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## The Diversity of Plant Species Used in The Three Large Green Spaces in The City of Constantine Algeria: (Jardin Bennacer, Ciloc and Bardou) and their exploitation in The Field of Tourism

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### Abstract:

This article aims to address the theme of plant varieties diversity used in green spaces in the city of Constantine, Algeria, and their exploitation in tourism, and the sample used is the three large spaces: Jardin Bennacer, Ciloc, and Bardou. We seek to present them and highlight the existing different plant varieties, and finally propose some recommendations and suggestions for their use in ecotourism for tourist attractions.

**Keywords:** green spaces, plant varieties, indicators, ecotourism, city of Constantine.

### Introduction:

Urban green spaces and gardens are considered as an extremely important part for a city which is looking to ensure enjoyment and comfort for its inhabitants; as they constitute the city's green lung and the unique space for physical activity and social communication. They reduce psychological stress in the urban environment, improve human health and living conditions, preserve ecological and climatic balance, provide aesthetic functionality, and reduce noise and hearing damage.

In order to preserve these spaces, laws and regulations related to green spaces in urban areas must be applied and specialized skills must be recruited to plan and implement them. On the other hand, activating citizen participation to the protection of green spaces, raising awareness on their importance, and working to correct their significant deficiencies to obtain a better reality for green spaces and a clean urban environment.

### **Objective of the Study:**

The aim of our work is to study the diversity of plant species used in the three large green spaces in the city of Constantine (Jardin Bennacer, Bel Air “Ciloc,” and Bardou) and to be exploited in the tourism sector.

The study will examine the localization, the inventory, the identification, and the determination of the structure and the composition of all plant species used and exploited in tourism by mapping the three large green studied spaces in the city.

The adopted method is based on the vectorization and localization of the green spaces (Jardin Bennacer, Bardou, and Bel Air “Ciloc”) directly on Google Earth software.

### **Problem Statement:**

To achieve our objectives, we asked the following questions :

- What are the most important urban green spaces (gardens) in the municipality of Constantine ? And what is the diversity of plant species used in the studied gardens ?
- How best to use plant species in the field of tourism?

### **Methodological Approach:**

The methodology followed in this study is based on the following steps :

- Locate and map the three large green spaces in the municipality of Constantine (green spaces : Bennacer, Bel Air (Ciloc), and Bardou) ;
- Conduct field trips (study sites) to undertake an inventory of these spaces (the diversity of plant species);
- Integrate the collected data into the Geographic Information System (GIS);
- Propose the most suitable recommendations to the potential of our case study green spaces in order to increase the tourist attractiveness.

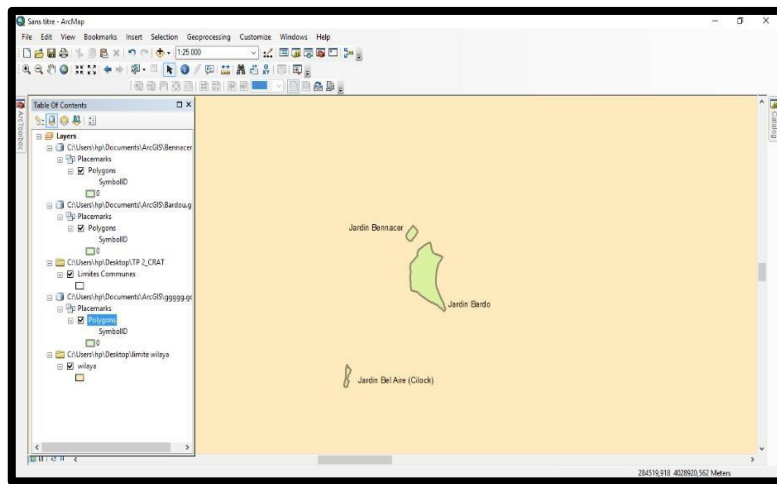
### **A. Vectorization and localization of the three green spaces:**

This step is carried out using Google Earth software. The boundaries of the three green spaces are vectorized directly on the software. Digitization was performed for delimitation using polygons.

