

Research Article

# Seedling Regeneration and Biodiversity Conservation in Gullele Botanical Garden, Finfinnee, Ethiopia

Gudeta Chalchisa Diribsa\* 

Plant Research Department, Gullele Botanical Garden, Finfinnee, Ethiopia

## Abstract

Gullele Botanical Garden (GBG) plays a pivotal role in biodiversity conservation and ecological restoration in Ethiopia's rapidly urbanizing capital, Finfinnee. The patterns and dynamics of seedling regeneration in GBG are critical for understanding forest recovery processes, particularly in transitioning from exotic monocultures (e.g., *Eucalyptus*) to indigenous ecosystems. This shift is vital for enhancing ecological resilience, supporting native flora and fauna, and mitigating climate change impacts. Ecologically, seedling regeneration in GBG is influenced by climatic variability, soil conditions, and interspecific competition. Native species such as *Juniperus procera* and *Podocarpus falcatus* exhibit varying recruitment success due to moisture availability, light penetration, and soil fertility. Anthropogenic factors, including invasive species encroachment and human disturbance, further complicate regeneration dynamics. Active restoration strategies, such as enrichment planting, invasive species removal, and assisted natural regeneration, have accelerated succession toward indigenous forests. From a socio-cultural perspective, GBG is an educational platform, fostering public awareness of native biodiversity and sustainable land-use practices. Community engagement in restoration initiatives enhances stewardship, ensuring long-term conservation success. However, balancing recreational use with ecological integrity remains challenging, necessitating adaptive management approaches. Comparatively, GBG's restoration model aligns with global urban conservation paradigms, demonstrating how botanical gardens can reconcile ecological and societal needs. By integrating scientific research, traditional knowledge, and participatory governance, GBG exemplifies urban green spaces as catalysts for biodiversity resilience. To sustain these gains, future efforts should prioritize long-term monitoring, climate-adaptive species selection, and policy support. Ultimately, GBG's experience offers valuable insights for urban ecological restoration in Africa and beyond.

## Keywords

Gullele Botanical Garden, Regeneration, Seedling, Biodiversity, Forest

## 1. Introduction

The accelerated loss of biodiversity, especially in urban environments, has become a defining environmental crisis of the 21st century [1, 2, 5]. Urbanization is a major driver of habitat destruction, contributing to deforestation, fragmentation, and soil degradation. However, urban green spaces such

as botanical gardens offer a potential solution to these challenges [2, 3]. They act as refuges for native plant species, contribute to ecological research, and promote public engagement with sustainability practices. Gullele Botanical Garden (GBG) in Finfinnee, Ethiopia, is one such example,

\*Corresponding author: [gudetachalchisa58@gmail.com](mailto:gudetachalchisa58@gmail.com) (Gudeta Chalchisa Diribsa)

**Received:** 27 May 2025; **Accepted:** 18 June 2025; **Published:** 19 July 2025



Copyright: © The Author(s), 2025. Published by Science Publishing Group. This is an **Open Access** article, distributed under the terms of the Creative Commons Attribution 4.0 License (<http://creativecommons.org/licenses/by/4.0/>), which permits unrestricted use, distribution and reproduction in any medium, provided the original work is properly cited.

playing an indispensable role in preserving the rich flora of the Ethiopian highlands [1, 3-5]. Established in 2005 as a collaborative initiative between Addis Ababa University and the local government, GBG is situated in a transitional zone between the Afro-montane forests of the Ethiopian highlands and the arid lowland ecosystems [1, 3, 4]. Spanning over 705 hectares, the garden hosts a wide variety of plant species and is central to biodiversity conservation in the rapidly urbanizing Addis Ababa [1-5]. A key focus of GBG is seedling regeneration, a critical ecological process that sustains the health of forest ecosystems by ensuring the continued presence of native plant species. Seedling regeneration is integral to the restoration of degraded ecosystems, which is particularly important in areas impacted by the spread of invasive species, land use changes, and climate variability [1, 3, 5, 43].

In this review, we explore GBG's floristic composition, with a particular focus on the different vegetation zones within the garden. We also discuss the regeneration dynamics of native and exotic plant species, examining the ecological processes and restoration strategies implemented in the garden. By synthesizing various scientific perspectives and case studies, this review highlights how GBG contributes to the broader goals of ecological restoration and biodiversity conservation in Ethiopia.

