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Review Article

Roles of Botanical Gardens for Conservation and Requirements for their Establishment: Review

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Abstract

Botanical gardens are extremely important institutions that safeguard the environment from ever-increasing environmental concerns, educate people about environmental issues, provision of recreational opportunities, conducting of various research and conservations. Their mission is to keep documented collections of living plants for scientific research, conservation, display, and education, but this may vary depending on the resources available and the special interests pursued at each garden. Botanists and gardeners are typically on the staff. Currently, about 3,765 botanical gardens conserve approximately 30% of the species. A wide and distinctive collection of living plants serves as a foundation for research and modern taxonomic studies in morphology, ecology, genetics, systematics, and evolution in the twenty-first-century botanical garden. Furthermore, botanical gardens provide germplasm for the hybridization of species, which allows for the improvement of economically important varieties of flowers, fruits, and vegetable plants. Prior to the establishment of the botanical garden, important components such as site selection, feasibility study, defined objectives, vision and mission, detailed design, construction specifications, theme establishment, weeds and pest control links, professional experts, and mode of operation must be considered. This review determines a brief description of the botanical garden, the conditions for establishment, and its role in plant and habitat protection.

Keywords: Botanical Garden, Conservation, Ecology, Germplasm, Plants

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1. INTRODUCTION

1.1.What is a botanical garden?

A botanical garden is a place for botanical research, conservation, education, and display, focusing on the region's native flora. Besides, a botanical garden is an establishment where plants are grown for scientific study and display to the public. According to Rakow and Lee (2011), a modern botanical garden comprises a herbarium, library, photographic studies, laboratory, lecture pavilion, and recreational facilities. On the other hand, it might also have specialist plant collections, such as those of cacti and other succulents, herb gardens, plants from particular parts of the world, and so on. Some others might comprise greenhouses and shade houses with special collections such as tropical plants, alpine plants, or other exotic species. Most are open to the public in some capacity and may provide guided tours, educational displays, art exhibitions, book rooms, open-air theatrical and musical performances, and other forms of entertainment (Raven, 1992).

1.2. **Historical background**

Botanical gardens have a long history that is intertwined with botany. The first botanic gardens were physic gardens built at European colleges for the study of medicinal plants. These early gardens were found near Pisa, Italy (1543) during the era of the Renaissance. The first botanical gardens were medical gardens in the 16th and 17th centuries, but as time went on, the idea of a botanical garden expanded to include displays of beautiful, exotic, unique, and occasionally economically valuable plant species brought back from European colonies and other far-off places. (Hill, 1915). Later, in the 18th century, they took on a more instructional role, exhibiting the most recent plant categorization systems established by botanists working in the accompanying herbaria as they attempted to organize these new treasures. Then, in the 19th and 20th centuries, there was a movement toward a mix of specialized and eclectic collections displaying many areas of horticulture and botany (Hill, 1915).In the 19th and 20th centuries, a considerable number of civic or municipal botanical gardens were established. Although no scientific facilities or programs were developed, the horticultural features were strong, and the plants were frequently labelled. They were botanical gardens in the sense that they grew plant collections and exchanged seeds with other gardens across the world, but individuals in charge of them on a daily basis established their collection policies. They tended to devolve into little more than nicely maintained parks and were frequently overseen by general park administrations (Heywood, 1987).

In the second part of the twentieth century, educational, visitor service, and interpretation services became increasingly advanced. Botanical gardens began to cater a wide range of interests, and their displays reflected this, frequently including botanical exhibits on themes of evolution, ecology, or taxonomy, horticultural displays of attractive flowerbeds and herbaceous borders, plants from around the world, special collections of plant groups such as bamboos or roses, and specialist glasshouse collections such as tropical plants, alpine plants, cacti, and orchids, as well as the traditional herb garden. Specialized gardens, such as the Palmengarten in Frankfurt, Germany (1869), which houses one of the world's most important orchid and succulent plant collections, have been extremely popular (Heywood, 1987). Botanic gardens in the twenty-first century are concentrated reservoirs of incredible expertise in horticulture, taxonomy, and ethnobotany, and this knowledge is continually expanding. Species are being researched for their medical benefits, evolution is being explored by creating DNA banks, and ex/in-situ conservation is being accomplished through the establishment of seed banks.

