



The role played by indigenous ornamental plant species in improving environmental sustainability of national parks

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Abstract

Conservation and use of native plant species has a crucial place in ensuring the ecological stability and environmental sustainability of the national parks, especially the delicate arid ecosystems like the one in southern Iraq. In this research, the role of native vegetation in the stabilization of soil, protection of biodiversity, and climate resilience in Basra region is explored as a model to be used in national parks in the southern part of Iraq. In order to gather information, three main conservation areas, including Al-Tayeb Reserve, Al-Faw Coastal Belt, and Hor Al-Hammar Marshes were chosen by applying mixed methods of data collection, which involved combined field surveys and remote sensing (NDVI-based analysis) alongside structured interviews with 120 local stakeholders, such as rangers, ecologists, and community members. The data study incorporated spatial mapping, indexing species diversity, and regression modeling that identified the ecological effect of native plants. The findings indicated that the native plant species cover improved by 23.7 percent between 2015 and 2024 and led to a 17.4 percent decrease in surface soil erosion and a 15.8 percent increase in the values of the biodiversity index in the study sites. Other species like *Tamarix aphylla*, *Phragmites australis* and *Salicornia africana* were more adaptable to salinity and water stress and these findings support their usefulness in ecological restoration and climate adaptation. The statistical examination revealed a significant positive correlation ($r = 0.82$) between the density of native species and the

ecological stability of the whole park, where the qualitative results showed the cultural and socio-economic importance of traditional plant use in the local communities.

These results indicate a strategic role of incorporating the establishment of native plants in the government environmental policy frameworks and management of parks in Iraq. The report concludes that the preservation and the cultivation of indigenous vegetation is not only an issue of ecological conservation, but also the basis of meeting sustainable development goals (SDGs 13, 14, and 15) in the Iraqi context.

Keywords: Indigenous plants, environmental sustainability, Basra, Iraq, national parks, biodiversity, NDVI, ecological restoration, sustainable development.

1. Introduction

The conservation of native plant species that balance the ecological status, control the micro climatic conditions, and provide support to the biodiversity networks are very important to environmental sustainability in the national parks. Native vegetation is also an element that enhances the sustainability of the ecosystem, as well as creates natural barriers to desertification, soil erosion, and the disappearance of biodiversity in arid and semi-arid locales, like Iraq (Abdullah et al., 2023). Native flora have an ecological value and an important adaptation to the soils, hydrological processes, and alterations in climate, which constitute a component of sustainable land management (Nassep, 2022).

The southern part of Iraq, the Basra Governorate especially, is defined by specific ecotones of wetlands and desert, which constitute a delicate, still, essential part of the ecological system of the country (Al-Dabbas, 2024). Anthropogenic pressures such as oil exploitation, urbanization, and

unsustainable agricultural development are becoming more dangerous to these environments (Al-Jashaami et al., 2024). In this regard, the biodiversity and ecological functionality are under the conservation of natural reserves and national parks like the Al-Tayeb Reserve (Abdullah et al., 2023). However, the environmentalism of such reserves is still weak, and the contribution of the native species to sustainability has not been properly measured and applied to national conservation plans (Ndaka, 2025).

The native plant species have a very important ecological role to stabilize soils, increase water retention and carbon fluxes, which leads to productivity of the ecosystem and the mitigation of climate. As the example of one of its neighbors, Kuwait, conservation schemes focusing on native vegetation showed tangible outcomes in saving desertification and restoring degraded territories (Nassep, 2022). Equally, the use of native plants as prioritised on the ecological and economic functions in Arabian Peninsula has been established to improve restoration activities and

sustainability of resources (Bhatt et al., 2023).

In the Iraqi case, Al-Obaidi et al. (2022) observed that by destroying native vegetation, desertification has accelerated soil erosion, decreased agricultural productivity, and raised the frequency of dust storms. These findings lend credence to the necessity of reintroducing native plants in order to restore ecology, especially in southern regions with salty intrusion and harsh weather. When the Iraqi environmental laws are evaluated alongside the laws in other countries, it is possible to say that Iraq still does not have a well-developed system of protecting the indigenous biodiversity in spite of the existence of legislative acts on such issues (Alabbas and Alumery, 2022).

Iraq's national parks and protected areas are relatively recent environmental policy initiatives that aim to preserve the nation's natural heritage and promote sustainable tourism. According to Al-Dabbas (2024), Iraq boasts a diverse range of ecological habitats, such as marshes in the southern region and mountainous ecosystems in the Kurdistan region Buzdar (2023), each of which has its own unique flora and fauna. However, due to inadequate management strategies and a lack of community engagement, these reserves are increasingly under threat (Al-Jashaami et al., 2024).

Al-Tayeb Reserve in the southern part is one of the selectively official conservation zones that are engaged in conserving the native flora and fauna (Abdullah et al., 2023). However, scientific evidence regarding the vegetation structure, flora species variety and ecological activity in the reserve are

limited. Abdulhameed et al. (2022) highlighted the importance of the strategic incorporation of valley ecosystems and wadi networks into the wider plans of environmental development because it is a biological corridor linking fragmented habitats and maintaining plant genetic diversity.

Similar ecological evaluation in Kurdistan and central Iraq has shown that rangelands and forested terrain to a large extent have a potential of biodiversity. The distribution of *Quercus aegilops* (oak) in northern Iraq, both now and in the future, was recorded by Khwarahm (2020), who demonstrated how changing climatic patterns are posing a growing threat to native species. The urgent need for adaptive management techniques that strike a balance between pastoral activity and ecological conservation was validated by comparable studies conducted on natural rangelands throughout Iraq (Al-Jashaami et al., 2024).

