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Traditional ecological knowledge of wild plant usage in the arid landscapes of Southwestern Saudi Arabia: Implications for biodiversity conservation

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ABSTRACT: Traditional ecological knowledge (TEK) offers place-based insights into plant use, resource dynamics, and biodiversity in arid landscapes. Despite long-standing community reliance on wild plants in Saudi Arabia, integrated assessments linking TEK with ecological status and conservation priorities remain limited. This study documents traditional knowledge of wild plant use and evaluates its implications for sustainable management in a desert landscape of southwestern Saudi Arabia. Ethnobotanical data were collected from 37 informants using snowball sampling and semi-structured interviews to record plant uses, parts utilized, growth forms, and perceived ecological status. Local communities reported multiple ethnobotanical applications, primarily for medicine, food, fragrance, herbal tea, and fodder. Apocynaceae and Fabaceae were the most frequently cited families, leaves were the dominant plant part used, and herbaceous perennials were the prevailing growth form. Medicinal uses mainly targeted gastrointestinal disorders, followed by dermatological, urinogenital, and febrile conditions. *Commiphora gileadensis* (UV = 0.49) and *Rumex vesicarius* (UV = 0.46) were the most culturally valued species. Although most taxa were considered ecologically stable, *Commiphora gileadensis* and *Commiphora kataf* were identified as threatened. Integrating TEK with ecological assessment identified multifunctional native species critical for local livelihoods and conservation planning. The findings emphasize prioritizing culturally important plants in restoration initiatives and demonstrate how TEK can strengthen biodiversity management, promote sustainable use, and guide re-vegetation strategies in dryland ecosystems.

KEY WORDS: Arabic, conservation, ecology, ethnobotanical uses, hyper arid, indigenous people, Saudi Arabia.

INTRODUCTION

In the context of accelerating environmental change and global biodiversity loss, the integration of ethnobotanical knowledge into conservation planning offers an essential bridge between scientific frameworks and local socio-ecological realities (Zhao *et al*., 2025). Local communities have developed enduring, place-based biocultural practices grounded in long-term observations of their biophysical environments and sustained interactions with natural systems (Swanson and Ardoin, 2021; Geng *et al.,* 2026). Traditional ecological knowledge (TEK) plays a pivotal role in enabling indigenous and tribal communities to respond to socio-ecological change, as its incorporation into livelihood strategies enhances long-term sustainability while strengthening both social and ecological resilience (Haq *et al*., 2023).

TEK encompasses a cumulative and evolving body of knowledge, practices, and belief systems that describe relationships among living organisms, including humans, and their surrounding environment, and is transmitted across generations through cultural pathways (Sharifian *et al*., 2022; Luo *et al*., 2024). Compared with conventional scientific approaches, TEK is typically applied at finer spatial scales and over longer temporal horizons, providing insights that are often inaccessible through short-term ecological studies (Jiang *et al.,* 2014; Reid *et al*., 2021; Suo *et al*., 2026). Documentation of traditional knowledge from diverse regions has demonstrated its value in informing sustainable plant resource management and habitat conservation at regional scales, while also identifying priorities for future scientific investigation (Molnár and Babai, 2021; Yang *et al*., 2026). This knowledge system is primarily transmitted orally and continuously reshaped through adaptive social, cultural, economic, environmental, spiritual, and political processes, reflecting its dynamic nature and relevance across generations (Redvers *et al*., 2023; Haq *et al*., 2021). However, there are significant challenges to the preservation of this valuable heritage due to the aging of knowledge holders and the increasing erosion of traditional lifestyles. Thus, it is crucial to record and digitally preserve indigenous and local knowledge to prevent its loss, make it easier for future generations (Tella *et al*., 2025; Miao *et al*., 2026).

Plants are essential to human life due to their many services in food, medicine, culture, agroforestry, and technology (Tian *et al.,* 2012a; Al-Robai *et al*., 2022). People have used plant resources for a variety of everyday needs since the beginning of time (Qari *et al*., 2024; Tian *et al.,* 2012b). A significant portion of the livelihoods of hundreds of millions of people, primarily in developing nations, originate from items made from wild plants (Baig *et al*., 2022). Moreover, TEK emphasizes the need to live in harmony with the environment and the interconnectedness of humans and nature (Haq *et al*., 2021; Taki and Kumari, 2023). Its foundation lies in the knowledge and traditions of the native and regional civilizations. Indigenous people have made universal contributions to a wide range of ecologically significant subjects (Alqahtany and Aravindakshan, 2022). The historical and contemporary significance of indigenous people for taxonomy, biodiversity cataloguing and, more generally, their role in biodiversity protection cannot be understated (Gebara *et al*., 2023; Tian *et al.,* 2013). Indigenous people have thus been able to acquire important information in pharmacology and medicine based on their in-depth understanding of the local biodiversity (Tounekti *et al*., 2019; Wang *et al.,* 2025a).

The availability and accessibility of plant resources have long shaped ecological structure and resource-use practices in arid and semi-arid environments (Abule *et al*., 2005; Wang *et al.,* 2025b). Plant species that are abundant and easily accessible are more readily incorporated into local cultural traditions, increasing their relative importance and perceived therapeutic or nutritional value (Yang *et al.,* 2020; Ansari *et al*., 2022); however, sustained and intensive harvesting of medicinal plants can place considerable pressure on natural populations, contributing to resource depletion and ecological vulnerability (Shabana *et al*., 2023; Zhang *et al.,* 2025). The sustainable management of these plant resources, critical for both biodiversity conservation and human well-being, relies heavily on TEK, which guides plant selection, utilization practices, and adaptive resource management (Couee, 2024). Despite its significance, TEK is increasingly threatened by rapid urbanization and broader socio-economic and socio-political changes, weakening the dynamic relationship between plant diversity and traditional ecological practices in arid regions of Saudi Arabia (Zhang *et al.,* 2021; Fajardo *et al*., 2021).

