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Plant Diversity and Useful Ecosystem Services of the Cholistan Desert, Pakistan

Rahmatullah Qureshi
Department of Botany, PMAS-Arid Agriculture University, Rawalpindi, Pakistan
e-mail: rahmatullahq@uaar.edu.pk

Abstract.

Aims*.** The studies were undertaken to analyse useful ecosystem services of the Cholistan Desert, one of the largest deserts in Pakistan, and the impacts of anthropogenic activities on them, and to prioritize such services based on people's perspectives. ***Methods*.** The Cholistan Desert also referred to as Rohi in the local dialect, is located in the southern part of Punjab Province in eastern Pakistan. Key informants and the local inhabitants were interviewed to obtain the basic data. Five different sites were selected for determining desert rangeland ecosystem services. A total of 150 questionnaires were circulated for recording the data on desert ecosystem services. ***Results. There is overexploitation of the flora/vegetation and wildlife useful resources in the Cholistan desert ecosystem, while its land resources are vulnerable due to the scarcity of water. This study recorded 141 plants distributed across 105 genera and 43 families, which are being used by the desert inhabitants to fulfill their various needs. It turned out that agro-pastoral plays a vital role in the growth of the local economy, and it accounts for more than half of the total agricultural income and shares 10.6% of the national gross domestic product of Pakistan. The most popular domesticated animal is the goat. In addition, locals breed donkeys, sheep, and camels. The local communities are utilizing wild plant resources to meet their food requirements. 21 species that are used as fruit, of which 16 are wild fruits. Thirty species were consumed as a vegetable, and for cooking food. The Cholistan locals are well-versed in the use of natural flora as the primary source of medicines. They have identified 87 plant species as having medicinal properties, which were used to cure 69 different illnesses and diseases. ***Conclusions*.** An analysis of plant diversity and useful ecosystem services in the Cholistan Desert demonstrates that nearly 150 species are utilized as fruits, vegetables, and food preparation, as well as a common source of medicine for treating various ailments and somatic diseases. In the Cholistan Desert, the harsh climate of high temperatures and intense drought hinders agricultural productivity. To mitigate the negative impacts of these problems, it is

necessary to screen and evaluate genetic resources of indigenous plants, as well as native and also alien drought- and salt-tolerant crops that can grow under conditions of lower water demand.

Key words: desertification, endemic flora, livelihood, phytodiversity, Punjab province.

Рослинне різноманіття та корисні екосистемні ресурси пустелі Чолістан, Пакистан

Рахматулла Куреші
Кафедра ботаніки, Пір Мехр Алі Шах Арідський сільськогосподарський університет, Равалпінді, Пакистан, e-mail: rahmatullahq@uaar.edu.pk

Реферат.

Мета. Дослідження було проведено з метою аналізу корисних екосистемних ресурсів пустелі Чолістан, однієї з найбільших пустель Пакистану, та впливу на них антропогенної діяльності, а також для визначення пріоритетності цих ресурсів місцевим населенням. ***Матеріали і методи.*** Пустеля Чолістан, яку також називають на місцевому діалекті Рохі, розташована на сході Пакистану в південній частині провінції Пенджаб. Для отримання основних даних були опитані ключові інформатори та місцеві жителі. Для визначення екосистемних послуг пустельних пасовищ було обрано п'ять різних ділянок. Загалом для збору даних про екосистемні ресурси пустелі було розповсюджено 150 анкет. ***Результати***. В екосистемі пустелі Чолістан спостерігається надмірна експлуатація корисних ресурсів флори/рослинності та дикої природи, тоді як її земельні ресурси є вразливими через дефіцит води. В результаті дослідження було визначено 141 рослину з 105 родів і 43 родин, які використовуються мешканцями пустелі для задоволення різноманітних потреб. З’ясувалося, що агро-скотарство відіграє життєво важливу роль у зростанні місцевої економіки, і на нього припадає понад половина загального доходу від сільського господарства та 10,6% національного валового внутрішнього продукту Пакистану. Найпопулярнішою одомашненою твариною є коза. Окрім того місцеві жителі розводять віслюків, овець і верблюдів. Місцеві громади використовують ресурси дикорослих рослин, щоб задовольняти свої потреби в продуктах харчування. 21 вид рослин, 16 з яких дикорослі, використовуються як фрукти, а тридцять видів — як овочі та для приготування їжі. Місцеві жителі Чолістану добре знаються на застосуванні природної флори як основного джерела ліків. Вони визначили 87 видів рослин, які використовувалися для лікування 69 різних хворобливих станів і соматичних хвороб. ***Висновки***. Аналіз різноманіття рослин та корисних екосистемних послуг у пустелі Чолістан

засвідчує, що майже 150 видів використовуються як фрукти, овочі та продукти харчування, а також як традиційне джерело ліків для лікування різних недуг та соматичних хвороб. Суворий клімат з високими температурами та інтенсивною посухою перешкоджає продуктивності сільського господарства у пустелі Чолістан. Щоб пом'якшити негативні впливи цих проблем пропонується провести скринінг і оцінку генетичних ресурсів місцевих рослин, а також місцевих та інтродукованих посухо- й солестійких культур, які спроможні рости в умовах водного дефіциту.

Ключові слова: спустелення, ендемічна флора, засоби до існування, фіторізноманіття, провінція Пенджаб.

Introduction. Nature has provided every bit of opportunity for the survival of human beings. The early man opened his eyes to the diversity of ecosystems that provided various services for his comfort. Four major human needs, such as food, shelter, clothing, and medicines, are directly obtained from plant resources to meet the basic needs of human beings. Ethnobotanical enumerations deal with such important information regarding the usage of plant species by the natives across the world. From Pakistan, a few studies have been reported (Shinwari & Khan, 2000; Bhatti, 2001; Abd El-Ghani et al., 2018; Zareef et al., 2023; Qureshi, 2025). The billions of people acknowledge the magnitude of ecosystem services in their daily life for their sustenance (Tallis & Kareiva, 2005).