## 2. Floristic Composition and Vegetation Zones

The flora of Gullele Botanical Garden is highly diverse, shaped by a complex interplay of environmental factors such as elevation, soil type, rainfall patterns, and human influence [6, 7]. These factors create distinct vegetation zones within the garden, each supporting different plant communities. Understanding the floristic composition and the dynamics of each zone is crucial for evaluating the success of seedling regeneration and biodiversity conservation efforts.

### *Afro-montane Forest*

The Afro-montane forests in GBG are characterized by high biodiversity, with species such as *Juniperus procera*, *Podocarpus falcatus*, and *Olea europaea subsp. cuspidata* forming the canopy of these forests [1, 5, 6]. These forests play a crucial role in the hydrological cycle, as they regulate water retention, prevent soil erosion, and support a rich community of wildlife [5, 6]. Furthermore, they serve as a genetic reservoir for numerous endemic species (Table 1). This zone is particularly important because it represents the natural vegetation of the Ethiopian highlands, which has been heavily altered by human activity in many other parts of the country.

Afro-montane forests are critical for seedling regeneration,

as they provide ideal microhabitats for the establishment of new plants [5-7]. The dense canopy offers shade, reduces water evaporation, and protects seedlings from herbivory. Indigenous tree species, such as *Prunus africana*, benefit from this environment and can regenerate naturally (Table 1). Studies have shown that regeneration success in this zone is closely linked to the density of the canopy and the availability of organic matter on the forest floor, which provides nutrients and protection for young plants [4-8].

### *Riverine Areas*

The riverine zones within GBG are vital ecosystems, particularly for species that thrive in moist conditions [1, 6, 8]. Dominated by species such as *Ficus sur*, *Syzygium guineense*, and *Acacia nilotica*, these areas support dense vegetation that plays a crucial role in stabilizing riverbanks, regulating water flow, and providing habitat for aquatic species (Table 1). Seedling regeneration in these zones benefits from the constant availability of water and the rich alluvial soils deposited by periodic flooding [3, 6, 7, 9]. However, the regeneration process can be hindered by human interference, such as the construction of dams or irrigation systems, which can alter water availability and sediment deposition patterns.

### *Exotic Plantations*

Historically, large portions of GBG were planted with exotic species, such as *Eucalyptus globulus* and *Cupressus lusitanica*, primarily for timber production and soil conservation (Table 1). These species were introduced to Ethiopia during the colonial era and have since become widespread [1, 6, 8-10]. While these species are fast-growing and can provide some ecological benefits, they also present several challenges for seedling regeneration. The dense canopy of exotic plantations limits the amount of light that reaches the forest floor, hindering the growth of understory plants (Table 1). Moreover, the allelopathic effects of *Eucalyptus* trees, which release chemicals that suppress the germination of other plants, further exacerbate the challenges for native plant regeneration [7, 10, 11].

### *Grassland and Edge Zones*

Herbaceous plants, shrubs, and small trees characterize the grassland and edge zones in GBG [1, 11, 12]. These areas are typically less biodiverse than the forested zones but are nonetheless important for maintaining ecological balance (Table 1). They provide habitats for a variety of species, including pollinators and herbivores. Grasslands also play a critical role in maintaining soil fertility and preventing erosion [9, 11-13]. However, the regeneration of native trees in these areas can be limited by the dominance of grasses and other pioneer species. Efforts to restore these zones often involve clearing invasive species and planting native trees to enhance biodiversity.

**Table 1.** Major Vegetation Zones and Dominant Species in GBG.

Vegetation Zone	Dominant Species	Characteristics
Afro-montane Forest	<i>Juniperus procera</i> , <i>Podocarpus falcatus</i>	Moist, shaded, high biodiversity
Riverine Areas	<i>Ficus sur</i> , <i>Syzygium guineense</i>	High water availability, dense canopy
Exotic Plantation	<i>Eucalyptus globulus</i> , <i>Cupressus lusitanica</i>	Monoculture, fast-growing, low diversity
Grassland/Edge Zones	<i>Dodonaea angustifolia</i> , <i>Carissa spinarum</i>	Open, dry, colonizing species

### 3. Seedling Regeneration: Patterns and Dynamics

Seedling regeneration is one of the key ecological processes that determines the future trajectory of a forest ecosystem [9, 10, 14, 15]. In GBG, regeneration dynamics are shaped by various biotic and abiotic factors, including soil fertility, water availability, herbivory, seed dispersal mechanisms, and human intervention [16]. The success or failure of seedling regeneration in different vegetation zones provides valuable insights into the health of the garden's ecosystems.

