O 27. WATER USE EFFICIENCY AND TECHNICAL APPLICATIONS IN LANDSCAPE ARCHITECTURE REGARDING CLIMATE CHANGE

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ABSTRACT: Turkey is a water-rich country with large water resources. However, the cross-border water resources are shared between Turkey and the neighboring countries. Thus, the water supply of the country must be managed effectively, and water usage must be restricted. Therefore, drip irrigation is the most sufficient way to achieve this goal. Sustainable, easy-care landscape projects that both suit the climatic conditions and could still be perceived as an aesthetic entity help to prevent environmental issues. Drought and rising temperatures that are caused by global warming affect plant growth in a negative way. This article examines the irrigation systems that require minimum usage of resources and obtain maximum benefit. Also, the importance of xerophytes is discussed.

Keywords*: Irrigation, Global warming, Landscape applications*

1. INTRODUCTION

Water is one of life's most essential substances and the primary necessity for life. Therefore, the presence and quality of water in the habitats are of vital importance. Water resources on earth are limited and the water cycle is constant. The rapid growth of population, high standard of living, industrialization cause the increasing need for water. Thus, problems in the share of water emerged and became one of the most strategical elements of the 21st century (Salturk, 2006; Gulgun Aslan et al., 2017). In recent years; climate change, high temperatures, irregular rainfall levels and drought risk become more significant which led designers, planners, local authorities to the search for efficient use of water. Water is the key factor in the life of ornamental plants which play an essential role in landscape architecture. The efficient use of water in landscape architecture is a necessity as water usage is high in public spaces such as parks, gardens (Yazici et al., 2013; Berkün, 2007). Irrigation of plants which need to be watered besides from precipitation is thought to be a prerequisite for the plants' optimum benefit to be gained from the irrigation. Today, deficit irrigation becomes more common due to limited water resources. Deficit irrigation is a watering approach that leads plants to experience water stress. The approach results in the reduction of cost and an increase in revenue (English and Raja, 1996).

1.1. World's Condition

The earth contains 1,4 billion km^3 of water. 97.5% (1.3 billion km^3) of earth covered in salty ocean water, 2.5% (35 million km^3) in freshwater (DPT, 2007). 70% (24 million km^3) of 35 million km^3 of drinking water is provided from Antarctica and polar regions (UNESCO, 2012). According to FAO (2002), in 1995 the ratio of people experience water shortage and stress was 29% and 12%. In 2005, it is expected to be 34% and 15%.

1.2. Turkey's Condition

There are 26 water basins in Turkey, the average precipitation is 642.6 mm which is equal to 501 billion m^3 of water. The water use limit in technical and economic areas is 112 billion m^3. 95 billion m^3 of it is provided from rivers in the country, 3 billion m^3 is from the rivers that originate from other countries, 14 billion m^3 is from underground water (Akuzum et al., 2010). Due to the lack of facilities, 35% of the water reserve can be used in Turkey (Berkun, 2007). In Turkey, 37% of precipitation is stormwater runoff. 274 km^3 of water transpirate from the leaves, stems, flowers and soil and return to the atmosphere. 41 km^3 of water is known to provide for the underground water, 186.1 km^3 flows through the rivers into the seas, lake and closed basins (URL-2). In Turkey, the water use limit per person is known to be 1555 m^3 / year and expected to be 1000 m^3 / year in 2025 (Akuzum et al., 2003; Akin and Akin, 2007). The European Environment Agency reported that the water shortage was

expected to occur in many regions in Turkey in 2030 (Anonymous, 2005). According to FAO (2002), Turkey was no more a water-rich country and the country experiences water stress. 16% of the total reserve of 112 billion m^3 is used as drinking water, 12% in industry and 72% in agriculture (URL-2). In 2023, Turkey's population was expected to hit the number of 100 million and 16% of the water is expected to be used as drinking water, 64% in agriculture and 20% in industry (Figure 2) (Akuzum et al., 2010). Water is mostly used for irrigation in agriculture both in Turkey and all over the world. Thus, the efficient use of water in irrigation became a necessity.

