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REVIEW ARTICLE

Landscaping with native plants in the UAE: A review

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ABSTRACT

The United Arab Emirates (UAE) has a unique experience in greening the desert. Huge efforts have been done to create green spaces across the country including afforestation and urban landscaping. Most of the landscaping designs were inspired from western landscapes comprises mostly of exotic species, which do not reconcile with the environmental conditions of the UAE. The intensive use of exotic species in artificial vegetation, high water requirements for the UAE greenery, coupled with water shortages and salinity, are causing major environmental and ecological challenges. Fortunately, the UAE hosts a unique flora and fauna that show remarkable adjustment to harsh weather conditions. Here we emphasize the use of native plants due to their potential to develop landscapes in saline and water shortage conditions, leading to reduced water usage for landscaping. The preservation of native biodiversity of the UAE will be an added benefit. In this article the main aspects of the UAE landscaping efforts, with the associated water resources using native plants in landscaping, problems in promoting native plants in landscaping and possible solutions are discussed.

Keywords: Landscaping; Native plants; Water shortages; Xeriscaping; UAE

INTRODUCTION

The United Arab Emirates (UAE) is located in the Arabian Peninsula, covering an area of 82,880 km^2 (Yearbook, 2010). Since the 1960s, huge development programs are started due to commercial oil exploration. As a part of this national development and modernization in UAE enormous resources are utilized for urban landscaping and agricultural development. The UAE has converted the natural desert into productive agricultural land with the idea of greening the desert (El-Keblawy and Ksiksi, 2005). In UAE more than 330,000 ha forest had been planted to promote soil conservation till 2009 (Abdelfattah et al., 2009) and the agricultural land of UAE has reached 75, 283 ha (Abu Dhabi Statistics Center, 2015). This artificial construction of a green nature has been cause of many environmental issues also. The UAE has the highest consumption of water per capita in the world, with the domestic consumption of only 13 per cent, while 80 per cent of water is utilized for different greening projects. This large amount of water demand is met by the desalination of sea water that requires large amounts of energy and releases massive amounts of carbon dioxide (Al-Rashed and Sherif, 2000).

URBAN LANDSCAPE DEVELOPMENTS IN UAE

Over a short period of time, large areas in the UAE have been transformed from deserts into green lands which include tree planting, creation of public parks gardens and recreational facilities in the cities and along the median and road sides (Yearbook, 2010). Greening of the Emirates is actually an active material construction of a nature. Urban Landscape of UAE appears difficult to reconcile with the ecological, social and cultural conditions of the country (Bolleter, 2015).

Threats to UAE Biodiversity

Huge urban landscaping and increasing population has resulted in the endangerment and/or extinction of many plant species in last few decades. The impact of this erosion in plant biodiversity has created environmental and socioeconomic problems which subsequently triggered the need of conservation of plant resources (Arif et al.,

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2010). According to Tourenq (2008) drought is the main threat facing biodiversity along with coastal development and urbanization and overexploitation of natural resources (grazing, fishing, hunting, and water extraction). Similarly, desert ecosystems in the western region of Abu Dhabi (UAE) has also been subjected to different types of human impacts (e.g. afforestation, grazing and urbanization), leading to the loss of biodiversity (Mousa and Ksiksi, 2009). The plants species having coastal habitat are diminishing very fast due to rapid urbanization (MOEW, 2015). Gardner and Howarth (2009) emphasized the maintaining of standing trees wherever possible while, designing around them where necessary. Abu Dhabi city municipality made mandatory the preservation of any existing landscape plantation adjacent to proposed roadway projects. Consultants are directed to do the survey of existing flora and fauna as part of the design survey stage, the results of this survey are to be agreed with Abu Dhabi municipality, Parks and Recreation Facilities Division and Environmental Agency Abu Dhabi. Road/bridge improvements including utility locations shall be designed to minimize removal of vegetation. The consultants design shall avoid, wherever possible, those habitat areas that support rare, threatened or endangered wildlife species (ADM, 2010; ADM 2014). UAE government continues its efforts in conservation of biodiversity and the protection of endangered plant species in the UAE in order to promote environmental sustainability.

Exotic Species for artificial greenery

Most of the urban landscapes are inspired by western landscape designs primarily focusing on aesthetics. This artificial greenery has introduced many new species in the country. Green sector of UAE depends mostly on imported exotic species (Pitman et al., 2009). Therefore UAE biophysical and cultural Landscape can be seen to be exotic (Ouis, 2002). According to Al-Mashhadani (2014) greenery at UAE comprised primarily of non-native species which are used mainly in the landscape. Non-native plant species need high maintenance and need substantial support systems to keep them alive. Moreover, these exotic plants are mostly introduced from the temperate and semi-temperate regions to the arid environment of UAE and have high irrigation requirements (Frenken et al., 2009). The purpose of planting exotic species is to increase the vegetation area and produce more aesthetic and green environment in marginal lands such as those with salinity or very drought prone areas. The exotic species may become invasive and become environmental risk. Due to this reason we have to focus the indigenous plants while selecting plants for our landscapes. Native plants have capacity to adapt the hostile arid environmental conditions which is an important factor to select them for landscaping (Frenken et al., 2009). As native plants are adapted to the local environment they have advantage over exotics plants that they are less likely to become invasive (Fiedler, 2006; Stephens et al., 2006). In UAE dates and Rhodes are two main agricultural plant species grown for fruit and forage purposes respectively (Pitman et al., 2009). Alfalfa and Rhodes grass are mostly produced to fulfill the shortfall of feed from the rangeland for grazing animals. These introduced species consume huge quantity of sweet water, mainly from groundwater water source. Due to combined effects of lowering of groundwater levels and accumulation of salts at soil surface have decreased the productivity of land as a consequence, of these farmers has to abandon the land (Peacock et al., 2002). According to the environmental agency Abu Dhabi, Rhodes grass production should be banned and replaced by *Chloris gayana* or other salt and drought tolerant species which can reduce water requirements by half (Pitman et al., 2009).

