


Native and xeric plant recommendations for urban landscapes in Kuwait

Athari Abdulaziz Almutawa^{1,2*} 

¹ Laboratory of Environmental and Urban Ecology, Department of Bioscience Engineering, University of Antwerp, Antwerp, Belgium

² Department of Desert and Coastal Marine Ecosystems Rehabilitation and Restoration, Public Authority of Agriculture and Fisheries, Al-Rabya, Kuwait

* Corresponding author, E-mail: Athari.Almutawa@gmail.com

Abstract

The utilization of native and xeric plants in urban landscapes has gained great interest in recent years due to two pressing issues; climate change effects and water scarcity. These two issues are further exacerbated by Kuwait's arid desert environment, poor soil and salinity, making it quite challenging for popular ornamental plants to flourish in urban landscapes. Kuwait is currently dominated by a European aesthetic in terms of urban green spaces, which include plants such as *Concarpus erectus*, *Nerium oleander*, *Vitex purpurea*, *Vitex trifolia* and *Bougainvillea glabra*, all of which are not compatible with Kuwait's harsh climate and are environmentally unsustainable. This paper discusses climatic conditions, soil characteristics and water resources that are available and includes a plant list that has been created of recommended native and non-native xeric species that are capable of withstanding Kuwait's harsh climatic conditions to create aesthetically pleasing and sustainable green urban landscapes.

Citation: Almutawa AA. 2022. Native and xeric plant recommendations for urban landscapes in Kuwait. *Technology in Horticulture* 2:7 <https://doi.org/10.48130/TIH-2022-0007>

Introduction

Growing ornamental plants in Kuwait is already quite challenging due to its harsh environmental conditions^[1]. In addition, the effects of global climate change are continuously accelerating, therefore effective biological responses need to be in place to guide the effective protection of biodiversity^[2]. Already less than 10% of Kuwait is covered with natural vegetation and there is evidence that the geographical distribution of dominant perennial plants in Kuwait is being impacted by climate change^[1,3–6]. Moreover, further natural landscapes are being lost as a consequence of altered land use as a result of population growth that has led to an increase in urbanization and industrialization. Altered land use is one of the main drivers of biodiversity depletion and habitat loss, pushing native plant populations to regional extinction^[7]. Additional activities that contribute to native plant loss are overgrazing, recreational activities (off-road driving and camping), industrial practices (specifically quarrying) and the remnant effects of the Gulf War^[7–9]. Efforts have been dedicated toward the rehabilitation and conservation of Kuwait's desert ecosystem. Of the total territorial area in Kuwait approximately, 11% is either terrestrial or marine protected areas^[10]. Several protected terrestrial areas that have been established in Kuwait include Sabah Al-Ahmad natural reserve, Jahra nature reserve, Doha reserve, Kuwait Institute of Scientific Research (KISR) Sulaybia Field Research Station, Al-Kabid nature reserve, Al-Khuwaisat, Al-Sulaibkhat nature reserve, Om-igdar, Khobar Al-awazim, Wadi Al-Babtain, Qurain Hill nature reserve, Al-Abdaliya nature and Al-Leyah protected area^[11]. However, the majority of these protected areas are situated away from urban landscapes and are located in the desert. Only one project incorporated native species on a

large scale in Kuwait, and that is at Bawabat Al-Shamiyah. Therefore, there is a need to connect these native habitats to urban areas to combat urban habitat fragmentation.

Native plants are defined as plants that are a part of the balance of nature that has developed over hundreds or thousands of years in a particular region or ecosystem^[12]. The utilization of native species in their natural habitat and xeric plants acclimatized to the region's geo-climatic conditions have been encouraged. As they have a higher survival rate, adaptation potential, lower maintenance, disease resistance, salinity tolerance, nitrogen fixation ability, ethnobotanical importance and medicinal uses^[13]. These plants can help create a sustainable landscape that can address habitat fragmentation and habitat loss through xeric landscaping. Xeric landscaping refers to low water use landscaping and water-efficient landscaping that potentially offers a balance of water-efficient landscapes without soil water limits^[14,15]. This method of landscaping has been widely applied in Australia, South Africa and Arizona, USA, where alternative man-made 'wild' nature is used in opposition to the more conventional 'obedient' landscapes^[16]. Xeric plant species can be native and non-native species that have drought survival adaptive mechanisms^[14,17]. These adaptive mechanisms encompass extensive root systems, thick cuticles, stomatal openings that are protected and the occurrence of bulliform cells^[14,17,18]. Low transpiration rates through small leaves lead to less evaporation of water due to the reduced total surface area of the leaf. Thick waxy cuticles, leathery or glossy cuticles that act as a barrier to evaporation and reflect sunlight^[14,17]. Their main growing period is winter and spring when rain is abundant^[19]. Bulliform cells are bubble-shaped epidermal cells that cause leaves to roll or fold in harsh environmental conditions by losing their turgor pressure in water stress conditions

preventing moisture loss through the vacuoles and reopening again under favourable conditions^[18,20]. Bulliform cells are especially associated with Poaceae, Cyperaceae and Juncaceae species^[18,20].

The plant selection process discussed in this paper covers a range of topics from the climatic conditions, and soil and water conditions in Kuwait, native and non-native species and annual and perennial species. All the plants discussed are native plants or introduced plants that have been studied, suggested or utilized by KISR and the Public Authority of Agriculture and Fisheries, Kuwait (PAAF) to give a more comprehensive overview of tackling urban landscaping that is distinct to the region.

Climatic conditions

As a desert environment, Kuwait experiences harsh climatic conditions, with prolonged periods of extreme heat (Table 1). During the summer months, the average temperature is 46.22 °C, while in the winter months, it can drop to 6 °C^[21,22]. Evaporation rates in summer range from 3.1 to 24.3 mm/day, despite low humidity (13%)^[23–25]. Precipitation is minimal, occurring in the spring and increasing in frequency around November, averaging 22 wet days which amounts to 115 mm, annually fluctuating between 25 and 250 mm^[24,26]. The wind blows predominantly during the summer from the northwest, forming 60% of the total wind direction and from the southeast to a lesser extent and shorter duration^[26]. Therefore, the dust activity in Kuwait, is low during winter, growing strong between March and April, and at its highest in June and July^[27]. The average monthly wind speed in June reaches a maximum of 20.8 km h⁻¹ and a minimum of 12.1 km h⁻¹ in November^[9]. Kuwait experiences an average of 3347 sunshine hr/year. The number of sunshine hours ranges; from an average of 7 hr/day in December, and 11 hr/day in August^[28].

It is inevitable that any long-term changes in climate patterns will have an impact on vegetation type and canopy structure, as well as bare land, which will have an impact on land-surface albedo and evapotranspiration, modifying near-ground temperatures and precipitation^[3,29,30]. Future changes in vegetation cover could have a similar impact on rainfall as climates change, but the magnitude of those changes is uncertain^[3,31].

Soil

Kuwait's topography consists of predominantly flat and gently undulating land that sparsely encounters elevations, wadies (drainage lines), depressions, sand dunes and salt marshes^[32,33]. The land rises gradually from the shores of the Arabian Gulf from an altitude of zero to approximately 300 m southwest of the country^[32]. There are eight soil groups that dominate Kuwait^[34]: spetrogypsid, torripsamments, haplocal-

cids, haplogypsid, aquisalids, calcigypsid, petrogypsid and torriorthents (Fig. 1, Table 2)^[34,35].

In many parts of Kuwait, soil is partially consolidated with a sediment of a massive calcrete type, known locally as 'gatch'^[38–40]. It is a caliche layer (duripan or hardpan) that is found in varying depths but on average at a 2 m depth, attaining a thickness of tens of meters^[22,38,40]. Gatch consists of a mixture of quartz sands, silica and gypsum, cemented predominantly by carbonates (calcite and/or dolomite)^[22,38,40]. This gatch zone decreases in porosity and effective permeability due to cementation by carbonate^[22]. Gatch soils are considered impervious and require proper drainage arrangements when used as fill material as the average shrinkage limit is 17% above normal moisture content. Therefore, soils are liable to swell when saturated and crack when dry^[22]. However, soil stability can be through the addition of natural and synthetic chemicals that can improve the physical and chemical soil properties through aggregate stability by enhancing soil strength, aggregate stability, and water infiltration. They also reduce the effects of salinity on plant growth and development and supply nutrients^[41, 43]. Additionally, a study on the development and evaluation of a new multi-purpose soil additive by Lahaliah^[39], determined the addition of 1.0% sulfonated urea-melamine-formaldehyde (SUMF) improved the compressive strength of gatch sand from 4.74 to 13.38 kg cm⁻²^[42]. The use of a mixture of a polyanionic polymer (sulfonated amino formaldehyde, polyanionic condensates) with polyvinyl alcohol was established to achieve very good stability for gatch, however, it is expensive and difficult to dissolve in water^[42]. Another more economical and time-feasible option is to drill holes at selected sites where trees or deep-rooted species will be planted. Growing vegetation on gatch soil has been successful in the past, as proven by Suleiman et al.^[40] in a study on plant enrichment in desert ecosystems in Kuwait, with relative growth rates of 113.2% for *Pennisetum divisum*, 67.8% for *Calligonum polygonoides*, 51.5% for *Farsetia aegyptia*, 30.1% for *Helianthemum lippii*, 12.8% for *Tephrosia haussknechtii*, 7.9% for *Prosopis juliflora* and 6.9% for *Prosopis spicigera*, with the exception of *Tephrosia haussknechtii* and *Rhanterium epapposum*, which had survival rates of less than 80%^[43].

It must be noted that, due to urbanization, landscape soils are usually physically and chemically altered, and the micro-climate in those spaces has been transformed^[43]. Moderate to severe land degradation and plant cover deteriorated, affecting around 75% of Kuwait's desert as a result of the high intensity of anthropogenic activities^[7,9,44,45]. Soil can be improved to promote plant survival and germination rate through the addition of mulch and fertilizer for selected plants. Nevertheless, since there is not a universal solution, therefore plant palette selection for the selected site needs to be determined ahead of soil preparation.

Table 1. Monthly climate and weather averages in Kuwait (adapted from www.timeanddate.com/weather/kuwait/kuwait-city/climate).

