Outlook on Climate Crisis in Urban Green Areas: Case Study of Istanbul-Sultanahmet Region

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Abstract
Today, one of the biggest problems in the world is climate change. According to the United Nations Framework Convention on Climate Change (UNFCCC); "In addition to the natural climate change observed in a comparable time period, it is a change in climate caused by human activities that directly or indirectly disrupt the composition of the global atmosphere". It is clear that the biggest responsible for these changes is human (Anonymus, 2002). The balance of nature is deteriorated due to some reasons such as urbanization, global warming and population growth. Water resources which are one of the indispensable elements are also threatened by climate change. Water resources that are increasingly limited reveal the need for efficient use of water and it shows that it is important to develop new landscape arrangements where water is used effectively, especially in outdoor landscaping. Some reasons such as green area application that requires intensive water use in landscaping works in metropolitan cities, the use of exotic trees and shrubs in the selection of plant species and large grass areas, wrong decisions in plant design, thirst problems etc. have negative impact on the adoption of sustainable identity of the city together with the ecological approach values. In this study, Sultanahmet Square and Hippodrome that have the most important public green area in Istanbul have been chosen as research area. The effective use of the water in the square has been examined considering the survey study related to these areas about water usage zones, mulch usage, determination of grass area, drought tolerances of the existing plant species. The concept of xeriscape, which is a new concept in our country, has gained importance day by day. In this context; some recommendation has been given for the effective use of water in public green areas by considering this study will contribute to the future studies.
Keywords: climate change, landscape design, Sultanahmet, sustainability, xeriscape

Kamusal Yeşil Alanlarda İklim Krizine Çözüm Arayışı: Sürdürülebilir Peyzaj Analizi- Sultanahmet Meydanı Örneği

Özet
Günümüzde dünyanın en büyük sorunlarından biri de iklim değişikliğidir. Birleşmiş Milletler İklim Değişikliği Çerçeve Sözleşmesi'nde (İDÇS), "Karşılaştırılabilir bir zaman periyodunda gözlenen doğal iklim değişikliğine ek olarak, doğrudan ya da dolaylı olarak küresel atmosferin bileşimini bozan insan etkinlikleri sonucunda iklimde oluşan bir değişiklik" biçiminde tanımlanmıştır (Anonim, 2002). Bu tanımdan da anlaşılacağı üzere bu değişimlerin en büyük sorumlusu insandır. Kentleşme, küresel ısınma, nüfus artışı gibi birçok nedenlerden dolayı doğanın dengesi bozulmaktadır. Yaşamın vazgeçilmez unsurlarından biri olan su kaynakları da iklim değişimleri ile tehdit altındadır. Giderek kısıtlı hale gelen su kaynakları suyun tasarruflu kullanım ihtiyacını ortaya koymakta ve özellikle dış mekan peyzaj düzenlemelerinde suyun etkin kullanıldığı yeni peyzaj düzenleme biçimlerinin geliştirilmesinin gerekliliğinin ne denli önemli olduğunu hissettirmektedir. Özellikle metropolitenşehirlerde yapılan peyzaj düzenleme çalışmalarında yoğun su kullanımı gerektiren yeşil alan uygulamaları, bitki türü seçiminde özellikle egzotik ağaç ve çalıların kullanımı ve çok geniş çim alanlar, bitkisel tasarımda yanlış verilen kararlar, susuzluk problemleri vb. nedenler, kentin ekolojik yaklaşım değerleri ile sürdürülebilir kimliğe bürünmesine olumsuz etkiler vermektedir. Bu çalışmada;İstanbul Metropolünde en önemli kamusal yeşil alana sahip Sultanahmet Meydanı ve At Meydanı araştırma alanı olarak seçilmiştir. Bu alanlara ait survey çalışması ile; su kullanım zonları, malç kullanımı, çim alan tespiti, mevcut bitki türlerinin kuraklık toleranslarına bakılarak, meydanda suyun etkin kullanımının ne derece karşılandığı araştırılmıştır. Ülkemiz için henüz yeni bir kavram olan (Xeriscape) kurakçıl peyzaj, önemi gün geçtikçe artmaktadır.Bu bağlamda;çalışma bundan sonraki çalışmalara katkı sağlayacağı düşünülerek, özellikle kamusal yeşil alanlarda suyun etkin kullanımı için öneriler getirilmeye çalışılmıştır.
Keywords: iklim değişimi, peyzaj tasarımı, Sultanahmet, sürdürülebilirilik, kurakçıl peyzaj