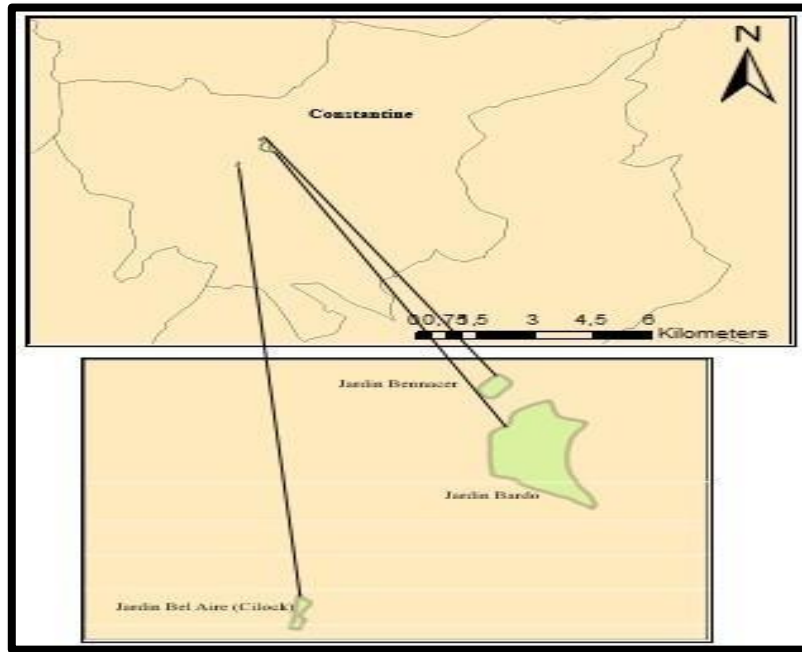



**C. Integration of Collected Data into the GIS:**

The final step consists of integrating all the collected data into the attribute tables of the Geographic Information System (Figure 3), in order to create the necessary geographic database for the spatial study and the structure analysis of the three selected green spaces in the city center of Constantine municipality.



**Figure 3.** Integration of collected data from the three studied green spaces into the Geographic Information System (GIS)



**Figure 4.** Location of the three green spaces in the municipality of Constantine

**Diversity Indices:**

**A. Alpha Diversity:**

**- Richness:**

Richness expresses the local diversity of a station or survey. A survey or study station recorded species number corresponds to richness. This latter represents the most common diversity index in measuring a station diversity.

**- Shannon Diversity Index <sup>(1)</sup>:**

$$H' = -\sum_{i=1}^S p_i \ln p_i$$

*H'* : Shannon biodiversity index

*i* : a species of the study area

*p<sub>i</sub>* : proportion of species *i* (relative frequency) in relation to the total number of species (*S*) in the study area (or specific richness of the area), which is calculated as follows :

$$p(i) = ni/N$$

Where *ni* is the number of individuals for species *i* and *N* is the total number (the individuals of all species).

**- The Simpson's Diversity Index <sup>(2)</sup>:**

$$D = 1 - \sum_{i=1}^S p_i^2$$

*D* : Simpson Index

*i* : a species of the study area

*p<sub>i</sub>* : Proportion of a species *i* in relation to the total number of species (*S*) in the study area (or specific richness of the environment), which is calculated as follows:

$$p(i) = ni/N$$

Where  $ni$  is the individuals' number for species  $i$  and  $N$  is the total number (the individuals of all species).

- **The Pielou Equitability Index** <sup>(3)</sup>:

$$E = \frac{H}{H_{max}} \text{ or } E = \frac{H}{\ln S}$$

$E$ : the Pielou Equitability Index

$S$ : the number of species (or richness) of each survey.

### **B. Beta Diversity:**

Beta diversity expresses the similarity percentage between two or more sites. If the beta diversity index is high, the similarity between the sites is low, indicating that the sites have different species. In our case, we used the Sørensen index to measure beta diversity between the different gardens of Constantine according to the following equation:

$$B_{SOR} = \frac{b+c}{2a+b+c}$$

Where:

$a$ . represents the number of common species between the two sites,

$b$ . represents the number of the existing species in the first site but not in the second,

$c$ . represents the number of the existing species in the second site but not in the first.

### **C. Statistical Analysis:**

For the calculation of alpha and beta diversity, we used the {Vegan} package in the R software.

#### **1. General Concepts:**

##### **1.1. Green Spaces:**

Urban green spaces are considered as an integral part of urban facilities. Their shapes, locations, as well as their sizes differ depending on specific needs they meet and the urban environment into which they are integrated. They are elements of urban aesthetics. It consists in creating natural spaces for breathing, relaxation, and leisure for urban dwellers. Green spaces also serve other functions: they can be areas for production such as forests or agricultural land, preservation of natural and human resources, and open areas for relaxation, breathing, or leisure <sup>(4)</sup>.

Thus, the contribution of urban green spaces to the quality of life has been extremely underestimated, it has never been recognized how much the external environment can influence our physical, social, and cultural development. Several of our agglomerations experience chaotic and uncontrolled development, leading to the unbridled consumption of woodlands and encroachment on sensitive areas favorable to plantations <sup>(5)</sup>.