	Month											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
High temperature (°C)	19	22	27	33	40	44	46	46	42	36	27	21
Low temperature (°C)	7	9	13	19	25	29	30	30	26	21	14	9
Mean temperature (°C)	13	15	20	26	32	36	38	38	34	28	20	15
Percipitation (mm)	10.8	3.7	2.3	15.7	11.8	10.1	18.4	3.7	1.7	0.3	0.9	4.1
Humidity	64%	54%	43%	34%	21%	13%	14%	18%	21%	36%	50%	62%
Wind (km/h)	12	14	14	15	15	20	19	16	14	12	12	12

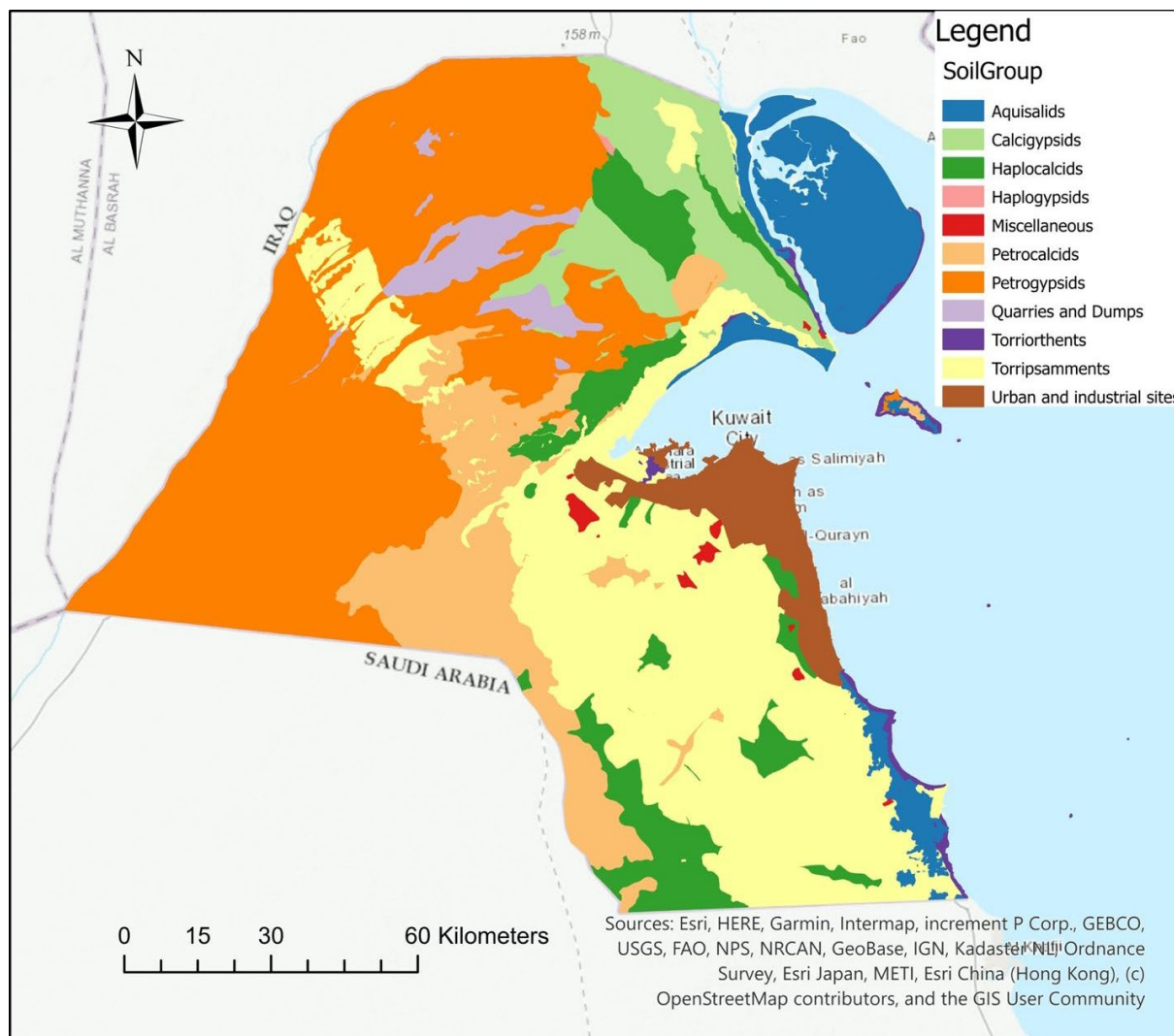


Fig. 1 Map indicating Kuwait soil group classification spread (data from KISR^[37]; PAAFR, 1999).

Table 2. Kuwait soil group classification (adapted from Shahid & Omar^[35]; Omar et al.^[34]; Soil Survey Staff^[36]; KISR^[37]; PAAFR, 1999).

Soil groups	Description
Torripsamments	Well to somewhat excessively drained, deep or very deep sandy soils.
Petrocalcids	Well drained or moderately drained, shallow or moderately deep, sandy to loamy soils overlying a calcic hardpan. When upper soil is truncated, it may appear at the surface.
Haplocalcids	Well drained, deep or very deep, sandy to loamy soils, which have a layer of carbonate masses and nodules in the profile.
*Haplogypsis	Well drained, deep or very deep, sandy to loamy soils, which have a layer of gypsum crystals in the profile.
Aquialids	Poorly or somewhat poorly drained, deep or very deep, sandy to clayey soils. Within the soil there is a layer of salt accumulation that usually occurs near the surface.
Calcigypsis	Well drained, deep or very deep, sandy to loamy soils containing a layer of carbonate masses and nodules and a layer of gypsum crystals within the profile.
Petrogypsis	Well drained, shallow or moderately deep, sandy to loamy soils overlying a gypsum hardpan. Hardpan may be exposed at surface, when upper soil is truncated.
Torriorthents	Excessively drained to well drained, moderately deep or very deep, sandy soils. Within the soil profile there is a high content of shell fragments and some gypsum accumulations
Miscellaneous	Refers to areas that are incapable of supporting vegetation without significant reclamation efforts. This includes dumps and quarries and urban and industrial areas.

*Due to map scale limitations, Haplogypsis are not shown.

Water resources

Kuwait has limited natural water resources, groundwater is the only natural water resource it has, with the exception of isolated freshwater lenses in Raudhatain and Umm Al-Aish in Northern Kuwait^[46]. The rest of the available groundwater is of

brackish quality, with the majority of it located in the western and central regions of Kuwait. The brackish water from these locations is utilized for landscaping and agricultural purposes, buildings and road construction, and is blended with desalinated seawater^[21,46]. Brackish water has a salt

concentration that ranges from 3,000 to 8,000 mg L⁻¹, which limits plant selection^[21]. The irrigation of landscape plants using treated municipal sewage water and industrial water, subjecting it to tertiary treatment has become a common practice^[21,25]. The salt concentration is 1,300–2,430 mgL⁻¹ and contains both organic and inorganic matter^[25].

Irrigation is a crucial part of many landscapes and important to maintaining healthy plants. To combat the dry climate in Kuwait and the low water holding capacity of soil, excessive irrigation is a common practice in landscaping^[47]. To ensure efficient water use, drip lines should be used instead of furrows and sprinklers as a method of irrigation. During summer, drip irrigation is recommended twice weekly; during winter, drip irrigation is recommended daily depending on the plant's water requirements^[43].

Plant selection

In the 1960s Kuwait developed the first National Greening Plan (NGP)^[21,48]. The aims of the NGP were: the beautification of Kuwait City and its suburbs, the rehabilitation of deteriorating rangelands, the establishment of green parks in the desert, the expansion of existing agricultural areas, the creation of plantations or artificial forests, and enriching the coastline with mangroves^[48,49]. Exotic species, such as *Eucalyptus*, *Tamarix*, *Ziziphus* trees and *Jasminum* and *Lantana* shrubs, were utilized during that time in urban spaces^[21]. Currently, green urban landscapes are made up predominantly of exotic species from temperate and semi-temperate regions: examples include *Concarpus erectus*, *Nerium oleander*, *Vitex purpurea*, *Vitex trifolia* and *Bougainvillea*. However, greening these urban spaces using the current limited regional and commercially available plant palette is generating a variety of ecological problems. These ecological problems include the risk of invasive plants, dominant plant populations taking over, changing the local ecosystem and having high-water requirements^[50,51].

Native and non-native

Residential landscapes that reflect local environmental conditions by utilizing native plant species for ornamental purposes can be a more viable option, as they offer a variety of benefits that maximize the future well-being of people and the natural environment^[52]. Native plant species are well adapted to the regional climatic conditions, have the capacity to adapt to adverse local environmental conditions, and have low water and maintenance requirements^[43,50,52]. They also promote the biodiversity of local native wildlife in Kuwait by preserving the ecological balance between native plants and fauna^[43,52]. Specific native plants have been selected in order to avoid any landscape design problems that may arise, including seasonal aesthetics, mass, form and color palette (Table 3). However, if locally adapted species become isolated and cannot colonize new habitats, they may not be able to shift their ranges with climate change^[2]. Additionally, native plants are not allowed to be commercially sold, propagated or collected by nurseries in Kuwait due to legislation stated in the list of unauthorized traded seeds and tubers created by PAAF.

Green urban landscapes do not have to encompass strictly native plant species to conserve resources. Incorporating non-native or naturalized species that are adapted to Kuwait's climatic conditions can provide economic landscape potential and a broader range of color palettes and aesthetics^[53].

Drought-tolerant species have specific characteristics that enable them to withstand extreme drought and desert conditions. These species can shed their leaves to further decrease water loss in severe drought conditions^[54]. In order to provide recommendations for future landscape projects in Kuwait, a list of previous research studies and projects in countries with similar climatic conditions and within the same region have been compiled (Table 4).

Annual and perennials

There are 374 native plant species that belong to 55 families^[9,40,112]. A significant amount of desert ecosystems are usually rich in annual flora^[6]. In Kuwait, annuals make up 68% of the native flora, herbaceous perennials 22%, shrubs, undershrubs 9% and there is only one tree species (*Vachellia gerrardii*)^[8,9,40,113]. There are five plant community types that have been identified in Kuwait; *Haloxylon salicornicum* (Moq.) Bunge ex Bion, *Rhanterium epapposum* Oliv. and *Cyperus conglomeratus* Rottb which are used for livestock grazing, *Zygophyllum qatarense* Hadidi and *Panicum turgidum* Forssk^[9,40,112,114]. Plant communities in arid extreme environments have the capacity to respond to environmental change and sustain functions that can impact species turnover and can shift interactions and net biodiversity^[115,116]. Perennial and annual plants have an interrelationship between them that create negative and positive interactions between these life forms^[62,115,116]. One of these interactions is that perennial plants benefit from early seedling emergence that is balanced by the risk of seedling mortality by adult longevity, in comparison to annuals that are more likely than perennials to postpone germination to following seasons^[117]. As annual plants development, flowering and seed yield communities, success in desert ecosystems is dependent on a variety of environmental factors: rain, temperature, relative humidity, soil moisture availability, seed location, seed size and seeds depth in the soil, day length, light, soil water content, soil organic matter availability and nitrogen recycling^[116,118]. Another interaction is that perennial plants provide two important contributions towards annual success; they act as organic-matter donors creating fertile islands from self-resource due to their root activity improving the quality of their understory soil as well as their intensive canopy cover acting as a physical structure in the ecosystem, creating a wind barrier and as soil-moisture moderators by providing shade^[62,116,118]. Therefore, a selection of perennial plants should be utilized in garden design to facilitate the success of annual plants that provide a seasonal aesthetic and also colourful accents.

