals with long-term conservation of biodiversity is becoming increasingly important (FAO, 2001; Lamb, 1998; Lugo, 1997). Because of a lack of detailed knowledge about native tree species, only a few exotic timber species, like Acacia, Eucalyptus, and Pinus, along with a few others like Gmelina arborea, continue to be favored in reforestation projects for their ability to grow quickly on degraded lands (FAO, 2001).

Seasonal changes in rainfall distribution are also key ecological factors in tropical dry forests. Generally, just two to three dry months can change the composition and structure of the forest ecosystem (Murphy & Lugo, 1986). For example, significant forest destruction occurred on Mount Badda in the Arsi region of Ethiopia around 1850 BP, suggesting widespread deforestation in the Afromontane forests. Dodonaea is among the species showing increasing pollen quantities, thought to be linked to human disruptions of the vegetation (Bonnefille & Hamilton, 1986). In addition to deforestation for fuel and building materials, the start of agricultural activities has greatly impacted the natural vegetation of the Ethiopian highlands, particularly in Wollo, over thousands of years (e.g., Hurni, 1986, Egziabher, 1988, Tadesse, 1991, Teketay, 1996). Recently, there has been a sharp decline in forest cover, indicating that forest resources in the country are quickly disappearing (Aklog, 1990).

Therefore, integrated conservation, rehabilitation, and community-based management of natural resources are crucial not just for maintaining local biodiversity and livelihoods, but also for protecting downstream ecosystems and communities (German et al., 2006). In Ethiopia, forest rehabilitation through the introduction of enrichment planting is commonly practiced to regenerate degraded forest lands. However, there is a limited information regarding the alternative and best adaptable trees and shrub species for the various types of agro-ecological zones of the South-eastern Ethiopia particularly the Eastern Amhara Region degraded landscapes. It is crucial to provide an agro-ecological and site specific adaptable tree species to support the ambigious rehabilitation objectives of the region and the country, Ethiopia, general. Before any tree species can be introduced to a specific agro-ecology, well-conducted field surveys and trials are necessary to match the species or provenance to the site (Abebe et al., 2000; Mebrate et al., 2004; Zobel & Talbert, 1984). Therefore it is essential to conduct an experiment to evaluate the survival rates, and growth parameters of different tree and shrub species to recommend for these types of degraded landscapes. The primary objective of this study is to select the best-performing tree and shrub species for rehabilitating degraded forest land across three agro-ecological zones (low, mid, and high-altitude) in Eastern Amhara, North Eastern Ethiopia.

2 Material and Methods

2.1 Study sites Description

The study was conducted in three purposively selected drought prone areas of Eastern Amhara Region of the North Eastern Ethiopia from 2020 to 2023. Three agro-ecological zones (AEZ) were selected and one site were selected from each AEZ. The mid-altitudinal agro-ecological zone (AEZ) chosen for studying the selection of tree and shrub species for the restoration of degraded lands was the Chorisa study site, South Wollo Zone, Amhara Region. Every year, it receives roughly 800 mm of rainfall. The soil is deep and black, and the slope is mild. The Borkena River, which flows through the valley and into the Afar region, is roughly 15 kilometers away.

Keyou Gariya in Kobo District was the location of the tree planting (testing) site in the low-altitude, severely moisture-stressed areas of the North Wollo Administrative Zone. The elevation is 1450 meters above sea level, and the annual precipitation is 692.8 mm (1973-2000 average, SARC 2010). The average high and low temperatures in the region are 30°C and 22°C, respectively. Eutric fluvisols is the type of soil. Were-illu-Woreda, also known as Segno-Gabeya, is home to the tree planting (testing) locations in the south Wollo Administrative Zone's high-altitude, severely moisture-stressed woreda. Based on an estimate from the local weather station. According to meteorological data from 1973 to 2000, Were-illuWoreda experiences 998.4 mm of rainfall annually, with mean maximum and mean minimum temperatures of 26.19°C and 13.43°C, respectively.

2.2 Planting of experimental trees and data collection

Seedlings of the selected species were initially raised at Sirinka Agricultural Research Center's nursery in 2019/2020 and later planted across three agro-ecological zones using site-specific field establishment techniques. Site-appropriate water-harvesting structures were implemented. The experiment followed a randomized complete block design with three replications, using 2m × 2m spacing between seedlings, 3m between blocks, and 2m between plots.

