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Plant Diversity in the Gardens of the University of Karbala and its Impact on Improving the University Environment

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Abstract

The University of Karbala, located in a semi-arid region of Iraq, faces significant environmental challenges including water scarcity and high temperatures. This study aimed to document the plant diversity within the gardens of the Freiha Complex at the University of Karbala and evaluate its impact on improving the university environment and student well-being. A comprehensive field survey and documentation of plant species were conducted, alongside a comparative analysis with similar international university campuses. The results identified Plant species, As a prelude to a future study that will inventory all cultivated plant species and specify their exact number such as Phoenix dactylifera, Acacia farnesiana, and Ziziphus spina-christi. The study found that these green spaces significantly contribute to local thermoregulation through shading and transpiration, as well as improving air quality by trapping dust and absorbing carbon dioxide.The research concludes that integrating diverse, drought-tolerant plant species and implementing sustainable water management practices are essential for maintaining a restorative academic environment. These findings provide a scientific basis for the development and management of university gardens in arid regions.

Keywords*: nvironmental impact, Karbala University, Plant diversity, Sustainable landscaping.*

1. Introduction

The university environment is one of the essential components that influence the construction of students' academic personality, as the green spaces and trees scattered throughout the campus form an integral part of this integrated ecosystem. Vegetation cover does not only perform an aesthetic function, but goes beyond that to be an active element in improving air quality, reducing pollution rates, and providing shade and psychological comfort, which reflects positively on the academic and mental performance of students. The University of Karbala is located within the holy province of Karbala, a city with a distinctive religious and historical character, famous for its scarcity of water resources and the difficulty of providing them due to its geographical location in a semi-arid region. Despite these environmental challenges, the university has sought to create a balanced green environment in the Freiha complex, which houses most of the university's faculties, by planting multiple types of native and sustainable trees and plants that are able to adapt to difficult climatic conditions. These efforts are of great environmental and cognitive importance, as trees contribute to improving air quality by increasing the amount of oxygen in the atmosphere and reducing the accumulation of polluting gases, as well as their role in stabilizing the soil and reducing dust flying, which are common problems in Iraqi cities with dry climates. These green spaces also provide a comfortable learning environment that contributes to raising concentration and stimulating creative thinking among students. From this perspective, this research aims to document the vegetation cover at the University of Karbala, shedding light on its types, and its impact on enhancing the academic and cognitive learning environment. Moreover, the role of green spaces in enhancing not only the physical environment but also the psychological well-being of students cannot be overstated. Studies have shown that exposure to nature significantly reduces stress levels and promotes mental clarity, which is crucial for academic success. This highlights the importance of incorporating more diverse plant species that are not only aesthetically satisfying but also contribute to biodiversity and ecological balance within the campus. By promoting richer plant diversity, the university can create habitats for various animals, thereby enriching the educational experience through real-world environmental observations. In addition, implementing sustainable landscaping practices, such as rainwater harvesting and the use of native plants, can alleviate the challenges posed by the region's arid climate, ensuring that these green spaces thrive while promoting environmental stewardship among students.

The study concluded that green spaces are a valuable addition to the university environment by students. Students prefer campus spaces with actual greenery or nature posters and expect green outdoor environments to be more restorative. These results suggest that the integration of green spaces into university environments will be well received by students

Research Objectives

1. Introducing the plant environment inside the Fraiha Complex at the University of Karbala.
2. Explaining the most important types of trees planted and their environmental role.
3. Clarifying the impact of trees in improving the university climate and reducing pollution.
4. Highlighting the relationship between vegetation cover and developing students' cognitive skills.
5. Documenting the university's efforts in maintaining the sustainability of the environment despite water scarcity.
6. Documenting Potential Plant Diversity in Karbala University Gardens - Fariha Complex
7. Identify native plant species suitable for cultivation in the study area
8. Comparison of the gardens of the University of Karbala with similar international universities
9. Environmental Impact Assessment of University Green Spaces
10. Providing scientific recommendations for the development and management of the complex's gardens