Although the role of TEK in supporting ecosystem services and sustainable resource use is increasingly recognized, persistent knowledge gaps continue to hinder its effective integration into conservation planning in arid landscapes. In this context, the main objectives of the study are (1) to document and analyze traditional ecological knowledge related to the multipurpose use of wild plant resources in an arid landscape of southwestern Saudi Arabia, and (2) to assess the ecological status and conservation relevance of the documented species. The findings are expected to inform biodiversity conservation, guide ecological restoration, and support sustainable resource management through the integration of local knowledge into arid-land conservation frameworks.

MATERIALS AND METHODS

Study area

Abu Arish Governorate is located in the Jizan Region of southwestern Saudi Arabia at 16°58′08″N 42°49′57″E (Figure 1). Abu Arish is one of the historical cities known since the fourth Hijri century. The word ‘Abu Arish’ indicates the land of traditional huts. The area of the Abu Arish Governorate is estimated at about 900 km^2. The population of Abu Arish Governorate is estimated to be 197,112. Abu Arish is one of the most important agricultural governorates in the region for its land and abundance. It is the most fertile agricultural land in the Jazan Region owing to the presence of a few valleys passing through its territory as well as the availability of groundwater. Many vegetables and cereals, such as sorghum, maize, and millet, as well as oilseed crops, are cultivated in the region. Abu Arish is also famous for different kinds of mangoes. The local people of Abu Arish are mainly farmers, and some rear livestock.

Data collection

Reconnaissance surveys were conducted among local people in the Jizan Region to obtain information on medicinal plants used in traditional healing practices and other traditional uses. The extensive ethnobotanical study was conducted in the Jizan Region, KSA, from October 2024 to April 2025. The study covered a total of nine (n=9) villages, and the data were collected from various tribal groups residing within the study area (Figure 1). The study employed a snowball sampling technique to select informants from various occupations and age groups, including livestock owners, farmers, traditional healers, government employees, and housewives (Haq *et al*., 2023). The age range of the participants was 20 to 65^+ years. Out of all the individuals providing information, 73% were male and 27% were female (Table 1). The underrepresentation of women in our study can be attributed to the prevailing social, religious, and cultural norms of the area.

Before each interview, participants provided verbal informed consent, and the ethical guidelines outlined by the International Society of Ethnobiology (ISE, 2008) were followed. A total of 37 semi-structured interviews were carried out in local language (Arabic), with one of the authors being proficient in the language. Subsequently, the interviews were translated into English. Participants were asked to identify the most common plant species in the region and those they frequently utilize, providing information on each species' local name

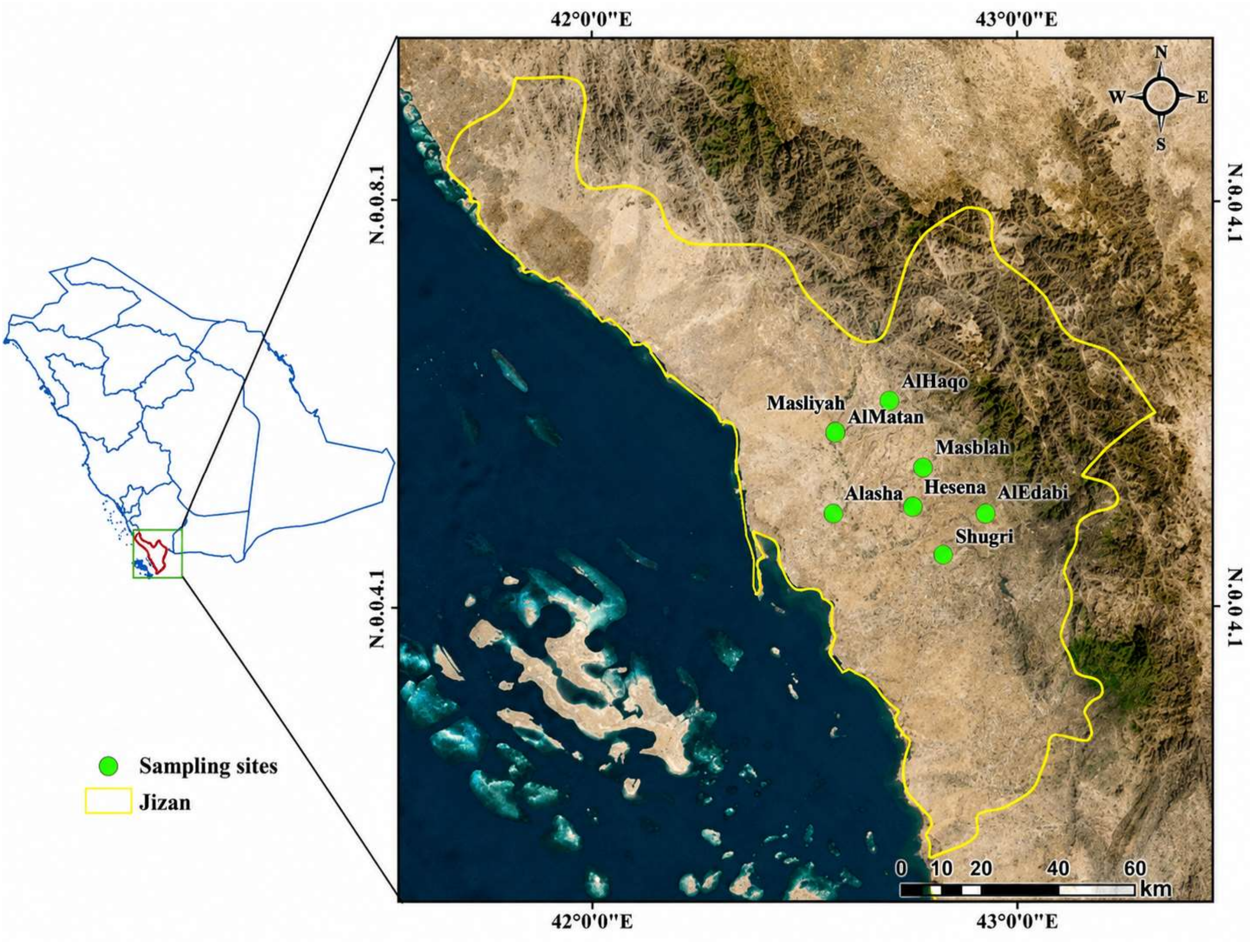

Fig. 1. Map of the study area and showing the locations of the survey villages in the Jizan Region.