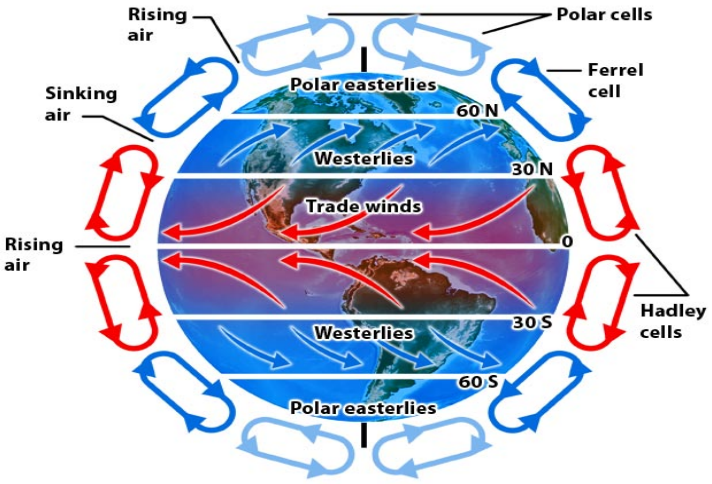

Figure 1. Water cycle

2. PURPOSE AND SCOPE OF IRRIGATION

Irrigation is defined as the process of watering plants that do not receive enough amount from the precipitation (Leliart, 1987). Irrigation of plants was discovered in Egypt (Gungor et al., 2002). In Turkey, the historical background of the first irrigation application goes back to the Ottoman Empire in the 19th century. Correction of rivers in Schodra and Thessaloniki, the irrigation channels in Medina, the irrigation network in Mosul are some application examples from the Ottoman Empire era (Yildirim, 2008). Plants constantly absorb water through the roots to sustain their visual and aesthetical development. A great amount of water is transferred into the atmosphere due to transpiration and the rest is reserved in the roots. Thus, plants' roots are to contain enough level of moisture (Akuzum and Cakmak, 1992). The main source of the humidity in the soil is the precipitation. In the dry and semi-arid climate regions, the level of the received precipitation is not sufficient enough for the plant during the growing season. Therefore, the moisture needed in the roots is provided from the irrigation (Gungor et al., 2002). In sub-humid lands, the level of the received precipitation exceeds the plants' needs. The sub-humid lands mostly and humid lands often require irrigation systems in case of a temporary change in humidity (Yildirim, 2008). The amount of water to be used in the irrigation of plants should be estimated. Every plant's water demand is different due to its morphological and physical characteristics. Therefore, water consumption for each plant in the irrigation area should be determined (Jensen, 1968). The estimation of plants' water requirements is based on direct measurement techniques or climate data calculations. The direct measurement techniques are mostly expensive however, they produce the most accurate results. Water requirements of the plants that are used in landscape projects are high. The irrigation systems ensure that plants receive the right amount of water contains many nutrients and agricultural chemicals for the optimum levels of growth (Orta, 2009). The common irrigation systems used in landscape projects are seen in Figure 2.

2.1. Water Use in Landscape Projects

The efficient use of water plays an essential role in irrigation systems due to the fact that the earth has limited water resources and 65-80% of water is used in irrigation systems (Evsahibioglu et al., 2010). Especially the high levels of water use in green areas entail the efficient use of water (Baris, 2007). To achieve this goal, precautions that save the water are taken. Accordingly, under the title of Water-Efficient Landscaping; some principles are developed which are 'The Efficient Use of Water',

'Limited Use of Water' and 'Natural Landscaping'. Xeriscaping is one of the first approaches that comes with the principles mentioned (Baris, 2007) (Figure 4).

Figure 2. Irrigation of ornamental plants

The other water-saving methods:

- Preventing the high amount of water use (Cakmak and Gokalp, 2011).
- Use of low water-demand plants (Atik and Karaguzel, 2007).
- Estimation and calculation of plants' water requirements (Bayramoglu, 2013a).
- Use of the spreading ground covers rather than creating large areas of grass.
- Use of the drip irrigation systems.
- Generation of irrigation programs for different regions in accordance with the meteorological data.
- Use of the deficit irrigation systems during a particular period of time.

