

# The assessment of degradation to sustainability in an urban forest ecosystem by GIS



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## ABSTRACT

Different factors affect the sustainability of urban forests. In this study, in order to distinguish the parameters affecting an ecosystem, the man-made Sorkhehesar Park of Iran was divided into homogeneous units (HUs) in accordance with natural (slope, aspect, elevation, soil depth, pure and mixed planting systems) and human (irrigation and recreation levels) factors using GIS, and their effects on ecosystem sustainability were investigated. All tree and shrub species (*Fraxinus excelsior*, *Cercis siliquastrum*, *Platanus orientalis*, *Robinia pseudoacacia*, *Cupressus arizonica*, *Pinus eldarica*, and *Cupressus sempervirens*) individuals of the park were studied qualitatively and quantitatively. Homogeneous units were identified on the basis of tree height, basal area, crown diameter and symmetry, tree vitality, canopy cover, and density of herbal vegetation. Results showed that the sustainability of the ecosystem was affected by different factors and the limiting factors were pure and mixed plantation system, slope, and soil depth. Local recreation resulted in unsustainability of the site in areas with slopes more than 15% and shallow soil. It was concluded that the status of *C. siliquastrum* and *C. sempervirens* individuals was more stable in similar conditions compared to other species.

## 1. Introduction

Urban forests include all natural and planted trees (including single trees, small groups of trees, and large stands) located in or near urban areas (Peckham et al., 2013). This green part of urban areas provides great ecological, social, and economic benefits and services to the people living in cities and towns (Chen and Wang, 2013; Lawrence et al., 2013; Wu, 2014), while they cover a small fraction of total land surfaces (approximately 3.1%) (Nowak et al., 2010; Gong et al., 2013). For example, a monetary evaluation indicated that the overall PM10 removal value of the Metropolitan City of Rome amounted to 161.78 million Euros (Marando et al., 2016). Also, as Fusaro et al. (2015) point out, urban and periurban forests fulfil a complementary role in the provision of ecosystem services in the metropolitan area of Rome, in relation to the removal of ozone and the resultant air quality improvement and climate regulation (Fusaro et al., 2015). On the other hand, Barò et al. (2014) quantified the ecosystem services and concluded that in order to be effective, green infrastructure-based efforts to offset urban pollution at the municipal level have to be coordinated with territorial policies on broader spatial scales (Barò et al., 2014).

Parks situated in urban ecosystems are mostly constructed by

humans and exhibit a patchy structure with spatial homogeneity. The species compositions of urban parks are generally highly variable. These may be composed of one or a few species or may contain a diverse number of native or indigenous trees and shrubs (Tan and Abdul Hamid, 2014; Timilsina et al., 2014). Trees in urban ecosystems in the forms of parks and tree-lined streets represented human coexistence with nature, environmental stewardship, and the understanding of natural processes and seasonal changes (Peckham et al., 2013). Timilsina et al. (2014) also showed that trees in urban ecosystems affected aboveground carbon stores, as the amount of sequestered carbon increased when land use changed from non-forest to forest in urban areas. Understanding the urban park structure and species composition is important because of their vital effects on ecosystem functions (Timilsina et al., 2014).

Human life and activities (e.g. recreation, tourism) in urban ecosystems degrade natural and man-made habitats and disturb energy flow and nutrient cycling in these habitats (Dizdaroglu and Yigitcanlar, 2014). Recreation and tourism in them can also disturb urban forests and parks through cutting of trees and shrubs for infrastructure. Human activities also contribute to internal fragmentation of the remaining parts of urban green areas (Ballantyne et al., 2014). Monitoring the

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effects of human activities on urban vegetation is an important tool in the assessment of sustainability of urban parks and forests. Tree health would also be an appropriate factor to understand the impacts of human activities on these parts of cities.

Environmental parameters (e.g. soil, water, air quality) and proximity to infrastructure may influence tree health, size, and longevity in urban parks. Compaction of soil is a common characteristic in anthropogenic areas that significantly reduce growth and vigour of urban trees by reducing soil water, aeration, and root growth. Their vitality may also depend on nutrient availability in soil (Koeser et al., 2013; Morgenroth et al., 2014). Scientists and urban foresters believe that water stress is one of the main problems encountered by trees in urban parks, which influences their growth (Gilman and Masters, 2010). Various environmental factors, are effective in impact of recreation. In fact, factors such as the type of vegetation, slope, aspect, soil type and climatic conditions, are effective on damage intensity of visitors (Makhdoum and Khorasani, 1985; Hill and Pickering, 2009). There is a direct relationship between recreation intensity and the type and density of ground-cover herbs and forest characteristics (i.e. production, fertility grade, and site quality) (Amerein et al., 2005; Marvie Mohadjer 2006). Tree height is also an important site quality index as it is affected by climatic and edaphic conditions and tree location in a stand (Marvie Mohadjer 2006). Injuries to tree caused by recreational activities directly impact stand height reduction and significantly reduce the growth of standing trees and shrubs (Guyette and Stambaugh, 2004; Hegetschweiler et al., 2009; Rusterholz et al., 2009). Vitality of trees is a criterion directly related to forest ecosystem sustainability and ecosystem disturbances are revealed in the health of plants.