Table 1. Demographic details of the informants in the study area.

Variable	Categories	Number of people (%)
Total	Informants	37
Gender	Male	27 (73%)
	Female	10 (27%)
Age group	Young (20-40 years)	12 (32%)
	Middle (41-64 years)	17 (46%)
	Old (65+ years)	8 (22%)
Education Level	Illiterate	9 (24%)
	Primary education	13 (35%)
	Secondary education	11 (30%)
	Higher education	4 (11%)
Profession	Traditional healers	6 (16%)
	Farmers	7 (19%)
	Housewives	10 (27%)
	Govt. Employees	4 (11%)
	Livestock owners	10 (27%)
Language	Arabic	

and traditional uses. The interviews were centered on the utilization of the indigenous plants for medical, religious, cultural, veterinary, and culinary purposes. The informants were shown both photographs and real plants to identify them and obtain local names (see supplementary Figure S1). The survey results were presented again to the informants following data collection to rectify any inaccuracies or exclusions in the data. During data collection, the research team was accompanied by at least one knowledgeable local informant who helped them to validate local names and verify traditional applications while adhering to established community norms. This collaborative method enabled accurate species classification, honored indigenous knowledge systems, and increased the reliability of the ethnobotanical data collected during the survey.

Harvesting of resin

Semi-structured interviews (n=30) with local informants were used to gather data on resin harvesting techniques. The oleo-gum-resin is collected using a knife or small hatchet to make shallow incisions in the bark of the major branches and trunks. The exuded resin is allowed to solidify naturally on the wound surface on the wound surface, generating resin "tears," which are then scraped off and collected. Harvesting is primarily done during the dry season, when resin production is expected to be highest. Informants further stated that unsustainable harvesting procedures, particularly repeated tapping of the same trees and the formation of deep incisions, might impair plant vitality, resulting in branch dieback and, in severe cases, the death of the entire tree.

Data analysis

Ethnobotanical data were compiled in Microsoft Excel and analyzed using the R statistical environment. Descriptive statistics were applied to summarize species composition, growth forms, life spans, plant parts used, preparation methods, ethnobotanical use categories, ecological status, and Use Value (UV). Alluvial diagrams were generated using the ggalluvial package to visualize relationships between plant species, growth forms, and life span categories (Brunson, 2020). Chord diagrams were constructed with the circlize package to examine associations between plant species and modes of preparation based on use frequencies (Gu *et al*., 2014).

Multivariate patterns in medicinal and non-medicinal ethnobotanical uses were explored through principal component analysis (PCA) using standardized variables in the FactoMineR package (Lê *et al*., 2008), with graphical visualization performed using factoextra (Kassambara and Mundt, 2017) and ggplot2 (Wickham, 2011). PCA was applied separately to assess species–ailment relationships and species–use category associations, with interpretation based on the first two principal components. The relationship between Use Value and number of reported uses was evaluated using a scatter plot produced with ggplot2 (Wickham, 2011), and species labels were optimized using ggrepel (Slowikowski *et al*., 2018).

Use value (UV)

The relevance of the documented species was determined by calculating their use value (UV) (Tardio and Pardo de Santayana, 2008). The UV was computed with the following formula:

$$UV=\sum U_i/N$$

Where N is the total number of informants interviewed in the study, and U_i is the number of reports cited for a given species by all informants. The UV value for species ranged from 0 to 1. Higher UV values indicate greater cultural importance and more frequent use of a species within the local community. If a species was mentioned by all informants, its UV value was 1.

RESULTS

Composition of ethnobotanical flora

A total of 39 plant species were identified as being used by local communities by the local communities for multiple traditional practices (see supplementary Table S1). These species belong to 37 genera and 25 families, demonstrating considerable botanical diversity in the region. The genus Commiphora had the highest species richness, represented by two species. The analysis of species counts per family revealed that Apocynaceae was the top-represented family in terms of species number (n=5) followed by Fabaceae (n=4 species), Lamiaceae and Zygophyllaceae (n=3 species each). Other significant families included Burseraceae, Moraceae and Vitaceae (n=2 species each), while the remaining eighteen (n=18) families were monotypic (one species each), demonstrating that species are not evenly distributed within families. This diversity highlights the rich traditional botanical knowledge and the region's extensive use of various plant resources.

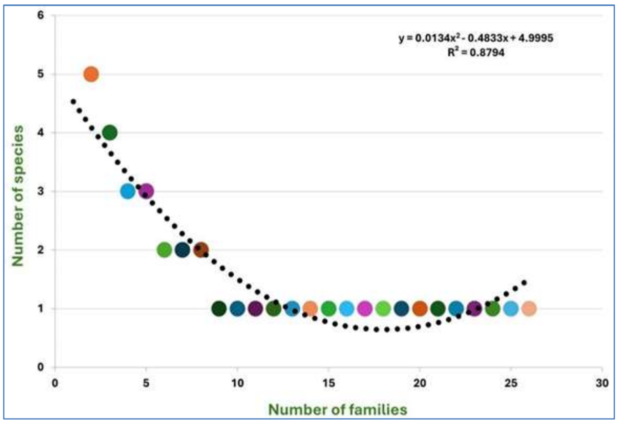

Fig. 2. The relationship observed between species and families in the reported flora. The circle-shaped dots in various colors in the graph show the species distribution pattern in the families.

In the documented flora, the species and family relationship ($y=0.0134x^2-0.4833x+4.9995$; $R^2 = 0.8794$) was observed (Figure 2). The dotted line represents the fitted polynomial trend observed in the recorded flora. Polynomial regression creates a curve to better capture nonlinear relationship trends in data. The coefficient of determination (R^2) value shows the strength of the association between the study variables (species vs families) (Figure 2).