According to Stevens et al. (2011) and Duraiappah et al. (2005), ecosystem services are the result of ecosystem functioning and benefit the local communities. The services that the forest ecosystems give can be roughly categorised into four main classes, including regulating (Boyd & Banzhaf, 2007), provisioning (Kremen, 2005) and supporting, and social groupings (Naidoo et al., 2008). These services may include purifying the air, dealing with waste, purifying and controlling water flow (Hein et al., 2006), preventing soil erosion, controlling climates, maintaining soil fertility (Klein et al., 2007), pollinating, dispersing seeds, controlling pests and diseases (Gallai et al., 2009), supporting migratory species' life cycles, recycling nutrients, preserving spiritual, religious, and aesthetic values, promoting ethnic diversity, engaging in leisure activities (Acharya et al., 2021; Qureshi, 2025) coupled with carbon sequestration (De Groot et al., 2002).

It has been estimated that approximately 10% human population is directly and 40% indirectly reliant globally on mountain forest resources for their existence (Schild, 2008; Schild & Sharma, 2011). There is a need to manage forest structures for the existence of local communities in addition to prevailing climatic conditions (Cronin & Pandya, 2009). Like mountain forests, the arid land of the Cholistan Desert is under high pressure from anthropogenic activities that include over-grazing, deforestation, crushing, soil erosion, over-exploitation, and intuitive collection, which

led to continuous deteriorating effects on the vegetation structure and services (Costanza et al., 1998). Keeping in view, this study was undertaken to record ecosystem services of the Cholistan Desert, Pakistan coupled with the impacts of anthropogenic activities and prioritize such services based on people's perspective and their market value.

This article uses some of the material from our previous publication (Qureshi et al, 2024), but in view of the importance of the issue of introducing climate-oriented agriculture in deserts, as well as the methodological adjustments we have made, we believe it is appropriate to publish the results of our research.

Materials and Methodology. Study area. The Cholistan Desert, also referred to as Rohi in the local dialect, is located in the southern part of Punjab Province in eastern Pakistan (Kahlown et al., 2004). At 112 meters above mean sea level, it is located between 27°42' and 29°45' north latitude and 69°52' and 75°24' east longitude (Baig et al., 1980). It had a length of around 480 km and a breadth of 32 to 192 km, covering an area of about 2.6 million hectares (Kahlown et al., 2004; Ahmad, 2008). In the northwest, it is bordered by the Sutluj River and the farmland of the Bahawalpur Division; in the south, it is bordered by the Sukkur district (Sindh); and in the southeast, there is an international border between India and Pakistan. This area is home to more than 110,000 nomadic pastoralists, and information about its geomorphic regions (Lesser Cholistan and Greater Cholistan), topography, parent material, seasonal fluctuations, and a wide range of edaphic conditions is available in our (Qureshi et al., 2024; Qureshi, 2025) and other (Baig et al., 1980; Akbar et al., 1996; Kahlown et al., 2004; Ahmad, 2008; Akram et al., 2008; Wariss et al., 2021) previous publications.

The survey techniques. Key informants and the local inhabitants were interviewed to obtain the basic data. The natural landscapes without alteration by human activities were selected as ecosystems. Five different sites were selected for determining desert rangeland ecosystem services. A total of 150 questionnaires were circulated for recording the data on desert ecosystem services. The survey addressed various parameters like profession, family size, income, present standing, profits, threats, and conservation management of forest ecosystem (Raymond et al., 2009); the extent of fuelwood consumption; favorite fuelwood, eatable and edible and medicinal (Qureshi & Bhatti, 2008; Qureshi, 2025; Acharya et al., 2021,), flock size; feeding area; wild vegetables; and timber-wood collection (Ogunkunle & Oladele, 2004). The value of the utilization index (FNI) was calculated with us as the number of needs of local communities in the Cholistan Desert that are fulfilled by each plant species studied. A plant species' higher FNI denotes its larger functional role in community support.

Results and Discussion. There is overexploitation of the flora/vegetation and wildlife resources in the Cholistan desert ecosystem, while its land resources are vulnerable due to the scarcity of water. All this hampered the production of the

valuable resources, which include wild and cultivated plants and wildlife (Chaudhry et al., 2004). An imaginary picture (Fig. 1) is shown that indicates the flowchart of the natural resources found in the Cholistan Desert.

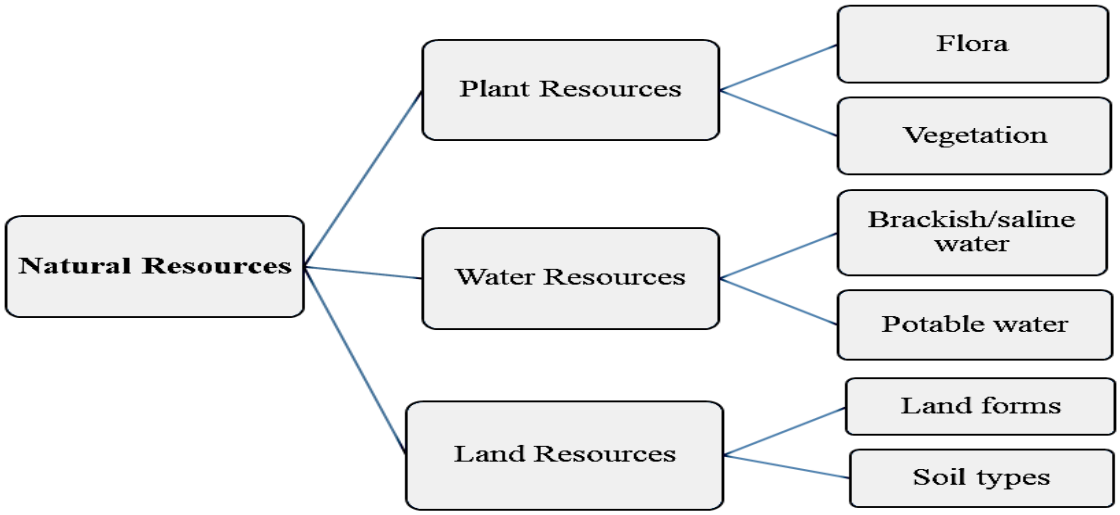

Figure 1**.** Flowchart of the natural resources of Cholistan Desert, Pakistan (according to Qureshi et al., 2024, as amended)