Plant establishment

There are varying methodologies towards vegetation establishment in urban landscapes either through using hardened seeding or direct seeding. Direct seeding offers a more cost-effective and highly efficient planting method. Several studies have been conducted in Kuwait towards desert habitat rehabilitation through direct seeding utilizing pretreatment to break seed dormancy^[43,57,59,62,68,71,118]. A study conducted by Suleiman et al.^[40] in Kuwait on plant enrichment in desert ecosystems used a desert seed mix of *Eragrostis curvula*, *Ambrosia chamissionis*, *Artemisia californica*, *Lasthenia glabrata*, *Mimulus aurantiacus* and *Limonium californicum*^[43]. Kuwait native species, hardwood cuttings of *Lycium shawii* treated with Hormex (1,000 mg/LL(IBA)) using the quick dip method and

Table 3. Recommended native plant species for green urban landscapes in Kuwait.

Vegetation form	Plant name	Family	Description	Plant spacing	Flowering time	Environmental conditions	Additional info
Shrubs	<i>Helianthemum lippi</i> Rakrouk (Fig. 2a)	Cistaceae	Small perennial shrubby plant 10–45 cm tall ^[60]	Triangular spacing of 2 m ^[53]	March–April	Occurs on sandy soils and sandy limestone gypsum ^[60]	<ul style="list-style-type: none"> Used in the stabilization of sand. Host plant for several species of desert truffles. Medicinal properties^[60]. Fodder yielding shrub. Source of fruit. Source of wood. Medicinal uses: bark is used in diarrhea, while roots are used to make digestive and nutritive tonic^[56].
	<i>Ziziphus nummularia</i> Jujube (Fig. 2b)	Rhamnaceae	Thorny shrub that grows to 1–5 m height. Branches zig-zag, covered with white coating. Stems and branches are purplish to ashy. Bark light brown. Multi-stemmed from the base leaves shortly stalked, ovate to orbicular, serrate, 12–18 mm long, 8–10 mm broad, round at apex and base, more or less tomentose above but densely wooly beneath. Stipular spines in pairs, one slender and straight whereas other short and recurved. Flowers cream color, flowers during July–August and the ripe fruits are available in November–December ^[56]	6 m × 6 m ^[56]	March–June	Hardy enough to grow not only in hostile arid environment but also in poor and different forms of soil profiles underneath ^[56] . It is adapted to flat alluvial plains with fairly deep (80–120 cm) sandy loam soils and with a hard kankar pan below ^[56] . Flat alluvial plains with sandy clay loam to clayey soils and a kankar pan at 45–60 cm below the soil also show high shrub density in semi-arid regions ^[60] . Drought hardy, thrives in areas with 125 to 850 mm rainfall ^[60] .	<ul style="list-style-type: none"> Traditionally used to treat toothache and gingivitis, and for sore eyes. A decoction of the plant mixed with alum is used as a mouth rinse and for disinfecting (Morocco)^[60].
	<i>Farsetia aegyptia</i> Al-Habana (Fig. 2c)	Brassicaceae	Native grey-green woody perennial about 30 cm in height. It has slender, smooth and multi-branched stems. The flowers are creamy brown with four petals. Two rows of seeds are formed in an oval-shaped seed pod. It flowers in April ^[61]	Triangular spacing of 2 m ^[53]	March–April	Grows on gravelly soils to stony ground. It grows in severe climatic conditions with under 100 mm rainfall per year ^[60] .	<ul style="list-style-type: none"> Fruiting tops and seed as animal feed. Seeds as emergency food. Wood as fuel. Different plant parts for medicine. Used in restoration of degraded lands^[58]
	<i>Haloxylon salicornicum</i> Rimth (Fig. 2d)	Amaranthaceae	Dwarf branching perennial shrub, with a plant height of 0.75–1.0 m. Bark is pale in color, stem and branches are pale yellow, jointed producing two triangular scales which take the place of leaves. Branches are erect or ascending terete. Almost leafless and leaves reduced to dilated tips of the joints. Has a wide-spread and deep tap root system that extends beyond 5 m and estimated to go 8–10 m deep. Flowers are bisexual and born singly by short twigs in axes of scale like bracts ^[58]	2 m	Sept–Oct	Is resilient to a variety of habitats: shallow runnels, alluvial fans, shallow silt, low dunes, hard gravel and sandy gravelly wadi-terraces, sandy plains, gravel desert, sandy undulating plains, sandy plains and inter-dunal areas. It requires a minimum annual rainfall of 100 mm ^[5] . It can tolerate high salinity up to 8,000–10,000 mg L ⁻¹ ^[58] .	<ul style="list-style-type: none"> Fruits are edible. provides honey for wild bees. Food and shelter for wild birds and animals. The roots are boiled and the decoction is used to treat sores in the mouth, coughs, backache and administered internally to cure tick fever in livestock. Leaves are used to treat constipation and stomach ache. Leaves are much liked by livestock^[59]. Fruits are one of the most important food sources for many animal species in the Arabian desert. <i>O. baccatus</i> have various medicinal uses. Useful in controlling root-knot nematodes. Planted as cover plant/ green manure^[68].
	<i>Lycium shawii</i> Roem. & Schult. Awsaj (Fig. 2e)	Solanaceae	Perennial shrub with purple, sometimes white, trumpet like flowers and sharp thorns. Leaves are elliptical and congested in closed clusters. Fruits are globular, red to orange berries which are edible ^[59]	2 m × 2 m ^[62]	March–April and throughout the year in irrigated soil	Grows in a variety of desert habitats; gravel plains, hillsides, valleys, sandy stone ridges and along drainage basin, such as valleys and depressions ^[67] .	<ul style="list-style-type: none"> Fruits are edible. provides honey for wild bees. Food and shelter for wild birds and animals. The roots are boiled and the decoction is used to treat sores in the mouth, coughs, backache and administered internally to cure tick fever in livestock. Leaves are used to treat constipation and stomach ache. Leaves are much liked by livestock^[59]. Fruits are one of the most important food sources for many animal species in the Arabian desert. <i>O. baccatus</i> have various medicinal uses. Useful in controlling root-knot nematodes. Planted as cover plant/ green manure^[68].
	<i>Ochradenus baccatus</i> Delle Tailly Weed (Fig. 2f)	Resedaceae	Perennial shrub, grows up to 2 m high, with grey green linear leaves, blooms yellow flowers, followed by white berries. Stems greenish in color ^[57] .	1.5 m × 1.5 m ^[62]	Dec–March	Grows on dry soils and colonizes arid environments where saline soils are common. Has high drought tolerance ^[68]	<ul style="list-style-type: none"> Fruits are edible. provides honey for wild bees. Food and shelter for wild birds and animals. The roots are boiled and the decoction is used to treat sores in the mouth, coughs, backache and administered internally to cure tick fever in livestock. Leaves are used to treat constipation and stomach ache. Leaves are much liked by livestock^[59]. Fruits are one of the most important food sources for many animal species in the Arabian desert. <i>O. baccatus</i> have various medicinal uses. Useful in controlling root-knot nematodes. Planted as cover plant/ green manure^[68].

(to be continued)

Table 3. (continued)

Vegetation form	Plant name	Family	Description	Plant spacing	Flowering time	Environmental conditions	Additional info
Grasses	<i>Calligonum polygonoides</i> Etta (Fig. 3a)	Polygonaceae	Small perennial shrub that is about 1 to 2 m high, with a girth of 30–60 cm. Stem has nodes and internodes which join stem and branches conspicuously. Flowers: are white, small, bisexual and regular. Fruit is oblong and nut-like; small and rounded seeds ^[63] . Ascending or procumbent, herbaceous perennial undershrub, that grows up to 50 cm. Dark green with semi-fleshy leaves and white bristles. Flowers, small, white, tubular; fruits achenes ^[74] .	Triangular spacing of 2 m ^[55]	March–April	Grows on dry sandy soil of the desert ^[69] . It is highly resistant to drought ^[70] .	<ul style="list-style-type: none"> Harvested for use as fodder. Fuel wood. Food. Used for sand dune stabilization^[70]
	<i>Heliotropium bacciferum</i> Salt heliotrope (Fig. 3b)	Boraginaceae	Perennial grass. It can grow quite large in substantial clumps up to 1–3 m in height ^[64] .	30–60 cm ^[75]	March–April	Grows in saline sandy soils, sandy wadis, on calcareous ridges. Dominate disturbed locations and roadsides ^[74] .	<ul style="list-style-type: none"> Dried and powdered plant is added to water and drunk to combat fatigue. Leaf sap is applied to burns. Applied topically to treat headache. Used internally to treat gonorrhoea and to increase lactation. Macerate of the plant is used as ink^[74]. Animal Fodder. Used in land stabilization for soil protection and sand dune fixation^[71].
Grasses	<i>Pennisetum divisum</i> Thammam (Fig. 3c)	Poaceae	Perennial grass. It can grow quite large in substantial clumps up to 1–3 m in height ^[64] .	Triangular spacing of 2 m ^[55] . Other options include; 90 m × 1.20 m, 50 cm × 50 cm, depending on aesthetic.	Feb–April	Drought-resistant; grows in depressions and shallow wadis with coarser textured sandy and gravelly soil ^[71] . Naturally found on torripsammant and aqusalid soil types, located on level coastal plains covered by uneven sand sheets or isolated hummocks ^[34] .	<ul style="list-style-type: none"> Animal Fodder. Used in land stabilization for soil protection and sand dune fixation^[71].
	<i>Panicum turgidum</i> Taman, tuman, or thaman (Fig. 3d)	Poaceae	Perennial growing to 1.5 m × 0.2 m at a fast rate ^[65] .	Triangular spacing of 2 m ^[55] . Other option include; 90 cm × 120 cm or 50 cm × 50 cm, depending on aesthetic.	Feb–April	Drought-resistant; grows in shallow wadis and runnels in deep sandy soil, salt-affected areas and is a salt excluder ^[71,72] . Naturally found on torripsammant and aqusalid soil types, located on level coastal plains covered by uneven sand sheets or isolated hummocks ^[34] .	<ul style="list-style-type: none"> Animal Fodder. Used in land stabilization for soil protection and sand dune fixation^[71].
Ground cover	<i>Cornulaca aucheri</i> Hadh, saley, or thalj (Fig. 3e)	Amaranthaceae	Annual or short-lived perennial, leaves are linear-filiform to triangular-subulate, long, greyish-green, re-curved, white spine and densely woolly in axils. Average length is 94.2 cm in average length, average height is 141.7 cm ^[73] .	-	April–May	Grows in wadi, depressions, and plays ^[73] . Have a short life span and dominate immediately after a disturbance ^[34] .	<ul style="list-style-type: none"> Used for sand fixation and stabilization^[73]. Used as camel fodder^[119].
	<i>Salsola imbricata</i> Saltwort, milayah (Fig. 3f)	Amaranthaceae	Succulent light green undershrub with rudimentary leaves on red and green branches. Flowers minute, green, bisexual with 5 stamens; calyces inflated in fruit forming transparent wings surrounding the fruit	-	June–Sept	Disturbed areas, saline soils, sandy desert and coastal areas ^[119] . Have a short life span and dominate immediately after a disturbance ^[34] . Naturally found on aqusalids soil types ^[34] .	<ul style="list-style-type: none"> Traditionally being used to treat asthma, cough and congestion.