Number of seedling: Sixteen seedlings per species per plot were planted (Table 1). While standard species adaptation trials recommend 25–100 seedlings per species (Franzel et al., 1996; Zobel & Talbert, 1984), this study used 16 seedlings per species per plot across three replications, resulting in 48 seedlings per species per agro-ecological zone. This sample size aligns with similar adaptation studies in resource-limited dryland regions (Mebrate et al., 2004; Tilahun et al., 2006) and provides statistically valid results for screening species under field conditions, as supported by the significant differences detected in growth and survival parameters. The main reason for reducing the number of seedlings was the undulating terrain across the experimental sites, which prevented us from placing more than this limit. Additionally, to minimize external factors such as slope, soil vertical profiles, and moisture variation, we decided to use 16 seedlings per plot with three replications. This resulted in a total of 48 seedlings per species at each experimental site.

Data collection frequency: The data were collected quarterly (every three months) over four years. This allowed continuous monitoring of growth and survival trends across seasons and years. The final year's data were used to assess long-term adaptability (survival rates) and growth performance (height, DBH), consistent with similar long-term species trials (Lamb, 1998; Parrotta & Knowles, 1997). Seedlings were arranged in a staggered pattern within water-harvesting structures. Statistical analysis was performed using R-software (v4.3.10), with treatment comparisons evaluated via ANOVA.

Table 1: Tree and shrub species used for the experimentation for different agroecology

Tree/shrubs selected at the low-altitude AEZ	Tree/shrubs selected at the mid-Altitude AEZ	Tree/shrubs selected at the high-altitude AEZ
Ziziphus mouritania, Leucaenea glabirata, Dodonaea angusstifolia, and Acacia saligna	Acacia saligna, Gravilia robusta, Olea europaea, and Cordia africana	Acacia saligna, Acacia melanoxilon, Chamaecytisus paleminensis, Dodonaea angusstifolia, Acacia abyssinica, and Acacia decurrence

N.B: Seeds where purchased from Ethiopian Environment and Forestry Research Institute.

3 Results

3.1 Growth and survival rates of selected species at low-altitude agro-ecologies

Seven tree/shrub species were tested for rehabilitating degraded lands in the low-altitude agro-ecology of Kobo (Keyu-Gariya) (Table 1). After 48 months, significant differences ($P < 0.05$) were observed among species in root collar diameter, height, and survival rate (Table 2). L. glabrata, D. angustifolia, and Z. mauritiana showed the highest survival rates (95.5%, 91.6%, and 75%, respectively). Maximum height and root collar diameter were recorded in the plots of A. saligna and L. glabrata. Species with superior growth in height and diameter generally exhibited higher survival rates except A. saligna, which underperformed in survival despite its acceptable growth. In contrast, C. equisetifolia, J. curcas, and S. sesban had the poorest performance, with zero survival and minimal growth across all measured parameters (Fig. 1).

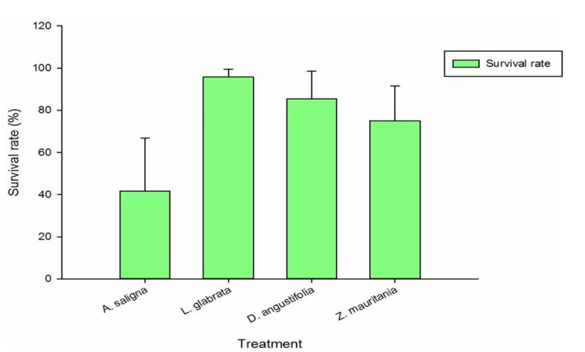

Figure 1: Survival rates of tree/shrub species tasted in the low-altitude agro-ecologies of Kobo- Keyu Garya research sites

Table 2: Growth performance of different tree species at the age of 39 months (Kobo Woreda)

Species	Root collar diameter (cm)	Height (cm)
L.glabrata	3.8a	168.42a
A.saligna	3.5a	199.7a
D.angusstifolia	2.8b	160.5ba
Z.mouritania	0.8b	47.67bc
LSD (0.05)	*	*
CV (%)	13.88	8.78

3.2 Growth and survival rates of the selected species at mid-altitude agro-ecologies

Similar to the low-altitude study sites, seven tree species were evaluated in this study. After 48 months, significant differences ($P < 0.05$) were observed among species in root collar diameter, height, and survival rate. C. africana and A. saligna exhibited the highest survival rates (85.4% and 73.1%, respectively; Table 3).