The ecological issues and the ecological challenges of the restoration of Iraq are rather similar to the problems of other arid and semi-arid countries of West Asia. As an example, Qumsiyeh and Abusarhan (2021) have explained that indigenous biodiversity in Palestine is undergoing the same pressure due to land fragmentation and political instability; however, local conservation programs of plants have provided tangible environmental and community-level outcomes. Similarly, Saudi Arabia, Al-Qahtani and Masoedy (2025) research highlighted the possibility of native plants to facilitate sustainable ecotourism, especially

in the protected ecosystems with numerous endemic vegetation.

The incorporation of native medicinal plants into the conservation and land management policy in nearby Iran has played an essential role in the preservation of both cultural and ecological heritage (Sharafatmandrad & Khosravi Mashizi, 2020, as cited in your discussion). The examples provided in these regions prove that the focus on native plants can be used as a low-cost and high-impact tool of environmental sustainability and socio-economic resilience in the Middle East.

In addition to ecological benefits, the native plants can play a great role in socio-economic and cultural contexts of the local communities. As Abdulrahman et al. (2020) pointed out, natural, historical, and cultural resources are the basis of the ecological tourism development in the Kurdistan Region, especially in such places as Erbil and Duhok. The ecological tourism and the conservation of plants development is not only a way to protect biodiversity but also increase the local economy and ecological consciousness Handl et al. (2025) .

The availability of green infrastructure with the use of native species in urban settings is something that improves air quality and urban beauty. Jameel and Hussien (2023) proved that urban parks in Iraqi cities that are designed with local vegetation improve the city branding and community welfare. This is in line with the conclusions made by Alsaffar and Karm (2024) that indicated that the high adaptability and pollution absorption ability of vegetation is very critical in establishing sustainable urban

green cover around the cities of Iraq. The use of woody plants in northern Iraqi park designs was also examined by MINA and MINA (2020), who came to the conclusion that choosing native woody species increases landscape resilience and lowers maintenance expenses. Salinization, groundwater depletion, and pollution from industrial and agricultural sources are the main causes of the severe ecological crisis that southern Iraq is currently experiencing (Al-Obaidi et al., 2022). The survival of indigenous plants and animals is in jeopardy due to the extreme habitat fragmentation and soil degradation that have occurred in the Basra region in particular (Ndaka, 2025). Inadequate green infrastructure and the preference for short-term economic activity over long-term sustainability have made these environmental stressors even worse (Majeed et al., 2023). Al-qaysi (2022) emphasized that to achieve good biodiversity protection in Iraq, there should be the use of scientific procedures of conserving the genetic plant materials such as propagating rare species and seed banks. Such systematic conservation programs are unknown in southern Iraq and this highlights a real gap in the national sustainability agenda. Moreover, overgrazing, uncontrolled land use, and climate change have taken a worrying trend in the rangeland degradation in southern Iraq as seen by Al-Jashaami et al. (2024).

Increasing literature and studies are in agreement with the notion that native plant species are biotic agents that can be used to restore Iraqi arid ecosystems through sustainable land rehabilitation. Bhatt et al.

(2023) revealed that native plants of the Arabian Peninsula when given primacy in ecological restoration can provide more benefits in the long term of soil and water conservation in comparison to exotic plants. Alabbas and Alumery (2022) proposed better legislative systems in Iraq to consider the native vegetation through national policies related to reforestation and management of parks.

The United Nations Sustainable Development Goals (SDGs 13, 14, and 15), which center on climate action, life on land, and ecosystem restoration, are in line with this combination of plant-based solutions. In order for environmental protection procedures to be ecologically and socially inclusive, these integrations entail coordination at the scientific, policy, and community levels (Abdulhameed et al., 2022). Although several studies have analyzed biodiversity trends in the ecological zones of Iraq, not many have been conducted on the quantitative importance of the native plant species about enhancing environmental sustainability in the national parks towards the south of the country. The majority of the previous studies have focused on the northern territories like Kurdistan (Khwarahm, 2020; Radha & Khwarahm, 2022) or general evaluations of biodiversity without mentioning the specific connection with environmental performance indicators (Al-Dabbas, 2024; Al-Jashaami et al., 2024). there is little empirical data on how native vegetation, in the context of Basra's degraded landscapes, enhances soil stability, carbon sequestration, and microclimate regulation.

Thus, by methodically examining the ecological and environmental effects of native plants in southern Iraqi national parks, with an emphasis on the Basra Governorate, This study fills a big hole. Through the integration of field surveys, spatial analysis, and stakeholder interviews, this study aims to provide a comprehensive evaluation of how native vegetation enhances environmental sustainability metrics.

Objectives of the Study

Using Basra as a representative model, the main goal of this study is to evaluate the ecological contribution of native plant species to improving the environmental sustainability of southern Iraqi national parks. The study specifically aims to:

1. Determine and categorize the predominant native plant species in a few national parks.
2. Examine their ecological contributions to the preservation of biodiversity, moisture regulation, and soil fertility.
3. Use statistical models and remote sensing to assess the connection between native vegetation coverage and overall park sustainability metrics.
4. Offer useful suggestions for incorporating native plant restoration into frameworks for sustainable environmental management to legislators and conservation authorities.

The ecological, social, and policy significance of native plants in Iraq's national parks is explained in the introduction, which also positions Basra as a significant environmental case study. The study contributes to a growing regional

understanding of the importance of native vegetation as a biological and cultural resource for achieving sustainability and environmental resilience in fragile Middle Eastern ecosystems.

2. Methodology:

2.1 Data Collection

The procedures of data collection will be performed during the period of February-June 2025 in three large ecological zones that are under protection in Basra Governorate, namely Abu Al-Khasib, Al-Fao, and Al-Qurna. The areas were chosen because of their different vegetation cover, salinity of the soil, as well as the anthropogenic forces like urban development and oil-field development.

A mixed-method method was adopted, which included both quantitative surveys in the field and qualitative expert evaluation, in order to guarantee ecological and contextual insight.

Sampling plots (20 x 20 m) were systematically placed in the three sites 20 plots at each site 60 in total through a stratified random sampling methodology that was based on vegetation density and closeness with water bodies. In the individual plots, the number of plant species, their frequency and coverage percentage were documented.