Fig. 2 (a) *Helianthemum lippi* (Rakrouk), (b) *Ziziphus nummularia* (Jujube), (c) *Farsetia aegyptia* (Allabana), (d) *Haloxylon salicornicum* (Rimth), (e) *Lycium shawii* Roem. & Schult. (Awsaj), (f) *Ochradenus baccatus* Delile (Taily weed).



Fig. 3 (a) *Calligonum polygonoides* (Erta), (b) *Heliotropium bacciferum* (Salt heliotrope), (c) *Pennisetum divisum* (Thammam), (d) *Panicum turgidum* (Taman, tuman, or thaman), (e) *Cornulaca aucheri* (Hadh, saley, or thalj), (f) *Salsola imbricata* (Saltwort, milayah).

Table 4. Recommended non-native xeric plant species that are tolerant of Kuwait's climatic conditions.

Vegetation form	Plant name	Family	Native to	Description	Exposure	Environmental conditions	Additional info
Trees	<i>Eucalyptus camaldulensis</i> DEHNN River red gum	Myrtaceae	Australia	Evergreen single-stemmed, large-barked, medium-sized tree, commonly grows to about 20 m tall, though occasional specimens can reach 50 m ^[80] .	Full Sun	High salinity tolerance, medium drought tolerance, medium irrigation is required ^[9] . It grows in areas where the mean annual precipitation is in the range of 250–2,500 mm and an annual temp. range of 3–22 °C min to 21–40 °C max ^[80] . Plant prefers a pH in the range 5–7, tolerating 4.5–8 ^[80] . Reported to grow in areas with only 200 mm rainfall, Succeeds in most soils ^[80] .	<ul style="list-style-type: none"> Leaves are used as an antiseptic and is used for relieving coughs and colds, sore throats and other infections. Plant is an aromatic, astringent, tonic herb that sticks to the teeth and turns the saliva red. Resin contains tannins and is used internally in the treatment of diarrhea and bladder inflammation, externally it is applied to cuts. Smoke from burning leaves helps to repel insects^[80].
	<i>Eucalyptus microtheca</i> F. MUELL Coolibah	Myrtaceae	Australia	Evergreen shrub or small tree grows to 3–20 m tall depending on growing conditions ^[78] .	Full sun	High salinity tolerance, medium drought tolerance, low irrigation is required ^[9] . Tolerant to mean annual rainfall in the range 250–1,000 mm, but tolerates 150–1,200 mm ^[79] . A pH in the range 6.5–8, tolerating 6–9 ^[79] .	<ul style="list-style-type: none"> Planted for shelterbelts, shade, soil conservation, and erosion control. Flowers are an excellent source of nectar and pollen for bees. Inner bark is a traditional Aboriginal medicine, mashed and prepared into a poultice to treat snakebites. Seeds are powdered and made into cakes. Source of water where no free water was available^[79].
	<i>Acacia rigens</i> Needle bush wattle	Fabaceae	Australia	Compact, rounded shrub grows from 2.4 to 3 m tall, bright yellow flowers ^[76] .	Full sun	Does well with dry conditions and a well-drained soil ^[76] .	<ul style="list-style-type: none"> Provide: fuel, firewood, timber, forage, gum, tannins, fiber, folk medicine, and food. useful for environmental protection and soil and water conservation.
	<i>Acacia saligna</i> Golden wreath wattle	Fabaceae	Australia	Small tree grows from 3 to 7.6 m tall with a bushy, spreading crown, Golden yellow to almost orange flowers ^[76] .	Full sun	It does well in almost any soil, from light to heavy ^[76] .	<ul style="list-style-type: none"> Support large numbers of herbivorous vertebrates and invertebrates and nectarivorous insects^[82]. Provide: fuel, firewood, timber, forage, gum, tannins, fiber, folk medicine, and food. useful for environmental protection and soil and water conservation. Support large numbers of herbivorous vertebrates and invertebrates and nectarivorous insects^[82].
	<i>Acacia ehrenbergiana</i> Hayne. Tamat	Fabaceae	Mauritania, Senegal, Mali, Upper Volta and Niger, and extending into the Sahara and to the Nile Valley.	4.5 m high	Full sun	Drought tolerant species, can survive in areas that experience rainfall of 50–400 mm/annum ^[82] .	<ul style="list-style-type: none"> Support large numbers of herbivorous vertebrates and invertebrates and nectarivorous insects^[82]. Provide: fuel, firewood, timber, forage, gum, tannins, fiber, folk medicine, and food. useful for environmental protection and soil and water conservation. Support large numbers of herbivorous vertebrates and invertebrates and nectarivorous insects^[82].
	<i>Acacia tortilis</i> (Forsk.) (Hayne)	Fabaceae	Angola, Botswana, Egypt, Eritrea, Ethiopia, Iran, Israel, Kenya, Mozambique, Namibia, Qatar, Saudi Arabia, Somalia, South Africa, Sudan, Swaziland, Tanzania, Uganda, United Arab Emirates, Zambia, Zimbabwe ^[95] .	Small to medium-sized evergreen tree or shrub that grows up to 21 m tall. Flat-topped or rounded, spreading crown; bark grey to black or dark brown, rough, fissured or smooth. Leaves glabrous to densely pubescent, glandular, short ^[95] .	Full sun	Drought tolerant species, can survive in areas with rainfall of 50–400 mm/annum ^[82] .	<ul style="list-style-type: none"> Support large numbers of herbivorous vertebrates and invertebrates and nectarivorous insects^[82]. Provide: fuel, firewood, timber, forage, gum, tannins, fiber, folk medicine, and food. useful for environmental protection and soil and water conservation. Support large numbers of herbivorous vertebrates and invertebrates and nectarivorous insects^[82].
	<i>Acacia sowdenii</i> Western myall	Fabaceae	Australia	Long-lived, frost- and drought-resistant small tree that grows from 3.6 to 5.5 m tall with drooping branches. Yellow flowers appear irregularly, but are prolific when conditions are right ^[76] .	Full sun	Prefers a dry, well-drained soil ^[76] .	<ul style="list-style-type: none"> Provide: fuel, firewood, timber, forage, gum, tannins, fiber, folk medicine, and food. useful for environmental protection and soil and water conservation. Support large numbers of herbivorous vertebrates and invertebrates and nectarivorous insects^[82].

(to be continued)

Table 4. (continued)

Vegetation form	Plant name	Family	Native to	Description	Exposure	Environmental conditions	Additional info
	<i>Prosopis cineraria</i>	Fabaceae	Arabian gulf	Evergreen tree, grows up to 6.5 m high. Leaves 1–3 jugate, glabrous or puberulous; greyish when dry ^[99] .	Full sun	Drought-tolerant and thrives in hot, arid regions with an annual rainfall of less than 500 mm ^[76] . Suitable for: light (sandy), medium (loamy) and heavy (clay) soils, prefers well-drained soil and can grow in nutritionally poor soil that are acidic, neutral and basic (alkaline) soils, pH of 6.5–8.5, tolerating 5.5–9.8 ^[76, 99] .	<ul style="list-style-type: none"> Pods are used as vegetable in the dried and green form. Bark is ground and used as flour. Plant is reported to be astringent, demulcent, and pectoral^[78].
Gaf							
	<i>Ebenopsis ebano</i>	Fabaceae	Texas/USA	Evergreen perennial shrub or tree (1.2 m) with multiple trunks. A rounded, dense crown. Medium green, Alternate, pinnately compound leaf with 3 to 5 pairs, oblong to obovate. Small, musty fragrant, cream-colored flowers in dense, slender, terminal spikes to 3.8 cm long, flowers strongly attract bees ^[105] .	Full sun	Tolerant of heat and cold and full sun. Highly tolerant of desert soils. Very drought tolerant once established. Providing supplemental water to young specimens will increase growth rate ^[105] .	<ul style="list-style-type: none"> Stipular spines that can draw blood. Grows a dense canopy to the ground; crown raising is the principal pruning technique that needs to be continuously done. Slow growth rate^[105].
	<i>Lysiloma watsonii</i>	Fabaceae	South west USA	Large spreading shrub with hard brittle wood, grow up to 3.6–4.5 m. Has dense, feathery canopy, that is evergreen to partly deciduous foliage ^[120] .	Full sun-partial shade	Drought tolerant species that requires full sun to partial shade. Survives in moist to dry soil, that is loam or sand texture. That is slightly acidic to highly alkaline soil in pH ^[120] .	<ul style="list-style-type: none"> Requires corrective pruning to remove suckers and to help develop good structure. Produces some leaf and seedpod litter A good selection for the landscape when light shade is needed for smaller, understory plants. Use around pools or ponds for a desert oasis theme, tropical effect, or background screen. Nice patio tree or specimen for small spaces^[121]. The bark is brewed into medicinal tea to relieve gas and symptoms of liver problems. Heating the tea is used to raise the body temperature for women who are infertile because of ingestion. Wood can be used to make posts and molds for building. Provides shelter for animals during hot weather and nesting season^[122]. Wood is used for furniture building, as a material for agave liquor stills, firewood, and as beams for building. Bark is brewed into a tea that can relieve upset stomachs. Provides shade and shelter for animals. Pods are edible and are often consumed by animals. Fragrant flowers, fruit, and nectar attract many different forms of wildlife^[87]. Suited to large, open desert gardens where its architectural uniqueness can be featured. Should not be planted in areas where its crown needs to be raised or pruned excessively^[81]. Needs little to no supplemental water once established^[81].
	<i>Havardia Mexicana</i>	Fabaceae	South west USA	Evergreen tree, with a dark grey trunk and branch structure, grows to 12 m. Has yellow or white flowers that are very fragrant and also produces fruit and nectar that often attract wildlife ^[87] .	Full sun	Prefers loose, well-drained soil with low water usage (monthly) and needs full sun for proper development. The Mexican ebony struggles in caliche or hardpan; it prefers deeper soils ^[87] .	<ul style="list-style-type: none"> Wood can be used to make posts and molds for building. Provides shelter for animals during hot weather and nesting season^[122]. Wood is used for furniture building, as a material for agave liquor stills, firewood, and as beams for building. Bark is brewed into a tea that can relieve upset stomachs. Provides shade and shelter for animals. Pods are edible and are often consumed by animals. Fragrant flowers, fruit, and nectar attract many different forms of wildlife^[87]. Suited to large, open desert gardens where its architectural uniqueness can be featured. Should not be planted in areas where its crown needs to be raised or pruned excessively^[81]. Needs little to no supplemental water once established^[81].
	<i>Parkinsonia praecox</i>	Fabaceae	Sonora, southern Baja California into Michoacan, Mexico, Columbia, Peru and Ecuador ^[81] .	Semi-evergreen tree, loose and unruly, umbrella top with age and proper pruning, spreading and broad, sometimes ranging to 6m with greater spread. Masses of yellow flowers in axillary clusters followed by light brown pods ^[81] .	Full sun	Drought-tolerant; suitable for xeriscaping. Grows well in areas that receive as little as 80–100 mm of annual rainfall. Supplemental irrigation will increase growth. Prefers full sun and well-drained soil in cultivated landscapes. Has a pH tolerance of 6.1–7.8 ^[86] .	
	Sonoran Palo Verde						