Life spans and growth forms

The analysis of plant resources used in traditional practices reveals a notable diversity in life spans and growth forms. Among the 39 species studied, (n=25) are perennials, including *Aerva javanica* and *Calotropis procera*, (n=13) are annuals, such as *Anastatica hierochuntica* and *Asphodelus tenuifolius*, and one is biennial, *Ducrosia flabellifolia* (Figure 3). Regarding growth forms, herbs are the most common with 20 species, including *Aerva javanica* and *Blepharis ciliaris*. Trees follow with 9 species, such as *Calotropis procera* and *Commiphora gileadensis*. Shrubs account for seven (n=7) species, including *Capparis cartilaginea* and *Leptadenia pyrotechnica*, Climbers were represented by two species (*Cissus quadrangularis* and *Cissus rotundifolius*), and there is one parasitic species, *Plicosepalus acaciae* (Figure 3).

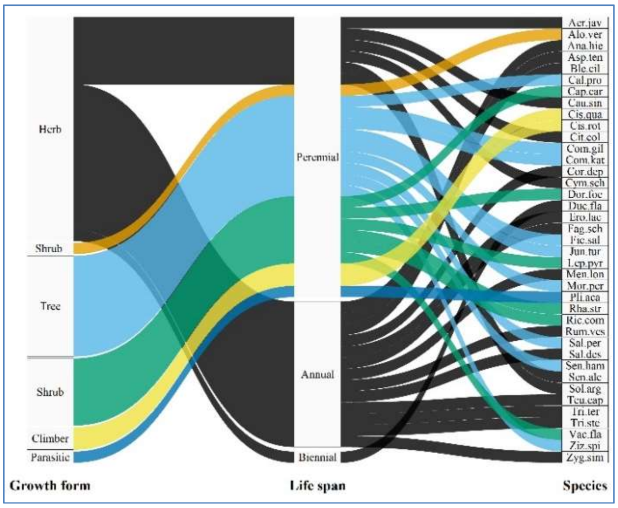

Fig. 3. The alluvial diagram depicts the distribution of 39 species in the Jizan Region based on their growth form and life span.

Part used

The analysis of plant parts used in traditional practices reveals a diverse utilization of various plant components, with leaves being the most used part, employed by 22 species such as *Aerva javanica*, *Blepharis ciliaris*, and *Calotropis procera* (Figure 4A). Seeds are utilized by seven species, including *Asphodelus tenuifolius* and *Moringa peregrina*, indicating their significance in traditional practices. Whole plants are used in three species, such as *Anastatica hierochuntica* and *Cymbopogon schoenanthus*, reflecting their multifaceted uses. Other parts utilized include stems *(Leptadenia pyrotechnica, Caudanthera sinaica*), roots (*Salvadora persica*), sap (*Commiphora gileadensis, Senegalia hamulosa*), flowers (*Solenostemma arghel*), bark (*Vachellia flava*), and fruits (*Citrullus colocynthis, Ziziphus spina-christi*).

Mode of preparation

The modes of preparation of plants used in traditional practices reveal a variety of methods employed to prepare plants for use (Figure 4B). Decoction is the most common method, used for plants such as *Anastatica hierochuntica, Blepharis ciliaris, Cymbopogon schoenanthus, Mentha longifolia, Salvia deserti, Teucrium capitatum, Trigonella stellata*, and *Juniperus turbinata*. Raw preparation is also widely used, with species like *Aerva javanica, Caudanthera sinaica, Erodium laciniatum, Rumex vesicarius, Salvadora persica, Commiphora gileadensis*, and *Ziziphus spina-christi*. Paste preparation is employed by *Citrullus colocynthis, Rhazya stricta, Senna alexandrina, Vachellia flava, Ficus salicifolia,* and *Senegalia hamulosa*. Infusion is utilized for *Calotropis procera, Solenostemma arghel,* and *Zygophyllum simplex*. Poultice is used for *Asphodelus tenuifolius* and *Capparis cartilaginea*. Other methods include extract for *Leptadenia pyrotechnica*, oil for *Ducrosia flabellifolia*,

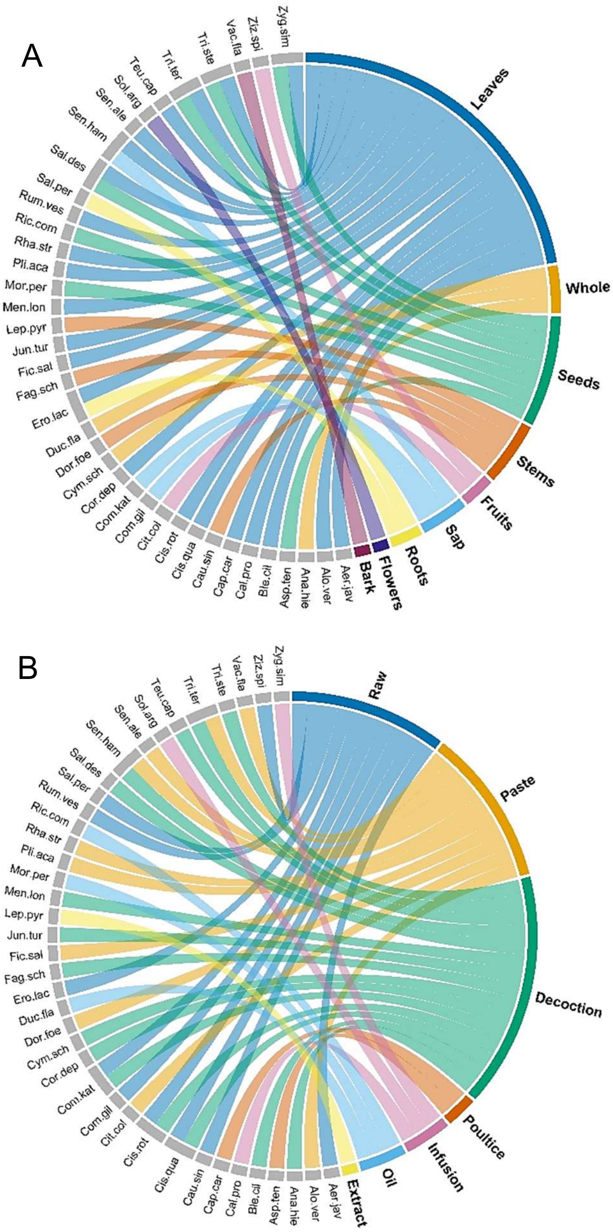

Fig. 4. A chord diagram showing the distribution of **A.** plant species and **B.** mode of preparation in the Jizan Region of Saudi Arabia, along with part-used patterns. The full name of each plant is listed in Table S1. The thickness of each bar represents the degree of frequency/number of use reports in each preparation category, while the direction of the lines indicates which plant is related to which type of preparation mode.

and a combination of decoction and paste for *Tribulus terrestris*, as well as raw and decoction for *Commiphora kataf*.