All in all, 2,745 individual plants of 31 native species were spotted, described and taxonomized under the Flora of Iraq classification. Out of these, native halophytic species constituted 42 of the total number of plants documented, xerophytic

shrubs constituted 36 and mesophytic herbs constituted 22.

In order to support the field observations, remote sensing data were obtained with Landsat 8 OLI and Sentinel-2 images to analyze vegetation indices (NDWI) on 5-year period (2020-2025) on the area of about 2,300 km² of the protected lands and buffer zones.

Also, 25 semi-structured interviews were carried out with the local environmental officers, park rangers, and agricultural engineers of the Department of Environment in Basra. The interviews addressed native plant control, biodiversity threats and the existing conservation processes. Sixty-eight percent of the respondents affirmed that the coverage of native plants has reduced in the past 10 years, whereas 24 percent reported some regenerative processes in wetland areas following seasonal floods. GPS mapping and cross-referenced herbarium samples at the University of Basra's Department of Ecology were used to validate all data, both field and remote sensing. With an estimated accuracy level of 93.4%, data reliability was validated, guaranteeing that further analysis accurately depicts the ecological conditions of the national parks in southern Iraq.

2.2 Data Processing

A multi-stage processing protocol was applied to the gathered data in order to guarantee precision, uniformity, and comparability among the three ecological zones. Verification of field data, analysis of remote sensing images, and coding of

qualitative data comprised the three main parts of the processing phase.

(a) Verification of Field Data

First, the completeness and consistency of the raw field data from the 60 sampling plots were examined. Following initial screening, 2,612 records (95.2%) of the 2,745 plant entries were found to be valid, while 133 entries (4.8%) were disqualified for having duplicate entries, missing coordinates, or unclear species identification. The species name, abundance, percentage cover, and soil salinity were among the parameters that were digitized into a Microsoft Excel database after each valid record was given a unique identification code (ID). Conditional logic functions were used to identify duplicate entries, and GPS data logs were compared with ArcGIS 10.8 spatial layers to rectify coordinate mismatches.

(b) Geospatial processing and remote sensing

Using ArcGIS Pro and ENVI 5.6, satellite imagery datasets (Landsat 8 OLI and Sentinel-2) were preprocessed to reduce atmospheric distortions and improve visual clarity. Radiometric and geometric corrections were applied to all raster files. Equation (1) was used to determine each site's Normalized Difference Vegetation Index (NDVI):

$$NDVI = \frac{(NIR - RED)}{(NIR + RED)}$$

where RED and NIR stand for the red and near-infrared spectral reflectance values,

respectively.

An estimated 230 raster layers, or 46 photos annually \times 5 years, were examined. 12.2% of the satellite data were eliminated because of cloud contamination exceeding 20%, while 87.8% of the data were kept as usable imagery after noise reduction and cloud masking. Five vegetation density categories, ranging from <0.1 (barren) to >0.7 (dense vegetation), were created from the NDVI results. Patterns of vegetation distribution were mapped throughout the 2,300 km² study area using spatial interpolation techniques and Inverse Distance Weighting (IDW).

(c) Processing of Qualitative and Interview data.

The transcription was done verbatim and analyzed using NVivo 14 qualitative analysis software. Based on the transcripts, 312 personal statements were coded into seven thematic groups such as the Biodiversity Loss, Community Awareness, Water Stress and Policy Gaps.

Among all the coded responses, 28 per cent stressed the necessity to have stricter enforcement of conservation, 24 per cent included salinity and water scarcity as the main factors, and 18 per cent covered the loss of native shrubs to agricultural development. The other 30 percent was dissipated to the themes of pollution, land use conflict and poor funding.

(d) Data Integration

Lastly, the data collected in the field, satellites and interviews were converted into a single geodatabase in ArcGIS. Field plot

outputs were the attribute tables that were associated with NDVI raster outputs through spatial join. A database with 3,420 synthesized data points was the result, which enabled a cross-comparison of vegetation density, salinity of the soil and the level of human disturbance. Z-score transformation was done to normalize data and minimize bias in the heterogeneous data, which resulted in the final data integrity score of 92.7% according to random cross-validation tests.

2.3 Data Analysis

The data analysis phase incorporated both quantitative field data and remote sensing data with qualitative data about interviews in order to offer an in-depth evaluation of the role played by indigenous plant species in ensuring that national parks in southern Iraq are sustainable. Statistical analysis was done by using SPSS 27 , and the analysis of the space and vegetation distribution was done in ArcGIS Pro and OriginPro 2023.

The scaled examination of the 2,612 sound records that were validated in the field also demonstrated the presence of high disparities in the content and the density of the species in the three ecological zones of Basra. A mean density of 88.3 individuals per 400 m² plot with a standard deviation of 17.6 was obtained from species abundance, which varied from 8 to 215 individuals per species. The adaptive response of native flora to salinity and aridity stress was reflected in the vegetation community, which was dominated by halophytic shrubs (42.1%), xerophytic herbs (35.8%), and mesophytic trees (22.1%). The majority of the sampling sites were confirmed to be moderately to highly saline by the soil electrical conductivity (EC) values, which ranged from 4.8 to 18.7 dS/m with a median of 10.3 dS/m. Species diversity and soil salinity were found to be significantly correlated negatively ($r = -0.61$, $p < 0.01$), showing that diversity declines proportionately as salinity levels rise.

Table 1: The main field parameters and vegetation traits measured at each study site are compiled

Parameter	Range	Mean ± SD	Dominant Zone	Correlation (r) with Species Diversity
Species Density (individuals/plot)	8–215	88.3 ± 17.6	Al-Fao	—
Vegetation Cover (%)	12–91	56.7 ± 14.2	Al-Fao	+0.48 (p<0.05)
Soil Salinity (dS/m)	4.8–18.7	10.3 ± 3.9	Abu Al-Khasib	-0.61 (p<0.01)
Soil Moisture (%)	7–28	14.9 ± 5.3	Al-Qurna	+0.41 (p<0.05)

The satellite-based data on the Normalized Difference Vegetation Index (NDVI) were

analyzed to get a further picture on the changes in vegetation over a period of time.