While most top-performing species in growth also had high survival rates, O. africana was an exception, declining below 50%. The poorest performers, A. decurrens, A. abyssinica, and C. equisetifolia, had minimal growth (near-zero values) and survival rates of 8.3%, 6.3%, and 4.2%, respectively (Fig. 2).

Table 3: Growth performance of different tree species at the age of 48 months (Kalu Woreda)

Species	Root collar diameter (cm)	Height (m)
A.saligna	7a	231.2a
C.africana	0.3b	53.58b
O.africana	1c	34.67cb
G.robusta	0.1dc	17.67cb
LSD (0.05)	*	*
CV (%)	12.89	18.5

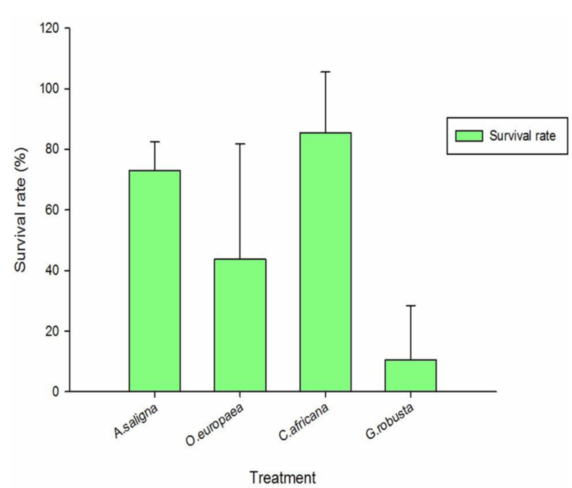

Figure 2: Survival rates of tree/shrub species tasted in the mid-altitude agro-ecologies

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3.3 Growth and survival rates of selected species at High-altitude agro-ecologies

After 51 months of growth, significant differences ($P < 0.05$) were observed among species for root collar diameter, height, and survival rate. A. saligna demonstrated superior performance with the largest root collar diameter (4.6 cm) and greatest height. Root collar measurements for A. decurrens, A. abyssinica, and D. angustifolia measured 2.5 cm, 2.22 cm, and 1.64 cm, respectively (Table 4).

Table 4: Growth performance of different tree species at the age of 39 months (Wereilu woreda)

Species	Root collar diameter (cm)	Height (cm)
A.saligna	4.6a	177.33a
A.decurrens	2.5ba	149ba
A.abyssinica	2.22ba	96.5ba
D.angusstifolia	1.64b	80.33ba
C.paleminensis	0.9b	33.33ba
A.melanoxilon	0.8b	44.17ba
LSD (0.05)	*	*
CV (%)	51.81	30.41

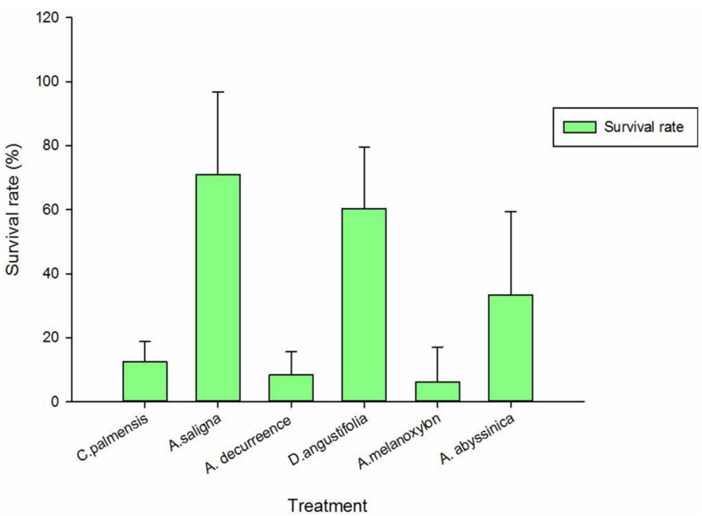

Figure 3: Survival rates of tree/shrub species tasted in the high-altitude agro-ecologi

4 Discussions

The quarterly data collection over four years allowed for tracking seasonal and annual variations in growth and survival, addressing the reviewer's concern regarding one-time data. This approach aligns with long-term species adaptation studies in drylands (Lamb, 1998; Parrotta & Knowles, 1997). The results indicate that species such as D. angustifolia and A. saligna exhibited consistent performance across multiple agro-ecological zones, demonstrating their drought tolerance and adaptability to moisture-stressed conditions. The current study on the survival rates of seedling are aligning with findings by Chibssa et al. (2006) with exceptional contrasting with G. robusta, which showed lower survival. A. saligna and C. africana also achieved the greatest height and root collar diameter in the current study report. Survival rates were highest for D. angustifolia and A. saligna, consistent with findings reported by Chibssa et al. (2006).