(to be continued)

Table 4. (continued)

Vegetation form	Plant name	Family	Native to	Description	Exposure	Environmental conditions	Additional info
Shrubs	<i>Acacia victoriae</i> Bramble wattle	Fabaceae	Australia	A multi-branched 3.5–4.5 m shrub that makes a good hedge if mass planted. It performs best in warm, dry conditions. Pale yellow flowers in two- to three-inch racemes ^[76] .	Full sun	Performs best in warm, dry conditions ^[76] . It grows best in areas where annual daytime temperatures are within the range 12–32 °C, but can tolerate 5–38 °C ^[83] . Prefers a mean annual rainfall in the range 300–800mm, but tolerates 100–1,000 mm. Succeeds in most soils, being able to tolerate occasional short-term inundation. Tolerant of saline soils, yet prefers soils with a pH in the range 6–7.5, tolerating 5–8.5 ^[83] . Stabilizing soil and/or make conditions more acceptable for the establishment by other species ^[51] . High salinity and drought tolerance.	The probable lifespan is 10–15 years ^[83] .
Shrubs/Grasses	<i>Atriplex spongiosa</i> Pop saltbush	Amaranthaceae	Australia	Annual or short-lived perennial forb, grows up 40 cm tall or sprawling. Leaves are 1–4 cm long, 3–15 mm wide. Flowers are tiny (less than 3 mm across), male and female flowers on the same plant ^[84] . Succulent-like blue-white shrub ^[85] .	Full sun	Grows well in most soils, including alkaline clays. Prefers full sun but will grow in partial shade in desert areas ^[85] . Drought tolerant once established ^[85] . Tolerance to extreme climatic variation such as prolonged drought, flood, submergence and extreme temperatures (15–60 °C). It can tolerate precipitation levels as low as 300 mm and with up to 6-month drought ^[77] .	<ul style="list-style-type: none"> • High fodder quality and biomass production. • High water efficiency^[51].
	<i>Maireana</i> sp.	Amaranthaceae	Australia	Succulent-like blue-white shrub ^[85] .	Full sun to partial shade	Grows well in most soils, including alkaline clays. Prefers full sun but will grow in partial shade in desert areas ^[85] . Drought tolerant once established ^[85] . Tolerance to extreme climatic variation such as prolonged drought, flood, submergence and extreme temperatures (15–60 °C). It can tolerate precipitation levels as low as 300 mm and with up to 6-month drought ^[77] .	<ul style="list-style-type: none"> • Makes an excellent container shrub and cut flower^[85].
	Band blue bushes <i>Chrysopogon zizanioides</i>	Poaceae	India	Stiff and erect stems, up to 2 m high, which can be trimmed to form neat hedges, stem flower heads with light purple flower, turning to mauve color later. It is sterile, so it is not invasive and has no weed potential ^[77] .	Full sun to partial shade	Inhabits semi-arid subtropical grasslands and open scrublands, mainly on low-fertility, acidic sands and light-textured sandy loams, and particularly areas with significant elevation ^[86] . It is often associated with disturbed or badly managed areas. Grows in areas where annual summer rainfall is 400–1,000 mm and mean minimum and maximum temperatures are between 0 °C and 30 °C respectively ^[86] .	<ul style="list-style-type: none"> • Massive and penetrating root system that can grow very fast, up to 3–4 m in the first year. • Will continue to grow with deposited silt eventually forming terraces, if trapped sediment is not removed. • New shoots develop from the underground crown making vetiver resistant to fire, frosts, traffic and heavy grazing pressure^[77]. • Can become dominant when subject to heavy grazing pressure on disturbed land. • Growth rates tend to decline when competing with other plants. • Often suffers from fungal infections, mites and nematodes in areas where summer rainfall exceeds 700 mm and poor tolerance to flooding and standing water^[86].
	<i>Eragrostis curvula</i> Weeping lovegrass	Poaceae	Angola, Botswana, Burundi, Cameroon, Cape Provinces, Eritrea, Ethiopia, Free State, Kenya, KwaZulu-Natal, Lesotho, Malawi, Mozambique, Namibia, Northern Provinces, Swaziland, Tanzania, Zambia, Zaire, Zimbabwe	Densely tufted, perennial grass. Its growth habit varies from erect to prostrate, reaching a height of 30–120 cm. Stems can be slender or robust, erect but sometimes bent at lower nodes. Leaves are dark green to blue-green. Basal leaf sheaths are keeled, strongly striate, usually hairless but sometimes silky hairy below and are typically straw-colored or purplish ^[88] .	Full sun	Inhabits semi-arid subtropical grasslands and open scrublands, mainly on low-fertility, acidic sands and light-textured sandy loams, and particularly areas with significant elevation ^[86] . It is often associated with disturbed or badly managed areas. Grows in areas where annual summer rainfall is 400–1,000 mm and mean minimum and maximum temperatures are between 0 °C and 30 °C respectively ^[86] .	<ul style="list-style-type: none"> • Attracts insects and birds. • Erosion control
Ground cover	<i>Ambrosia charmissonis</i> Silver bur, ragweed	Asteraceae	Alaska, British Columbia, California, Chile Central, Chile South, Mexico Northwest, Oregon, Washington	Perennial herb from long, creeping rhizomes; stems leafy, spreading-hairy, stout, branched just below the surface, forming large, lax clumps 20–160 cm tall. Leaves are succulent, mostly alternate, oblong to rounded in outline ^[89] .	Full sun	Plants occur in moist to mesic coastal sandy or gravelly upper beaches and shorelines ^[90] .	(to be continued)

Table 4. (continued)

Vegetation form	Plant name	Family	Native to	Description	Exposure	Environmental conditions	Additional info
	<i>Artemisia californica</i>	Asteraceae	California, Mexico Northwest	Aromatic, subshrub usually 0.6–1.5 m tall but sometimes reaches 2.5 m, tend to be wide with many branches from the base. Upper branches are somewhat unbranched and the stems are whitish with appressed hairs, long, slender, leafy, and flexible ^[91] .	Full sun	Occur on virtually all soil types except serpentine and on a variety of soil textures including depth loams, clayey loams, sandy loams, and loamy sands ^[90] . Drought tolerant, total annual precipitation ranges from about 25 – 60 cm, but can be higher. Requires full sun or nearly full sun ^[91] . California sagebrush can be compact if kept pruned and subjected to occasional pinching.	<ul style="list-style-type: none"> • Provides habitat for many plant and animal species. • Leaves have been used by Native Americans for smoking, in sweat-houses, and various other purposes. • Said to stimulate the uterine mucosa, ensuring rapid childbirth and, if regularly consumed as a decoction prior to the onset of each menstruation, to prevent menstrual cramps and alleviate menopausal trauma. • Fresh or dried leaves were chewed to alleviate colds^[91].
	<i>Lasthenia glabrata</i>	Asteraceae	California, Mexico Northwest	An annual that grows up to 0.3 m, with daisy like yellow flowers. The species is a hermaphrodite ^[92] .	Full sun	Grows in light sandy soils to heavy clay soils, vernal pools, low alkaline fields, hillsides etc, especially in grassland and alkaline marshes, up to 1,300 m. Prefers a sunny position ^[92] .	<ul style="list-style-type: none"> • Seeds are edible raw or cooked. They can be parched and eaten dry or made into a powder or cooked like a porridge^[92].
	yellowray goldfields <i>Mimulus aurantiacus</i>	Phrymaceae	Southwestern North America, southwestern Oregon, California, Baja, Mexico	Bushy evergreen shrub with narrow lanceolate dark green leaves and flowering stems with trumpet shaped flowers, grows up to 90–120 cm tall and 90 cm wide ^[93] .	Full sun to partial sun	Grows in clay, loamy and sandy soils with a soil pH that ranges acidic to alkaline, in full to partial sun ^[93] .	<ul style="list-style-type: none"> • Pollinated by birds and bees. • Great choice for beds, borders and rock gardens and stone walls^[93].
	Bush monkey flower <i>Limonium californicum</i>	Plumbaginaceae	California, Mexico Northwest, Nevada, Oregon	Half-hardy annual, Hardy perennial, half hardy perennial, 10–70 cm tall ^[94] .	Full sun	Full sunlight. Light soils. Sandy soil. However, can survive in dry soils ^[94] .	<ul style="list-style-type: none"> • Yearly feed for perennials. • Cut perennials to the ground in autumn. • Propagate: divide perennials in spring or autumn^[94].
	Western Marsh Rosemary <i>Alhagi graecorum</i> Mannatree	Fabaceae	California, Mexico Northwest, Texas	Perennial thorny shrub that grows up to 1 m tall, woody at the base in older plants, glabrous or sparingly hairy, with long creeping solons; stems erect or ascending, much branched, twigs spiny at their tips. Leaves are alternate, simple, entire, elliptic to obovate. 7–20 mm long with short petioles 1–2 mm long and stipules 1 mm long. flowers are pink to maroon, approximately 10 mm long with a short slender pedicel ^[95,96] .	Full sun	Occurs on a range of soils from silty loams to clays as well as saline depressions ^[96] . It is adapted to alkaline to neutral soils.	<ul style="list-style-type: none"> • Roots are used to treat kidney stones and diarrhea^[95].
Ground cover	<i>Convolvulus virgatus</i> Morning glory	Convolvulaceae	Gulf States, Iran, Oman, Pakistan	Under shrub forming a small bush up to 40 cm high and 60 cm wide; stems from a deep woody taproot, many, ascending, rigid, green, glabrous, sometimes spinescent at the tips, weakly divaricate. Leaves sessile lanceolate or linear-lanceolate, glabrous, acute or acuminate, corolla 1.3–2.1 cm, usually white, sometimes pinkish ^[97] .	Full sun	Full sunlight. Good drainage. Soil pH 6–8. Regular watering. It may be necessary to trim leaves to display flowers ^[98] .	<ul style="list-style-type: none"> • Great container plants and indoor plants, and also perform well in rock gardens, sunny beds and borders, or gravel patios. • Best to prune in middle to late spring or once flowering has completed^[98].
	<i>Crotalaria aegyptiaca</i> Rattlepod	Fabaceae	Egypt, Gulf States, India, Oman, Palestine, Saudi Arabia, Sinai, Somalia, Yemen	Perennial Shrub, reaches up to 60 cm high, multi-branched, leafless at flowering ^[100] .	Full sun	Dominates sandstone stone soils, but not found in limestone soils ^[100] .	<ul style="list-style-type: none"> • Grazed by camels and gazelles, but poisonous to sheep and goat. • Old dry plants may revive after rainfall^[100].