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1. INTRODUCTION

It is indicated that available water resources will rapidly decrease together with the increasing population and environmental pollution; antecedent precipitation will change; the frequency and intensity of natural disasters such as drought and flood will increase; the climate in Turkey will turn into arid climate after the 2020s and arid areas will appear in interior areas (Aküzüm et al, 2013). Indeed, in the report prepared by the European Environment Agency, medium and high levels in many regions of Turkey in 2030 will experience drought (EEA, 2005). It is estimated that the amount of usable water per person will be around 1100 m^3/ year for 2030; that's why, Turkey has potential to be water scarce country (Anonymous, 2018). Therefore, Turkey needs to protect the resources and use them rationally in order to leave healthy and sufficient water to the next generations (Güvenç and Demiroğlu, 2016).

Efficiency should be the most important starting point in order to ensure the continuity at optimal level for years within the scope of sustainability (Atıl et al, 2005). In the previous years, especially in landscape architecture applications, the first objective was to increase the quality of the environment-surrounding relationship, but today the main objective is to remove the problems caused by global warming by using drought resistant species in planting works (Bayramoğlu, 2016).

In the "Xeriscape" approach, which is at the top of the new landscaping methods where water is used effectively, plants with low water requirement in planting should be used. In addition, natural plant species in the design should be used in the design because natural plants will require less watering after the completion of regulation work, or will not require additional irrigation, except for natural rainfall (Barış, 2007; Yazgan and Özyavuz, 2008). Xeriscape does not necessarily mean that there is no water use.

The use of mulch is important in "Xeriscape" approach. Mulch layer reduces the amount of lost water which evaporates over the soil; this layer prevents the crusting of the solid surface and allows water to pass easily to plant roots. It prevents the growth of weed around plants (Wade et al, 2007). Fertilization, pruning, weed control, disease and pest control activities are important for the plants to continue their lives more healthy in accordance with suitable time and technique.

In this context, it is thought that sustainable landscape design, in which the landscape arrangement forms can be changed by using water effectively, will provide solutions to the crises that will emerge in the present day.

2. MATERIAL AND METHODS

2.1. Research Area

Especially in the landscaping studies in metropolitan cities, green area applications requiring intensive water use, especially the use of exotic trees and shrubs in the selection of plant species and large lawn areas have negative effects on the city's ecological approach values and sustainable identity due to the problems of thirst.

In this context, Sultanahmet region, which has the most intense use in Istanbul, carries the traces of different civilizations and cultures with its thousands of years of history, and is the center of architecture and social texture, trade and tourism, as well as its physical and functional change, transformation and its privileged urban fabric has been chosen as research area. The area where some races had been organized during the Byzantine period; bloody riots, javelin games and cauldron lifts during the history had been conducted, is thought as Hippodrome; and the place

where the meetings, shopping, caravans and entertainments in the Republican era had been arranged is seen as Sultanahmet Square. Many works from the events and periods in the past continue to exist in Sultanahmet Square (Cinar and Kart Aktas, 2018). In this context, Hippodrome continued to exist as an architectural structure that breathed the organic texture and complexity of the city. Although known as "Hippodrome" during the Ottoman Empire, it was a square that hosted many festivals and weddings. It is the practice of public entertainment that integrates Hippodrome Square with its history in terms of functionality (Bedirhan, 2014).

2.2. Location

The square is surrounded by important buildings such as Hagia Sophia Mosque, Sultan Ahmet Mosque, Ibrahim Pasha Palace and Marmara University Rectorship (Figure 1).

Figure 1. Study area location map (Url 1)

2.3. Climate

In winter, there is much more rainfall in Istanbul than in summer. According to Köppen and Geiger, this climate is classified as Csa (warm in the winter, hot and dry in the summer (Mediterranean climate)). The average annual temperature in İstanbul is 14.1ºC. In a year, the average rainfall is 823mm. At an average temperature of 26.9ºC, August is the hottest month of the year. January has the lowest average temperature of the year. It is 3.2ºC., the difference in precipitation between the driest and wettest months is 100 mm. The variation in temperatures throughout the year is 14.4ºC, (Url 2).