The study's findings show that, with careful species selection that is appropriate for the area, enrichment planting can rehabilitate degraded land (Mebrate, 2004). The establishment of tree plantations can support the recovery of native forest ecosystems and reduce the effects of biological and physical obstacles to forest regeneration (Lugo, 1997; Parrotta et al., 1997). By employing various restoration approaches, trees can transform degraded or unproductive areas into productive ones (Marcar et al., 1999).

As a result of many environmental, human, and animal issues, the treatments eventually forced them to lose the competition by slowing down their development and survival rates. The principal obstacles to the regeneration of degraded fields were prolonged drought, animal trespass, human destruction of seedlings, and lack of awareness. Every year between April and June, the majority of the treatments experienced drought stress. One of the most significant and prevalent biological elements in tropical dry forests is seasonal variation in rainfall distribution (FAO, 2001). It just takes two to three dry months to change the structure and content of the forest ecosystem (Murphy & Lugo, 1986). The majority of reforestation initiatives seek to increase the forest's potential for future timber production, but it's becoming more and more crucial to balance immediate financial goals with long-term biodiversity preservation (FAO, 2001; Lamb, 1998; Lugo, 1997).

The use of 16 seedlings per plot, though below the conventional threshold of 25–100 seedlings per species, was logistically feasible in these remote, resource-limited dryland sites and provided statistically significant results. Similar studies in Ethiopia have used comparable sample sizes and yielded valid recommendations for species selection (Mebrate et al., 2004; Tilahun et al., 2006). Future studies could increase seedling numbers to further validate these findings.

5 Conclusion

Based on the multi-year evaluation of native and exotic tree and shrub species across three agro-ecological zones in northeastern Ethiopia, this study provides clear, evidence-based recommendations for rehabilitating degraded drylands. The results demonstrate that species selection must be agro-ecology-specific, as performance varied significantly across altitude and moisture regimes.

Dodonaea angustifolia and Acacia saligna emerged as the most resilient and adaptable species, showing consistently high survival and growth across multiple zones. D. angustifolia exhibited remarkable ecological plasticity, thriving from low to high altitudes, while A. saligna excelled in low and mid-altitude drylands. Other promising species include Leucaena glabrata and Cordia africana in low and mid-altitudes, respectively, though their suitability is more zone-specific.

Conversely, species such as Casuarina equisetifolia, Jatropha curcas, Sesbania sesban, and Olea africana showed poor adaptation and are not recommended for restoration in moisture-stressed environments without intensive management.

Critically, the study found that drought tolerance and adaptive capacity, not native versus exotic origin, determined species success. This supports a pragmatic, trait-based selection approach for dryland restoration. The quarterly monitoring over four years captured seasonal survival patterns and reinforced the importance of long-term, climate-resilient species evaluation.

To promote sustainable reforestation in northeastern Ethiopia and similar dryland environments, we recommend a targeted strategy that prioritizes proven, resilient species such as Dodonaea angustifolia and Acacia saligna in restoration portfolios. Effective rehabilitation also requires carefully matching species to specific agroecological conditions using evidence-based performance data, integrating supportive silvicultural practices like water harvesting to improve seedling establishment, and adopting continuous monitoring and adaptive management practices to proactively address biotic and abiotic stresses throughout the restoration process

This research contributes to the growing body of knowledge on dryland restoration and provides a practical framework for species selection that balances ecological resilience, restoration goals, and local livelihood needs. Future studies should scale up seedling numbers and include socioeconomic evaluations to support community-based implementation.

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Conflict of interest

The author declare that no competing interests

Data availability Statement

Data can be made available on the behave of the request

Ethical considerations:

All ethical considerations were fully adhered during data collection, analysis and writing.

References

Abebe, Y., Diriba, B., & Taye, B. (2000). Growth performance of different tree and shrub species at Bako, Western Oromia, 177–186.

Aklog, D. (1990). No specific bibliographic details for this reference were found in the search results. The author or title needs to be verified.