(to be continued)

Table 4. (continued)

Vegetation form	Plant name	Family	Native to	Description	Exposure	Environmental conditions	Additional info
	<i>Dipterygium glaucum</i> Blooming shrub	Cleomaceae	Djibouti, Egypt, Eritrea, Gulf States, India, Iran, Oman, Pakistan, Saudi Arabia, Somalia, Sudan, Yemen	Erect woody herb up to 80 cm high with numerous basal branches, slim olive-green leathery leaves. Flowers small with tubercles, yellow with pink tinge in few-flowered racemes; fruit/winged, pale green ^[108] .	Full sun	Habitat sandy soils ^[85] . Mostly grows on deep sands, also on saline sands ^[108] .	<ul style="list-style-type: none"> • Grazed by livestock and often very stunted • Often flowering and fruiting in the first year • Used to treat respiratory disease^[108].
	<i>Heliotropium curassavicum</i> Salt heliotrope	Boraginaceae	Americas; from Canada to Argentina	Perennial herb, glaucous green borage. Leaves blue-green, obovate cuneate slightly fleshy. Flowers in scorpioid cymes usually a pair of cymes, white with yellow tinge ^[74] .	Full sun	Habitat: Fields ^[74] . Sandy soils with a pH in the range of 6.6–8.5. It has a high tolerance to drought and anthropogenic disturbance. It can withstand areas with a rainfall of 200mm ^[106] .	<ul style="list-style-type: none"> • Dried and powdered plant is added to water and drunk to combat fatigue. • Topically to treat headache and used internally to treat gonorrhoea and to increase lactation. • Macerate of the plant is used as ink • Leaf sap is applied to burns^[74]. • Used as a bitter tonic, to treat sore throat and fever. • Used to treat liver ailments^[102].
	<i>Rhazya stricta</i> Decne. Harmal	Apocynaceae	Afghanistan, Gulf States, India, Iran, Iraq, Oman, Pakistan, Saudi Arabia, West Himalaya, Yemen	Evergreen dwarf shrub with thick foliage. It is a glabrous, upright perennial plant with many branches emerging from the base. Flowers are bisexual, white ^[102,103] . Yellowish-green shrub, up to 70 cm high.	Full sun	Grows in depressions with silty and sandy soils sometimes forming a pure stand and moderately salt-tolerant ^[102] .	<ul style="list-style-type: none"> • Plant is used as food for making sweet meats. • Root is laxative, vermifuge. It is used in the treatment of diarrhea, dysentery. • Leaf-sap and the root are used to treat hemorrhoids. • Leaves are abortifacient, inducing contractions of the uterus^[119].
	<i>Rhynchosia minima</i> Jumby-bean	Fabaceae	Afghanistan, Gulf States, India, Iran, Iraq, Oman, Pakistan, Saudi Arabia, West Himalaya, Yemen	Perennial herb, prostrate-trailing herb growing up to several meters long with trifoliolate leaves, the terminal leaflet rhomboid. Fruit a 2-seeded brown pod constricted between the seeds ^[119] .	Full sun	Grows in woodland and grassland, roadsides, disturbed areas and depressions with sandy-clayey soil ^[119] .	<ul style="list-style-type: none"> • Plant is used as food for making sweet meats. • Root is laxative, vermifuge. It is used in the treatment of diarrhea, dysentery. • Leaf-sap and the root are used to treat hemorrhoids. • Leaves are abortifacient, inducing contractions of the uterus^[119].
	<i>Senna italica</i> Italian senna	Fabaceae	Africa to the Indian Subcontinent.	Leafy low shrub, up to 0.60 cm high with numerous branches ending in terminal racemes of yellow flowers distinct by the orange spots at the bases of the leaflets; fruits falcate tuberculated pods with persistent styles ^[118] .	Full sun	It is found in Runnels, wadis and depressions ^[119] . Will tolerate moistly and very poorly draining soils ^[107] .	<ul style="list-style-type: none"> • Leaves, pods and unmaturing seeds are used as purgative, decoction and maceration to treat stomach complaints, fever, jaundice, venereal diseases and biliousness. • Used as abortifacient and against intestinal worms. • Leaves fresh or dried or pulverized used to dress skin problems, burns and ulcers. Flowers are made into tea and used as purgative and to induce labor. • Root maceration are used to cure colic and influenza. • Boiled roots are used to dress wounds. • Root infusion is used as eye drops for sore eyes and for the treatment of indigestion, liver complaints, gall bladder, nausea, vomiting and dysmenorrhea. Young seeds are eaten as snacks or as vegetable^[107]. • No records of its use^[109].
	<i>Tribulus arabicus</i> Zahr	Zygophyllaceae	Gulf States, Oman, Saudi Arabia, Yemen.	Perennial herb up to 70 cm high with grey-green leaves and with large yellow flowers (1.5–2.0 cm) ^[104] .	Full sun	Stabilizes sand and sand plains ^[109] .	<ul style="list-style-type: none"> • No records of its use^[109].
	<i>Pulicaria glutinosa</i> False fleabean	Asteraceae	NE. Tropical Africa, Arabian Peninsula, S. Pakistan.	Subshrub 20–45 cm high, densely branched. Branches glabrous, glutinous. Leaves linear, 10–30, 1–2 mm, margins strongly revolute, apex apiculate, glabrous, sticky ^[110] .	Full sun	Salt-tolerant plants grow in exceptionally salt-rich soil or waters of high-salinity conditions, including marshy and coastal lands. Adapted to survive in the prevailing dry climate and high-salt soil conditions ^[111] .	<ul style="list-style-type: none"> • Several <i>Pulicaria</i> species are used to treat inflammation, diabetes, and gastrointestinal disorders. • Plants from the genus are also used as tonic, food-preservative, in perfumes, and as part of salad^[111].

Plant recommendations for urban landscapes: Kuwait

treated seeds of *Ochradenus baccatus*, *Rhanterium epapposum* and *Nitraria retusa*, with 500, 750 and 1,000 mg/L GA_3 , respectively, and untreated seeds of *Peganum harmala* were tested^[62]. A 100% survival rate was observed in *Lycium shawii*, *Nitraria retusa* and *Ochradenus baccatus*, in comparison to *Peganum harmala* and *Rhanterium epapposum*, which had a survival rate of 97.8% over approximately a one-month period^[62]. The recommended plant spacing for native plants (Table 3) is only a guideline based on previous research^[43,62]. However, plant spacing is dependent on the space, aesthetic or whether it is grown in a square grid, rectangular grid, or triangular spacing.

Conclusions

Combating natural habitat loss and enhancing plant diversity by improving urban landscapes in Kuwait is a critical issue that needs to be addressed to ensure the survival of native flora and fauna. Conservation and rehabilitation efforts should not be focused solely on desert areas and nature reserves as they fail to address the issues of habitat fragmentation. As the main constraints faced by plants are Kuwait's harsh desert environmental conditions, poor soil and water scarcity, there needs to be a shift away from the current plant palette that utilizes plant species that have become invasive and have high water and fertilizer requirements. The use of native and xeric plant species that have been recommended in this paper will assist in providing guidance in the future when creating more sustainable urban green landscapes that offer a variety of ecosystem services.

Acknowledgements

A special thanks to Proceso T. Ramos Jr. for contributing to the identification and confirmation of native plant species.

Conflict of interest

The author declares that there is no conflict of interest.

Dates

Received 7 April 2022; Accepted 8 October 2022; Published online 31 October 2022

REFERENCES

- Al-Awadhi JM, Misak RF, Omar SS. 2003. Causes and consequences of desertification in Kuwait: A case study of land degradation. *Bulletin of Engineering Geology and the Environment* 62:107–15
- Urban MC, Bocedi G, Hendry AP, Mihoub JB, Pe'er G, et al. 2016. Improving the forecast for biodiversity under climate change. *Science* 353:6304
- Al-Dousari A, Ramadan A, Al-Qattan A, Al-Ateeqi S, Dashti H, et al. 2020. Cost and effect of native vegetation change on aeolian sand, dust, microclimate and sustainable energy in Kuwait. *Journal of Taibah University for Science* 14:628–39
- Aba A, Al-Dousari AM, Ismaeel A. 2018. Atmospheric deposition fluxes of ^{137}Cs associated with dust fallout in the northeastern Arabian Gulf. *Journal of Environmental Radioactivity* 192:565–72
- Ahmed M, Al-Dousari N, Al-Dousari A. 2016. The role of dominant perennial native plant species in controlling the mobile sand encroachment and fallen dust problem in Kuwait. *Arabian Journal of Geosciences* 9:134
- Aba A, Al-Dousari AM, Ismaeel A. 2016. Depositional characteristics of ^{7}Be and ^{210}Pb in Kuwaiti dust. *Journal of Radioanalytical and Nuclear Chemistry* 307:15–23
- Abdelaal M. 2017. Current status of the floristic composition in Wadi Hagul, Northwest Suez Gulf, Egypt. *Rendiconti Lincei* 28:81–92
- Brown G. 2001. Small-scale dynamics of desert annuals in an ungrazed *Rhanterium epapposum* community over three growth seasons in Kuwait. *Flora* 196:353–363
- Al-Houty W. 2009. Insect biodiversity in Kuwait. *International Journal of Biodiversity and Conservation* 1:251–57. https://academicjournals.org/article/article1379950452_Al-Houty.pdf
- Environmental protection Agency (EPA). 2018. Kuwait National Adaptation Plan 2019–2030, <https://unfccc.int/sites/default/files/resource/Kuwait-NAP-2019-2030.pdf>
- Omar S, Leadlay E. 2007. In situ and ex situ conservation of genetic diversity of desert plants in Kuwait. 3rd Global Botanic Gardens Congress. pp. 1–5
- The University of Rhode Island. 2022. What are native plants? <https://web.uri.edu/rinativeplants/what-are-native-plants/>
- Phondani PC, Bhatt A, Elsarrag E, Alhorr, YM, El-Keblawy A. 2016. Criteria and indicator approach of global sustainability assessment system for sustainable landscaping using native plants in Qatar. *Ecological Indicators* 69:381–89
- Sun H, Kopp K, Kjelgren R. 2012. Water-efficient Urban Landscapes: Integrating Different Water Use Categorizations and Plant Types. *HortScience* 47:254–63
- Khelil R, Jardé E, Cabello-Hurtado F, Ould-el-Hadj Khelil A, Esnault MA. 2016. Structure and composition of the wax of the date palm, *Phoenix dactylifera* L., from the septentrional Sahara. *Scientia Horticulturae* 201:238–46
- Keshavarzi M. 2021. An Overview of Ecological Anatomy of Poaceae Halophytes from Iran. In *Handbook of Halophytes: From Molecules to Ecosystems towards Biosaline Agriculture*. Berlin Heidelberg: Springer. pp. 1035–62
- Baltzoi P, Fotia K, Kyrkas D, Nikolaou K, Paraskevopoulou AT, et al. 2015. Low water-demand plants for landscaping and agricultural cultivations – A review regarding local species of Epirus/Greece and Apulia/Italy. *Agriculture and Agricultural Science Procedia* 4:250–60
- Grigore MN, Toma C, Boscaiu M. 2010. Ecological implications of bulliform cells on halophytes, in salt and water stress natural conditions. *Analele Stiintifice ale Universitatii "Alexandru Ioan Cuza" din Iasi. Biologie Vegetala*. 56:5–15. <http://hdl.handle.net/10251/101713>
- Suleiman MK, Abdal MS. 2002. Water availability for the greening of Kuwait. *Limnologia* 32:322–28
- Al-Sulaimi JS, Mollah MA, Matti MA. 1990. Geotechnical properties of calcrete soil (Gatch) in Kuwait. *Engineering Geology* 28:191–193, 197–204
- Abd El-Wahab RH. 2016. Species richness, structure, and conservation of *Nitraria retusa* communities in the coastal salt marshes of Kuwait. *Regional Environmental Change* 16:1097–107
- Zaman S, Padmesh S, Tawfiq H. 2009. Effect of pre-germination treatments on seed germination of *Helianthemum lippii* (L.) Dum. Cours. *Desert Plants* 25:18–21
- Al-Mutawa YAA. 1993. *Landscape design guidelines for Kuwait*. Doctoral dissertation. The University of Arizona.
- Al-Awadhi JM, AlShuaibi AA. 2013. Dust fallout in Kuwait city: Deposition and characterization. *Science of the Total Environment* 461–462:139–48
- Al-Dousari AM, Al-Awadhi J. 2012. Dust fallout in northern Kuwait, major sources and characteristics. *Kuwait Journal of Science* 39:171–87
- Bou-Rabee M, Sulaiman SA, Saleh MS, Marafi S. 2017. Using artificial neural networks to estimate solar radiation in Kuwait. *Renewable and Sustainable Energy Reviews* 72:434–38