Medicinal Uses

The investigation into the use of medicinal plants revealed that gastrointestinal issues were the most treated(14 plants), followed by dermatological (7 plants), urinogenital, fever and muscular and joint diseases (4

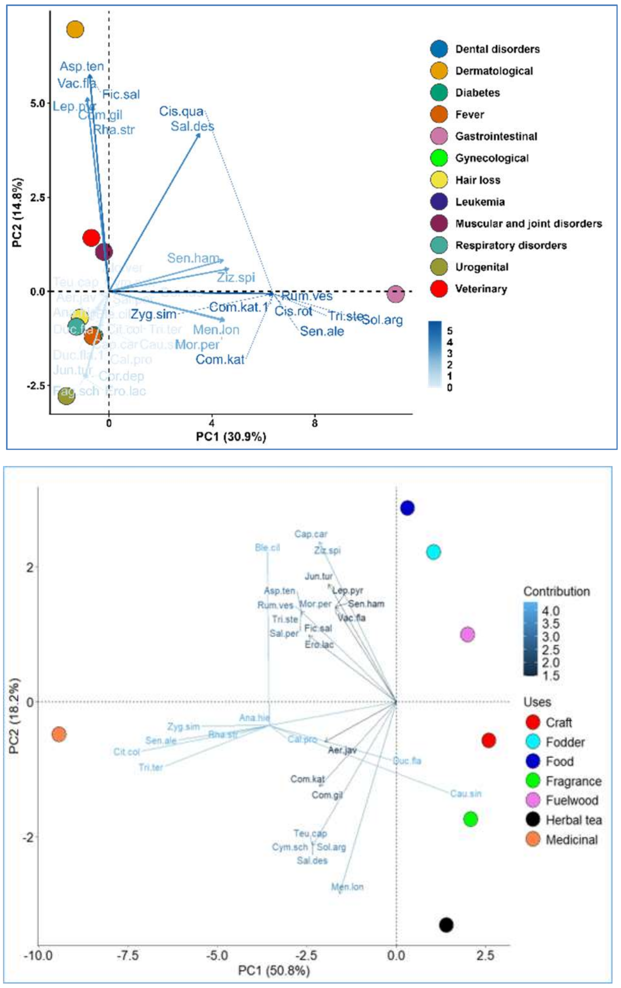

Fig. 5. Principal component analysis (PCA) biplot of **A.** different reported ailment categories and **B.** different ethnobotanical uses of plants reported by local people in the Jizan Region of Saudi Arabia.

plants each). Diabetes issues were treated with 3 plants, while dental disorders were treated by 1 plant. Respiratory disorders and gynecological conditions were managed with 2 plants each, with hair loss diseases having the least representation (1 plant).

PCA biplot showed associations between documented plant species and the ailment categories reported by informants. The first two principal components explained 45.7% of the total variance (PC1 = 30.9%, PC2 = 14.8%) (Figure 5A). A clear separation of ailment groups was observed along PC1. The gastrointestinal category plotted distinctly on the positive side of PC1, notably *Commiphora kataf*, *Rumex vesicarius*, *Trigonella stellata*, *Senna alexandrina*, *Cissus rotundifolius*, *Zygophyllum simplex*, and *Solenostemma arghel*. In contrast, ailment categories located closer to the origin (e.g., respiratory, fever, diabetes, and gynecological conditions) displayed weaker separation and overlapped substantially. Species clustered near the lower-left quadrant (negative PC1/PC2), including *Calotropis procera*, *Citrullus colocynthis*, *Capparis cartilaginea*, *Corchorus depressus*, and *Juniperus turbinata*, were broadly aligned with these multi-use categories rather than showing a highly specific association with a single ailment group. Along PC2, the upper portion of the biplot captured species linked more strongly with dermatological and related conditions. Species with high positive PC2 scores, such as *Asphodelus tenuifolius*, *Vachellia flava*, *Ficus salicifolia*, *Rhazya stricta*, *Leptadenia pyrotechnica*, and *Commiphora gileadensis*, were oriented in the same direction as the dermatological cluster.

Medicinal plants offer diverse remedies for various ailments. For instance, *Aerva javanica* is utilized for colds and coughs, *Anastatica hierochuntica* aids in childbirth, and *Asphodelus tenuifolius* is effective against skin diseases. *Blepharis ciliaris* treats influenza, *Calotropis procera* is used for fever, and *Capparis cartilaginea* addresses headaches. *Erodium laciniatum* addresses urinary inflammations, *Leptadenia pyrotechnica* is used for wound treatment, and *Mentha longifolia* treats headaches and stomachaches. *Salvadora persica* serves as a traditional toothbrush, *Salvia deserti* treats inflammations, bacterial infections, and indigestion. *Tribulus terrestris* stimulates sexual function, and *Trigonella stellata* relieves abdominal pain.

Veterinary use

The survey revealed three plant species used in traditional veterinary medicine to treat livestock diseases. *Rhazya stricta* was used to cure wounds, and *Leptadenia pyrotechnica* was said to repair bone and joint fractures. *Senegalia hamulosa* has been used to treat animal eye infections. These findings demonstrate that local populations possess valuable ethnoveterinary knowledge and rely on plant-based remedies to keep animals healthy.