2.4. Method

The aim of this study is to determine the plants and grass surfaces used in the study area within the scope of sustainable landscape regulation, to determine their suitability in line with the principles of drought landscape, and to develop solutions for possible problems. The struggle against climate change and its effects to urban areas and their effects on urban green areas (Grimmond, 2007; Mc Carty et al, 2010), and the effects of heat islands caused by hard surfaces in cities have been emphasized in various studies (Fernendez et al, 2015; Zhang et al, 2017; Du et al, 2017). Consequently, the most important task of landscape architects should be to conduct survey of urban green area arrangements for the efficient use of water in urban areas and to bring sustainable landscape works to the forefront by evaluating the results (Çınar et al, 2018).

In this study, plant species in the area, water requirements of these species, size of grass area and irrigation methods used in green areas have been determined. With the determination of grass areas, the amount of water used in the area has been calculated and the status of the squares selected as research areas has been determined in terms of arid landscapes.

3. RESULTS AND DISCUSSION

A total of 303 species have been identified in Sultanahmet Square and Hippodrome, which have been determined as the study area (Senel, 2013). 150 of these species are deciduous and 142 are coniferous trees; and 292 of them are trees, 9 are palms and 2 are shrubs. 49.50% of the total 303 plants consist of deciduous trees and 46.86% consist of coniferous trees; 2.97% are palms and 0.67% are shrubs. The species / subspecies names, numbers and water requirements of the plants used in the study area are shown in Table 1.

Table 1. Number and Species Distribution by Plant Groups in the Study Area

Plant Groups	Sultanahmet Square		Hippodrome		Total	
	Item	Percent (%)	Item	Percent (%)	**Item**	**Percent (%)**
Deciduous Trees	127	79,37	23	16,08	**150**	**49,50**
Coniferous Trees	22	13,75	120	83,91	**142**	**46,86**
Palms	9	5,63	-	-	**9**	**2,97**
Shrubs	2	1,25	-	-	**2**	**0,67**
Total	**160**	**100**	**143**	**100**	**303**	**100**

- **Sultanahmet Square – Drought Tolerance of Plants**

The plant list (Table 2), which is formed by determining the locations of 160 plants in Sultanahmet Square, are given below.

Table 2. Plant species and the water needs in Sultanahmet Square

	NO	COMMON NAME	WATER NEEDS	AMOUNT
CONIFEROUS TREES	1	*Abies bornmülleriana*	**Moderate**	1
	2	*Cedrus atlantica*	**Moderate**	2
	3	*Cedrus deodora*	**Moderate**	3
	4	*Picea orientalis*	**Moderate**	1
	5	*Picea pungens*	**Low/moderate**	3
	6	*Pinus nigra*	**Moderate**	1
	7	*Platycladus orientalis*	**Moderate**	1
	8	*Taxus baccata*	**Low/moderate**	8
	9	*Thuja occidentalis*	**Moderate**	2
DECIDUOUS TREES	1	*Aesculus hippocastanum*	**Moderate**	27
	2	*Lagerstroemia indica*	**Low/moderate**	94
	3	*Laurus nobilis*	**Low/moderate**	1
	4	*Morus alba 'Pendula'*	**Moderate**	2
	5	*Prunus avium*	**Moderate**	2
	6	*Prunus serrulata 'Kanzan'*	**Low**	1
PALMS	1	*Trachycarpus fortunei*	**Low**	3
	2	*Washingtonia filifera*	**High**	3
	3	*Phoenix canariensis*	**Low**	3
SHRUBS	1	*Buxus sempervirens*	**Moderate**	Fence plants
	2	*Photinia x fraseri*	**Moderate**	1

160 plants in the green areas of Sultanahmet Square consist of 127 deciduous trees (78%), 22 coniferous trees (14%), 9 palms (6%) and 2 shrubs (1%) (Figure 2).