##### **1.2. Different Types of Green Spaces:**

- **Public Garden:** It is characterized by its proximity to the neighborhood population, offering a diverse range of landscape arrangements on a smaller scale than urban parks: tree and shrub plantations, pedestrian pathways, kiosks, and urban light furniture, etc.

- **Square:** It differs from the public garden by the fact that it is not enclosed within the urban fabric but delineated at all sides by traffic lanes; its boundaries are generally more geometric. Squares are primarily urban setting, places for walking and relaxation.

- **Playgrounds:** they are heavily planted areas, offering a space of proximity to the neighborhood residents where young children and tweens can play.

- **Neighborhood Parks:** Neighborhood parks provide a place for rest and relaxation like squares and serve in addition as a location for recreational activities <sup>(6)</sup>.

### 1.3. Tourism:

According to the UNWTO: Tourism groups together all the activities carried out by people during their travels and stays in places outside their usual environment for a consecutive period that does not exceed 12 months. Those moves are motivated by leisure or other reasons not related to the exercise of a gainful employment on the visited place <sup>(7)</sup>.

*Le Petit Robert* dictionary defines tourism as: "It is the act of travelling and discovering, for one's pleasure, a different place from our own residence, even if a short trip or if the main purpose of the trip is other than leisure" <sup>(8)</sup>.

The French National Economic and Social Council, for its part, defines tourism as "an art aimed at satisfying various aspirations that have driven humans to want to leave their everyday surroundings" <sup>(9)</sup>.

### 1.4 The Tourist:

The UNWTO defines a 'tourist' as a person who travels to a place outside his/her usual environment for a period of less than 12 months and whose main purpose is to visit without engaging in any remunerated activity. Visitors can be classified as follows <sup>(10)</sup>:

- **International visitors:** tourists (staying at least one night); day trippers (carrying out day visits only).
- **Domestic visitors:** who are also tourists (staying at least one night); day trippers (carrying out day visits only).

### 1.5 Types of Tourism:

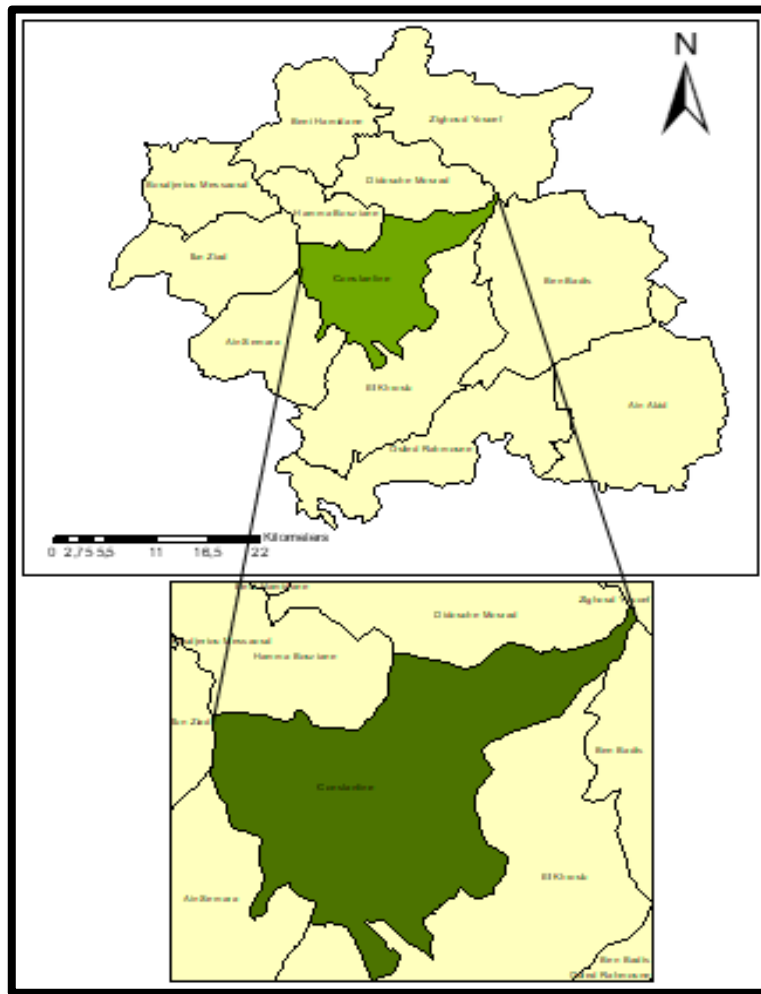
There are several types of tourism, depending on the objective, as follows <sup>(11)</sup>:

- **Religious Tourism:** Considered as one of the oldest types of tourism, it involves visiting religious sites. Among the most famous religious sites in the world are Mecca and Medina, combining religious and cultural contemplation.