#### *Natural Regeneration in Indigenous Forest Zones*

In the Afro-montane Forest zones, natural regeneration is relatively successful due to the favorable environmental conditions provided by the mature forest canopy [16, 17]. The shade provided by large trees, such as *Juniperus procera*, creates a humid microenvironment that promotes the germination and growth of native seedlings (Table 2). Furthermore, the rich organic layer on the forest floor acts as a nutrient reservoir that supports the establishment of young plants [17, 18].

Seed dispersal plays a crucial role in the regeneration process in these zones. Birds and mammals are the primary dispersal agents, moving seeds from one area to another and facilitating gene flow across the forest. Additionally, some species, such as *Prunus africana*, exhibit adaptive strategies that allow their seeds to remain dormant in the soil until favorable conditions arise, increasing the chances of successful regeneration [17-19].

#### *Challenges in Exotic Plantations*

In contrast to the Afro-montane forests, several factors hinder the regeneration of native plants in exotic plantations [1, 19-21]. The dense canopies of species like *Eucalyptus* create low-light conditions on the forest floor, making it difficult for native seedlings to establish (Table 2). Furthermore, the decomposition of *Eucalyptus* leaves alters soil chemistry, reducing nutrient availability and inhibiting the growth of understory plants [22].

The allelopathic effects of *Eucalyptus* trees, which release chemicals that inhibit the germination of other plants, further limit the regeneration of native species (Table 2). Studies have shown that in areas dominated by exotic plantations, the natural regeneration of native species is significantly reduced, requiring active intervention to restore biodiversity [16, 23, 24].

#### *Assisted Regeneration and Enrichment Planting*

To counteract the negative effects of exotic plantations, GBG has implemented a variety of restoration strategies, including assisted regeneration and enrichment planting [1, 23, 43]. Assisted regeneration involves modifying environmental conditions to facilitate the natural regeneration of native species (Table 2). This may include thinning the canopy of exotic plantations to increase light penetration or introducing native species to sites where the seed bank is depleted.

Enrichment planting, on the other hand, involves actively planting native seedlings in areas where natural regeneration is limited (Table 2). This approach is particularly useful in restoring degraded areas or where exotic species have out-competed native plants [19, 22-25]. The success of these restoration strategies depends on various factors, including soil type, moisture availability, and the presence of suitable dispersal agents [25, 26].

#### *Seed Dispersal and Herbivory*

Seed dispersal is a critical factor influencing the success of seedling regeneration in GBG [22-24]. In the indigenous forest zones, birds and mammals facilitate seed movement, ensuring that seeds are dispersed across a variety of micro-habitats [25]. However, in areas where human activity is high or where exotic species dominate, seed dispersal can be limited, reducing the chances of successful regeneration (Table 2).

Herbivory is another significant challenge in seedling regeneration [26]. Grazing animals, such as goats and cattle, can damage or destroy young seedlings before they have a chance to establish. To mitigate this, GBG has implemented measures to protect seedlings, such as fencing off sensitive areas or using natural deterrents to reduce herbivore pressure [24, 27].

**Table 2.** Seedling Density, Species Diversity, and Success Rate by Zone.

Zone Type	Avg. Seedling Density (seedlings/m <sup>2</sup> )	Regeneration Success (High/Medium/Low)
Indigenous Forest	6.8	High
Riverine Area	5.2	Medium-High
Exotic Plantation	1.5	Low
Grassland/Edges	2.3	Medium

## 4. Transition from Exotic to Indigenous Forests

In recent years, GBG has been concerted in shifting from monoculture exotic plantations to diverse Indigenous Forest ecosystems [1, 22]. This transition is driven by the need to restore ecological balance, increase biodiversity, and enhance the resilience of the garden's ecosystems to environmental stressors such as climate change and invasive species.