Other ethnobotanical uses

The investigation revealed diverse ethnobotanical uses among the studied plant species. *Aerva javanica* was utilized in crafting, while *Asphodelus tenuifolius* served as a food source. *Capparis cartilaginea* found applications in both food and fodder. Fragrance production was associated with *Commiphora gileadensis* and *Commiphora kataf*. *Cymbopogon schoenanthus* and *Mentha longifolia* were used for making herbal tea and fragrance. *Moringa peregrina* was a food source, *Salvadora persica* was consumed as food, while *Salvia deserti* was used for herbal tea. *Solenostemma arghel* contributed to herbal tea production, and *Teucrium capitatum* served as herbal tea ingredient. *Trigonella stellata* was a food source, and *Vachellia flava* served as fodder and fuelwood. *Ziziphus spina-christi* was used for both food and fodder. *Juniperus turbinata* was consumed as food and fuelwood, while *Ficus salicifolia* was utilized as fodder.

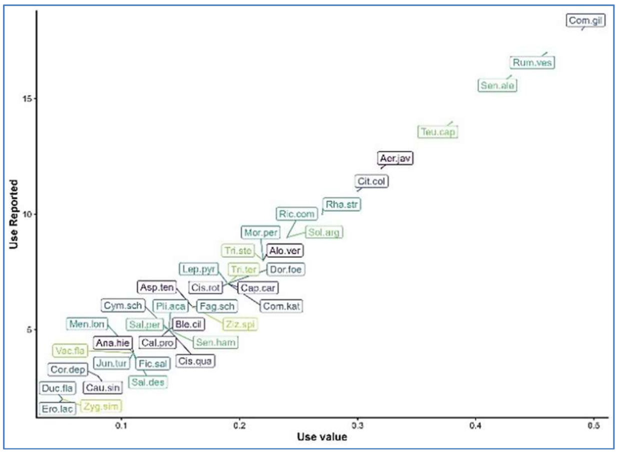

Fig. 6. Scatter plot showing the relationship of use value and use report of ethnobotanically significant plants in the Jizan Region of Saudi Arabia.

PCA biplot shows the relationships between documented plant species and their reported ethnobotanical use categories in the Jizan Region (Figure 5B). The first two principal components explained 69.0% of the total variance, with PC1 accounting for 50.8% and PC2 for 18.2%. Along PC1, plant species used primarily for medicinal purposes were positioned on the negative axis, forming a distinct cluster. Species such as *Citrullus colocynthis*, *Senna alexandrina*, *Rhazya stricta*, *Zygophyllum simplex*, and *Anastatica hierochuntica* were closely associated with this axis. In contrast, species associated with fodder, fuelwood, fragrance, food, herbal tea, and craft were distributed mainly along the positive side of PC1. The PC2 axis further differentiated the non-medicinal use categories. Food-related species were positioned in the upper-right quadrant, including *Capparis cartilaginea*, *Ziziphus spina-christi*, *Juniperus turbinata*, and *Moringa peregrina*. Species used for fodder occupied the upper portion of the biplot, while fuelwood-related taxa were in the positive PC1 and moderately positive PC2 space. Fragrance-associated species, such as *Commiphora gileadensis* and *Commiphora kataf*, were separated along the lower-right quadrant, whereas herbal tea species were grouped mainly along the lower section of PC2.

Use value (UV)

The ethnobotanical data collected from the local community revealed a diverse range of plant species used for various purposes. The reported use value (UV) of the plant species ranged from 0.05 to 0.49, with a mean UV of 0.18. The most frequently used plant species, *Commiphora gileadensis* (L.) C.Chr., with a UV of 0.49, was used in 18 instances, followed by *Rumex vesicarius* L. with a UV of 0.46. The top 10 plant species with the highest reported use value were characterized by their high frequency of use, with *Senegalia hamulosa* (UV = 0.43), *Teucrium capitatum* (UV = 0.38), *Aerva javanica* (UV = 0.32), *Citrullus colocynthis* (UV = 0.30), *Rhazya stricta* (UV = 0.27). Furthermore, *Solenostemma arghel* and *Ricinus communis* each recorded a UV of 0.24, while *Moringa peregrina*, *Aloe vera*, and *Tribulus terrestris* showed comparatively high UVs of 0.22 (Figure 6). Although these species were not widely favored by the local population, local healers frequently included them in their regional herbal concoctions.

Ecological status of the documented flora

The ecological status of the plant species studied in this research was assessed and categorized as Stable, Opportunistic, Threatened, Declining, or Rare. The results revealed that 25 species were classified as Stable, indicating that they are well-established and widespread in their natural habitats. In contrast, 4 species were classified as Opportunistic, indicating that they can thrive in a variety of environments and can colonize disturbed areas. This category includes species such as *Asphodelus tenuifolius, Calotropis procera, Citrullus colocynthis,* and *Juniperus turbinata*. The threatened category included 2 species, which are at risk of extinction due to habitat degradation, overexploitation, or other environmental factors. This category includes species such as *Commiphora gileadensis* and *Commiphora kataf*, thus restoration activities in the region should focus on planting these species in the region. The Declining category included 2 species, such as *Salvadora persica* and *Commiphora kataf*. The Rare category included 6 species, which are extremely rare (see supplementary Table S1).

DISCUSSION

Traditional plant-based knowledge is an essential link between cultural legacy and environmental sustainability (Haq *et al*., 2023). Local communities frequently have centuries-old knowledge about the use, management, and protection of plant resources that are ingrained in their everyday activities, rituals, and livelihood (Zaman *et al*., 2025). Such knowledge systems also contribute to biodiversity conservation and enhance environmental resilience. Regions with diverse floras typically report more useful wild plant species utilized by local population (Hong and Zimmerer, 2022). This relationship reflects the broader availability of plant resources, which increases opportunities for their utilization (Waheed *et al*., 2023a; Haq *et al*., 2024b; Jabeen *et al*., 2024). However, the pattern of plant use is also shaped by socioeconomic conditions, resulting in spatial variation in species preferences and prevalent utilization (Kunwar *et al*., 2022; Muhakr *et al*., 2024). The widespread utilization of plant resources by various groups highlights the crucial necessity of these species to the survival of local populations. The study found a strong reliance on various plant resources for medical uses. Other ethnobotanical studies in Saudi Arabia (Ati *et al*., 2019; Alqethami and Aldhebiani, 2021; Al-Robai *et al*., 2022; Qari *et al*., 2024) and the surrounding Middle East (Hegazy *et al*., 2020; Muhakr *et al*., 2024; Al-Fatimi, 2024) discovered a similar pattern of plant consumption. This commonality stems from the arid and semi-arid regions' same floristic composition, cultural norms, and long-standing reliance on medicinal herbs.