- **Therapeutic Tourism:** This involves visiting tourist resorts dedicated to this purpose, relying on natural elements to treat and heal patients, such as mineral springs, sand, and sunlight.
- **Historical Tourism:** This is the best type of tourism as it attracts large groups of tourists, especially if these historical monuments have rest and entertainment centers, as well as all necessary amenities for their preservation.
- **Cultural Tourism:** This type of tourism interests a particular segment of tourists at different levels of culture and education, based on visiting countries with many historical and urban assets.
- **Leisure Tourism:** One of the oldest and most widespread types of tourism. The Mediterranean Sea is considered one of the most attractive areas for leisure tourism due to its beautiful beaches. Leisure tourism aims for personal pleasure and entertainment.
- **Sports Tourism:** This involves temporarily moving from one's place of residence to practice various sports activities or to enjoy their spectacle, such as the Olympics and various world championships.
- **Ecotourism:** This involves traveling and moving from one place to another to enjoy, study, understand, and appreciate natural areas with a sense of responsibility, including all their elements, such as mineral springs, plants, animals, mountains, forests, deserts, etc<sup>(12)</sup>.

## **2. The study Area Presentation:**

Constantine is one of the 58 Algerian provinces. It is located in the northeast of the country and gives its name to its capital. The municipality covers an area of 231.63 km<sup>2</sup>. It is situated between latitudes 36°15'25" and 36°26'56" North and longitudes 6°31'40" and 6°46'04" East (Figure 5).



**Figure 5.** Location of the Municipality of Constantine

### 3. Studied Sampling:

#### 3.1. Bennacer Garden:

- **Location:** The garden Bennacer is located in downtown Constantine in Ben Boulaid Street, within Sidi Rached sector. It was created in 1865 and covers an area of 10,000 square meters.
- **Equipment:** Bennacer Bachir park contains iron benches, a fountain, modern lighting poles, special facilities such as toilets, and a designated area for staff.



**Photo 1.** The garden of Bennacer, Municipality of Constantine (2022)

### 3.2. The garden Bel Air « Ciloc »:

- **Location:** The garden is located in the Ciloc area, next to the tramway. Its location is strategic due to the presence of two urban fabrics, “Belle Vue and Ciloc.” It was created in 1973 and covers an area of 15,400 square meters.

- **Equipment:** It contains well-maintained benches and tables, lighting poles, and trash bins <sup>(13)</sup>.



**Photo 2.** The garden of Bel Air « Ciloc », Municipality of Constantine (2022)

### 3.3. Bardou Garden:

- **Location:** It is located under the Sidi Rached Bridge in the city center of Constantine, to the south Rock, over Oued Rhumel Valley. The Bardou urban garden is bounded to the east by Zamouch Ali Avenue, to the west and southwest by Rahmani Achor Avenue, to the north by Sidi Rached Bridge, and to the south by Mdjez Lagnem Bridge. It was created in 2018 and covers an area of 65 hectares.

- **Equipment:** This garden includes numerous facilities, such as a children's playground, a cafeteria, a restaurant, a parking lot, and a nursery garden for vegetation cover renewal.