Water Requirements for artificial greenery

UAE has limited fresh water resources with average annual rainfall ranges from 80 and 140mm (Sherif et al., 2014). Abdelfattah et al. (2009) reported the groundwater potential of both deep and shallow aquifers is about 757.6 km^3 while fresh is less than 7.5 %. The annual groundwater extraction is about 2668 million m^3 compared to recharge i.e. 350 million m^3. During the last three decades the excess pumping of groundwater for irrigation has decreased the groundwater flow by one tenth. Current extraction rates need to be reduced by at least 25% to achieve sustainable development and to mitigate the present severe groundwater depletion in the area (Mohamed et al., 2016).

The main source of water supply for greening the desert is ground water which is 70 % of the total water consumed in the country. The green sector in the UAE consists of forestry, agriculture and the amenities. The forestry sector is used for the landscaping purposes and amenities which include parks, gardens and recreational areas while the agricultural sector is focused on crop production (Frenken et al., 2009). From a demand perspective, agriculture is the single largest consumer of water by sector, accounting for up to 95% of groundwater usage and total amenity water use which was estimated at 547 Mm^3/yr. in 2007. The low water use figures of residential flats relative to villas and shabiyats are also due to the watering of gardens rather than the actual use by the residents (Pitman et al., 2009). As declared by the EAD, agriculture in the UAE is living on borrowed time, including palm plantations (Pitman et al., 2009). The year 2030, could be the first year with no more supply from groundwater aquifers. In the UAE, landscaping sector will face challenges, in terms of irrigation resources. The potential concern related to the green sector in the UAE is that water requirement for green sector is increasing while the groundwater supply is vanishing. The difference

between the (incoming) feeding and the (outgoing) consumption of water from the aquifer has resulted in certain issues like, dryness of wells, reduction in ground water recharge, groundwater intrusion with seawater and increase in the water salinity (MOEW, 2015).

Ground water salinity

Globally 800 Mha of lands are affected by salinity, which represents 6% of the world's total land area (FAO, 2000). Though salinity is a natural phenomenon however, cultivated agricultural land has become saline due to land clearing or irrigation and sea water intrusion. Globally 45 Mha land is salt-affected out of the current 230 Mha of irrigated land, which is equal to 20 % of irrigated land (FAO, 2000). Some estimates being as high as 50% of agriculture land (Pitman et al., 2009). It is estimated that about 10 Mha of agricultural land is vanished annually due to salinization, of which about 1.5 Mha is irrigated land (Khan et al., 2006). Furthermore, the saline areas are increasing at a rate of 10% annually for various reasons. It has been estimated that by the year 2050 more than 50% of the arable land would be salinized (Jamil et al., 2011) Groundwater salinity, is one of the problem that sustainable development and greenery is facing. The groundwater salinity in the northern part of the UAE has doubled during the period from 1981 to 1993 (Rizk et al., 2007). In the southern and northern parts of UAE the salinity of groundwater has increased abruptly three folds during the period of 1985 to 1996. Same conditions have been observed in the central part of UAE where ground water salinity level has doubled (Murad et al., 2007). In UAE seawater intrusion is also a main cause of water salinity in the aquifer especially near the coast. Recently after 2000 sea water intrusion extended 8 km inland from the coast of the Gulf of Oman (Kunth et al., 2006).

IMPACT OF CLIMATE CHANGE IN UAE

Arab world have started to face the climate change effects in form of extreme weather events and higher temperatures etc. UAE has the highest carbon footprint in the world according to the published reports. The year 2010 was reported to be the warmest year in last two centuries in the region. In the UAE such climate change poses great threat to the desert ecology. It is predicted that increase water shortage and decreased agriculture production will affect the tourism thereby revenue source also. Now UAE is determined to take necessary measures to go green and sustainable (Almheiri, 2015).

Water status and climate change impacts

Climate change effects on temperature and rainfall can increase water shortage problem of the country. The potential changes to the climate are the cause for a very serious concern to encourage the best planning (Dougherty et al., 2009). The predicted increase in temperature will increase evaporation in the region. Due to this rise in temperature and changes in rainfall the demand for water is going to rise even more.