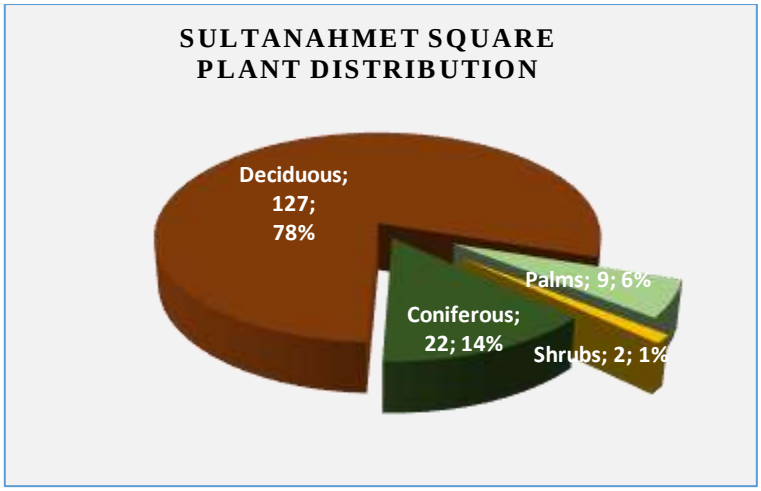

Figure 2. Sultanahmet Square Plant Distribution

Coniferous trees in the green areas include *Cedrus atlantica*, *Cedrus deodora*, *Taxus baccata, Picea pungens*, *Picea orientalis*, *Platycladus orientalis, Thuja occidentalis*, *Abies bornmülleriana,* and *Pinus nigra*. Deciduous trees include *Aesculus hippocastanum*, *Laurus nobilis*, *Lagerstromia indica*, *Prunus serrulata 'Kanzan'*, *Prunus avium*, and *Morus alba 'Pendula'*; Palms include *Trachycarpus fortunei, Washingtonia filifera;* and shrubs include *Photinia x fraseri* and *Buxus sempervirens*. In the area, there are plants that require less water with a rate of 4.37%, low/moderate water requirement with 66.25%, moderate water requirement with 27.5% and high water requirement with 1.88% (Figure 3). In addition, there is 6.851.41 m^2 grass area in the area.

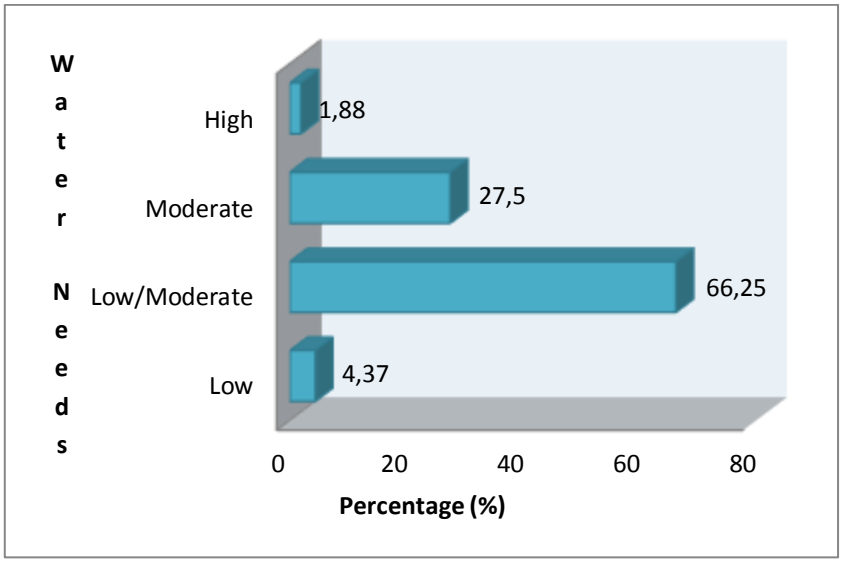

Figure 3. Drought Tolerance of Plants in Sultanahmet Square

- **Hippodrome – Drough Tolerance of Plants**

Aesculus hippocastanum, which is old in Hippodrome but integrated with round crowns, is the most intense species in this border (Şenel, 2013). 143 plants in the green areas of Hippodrome Square consist of 120 deciduous trees (80%), 23 coniferous trees (16%) (Figure 4).