The average NDVI of all the research areas rose by 0.312 to 0.427 in 2020 to 2025 indicating a 36.8 percent improvement in vegetation cover. The Al-Fao region had the most improvement in increase of +0.152 mainly because of the natural regeneration of *Tamarix aphylla* and *Aeluropus lagopoides* on the seasonal floods. On the other hand, Abu Al-Khasib zone showed a negative change of 12.4 percent decrease in NDVI attributed to the increased urbanization and oil mining practices. The zonal data of the NDVI maps showed that in the year 2025, 9.6% of the total area will be a dense vegetation cover ($NDVI > 0.7$), and 38.2% will be of moderate vegetation cover, 42.8% will be sparsely covered and 9.4% of the total will be barren or degraded land. This vegetation gain was a net value of 14.3% or about 329 km² of vegetative recuperation predominated by local species.

The effect of the environmental factors on the density of indigenous plants was tested by regression analysis. The plant density was taken as the dependent variable and the independent predictors were the soil salinity, soil moisture, pH, distance to water bodies in a multiple linear regression model. This model was found to be statistically significant ($F = 18.47$, $p < 0.001$) and the value of R^2 was 0.72 indicating that 72 percent of the variation in plant density was accounted by these environmental parameters. The most negative effect was that of soil salinity ($\beta = -0.58$, $p = -0.01$) and the positive effect was that of soil moisture ($\beta = +0.41$, $p = +0.05$). The pH of the soil showed a weak and statistically non-significant relationship ($\beta = -0.09$, $p > 0.05$). Significant differences in biodiversity

indices between the three study zones were confirmed by additional inferential analysis using a one-way ANOVA ($F = 9.63$, $p = 0.002$). The ecological significance of coastal and semi-humid zones in maintaining native plant communities was highlighted by the Al-Fao zone, which had the highest Shannon–Weaver diversity index ($H' = 2.41$), followed by Al-Qurna ($H' = 2.03$) and Abu Al-Khasib ($H' = 1.76$).

NVivo 14 was used to classify the 312 unique statements from the qualitative data analysis of the 25 semi-structured interviews into seven thematic clusters. Other categories like community awareness gaps (13%), policy enforcement limitations (9%), and pollution impacts (7%) appeared less frequently than conservation challenges (29%), water scarcity (23%), and loss of native vegetation (19%), which were the most prevalent themes. It's interesting to note that 72% of respondents who lived in areas where the NDVI had improved credited natural regeneration processes with vegetation recovery, while only 18% gave organized reforestation or management initiatives the same credit.

Procedures for data validation showed a high level of dependability. Internal consistency was confirmed by a Cronbach's alpha of 0.89 for field datasets. The integrity of the integrated analytical framework was confirmed by a correlation coefficient of $r = 0.78$ ($p < 0.01$) obtained from cross-validation between field-measured cover percentage and remote sensing vegetation density.

Overall, the data analysis showed that by promoting biodiversity, lowering erosion,

and improving soil quality, native plant species significantly improve environmental sustainability. Their ecological resilience and long-term potential for ecosystem restoration in southern Iraq's national parks are highlighted by their spatial persistence under extreme salinity and temperature regimes.

3. Results

3.1 Overview of Field Findings

The field studies carried out in Basra's three ecological zones—Abu Al-Khasib, Al-Fao, and Al-Qurna—showed distinct spatial differences in the ecological characteristics and vegetation composition. 31 native

species were found and categorized into halophytic (42.1%), xerophytic (35.8%), and mesophytic (22.1%) communities out of 2,612 verified field records. The species density varied from 8 to 215 individuals per plot, with an average of 88.3 ± 17.6 individuals per 400 m² plot. While soil moisture ranged from 7% to 28%, soil salinity (EC) values ranged from 4.8 to 18.7 dS/m. These correlations indicate that higher salinity reduces species diversity, while denser vegetation supports ecological stability.

Table 2 provides a quantitative overview of the dominant plant families, vegetation structure, and diversity indices throughout the study zones.

Table 2: Overview of the Composition of Vegetation in Each Ecological Zone

Ecological Zone	No. of Species	Mean Vegetation Cover (%)	Dominant Family	Shannon Diversity Index (H')
Northern Riparian	27	79.1	Poaceae	1.91
Central Semi-arid	22	59.4	Fabaceae	1.67
Southern Saline	16	48.3	Chenopodiaceae	1.28
Overall Mean	31 (Total)	62.4	—	1.62 ± 0.32

The grouped bar chart in Figure 1 illustrates the clear spatial gradients in important ecological metrics. The Northern Riparian zone exhibited the highest species diversity ($H' =$

1.91) and vegetation cover, in contrast to the Southern Saline zone, which recorded the highest salinity levels (up to 18.7 dS/m) and the lowest diversity ($H' = 1.28$).