2.Theoretical Framework and Previous Studies

University parks as hubs of biodiversity

Global surveys have shown that more than 300 campuses around the world have conducted biodiversity studies, confirming the great potential of campuses as urban plant repositories and laboratories (Ives et al., 2016). University parks perform multiple functions including:

- **Environmental conservation**: protection of native and endangered species
- **Scientific Research**: Providing Platforms for Environmental and Taxonomic Studies
- **Education**: Creating outdoor learning spaces for students
- **Community Services**: Supporting student and community projects

World Botanic Gardens

The Global Botanic Garden Network manages extensive living collections of at least 105,634 plant species, demonstrating the large capacity of living populations in institutional settings (Mounce et al., 2017). These parks play a pivotal role in:

- Ex-situ conservation

- Coordinate global networks for plant conservation

Scientific Name	Family	Description and Significance
Artemisia herba-alba	Asteraceae	A perennial, drought-tolerant herbaceous plant, used in folk medicine
Cornulaca monocantha	Amaranthaceae	A desert shrub that is tolerant of salt and drought
Hammada salicornica	Amaranthaceae	A desert plant adapted to harsh environments
Ziziphus nummularia	Rhamnaceae	A native shrub of environmental and economic importance
Pennisetum divisum	Poaceae	Drought tolerant perennial grass
Plantago boisseri	Plantaginaceae	Native herbal plant

- Scientific Research and Plant Classification
- Environmental Awareness and Public Education

Study Area: University of Karbala - Freiha Complex

Geographical location and climatic characteristics

The city of Karbala is located in central Iraq, and is classified as a hot and dry city characterized by:

- **Temperatures**: Significant rise in temperatures during the summer (exceeding 45°C)
- **Rainfall**: Low and fluctuating rainfall rates
- **Humidity**: Low humidity most days of the year
- **Solar radiation**: High levels of direct solar radiation

Environmental Challenges in Karbala

The Karbala region, like the rest of Iraq, faces increasing environmental challenges:

1. **Climate change**: Temperature increases by 0.97°C per decade (Muhaimeed et al., 2025)
2. **Decrease in rainfall**: general decline in precipitation rates
3. **Desertification**: Increasing intensity of soil erosion and loss of vegetation (Muhaimeed et al., 2025)
4. **Water scarcity**: Decreasing water availability for irrigation and agriculture

The Importance of Botanical Design in Karbala

Local studies have emphasized the role of urban vegetation design as a key element in modifying the local climate by(Al-Saffar, 2018):

- Shading and reducing direct solar radiation
- Increased local humidity
- Improve air quality
- Creating a more comfortable environment for users

Plant diversity in Iraq and the Karbala region

Overview of the Flora of Iraq

Iraq is one of the most plant-rich countries in the Middle East, as it contains:

- **Total species**: about 3,300 scientifically accepted plant species
- **Genera**: 908 plant genera
- **Families**: 136 Plant families (Ghazanfar & McDaniel, 2016)

Most important plant families in Iraq

The following families are the largest in terms of species in the flora of Iraq (Ghazanfar & McDaniel, 2016):

1. **Asteraceae (compounds):** large family with many herbaceous plants
2. **Fabaceae (legumes):** includes species that are environmentally and economically important
3. **Poaceae (grasses):** Grasses and herbaceous plants family
4. **Brassicaceae (Cruciferous):** Plants adapted to diverse environments
5. **Apiaceae (tents):** include aromatic and medicinal species

Native plant species recorded in the Karbala region

Based on field surveys in areas near Karbala, the following types have been recorded (Al-Mayah, 2019):

4.3.1 **Desert and drought-tolerant plants**

Endemic and rare species

The flora of Iraq contains 174 endemic species distributed in 27 families and 75 genera (Guest & Al-Rawi, 1966–1985). Newly registered species include:

- *Morettia philaeana*: Recorded as a new addition to the flora of Iraq in the Western Desert (Al-Musawi, 2020)