Due to urbanization, the indigenous knowledge of plants is rapidly declining. For recording the uses of plants by the Cholistan Desert native population, it was thoroughly surveyed from 2013 to 2016 its area. This study recorded 141 plants distributed across 105 genera and 43 families, which are being used by the desert inhabitants to fulfill their various needs.

Grasses were dominant in the area, and *Poaceae* Barnhart contributed the maximum species (23 spp., 16.31%), followed by *Fabaceae* Lindl. (13 spp., 9.22%), *Amaranthaceae* Juss., *Asteraceae* Bercht. & J.Presl, *Mimosaceae* R.Br., and *Solanaceae* Juss. (6 spp., 4.26% each), and *Boraginaceae* Juss., *Brassicaceae* Burnett, *Euphorbiaceae* Juss., and *Moraceae* Gaudich. (5 spp., 3.55% each).

There were eight life form classes of the flora, out of which herbs were dominating in the area with 64 plant species (40.76%), followed by trees (28 spp., 17.83%), grasses (24 spp., 15.29%), shrubs (23 spp., 14.65%), and subshrubs (10 spp., 6.37%), while the rest of the three life forms had fewer species (Fig. 2).

This ecosystem fulfills nine different needs of the local communities of the area. According to the use value index (FNI) of individual species, three species, such as *Azadirachta indica* A.Juss., *Cordia myxa* L., and *Prosopis cineraria* (L.) Druce, ranked first, fulfilling eight use classes, followed by *Capparis decidua* (Forssk.) Edgew., *Melia azedarach* L., *Acacia nilotica* (L.) Willd. ex Delile, *Morus alba* L., and *Ziziphus mauritiana* Lam., which meet seven different needs of the local inhabitants.

Nine species fulfilled six use categories, 10 species fulfilled six requirements, 20 species accomplished four needs, 29 species were used to overcome three use classes,

and 37 species for two classes, while 27 species were used to fulfill a single use class (Fig. 3).

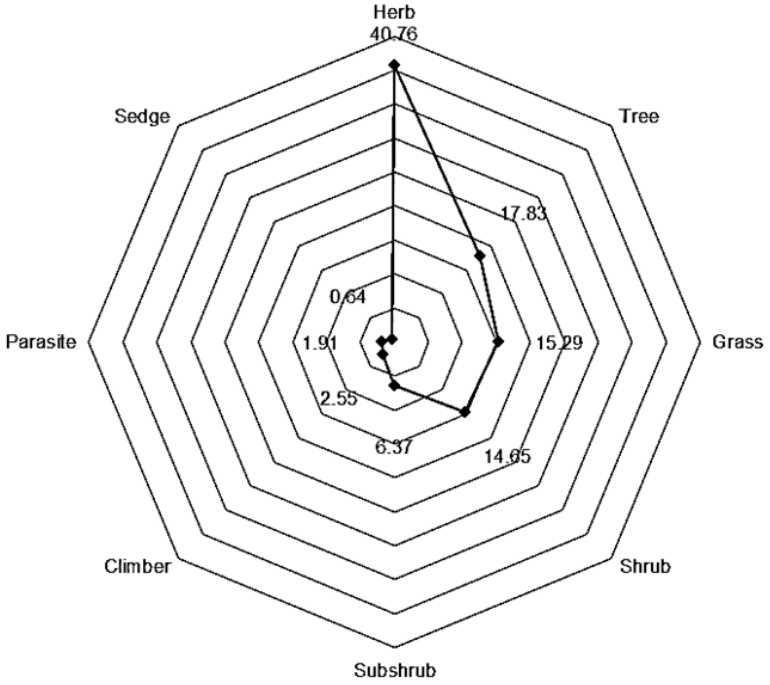

Figure 2.
Life form classes of the flora of Cholistan Desert, Pakistan (according to Qureshi et al., 2024, as amended)

Since this desert is arid rangeland, thus, this ecosystem feeds the livestock, which is the only livelihood of the local communities. The area is blessed with maximum palatable species in the form of fodder (122 spp., 28.37%), followed by medicinal (78 spp., 18.14%), other services (76 spp., 17.67%), fuel (65 spp., 15.12%), vegetable (26 spp., 6.05%), and fruits (20 spp., 4.65%), whereas the rest of the three use categories were in the range of 11–17 species.

Among the palatable species, *Lasiurus scindicus* was the most important fodder species, which is favorably grazed by all animals, while *Salvadora oleoides* was only browsed by the camel. Some species, viz., *Aeluropus lagopoides*, *Aristida adscensionis*, and *A. funiculata*, *Brachiaria reptans*, *Cenchrus biflorus*, *C. ciliaris*, *C. pennisetiformis*, and *C. setigerus*, *Cynodon dactylon*, *Cyperus conglomeratus*, *Dactyloctenium aegyptium*, *D. aristatus*, and *D. scindicum*, *Heliotropium strigosum*, *Ochthochloa compressa*, *Panicum maximum*, and *Tribulus longipetalus* were jointly grazed/browsed by cows, sheep, and goats.