Microclimate

The climate is the average weather over several years divided into main zones with similar characteristics. Within a particular region, climate can differ from place to place within a few kilometers distance, forming a small scale pattern of climate, called microclimate (Santamouris et al., 1996).

Micro climate modification

Vegetation has a strong relationship with the microclimate (Masmoudi and Mazouz, 2004). Plants color and surface characteristic act as a neutralizer to the thermal environment. Decrease of air temperature have been observed during hot summer days in areas with greenery (Shashua-Bar and Hoffman, 2000; Dimoudi and Nikolopoulou, 2003). Air temperature along with greenery is considered to be the most crucial parameter in improving the microclimate due to its multiple benefits (Mahmoud, 2011). Spangenberg et al. (2008) observed a small decrease in temperature for tree-aligned streets (1°C), but up to 20 °C lower surface temperatures and more than 4^0C lower mean radiant temperatures. Vegetation has proved to enhance the microclimate mainly through shading, reduction of surface temperatures and evaporative cooling (Bradley, 1995). An environment of a natural forest can be recreated through increasing urban greenery by tree cover of 30% of the ground and 100% green roofs (Spangenberg, 2004).

Wilmers (1990) has mentioned that cooling effect of vegetation is extended to its surrounding built environment called the background effect (ShashuaBar and Hoffman, 2000; Wong et al., 2007). In Contrast to the Urban Heat Island effect this cooling effect due to vegetation in parks and open spaces has been known as, 'park cooling island'. It can be easily concluded that the higher the ratio of green to build area the greater the air temperature decrease is likely to be in the area (Dimoudi and Nikolopoulou, 2003). Al-Yaqoob (2012) studied the effects of vegetation on the shape of sand dune formations to help reduce effects of urban heat island in Dubai. Application of trees having a mix of different vegetation types around the urban areas is found to be the most effective strategy in tackling excess heat in urban areas. Vegetation has an adverse benefit not only on the reduction of temperatures around the urban area but from many of the studies, additional benefits are received for user's comforts when living around or nearby vegetation (Picot, 2004). Givoni (1991) revealed the use of

greenery as an energy saving method due to the reduction of cooling loads on the surrounding buildings. Studies done by Parker (1989) mentioned that the effect of landscaping (consisted of trees and shrubs) on the cooling loads of the surrounding buildings was marked by around 50% savings.

Sustainable landscape

Sustainable landscaping in general the theory comprises all the environmental, social and economic elements. Pitman et al. (2007) defines sustainable landscape as a healthy and strong landscape that is in harmony with native environmental settings containing climate, water, soil and topography. According to Taheri (2015) urban landscapes can significantly improve urban ecological footprint with proper design, careful energy use and plant and material selections. Advocated practices include selecting sites to maximize wildlife habitat preservation and managing storm water on site, preserving and restoring native plant communities. Al-Yaqoob (2012) illustrated the significance of greenery in reducing surplus heat and creating balanced microclimatic conditions in urban areas of UAE, He recommended that while designing the landscape we should try to mesh with the existing surroundings, linking back to the area's historic characteristics for additional visual benefits. Cost of maintenance of vegetation in different forms and energy savings should be explored. Effects of orientation of vegetation should also be analyzed.

Sustainable landscaping and smarter cities in UAE

The leadership of Abu Dhabi is progressing with the principles and imperatives for sustainable development, through "Estidama" which is a design methodology for constructing and operating buildings and communities more sustainably, while recognizing the unique regional needs. Abu Dhabi 2030 urban master plan developed by Department of economic development and urban planning council also focused sustainability as a core principle. Pearl Rating systems (PRS) system is design guidance and detailed requirements for rating projects according to the four pillars of Estidama (Moktar, 2012). Natural system of PRS focused on mitigating the negative impacts of construction activities on the local environment by conserving, preserving and restoring the regions critical natural environments and habitats. NS-3: Ecological Enhancement in the category Natural Systems have rating system as below;

Enhance the ecological value of the site by planting native or adaptive species:

1 Credit Points: 50% plants specified for planting on the site to comprise native and adaptive drought and/ or saline tolerant species including a minimum of 5 different types of species.
2 Credit Points: 70% plants specified for planting on the site to comprise native and adaptive drought and/ or saline tolerant species including a minimum of 10 different types of species.

Achuthan (2009) carried out a study of the LEED text Version 2.2 in order to identify sustainability elements relevant to the region. The researcher identified six sustainability elements including Water Efficiency in Landscaping to the context of Dubai. He recommended landscape design should include the plants that consume less water and are better adapted to hot arid climate.