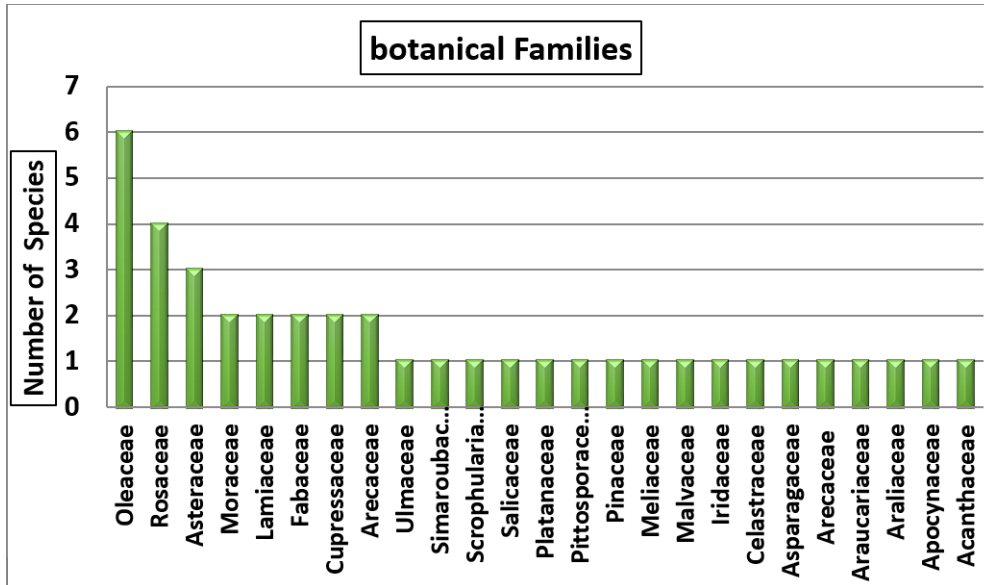


**Photo 3.** Bardou Garden, Municipality of Constantine (2022)

**4. Comparison of Plant Species Diversity in the three studied gardens:**

**4.1. Botanical Families:**

Across all three gardens, we have recorded 40 species belonging to 25 botanical families. The Oleaceae family is represented by six species, followed by the Rosaceae family with four species, the Asteraceae family with three species, and the remaining families are represented by two or one species (Figure 6).

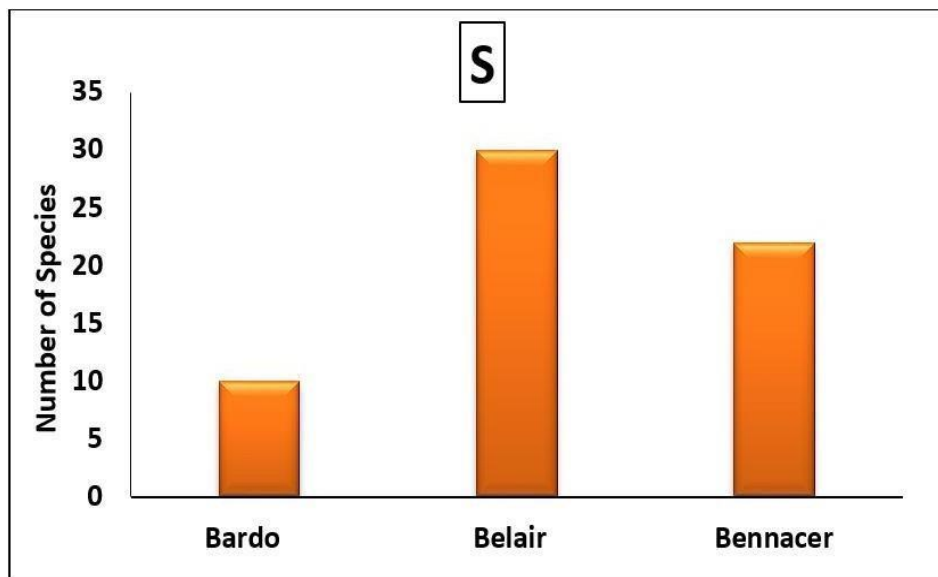


**Figure 6.** Botanical families recorded in the three gardens

**4.2. Alpha Diversity:**

**. Richness:**

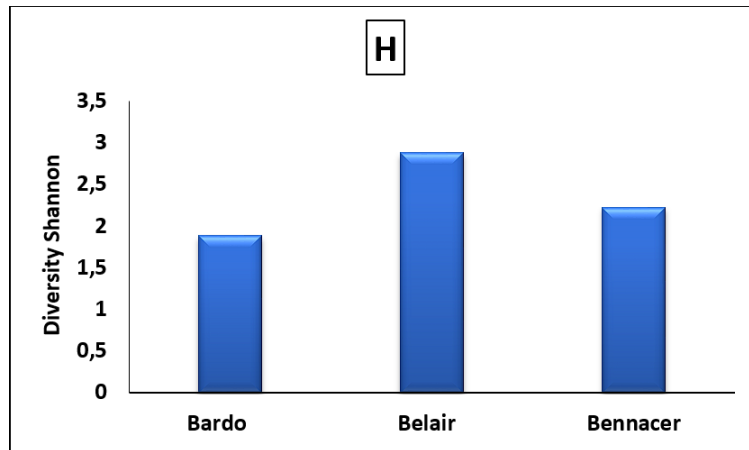
The results illustrated in figure (7) show significant variations in species richness across the different studied gardens. Thus, the highest number (30 species) is recorded for Bel Air garden with 30 species, whereas the lowest number is observed in Bardou garden with 10 species.