Goats mostly depend solely on forages, including grasses, browse (shrubs and trees), weeds, forbs, small grains, hays, and silages, to meet their nutritional needs. Except for some species, these species are rich in protein, energy, minerals, and vitamins in valuable proportions. Goats typically select shrubs and bushes for browsing on bushes compared to grasses. Besides, this animal typically uses approximately 25% grasses, 5% forbs, and 70% browses in various seasons. Sheep mostly choose grasses and forbs as compared to shrubs. The diet of sheep is mostly

comprised of more than 50% grasses, while goats utilize 79 to 86% bushes/shrubs during various seasons.

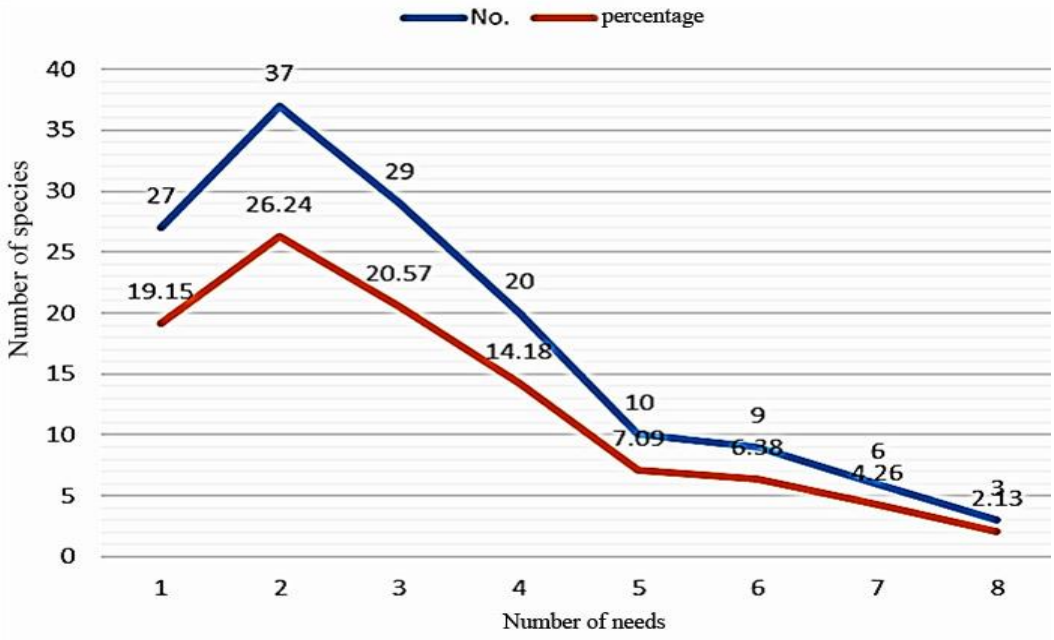

Figure 3. Use Value Index (FNI) of plants from the study Cholistan Desert area (according to Qureshi et al., 2024, as amended)

Animal feed. The locals prefer to domesticate four animals: donkeys, sheep, goats, and camels. The most important preferred animal was the goat, which heavily utilizes most of the plant species. This arid land is blessed with palatable grasses, forbs, shrubs, and trees to feed their livestock. Altogether 141 species are recorded to be used as fodder/forage to feed the livestock of the local communities (Table 1).

The census of such species revealed that there was a maximum number of species that were found highly palatable (68 spp., 47.22%), followed by moderately palatable (46 spp., 31.94%) and less palatable (26 spp., 18.06%), whereas there was an almost negligible proportion that were non-palatable (4 spp., 2.78%).

The top 30 highly palatable species were mostly consumed by goats (29 spp.), followed by sheep (24 spp.), cows (19 spp.), donkeys (17 spp.), and camels (14 spp.). *Lasiurus scindicus* was to be the most important feed, which was favorably utilized by all domesticated animals. On the other hand, *Salvadora oleoides* was only browsed by camel. Eighteen species, such as *Aeluropus lagopoides, Aristida adscensionis, A. funiculata, Brachiaria reptans, Cenchrus biflorus, C. ciliaris, C. pennisetiformis, C. setigerus, Cynodon dactylon, Cyperus conglomerates, Dactyloctenium aegyptium, D. aristatus, D. scindicum, Heliotropium strigosum, Ochthochloa compressa, Panicum maximum, Tribulus longipetalus,* and *Withania coagulans*, were jointly grazed/browsed by cows, sheep, and goats.

The camels typically graze on a range of fodder plants, including prickly shrubs, halophytes, and scented species. Additionally, camels are adapted to the challenging

feeding conditions of deserts by choosing high-quality foods year-round. These diets contain plants with high crude protein content and good digestibility (Rutagwenda et al., 1989; Iqbal & Khan, 2001). Fourteen species, viz., *Acacia nilotica* subsp. *cupressiformis, A. nilotica* subsp. *indica, A. jacquemontii, Capparis decidua, Haloxylon salicornicum, Heliotropium crispum, H. strigosum, Lasiurus scindicus, Prosopis cineraria, Salvadora oleoides, Stipagrostis plumosa, Withania coagulans, Ziziphus mauritiana,* and *Z. nummularia* were delicious species and consumed by the camel.