PLANT SELECTION FOR CULTIVATION IN SALT AND DROUGHT CONDITIONS

Presently two types of strategies are adopted for sustainable landscaping under adverse drought and saline conditions; engineering the environment by irrigation and drainage management to manage increased salt level in soil and reduce water loses or by engineering the plants to increase their salt and drought tolerance. However, large areas of saline land cannot be managed in this way (Patane et al., 2013). Most of the possible solutions are much expensive in term of money, energy and time duration. So long term effective method is the utilizing salt and drought tolerant plant species which can be most feasible and economic solution (Ahmad, 1999). Complex mechanisms of a biotic stress resistance in plants make difficult to produce stress tolerant varieties (Wang et al., 2003). Salt tolerance has been studied in all types of plants ranging from grasses, herbs, shrubs to tree species, Choice of the plant group and species in most of the cases is site specific. Plant species should also be screened under localized conditions as in most cases different response is expected. Example is the introduction of saltbushes (*Artiplex* sp.) and band blue bushes (*Maireana* sp.) from Australia to Pakistan under ACIAR project 8619. Species that performed well in Australia and were expected to show the same response in Pakistan under identical saline conditions but did not show the same response (Ismail, 1998). The best way to utilize the degraded land is to domesticate the wild native species rather than to increase the salt tolerance of plant species. One of the successful approach is to select the wild species that have genetic tolerance to salt stress and have some economic and landscape potential. Thus a new policy is proposed to promote arid landscaping and maximum use of water for the conserving amenity planting. This approach has been successful to save water in the arid cities of south western USA. It also helped to increase beauty and aesthetic value of desert cities. The adoption of an arid landscape policy would reduce the energy requirements by more than half and maintenance costs of the landscape design (Pitman et al., 2009).

Native plants in landscaping

There is no universally accepted definition of native plants. The U.S. fish and wildlife service defines native as "with respect to a particular ecosystem, a species that, other than as a result of introduction, historically occurred or currently occurs in that ecosystem" (U.S. Fish and Wildlife Service, 2001), whereas, the U.S. national park service defined native plants as "all species that have occurred or now occur as a result of natural processes on lands designated as units of the national park system. Native species in a place are evolving in concert with each other" (U.S. National Park Service, 2000). Regardless of the variation in terminology, generally native plants usually include plants that are found to occur in distinct natural places without the aid of, or introduction by humans. Naturally, native plants species that have grown accustomed to local climate conditions are the best when designing xeriscape, as they are enabled with high efficiency of water consumption and minimization of maintenance time and cost (ADM, 2011). Karim et al. (2006) have screened 170 different plants in the UAE (tree, shrubs and grasses) which are salt resistant along with their description, distribution and uses (Karim et al., 2006).

Different landscape plant species are mostly considered as drought tolerant based upon anecdotal observations and performance in landscape (Garci et al., 2004; Levitt et al., 1995). During plant selection for a specific sites indigenous species are mostly preferred as drought tolerant by the public (Haehle and Brookwell, 2004; Hostetler et al., 2003). Landscape designs with the maximum use of native or drought tolerant species which require minimal supplemental irrigation after establishment has the potential to outclass the exotic species in landscape (Montague et al., 2007; Haehle and Brookwell, 2004: Hostetler et al., 2003). However, species performance is unknown in maintained landscapes (Anella, 2000). It is also well known that some wild species are more salt tolerant than their cultivated relative's e.g. ornamental characteristics of wild and cultivated *Limonium* spp. differ by salinity (Morales et al., 2001). Scheiber et al. (2008) also emphasized on the importance of selecting plant material already adapted to environmental conditions of a landscape. Native plants also assist to restore wild life habitat by providing food, shelter and other ecological parameter and increase the overall biodiversity of a given landscape (Fiedler, 2006; Stephens et al., 2006). Native plants also found to attract and retain greater numbers of natural enemies and are used as habitat management in Biological control (Fiedler, 2006; Fiedler and Landis, 2007a; Fiedler and Landis, 2007b).

Various studies have been carried out advocating use of native plants for landscaping. Many countries including China (Zheng and Chen, 2008) and Oman (Hopkins and Al-Yahyai, 2015) and different states of USA in particular including Utah (Mee et al., 2003), Arizona (McPHERSON and Haip, 1989), New Mexico (Spinti et al., 2004) Idaho (Quinn, 2009), Missouri (Anonymous, 2015), Hawaii (Tamimi, 1996; Ricordi et al., 2014), North America (Flint, 1997), Southeastern United States (Brzuszek et al., 2007) and California (Keator, 1994); Reid et al., 2008; Bornstein et al., 2005) have used native plants in landscaping transitionally irrespective of the government policy. Ochoa et al. (2009) found native species have great ability to adapt to abiotic stresses and he also developed a guide for use of native species of Spain with ornamental value for landscaping and xerogardening in semiarid regions. By promoting native plants landscape architects have not only created a vernacular landscape, but also helped to find solutions to rising summer temperatures and excessive use of borrowed water (Crewe, 2013). Native species are also found to be better suited to difficult or unique site conditions (Brzuszek et al., 2007). Gardening with native and indigenous plants due to their water use efficiency and all other associated ecological, cultural and landscape benefits getting importance since last few decades. Native pants are always well adapted to soil climate and environment need less maintenance less use of pesticide and fertilizer.

Usually introduced ornamental plants are difficult to acclimatize, need care and utilize enormous quantities of irrigation water in addition to other production inputs. Contrary native plants are best adapted to local climatic and soil conditions, use of native plants in landscape projects can be highly beneficial in conserving limited resources. Natural landscaping is an opportunity to reestablish and diverse native ecosystem while at the same time provides a natural look to parks and gardens reflecting the national heritage and culture (Bhat et al., 2009). As water scarcity problem has reached at alarming level, trend is shifting towards water efficient landscaping. Therefore, use of drought tolerant native plants is getting more attention (Paine et al., 1992).