Areas of Plant Richness in Iraq

The following areas record the highest levels of plant diversity in Iraq (Ghazanfar & McDaniel, 2016):

1. **Mountainous regions**: Iranian-Turanian region
2. **Semi-Natural Areas**: Central Plains
3. **Wetlands**: Marshes and riverbanks

Comparison of the gardens of the University of Karbala with international universities

Models of universities in climate-similar regions

University of Gujarat (India – Ahmedabad)

- **Location**: Ahmedabad, India (hot and dry climate)
- **Number of species**: 451 registered plant species on campus (Modi & Dudani, 2013)
- **Features**:
    - Urban campus
    - Great plant diversity despite harsh climatic conditions
    - Use of native and adapted plants

Gulele Botanical Garden (Ethiopia)

- **Location**: Addis Ababa, Ethiopia
- **Number of species**: 928 plant species (Abyot & Zemede, 2021)
- **Functions**:
    - Urban and conservation botanical garden
    - Focus on medicinal plants and timber
    - Active Research and Educational Programs
    - Meeting the Challenges of Invasive Species

Botanical Gardens in the Middle East

Emirates Plant Database

It contains more than 760 documented native plant species, with ecological and descriptive data fields that

can be used to select locally adapted species (UAE National Plant Database, 2023).

5.3 Comparative Table of Universities and Botanical Gardens

Enterprise	Country	Climate	Number of species	Main Uses
Gujarat University	India	Hot Dry	451	Research, teach, save
Guilli Park	Ethiopia	Tropical	928	Memorization, medicine, research
University of Karbala	Iraq	Hot Dry	Under Documentation	Education, Research, Memorization

Lessons learned from global experiences

1. **Career Diversity**: Successful Universities Integrate Multiple Functions (Research, Education, Preservation, Community Service)
2. **Scientific Documentation**: The Importance of Regular Surveys and Digital Documentation
3. **Local adaptation**: selection of plants adapted to local climatic conditions
4. **Sustainable Management**: Applying Water and Resource Management Practices
5. **Community Engagement**: Engaging Students and the Community in Environmental Programs

Plant species found in the gardens of the University of Karbala

1. Date palm – *Phoenix dactylifera L.*
- **Description:** A vertical perennial tree, 10–20 m high, its leaves are pinnate and tolerate high heat.
- **Watering:** Moderate, tolerant of relative drought.
- **Light:** You need full sun.

2. Acacia – *Acacia farnesiana (L.) Willd.*
- **Description:** A medium-sized shade tree (5–10 m), compound leaves and fragrant yellow spherical flowers.
- **Watering:** Low, drought resistant.
- **Light:** Direct sun.

3. Eucalyptus camaldulensis Dehnh.
- **Description:** An evergreen tree, fast growing, up to 30 m tall, with an oily aroma.
- **Watering:** Moderate, drought tolerant.
- **Light:** Strong direct sun.

4. Sesbania grandiflora (L.) Pers.
- **Description:** A fast-growing tree with a height of 5–10 m, its leaves are feathers and its flowers are white or red.
- **Watering:** Medium to regular.
- **Light:** Full sun.

5. Casuarina – *Casuarina equisetifolia L.*
- **Description:** A thin, densely leaved, wind-resistant tree, up to 15 m tall.
- **Watering:** Low to medium.
- **Light:** Full sun.

6. Ficus (Shade Shade) – *Albizia lebbeck (L.) Benth.*
- **Description:** A wide-crowned shade tree, up to 20 m high, compound leaves and aromatic white flowers.
- **Watering:** Medium.
- **Light:** Full sun or half shade.

7. Tecoma – *Tecoma stans (L.) Juss. ex Kunth*
- **Description:** A small tree or large shrub, its flowers are trumpet-yellow.
- **Watering:** Medium.
- **Light:** Full sun.

8. Dodonia – *Dodonaea viscosa Jacq.*
- **Description:** An evergreen shrub, 1–4 m high, its leaves are simple narrow and glossy green.
- **Watering:** Low, drought resistant.
- **Light:** Full sun.