2. Why botanical garden is established?

Botanical Gardens are established to conserve plant species in and out of their natural habitat. Currently, about 3,765 botanical institutions are established worldwide (BGCI, 2023). The 3,269 botanical institutes in 180 different countries have preserved over 41% of known vulnerable species, and at least 30% of the diversity of all plant species has been estimated to be preserved. Despite the tropical region being endowed with diverse and abundant plant species, about 93% of species preserved in the botanical garden are from the temperate region (Mounce et al. 2017. Consequently, 76% of species estimated to be disappeared from extant collections are of tropical origin (Mounce et al., 2017). To overcome such challenges the establishment of botanical gardens and organizers such as Botanical Gardens Conservation International (BGCI) are essential to rescue plants globally by providing accessions. Thus, among many other things, botanic gardens offer the opportunity to preserve plant diversity outside of their natural habitats (*Ex-situ* conservation services) and play a significant part in averting the extinction of species through coordinated conservation efforts (Krishnan and Novy, 2017).

Before establishing a botanical garden, the importance and objectives should be thoroughly investigated, according to Rakow and Lee (2011) and Patzelt and Anderson (2016). Here are some of the functions and significance of botanical gardens:

i. Growing only a few or specific plants in the area so that homeowners can become familiar with their names, ornamental characteristics, and appropriate cultural methods.

ii. To exhibit a comprehensive collection of everything considered to be the best from an ornamental standpoint among the woody plants that can be grown in the area (if an arboretum, or among the perennials, annuals, and bulbs as well, if a botanical garden).

iii. To act as a means of introducing new plants into the area, regardless of where they may originate.

iv. To provide a lab for students of botany, horticulture, and nature study.

v. To introduce new plants that have not previously been cultivated there, as well as to strategically plant areas in order to increase production, economic significance, and attractiveness.

vi. To aspire the public's interest in recreation through walks, drives, stunning displays, flower exhibitions, and so on, and to foster the joy of discovering new species suitable for planting on private property.

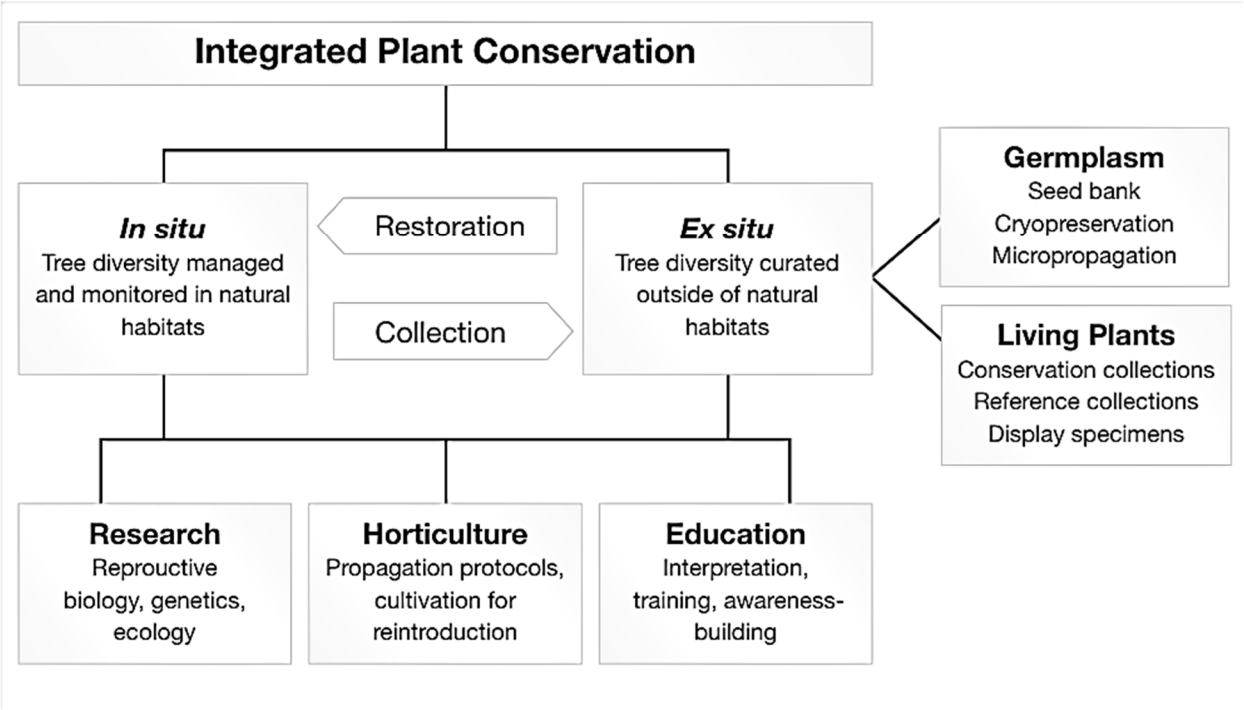


Figure 1. Integrated plant conservation (source: BGCI, 2023)

3. What requires to establish a botanical garden?

The concept of a new botanic garden development is frequently associated with an existing site or with several alternative sites, from which the best location is chosen.