In Tucson, Arizona thousands of trees were planted early in the twentieth century and the city became an arborescent oasis. Tucson is wholly dependent on groundwater, and due to declining groundwater supplies in 1988 the city adopted a water conservation landscape ordinance that restricted the use of turf and mandates planting of low water using native species. The lush green vegetation of trees was replaced by desert landscaping. Perceived water shortage has boost up the adoption stone mulch and arid-adaptive plants in Arizona which will be informative for other cities facing similar water shortages (Mcpherson and Haip, 1989).

Functional benefits associated with native plants

Native Plants of UAE have been used in traditional medicine long ago in the UAE but ethnobotanical literature

about most of species is rare. Zayed Complex for Herbal Research and Traditional Medicine did publication about medicinal plants which enlisted only 29 species, including some non-indigenous (El-Ghonemy, 1993). Sakkir et al. (2012) analyzed the medicinal status of UAE flora. He listed a total of 132 plants (nearly 20% of total species) which are traditionally used in the UAE for the medicinal properties.

Indigenous rangeland grasses such as *Cenchrus ciliaris, Pennisetum divisum, Panicum turgidum and Coelachyrum piercei* are also important sources of feed for grazing camel and sheep. These grasses survive with very little water and have excellent adaption to the harsh desert environment, which make them ideal choices for sustainable forage production, thus reducing the use of scarce fresh water resources (Osman et al., 2008)

Native plants can help restoring wild life habitat by providing food, shelter and other ecological processes. Indigenous plants may increase native biodiversity when used to restore degraded habitats (Osman et al., 2008; Stephens et al., 2006). For restoration and preservation purpose, native plants are of vital importance in dealing with the impacts of noxious weeds. Native plants are able to cultured landscapes transition into natural areas (Potts et al., 2002). Native shrubs and trees have critical importance in the desert ecosystem as they provide shade shelter and habitat for indigenous wildlife. They also have an important cultural association and are aesthetically pleasing in the landscape.

Public behavior to adopt Native plants in iandscaping

Gardening with indigenous species increasingly demanded due to the biological and cultural functions associated with it (McMahan, 2006). Indigenous plants are considered as an emerging market in the UAE. Demand and sales can be increased by many ways (Hamill, 2005). Costumer behavior can be changed by labeling a plant as labeling invasive or native. Plant can get more customer interest if labeled native (Curtis et al., 2009). Customers are also willing to pay more for native/noninvasive plants compared with non-native or invasive plants (Yue et al., 2011; Helfand et al., 2006). For instance, for plants labeled as Nevada Grown about one third of Nevada customers were ready to pay 20% more (Curtis et al., 2009). Consumers are also concerned about the environment and they are ready to pay more for environmental friendly products (Russo and Fouts, 1997; Laroche et al., 2001; Yue et al., 2011). In drought affected areas due to watering restrictions public has shown great interest in native plants (Brzuszek et al., 2010). In addition to this, desert landscape and native plants are preferred over non-native plants by public (Yabiku et al., 2007; Spinti et al., 2004; Hooper, 2003; Larson et al., 2009; Hilaire et al., 2010).

NATIVE PLANTS IN UAE LANDSCAPES

It is assumed that common people think indigenous plant look shaggy and weedy (Crewe, 2013; Reid et al., 2008; Uren et al., 2015) which don't seems true in case of UAE. Native plant species including *Prosopis cineraria* (UAE National tree), Date palm, *Moringa peregrina,* and many other native species are commonly found in lawns of UAE national's houses which showed the interest of UAE people in native plants and also proves the suitability of these plant species in landscape (Crewe, 2013). A landscape project is completed to beautify Sheikh Zayed Street, by introducing the native plants on large scale. This pioneering project is compatible with Abu Dhabi 2030 vision to create a sustainable city that promotes comfortable and sustainable transport routes. The soft landscape design takes advantage of the native flora, by encouraging the use of native plant species, to reduce water consumption and economize maintenance costs (Al-Mashhadani, 2014). Adopting the policy of cultivation of native plants that are tolerant to dry conditions to beautify Abu Dhabi has preserved native plants species that are disappearing due to urbanization (ADM, 2011). Most of native plants are not only xerophytic in nature but also belong to halophytes which can tolerate high level of salinity (Western, 1989) like *Zygophyllum qatarense* and *Salsola drummondi* (El-Keblawy and Ksiksi, 2005). Native plants in the UAE are thought to be a possible biotic solution for water shortage and sustain the landscaping beauty. Indigenous plants are only way to save the future of the green sector in the country (Shahin and Salem, 2014).

Native plants of UAE

UAE's desert ecosystem is very simple, having a low biodiversity with low rainfall and high temperatures. However this country has habitats which host species that show unique physiological, behavioral and morphological features to survive under harsh environmental conditions (Tourenq and Launay, 2008). These features have enabled plants species found in the UAE ecosystems to cope with higher levels of salinity and high temperature that may reach up to 50 ^{0}C during summers.

