

Research Article

The Assessment of the Role of Parks and Botanical Gardens in Ethiopia

Gudeta Chalchisa Diribsa* 

Plant Research Department, Gullele Botanical Garden, Finfinnee, Ethiopia

Abstract

In Ethiopia, national and regional parks are crucial in conserving wild animals and plants in situ, protecting ecosystems, and maintaining biodiversity. Alongside these parks, botanical gardens serve as vital institutions for studying and preserving plant diversity, both in situ and ex-situ. These gardens are essential in addressing growing environmental challenges by safeguarding endangered plant species, promoting ecological awareness, and offering recreational and educational opportunities for the public. Their primary mission is to maintain documented collections of live plants to support scientific research, conservation efforts, public exhibitions, and environmental education. Botanical gardens engage in various scientific activities, including seed banking, taxonomy, systematics, genetics, biotechnology, plant propagation, horticulture, and restoration ecology. They also play a key role in public outreach, educating communities about the importance of biodiversity and sustainable practices. Additionally, these gardens contribute to climate resilience by reducing soil erosion, mitigating wind and water loss, and serving as green buffers against pollution and noise. They provide habitats for wildlife, including fish and other aquatic species, and function as ecological corridors connecting fragmented ecosystems. Similarly, national and regional parks protect flora and fauna and support scientific research, ecotourism, and community-based conservation initiatives. They act as natural barriers against environmental degradation, help regulate microclimates, and serve as buffer zones between human settlements and fragile ecosystems. Parks and botanical gardens form a network of conservation efforts essential for sustaining Ethiopia's rich biodiversity, combating climate change, and ensuring environmental sustainability for future generations. Their integrated approach combines research, education, and ecosystem services, which makes them indispensable in global conservation strategies.

Keywords

Parks, Botanica Garden, Biodiversity

1. Introduction

Ethiopia is regarded as one of the global centers of biodiversity resources, and part of its richness is thought to be attributed to the country's wide altitudinal range [1]. The concept of a botanical garden originated in Italy in 1545 [1, 2]. According to studies, the number of botanical gardens

worldwide is around 2500 [3]. Botanical gardens are essential to studying and preserving plant biodiversity worldwide, both in situ and ex-situ [3, 4]. The primary purpose of a botanical garden's initial collection of live plants was to show the links between different plant groups. Most botanical gar-

*Corresponding author: gudetachalchisa58@gmail.com (Gudeta Chalchisa Diribsa)

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dens nowadays focus on showcasing decorative plants, whenever feasible, in a layout that highlights natural relationships. The Global Strategy for Plant Conservation aims to save 70% of the world's vulnerable plant species ex-situ [4]. Additionally, botanical gardens play a significant role in maintaining species essential to human usage and welfare [5]. Botanical gardens engage in a wide range of scientific endeavors, including the study of seeds, taxonomy, systematics, genetics, biotechnology, propagation, horticulture, public education, restoration ecology, and many other subjects [6]. Gullele Botanical Garden focuses on this than Jimma and Shashamanne Botanical Garden. Preserving large plant collections labeled with common and scientific names and origin locations is one of the key goals of botanical gardens nowadays. The number of plant varieties in these gardens ranges from a few hundred to several thousand, contingent upon the available land space and the institutional financial and scientific resources. Ecosystem services are declining due to the unprecedented loss of plant diversity. As a result of numerous destructive human activities, such as overharvesting, overexploitation through destructive agricultural and forestry practices, urbanization, environmental pollution, changes in land use, exotic invasive species, and global climate change, approximately one-third of the 300,000–450,000 vascular plant species in the world are currently in danger of going extinct [6, 7].

The word "park" implies "enclosure" in Latin. The terms "preservation," "protection," and "conservation" basically mean "keeping certain areas or natural aspects away from the present demand." Similarly, administration refers to specific methods of overseeing the field, often involving the entire spectrum of new organizations, professionals, and procedures. At the same time, establishment designates a legal event of bringing into existence. A park in the community symbolizes various cultural, artistic, and spiritual qualities [8].