Table 1. The contribution of plant families to the useful flora of the Cholistan Desert, Pakistan

S. No.	Family	Number of species		S. No.	Family	Number of species	
		pcs	%			pcs	%
1	*Poaceae*	23	16.31	**23**	*Cyperaceae*	2	1.42
2	*Fabaceae*	13	9.22	**24**	*Meliaceae*	2	1.42
3	*Amaranthaceae*	6	4.26	**25**	*Rhamnaceae*	2	1.42
4	*Astraceae*	6	4.26	**26**	*Agavaceae*	1	0.71
5	*Mimosaceae*	6	4.26	**27**	*Aizoaceae*	1	0.71
6	*Solanaceae*	6	4.26	**28**	*Alloaceae*	1	0.71
7	*Boraginaceae*	5	3.55	**29**	*Arecaceae*	1	0.71
8	*Brassicaceae*	5	3.55	**30**	*Bombacaceae*	1	0.71
9	*Euphorbiaceae*	5	3.55	**31**	*Caesalpiniaceae*	1	0.71
10	*Moraceae*	5	3.55	**32**	*Cuscutaceae*	1	0.71
11	*Capparidaceae*	4	2.84	**33**	*Fumariaceae*	1	0.71
12	*Chenopodiaceae*	4	2.84	**34**	*Liliaceae*	1	0.71
13	*Molluginaceae*	4	2.84	**35**	*Malvaceae*	1	0.71
14	*Zygophyllaceae*	4	2.84	**36**	*Moringaceae*	1	0.71
15	*Asclepiadaceae*	3	2.13	**37**	*Nyctaginaceae*	1	0.71
16	*Convolvulaceae*	3	2.13	**38**	*Orabanche*	1	0.71
17	*Myrtaceae*	3	2.13	**39**	*Oxaladaceae*	1	0.71
18	*Polygonaceae*	3	2.13	**40**	*Papaveraceae*	1	0.71
19	*Tiliaceae*	3	2.13	**41**	*Primulaceae*	1	0.71
20	*Aizoaceae*	2	1.42	**42**	*Tamaricaceae*	1	0.71
21	*Apocynaceae*	2	1.42	**43**	*Typhaceae*	1	0.71
22	*Cucurbitaceae*	2	1.42	Total		141	100

Ali El-Keblawy (2003) demonstrated that palatable plants such as *Crotalaria aegyptiaca, Indigofera articulata, Pennisetum divisum, Stipagrostis plumosa*, and *Panicum turgidum* were significantly reduced as a result of camel overgrazing in the United Arab Emirates, indicating that these species are crucial components of camel

diets in arid rangelands. These genetic resources have tremendous importance and can be exploited to advance agricultural methods. Sustainable management of natural resources will be achieved through the preservation of these natural environments and their genetic diversity.

Agro-pastoral plays a vital role in the growth of the local economy, and it accounts for more than half of the total agricultural income and shares 10.6% of the national gross domestic product of Pakistan (Ghazali, 2010). The desert regions of the country are of vital importance to the national economy, since these are rangelands and livestock husbandry is the only source of income for the local communities. Besides, milk and meat production may be offset by the climatic fluctuations, especially in those areas that are facing food starvation. In Pakistan, 8.1% of buffaloes, 13.5% of cattle, 15.3% of sheep, and 14.4% of goats are raised in the desert areas. Nevertheless, there are various constraints that limit the local livestock productivity, such as the shortage of fodder, high rate of diseases, limited availability of veterinary services, and poor access to animal vaccination (Farooq et al., 2009). For the sustainable production of livestock in desert habitats, there is a need to ensure the availability of plentiful fodder resources and management (Hussain & Durani, 2009). Since Cholistan is a rangeland, the vegetation is typically xerophytic in nature, adapted to the xeric/arid conditions. The plants are responsive to the extreme temperature fluctuations, moisture, and edaphic conditions. Besides these harsh climatic conditions, this rangeland sustains and supports the livestock by providing palatable plant species with a wide diversity of growth patterns (Qureshi et al., 2024).

First and foremost, the grasses such as *Cynodon dactylon*, *Cenchrus ciliaris*, *C. setigerus*, *C. pennisetiformis*, *Eragrostis barrelieri*, *Lasiurus scindicus*, *Ochthochloa compressa*, *Panicum antidotale*, *P. turgidum*, and *Sporobolus* species are interesting plants that provide feed to the grazers for livestock. The domesticated animals prefer to graze/browse on various species. For instance, camels are fond of halophytic plants such as *Haloxylon*/*Suaeda* species, *Calligonum polygonoides*, and *Salvadora oleoides*. The *Leptadenia pyrotechnica* and *Crotalaria burhia* young plants may be browsed by goats and other livestock, though these species are less palatable and usually left due to the higher fiber and silica contents and due to ample availability of fodder. The poisonous or thorny species, such as *Calotropis procera*, *Tephrosia* spp., and *Dipterygium glaucum*, are not browsed by the majority of animals (Chaudhry and Nasim, 1995); however, in a shortage of fodder, these are browsed by goats and camels.

Human diet/Food. The existence of mankind, as well as other main organisms, is greatly dependent on plants. It is appraised that approximately 5000 plants are utilized by the human beings as food and out of which, only 20 species feed majority of the human population and 3 or 4 plant species are grown as staple food crops. Conserving wild plant resources enables us to sustainably use the wild gene pool in

developing food crops for various purposes, such as disease resistance, tolerance to various environmental factors, and improved productivity (Plotkin, 1988; Reid & Miller, 1989). Khushab (Punjab, Pakistan) is an arid land that is facing a shortage of food; however, the local communities are utilizing wild plant resources to meet their food requirements. Twenty-one of these species are used as fruit, of which 16 are wild fruits. The most commonly used fruits are *Citrus medica* var. *acida*, *C. sinensis*, *Ficus carica, Morus alba, M. nigra, Phoenix dactylifera, Psidium guajava, Syzygium cumini,* and *Ziziphus mauritiana*. The fruits of *Salvadora oleoides* (Peelu) and *Ziziphus numularia* (Jhar beri) and of other wild locally are collected and consumed and also sold in the local market.

Thirty species were consumed as vegetable cooking, and out of them, eight species viz., *Amaranthus viridis*, *Anethum graveolens*, *Brassica campestris*, *Cicer arietinum, Eruca sativa, Momordica balsamina, Portulaca oleracea*, and *Spinacea oleracea* are sold in the market. Besides, seven species such as *Cordia myxa* (unripe fruit), *Capparis decidua* (unripe fruit), *C. spinosa* (unripe fruit), *Citrullus colocynthis* (fruit), *Citrus lemon* (ripened fruit), *Momordica balsamina* (unripe fruit) and *Moringa oleifera* (roots/unripe fruit) are made into pickle which is locally sold and consumed.