The flora of UAE, has received very little attention and unfortunately very little scientific literature is available on the flora of UAE. Undoubtedly, the local Bedouin (nomadic Arab of the desert) had traditional knowledge of many plants, but this was also not documented (Jongbloed et al., 2003). Despite the extreme arid conditions, UAE have more than 700 vascular plant species from diverse

habitats (Sakkir et al., 2012). Sir Wilfred Thesiger was the first botanist to collect plants specifically from the region for scientific identification and research purpose in the 1950s. Until now, the flora of Eastern Saudi Arabia (Mandaville, 1991) remains a source of reference, relating it to desert ecosystems of UAE. There has been an upsurge in botanical activities during last two decades, but much basic research still need to be done (Hellyer and Aspinal, 2005). Scientific work about habitats vegetation and flora of the UAE begun recently and Jongbloed et al. (2003) and Western (1989) were the first publications on the wild plants of the UAE (Boer and Al Ansari, 1999). Western (1989) was the first to document 501 plants species for the UAE. Later on Roshier et al. (1996) and Boer and his co-workers (Booer and Al Ansari, 1999) published many articles. Many new plants species have been reported by Karim (1991) Karim (1995) Boer (1997) Baer and Eschmann-Grupe (1996) Feulner (1997). The first volume of the flora of the Arabian Peninsula and Socotra by A.G. Miller and T.A. Cope appeared in 1996 (Miller et al., 1996). To collect record and analyze the traditional medicinal plants, UAE has established Zayed complex for herbs research and traditional medicine in 1996 (Correa, 2002). A first comprehensive checklist of species (bryophytes, ferns, flowering plants) appeared in 2000, authored by M. Jongbloed, R. Western and B. Boer. In April, 2003, Jongbloed et al. (2003) published the comprehensive guide to the wild flowers of the UAE which encouraged the research on flora of the country (Jongbloed et al., 2003). Many new species are still being reported which are summarized in Table 1 and total number of plant taxa reported from UAE reached to 820 (Shahid and Rao, 2016a).

Current knowledge about flora of UAE is at primary stages so to promote the native plants in landscaping for sustainable greenery, there is a great need to perform more research on this subject (Shahin and Salem, 2014). Unfortunately, there is no current germplasm bank center and no database for UAE flora available in UAE. Even there is no clear list for total native and indigenous plant species and recommended species for landscaping, which is the great obstacle in promoting the flora of UAE flora for landscaping. Therefore, more efforts have to be done, to establish a national germplasm data bank and national data center, in order to conserve and sustain the available flora. In addition, more attention should be given in improving the germplasm collection and storage (Shahin and Salem, 2014).

Species suitable for landscape

UAE flora is rarely studied but landscape experts used traditional knowledge of UAE nationals to select plants to use them for their landscape projects. Studies are also done in other Arab countries with similar arid conditions and flora which can be useful. Despite the harsh environmental conditions, UAE have diverse flora having which can be used for all requirements of any landscape.

Examples of few species which can be selected for different landscape needs are below

Shade trees

Prosopis cineraria, Moringa peregrina, Acacia Arabica, Acacia ehrenbergiana, Acacia tortilis, Boswellia sacra, Ziziphus spinachristi, Vitex-agnus castus, Tecomella undulata, Haloxylon persicum, Tamarix aphylla, Ficus carica.

Hedges

Atriplex halimus, Dodonea viseosa, Vitex-agnus castus, Pluchea dioscoridis

Shrubs

Aerva javanica, Atriplex leucoclada, Calligonum comosum, Haloxilon salicarnicum, Lawsonia innermis, Leptadenia pyrotechnica, Ochradenus arabicus, Pluchea dioscoridis, Salvadora persica, Tamarix nilotica.

Grasses

Canchrus cilraris, Cymbopogon commutatus, Penicum antidotale, Penicum turgidum, Pennisetum divisum, Coelachyrum piercii.

Ground covers

Alhagi graecorum, Carnulaca aucheru, Convolvulus virgatus, Crotalaria aegyptiaca, Dipterygium glaucum, Heliotropium bacciferum, Heliotropium curassavicum, Rhazya stricta, Rhynchosia minima, Salsola imbricate, Senna italica, Tribulus arabicus, Zygophyllum mandaveli, Pulicaria glutinosa.

Native plantation in forest and landscapes of UAE

According to World Map of Desertification (UNEP, 1997) UAE is at risk of desertification. In contrast to combating desertification, UAE has adopted policy of greening the desert. Huge deserts areas have been transformed into green lands over a short period in the UAE (Abdelfattah et al., 2009). The concept of "desert greening" was a great motivator to turn the arid desert into green paradise (Ouis, 2002). UAE made great efforts to increase forest area to approximately 318.36 thousand hectares in 2011 (MOEW, 2015). The dominated agricultural land of UAE is in Abu Dhabi was 75, 283 ha (Abu Dhabi Statistics Center, 2015). Forest of UAE now comprises of following native and adoptive species.