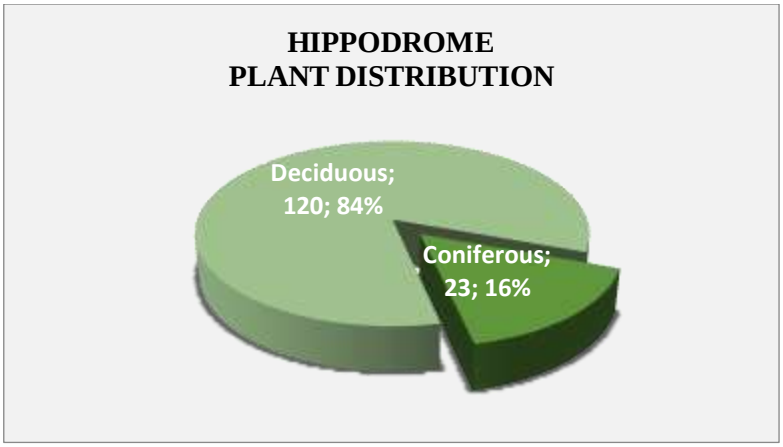

Figure 4. Hippodrome Plant Distribution

Coniferous trees include *Cedrus deodora*, *Cedrus libani*, *Pinus brutia*, *Pinus pinea* and *Cupressus sempervirens*; on the other hand, deciduous trees include *Acer negundo, Aesculus hippocastanum, Albizzia julibrissin, Laurus nobilis, Ligustrum lucidum, Platanus orientalis, Platanus x acerifolia, Robinia pseudoacacia, Pterocarya fraxinifolia*, *Quercus ilex, Quercus robur* and *Tilia tomentosa* (Table 3).

Table 3. Plant species and the water needs in Hippodrome

	NO	COMMON NAME	WATER NEEDS	AMOUNT
CONIFEROUS TREES	1	*Cedrus deodora*	**Moderate**	15
	2	*Cedrus libani*	**Low/Moderate**	3
	3	*Cupressus sempervirens*	**Low/Moderate**	2
	4	*Pinus brutia*	**Low**	1
	5	*Pinus pinea*	**Moderate**	2
DECIDUOUS TREES	1	*Acer negundo*	**Moderate**	6
	2	*Aesculus hippocastanum*	**Moderate**	68
	3	*Albizzia julibrissin*	**Low/Moderate**	4
	4	*Laurus nobilis*	**Low/Moderate**	1
	5	*Ligustrum lucidum*	**Moderate**	5
	6	*Platanus orientalis*	**Moderate/High**	13
	7	*Platanus x acerifolia*	**High**	1
	8	*Pterocarya fraxinifolia*	**High**	1
	9	*Quercus ilex*	**Low/Moderate**	5
	10	*Quercus robur*	**Moderate**	4
	11	*Robinia pseudoacacia*	**Moderate**	5
	12	*Tilia tomentosa*	**Moderate**	7

In the area, there are plants that require less water with a rate of 0.7 %, low/moderate water requirement with 10.49 %, moderate water requirement with 78.32% and moderate/high water requirement with 9.09 %, high water requirement with 1.4% (Figure 5). In addition, there is 5.269,39 m^2 grass area in the area.

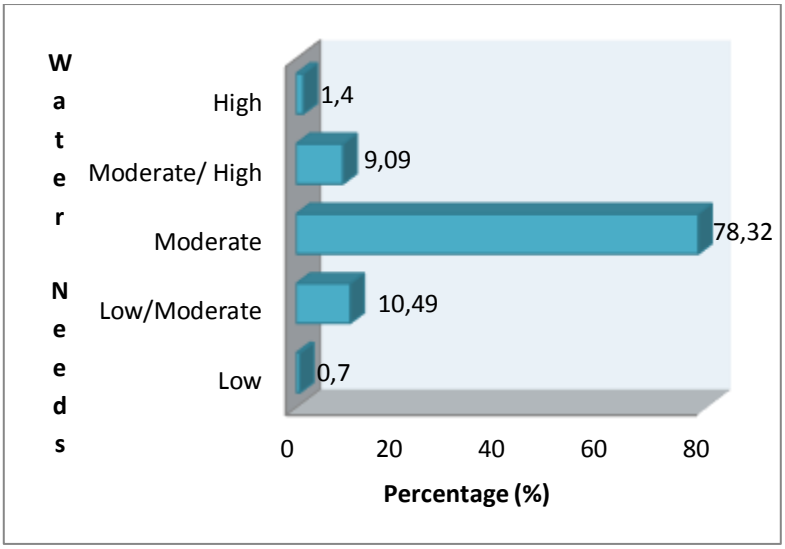

Figure 5. Drought Tolerance of Plants in Hippodrome Square

The drought tolerance of 303 plants in Sultanahmet Square and Hippodrome is as follows: the plants that require less water with a rate of 2.64 %, low / moderate water requirement with 39.93 %, moderate water requirement with 51.48 % and moderate/ high water requirement with 4.29 %, high water requirement with 1.66% (Table 4, Figure 6). In addition, there is 12.120,80 m^2 grass area in the both areas.