Ecological factors, especially altitude, species abundance and life-form composition, generally impact plant-use patterns (Niaz *et al*., 2026). Ethnobotanical knowledge and plant-use practices can be influenced by altitudinal variation, which can also change vegetation structure, microclimatic conditions, and resource availability (Haq *et al*., 2022). Therefore, changes in plant composition and accessibility across elevation gradients commonly induce differences in plant species selection and utilization (Ye *et al*., 2024). Herbs are often more accessible and consequently more widely utilized in traditional medicine than shrubs and trees. Herbs are prevalent in nature, commonly found in natural desert ecosystems usually after rainfall (Roy *et al*., 2022). In the study area, the frequent utilization of herbs is largely due to their easy accessibility from nearby natural landscape (Khoja *et al*., 2022). Herbaceous species constitute a significant portion of the plant diversity in semi-arid and arid ecosystems (Al-Rowaily *et al*., 2015; Waheed *et al*., 2023b), which likely explains their dominance among the ethnobotanically important life form. Herbs play a significant role in arid ecosystems, particularly in Saudi Arabia, where they are integral to the daily needs of local communities (Hegazy *et al*., 2014; Baig *et al*., 2022). Moreover, many annual and perennial herbs are rich in bioactive chemicals and other secondary metabolites, making them highly effective in treating seasonal illnesses (Vitale *et al*., 2022; Greff *et al*., 2023).

The dependence of indigenous communities on plants for food and healthcare leads to the selective use of plant parts according to their specific applications (Turner *et al*., 2011; Eshete and Molla, 2021; Hegazy *et al*., 2020). Leaves together with other aerial parts are among the most utilized parts because they are rich in bioactive compounds and can be harvested more sustainably than underground parts (Stanley *et al*., 2012; Ahad *et al*., 2021). Furthermore, seeds are commonly employed in traditional medicine due to their believed therapeutic uses in treating a variety of ailments (Mazé *et al*., 2021). Seeds are highly regarded for their bioactive chemical content (Quílez *et al*., 2020; Ayalew *et al*., 2022). Traditional remedies are commonly prepared through methods such as grinding, boiling, and crushing to extract active ingredients (Haq *et al*., 2021), and are often stored in bottles or other containers for use during periods when fresh plant material is unavailable, particularly in winter or the off-season. Leaf collection is generally considered less destructive and more sustainable than harvesting roots, rhizomes, bark, or entire plants. The latter practices is fundamentally more destructive and may lead to population decrease. Similarly, intensive harvesting of resin-producing species, such as *Commiphora* sp., can harm plant health if repeated tapping or incorrect harvesting methods are used. According to local informants, excessive resin extraction can lower plant vigor, result in branch dieback, and, in severe cases, cause the death of entire trees. To preserve the ecological stability of natural populations and guarantee the long-term conservation of medicinal plant resources, sustainable harvesting methods are crucial (Papageorgiou *et al*., 2020; Guzo *et al*., 2023).

The prevalence of gastrointestinal issues in these areas can likely be attributed to poor hygienic conditions, malnutrition, and a lack of clean water. Similar findings have been reported by studies in Pakistan (Ullah *et al*., 2013), Nigeria (Gbadamosi and Obogo, 2013), and among various ethnic groups in Saudi Arabia (Tounekti *et al*., 2019; Ati *et al*., 2019). The treatment of gastrointestinal diseases constitutes a significant use of medicinal plants in many regions (Thirunatayanan and Rajkumar, 2012; Sargın *et al*., 2013; Moradi *et al*., 2016; Benkhnigue *et al*., 2023). How local communities engage with their environment and resources is closely linked to traditional knowledge. However, because plant resources were not given priority in forest policies until recently, the sustainability of this priceless wild treasure has gotten little attention. There is a decline in the ethnomedical knowledge of numerous medicinal plants in the study area as well as other regions of Saudi Arabia (Ati *et al*., 2019; Tounekti *et al*., 2019; Al-Robai *et al*., 2022). The younger generation's lack of interest in maintaining and using these old customs is blamed for this loss (Bhatia *et al*., 2014).

The high usage reports indicate a substantial demand for these medicinal plants to treat various disorders, leading to their overharvesting and subsequent decline in their natural habitats. Multiple studies have underscored the significance of certain plants in Saudi Arabia and their traditional medicinal uses among various tribal communities, providing evidence for the widespread utilization of these species as herbal medicines (Saad *et al*., 2005; Azaizeh *et al*., 2010; Alharbi, 2017; Al-Asmari *et al*.,2017; Alqethami *et al*., 2020). For example, local populations have long used *Rumex vesicarius* and *Commiphora gileadensis* to treat digestive diseases, inflammation, diarrhea, urinary infections, and high blood pressure (Ali *et al*., 2017; Ati *et al*., 2019; Al-Robai *et al*., 2022). Lactones and terpenoids are among the phytochemicals found in these plants that give them their therapeutic qualities (Al-Sieni, 2013; Alhazmi *et al*., 2022; Alfawaz, 2006; Gomaa and Saleh, 2014). The documented uses in the current study are mainly based on local knowledge, and more pharmacological and clinical research is needed to thoroughly confirm the effectiveness and safety of several reported medicinal species, even though these results offer some support for the traditional uses of these plants. Some medicinal plants such as *Citrullus colocynthis, Calotropis procera, Rhazya stricta,* and *Datura innoxia* may exhibit toxic effects if used improperly or in excessive amounts. The documented uses are based on local knowledge and should not be considered clinical dosage recommendations. Further toxicological, pharmacological, and clinical studies are needed to establish safe dosage ranges, efficacy, and potential adverse effects of the reported species.