Acacia ehrenbergiana Hayne, *Acacia nilotica* (L.)Delile Garath, *Acacia tortilis* (Forssk.) Hayne, *Prosopis cineraria* (L.) Druce, *Ziziphus spina christi* (L.) Willd, *Salvadora persica* ., *Phoenix*

Table 1: New species added to Flora of UAE since 2003

S. No.	Species	Family	Reference
1	*Cutandia dichotoma*	Poaceae	(Brown et al., 2006)
2	*Aristida mutabilis*	Poaceae	(Gairola et al., 2013)
3	*Boerhavia erecta*	Nyctaginaceae	(Gairola et al., 2013)
4	*Chaenorhinum rubrifolium*	Plantaginaceae	(Gairola et al., 2013)
5	*Centaurium tenuiflorum*	Gentianaceae	(Gairola et al., 2013)
6	*Echiochilon callianthum*	Boraginaceae	(Gairola et al., 2013)
7	*Limonium stocksii*	Plumbaginaceae	(Gairola et al., 2013)
8	*Gamochaeta pensylvanica*	Asteraceae	(Shahid, 2014)
9	*Verbesina encelioides*	Asteraceae	(Shahid, 2014)
10	*Silene arabica*	Caryophyllaceae	(Shahid and Rao, 2014a)
11	*Vaccaria hispanica*	Caryophyllaceae	(Shahid and Rao, 2014a)
12	*Datura ferox*	Solanaceae	(Shahid and Rao, 2014b)
13	*Oldenlandia corymbosa*	Rubiaceae	(Shahid and Rao, 2014b)
14	*Bromus diandrus*	Gramineae	(Shahid and Rao, 2015)
15	*Lolium multiflorum*	Gramineae	(Shahid and Rao, 2015)
16	*Diplotaxis erucoides*	Cruciferae	(Shahid and Rao, 2015)
17	*Alternanthera sessilis*	Amaranthaceae	(Shahid and Rao, 2015)
18	*Amaranthus lividus*	Amaranthaceae	(Shahid and Rao, 2015)
19	*Commelina benghalensis*	Commelinaceae	(Shahid and Rao, 2015)
20	*Kickxia elatine*	Scrophulariaceae	(Shahid and Rao, 2015)
21	*Cyperus eremicus*	Cyperaceae	(Shahid and Rao, 2015)
22	*Sphaeralcea bonariensis (Cav.) Griseb.*	Malvaceae	(Gairola et al., 2015)
23	*Parthenium hysterophorus* L.	Asteraceae	(Mahmoud et al., 2015)
24	*Bidens pilosa* L.	Asteracea	(Mahmoud et al., 2015).
25	*Sesbania bispinosa (Jacq.) W. Wight*	Fabaceae	(Mahmoud et al., 2016a)
26	*Trifolium repens* L.	Fabaceae	(Mahmoud et al., 2016a)
27	*Glinus lotoides*	Molluginaceae	(Mahmoud et al., 2016b)
28	*Senna occidentalis*	Fabaceae	(Mahmoud et al., 2016b)
29	*Arenaria deflexa Decne.*	Caryophyllaceae	(Shahid and Rao, 2016a)
30	*Cyperus longus* L.	Cyperaceae	(Shahid and Rao, 2016a)
31	*Eleusine indica* L.	Poaceae	(Shahid and Rao, 2016a)
32	*Chenopodium carinatum* R.Br.	Chenopodiaceae	(Shahid and Rao, 2016a)
33	*Iphiona mucronata* (Forssk.) Asch. and Schweinf.	Asteraceae	(Shahid and Rao, 2016a)
34	*Medicago lupulina* L.	Leguminosae	(Shahid and Rao, 2016a)
35	*Gossypium herbaceum*	Malvaceae	(Shahid and Rao, 2016b)
36	*Hibiscus trionum*	Malvaceae	(Shahid and Rao, 2016b)
37	Sida spinosa	Malvaceae	(Shahid and Rao, 2016b)

dactylifera L., *Eucalyptus camaldulensis* Schlecht., *Azadirachta indica* (L.), *Cassia italica* (Mill.) F.W. *Atriplex* spp., *Haloxylon salicornicum* (Moq.) Bunge ex Boiss., *Simmondsia chinensis* (Link.)C.K., *Calligonum comosum*, *Leptadenia pyrotechnica* (Forssk.), *Haloxylon persicum* Bunge, *Zygophyllum qatarense* Hadidi (Abdelfattah, 2009).

According to Environmental Agency Abu Dhabi list the average percentage of selected NPS in ornamental landscape projects for 2010 to 2012 in Abu Dhabi city is between 35 -37% (Al-Mashhadani, 2012). Accordingly, at the mid 2013 the ADMA had adopted a strategy of introducing the native plant species in landscaping projects and issued a guide "Introducing of native plants in landscape projects in Abu Dhabi Emirate". This guide directs the concerned stakeholders to begin introduction of native plants in landscaping projects. According to Abu Dhabi public realm design manual (2010) at least 80% of the total proposed landscape areas in public realms projects should consists of locally occurring, drought tolerant plant species. During the recent years a strong drive has been raised for intensive use of native plants in the landscaping. Municipal authorities are focusing more on water conservation landscapes in all govt. projects. Hence now landscaping with native plants can be observed in all major road sides and median strip in Al Ain. Data regarding total projects completed dominated with native plants and their impact on water conservation in city landscape projects is yet to be evaluated.