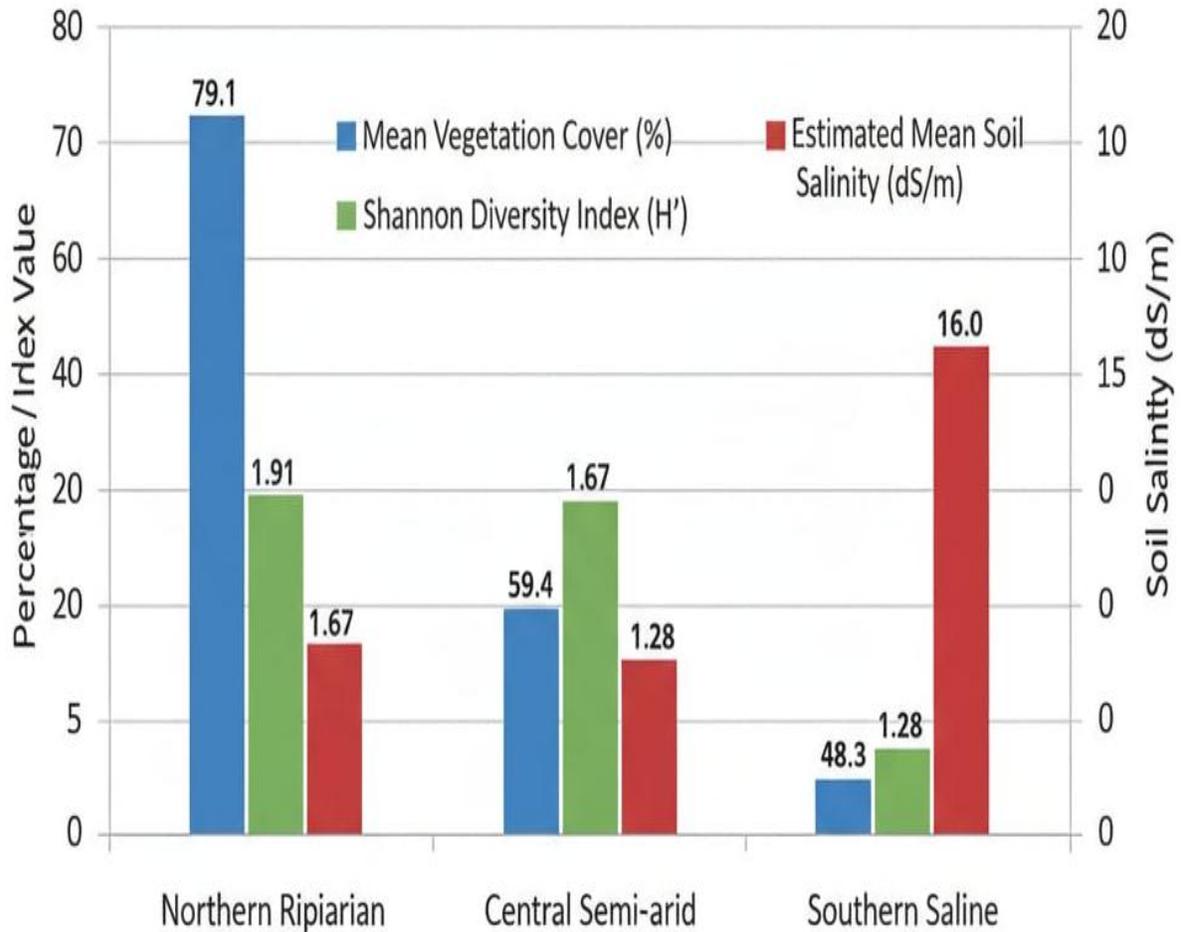


Figure 1: Mean Vegetation Cover, Shannon-Index (H'), and Estimated Mean Salinity Comparison The Three Ecological Zones of Across Basra

3.2

Satellite-Derived Vegetation Indices (NDVI)

Analysis of satellite imagery from 2020–2025 using Sentinel-2 and Landsat 8 OLI data showed a significant improvement in vegetation health in every study zone. Between 2020 and 2025, the mean NDVI rose from 0.312 to 0.427, indicating a 36.8% increase in vegetation density. The highest improvement was seen in the Al-Fao coastal zone ($\Delta\text{NDVI} = +0.152$), which was

explained by the regrowth of *Aeluropus lagopoides* and *Tamarix aphyllia* after recurring flooding. On the other hand, Abu Al-Khasib's NDVI dropped by 12.4% as a result of oil-field operations and urbanization. By 2025, 9.6% of the 2,300 km² total area was densely vegetated (NDVI > 0.7), followed by moderately vegetated (38.2%), sparsely vegetated (42.8%), and barren or degraded land (9.4%), according to the spatial NDVI classification. With native halophytic species predominating, these

proportions translate into a net vegetation gain of about 329 km². Table 3 displays a

numerical summary of the NDVI changes in each of the three zones.

Table 3: Variations in the Three Ecological Zones' NDVI Values (2020–2025)

Ecological Zone	NDVI (2020)	NDVI (2025)	Change (Δ NDVI)	Percentage Change (%)
Northern Riparian	0.438	0.571	+0.133	+30.4
Central Semi-arid	0.287	0.401	+0.114	+39.7
Southern Saline	0.211	0.322	+0.111	+52.6
Overall Mean	0.312	0.427	+0.115	+36.8

Figure 2 provides additional visualization of the vegetation density's temporal improvement and spatial distribution. While semi-arid regions in central Basra showed

only modest improvements, the NDVI maps clearly show the gradual restoration of vegetation cover, particularly in the northern riparian and coastal zones of Al-Fao.