9. Oleander – *Nerium oleander L.*
- **Description:** A branching shrub with multicolored bright flowers.
- **Watering:** Medium to low.
- **Light:** Full sun.

10. Ficus *nitida Thunb.*
- **Description:** A small evergreen shrub or tree, its leaves are dense glossy green.
- **Watering:** Medium to regular.
- **Light:** Full sun to half shade.

11. Capparis (Goose) – *Capparis spinosa L.*
- **Description:** A creeping spiny shrub, its flowers are beautiful pink-white, used in dry arrangement.
- **Watering:** Very low.
- **Light:** Full sun.

12. Hibiscus (Hibiscus zinni) – *Hibiscus rosa-sinensis L.*
- **Description:** An ornamental shrub with large red or yellow flowers, medium growing.
- **Watering:** Medium.
- **Light:** Full sun.

13. *Rhanterium epapposum Oliv.*
- **Description:** A small desert shrub with a height of 50–100 cm, its leaves are silvery gray.
- **Watering:** Very low.
- **Light:** Direct sun.

14. Henna – *Lawsonia inermis L.*
- **Description:** A medium-height shrub, its leaves are used for cosmetology and dyeing, its flowers are fragrant white.
- **Watering:** Medium.
- **Light:** Full sun.

15. Dieffenbachia – *Dieffenbachia maculata (Lodd.) Schott*
- **Description:** A sheltered indoor or outdoor shade shrub, its leaves are dotted with white and green.
- **Watering:** Medium to high, drought tolerant.
- **Light:** Shadow or half shadow.

16. *Bougainvillea spectabilis Willd.*
- **Description:** Brightly flowering wooden climber.
- **Watering:** Medium.
- **Light:** Full sun.

17. Jasmine – *Jasminum sambac (L.) Aiton*
- **Description:** An aromatic climber with small white flowers.
- **Watering:** Medium.
- **Light:** Full sun to half shade.

18. Ivy – *Hedera helix L.*

- **Description:** Evergreen climber, its leaves are dark green lobed.
- **Watering:** Medium to high.
- **Light:** Half shadow to shadow.

19. Chrysanthemum indicum L.

- **Description:** **A** flowering annual, yellow or white flowers, 30–60 cm high.
- **Watering:** Medium.
- **Light:** Full sun.

20. Eye of the Horn – *Zinnia elegans Jacq.*

- **Description:** A short annual, multi-colored flower, blooms in summer.
- **Watering:** Medium.
- **Light:** Full sun.

21. Jaafari (Marigold) – *Tagetes erecta L.*

- **Description:** A flowering annual, its flowers are yellow or orange.
- **Watering:** Medium.
- **Light:** Full sun.

22. Violet – *Viola odorata L.*

- **Description:** A small annual, with purple flowers, used to cover areas.
- **Watering:** Medium.
- **Light:** Half shade.

23. Petunia – *Petunia hybrida Vilm.*

- **Description:** A short seasonal plant (20–40 cm) with multicolored flowers.
- **Watering:** Medium.
- **Light:** Full sun.

24. The Carpet (Coleus) – *Coleus blumei Benth.*

- **Description:** An ornamental annual plant with multicolored leaves (green, purple, yellow).
- **Watering:** Medium to high.
- **Light:** Half shade.

25. Marigolds – *Calendula officinalis L.*

- **Description:** An annual plant with yellow-orange flowers, grown in winter.
- **Watering:** Medium.
- **Light:** Full sun.

26. Clove – *Dianthus caryophyllus L.*

- **Description:** Flowering ornamental plant, multi-colored flowers, 30–50 cm high.
- **Watering:** Medium.
- **Light:** Full sun.

27. Purslane – *Portulaca grandiflora Hook.*

- **Description:** **An** annual creeping plant, its flowers are bright, cultivated to cover the soil.
- **Watering:** Low.
- **Light:** Strong sun.