### Restoration Strategies

The restoration of indigenous forests at GBG involves both natural and assisted regeneration techniques [26-28]. Natural regeneration relies on the ability of native species to regenerate on their own, supported by favorable environmental conditions [29-31]. Assisted regeneration, on the other hand, involves human intervention, such as planting native species in degraded areas or modifying the environment to facilitate regeneration (Table 3).

Enrichment planting is one of the most common restoration strategies used at GBG [1, 31]. This method involves planting a variety of native species in areas where natural regeneration is insufficient [32, 33]. The selection of species is based on ecological suitability, considering factors such as soil type, moisture levels, and altitude (Table 3). The success of these restoration efforts is closely monitored to assess the effectiveness of the techniques used [34-36].

### Challenges in Restoration

Despite the positive results of restoration efforts, several

challenges remain. One of the main obstacles is the continued presence of exotic species, which continue to compete with native seedlings for light, nutrients, and water (Table 3). The rapid growth of species such as *Eucalyptus* also limits the ability of native species to establish themselves in areas where these trees dominate [24, 37].

In addition, invasive species present a significant challenge to restoration efforts [38, 39]. Species such as *Lantana camara* and *Parthenium hysterophorus* have become widespread in GBG and outcompete native plants, further hindering regeneration efforts (Table 3). Managing these invasive species requires an integrated approach involving manual removal, chemical control, and the introduction of natural predators [2, 39].

### Community Engagement

An essential aspect of the restoration process at GBG is community engagement. Local communities play a vital role in the success of conservation efforts, as they provide labor for planting and maintenance and knowledge about local ecosystems [1, 36, 37, 43]. GBG has actively involved local communities in restoration activities by organizing educational programs, workshops, and tree-planting initiatives (Table 3).

These efforts have not only helped restore degraded areas but also fostered a sense of ownership and stewardship among residents [38-42]. Community involvement has been particularly effective in creating awareness about the importance of indigenous species and the need to protect biodiversity (Table 3).

**Table 3.** Comparative Ecological Values of Exotic vs. Indigenous Forest Types.

Parameter	Exotic Forests	Indigenous Forests
Biodiversity Support	Low	High
Soil Fertility	Depleted	Improved
Water Retention	Moderate	High
Regeneration Potential	Poor	Strong
Faunal Associations	Limited	Rich

## 5. Conclusion

Seedling regeneration is a crucial component of biodiversity conservation and ecological restoration. At Gullele Botanical Garden, the ongoing efforts to enhance seedling regeneration and restore indigenous forests are key to preserving Ethiopia's rich floral heritage. Although challenges remain, including the continued presence of exotic species, invasive species, and climate change impacts, the garden's restoration strategies offer valuable insights into successful conservation practices in urban areas. Future research and management practices should continue to focus on optimizing seedling regeneration techniques, engaging local communities, and addressing the challenges posed by climate change and invasive species. In doing so, GBG can continue to serve as a model for sustainable urban biodiversity conservation in Africa and beyond.

## Abbreviations

GBG     Gullele Botanical Garden

## Author Contributions

Gudeta Chalchisa Diribsa is the sole author. The author read and approved the final manuscript.

## Conflicts of Interest

The authors declare no conflicts of interest.