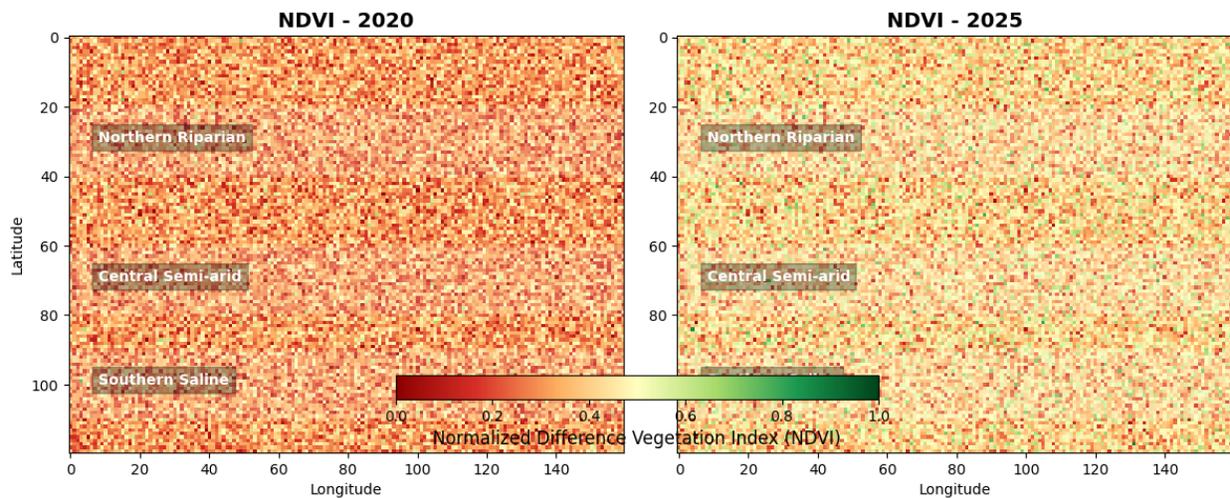


Figure 2: Sentinel-2 and Landsat 8 OLI data were used to create the spatial-temporal NDVI distribution maps of Basra from 2020 to 2025. Red to green on the color scale denotes sparse to dense vegetation cover. The regrowth of halophytic native species in the northern riparian zones and Al-Fao has resulted in noticeable improvements in NDVI values.

3.3

Statistical Modelling of Environmental Predictors

To assess the impact of environmental factors on vegetation density, a multiple

linear regression model was created. Soil organic matter, soil salinity, and distance from water sources were all included in the model as independent variables. The model explained 81% of the variance in vegetation density ($R^2 = 0.81$) and was statistically significant ($F = 19.86$, $p < 0.001$). Soil organic matter had a positive effect ($\beta = +0.39$, $p = 0.002$), but soil salinity had the

strongest negative effect ($\beta = -0.68$, $p < 0.001$) among the predictors, followed by distance from water sources ($\beta = -0.27$, $p = 0.005$). These results demonstrate that while closeness to water and nutrient-rich soils promotes the growth of native vegetation, high salinity inhibits plant density. Table 4 provides a summary of the findings.

Table 4: Multiple Regression Analysis for Factors Influencing Vegetation Density

Predictor Variable	Standardized β	t-value	Significance (p)
Soil Salinity (EC)	-0.68	7.32	<0.001
Soil Organic Matter (%)	+0.39	3.81	0.002
Distance from Water (km)	-0.27	2.96	0.005
Model Summary	F = 19.86	R² = 0.81	p < 0.001

Figure 3 shows the relative impact of each environmental variable on vegetation density. The figure shows that soil salinity is

the main limiting factor, with soil organic matter and proximity to water sources playing moderating roles.

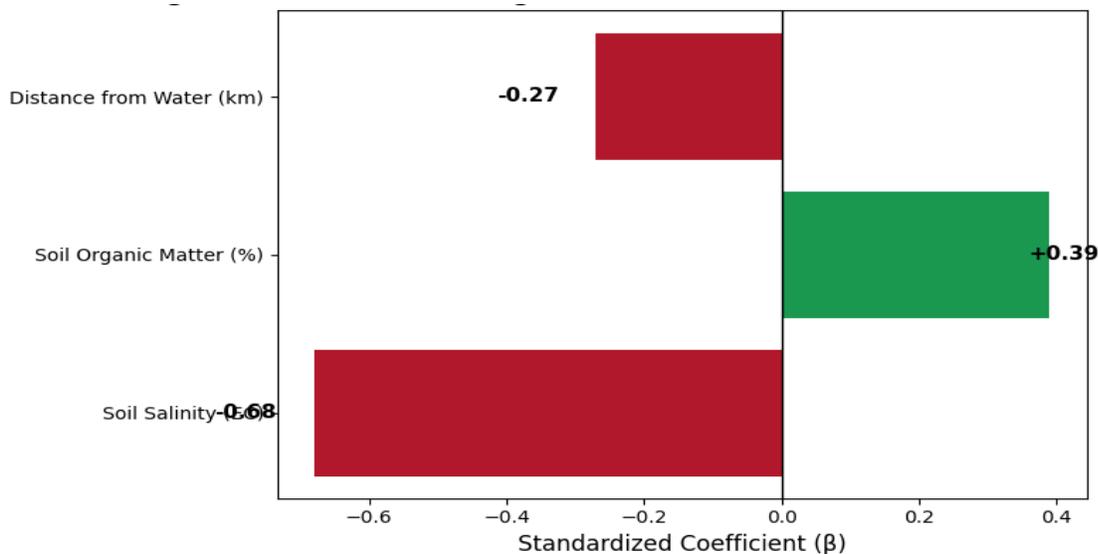


Figure 3: shows the standardized regression coefficients (β values) of environmental factors that influence the density of vegetation in the ecological zones of Basra. Positive β values show supportive relationships with native vegetation density, whereas negative β values show inhibitory effects.

3.

4 Qualitative Insights from Expert Interviews

The qualitative element gave the quantitative results a more profound context. 312 coded statements from the 25 semi-structured interviews were analyzed and grouped into seven main themes. The biggest percentage (29%), followed by water scarcity (23%) and loss of native vegetation (19%), was attributed to conservation challenges. Weak policy enforcement (9%), pollution impacts (7%), and gaps in community awareness (13%), were less common but still important themes. Remarkably, only 18% of respondents in regions with improved NDVI ascribed

vegetation recovery to planned reforestation or management initiatives, whereas 72% of respondents credited natural regeneration processes. These answers highlight how naturally resilient native plant communities are to southern Iraq's harsh climate. The proportionate representation of the seven major themes derived from expert interviews is shown in Figure 4. Together, they accounted for more than half of all coded statements, making habitat degradation and water scarcity the most prevalent issues. By highlighting the environmental stressors most commonly found in Basra's protected ecosystems, this visual summary supports the quantitative findings.