The Cholistan Desert does not sustain proper agriculture due to the unavailability of water. Yet, the inhabitants of this area collect seeds, fruits/pods, and vegetative parts for preparing curry and food dishes to meet the needs of their diet. Though these plant resources are less palatable and deficient in dietary components, wild plants provide instant relief during the drought and famine period. The fruit of *Capparis decidua* (Karir), roots/pods of *Moringa oleifera* (Suhanjna), and pods of *Prosopis cineraria* (Jand) are gathered for food and sold in the local market.

The floral buds of *Capparis decidua* and *Moringa oleifera* are cooked as vegetables, whereas unripe fruits are pickled. Most expensive pickles have a good market in Europe and are served in top restaurants. *Calligonum polygonoides* (Phog) is a very common shrub, and its flower buds, either fresh or sun-dried, are used to make a luscious dish locally called as *Phugusi*. Fruits of *Salvadora oleoides* (*Peelu*) and *Ziziphus numularia* (*Jhar beri*) growing in the Cholistan Desert are collected and harvested for human utilization (Fig. 4). During the famine period, seeds of *Panicum turgidium* and *Cenchrus ciliaris* are mixed with flour for bread making. In addition to this, gums are obtained from various plants, such as *Acacia nilotica and Prosopis cineraria.*

Medicinal resources. Since the beginning of time, man has relied on herbs as his primary source of medical care because they could be obtained locally. Medicinal plants are the primary source of medication for the nomads living in the Cholistan Desert. They rely on the available plant resources to meet their health needs because they live far from cities and lack access to basic medical facilities (Qureshi & Bhatti, 2008; Qureshi, 2018). The Cholistan locals are well-versed in the use of natural flora as the primary source of medicines. They have identified 87 plant species as having

medicinal properties, which were used to cure 69 different illnesses and diseases (Table 2).

Figure 4.
Collection of wild fruit from *Salvadora oleoides* by the nomadic girls (according to Qureshi et al., 2024, as amended)

The majority of the species (20 spp., 6.39%) were used to treat the most common ailment in the region, which was constipation. Following that were boils (14 spp., 4.47%), stomach issues (13 spp., 4.15%), blood purifier (12 spp., 3.83%), gas problems (11 spp., 3.51%), liver tonic, and skin itching (10 spp., 3.19% each). These are just a few of the studies that have yielded similar results (Akram et al., 2008; Mohan et al., 2008; Qureshi & Bhatti, 2008; Shinwari, 2010; Pradhan & Badola, 2015). Residents of the Nara Desert used the 51 plant species, which are divided into 43 genera and 28 families, to treat a range of human illnesses. Their research helps apply the current findings and offers more details about the medicinal plants found in this area.

Fagonia cretica is boiled in water and used as a bath to treat skin diseases, including itching and irritation. The floral branches and leaves of *Azadirachta indica* are ground in water and used orally as a blood purifier and hepatoprotective agent. All parts of *Calotropis procera* are used to treat various diseases (Bhatti et al.,1998). For example, the powder of leaves is dusted on wounds to heal. The young twig is forcefully given to cattle to treat colic and indigestion due to overgrazing. *Leptadenia pyrotechnica* was used to treat eczema/ringworm. Most of the desert dwellers use a single species to treat two or more diseases (Qureshi, 2018). For instance, *Achyranthes aspera* was used to treat asthma, cough, cold, pneumonia, joint pain, cuts, and wounds. *Calotropis procera* was used for earache, sciatic pain and pneumonia, painful joints, and chest pain. *Capparis decidua* was reported in asthma, cough, joint pain, inflammation, boils, muscular injuries, and wounds. *Tamarix aphylla* was applied to boils and wounds. *Schweinfurthia papilionacea* is used for

typhoid fever: skin impurities, chronic ulcers, and cancerous wounds. Fruits of *Withania coagulens* are soaked in water overnight and used as blood purifiers and cooling agents. *W. somnifera* is used in glandular swellings, joint pain, and spermatorrhea, and as a nerve tonic (Qureshi, 2018). A list of the most important medicinal plants is provided in Table 2.

Table 2. Medicinal plants of the Cholistan Desert, Pakistan (according to Qureshi et al., 2024, as amended)

Sr. No.	**Botanical names** (family, species & infraspecific taxon)		**Vernacular name**
1	Acanthaceae	*Blepharis scindica* T. Anders.	Utangan
2	Aizoaceae	*Zaleya pentandra* (L.) C.Jeffrey	Itsit
3	Aizoaceae	*Trianthema portulacastrum* L.	Itsit
4	Aizoaceae	*Gisekia pharnaceoides* L.	Buloka sag
5	Amaranthaceae	*Aerva javanica* var. *javanica*	Boi
6	Amaranthaceae	*Amaranthus viridis* L.	Cholai
7	Asclepiadaceae	*Calotropis procera* subsp. *hamiltonii* (Wight) Ali	Ak
8	Asclepiadaceae	*Leptadenia pyrotechnica* (Forsskal.) Decne	Khipp
9	Asclepiadaceae	*Oxystelma esculentum* (L. f.) R. Brown	Dudhi
10	Asclepiadaceae	*Pergularia daemia* (Jacq.) N. E. Brown.	Karial
11	Asteraceae	*Echinops echinatus* Roxb.	Unt katara
12	Asteraceae	*Launaea nudicaulis* Less	Dudhkal
13	Asteraceae	*Oligochaeta ramosa* (Roxb.) Magenitz	Birham dandi
14	Boraginaceae	*Cordia gharaf* Ehrenb. ex Asch.	Lassura
15	Boraginaceae	*Heliotropium crispum* Desf.	Kali lani
16	Boraginaceae	*Heliotropium strigosum*	Gorakh Pan
17	Brassicaceae	*Farsetia hamiltonii* Royle	Lathi or Farid booti
18	Caesalpinaceae	*Cassia italica* subsp. *italica*	Ghora wall or Sana
19	Caesalpinaceae	*Cassia fistula* L.	Amaltas
20	Capparidaceae	*Capparis decidua* (Forsskal.) Edgew	Karir
21	Capparidaceae	*Capparis spinosa* L.	Kubber