**Figure 7.** Richness Index for the three gardens

**. Shannon Diversity Index:**

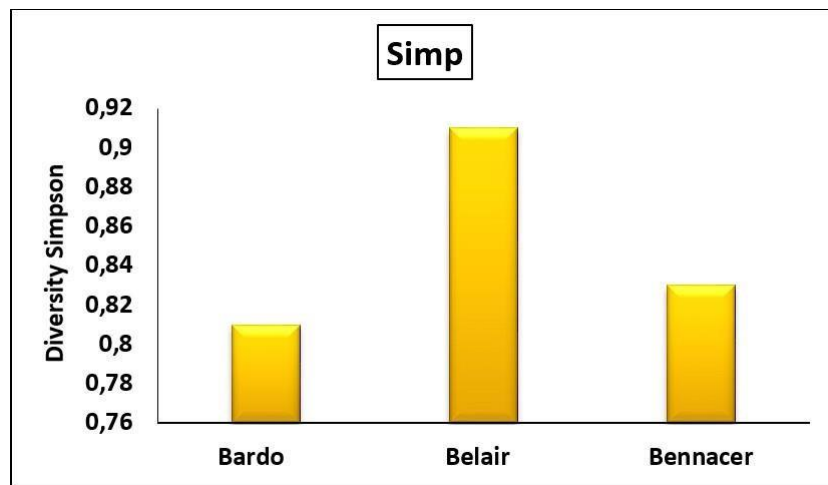
According to the Shannon diversity index, the highest values are recorded in Bel Air garden (2.88), while the lowest values are recorded in Bardou garden (1.89). Bennacer garden presents an average values (2.23) (Figure 8).



**Figure 8.** Shannon Index for the three gardens

**. Simpson Diversity Index:**

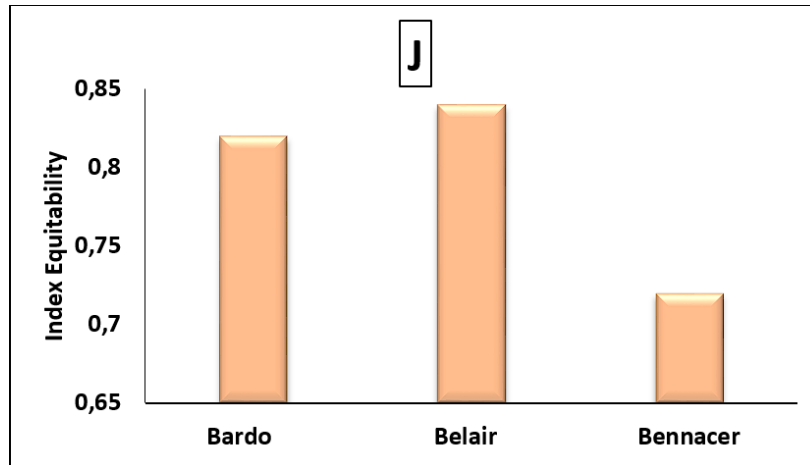
The obtained measures from the Simpson diversity index indicate that the values for Bel Air garden are higher than those of the other two gardens (0.91), the lowest average is obtained in Bardou garden (0.81).