Bale National Parks, Naci Sar, and Chebera Churchura Parks are examples of important natural resources since they support the livelihoods of many people worldwide and positively impact the ecological balance. However, many ecologically significant regions, such as parks, are severely degraded due to rising population growth, decreased agricultural yield, and the rapid extension of farmlands in most countries [9]. Beyond the harmful impacts of environmental pollution, a well-managed and maintained ecosystem is also crucial for human health. Natural disasters negatively impact humans' physical and emotional well-being. Exposure to diseases or hazardous substances can harm biodiversity, while biodiversity with ecosystem services can have a positive impact on health-related concerns by altering the aesthetic, cultural, and recreational characteristics of natural ecosystems. By assuming plant species' nativity and threat status, botanical gardens are currently a good technique for the ex-situ conservation of those species [9, 10]. Ethiopia's botanical gardens are utilized to protect the nation's rarest

plant species and indigenous, endangered, endemic, and commercially significant plant species. The primary goals of botanical gardens in Ethiopia are plant conservation, research, education, and ecotourism. Prioritizing native, endangered, endemic, and commercially significant plants together with uncommon species unique to the nation is part of the conservation effort. The Gullele Botanical Garden has created a variety of infrastructures to help it carry out its vision and mission in an equitable manner. The garden creates an evolution garden and a themed garden with collections of diverse in situ and ex-situ conservation approaches. According to ecosystem services, diseases and natural disasters are partially controlled by the ecosystem, which has a negative impact on health [10, 11]. In well-known public areas, these activities offer exceptional chances for gardening, conservation biology, and the study of plant biodiversity. Nonetheless, the role of botanical gardens and parks remains scarcely explored. This study aims to increase public knowledge of the issues affecting our environment and world to effect significant behavioral changes.

2. Role of Parks and Botanical Gardens in Ethiopia

In Ethiopia, parks serve a vital role in preserving healthy ecosystems, providing clean water and air, and permitting the conservation of natural resources, all of which are essential to maintaining the health of our environment. There are numerous advantages of Parks to environmental care and conservation, such as:

- 1) Supplying environmentally friendly, carbon-reducing landscapes that refill aquifers, clean the air and water, lessen stormwater runoff, and save wildlife habitat; Granting the general people access to inexpensive, healthful, and safe means of experiencing and appreciating nature.
- 2) Supplying several financial advantages to communities from outdoor leisure and making a major contribution to their economic well-being through resource and energy conservation.

In Ethiopia, the nation's plant genetic resources are maintained and preserved in large part by the Botanic Garden. It is presently putting in much effort and is successful in a range of tasks that aid in the achievement of its goal. The organization's primary objectives are the study and the preservation of native and different plants; parks mostly serve the purpose of conservation. The main functions of a botanical garden are a) To display an extensive assortment of everything deemed ideal from an attractive perspective from the woody plants that can be grown in the region (if a botanical garden, then among the perennials, annuals, and bulbs as well, if an arboretum). b) To serve as a way to introduce new plants, wherever they may have originated, into the region. c) To give botany, horticulture, and natural study students ac-

cess to a lab. d) To strategically plant areas to boost output, economic significance, and aesthetic appeal; additionally, to introduce novel plants that have not been planted there before. e) To stimulate the public's interest in leisure activities such as drives, walks, breathtaking displays, and flower shows [12-14]. Parks, woods, and other vegetation provide numerous significant environmental advantages. In addition to giving all land-dwelling animals a place to live, trees' ability to sequester carbon helps to fend off climate change and global warming. Forests greatly influence the distribution and intensity of local and regional rainfall. Plants in parks provide a plentiful supply of food and clean water, and therapeutic, decorative, and recreational uses for many individuals [15, 16]. However, the botanical garden's role is conservation and scientific research, and it can cover all park activities. A botanical garden is the perfect location for a variety of scientific [15, 16], as shown in Figure 1. Unlike parks, botanical gardens and arboreta are typically designed with the scientific relationships of their plant collections in mind rather than just for aesthetic purposes or the use of playing fields or other primarily recreational areas. For instance, grouping trees and plants in an arboretum area of the garden is the customary method of designing a botanical garden. However, shrubs and trees are frequently employed to improve the effects of the landscape by being strewn throughout the garden in groups according to their taxonomy, with collections of herbaceous plants. Plant physiology and growth strategies, plant-animal interactions, and phonological indicators of climate change are among the data on plant ecology that are collected from this significant source [17, 18].

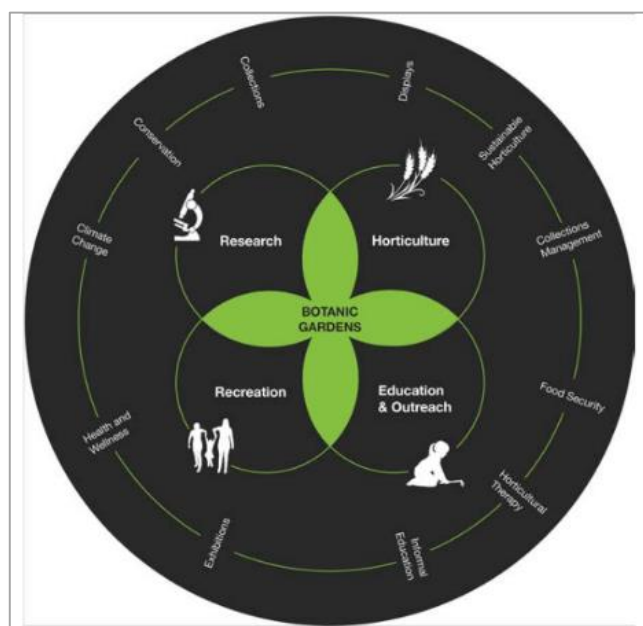


Figure 1. Role of botanical garden.