28. Wonka (Purlin Plant) – *Catharanthus roseus (L.) G. Don*

- **Description:** An upright annual plant, pink or white flowers, drought resistant.
- **Watering:** Medium to low.
- **Light:** Full sun.

29. Tulip – *Lilium candidum L.*

- **Description:** A perennial bulbous plant, its flowers are fragrant white, about 1 m high.
- **Watering:** Medium.
- **Light:** Full sun to half shade.

30. Basil – *Ocimum basilicum L.*

- **Description:** A seasonal aromatic plant, its leaves are bright green, used for decoration and fragrance.
- **Watering:** Medium to regular.
- **Light:** Full sun.

31. Arak (*Salvadora persica*)
is a medium-tall (2–4 m) evergreen shrub, with small, glossy oval leaves. It is drought and salinity tolerant, and is grown as a vegetable fence.
Lighting: Full sun.
Water requirement: Very low.

32. Conocarpus *erectusA*
fast-growing tree, up to 8–10 m high, with dense green leaves, used as a windbreaker and in shade of walkways.
Lighting: Full sun.
Water requirement: Low.

33. Lantana *(*Lantana camara
)A small flowering shrub (1–2 m), with multicolored flowers (yellow, pink, orange). It is cultivated to decorate walkway beds and central gardens
.Lighting: Full sun.
Water requirement: Medium.

34. Elephant (*Jasminum sambac*)
A small shrub with fragrant white flowers that is grown near college entrances and side walkways.
Lighting: Full sun to half shade.
Water requirement: Medium.

35. Moringa oleiferaA fast-growing tree, 5–10 m high, compound leaves and used medicinally and
nutritionally.
Lighting: Full sun.
Water requirement: medium to low.

36. Sidr (Buckthorn) (*Ziziphus spina-christi*)
A drought-resistant native tree, its leaves are dense green, and its fruits are edible. It is grown on the ends of walkways.
Lighting: Full sun.
Water requirement: Very low.

37. Fig (*Ficus carica*)
A medium-sized tree with large, lobed leaves, its fruits are edible summer.
Lighting: Full sun.
Water requirement: Medium.

38. Casuarina *(*Casuarina equisetifolia
) A slender tree with needle-shaped leaves, used as a windbreaks and as a green belt
.Lighting: Full sun.
Water requirement: Low.

39. Dwarf oleander *(Nerium oleander nana*) is
a small variety of oleanderE, grown on the sides of sidewalks and in driveways to decorate edges.
Lighting: Full sun.
Water requirement: Low.

40. Pomegranate (*Punica granatum*)
is a small tree (3–5 m), with red flowers and antioxidant-rich fruits.
Lighting: Full sun.
Water requirement: Medium.

41. Tamarind (*Tamarindus indica*)
A medium-sized evergreen tree, with compound leaves and yellow flowers. It makes an aesthetic appearance in open gardens.
Lighting: Full sun.
Water requirement: medium to low.

42. *Citrus limon* is
a small to medium-sized, evergreen tree, with bright green leaves and fragrant white flowers, grown in open spaces near buildings.
Water requirement: Medium – you need regular watering, especially in summer.
Lighting Needs: Full sun – does not tolerate long shade.
43. Orange (*Citrus aurantium*)
is a medium-tall, evergreen, fragrant tree with a distinctive scent and fragrant white flowers, used to decorate walkways and indoor gardens.
Water requirement: Medium – it is preferable to irrigate it regularly without watering the soil.
Lighting Need: Full sun to half shade – thrives more in direct sunlight.
44. Thiel (*Cynodon dactylon*)A
creeping herbaceous plant used to cover the green areas of the university, it is characterized by its rapid growth and high endurance.
Water Requirement: High – It needs frequent irrigation to keep it green.
Lighting Need: Full sun – does not thrive in the shade.
45. Elias (*Myrtus communis*)
An evergreen shrub with small, fragrant leaves and beautiful white flowers, used in landscaping and walkways.
Water requirement: Medium – needs regular irrigation with good water drainage.
Lighting Need: Full sun to half shade – tolerates partial shade.
46. *Washingtonia (Washingtonia robusta*) A
tall, fast-growing palm with a stem 30-40 cm in diameter and helicopter-shaped leaves, planted on the sides of main roads and corridors of the university.
Water requirement: Low to moderate – tolerates long periods of drought.
Lighting Needs: Full sun – You need strong light for good growth.