**Figure 9.** Simpson Index for the three gardens

**. Equitability Index:**

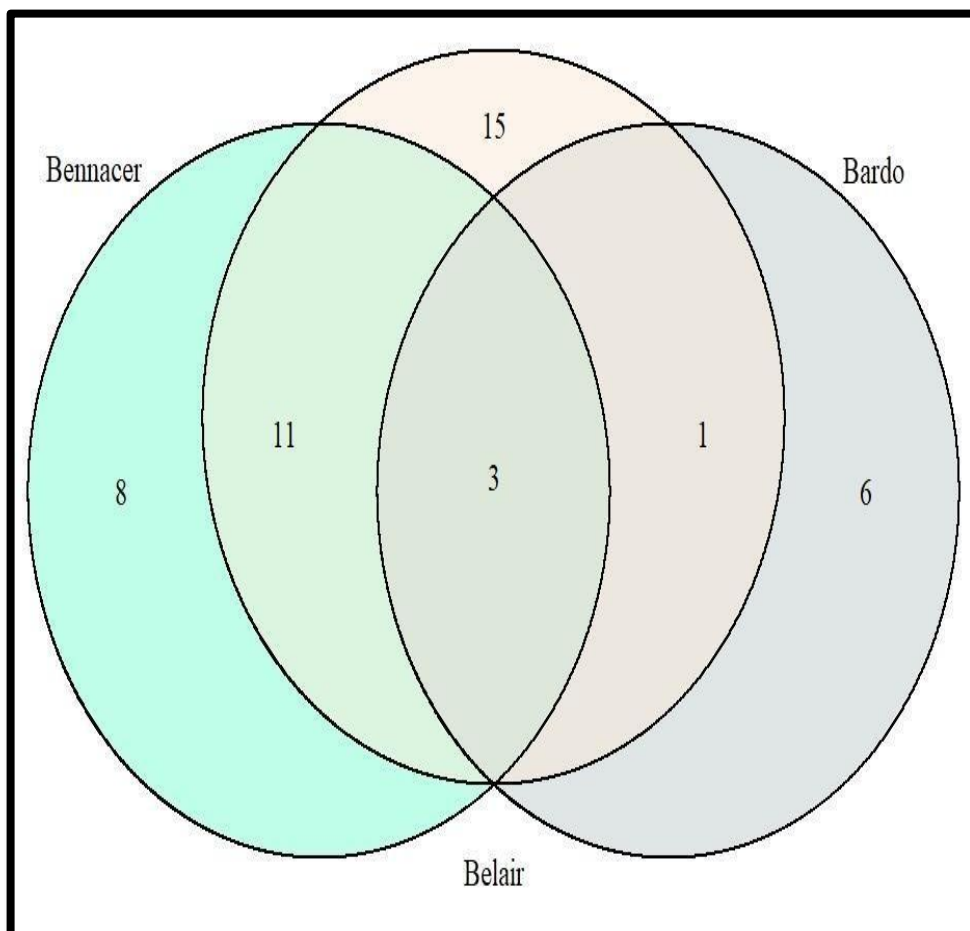
As shown in figure 10, we noted a significant increase at Bel Air garden compared with the two other gardens, averaging 0.84 according to the equitability index. Bennacer garden presents the lowest average (0.72).



**Figure 10.** Equitability Index for the three gardens

**4.3. Common species number and Beta Diversity:**

According to the Venn diagram, it shows that the three gardens have three species in common. The gardens Bennacer and Bel Air have 14 species in common, whereas, there are four species in common between the gardens Belair and Bardou. Bennacer Garden has eight unique species, we recorded 15 species that exist only in Belair garden and six species that exist only in Bardou garden (Figure 11). The calculated beta diversity index indicates a value of 0.62, therefore we can say that the gardens have different compositions in terms of plant species.



**Figure 11.** Venn Diagram for the three gardens

#### 4.4. Origins of Species:

According to the results, more than 77% of the species planted in the three gardens are introduced species, while the rest (23%) are native species. Exotic species may represent a risk of invasion of other indigenous species natural areas, and potentially leading to the extinction of native species; so monitoring and control of these species is very important.

**Table 2. List of Species in the three gardens in the municipality of Constantine**

Scientific Name	int/native	Origin	Families
<i>Agave sisalana</i> Perrine	Introduced	Mexico	Asparagaceae
<i>Ailanthus altissima</i> (Mill.) Swingle	Introduced	China	Simaroubaceae
<i>Araucaria heterophylla</i> (Salisb.) Franco	Introduced	Norfolk Island	Araucariaceae
<i>Argyranthemum haouarytheum</i> Humphries & Bramwell	Introduced	Canary Islands	Asteraceae
<i>Argyranthemum maderense</i> (D.Don) Humphries	Introduced	Canary Islands	Asteraceae
<i>Artemisia thuscula</i> Cav.	Introduced	Canary Islands	Asteraceae
<i>Cercis siliquastrum</i> L.	Introduced	France to Afghanistan	Fabaceae
<i>Crataegus azarolus</i> L.	Native		Rosaceae
<i>Cupressus sempervirens</i> L.	Introduced	E. Medit. to Iran	Cupressaceae
<i>Euonymus japonicus</i> Thunb	Introduced	Korea, Japan	Celastraceae
<i>Ficus carica</i> L.	Introduced	E. Medit	Moraceae
<i>Ficus macrophylla</i> Pers.	Introduced	E. Australia	Moraceae
<i>Ficus retusa</i> L.	Introduced	S. Borneo to Jawa	Oleaceae
<i>Fraxinus angustifolia</i> Vahl.	Native	Central & S. Europe	Oleaceae
<i>Fraxinus</i> sp			Oleaceae
<i>Hedera canariensis</i> Willd.	Introduced	Canary Islands	Araliaceae
<i>Iris albicans</i> Lange	Introduced	Arabian Peninsula	Iridaceae
<i>Justicia adhatoda</i> L.	Introduced	Afghanistan	Acanthaceae
<i>Lavandula dentata</i> L.	Native		Lamiaceae
<i>Ligustrum japonicum</i> Thunb	Introduced	SE. China	Oleaceae
<i>Ligustrum</i> sp	Introduced		Oleaceae
<i>Livistona</i> sp	Introduced		Arecaceae
<i>Malvaviscus penduliflorus</i> Moc. & Sessé ex DC.	Introduced	Texas to Venezuela	Malvaceae
<i>Medicago arborea</i> L.	Introduced	S. Europe to Turkey	Fabaceae
<i>Melia azedarach</i> L.	Introduced	Tropical & Subtropical Asia	Meliaceae
<i>Myoporum laetum</i> G.Forst.	Introduced	New Zealand	Scrophulariaceae
<i>Nerium oleande</i> L.	Native	Mediterranean	Apocynaceae
<i>Olea europea</i> L.	Native	Mediterranean	Oleaceae