The use value (UV) metric can be used to quantify the total utilization of plant species in ethnomedicine, which is correlated with the number of species employed. The use value index is a quantitative ethnobotanical metric that evaluates the relative importance of plant species based on their frequency of citation and usage by local people (Alharbi, 2017; Al-Asmari *et al*., 2017; Alqethami *et al*., 2020). Higher UV values suggest greater cultural and medical significance; nevertheless, a higher UV does not always reflect a broader range of applications, but rather a higher level of local knowledge and use (Rasul *et al*., 2012). Several ethnobotanically significant species are declining due to both environmental and anthropogenic factors, such as habitat degradation, overharvesting, and land-use change (Alatawi, 2022). *Caudanthera sinaica, Salvadora persica, Senna alexandrina,* and *Salvia deserti.* are among the species under conservation concern in the current study, and they may require specific conservation and sustainable management methods to ensure their viability in the future. The local informants consistently identified that these species are becoming scarcer because of habitat degradation and harvesting pressure. These findings are consistent with conservation data, and they reveal the overlap between traditional ecological knowledge and formal conservation decisions. Thus, integrating traditional use with ecological status is regarded as one of the most significant aspects that emphasize the practitioners' conservation needs (Bhatt *et al*., 2023; Haq *et al*., 2023). In addition to ecological influences, socioeconomic changes may influence the use and transfer of ethnobotanical knowledge. Higher income levels, higher living standards, more educational opportunities, and greater access to commercially available products can all help to reduce reliance on wild plant resources, contributing to the gradual erosion of traditional ethnobotanical knowledge, especially among younger generations (Kodirekkala, 2017). Older community members, on the other hand, frequently have a deeper understanding of wild plant applications due to their lifelong relationships with local ecosystems and cultural traditions. Understanding these socioeconomic drivers is therefore critical, and it represents an essential area for future research.

Furthermore, TEK offers important insights into environmental stewardship, biodiversity protection, and sustainable resource management. Local communities are essential to the preservation and use of indigenous knowledge about ecosystem resilience and climate change adaptation (Haq and Kyarong, 2026). Global approaches frequently overlook the complexities of local cultures, languages, and accent differences. Overall, these factors contribute significantly to society, but they are rarely addressed in broad strategic frameworks (Haq *et al*., 2024a). This comprehensive and social context includes nature awareness, citizen participation and advocacy, stakeholder and community involvement, human-nature interactions, biodiversity, landscape and ecosystem management.

Implications for conservation

The results of this study reveal clear conservation priorities for ethnobotanically important plant species in the Jizan Region, where the wild flora continues to support the healthcare, food security, and livelihood activities of local communities. Species with high use values: *Commiphora gileadensis*, *Commiphora kataf*, *Rumex vesicarius*, and *Senegalia hamulosa*, experience sustained harvesting pressure, increasing the risk of population decline when combined with habitat degradation and land-use change. The presence of threatened, declining, and rare taxa indicates reduced ecological resilience and limited natural regeneration in several key species, necessitating targeted management actions. Conservation efforts should therefore focus on protecting natural populations through habitat protection, regulating extraction intensity, and implementing restoration programs based on native species propagation. Many traditional plant-use practices are passed through oral transmission and are at risk of fading. Establishing community-led documentation programs, ethnobotanical training, and school-based knowledge-sharing activities can all help to preserve TEK for future conservation efforts.

The documented linkage between cultural reliance and ecological vulnerability supports the integration of local knowledge into conservation frameworks, as community members possess detailed understanding of species availability, seasonal dynamics, and customary harvesting norms. Engaging local stakeholders in conservation planning and restoration activities can strengthen long-term resource stewardship, enhance monitoring efficiency, and align management strategies with socio-cultural realities. Protecting ethnobotanically valuable species is fundamental not only for maintaining regional biodiversity but also for sustaining ecosystem services, cultural continuity, and community well-being in arid environments of Saudi Arabia. Further multidisciplinary studies that combine ethnobotany, ecology, and socio-cultural research are needed to quantify the ecological implications of traditional practices, identify conservation-priority species, and assess how TEK might guide climate adaption strategies in desert ecosystems.

CONCLUSION

The current study fills the gap in knowledge by documenting the local knowledge and cultural practices of 39 plant species utilized for multiple purposes, demonstrating the rich ethnobotanical heritage and local people's relationship to their environment. The widespread usage of herbaceous plants and the dominance of Apocynaceae and Fabaceae demonstrate how these taxa have adapted to the arid climate and how crucial they are to traditional healthcare systems. Medication was the most prevalent category, with the most common treatments being for gastrointestinal and dermatological disorders. In addition to their medicinal applications, several species contributed to the production of fuelwood, food, fodder, scents, herbal tea, and crafts, underscoring their multifaceted significance in local life. The most used plant portion was leaves, and the most common method of preparation was decoction, indicating long-standing customs for making remedies. The survey revealed three plant species used in traditional veterinary medicine to treat livestock diseases, underscoring their importance to traditional livestock management approaches.

The ecological status of the described species revealed that two species, *Commiphora gileadensis and Commiphora kataf,* are classified as Threatened. Other species includes *Caudanthera sinaica, Salvadora persica, Senna alexandrina,* and *Salvia deserti,* were reported as declining and rare category due to a combination of environmental and human influences. High-value species may be more sensitive to harvesting pressure, emphasizing the importance of sustainable harvesting, medicinal plant cultivation, community-based conservation, and traditional knowledge preservation. The reported medicinal uses also serve as a solid platform for future phytochemical and pharmacological research to confirm their therapeutic potential. Overall, this work helps to preserve ethnobotanical knowledge and promotes the sustainable use, restoration, and management of plant resources in Saudi Arabia.

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