many ways (Asgarzadeh et al., 2014; Master Plan for development and improvement Sorkhehesar Forest Park. 2006).

We aim to investigate different biometric characteristics of the main tree species in Sorkhehesar Park in accordance with environmental conditions and human impacts. Finally, we target the determination of optimum amounts of influential parameters on the sustainability of Sorkhehesar Park. Considering that this study has been conducted in Iran, which is among the arid and semiarid regions of the world, and since in the global ranking such countries are categorized as low forest cover countries (LFCCs)—and considering that establishment of sustainable planted forests is accompanied with challenges, including water management, concentration of recreational activities, appropriate planting pattern, etc.—this study can be helpful to monitor the sustainability of afforestation in arid and semi-arid areas in similar climates.

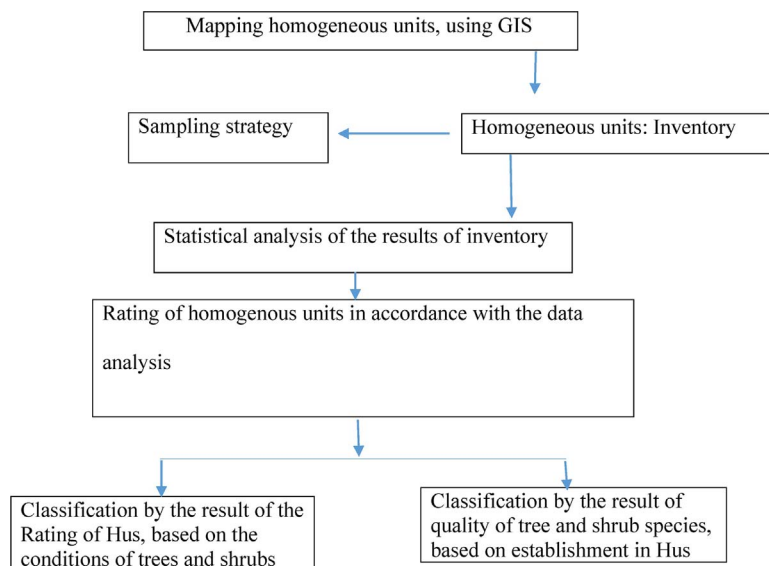
## 2. Material and methods

### 2.1. Study area

Sorkhehesar Park has an area of 450 ha, and is located at 42°35'N and 30°51'E in the east of Tehran (Capital of Iran). The climate is warm and semi-dry, with an average annual temperature of 12.6 °C and an average annual precipitation of 334.2 mm. Fig. 1 shows the study area.

### Research methodology

The following flowchart shows the Research Methodology:



Inherited traits, site parameters, and crown shape affect diameter and basal area growth in trees. Large diameter is not an appropriate index: regularity of growth rings is more important than diameter (Marvie Mohadjer 2006). Dense canopy closure—a site quality index—may be caused by improper regeneration of unwanted species, which disturbs the management of urban parks. Crown diameter and symmetry also represent the site quality, which is influenced by tree health, percentage of canopy closure, slope, and site conditions (Bale et al., 1998).

Tehran, the capital of Iran, is a rapidly developing metropolitan area, facing different kinds of urban pollution. Green belts and urban forests and parks covered with appropriate plant species (especially native species) may contribute to the sustainability of Tehran city in

### 2.2. Mapping homogeneous units (HUs)

The environmental parameters (slope, aspect, elevation, and soil depth), recreation and irrigation were classified to study their effects on the main tree species (Table 1). The map of HUs was obtained by overlaying the layers included in Table 1 in geographic information systems (GIS). Topography layer was taken from Iran National Cartographic Center, and Elevation, slope and aspect layers, were made. The other layers were taken from Municipality of Tehran.

### 2.3. Sampling strategy

Different sampling points were separately selected in each HU to

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