22	Capparidaceae	*Cleome brachycarpa* Vahl. ex. DC.	Noli or Kastoori
23	Capparidaceae	*Cleome scaposa* DC.	Khastoori boti
24	Capparidaceae	*Dipterygium glaucum* Decne.	Phel
25	Chenopodiaceae	*Haloxylon recurvum* Bunge. ex. Boiss.	Khar or Sajji
26	Chenopodiaceae	*Haloxylon salicornicum* (Moq.) Bunge	Lana
27	Chenopodiaceae	*Salsola baryosma* (Roem. ex. Scult.) Dany.	Lani
28	Chenopodiaceae	*Suaeda fruticosa* Forssk. ex J. F. Gmelin	Kali lani
29	Compositae	*Pulicaria crispa* (Cass.) Benth. & Hook. f.	Bui
30	Convolvulaceae	*Convolvulus prostratus* Forssk.	Hiran booti
31	Convolvulaceae	*Cressa cretica* L.	Oini
32	Cucurbitaceae	*Citrullus colocynthis* (L.) Schrad.	Tumma/ Kaur tumma
33	Cucurbitaceae	*Cucumis melo* var. *agrestis* Naudin	Chibbarr
34	Cucurbitaceae	*Momordica balsamina* L.	Jangli Karela
35	Cucurbitaceae	*Mukia maderaspatana* (L.) M.J. Roem	Gawala kakri
36	Cuscutaceae	*Cuscuta reflexa* Roxb.	Akash bail
37	Cyperaceae	*Cyperus rotundus* L.	Mootha
38	Euphorbiaceae	*Chrozophora sabulosa* Kar. & Kir.	Nilakari
39	Euphorbiaceae	*Euphorbia granulata* Forssk.	Dudheli
40	Euphorbiaceae	*Euphorbia prostrata* Ait.	Hazar dani
41	Malvaceae	*Abutilon muticum* (Del.ex DC.) Sweet	Kanghi buti
42	Meliaceae	*Azadirachta indica* A.Juss.	Neem
43	Meliaceae	*Melia azedarach* L.	Bakain
44	Mimosaceae	*Acacia jacquemontii* Benth.	Banwli
45	Mimosaceae	*Acacia nilotica* (L.) Delile	Babul or Kikar
46	Mimosaceae	*Albizia lebbeck* (L.) Benth.	Shirin
47	Mimosaceae	*Prosopis cineraria* (L.) Druce	Jand
48	Molluginaceae	*Glinus lotoides* L.	Gandi-booti
49	Molluginaceae	*Mollugo cerviana* (L.) Seringe	Padi or Sarr
50	Molluginaceae	*Mollugo nudicaulis* Lamk.	Gandi-buti
51	Neuradaceae	*Neurada procumbens* L.	Chhapri

52	Nyctaginaceae	*Boerhavia procumbens* Banks ex Roxb.	Biskhipra
53	Papilionaceae	*Alhagi maurorum* Medic.	Jawansa
54	Papilionaceae	*Crotalaria burhia* Buch.-Ham. ex Benth.	Chagg
55	Papilionaceae	*Indigofera argentea* Burm. f.	Neel
56	Poaceae	*Cenchrus biflorus* Roxb.	Mohabat Boti
57	Poaceae	*Cenchrus ciliaris* L.	Daman
58	Poaceae	*Cenchrus setigerus* Vahl.	Chuti Daman
59	Poaceae	*Cymbopogon jwarancusa* (Jones) Schult.	Katrin or Khavi
60	Poaceae	*Panicum antidotale* Retz.	Murrot
61	Poaceae	*Sporobolus ioclados* (Nees ex Trin.) Nees	—
62	Polygonaceae	*Calligonum polygonoides* L.	Phog
63	Polygonaceae	*Polygonum plebejum* R. Br.	Indrani
64	Rhamnaceae	*Ziziphus nummularia* (Burm. f.) Wight & Arn.	Jhar beri
65	Salvadoraceae	*Salvadora oleoides* Decne.	Pilu
66	Solanaceae	*Datura metel* L.	Dhatura
67	Solanaceae	*Solanum nigrum* L.	Mako
68	Solanaceae	*Solanum surattense* Burm. F.	Kateli
69	Solanaceae	*Withania coagulans* (Stocks) Dunal	Paneer
70	Solanaceae	*Withania somnifera* (L.) Dunal	Asgandh
71	Tamaricaceae	*Tamarix aphylla* (L.) Karst	Jhao, Ukan, Frash
72	Tiliaceae	*Corchorus depressus* (L.) Stocks	Boophali
73	Tiliaceae	*Grewia villosa* Willd.	Jalidar
74	Zygophyllaceae	*Fagonia cretica* L.	Dhmasa
75	Zygophyllaceae	*Peganum harmala* L.	Harmal
76	Zygophyllaceae	*Tribulus longipetalus*	Tirkandi or
77	Zygophyllaceae	*Tribulus terrestris*	Bakhara
78	Zygophyllaceae	*Zygophyllum simplex* L.	Lunak

Some of the most significant medicinal plants with a commercial focus are gathered and harvested from desert regions and offered for sale in the nation's major cities or at neighborhood bazaars (Fig. 5). These are collected during various growing seasons for preparing medicines. For example, *Corchorus depressus* mixed with

seeds of *Papaver somniferum* and candy is ground with water (locally known as *Thandai*) and used as a demulcent drug to reduce thirst during summer.