3. USE OF DEFICIT IRRIGATION

According to Bayramoglu et al. (2013b), the irrigation systems used in urban green areas have a significant part in preventing the pollution of water resources. Today's irrigation approaches are the full and deficit irrigation systems. The full irrigation systems ensure that the plant receives the full amount of water it requires. Also, the plant's fertility is at maximum levels. However, some plants are negatively affected due to the high amount of water in the soil and the limited transfer of gases between the soil and air. Deficit irrigation is a systematic strategy in which irrigation of plants is limited. Also, it is a commonly used way of providing a minimum amount of water all over the world (Trimmer, 1990; English et al., 1990; Jurriens and Wester, 1994). Trimmer (1990)'s research shows that the supply of water provided is less than the plants' requirements at a rate of 35% in Pakistan. Sarwar (2002) stated that if 60% of plants' water requirements are provided, plants' fertility decreases at the rate of 15%. Demirel et al. (2018) express that proper irrigation systems ensure water-saving and visual quality. Also, the research set an example for landscape projects in Canakkale and other cities. English et al. (1990) state that deficit irrigation increases the revenue in agriculture. The method is used in specific periods of time not to harm the plants. The main goal of the deficit irrigation system is to gain maximum benefit from the irrigation and improve the water use efficiency. The most significant characteristic of the method is that always the same amount of water is provided for the plant and larger areas are watered using the water that was saved during the process. Thus, the revenue per unit of area is increased (English et al., 1990).

The deficit irrigation system creates water stress which results in the reduction of cost. The regions where the price of water is high and water use is limited, the method ensures an increase in profit (English and Raja, 1996). Several researchers state that deficit irrigation assures an increase in profit under particular conditions (English et al., 1990).

Figure 3. The deficit irrigation system (URL-1)

Figure 4. The deficit irrigation system (URL-2)

Though the deficit irrigation systems cause a decrease in the production, the aim is to ensure the efficient use of water. Potential benefits are listed below (English et al., 1990):

- Increase in watering performance
- Reduction of irrigation costs

The deficit irrigation provides a limited amount of water for the plants. Limitations are arranged both constant and scheduled. Constantly limited arrangements supply a small amount of water, time gaps between watering can be longer and one side of the beds are watered. Scheduled limitations ensure that the plants are not watered in particular seasons when the plants can sustain themselves without water consumption (Cakmak and Gokalp, 2011).

Advantages of the deficit irrigation systems:

- Water saving is ensured therefore, water and labour costs are reduced.
- Larger areas can be irrigated due to the water saved beforehand.
- Production performance, the profit gained from production and the national income increase.
- Drainage costs decrease.
- Providing water for the soil can be problematic at times, therefore the ecological problems in the soil are prevented.
- The amount of water that the soil contains does not rapidly increase. Thus, the benefit gained from the precipitation is optimized. (Biber and Kara., 2005).

In agricultural operations, the deficit irrigation systems are applied to crops, however in landscape architecture, the method is yet to be used in watering plants.

3.1. Deficit Irrigation in Landscape Architecture

The rapid population growth leads to the need for urban recreational areas. The maintenance of urban greenery depends on the reinforcement of the irrigational infrastructure (Orta, 2009). Both large and small-scale projects require a well-planned irrigation system to maintain the development of plants which are the key elements for design, therefore, irrigation plays an important role in landscape architecture. The water demand of plants should be met (Altunkasa, 1998). Nowadays; high temperatures and decreasing levels of rainfall lead to the efficient use of water in planting design. Deficit irrigation is still a new research field. There are many articles written regarding the topic abroad.

Figure 5. The deficit irrigation system (URL-3)

Bayramoglu et al (2013a) reported that *Rosmarinus officinalis* (Sánchez-Blanco et al., 2004; Singh and Ramesh, 2000), Tahiti Lime (Júnior et al., 2011), *Amygdalus communis* L. (Franco et al., 2000), *Dianthus caryophyllus* L. (Álvarez et al., 2009) show less improvement when the deficit irrigation is applied. However, deficit irrigation is a reliable method in watering plants due to the efficient use of water in today's world with limited water resources.

Figure 6. Underground irrigation system (URL-4)

Geerts and Raes (2009), observed the improvement of the plants that receive a limited amount of water in dry climates. Geerts and Raes (2009) state that plants that receive water from a deficit irrigation system do not significantly show less improvement than the ones from the full irrigation system. Therefore, the researchers suggest that the deficit irrigation system strategies should be developed and combined with plant-water efficiency. Debaeke and Aboudrare (2004), also mention that these systems should not be applied in the seasons when the plants are in the maximum growth period, therefore the maximum performance of the production can be ensured.

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