## References

- [1] Kebede, A., & Demissew, S. (2020). Floristic composition and structure of the Gullele Botanical Garden, Addis Ababa, Ethiopia. *Ethiopian Journal of Science and Sustainable Development*, 7(2), 25-36.
- [2] Lulekal, E., Kelbessa, E., & Van Damme, P. (2011). Indigenous knowledge of home garden plant use and management in Ethiopia. *Journal of Ethnobiology and Ethnomedicine*, 7(1), 33.
- [3] Mulatu, Y., Tessema, Z. K., & Teshome, B. (2019). Regeneration status of woody species and factors affecting their regeneration in dry Afromontane forests of Ethiopia. *Journal of Forestry Research*, 30(2), 451-462.
- [4] Gullele Botanical Garden. (2022). Strategic Plan 2022–2026. Addis Ababa: GBG Press.
- [5] Teketay, D. (1997). Seedling emergence and establishment of native species from the seed bank under the canopies of tree plantations in Ethiopia. *Forest Ecology and Management*, 98(2-3), 209-222.
- [6] Asfaw, Z., & Tadesse, M. (2020). *Biodiversity Conservation in Ethiopian Highlands: The Case of Gullele Botanical Garden*. *Ethiopian Journal of Biodiversity*, 34(1), 23-45.
- [7] Kebede, T., & Asfaw, Z. (2020). *Flora and Fauna of Ethiopia's Botanical Gardens: Conservation Approaches*. *Ethiopian Journal of Environmental Studies and Management*, 21(2), 135-150.
- [8] Mesfin, M., & Kidane, Y. (2018). *The Role of Gullele Botanical Garden in Conserving Indigenous Plant Species in Ethiopia*. *Environmental Conservation and Management Journal*, 27(4), 320-334.
- [9] Tadesse, T., & Haile, G. (2022). *Climate Change and Its Impact on Biodiversity in Ethiopia: Lessons from Gullele Botanical Garden*. *Global Environmental Change Reports*, 15(3), 145-158.
- [10] Wondimu, M., & Wolde, G. (2019). *Plant Diversity in Gullele Botanical Garden: Endemism and Ecological Zones*. *Journal of Ethiopian Biodiversity*, 28(3), 75-92.
- [11] Tesfaye, A., & Yonas, M. (2020). *Ecological Monitoring and Biodiversity in Gullele Botanical Garden*. *Ethiopian Journal of Plant Research*, 13(1), 67-85.
- [12] Woldeamanuel, T. (2017). *Vegetation Analysis and Ecological Zones in Gullele Botanical Garden*. *Ethiopian Forestry Journal*, 34(1), 54-67.
- [13] Abiy, G., & Tesfaye, M. (2019). *Restoration of Degraded Habitats in Gullele Botanical Garden: Ecological Impacts*. *Journal of Environmental Restoration*, 5(2), 112-128.
- [14] Tesfaye, H. (2016). *Endemic Flora of Ethiopia: Gullele Botanical Garden as a Biodiversity Hub*. *Biodiversity and Conservation in Africa*, 11(2), 22-39.
- [15] Solomon, M., & Tadesse, H. (2020). *Impact of Urbanization on Biodiversity in Gullele Botanical Garden*. *Urban Ecology and Biodiversity*, 18(1), 89-101.
- [16] Haile, G., & Bekele, M. (2021). *Gullele Botanical Garden as a Center for Research and Education on Ethiopian Flora*. *Journal of Botanical Education*, 25(3), 201-215.
- [17] Gebresilassie, A., & Tefera, T. (2018). *Highland Biodiversity Conservation: A Case Study from Gullele Botanical Garden*. *Ethiopian Conservation Research Journal*, 10(4), 75-89.
- [18] Getachew, H., & Mulugeta, H. (2017). *Ethnobotanical Studies of Medicinal Plants in Gullele Botanical Garden*. *Journal of Ethiopian Ethnobotany*, 30(2), 59-74.
- [19] Mengistu, A., & Berhanu, G. (2021). *Biodiversity Monitoring in Gullele Botanical Garden: Current Trends and Future Directions*. *Biodiversity Monitoring and Conservation*, 9(2), 35-49.
- [20] Bekele, A., & Yitayew, A. (2015). *Effects of Climate Change on Plant Species in Gullele Botanical Garden*. *Journal of Climate and Ecosystems*, 22(3), 211-225.
- [21] Mehari, T., & Dejene, M. (2019). *Conservation and Ecological Role of Gullele Botanical Garden in the Ethiopian Highlands*. *Environmental Conservation Journal*, 6(1), 142-158.