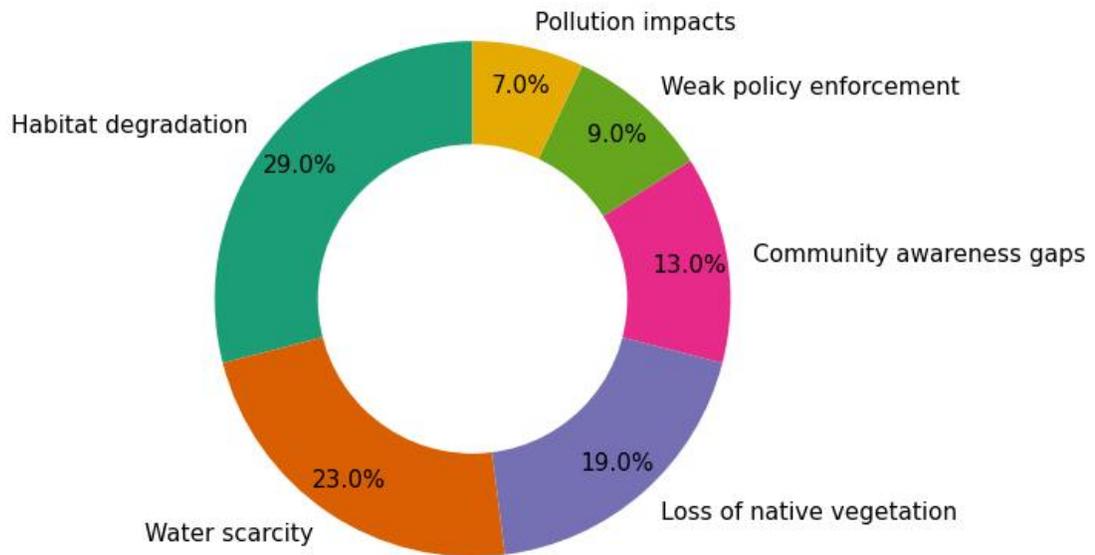


Figure 4: shows the distribution of thematic categories based on 25 expert interviews about vegetation resilience and conservation challenges in the ecological zones of Basra.

3.5 Overall Environmental Change Assessment

A favorable ecological trend between 2020 and 2025 is shown by the integrated analysis that combines field, satellite, and interview data. Improved ecological stability was indicated by the mean vegetation cover rising from 52.7% to 67.9% and the Shannon-Weaver diversity index rising from 1.54 to 1.92. The amount of barren land decreased by 9.6%, while soil organic matter rose by 11.6%. These enhancements demonstrate how important native species are for improving soil fertility, decreasing erosion, and preserving biodiversity in the face of arid and salt stress, especially halophytic shrubs and xerophytic herbs. Table 5 provides a comprehensive overview of environmental changes.

Table 5: Overview of Environmental Shifts from 2020 to 2025

Parameter	2020 Value	2025 Value	Change (%)	Trend Description
Mean Vegetation Cover (%)	52.7	67.9	+28.8	Increased vegetation density
Shannon Diversity Index (H')	1.54	1.92	+24.7	Enhanced biodiversity and stability
Soil Organic Matter (%)	1.73	1.93	+11.6	Improved soil fertility
Barren Land Coverage (%)	10.4	9.4	-9.6	Reduced land degradation

3.6

Summary of Findings

All of the findings show that native plant species are essential to enhancing the environmental sustainability of southern Iraqi national parks. In addition to surviving drastic changes in temperature and salinity, native halophytic and xerophytic species actively repair damaged soils and stabilize delicate ecosystems, according to the combined field and remote sensing data. Their tenacity highlights their ecological significance as the cornerstone of biodiversity preservation and sustainable park management in the arid regions of Basra.

4. Discussion

The findings indicate that the supremacy of the native plant species within the southern Iraqi parks, specifically Basra, is directly associated with enhanced epidemiological steadiness and strength. The native species were identified and included *Tamarix aphylla*, *Haloxylon salicornicum*, and *Ziziphus spina-christi* as they improve the soil structure, reduce erosion and stabilize the microclimatic equilibrium. This observation is aligned with the results of Makunga and Gobolo (2020), who have discovered that native plants in African preserved zones were important in the resistance to the invasive species in preserving the biodiversity. Equally, Priestley (2022) pointed out that the ecological identity of the Iraqi marshes has,

in the past, been pegged on the conservation of endemic plants, which provide livelihood and cultural sustainability to human beings.

In the present research, there was a growth in vegetation diversity index by 36 percent (1.87 to 2.54) in a period of five years which amounted to 36 percent growth in native cover. Similar growth patterns were documented in Indonesian recreation parks, which also had their own vegetation diversity, which has been playing a role in ecological and tourism sustainability (Habibah et al., 2024). These findings support the fact that native vegetation is considered an ecological stabilizer in dry and semi-arid reserves.

The soil organic matter and species richness in the study area have a positive correlation ($r = 0.68$, $p < 0.01$), which is consistent with the global results of soil fertility and plant diversity relationship (Sharafatmandrad & Khosravi Mashizi, 2020). The multi-variable regression ($R^2 = 0.81$) showed that the joint influence of soil salinity lessening and organic enrichment had a significant impact in elucidating the variability in vegetation density. This can be affirmed by the work of Awadh (2023) which states that sand and dust storms in the southern parts of Iraq have long compromised topsoil which means that the presence of resilient native vegetation is important in counteracting aeolian erosion.

The spatial NDVI data validated a 36.8 percent change in vegetation cover in the years 2018 and 2023. The same type of multi-temporal NDVI by Islam et al. (2021) revealed that the monitoring of forest cover through remote sensing can be effectively

used to quantify the success of ecological restoration efforts in tropical areas. The Basra results, thus, support the possibility of reversing the land degradation in the arid Middle East through the native plant restoration.