Environmental Impacts of University Greens

Improving Air Quality

Vegetation spaces contribute to improving air quality by(Ives et al., 2016):

- **Dust and particle** trapping: leaves and stems act as a natural strainer
- **Carbon Dioxide Absorption**: Photosynthesis
- **Oxygen Production**: Improving Air Quality
- **Reducing pollutants**: Absorption of harmful gases

Local thermoregulation

Trees and plants play a crucial role in modifying the local climate (Al-Saffar, 2018):

Cooling mechanisms

- **Shading**: Reduce direct solar radiation
- **Transpiration evaporation**: Ambient air cooling
- **Wind insulation**: reduce the speed of hot winds
- **Reduced heat reflection**: from hard surfaces

Effect of Botanical Design

Studies in Karbala have shown that (Al-Saffar, 2018):

- Trees are the most influential design element in adapting the local climate
- Tree row planning is an effective design element
- Choosing varieties with a dense crown that lowers surface temperatures
- Plant wind belts filter dust and lower wind speed

Educational and Research Benefits

Live Laboratory

Campus gardens (Ives et al., 2016) allow:

- **Field Experiences**: Practical Studies for Students
- **Location-Based Approaches**: Experiential Learning
- **Graduation Projects**: Research in Taxonomy and Conservation
- **Agricultural Applications**: Experiences of Sustainable Agriculture

Scientific Research

- **Biodiversity studies**: regular species surveys
- **Climate Adaptation Research**: Plant Response to Change
- **Urban Ecology**: Interactions in the Built Environment
- **Conservation and Breeding**: Techniques for Saving Threatened Species

Social and psychological benefits

- **Improving Mental Health**: Reducing Stress and Anxiety
- **Increased Productivity**: A Better Study Environment
- **Socializing**: Spaces for Interaction
- **Institutional Identity**: Enhancing the University's Image

Recommendations for the Development of Karbala University Gardens - Freiha Complex

Phase I: Survey and Documentation

Conducting a Comprehensive Fluorescence Survey

- **Field survey**: Documentation of all plant species currently present
- **Scientific Classification**: Identifying the Exact Scientific Names
- **Photography**: Visual documentation of all genres
- **Database**: Create an Updated Digital Record

Assessment of Environmental Conditions

- **Soil Analysis**: Physical and Chemical Properties
- **Study of the local climate**: temperature, humidity, wind
- **Water Assessment**: Irrigation Sources and Water Quality
- **Site Map**: Identifying Suitable Areas for Agriculture

Stage II: Selection and cultivation of plants

Criteria for Plant Selection

Priority for native plants:

- Species endemic to Iraq and the Karbala region
- Plants adapted to dry and hot climates
- Species of Environmental and Scientific Importance

Recommended plants for cultivation:

Scientific Name	**genre**	**Importance**	**Water Requirements**
Ziziphus nummularia	Shrub	Environmental and economic	Low

Artemisia herba-alba	Herbaceous	Medical & Environmental	Very low
Pennisetum divisum	Perennial Grass	Floor Covering	Low
Tamarix spp.	tree	Salinity Resistant	Medium
Phoenix dactylifera	Palm	Economic and Shadow	Medium
Prosopis spp.	tree	Nitrogen fixation	Low

Design of thematic areas

Dividing the garden into units:

1. **Local Flora Area**: View of Native Iraqi Flora
2. **Desert Botanical Garden**: Drought Tolerant Species
3. **Medicinal plant garden**: species with therapeutic uses
4. **Research Area**: Experimental pieces for students and researchers
5. **Environmental Education Park**: Guided Paths and Signboards
6. **Shade and rest area**: dense trees for rest

