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Criteria and indicator approach of global sustainability assessment system for sustainable landscaping using native plants in Qatar

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ABSTRACT

The present study focuses on the importance and need to identify criteria and indicators (C&I) for sustainable landscaping using native plants in Qatar. The conditions for operationalizing the criteria and indicators approach are being incorporated into sustainable development practices and management planning in Qatar. This paper aims to develop criteria and related indicators for strengthening the global sustainability assessment system (GSAS) in order to provide a holistic approach for sustainable environmental assessment and the enhancement of ecosystem services. A total of 50 potentially native plant species were prioritized and categorized based on the following different parameters: weather conditions tolerated (temperature, humidity, and rainfall), multiple use value (ecological, economical, and medicinal), standard crown size ($\leq$50 cm and $\geq$50 cm) and water requirement (moist, moderate, and dry). Diverse local stakeholders as well as international experts were consulted to rank the plant species, and concluded that these prioritized native species are fit for sustainable landscaping as opposed to the exotic plant species which are imported from different geo-climatic zones. Environmental, social, economic, human, and policy sustainability aspects were considered, along with 12 criteria and 49 related indicators which were identified by promoting the use of potential native plants for sustainable landscaping in Qatar.

1. Introduction

The use of criteria and indicators (C&I) to quantify and standardize measurements of native vegetation condition has long been suggested (Noss, 1990). The C&I proposed in this paper address the maintenance of ecosystem functions, including the potentially adverse environmental impacts of plantation development and the protection of land and water resources. The long-term sustainability of landscaping using native plant resources requires management to take into account not only ornamental purposes but also ecological and environmental value (e.g., soil, water, biodiversity) as well as socio-economic issues (Muhtaman et al., 2000). The use of native plants for sustainable landscaping and conserving the native plant diversity in their natural habitat is gaining popularity as a means of strengthening the global sustainability assessment system (GSAS). The prime goals of GSAS include creating a better living environment, minimizing resource utilization and reducing environmental degradation (GSAS, 2014). GSAS has grown into a pan-regional system offering a comprehensive framework for sustainable landscape management, and is flexible to incorporate the specific needs of the local environments around the globe. In the Gulf Cooperation Council (GCC) countries which include Qatar, a range of developmental activities such as construction, landscaping, the conservation of natural resources, environmental protection, and improving human wellbeing have been implemented.

Qatar is largely an arid, desert area with a hot sunny climate, receiving minimum rainfall which is often sporadic in occurrence (Bassam et al., 2013). All plant species discussed in this paper grow in the wild and are considered native. However, some of them have been introduced intentionally or accidentally and are now naturalized (Norton et al., 2009). In Qatar, the development plan for two smart cities (Lusail and Duhail) was initiated based on the GSAS criteria measures to enhance the quality of new infrastructure or quality of urban life, improve outdoor environments, protect cultural and economic values, minimize energy consumption and the material needs for infrastructure development (Fadli, 2014). However, infrastructure development in Qatar is taking place at

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an unprecedented rate (Ibrahim, 2012) and such developmental activities are putting the environment at risk, and threatening the ecosystem and biodiversity of the country. According to Qatar National Vision 2030 (QNV, 2008), the country seeks to preserve and protect its unique environment. Sustainable development would be carried out with responsibility and respect, balancing the needs of economic growth and social development with the conditions necessary for environmental protection. According to the vision document, environmental degradation can be reduced by avoiding fast and unplanned development. It is also stated that the country must commit to making its future path of sustainable development companionable with the requirements of protecting and conserving the environment using native plants.

Native plants, comprising trees, shrubs and ground vegetation, have long been recognized as important and valuable natural resources and provide many vital ecosystem services (Costanza et al., 1997) which directly and indirectly benefit humans, including agricultural production, cultural benefits, and support services (Yapp et al., 2010). Native plants are those that have evolved naturally under the local environmental conditions (Miller et al., 1996). In natural landscaping such plants can be utilized for sustainable landscaping because they are adapted to local environmental conditions (Kermath, 2007; Phondani et al., 2015a). The dominant vegetation of Qatar is comprised of annual and perennial herbs, grasses, climbers, dwarf shrubs and a few tree species. These plants provide an ornamental, hardy, drought resistant, low maintenance landscape while benefiting the environment (Vickers, 2006; Phondani et al., 2015b). In the present context landscaping is a kind of human practice to develop and manage natural landforms for aesthetic as well as practical purposes. The planting of selected native plant species on marginal or uncovered terrain, especially in urban areas is a regular practice to enhance the appearance and maintain the outdoor environment. Using native plants for sustainable landscaping will be promoted in a time critical manner to ensure that current and future development plans support the country's goal of sustainable development and enhancing the quality of the environment. The present study is an attempt to identify (i) criteria and indicators for strengthening GSAS, and (ii) potential native plant species for sustainable landscaping.