3. Role in Climate Change

Because forest plants and soils store carbon, they are essential for maintaining local and regional weather patterns because they sequester carbon through photosynthesis and release it through respiration. However, it is a sad fact that forests are being cleared for a variety of livelihood activities around the world, including farming, fiber production, timber, and fuel wood. When forests are burned or cleared of their surface, they release carbon back into the atmosphere because human activity is changing their ability to store carbon. Tropical deforestation is the main factor contributing to the extinction of forest species and accounts for 20% of annual carbon dioxide emissions caused by humans [19-22]. Temperature, wind, sun radiation, and humidity are all influenced by trees. Because of their high canopy, forests are warmer in the winter and colder in the summer than open spaces. This is valid for the daily variations. Forests, therefore, have a moderating effect on temperature. The canopy of the night forest stops heat gained during the day from radiating back. Because trees block off the wind, the air inside a forest is moister than it is outside. If a mountain range is covered in forests, rain-bearing winds are diverted further up into the atmosphere, which cools the air and increases precipitation [23-26]. Many effects of climate change on plants have been documented by scientists, including changes in phenology, physiology, anatomy, and other facets of plant ecology and evolution [26]. Plant carbon budgets and functional characteristics are shifting, as is the timing of plant leaves out, blooming, fruiting, and senescence [27]. Plant conservation is also being impacted by climate change, as scientists work to identify and protect the plant species that are most at risk from shifting environmental conditions. Aiming to study plant reactions to climate change, community and citizen science activities are only one way that scientists and educators are including the public in botany and plant ecology as part of these efforts [28, 29]. Due to their extensive collections of plants from a variety of geographical regions, as well as their expertise and data on plant physiology, distribution, and systematics, botanical gardens are in a good position to take the lead in climate change research and education [29, 30]. In botanical gardens, hundreds or even thousands of species are studied. More insight into the reasons for the variations in plant responses to climate change can be obtained by looking into and taking into consideration the evolutionary history of those species. Researchers now have more options to take advantage of the many living collections and herbaria at botanical gardens, thanks to recent advancements in phylogenetic methods and trait databases. One advancement is the high-resolution plant phylogenies that are publicly available [29]. Interconnections across botanical gardens increase the power of comparison analyses conducted at individual gardens. Researchers can examine the same species thriving under various current climatic conditions in different areas thanks to networks of botanical gardens [28, 29]. Different

species, regions, and seasons have very different and intricate reactions of plant phenology to climatic variations. These variables can affect how plants respond to stimuli in different seasons, and plant phenology can react to variations in temperature, precipitation, snowmelt, or day length [29, 30]. Growing-season productivity was found to be a major determinant of tree leaf senescence phenology throughout Europe, partly based on data from botanical gardens. This suggests that, contrary to previous models, leaf senescence will occur earlier in the year as conditions continue to warm [29]. The natural and cultural resources that it safeguards are being increasingly impacted by climate change. Reliable interpreters and educators must communicate the processes and impacts of climate change in light of this unprecedented and pressing challenge. America's parks are among the best spots for inspiration, education, and pleasure. They also offer striking illustrations of how climate change is having an impact. It is our responsibility as dependable information providers to educate others on this important matter as the guardians of these locations and the tales they represent [27-29]. Climate change is becoming a greater danger to the integrity of park areas. Among the most obvious signs of a changing climate are melting glaciers, increasing sea levels, species shifts, and altered precipitation patterns. Parks have a remarkable and special potential for conveying climate change because they allow people to see and feel the effects of climate change in a setting they are familiar with and appreciate. This dedication to these unique locations enables people to discover how they relate to climate change and to inspire others to do the same [30].