27. Brovkin V, Boysen L, Raddatz T, Gayler V, Loew A, Claussen M. 2013. Evaluation of vegetation cover and land-surface albedo in MPI-ESM CMIP5 simulations. *Journal of Advances in Modeling Earth Systems* 5:48–57
28. Fuller DO, Ottke C. 2002. Land cover, rainfall and land-surface albedo in West Africa. *Climatic Change* 54:181–204
29. Al-Ateeqi S, Al-Harban A. 2006. Plants as soil indicators in Al-Khيران area, Kuwait. In *Proceedings of the 8th International Conference on the Geology of the Arab World (GAW8)*. Egypt: Cairo University. pp. 107–16
30. Al-Sulaimi JS, El-Rabaa SM. 1994. Morphological and morpho-structural features of Kuwait. *Geomorphology* 11:151–67
31. Al-Nakshabandi GA, El-Mansy H. 1987. A Review of Soil Survey Work in Kuwait. *Technical Report*. KISR, Kuwait
32. Abdal MS, Suleiman MK. 1984. Kuwait Desert Soil Properties And Genesis. *Symposium No. 15*. pp. 1968–71
33. Al-Salem SM, Zeitoun R, Dutta A, Al-Nasser A, Al-Wadi MH, et al. 2020. Baseline soil characterisation of active landfill sites for future restoration and development in the state of Kuwait. *International Journal of Environmental Science and Technology* 17:4407–18
34. Omar SAS, Misak R, King P, Shahid SA, Abo-Rizq H, et al. 2001. Mapping the vegetation of Kuwait through reconnaissance soil survey. *Journal of Arid Environments* 48:341–55
35. Shahid SA, Omar SA. 2022. *Kuwait Soil Taxonomy*. Switzerland AG: Springer Nature
36. Soil Survey Staff. 1999. Soil taxonomy a basic system of soil classification for making and interpreting soil surveys, 2nd edition. USDA. Agriculture Handbook. No. 434:869.
37. KISR. 1999. Soil Survey for the State of Kuwait. Volume II Reconnaissance Survey. AACM International. Australia. 270 pp.
38. Jaradat AA. 2011. Biodiversity of date palm. Encyclopedia of life support systems: Land use, land cover and soil sciences. Oxford, UK: Eolss Publishers. 31 pp
39. Lahalih SM. 1998. Development and evaluation of new multipurpose soil additives. *Industrial and Engineering Chemistry Research* 37:420–26
40. Al-Gharabally D, Al-Barood A. 2015. Kuwait environmental remediation program (KERP): remediation demonstration strategy. *Biological and Chemical Research* 32:289–96
41. Abd El-Wahab RH, Al-Rashed AR, Al-Dousari A. 2018. Influences of physiographic factors, vegetation patterns and human impacts on aeolian landforms in arid environment. *Arid Ecosystems* 8:97–110
42. Brown G. 2003. Species richness, diversity and biomass production of desert annuals in an ungrazed *Rhanterium epapposum* community over three growth seasons in Kuwait. *Plant Ecology* 165:53–68
43. Al-Rashed M, Al-Senafy MN, Viswanathan MN, Al-Sumait A. 1998. Groundwater utilization in Kuwait: Some problems and solutions. *International Journal of Water Resources Development* 14:91–105
44. Bhat NR, Suleiman MK, Abdal M. 2009. Selection of crops for sustainable utilization of land and water resources in Kuwait. *World Journal of Agricultural Sciences* 5:201–6
45. Alfudhala SM. 2010. *On the urban ecology of Kuwait: Structure and function of public gardens*. Library and Archives Canada = Bibliothèque et Archives Canada, Ottawa.
46. Al-Nafisi R, Al-Ghadban A, Gharib I, Bhat N. 2009. Positive impacts of mangrove plantations on Kuwait's coastal environment. *European Journal of Scientific Research* 26:510–21
47. Hopkins E, Al-Yahyai R. 2015. Landscaping with native plants in Oman. *Acta Horticulturae* 1097:181–92
48. Simmons MT, Venhaus HC, Windhager S. 2007. Exploiting the attributes of regional ecosystems for landscape design: The role of ecological restoration in ecological engineering. *Ecological Engineering* 30:201–5
49. Uren HV, Dzidic PL, Bishop BJ. 2015. Exploring social and cultural norms to promote ecologically sensitive residential garden design. *Landscape and Urban Planning* 137:76–84
50. Alam, H, Khattak JZK, Ppoyil SBT, Kurup SS, Ksiksi TS. 2017. Landscaping with native plants in the UAE: A review. *Emirates Journal of Food and Agriculture* 29:729–41
51. Green D, Richards R, Hart D, Watson I. 2001. *Rangeland monitoring, condition assessment and resource inventory activities in New South Wales conducted by the Department of Land and Water Conservation*. National Land and Water Resources Audit, Canberra, ACT.
52. Boulos L, Al-Dosari M. 1994. Checklist of the flora of Kuwait. *University of Kuwait Journal* 21:203–17
53. Kernick MD. 1966. Plant resources, range ecology and fodder plant introduction. *Report*. Report to the Government of Kuwait. FAO, Mimeo.
54. Dickson V. 1955. *The Wild Flowers of Kuwait and Bahrain*. UK: Allen and Unwin. 120 pp.
55. Suleiman MK, Bhat NR, Zaman S, Delima E, Al-Mulla LA, et al. 2007. Plant enrichment in the desert ecosystem. *Journal of Food, Agriculture and Environment* 5:328–31
56. Mann HS, Saxena SK. 1981. BORDI (*Ziziphus nummularia*) - A shrub of Indian arid zone - Its role in silvipasture. *Monograph 13*. Central Arid Zone Research Institute. Jodhpur, India: Harvard Press. pp. 1–93
57. Suleiman MK, Bhat NR, Jacob J, Thomas RR. 2011. Germination studies in *Ochradenus baccatus* Delile., *Peganum harmala* L. and *Gynandrisis sisyrinchium* Parl. *Research Journal of Seed Science* 4:58–63
58. Singh JP, Rathore VS, Roy MM. 2015. Notes about *Haloxylon salicornicum* (Moq.) Bunge ex Boiss., a promising shrub for arid regions. *Genetic Resources and Crop Evolution* 62:451–63
59. Suleiman MK, Bhat NR, Jacob S, Thomas RR. 2011. Germination studies in *Lycium shawii* Roem. and Schult. *World Journal of Agricultural Sciences* 7:26–28
60. Zaman S, Padmesh S, Tawfiq H. 2009. Effect of pre-germination treatments on seed germination of *Helianthemum lippii* (L.) Dum. Cours. *Desert Plants* 25:18-21. <https://repository.arizona.edu/handle/10150/556666>
61. Suleiman MK, Bhat NR, Jacob S, Thomas RR, D'Cruz G. 2011. Performance of selected native plants under deficit irrigation. *World Journal of Agricultural Sciences* 7:19–25
62. Almulla L, Suleiman MK, Bhat NR, Jacob S, Islam MA, et al. 2017. Propagation studies on selected keystone plant species for use in restoration projects in Kuwait. *International Journal of Agricultural Science* 2:27–31
63. Swarnkar SK, Khunteta A, Gupta MK, Jain P, Paliwal S. 2019. Pharmacognostic, Phytochemical and Pharmacological Review of "Phog" - *Calligonum polygonoides* L.. *Journal of Drug Delivery and Therapeutics* 9:469–73
64. Bosman A. 2021. Angiosperms (Flowering Plants). Earth.com. www.earth.com/plant-encyclopedia/Angiosperms/Poaceae/cenchrus-divisus/en/
65. Plants For A Future. 2022. *Panicum turgidum* Desert Grass. *Turgid panic grass*. <https://pfaf.org/user/Plant.aspx?LatinName=Panicum+turgidum>
66. The International Union for Conservation of Nature and Natural Resources Malaga. 2005. *A guide to medicinal plants in North Africa*. IUCN Centre for Mediterranean Cooperation.
67. Ahmed MM, Al-dousari AM. 2017. Restoration and conservation of deteriorated arid land by a native thorny shrub *Lycium shawii*. *Journal of Agricultural Science and Technology* 7:100–6
68. Bhatt A, Pérez-garcía F. 2016. Seed dormancy of *Ochradenus baccatus* (Resedaceae), a shrubby species from Arabian desert regions. *Revista De Biología Tropical* 64:965–74
69. Samejo MQ, Memon S, Bhangar MI, Khan KM. 2011. Preliminary phytochemicals screening of *Calligonum polygonoides* Linn. *Journal of Pharmacy Research* 4:4402–3