As needed, a list of potential sites for consideration based on standards to fulfil the project's vision and mission may be created. It is critical to assess the suitability of these potential locations. Patzelt

and Anderson (2016) stated that the following matters should be required for the establishment of a botanical garden.

- Accessibility and suitability for visitor and operational use
- Existing site-use bylaws, zoning, or legal restrictions;
- Existing structures and infrastructure;
- Conditions of the biophysical site (climate, topography, solar aspect, soils, geology, hydrology, vegetation, wildlife habitat);
- Views into and out of the site, as well as views of the surrounding landscape;
- Special or distinguishing features of a specific location;
- Sensory experiences (views, sounds, seasonality);
- Has a broad vision and specific goals to achieve;
- Feasibility Study, which typically includes a preliminary analysis of the project, potential sites, and development ideas;
- Size and scope for expansion in the future.

4. Who should design the project?

To turn the project's objectives into reality, the steering group often collaborates with a designer or a team of designers (Loudon, 1843; Crewe and Forsyth, 2003). They noted that, depending on the specific needs of each project, the number and composition of the design team could include: landscape architects or landscape designers, architects, botanists and horticulturalists, irrigation designers, lighting designers, interpretation designers and education experts, engineers, transportation and circulation experts, operational experts, business planners as well as other specialist designers and experts tailored to the project.

5. Functions of botanical garden

According to Ocak and Kurtaslan (2015), Botanical gardens have four main functions:

A. Research Function

Botanical garden serves as an outdoor laboratory. Conduct a study on various plant species, species interactions, ecological dynamics, vegetation, and the effects of climate change on local, regional, and national socioeconomic development.

B. Conservation:

Botanical garden improves biodiversity conservation by providing a safe haven for threatened species, ecological models, genetic and species variety, and contributing to global plant germplasm conservation initiatives. Besides, it conserves and propagates rare species and genetic diversity. Plant conservation genetics provides appropriate tools for guiding conservation and successful restoration, measuring and monitoring processes, and ultimately reducing the risk of extinction of threatened plant species in nature.

C. Recreational Function

Botanical garden attracts people who have made gardening their hobby**.** Thus, botanical gardens are an excellent platform for developing nature-based relaxation and tourism destinations for both domestic and international visitors.



Figure 2. the value of botanical garden for recreation © Chicago Botanic Garden

D. Educational Function

Environmental education is a multidisciplinary field of study that refers to organized efforts to teach how natural environments function, specifically how humans can control behaviour and ecosystems to live sustainably and so build a nature-sensitive citizenship idea. Environmental sensitivity and awareness should be used to resolve the conflict between environmental problems and values and to prevent the emergence of new environmental problems. Therefore, environmental education must contribute to the creation of a high-quality environment in order to help people achieve good living standards.



Figure 3. The role of botanical garden in environmental education © North Carolina State University

6. Role of Botanical garden

Botanical garden is an ideal destination for a wide range of scientific studies Krishnan and Novy (2017). It is important source of plant ecology data collection, including phonological indicators of climate change, plant physiology and plant growth tactics, and plant-animal interactions (Herben et al. 2012). Botanical garden can provide a large set of species for studying functional trade-offs between species traits and plant performance (Dawson et al. 2009). Furthermore, botanical gardens are ideal locations for research into pollination ecology, seed dispersal, and other plant-animal interactions (Wang et al. 2018). Based on the Krishnan and Novy (2017) review botanical gardens in the twenty-first century have the following roles:

a. Botanical gardens are unique acclimation sites where exotic plants from all over the world grow together in the open air, despite being removed from their original environment.
b. The diverse and distinctive collections of living plants serve as a foundation for research and modern taxonomic studies in morphology, ecology, genetics, systematics, and evolution. They provide living plant resources for academic research in cytology, embryology, anatomy, photochemistry, and other fields.
c. They include knowledge on food plants, ornamental plants, medicinal plants, and other related topics.