Figure 5. Collection and harvesting of *Cirtullus colocynthis* for commercial use (according to Qureshi et al., 2024, as amended)

Wood products. Wood is a commodity that is utilised everywhere and is still primarily harvested from the wild. It serves as the main source of fuel. New biological resources are found as a result of the plant exploration for human benefit. The preservation of biological variety and the cataloguing of fresh bioresources are closely related. The cultivated species of today are the result of ongoing research into carefully chosen breeding lines derived from germplasm. Documenting cultural knowledge can help plant species be developed for greater usage or economic gain. These species may hold considerable potential, but many remain undiscovered (Iltis, 1983).

Overall, 76 species were utilized as fuel-wood and timber. Of them, 33 species, such as *Acacia jacquemontii*, *A. nilotica* subsp. *cupressiformis*, *A. nilotica* subsp. *indica*, *Aerva javanica*, *Albizia lebbeck*, *Arundo donax*, *Bombax malabaricum*, *Calligonum polygonoides*, *Capparis decidua*, *Chrozophora tinctoria*, *Crotalaria burhia*, *Dalbergia sissoo*, *Ficus benghalensis*, *F. carica*, *F. religiosa*, *Haloxylon salicornicum*, *Leptadenia pyrotechnica*, *Mangifera indica*, *Melia azedarach*, *Moringa oleifera*, *Morus alba*, *M. nigra*, *Phoenix dactylifera*, *Phragmites karka*, *Physorhynchus brahuicus*, *Prosopis glandulosa*, *P. juliflora*, *Salvadora oleoides*, *Tamarix aphylla*, *Typha elephantina*, *Ziziphus mauritiana* and *Z. nummularia* were preferably used as the fuel wood source.

Trees are very few in the Cholistan Desert, and all of these are heavily exploited for fuelwood collection. The common trees of this desert include *Acacia nilotica*, *Capparis decidua*, *Prosopis cineraria*, *P. juliflora*, *Tamarix aphylla*, and *Salvadora oleoides*. A large amount of wood is collected by the dwellers for not only their

household use but also to sell out in the nearby localities/small cities. Besides these trees, various shrubs such as *Acacia jacquemontii*, *Aerva javanica*, *Calligonum polygonoides*, *Haloxylon salicornicum*, *H. stocksii*, *Salsola baryosma*, and *Ziziphus* spp. are also used as a fuelwood source. The collection and digging of large numbers up to the root level loosens the soil, thus exacerbating the process of desertification. Plant uprooting has numerous detrimental long-term effects on the careful species composition as well as the desert ecosystem.

Thirteen species, such as *Acacia nilotica* subsp. *cupressiformis, A. nilotica, Azadirachta indica, Bombax malabaricum, Cordia gharaf, C. myxa, Dalbergia sissoo, Mangifera indica, Melia azedarach, Pongamia pinnata, Prosopis cineraria, P. juliflora*, and *Ziziphus mauritiana* were used for making agricultural implements. The implements include the sickle, awx, hull, etc.

The local plants play a critical role in the manufacture of furniture and houses. Fifteen species like *Acacia nilotica* subsp. *cupressiformis*, *Acacia nilotica* subsp. *indica, Azadirachta indica, Bombax malabaricum, Capparis decidua, Cordia myxa, Dalbergia sissoo, Ficus religiosa, Mangifera indica, Melia azedarach, Morus alba, Pongamia pinnata, Prosopis cineraria, Prosopis juliflora,* and *Ziziphus mauritiana* were used for building, furniture, and charcoal formation.

The timber industry plays a significant role in the economy of the county. Certain plant species, such as *Acacia* spp., *Azadirachta indica, Capparis decidua, Dalbergia sissoo, Mangifera indica, Melia azedarach, Prosopis cineraria*, and *Ziziphus mauritiana,* are used preferentially by the timber industry.

Plants for Construction. For constructing a house in the desert areas, local people use various plant materials for roof thatching as a source of fiber**.** These houses, locally called "*Gopas*", are constructed with mud walls, armed with branches of *Capparis decidua*, *Prosopis cineraria,* or *Acacia nilotica*. Usually, a single straight trunk of *Acacia nilotica, Prosopis cineraria,* or *Capparis decidua* is kept in the center to hold the thatched roof. The various woody branches of these trees are used as frameworks for constructing these houses, and for thatching *Leptadenia pyrotechnica* is mostly used along with *Crotalaria burhia* and *Dipterygium glaucum*.

Research, education, and monitoring. There is still a lot to learn about how to use biological resources more effectively, how to preserve the genetic diversity of harvested biological resources, and how to restore deteriorated ecosystems. For such investigations, for comparison with other regions using other methods of use, and for the important study into ecology and evolution, natural areas make good living laboratories. Unaltered habitats are often essential for certain research methodologies to track and assess the changes caused by different management regimes.

Conclusions. An analysis of plant diversity and useful ecosystem services in the Cholistan Desert demonstrates that nearly 150 species are utilized as fruits, vegetables, and food preparation, as well as a common source of medicine for treating various ailments and somatic diseases. In the Cholistan Desert, the harsh climate of high temperatures and intense drought hinders agricultural productivity. The range management and livestock rearing are the only effective practices in regions with limited agricultural practice because this is essentially rangeland. Numerous issues are plaguing this desert, including severe water scarcity, excessive wind erosion, overgrazing, deforestation, salinity, and an increase in cultivation on marginal lands. To mitigate the negative impacts of these problems, it is necessary to screen and evaluate genetic resources of indigenous plants, as well as native and also alien drought- and salt-tolerant crops that can grow under conditions of lower water demand.

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