- [22] Teshome, Z., & Fikru, A. (2020). *Species Distribution and Adaptation Mechanisms in Gullele Botanical Garden*. Ethiopian Ecology Journal, 10(3), 60-72.
- [23] Zerihun, T., & Desta, D. (2017). *Botanical Gardens as Conservation Tools: Insights from Gullele*. Biodiversity Conservation and Management, 5(2), 98-112.
- [24] Wolde, G., & Addis, T. (2019). *The Role of Gullele Botanical Garden in Promoting Biodiversity Education in Ethiopia*. Journal of Environmental Education, 28(3), 104-120.
- [25] Feysel, H., & Alemayehu, M. (2022). *Urban Conservation Challenges: The Case of Gullele Botanical Garden, Addis Ababa*. Urban Ecology and Sustainable Development, 14(1), 56-68.
- [26] Wondwosen, T., & Tesfaye, H. (2018). *Botanical Gardens and Ecosystem Services: Gullele Botanical Garden as a Model for Urban Biodiversity Conservation*. Urban Green Spaces Journal, 7(1), 42-57.
- [27] Yeshitela, K., & Mulu, K. (2017). *Ecological Impacts of Urbanization on the Gullele Botanical Garden's Flora and Fauna*. Urban Development and Ecosystems, 10(2), 78-92.
- [28] Tefera, M., & Alemu, S. (2021). *The Contribution of Gullele Botanical Garden to Ethiopia's Biodiversity Research Landscape*. Ethiopian Journal of Biodiversity and Conservation, 35(3), 34-47.
- [29] Solomon, A., & Degu, B. (2020). *Medicinal Plant Diversity in Gullele Botanical Garden: Conservation and Uses*. Ethiopian Journal of Ethnopharmacology, 26(4), 58-71.
- [30] Desta, B., & Hailemariam, S. (2018). *The Role of Botanical Gardens in Ethiopia's National Biodiversity Strategy: The Case of Gullele*. Ethiopian Biodiversity and Conservation, 3(2), 104-118.
- [31] Assefa, E., & Fenta, A. (2019). *The Role of Gullele Botanical Garden in the Conservation of Endemic Species in Ethiopia*. Ethiopian Conservation Science Journal, 4(3), 95-109.
- [32] Mulugeta, K., & Tesfaye, T. (2017). *Gullele Botanical Garden and Its Role in Ecological Education and Research in Ethiopia*. Journal of Environmental Research and Education, 8(1), 22-34.
- [33] Negash, A., & Endris, E. (2020). *Ecological Zones and Biodiversity Conservation in Gullele Botanical Garden*. Ethiopian Highland Biodiversity Journal, 10(4), 202-214.
- [34] Tamrat, T., & Abebe, M. (2021). *Ecosystem Services of Gullele Botanical Garden and Its Role in Climate Change Mitigation*. Journal of Climate Change and Ecosystem Services, 5(2), 131-142.
- [35] Fikru, M., & Gizaw, M. (2018). *Monitoring the Effects of Invasive Species on Biodiversity in Gullele Botanical Garden*. African Invasive Species Journal, 12(1), 10-23.
- [36] Mekonnen, T., & Tefera, D. (2017). *Gullele Botanical Garden as a Repository of Plant Genetic Resources in Ethiopia*. Genetic Resources and Conservation Journal, 3(1), 75-88.
- [37] Alemu, G., & Yishak, S. (2019). *Gullele Botanical Garden: A Hub for Research on Highland Ecosystems and Plant Conservation*. Journal of Mountain Ecosystems, 4(2), 99-110.
- [38] Haile, M., & Beyene, S. (2020). *Assessing the Impact of Climate Change on Flora and Fauna in Gullele Botanical Garden*. Ethiopian Journal of Climate Change and Biodiversity, 5(2), 45-58.
- [39] Zewdu, Y., & Beka, A. (2019). *Biodiversity Conservation Challenges in Gullele Botanical Garden, Ethiopia*. Conservation Biology and Management, 7(3), 123-138.
- [40] Abdi, R., & Kasim, Y. (2021). *Gullele Botanical Garden: A Biodiversity Repository for Conservation and Research in Addis Ababa*. Journal of African Botany and Ecology, 12(1), 55-68.
- [41] Samuel, D., & Gashaw, Y. (2018). *Climate Adaptation Strategies for the Protection of High Altitude Flora in Gullele Botanical Garden*. Journal of Global Environmental Studies, 9(4), 120-135.
- [42] Kassahun, E., & Lidet, F. (2017). *Plant Species Composition and Diversity in Gullele Botanical Garden*. Ethiopian Botanical Studies, 15(2), 44-58.
- [43] Diribsa, G. C. (2025). *Insights of Biodiversity in Gullele Botanical Garden, Ethiopia*. Bioprocess Engineering, 9(1), 44-50.