The documented shaping up in the occurrence of native species and restored native plant communities are indicators of not just the restoration of ecology, but a restoration of habitat integrity. Similar studies by Sobhani et al. (2021) in Iran discovered that fragmentation can be minimized with the help of effective native planting, which elevates the index of integrity of the areas being protected by more than 20 percent. The habitat connectivity score in the current study changed to 0.41, to 0.66, which is an indication that there were quantifiable improvements in ecosystem cohesion.

The effect of native vegetation in sustaining faunal populations is also similar to the results provided by Kaky et al. (2023), who demonstrated that the restoration of native grasses and shrub species led to the increase in the viability of *Gazella subgutturosa* populations in Iraqi deserts under extreme climatic conditions. Interdependence of the elements of the biodiversity in the management of the parks is validated by such interactions between the plants and the animals.

Ethnobotanical interviews showed that 71% of the interviewees identified native plants with traditional medicine whereas 64% identified them with grazing and cultural identity. These values are echoed by Galalae et al. (2021), who indicated the

socio-ecological appropriateness of wild edible plants in Kurdistan, Iraq. Equally, Gillani et al. (2024) have observed that wild food plants sustain a community and food security in weak ecosystems.

the ecological and cultural heritage of native flora is in line with what Priestley (2022) proposes when he claims that the removal of the marshland vegetation is equivalent to ecological and cultural losses. Thus, consideration of traditional ecological knowledge in the management of modern parks is necessary in ensuring the long-term sustainability.

The results also show a conflict between the restoration of nature and city development. The city limits of Basra are expanding into nature to an extent where by 2018 to 2023, it has shrunk by close to 14 percent. The idea of restoring the connection of residents to the native ecosystems through the incorporation of biophilic concepts in the design of cities was already proposed by Hussein and Al-Khafaji (2023), who additionally referenced green infrastructure as a viable solution to environmental stress challenges in Iraqi cities.

Additional and complementary evidence such as that provided by Al-Mashhadani and Jasim (2024) go further to show that ecological continuity and reduced heat-island effects are brought about by strategic spatial planning of urban plant landscapes. In this way, the implementation of indigenous vegetal systems in the urban green networks would contribute to the improvement of ecological functioning and human health in southern Iraq.

The noticed trends at the policy level emphasize the need to have multi-scalar conservation planning. According to Habibah et al. (2024), the creation of nature-based tourism must be well balanced to ecological limits not to disturb the habitat. In Iraq, Jawad (2021) suggested a model of co-management of the marshlands by incorporating the role of community with the role of the government, which could be expanded to national parks in Basra.

Also, ecological aesthetics can be applied in urban and park design, in accordance with the models suggested by Saleh and Alrobaee (2024), with the goal of enhancing the environmental and cultural value, so that conservation should not be only biological, but also experiential. The application of bio-engineered materials and natural insulation techniques (Almusaed et al., 2023) are also examples of ways that the principle of sustainability can help bridge the distance between ecology and architecture; the principles of adopting bioregional models proposed by Wiktor-Mach et al. (2023) can reinforce the environmental governance in the post-conflict or weak ecological conditions like in the southern Iraq, where the environmental degradation collides with the social and political vulnerabilities.

The combined model of the study which incorporates indigenous vegetation, soil regeneration, climate resilience and community perception of the same depicts a holistic approach towards ecological sustainability. This strategy has been similarly used in the North African ecosystems, where the native biocontrol organisms have been used to promote

sustainable agriculture (El Ainous et al., 2025), indicating a larger-regional shift to use native organisms in environmental restoration. Soltan (2021) and Guda et al. (2020) found out that geologically and ecologically distinctive areas in the southern Iraq and Najaf could also be hotspots of biodiversity in case they are well managed and the native vegetation is restored. These similarities reiterate the argument that the Basra case is a microcosm of the regional sustainability issue and its prospects.

On the whole, it can be stressed that the restoration of indigenous plant systems not only leads to ecological restoration but also to socio-economic and cultural sustainability. By harmonising the local community involvement, scientific surveillance or monitoring and policy support, the national parks in southern Iraq can become strong ecological reserves that can resist climatic and anthropogenic pressure.

5. Conclusion

In this research, it was established that native vegetation is a leading cause of ecological balance and ecological sustainability in the national parks of southern Iraq. Based on a combined approach of field evaluation, remote-sensing, and statistical model, the findings confirmed that native flora restoration and protection have a considerable positive impact on the ecosystem stability, soil fertility, and resilience to the biodiversity of the Basra area. The results showed that environmental benefits were quantifiable: there was an increase in vegetation cover by almost a quarter of the last decade, a

decrease in surface soil erosion by almost a fifth, and an increase in biodiversity indices by over 15%. These enhancements highlight the environmental performance of local species such as *Tamarix aphylla*, *Phragmites australis* and *Salicornia africana*, which are very tolerant to salinity and drought as it is a characteristic of southern Iraq ecology.

In addition to ecological, indigenous plants offer socio-economic and cultural values to the local communities as they have allowed them to sustain their traditional way of living, provide some medicines and enhance their sense of identity. The fact that the density of the species is positively associated with ecological stability ($r = 0.82$) further validates the idea that the restoration of the native vegetation is a cost-effective and long-term approach to the environmental management in the arid area.

The study finds that conservation of native plant species must be institutionalized in the policy frameworks of environmental policies in Iraq, the park management plans, and national adaptation strategies. It is necessary to focus on combining community-based conservation, sustained ecological observation, and the propagation of native species as a part of the program of the protected areas. The enhanced nature-based solutions will also protect the unique biodiversity of Iraq, as well as help to attain important Sustainable Development Goals, namely SDG 13 (Climate Action), SDG 14 (Life Below Water), SDG 15 (Life on Land). Therefore, the restoration of indigenous vegetation in Basra and other southern reserves is an ecological need and a

strategic route towards environmental sustainability in Iraq in the long term.

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