Table 4. Drought Tolerance of Plants in Sultanahmet Square and Hippodrome

Drought Tolerance of Plants	Sultanahmet Square		Hippodrome		Total	
	Number of plants	Percentage (%)	Number of plants	Percentage (%)	**Number of plants**	**Percentage (%)**
Low	7	4,37	1	0,7	**8**	**2,64**
Low/Moderate	106	66,25	15	10,49	**121**	**39,93**
Moderate	44	27,5	112	78,32	**156**	**51,48**
Moderate/High	-	-	13	9,09	**13**	**4,29**
High	3	1,88	2	1,4	**5**	**1,66**
Total	**160**	**100**	**143**	**100**	**303**	**100**

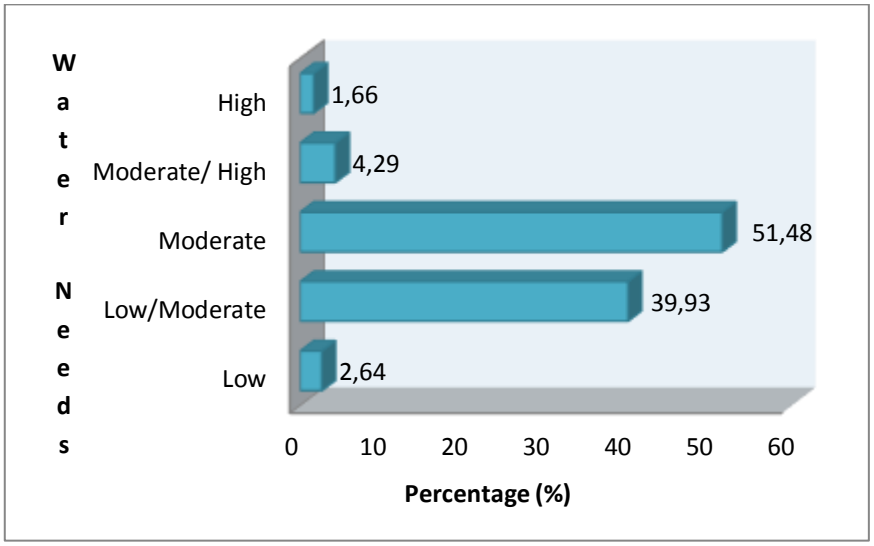

Figure 6. Drought Tolerance of Plants in Sultanahmet Square and Hippodrome

Foursome mixture that consists of *Festuca arundinacea Golden gate* (65%), **Festuca arundinacea Firaces** (15%), *Poa pratensis Prafin* (10*%), Lolium perenne Ringles* (10%) has been used in the facility of grass fields. The grass applied in the square is coco grass, which provides a 50% advantage in water consumption as it can maintain its moisture for a long time and also reduces fertilizer consumption due to irrigation. All areas are automatically irrigated by sprinkler irrigation.

5. CONCLUSION

Many countries around the world have investigated the future impacts of global climate change on water resources, agricultural potential, economic and social impacts (Aksay et al, 2005). When considering the growing population and a more arid climate, Turkey will be a poor country in 2050. In our country, global climate change forecasts will be reduced to regional or even smaller scale and it will be possible to act urgently by revealing possible climate change forecasts for our country. Measures that can be made from small-scale areas to large-scale areas will bring multidisciplinary studies. In particular, landscape architects have a great role in the efficient use of water.

The use of plants in groups according to water requirements provides significant water savings. Ground cover plants should be preferred instead of intense grass areas to conserve water by reducing irrigation. Grass areas in green areas should be established in areas that are generally considered and where users carry out their recreational activities. These areas should be planned to be connected and grouped with each other.