Phase III: Climate Design

Shading Strategies

- **Rows of** trees: On both sides of the main walkways
- **Arboreal groups**: in clustering areas
- **Wind** Belts: Around the Perimeter of the Complex
- **Covering Situations**: Using Shade Trees

Sustainable Water Management

Water Conservation Techniques:

- **Drip irrigation**: to reduce wastage
- **Rainwater Collection**: Collection Tanks
- **Water Reuse**: Greywater Treatment
- **Organic mulching**: reducing evaporation from the soil
- **Choosing Low-Consumption Plants**: Drought-Tolerant Species

Soil Improvement

- **Adding Organic Matter**: Improving Structure and Fertility
- **Balanced fertilization**: according to the needs of each species
- **Salinity Treatment**: If Required
- **Surface Coverage**: Erosion Protection

Phase IV: Research and Educational Programs

Monitoring and Research Programs

- **Periodic surveys**: regular documentation of biodiversity
- **Growth Studies**: Monitoring the Performance of Different Species
- **Adaptation Research**: Plant Response to Local Conditions
- **Student Projects**: Integrating the Garden into the Curriculum

Education and Outreach

- **Guided tours**: Students and visitors
- **Workshops**: On native plants and conservation
- **Signage**: Information on each type
- **Digital App**: An Interactive Guide to the Garden

Phase V: Management and Maintenance

Long-Term Management Plan

- **Dedicated Team**: Gardeners and Botanists
- **Maintenance Schedule**: Irrigation, Fertilizing, Pruning, Pest Control
- **Quality Control**: Regular Assessment of Plant Health
- **Documentation**: Accurate records of all activities

Partnerships and Collaborations

- **International Universities**: Exchange of Experiences and Botanical Materials
- **Botanic Gardens:** Joining International Networks (**Botanic Gardens Conservation International**)
- **Research Institutions**: Collaboration on Projects
- **Local Community**: Volunteering and Awareness Programs

Conclusion and Conclusions

Key findings

1. **Iraqi Botanical Richness**: Iraq has ~3,300 plant species that provide a rich base for the development of university gardens
2. **Available local species**: Several native species suitable for cultivation in the Freiha complex have been identified, especially drought-tolerant species
3. **International Comparisons**: Universities in Climate-Similar Regions Successfully Run Botanical Gardens with Hundreds to Thousands of Species
4. **Environmental impacts**: University greenery offers multiple benefits in improving local climate, air quality, and biodiversity
5. **Research Potential**: University of Karbala Gardens Could Become a Regional Center for Research and Conservation

Expected Challenges

1. **Extreme climate**: extreme heat and drought
2. **Water Limitation**: Water Scarcity
3. **Finance**: The Need for Sustainable Financial Resources
4. **Specialized Cadres**: Lack of Experience in Botanical Garden Management
5. **Maintenance**: Ongoing maintenance requirements

Available Opportunities

1. **International Cooperation**: Partnerships with Global Universities and Botanical Gardens
2. **Research Funding**: Grants and Funded Projects
3. **Growing Interest**: Growing Environmental Awareness
4. **Strategic location**: Karbala is an important religious and cultural center
5. **Human Resources**: Passionate Students and Researchers

Final Recommendations

For the University Administration:

1. Allocating an annual budget for the development and maintenance of gardens
2. Establishment of a specialized unit for the management of gardens and green spaces

3. Integrating the park into the university's strategic plan
4. Encouraging research and student projects related to the park

For Researchers and Academics:

1. Conducting regular field surveys
2. Publication of research in peer-reviewed journals
3. Collaboration with international experts
4. Development of specialized postgraduate programs

For Students:

1. Participation in environmental volunteering programs
2. Selection of research topics related to the garden
3. Contributing to documentation and monitoring
4. Spreading environmental awareness among colleagues

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