Promotion of native plants market

Several reports have been published about trends in native plant markets, customer preference and problems faced by native plants growers and landscape architects.

Top concerns included: Propagation, issues of genetic variability, maintenance in landscapes and on restoration sites, cultural and other information, availability of retail quality native plant material, lack of commercially available seeds, and finally, public perceptions that often hinder acceptance of projects that incorporate native plants (Potts et al., 2002). Major concerns limiting the Florida native wildflowers market included lack of shared knowledge, concerns about plant material origin and source and seed processing issues and limited seed supply (Kauth and P´erez, 2011). Most of the native plants growers face much difficulty in seed conditioning, breaking dormancy, testing seed viability, and maintaining seed viability (Kauth and Perez, 2011). Most of the native plants grower collect the seed/plants from wild (Neufeld, 2010) which can be threat to wild populations and habitats especially in case of rare plants species. Lack of scientific research on propagation techniques is a limiting factor for involvement of nurserymen and other green industry professional in more difficult to propagate species so specific propagation guidelines would be extremely valuable for nurseries and other green industry professionals (Potts et al., 2002). For landscape architect non-availability of plants, undefined maintenance requirements and difficulty in selection of plants for a site are the major constraints faced and that may inhibit the use of native plants (Tamimi, 1996). Important factors which limit the use of native plants is desired plant species and plant vigor, followed by customers' perceptions of native plant aesthetics. Customer's unfamiliarity with native plant care and limited knowledge about specific native plant use is also the matters of concern (Hooper, 2003; Ricordi et al., 2014).

Although promotion and adoption of native plant has been slow, customers are willing to buy and plant native species (Gagliardi and Brand, 2007; Yue et al., 2011). Demand can be increased much more by educating consumer's nurserymen and landscape designers about native plants. For successful implementation and promotion of native wildflowers and native plant market, education of both professionals and the customers is critical. In addition Woosaree (2000), Meyer (2005) and Peppin et al. (2010) suggested that educating consumers regarding the use of native plants would bring awareness to the native plant market. Studies should be carried out to develop viable and faster propagation methodologies of native plants. The potential of native plants to be used in landscaping due to their growth habits and their water use efficiency as compared to exotic species and its effect on water sources and ecology is still need to be assessed. All the available landscape plants should be evaluated for their physiological, morphological and horticultural properties to make best use of this hidden natural treasure. To ensure sustainable landscaping we need to identify stress tolerant plants with distinct morphological characters suitable for desert landscaping. Most of the native plants recommendation seems to be based on anecdotal observations as many of them are not available in the market. Regeneration of native species is not well known and propagation techniques for most of native species are not developed and only few are available in the local market, so recommending native plants in the landscapes without proper production technology may exploit the population in the natural habitat.

So before going to commercial plantation, research should be carried out to recommend best suitable technique for the commercial production and recommendation should be made based on that. Educational programs should be started to increase the awareness in the public about native plants and provide technical and scientific information to landscape architects and contractors through nursery catalogs, plant lists etc. This can assist in the selection of suitable plants for landscape designs. Market surveys should be carried out to know the issues and problems faced by the nursery owners, native plants growers and landscape architects regarding native plants.

CONCLUSION

Landscaping with native plants can be the alternative way for sustainable greenery under extreme conditions with low/saline water with many other ecological and economic benefits. Green sector in UAE depends completely on exotic species and irrigation water mostly from nonrenewable ground resources.

Excessive use of water for irrigation and increasing population demand can be the reasons of extreme water shortage in UAE in the near future. This water shortage is the limiting factor for the landscaping and greenery. Native plants have different qualities due to which they can be used as fodder, medicine, landscaping, afforestation, sand stabilization, wind break and alternative crops in drought and saline conditions, all of which can contribute to sustainable greenery and maintaining specific unique and traditional desert landscape of UAE. Using native plants will not only reduce water requirement but also the maintenance, fertilizer and pesticide cost of any landscape project. Moreover landscaping with native plants will also conserve the Indigenous flora through utilization. More studies should be carried out to identify best suitable local plants and techniques for their commercial production and recommendation should be made based on that. Educational programs should be started to increase the awareness among the public about native plants and provide info to Landscape architects and contractors through nursery catalogs, plant lists etc. to help them select

suitable plants for their landscape designs. Through this we can improve our landscape plans with maximum utilization of native species so it is more suitable in desert background and also represent horticultural heritage of UAE. We can make future designs more sustainable and traditional giving a specific identification of national landscape.

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Authors's contributions

HA - Conception, designing, literature searching and data extraction, drafting of the manuscript; SBTP - Analysis and interpretation of data, drafting of the manuscript; JZ KK and SK - critically reviewed and modified the manuscript; TSK - Conception, designing and coordinating the review.

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