2. Materials and methods

The State of Qatar is a peninsula extending from the Arabian Desert as outcrop in the western Arabian Gulf, which is marginal, fragile, arid/semi-arid and highly saline. The typical landscape is rocky desert, depressions and salt marshes, and in general it is flat to undulating. The country is situated midway along the western coast of the Arabian Gulf between latitudes 24°27′–26°10′N and longitudes 50°45′–51°40′E. It is approximately 11,437 sq km on a low-lying limestone peninsula projecting northward about 160 km into the Gulf. The coastline is approximately 550 km long and bounds the country to the west, north and east. This region is among the warmest regions of the world; the temperature during summer reaches up to 50 °C or above. The average rate of precipitation in this region clearly indicates that the rain is scarce and rarely exceeds 152 mm per year (Persian Gulf, 2012).

Based on the weather condition (temperature, humidity and rainfall), multiple use value (ecological, economical and medicinal), crown size (≤50 cm and ≥50 cm) and water requirement (moist, moderate and dry) a total of 50 potential native plant species were prioritized for sustainable landscaping. An extensive literature review was carried out to gather information on significance of native plants, GSAS criteria measures, the impact of climate change/climatic variability, infrastructure development and landscaping using native plants in Qatar (Kotwal et al., 2008; Ibrahim, 2012; Singh et al., 2012; Bassam et al., 2013; GSAS, 2014; Phondani et al., 2015a,b). Perceptions of local stakeholders and international experts (local and non-local people, shepherds, camel owners, agricultural laborers, horticulturalists, researchers, architectures and academicians) were obtained for the documentation, prioritization, categorization, and the scoring of potential native plant species for sustainable landscaping.

A survey on the native plant diversity in the desert climate of Qatar was conducted and plant species used for different purposes were identified with the help of a semi-structured questionnaire survey, existing literature survey, personal interviews, and consultations with local and non-local informants (Phondani et al., 2015b). During the surveys, attempts were made to collect all possible information regarding the ecological, economical and medicinal uses of the 50 prioritized native plant species, as well as their salinity tolerance and nitrogen fixation ability. Plant species were categorized into three categories; moist (high water requirement 3.42 l/m^2/day), moderate (medium water requirement 2.52 l/m^2/day), and dry (low water requirement 1.60 l/m^2/day). The water requirement was calculated based on the required amount of water per square meter of nursery bed per day (Salvador et al., 2011). We have also prioritized and observed the adaptation rates of these selected plant species based on meteorological data encompassing minimum and maximum temperature, humidity, and rainfall (Bassam et al., 2013) for confirmation of the reality of weather conditions and also to assess the impact of climate change and/or climatic variability, and the survival percentage of selected plant species in harsh climatic conditions. The criteria for scoring of selected native plant species prioritized maximum survival rate and good adaptation potential under harsh climatic conditions.

3. Results

The present study emphasized the potential of criteria and indicators (C&I) approach as a means of strengthening GSAS for sustainable landscaping using native plants, which aims to develop environmental protection and at the same time ensure a high standard of living. In this study 5 broad categories of sustainability comprising environmental, social, economic, human and policy along with 12 criteria and 49 related indicators were identified for promoting the use of native plants for sustainable landscaping in Qatar. The criteria from serial number 1–3 pertain exclusively to environmental sustainability with 14 related indicators, criteria 4–6 concern to social sustainability that largely govern sociocultural and spiritual benefits with 11 related indicators, criteria 7–8 pertain to economic sustainability with 7 related indicators and criteria 9–11 relate to human sustainability with 12 related indicators. The rest of the criteria pertain to development and sustainability of adequate policy with 5 related indicators (Table 1). The C&I approach of GSAS was developed to enhance the sustainable landscaping for creating large green zones in urban settings using potential native plants.

In this study we recorded a total of 134 plant species based on the preliminary survey and in the institute experimental nursery. These recorded species are reported to be native, but many of them have been introduced intentionally or accidentally and some of them are now naturalized. Therefore, we have only selected 50 plant species which are truly native for detailed investigation. Prioritization of the species was performed based on their standard crown size (≤50 cm and ≥50 cm), water requirement (moist-high water requirement, moderate-medium water requirement, and dry-low water requirement) for a particular category of native plant species in the institute experimental nursery. The assessment of scoring based on water requirements and crown