Scientific research

Many areas of scientific inquiry benefit from the presence of botanical gardens. Botanical gardens function as centers for systematic and taxonomic research as well [29, 31]. However, they also serve as essential sources of data for the study of plant ecology, including phenological indicators of climate change, plant physiology and growth strategies, and interactions between plants and animals [29, 31, 32]. Botanical gardens can offer a wide variety of species for studying functional trade-offs between species attributes and plant performance in terms of plant functional qualities [32], [Figure 2](#). Gullele Botanical Garden has a hole in studying endangered plant species in their ex-situ collections, which has also taught environmentalists not to overlook the possible dangers of hybridization. Particularly, it has been demonstrated that spontaneous hybridization in ex-situ settings compromises the genetic integrity of ex-situ collections and may contaminate open-pollinated seeds or seedlings [32, 33]. Pollination ecology, which includes the breeding system, efficient pollinators, and other elements, should be meticulously documented and observed to preserve and maintain the ex-situ population of endangered species in botanical gardens [29]. Plant conservation genetics offers useful instruments to assess and track processes, direct conservation, and effective restoration, and eventually reduce the danger of

extinction for threatened plant species in the wild [29, 34]. Conservation genetics has spent the last few decades mostly examining the genetic effects of small populations, which may limit the ability of populations and species to survive. However, according to recent evaluations on the genetic aspects of plant conservation, genetic erosion is becoming a bigger hazard to the long-term survival of both common and uncommon species [34, 35].



Figure 2. Greenhouse at Gullele Botanical Garden, Addis Ababa.

National Science

The method by which citizens conduct scientific research is known as citizen science and is historically connected to gardens of botany. Currently, "citizens as scientists" is the main goal of contemporary citizen science as opposed to "scientists using citizens as data collectors" [28, 29]. Aspects of nature and leisure offer distinctive experiences in botanical gardens that may affect visitors' well-being. Gardens are visually beautiful physical spaces that can be used to lessen social issues brought on by numerous societal strains, improving people's well-being and lengthening life expectancy, among other things. To strengthen their capacity to oversee and manage natural resources, evaluate species that are at risk, and safeguard natural conservation areas, policymakers and non-governmental organizations are actually making greater use of volunteers [27, 33]. In western North America, for example, volunteers were able to present evidence of sharp drops in monarch butterfly populations during the previous 36 years [29, 32]. Numerous university-affiliated botanical gardens are equipped with large herbaria, libraries, and lab research spaces. For the expert plant taxonomist, these gardens provide invaluable services. For the inexperienced gardener, some sizable urban botanical parks offer classroom and greenhouse workshop spaces, and the tendency towards popular-level education is expanding. Investigating the spread of invasive plant species by residents through a citizen science programme may help to increase awareness and modify local behavior [29]. Initiatives for certain audiences, like kids, adults, and professional educators, must be designed and improved. It is a reality that creating and carrying out public data collection initiatives frequently results in scien-

tific and educational outputs like scientific teaching, biodiversity monitoring, and biological research [26, 27, 29], as shown in Figure 3.



Figure 3. Scientific teaching about plants at the Gullele botanical garden.

Reduction of Wind and Water Loss

Raindrops trickle down the leaves and branches of trees, preventing the moisture from striking the ground with force. Runoff is decreased by the humus and ground litter, which absorb water. Because organic matter maintains the soil's porosity and permeability, water can penetrate and be stored in the substratum [33-35]. The decline is caused by sand being blown across fertile areas by wind, which also increases evaporation, dries out the soil, and destroys fertile topsoil. Trees serve as shelterbelts and windbreaks. Wind speed is significantly lower [33].

Shelter for Fish and Wild Habitat

While forest growth shades the water courses, it keeps streams from getting too hot, which is good for fish life. When trees were cut down in American rivers and streams, the water became unsuitable for trout to live in. Clear streams that are ideal for fish life are another benefit of forests. Many types of wild species find food and shelter in forests. Certain wildlife species vanish when forest trees are cut down. Other types of wildlife that depend on weeds, bushes, and young trees may be able to live there once the habitat for trees has been restored. Over time, all wildlife will vanish when trees and other forest vegetation are eliminated.

Noise and Pollution Control

As part of their regular gas exchange, trees take in airborne contaminants. The trees absorb and use trace amounts of sulfur dioxide in their metabolism. Additionally, trees help to clean soil and water by absorbing different types of pollutants through their roots. Making appropriate use of trees and plants can help reduce noise. Even a few trees can be helpful if they are positioned between the people and the noise source. In the winter, deciduous trees are not very useful. Trees need to be near the noise source to be effective.