Plant recommendations for urban landscapes: Kuwait

70. Rathore VS, Singh JP, Bhardwaj S, Nathawat NS, Kumar M, et al. 2015. Potential of native shrubs *Haloxylon salicornicum* and *Calligonum polygonoides* for restoration of degraded lands in arid western Rajasthan, India. *Environmental Management* 55:205–16
71. Bhatt A, Bhat NR, Al-Nasser A, Carón MM, Santo A. 2020. Inter-population variabilities in seed mass and germination of *Panicum turgidum* and *Pennisetum divisum* on the desert of Kuwait. *Journal of Arid Land* 12:144–153
72. Khan MA, Ansari R, Ali H, Gul B, Nielsen BL. 2009. *Panicum turgidum*, a potentially sustainable cattle feed alternative to maize for saline areas. *Agriculture, Ecosystems & Environment* 129:542–46
73. Ahmed MM, Al-Dousari N, Al-Dousari AM. 2019. The ecological role of *Cornulaca aucheri* (Amaranthaceae) in the stabilization of degraded sandy soils in Kuwait: The case study of Liyah area. *Conference of the Arabian Journal of Geosciences 2018: Exploring the Nexus of Geoecology, Geography, Geoarchaeology and Geotourism: Advances and Applications for Sustainable Development in Environmental Sciences and Agroforestry Research, Sousse, Tunisia, 2018*. Switzerland: Springer, Cham. pp. 47–49. ham. pp. 47–49. https://doi.org/10.1007/978-3-030-01683-8_10
74. Fern K. 2022. Heliotropium ramosissimum – Useful Tropical Plants. <http://tropical.theferns.info/viewtropical.php?id=Heliotropium+ramosissimum&redir=Heliotropium+bacciferum>
75. Ravenscroft D. 2022. Heliotropium Plants - Heliotrope Growing Guide. www.gardenershq.com/Heliotropium-Heliotrope.php
76. Starr G. 1983. Australian Acacias Used for Landscaping in Arizona. *Desert Plants* 5:72–76 <https://repository.arizona.edu/handle/10150/552189>
77. Truong P, Hedrick J, Searle G, Director TVN, Asia E. 2006. Vetiver Grass for Environmental Protection and Landscaping in Australia and Around the World. In *The Fourth International Conference on Vetiver (ICV-4), Vetiver and People*, Caracas, Venezuela. pp. 1–13
78. Plants for a Future. *Prosopis cineraria* Jandi, Ghaf. <https://pfaf.org/user/Plant.aspx?LatinName=Prosopis+cineraria>
79. Fern K. 2022. Eucalyptus microtheca – Useful Tropical Plants. <http://tropical.theferns.info/viewtropical.php?id=Eucalyptus+microtheca>
80. Fern K. 2022. Eucalyptus camaldulensis – Useful Tropical Plants. <http://tropical.theferns.info/viewtropical.php?id=Eucalyptus+camaldulensis>
81. Arizona State University. *Parkinsonia praecox*. www.public.asu.edu/~camartin/plants/Plant%20html%20files/parkinsoniapraecox.html
82. Adgaba N, Ahmed AGA, Awraris SG, Al-Madani M, Ansari MJ, et al. 2016. Pollination ecology, nectar secretion dynamics, and honey production potentials of *Acacia ehrenbergiana* (Hayne) and *Acacia tortilis* (Forsk.) Hayne, leguminosae (Mimosoideae), in an arid region of Saudi Arabia. *Tropical Ecology* 57:429–44
83. Useful Tropical Plants Database. *Eucalyptus microtheca*. <http://tropical.theferns.info/viewtropical.php?id=Eucalyptus+microtheca>
84. PlantNET. Factsheet - *Atriplex lindleyi*. https://keys.lucidcentral.org/keys/v3/scotia/key/Plants%20and%20Fungi%20of%20south%20western%20NSW/Media/Html/Atriplex_lindleyi.htm
85. Australian Native Plants. *Maireana sedifolia*. www.australianplants.com/plants.aspx?id=1371
86. Schuch UK, Kelly JJ. 2008. Palo verde trees for the urban landscape. *Aridus* 20:1–8
87. Mielke J. 1993. Find Trees & Learn. University of Arizona Campus Arboretum. <https://apps.cals.arizona.edu/arboretum/taxon.aspx?id=829>
88. Csurhes S, Leigh C, Walton C. 2016. African Lovegrass - *Eragrostis curvula*. In *Invasive plant risk assessment*. Brisbane, Australia: Department of Agriculture and Fisheries. www.daf.qld.gov.au/_data/assets/pdf_file/0004/62716/IPA-African-Lovegrass-Risk-Assessment.pdf
89. Fact Sheet Fusion V2. 2020. *Eragrostis curvula* - Tropical Forages. www.tropicalforages.info/text/entities/eragrostis_curvula.htm
90. Klinkenberg BE, Flora BC. 2008. Electronic Atlas of the Plants of British Columbia. Vancouver: Lab for Advanced Spatial Analysis, University of British Columbia. <http://linnet.geog.ubc.ca/Atlas/Atlas.aspx?sciname=Ambrosia%20chamissonis>
91. Montalvo AM, Koehler CE, Riordan EM, Beyers J. 2017. Plant profile for *Artemisia californica*. *Native Plant Recommendations for Southern California Ecoregions*.
92. Plants for a Future. n. d. *Lasthenia glabrata* Yellowray Goldfields Coulter's goldfields. <https://pfaf.org/user/Plant.aspx?LatinName=Lasthenia+glabrata>
93. Gardenia. *Mimulus aurantiacus* (Bush Monkey Flower) www.gardenia.net/plant/mimulus-aurantiacus-monkey-flower
94. Ravenscroft D. 2022. Limonium Plant - Sea Pink Growing Guide. www.gardenershq.com/Limonium-sea-pink.php
95. Modzelevich M. Israel flowers: Alhagi graecorum. www.flower.sinisrael.com/Alhagigraecorum_page.htm
96. CABI. 2021. Alhagi maurorum (camelthorn). www.cabi.org/isc/datasheet/4215
97. Wood JRI, Williams BRM, Mitchell TC, Carine MA, Harris DJ, et al. 2015. A foundation monograph of *Convolvulus* L. (Convolvulaceae). *PhytoKeys* 51:1–282
98. Ravenscroft D. 2022. *Convolvulus* Plant - Silverbush Growing Guide. www.gardenershq.com/Convolvulus-Silverbush.php
99. Orwa C, Mutua A, Kindt R, Jamnadass R, Simons A. 2009. Agroforestry Database: a tree reference and selection guide. Version 4. www.cabdirect.org/cabdirect/abstract/20177200441
100. Mahmoud T. 2010. *Desert Plants of Egypt's Wadi El Gemal National Park*, 1st edition. Cairo: The American University in Cairo Press
101. Zahran MA, Willis AJ. 2014. *The Vegetation of Egypt (Plant and Vegetation, 2)*, 2nd edition. Springer Science & Business Media
102. Bukhari NA, Al-Otaibi RA, Ibrahim MM. 2017. Phytochemical and taxonomic evaluation of *Rhazya stricta* in Saudi Arabia. *Saudi Journal of Biological Sciences* 24:1513–21
103. Albeshri A, Baeshen NA, Bouback TA, Aljaddawi AA. 2021. A review of *Rhazya stricta* decne phytochemistry, bioactivities, pharmacological activities, toxicity, and folkloric medicinal uses. *Plants* 10:25081
104. Böer B, Sargeant D. 1998. Desert perennials as plant and soil indicators in Eastern Arabia. *Plant and Soil* 199:261–66
105. Arizona state University. *Ebenopsis Eban*. www.public.asu.edu/~camartin/plants/Plant%20html%20files/ebenopsisebano.html
106. Rojas-Sandoval J. 2018. *Heliotropium curassavicum* (salt heliotrope). *Invasive Species Compendium*. Wallingford, UK: CABI. <http://doi.org/10.1079/ISC.114723.20203482795>
107. Bharathi V, Raja M, Radha R, Sasikala P. 2018. A Review Article on *Senna italica* Mill. *International Journal of Pharmaceutical Sciences Review and Research* 52:44–46
108. Dubai Desert Conservation Reserve. 2022. Saffron. [www.ddcr.org/florafauna/Detail.aspx?Class=Plants&Referrer=Capparaceae%20\(Shrubs\)&Subclass=Shrubs&id=221](http://www.ddcr.org/florafauna/Detail.aspx?Class=Plants&Referrer=Capparaceae%20(Shrubs)&Subclass=Shrubs&id=221)
109. Dubai Desert Conservation Reserve. 2022. Zahar. [www.ddcr.org/FloraFauna/Detail.aspx?Class=Plants&Referrer=Zygophyllaceae%20\(Herbs\)&Subclass=Herbs&id=237](http://www.ddcr.org/FloraFauna/Detail.aspx?Class=Plants&Referrer=Zygophyllaceae%20(Herbs)&Subclass=Herbs&id=237)
110. JSTOR. 2000. *Pulicaria glutinosa*. <https://plants.jstor.org/pilation/Pulicaria.glutinosa>
111. Mohammed HA, Al-Omar MS, Khan RA, Mohammed SAA, Qureshi KA, et al. 2021. Chemical profile, antioxidant, antimicrobial, and anticancer activities of the water-ethanol extract of *pulicaria undulata* growing in the oasis of central saudi arabian desert. *Plants* 10:1811

112. Lortie CJ, Zuliani M, Ghazian N, Haas S, Braun J, Owen M, Lucero J, etc. 2021. Too much of a good thing: Shrub benefactors are less important in higher diversity arid ecosystems. *Journal of Ecology* 109:2047–53
113. Tielbörger K, Kadmon R. 2000. Indirect effects in a desert plant community: Is competition among annuals more intense under shrub canopies? *Plant Ecology* 150:53–63
114. Berg N, Steinberger Y. 2012. The role of perennial plants in preserving annual plant complexity in a desert ecosystem. *Geoderma* 185–186:6–11
115. Tielbörger K, Prasse R. 2009. Do seeds sense each other? Testing for density-dependent germination in desert perennial plants *Oikos* 118:792–800
116. Shahrakht TS, Jankju M, Mesdaghi M. 2013. Effects of Shrub Canopy on the Microclimate and Soil Properties of Steppe Rangeland. *Journal of Rangeland Science* 3:213–22
117. Suleiman MK, Bhat NR, Abdal MS, Zaman S, Jacob S, et al. 2010. Propagation studies in *Farsetia aegyptia* Turra. *International Journal of Biodiversity and Conservation* 2:30–32
118. Suleiman MK, Zaman S, Al-Dosseri S, Thomas RR, Jacob S. 2009. Germination studies in *Horwoodia dicksoniae* Turril. *International Journal of Environmental Studies* 66:221–225
119. Bary EMMA. 2013. *The Dicotyledons*. <https://books.google.com.kw/books?id=HbLiDAEACAAJ>
120. SelecTree. 2021. *Lysiloma watsonii* Tree Record. <https://selectree.calpoly.edu/tree-detail/lysiloma-watsonii>
121. Horticulture Unlimited. 2014. *Lysiloma watsonii*. <https://horticultureunlimited.com/tree/lysiloma-watsonii/>
122. Arizona Board of Regents. 2012. Find Trees & Learn. University of Arizona Campus Arboretum. <https://apps.cals.arizona.edu/arboletum/taxon.aspx?id=307>



Copyright: © 2022 by the author(s). Published by Maximum Academic Press, Fayetteville, GA. This article is an open access article distributed under Creative Commons Attribution License (CC BY 4.0), visit <https://creativecommons.org/licenses/by/4.0/>.