Phoenix canariensis H.Wildpret	Introduced	Canary Islands	Arecaceae
Pinus halepensis Mill.	Native		Pinaceae
Pittosporum tobira (Thunb.) W.T.Aiton	Introduced	S. Korea,	Pittosporaceae
Platanus orientalis L.	Introduced		Platanaceae
Platycladus orientalis (L.) Franco	Introduced	Russian Far East	Cupressaceae
Populus nigra L.	Native		Salicaceae
Prunus avium (L.) L.	Native		Rosaceae
Prunus cerasifera Ehrh.	Introduced	SE. Europe	Rosaceae
Rosa sp	Introduced		Rosaceae
Salvia fruticosa Mill.	Introduced	Central & E. Medit.	Lamiaceae
Ulmus minor Mill.	Native		Ulmaceae
Washingtonia robusta H.Wendl.	Introduced	Mexico	Arecaceae

### 5. Development Proposals for each green space:

Each concept is designed to meet users' specific needs while highlighting the characteristics of the Constantine region.

#### • Green Space 1: Ornamental Park (Bennacer)

An outdoor area conducive to relaxation with predominantly ornamental vegetation.

##### Development Proposal:

- Natural stone cladding;
- Oleander bushes at the borders;
- Circular central fountain with modern design;
- Brightly colored flower areas to energize the space;
- Scent garden: lavender, jasmine, rosemary, and thyme to stimulate the senses;
- Stone benches placed under the trees;
- Ambient lighting integrated into the ground or on sculptures;
- Interactive educational panels with QR codes to learn more about the garden's flora;
- Ramp integration for persons with reduced mobility.

#### • Green Space 2: Cultural and Recreational Park (Ciloc)

An open-air interface place between culture and leisure, with zones conducive to relaxation. This space incorporates educational and interactive elements.

##### Development Proposal:

- Clumps of Mediterranean plants;
- Mosaic covering inspired by Constantine's heritage;
- A rectangular mosaic scene for Algerian mosaics traditional representations;

- A rectangular stone scene for cultural performances, with panels illustrating the history of Constantine;
- Interactive educational panels with QR codes to learn more about the history of Constantine's plants;
- Solar lighting along the aisles for nighttime safety;
- Ramp integration for persons with reduced mobility.

- **Green Space 3: Family Urban Park (Bardou)**

Create a space where families can relax, have fun, and enjoy nature safely, with recreational facilities and a pleasant aesthetic setting.

**Development Proposal:**

- Flower bordered paved walkways (roses, lavender);
- Nearby sensory gardens to stimulate children's curiosity;
- Resistant lawns for free activities;
- Bright colored flowering areas for making spaces more dynamic;
- Solar lighting all along the aisles for nighttime security;
- Ramp integration for persons with reduced mobility.

In addition to these specific proposals for each garden (the study sample), we formulate general suggestions as follows:

- Promote the implementation of these gardens and the different plant species to make them focal point for researchers and visitors, whether for discovery or conducting research;
- Produce a specific tourist guide for these gardens, including datasheets and photos of the different plant species, and using them in ecological tourism;
- Extend these ideas to different gardens in the city and not only large gardens (which were taken as the study sample), so that their role is not limited to relaxation and leisure, but also become places of discovery and research;
- Raise awareness among city residents about the need to preserve these different plant species, due to their major role in the aesthetic aspect of the gardens in particular and the city in general.

**Conclusion:**

Based on the above discussion, we find that the three major gardens of the city of Constantine (Bennacer Park, Ciloc Park, and Bardou Park) are distinguished by various plant species, some common and others not (some of global origin). These species play an important role in the aesthetic aspect of these gardens in particular and of the city in general. They can be leveraged to attract tourists, whether for relaxation and leisure or for ecotourism (discovering these different

species or conducting research on them). The development of these gardens with significant facilities, such as a children's playground, lighting, etc., also plays a crucial role in enhancing this ecotourism.

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