Serves as a Buffer Zone

A healthy ecosystem's services and activities depend critically on the integrated ecological responsibilities of forest trees, shrubs, forbs, grasses, water bodies, soils, and other elements. The existence of a network of these various resources is essential to ecosystem functions because they each play a different role in fostering a healthy environment. When these resources work together, they can filter water resources, act as a sink for carbon dioxide, support the growth of a healthy ecosystem for various microorganisms, provide food and shelter for wild animals, enhance fish habitats, and more. Most botanical gardens participate in initiatives that engage with nearby communities to increase access to food and nutrition by teaching people about valuable plants, how to cultivate them, and how to use them. These initiatives enhance the nutrition and general health of the people they serve by encouraging home and community gardens [33, 35].

4. Future Challenges and opportunities of Parks and botanical Gardens in Ethiopia

Several human endeavors are reuniting once separated populations and species, such as in situ/ex-situ conservation studies and horticultural hybridization procedures in botanical gardens [34, 35, 37]. Nevertheless, throughbreeding depression, the artificial gene flow that results from this could cause plant species to decline or become extinct. In fact, new research has shown that outbreeding depression negatively affects population persistence [35-37]. The purpose of botanical gardens is to advance knowledge, research, and preservation of the diversity of plant species. Gullele Botanical Garden also focuses on research and conservation of IUCN Red List plants. Most Ethiopian parks, like Bale National Park, Nac Sar National Park, and others, focus on in situ conservation. However, a botanical garden like Gullele Botanical Garden is a huge garden, and it focuses on endemic and indigenous plants. Studies on the species variety of botanical gardens themselves, however, are scarce [35, 36]. The patterns of species richness seen in natural ecosystems have little to do with the living collections found in botanical gardens around the globe. The writers advocate for more funding for scientists in underfunded nations and botanical gardens located in areas rich in species. Furthermore, in order to track changing environmental conditions in gardens, botanical gardens ought to be major players in the creation of a plant information database [31, 34, 35]. However, many studies have overlooked the beneficial impact that horticulture in botanical gardens has had on plant conservation in recent decades. As a result, we advise horticulturists at botanical gardens to work in conjunction with scientists studying taxonomy, genetics, systematics, and environmental education [30, 32, 33]. Staff members in these scientific centers should make use of their vast field expertise and experience to perform conservation effect assessments and related stud-

ies, since they are essential to the effectiveness of conservation efforts in botanical gardens. Failure to do so may prevent the goals of scientific plant species conservation from being met. With the enormous volume of visitors both in person and virtually, citizen science offers botanical gardens a unique potential [35-37]. When designing a citizen science program, it is important to consider possible conflicts between scientific research, educational activities, and participant motivation. Basic guidelines should be followed by citizen science initiatives in botanical gardens: information gathered from the general public should be verified by various experts; data collection techniques should be standardized; and volunteers should be given feedback regarding their involvement in the gardens [35, 37, 38]. Botanical gardens are excellent places to study the diversity of plants and how they use their resources. Still, research carried out in botanical gardens is generally overlooked in mainstream plant science. Leaders in the plant science community are not usually scientists working at botanical gardens. Plant collection and identification, species documentation and evaluations, horticulture and conservation methods, public education, and citizen science are examples of capacity-building and training activities that should be carried out in botanical gardens to prepare future botanists and horticulturists [35, 37-39]. In conclusion, given the onset of the Anthropocene, it is imperative to deliberate on the notion of "new conservation." Additionally, novel technologies could potentially offer novel prospects for botanical garden researchers in the aftermath of GSPC 2020. It is essential for a scientific botanical garden that prioritizes science and conservation to have a thorough collecting policy for living collections. Plants of wild origin, representative populations, sufficient sample sizes, clear provenance, and other collection details, as well as a direct connection between collections and botanical project design, are a few examples of what this would consider. Ethiopia Botanical Gardens should i) create specialized gardens and support research linked to those gardens, ii) enhance and build facilities for molecular biology research, and iii) create digitalized botanical gardens to boost capacity and scientific research [40].

5. Conclusion and Recommendations

The botanical garden has a huge role in conserving fauna and flora with in-situ and ex-situ methods in scientific ways. National parks provide refuge to untamed fauna and flora that would face extinction due to human activity. They also offer protection to many vulnerable and endangered species, preserve declining habitats, and offer safe havens for breeding where endangered species can thrive. For the benefit of the next generations, these vital ecosystems may be preserved with everyone's kindness and upbeat outlook. Globally, the depletion of natural resources poses a major danger to sustainable development. In developing nations, where a sizable portion of the population depends on natural re-

sources for their livelihood, the effects of resource degradation are more acute. Growing population pressure drives these countries' households to overuse their natural resources, which increases poverty, and households' motivation to labor for the defense of the park rather than the botanical garden. Ethiopia has a variety of indigenous and endemic plants and animals that need preservation.

Abbreviations

IUCN International Union for Conservation Nature

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.

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