d. Botanical gardens supply germplasm for hybridization in order to economically generate superior types of flowers, fruits, and vegetable plants from these plants.
e. The many glass-houses, greenhouses, and other facilities in botanical gardens provide protection for many endangered plants as well as means of propagation for uncommon plants.
f. Around the world, several botanical gardens have functioned as acclimatization centers and have offered suitable facilities for the conservation of economic plants. Many people are responsible for the commercialization and spread of many important plants, such as tea, rubber, coffee, cotton, teak, cinchona, hemp, vanilla, and so on, which are native to one area but have been introduced to other countries.
g. Botanical gardens also provide seeds and saplings of important plants on an exchange basis to other gardens, to encourage the introduction of some exotic, useful and economical plants.
h. Botanical gardens practice and provide training for the conservation of nature and are useful for training people in growing horticultural plants, landscapes and gardening.
i. They are a center for recreation and aesthetic beauty.

7. Main components required in a botanical garden plan

A study conducted by Patzelt and Anderson (2016) the botanical garden planning and establishment has the following main components

1. **Site selection:** A new botanic garden development is frequently associated with an existing site or with several alternative locations from which the best suited location is chosen. These potential sites' suitability should be determined.
   - Current ownership and availability;
   - Existing bylaws, zoning, or legal restrictions on site uses;
   - Access and suitability for visitor and operational access;
   - Existing buildings and infrastructures;
   - Biophysical site conditions (climate, topography, solar aspect, soils, geology, hydrology, vegetation, wildlife habitat);
   - Key views into and out of the site into the surrounding landscape;
   - Special or unique features of the site; (and scope for expansion in the future).
   - Availability of water potential and soil suitability.

2. **Feasibility study:** A thorough feasibility study should ideally precede the development of any new botanic garden. This includes a review and analysis of a proposed project's possibilities, as well as detailed investigation and research to aid in decision-making. Depending on the scope and complexity of the botanic garden project, external expertise may be required to prepare a Feasibility Study. A small group of educated stakeholders may be sufficient to determine the feasibility for smaller initiatives.
3. **Defined objectives, Vision and Mission**: When developing a botanic garden, the institution's intention must be clearly articulated from the start. The Vision and Mission guide the identification of specific project goals and objectives and provide a tangible direction for the project's design, development, and implementation.
4. **Detailed design**: The detailed design is led by the design team, with ongoing involvement and feedback from the steering group, project manager, and other stakeholders. Architectural/building plans (as specified in the Scope of Work), site preparation plans, layout plans, phasing plans, grading, drainage, and stormwater management plans, hardscape plans, planting plans, electrical plans, irrigation plans, technical construction details, and signage and wayfinding plans are among the project-specific scaled plan drawings, cross-sections, elevations, and construction details included in the tender drawings.
5. **Construction specifications**: Construction specifications are as varied as the potential design aspects of a project, but within the construction industry, they are frequently classified into specific categories. Some typical landscape construction specifications are as follows: The process includes clearing and preparing the site, protecting the existing landscape and vegetation, stripping and stockpiling topsoil, grading and earthworks, drainage and stormwater management, unit paving, concrete works, stone masonry, bed and tree pit preparation, soil preparation, plant material installation and staking, and mulching.
6. **Theme establishment**: Plants are habitat-specific, requiring microhabitats for growth and adaptation. A specific garden's theme would have to develop plants based on their characteristics and applications. A botanical garden's primary goals (conservation, education, recreation, and research) should each have its own area and design.
7. **Weeds and pest control:** A botanical garden should have methods for controlling invasive species, insects and other vectors that are detrimental to species variety.

8. **Links:** A garden should have governmental and non-governmental connections to be successful in fulfilling its goal. Non-governmental organizations have an important role in addressing both technical and financial concerns.
9. **Professional experts:** Botanists, horticulturalists, taxonomists, landscape designers, ecologists, GIS experts, Biologists (Molecular biologists), Civil/ Construction engineers, soil science experts, and lab technicians accompanied by other supporting staff.
10. **Methods of operation**: Botanic Garden operation techniques include establishing an existing botanic garden organization, recruiting and training staff, developing the plant collection and documentation, providing expert design advice, developing strategic frameworks and policies, carrying out horticultural and botanical work, and developing education, interpretation, and communication programs, including marketing.

CONCLUSIONS

One of humanity's greatest contributions to the earth is the preservation and distribution of botanical gardens to future generations. Throughout history, these gardens have contributed to the region's cultural improvement, scientific breakthroughs, economic expansion, and commercial development. Following the aforementioned functions, these botanical gardens must be renovated, safeguarded, and enlarged in number in accordance with scientific results. Only in this way can fast depleting natural resources be saved and steps made to address rapidly developed environmental concerns.

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