Sultanahmet Square and Hippodrome, chosen as a research area, have not been designed to attract attention in four seasons, considering the historical and touristic structure. All kinds of plants, which are applied with the design elements and principles in planting, lacking the concepts of association and integrity, have been preserved and the species that have come together with the added ones have created green areas where there is a lack of landscape quality. Although the trees along the two sides of the Hippodrome Square become definite to the boundaries of this square, which is a closed square, there is no integrity in the green areas in the middle areas. It is necessary to use drought-resistant species, especially the natural ones, to reduce seasonal use and grass areas as much as possible. Exotic plants are more expensive than the other species and they can spread the diseases and pests they can bring to the local species can cause greater damage.

Since the value of water will increase day by day, every drop should be used in the most efficient way. As a result of the study, it has been determined that 4 of 34 plant species in the study area had low water demand, 8 of them had low / moderate water demand, 18 of them had moderate, 1 of them had moderate / high and 3 of them had high water demand. When the plants have been evaluated in terms of the water requirements, it has been determined that the majority of the plants used in the area have been plants with moderate tolerance to drought. The number of species with high water demand is 3; the total number of species with low and moderate water demand is 12. It has been determined that 51.48% (156) of the 303 plants in the research area were moderate and 39.93% of the water demand was low / moderate (Table 5).

Creation of shade areas by planting broad-leaved trees is an important criterion for landscaping. There are also available trees and shrubs in the area. Although the trees with high water demands are located in the area, it is an advantage that the water demands are not as high as in youth, since the majority of the trees are old. In addition, both areas have grass with high maintenance and water demand. Occasionally flower beds are used on these grass surfaces. The

traditional type of Turkish gardens such as rose, tulip, seasonal velvet, salvia, begonia, petunia and so on has been used in flower beds. Flower beds are designed with white pebbles, a type of mulching, for aesthetic use.

In Istanbul conditions, the daily water consumption requirement of grass fields is considered as 6 liters / m^2 considering the water losses. Due to the seasonal averages of Istanbul Province, irrigation is done every three days between 15 April - 30 October, 15 April - 15 May, every day between 15 May - 15 September, and every three days between 15 September - 30 October. The average number of annual irrigation days is 120 days (Büyükköz, 2012).

In 1000 m^2 grass area; 1000 m^2 x6 liters per day: 6000 liters as 6 tons of water is spent. Due to the number of annual irrigation days is 120 days, annual water consumption in this garden, which is not regulated in the Xeriscape, is 6 tons x 120 days: 720 tons (Çınar and Kart Aktaş, 2018). Total grass area in the research area is 12.120.80 m^2. Annual water consumption is approximately 72 tons of water. In this case, the annual water consumption is about 8700 tons.

For example, let's reduce the area of 12.120,80 m^2 to 6000 m^2 and consider the remaining 6120 m^2 from groundwater consuming water such as sedum and drought-resistant shrubs or trees. 6000 m^2 x6 tonx120 days: 4320 tons / year (annual amount of water spent for the lawn in the xeriscape garden) 6120 m^2 x 6 liters x 40 days: 1500 tons (6120 m^2 for the part consisting of drought plants annual irrigation days 40 were taken. For these gardens, less than 1/4 watering is sufficient compared to normal grass areas.) 1500 tons + 4320 tons: 5820. Accordingly, annual water consumption reduces from 8700 tons to 5820 tons. The difference is 2880 tons and it can be thought as earning for irrigation within a year.

The use of natural species that can be more esthetic and functional rather than those with high water demand, or preferring less water-demanding species than these plants, will help to use water more effectively in landscaping arrangements. No mulching is done in the research area. In spring and autumn, fertilization is carried out. Because of not making mulching, it has a negative impact on the area in terms of drought landscape principles. This problem needs to be solved urgently.

Ignoring the historical and touristic structure of the square, the species brought together in the revised works, planting errors, preventing the physiological development of plants caused by planting errors, excess lawn surfaces, lack of mulching in the maintenance of lawn areas have created lack of maintenance quality, landscape and visuality.

In plant design studies, it is imperative for landscape architects to start with a holistic plan and design in cooperation with ecologists and meteorologists. The irrigation system needs to be well planned and managed. Thus, it will be easy to respond to possible crises.

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