Bonnefille, R., & Hamilton, A. (1986). Quaternary and late Tertiary history of Ethiopian vegetation. In I. Hedberg (Ed.), *Proceedings of the first Ethiopian Flora Symposium held in Uppsala May 22-26 1984* (pp. 48–63).

Chibssa, T., Didita, M., Yifru, A., & Mengistu, Y. (2006). Screening of multipurpose trees and shrub species for adaptability and growth performance at Sinana, South-Eastern Ethiopia. *Ethiopian Journal of Natural Resources*, *8*(2), 271–279.

Egziabher, T. (1988). Vegetation and Environment of the Mountains of Ethiopia: Implications for Utilization and Conservation. *Mountain Research and Development*, *8*(2), 211.

FAO. (2001). *Trees outside forests: Towards rural and urban integrated resources management*. http://www.fao.org/docrep/fao/005/y1785e/y1785e00.pdf

FAO. (2015). Global Forest Resources Assessment 2015.

FAO. (2005a). *State of the world's forests*.

Franzel, S., Jaenicke, H., & Janssen, W. (1996). *Choosing the right trees: Setting priorities for multipurpose tree improvement* (ISNAR Research Report No. 8). International Service for National Agricultural Research.

German, L. A., Kidane, B., & Shemdoe, R. (2006). Social and environmental trade-offs in tree species selection: A methodology for identifying niche incompatibilities in agroforestry. *Environment, Development and Sustainability*, *8*, 1–18.

Harwood, R. (1993). Sustainable Agriculture and the Environment in the Humid Tropics.

Hurni, H. (1986). *Guidelines for development agents on soil conservation in Ethiopia*. Community Forests; Soil Conservation Development Department, Ministry of Agriculture.

Lamb, D. (1998). Large-scale ecological restoration of degraded tropical forest lands: The potential role of timber plantations. *Restoration Ecology*, *6*(3), 271–279.

Lugo, A. E. (1997). The apparent paradox of reestablishing species richness on degraded lands with tree monocultures. *Forest Ecology and Management*, *99*, 9–19.

Marcar, N., Crawford, D., Leppert, P., Jovanovic, T., Floyd, R., & Farrow, R. (1999). *Trees for saltland: A guide to selecting native species for Australia*. CSIRO Publishing.

Mebrate, M. (2004). Growth Performance of Some Indigenous and Exotic Tree Species in Southwestern Ethiopia.

Mebrate, M., Alemu, G., & Belachew, G. (2004). Early survival and height performance of some Australian tree species in field trials at Dedissa, Western Ethiopia. *Ethiopian Journal of Natural Resources*, *6*(2), 253–263.

Murphy, P., & Lugo, A. (1986). Structure and biomass of a subtropical dry forest in Puerto Rico. *Biotropica*, *18*(2), 89–96.

Parrotta, J. A., & Knowles, O. H. (1997). Development of floristic diversity in ten-year-old restoration forests on a bauxite-mined site in Amazonia. *Forest Ecology and Management*, *99*, 21–42.

Parrotta, J. A., Turnbull, J. W., & Jones, N. (1997). Catalysing native forest regeneration on degraded tropical lands. *Forest Ecology and Management*, *99*, 1–8.

Rashid, M. (2004). No specific bibliographic details for this reference were found in the search results. The author or title needs to be verified.

Reynolds, J. F., Stafford Smith, D. M., Lambin, E. F., Turner, B. L., Mortimore, M., Batterbury, S., & Walker, B. (2007). Global desertification: Building a science for dryland development. *Science*, *316*(5826), 847–851.

Tadesse, M. (1991). Some endemic plants of Ethiopia.

Teketay, D. (1996). Seedling populations and regeneration of woody species in dry Afromontane forests of Ethiopia. *Forest Ecology and Management*, *98*, 149–165.

Tilahun, C., Motuma, D., Yifru, A., & Mengistu, Y. (2006). Screening of multipurpose trees and shrub species for adaptability and growth performance at Sinana, South-Eastern Ethiopia. *Ethiopian Journal of Natural Resources*, *8*(2), 271–279.

UNEP. (2018). The State of the World's Forests 2018.

White, M. P., Alcock, I., Wheeler, B. W., & Depledge, M. H. (2019). Would you be happier living in a greener urban area? A fixed-effects analysis of panel data. *Psychological Science*, *24*(6), 920–928.

Zobel, B., & Talbert, J. (1984). *Applied forest tree improvement*. John Wiley & S.