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DROUGHT TOLERANT LANDSCAPE DESIGN APPROACH EXAMPLE OF RTE CAMPUS

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ABSTRACT

In recent years, there have been undesirable situations in urban areas due to climate change. Extreme temperatures and sudden rains from the possible effects of climate change affect the city and consume natural resources. Experiencing climate changes causes the quality of natural resources to deteriorate and depletion rapidly. Depending on these results, the deterioration in natural resources has created serious problems. Cities and urban green areas are the most affected by this situation. Urban areas have increased due to technological developments and so open green areas have decreased. Urban planners have started to consider new design approaches in order to reduce these negative effects. Most of the approaches determined are for planning vegetative design criteria used in open green spaces. It is a solution to implement practices that enable more efficient use of water in urban open green areas and designs where drought-resistant plant species are preferred. The determined plant species should consist of natural species specific to the region and the region, should be selected from groups that consume less water, and most importantly, should be aesthetic.

In this context, the study was carried out area of Recep Tayyip Erdoğan University campus in Rize province in the Black Sea region. Drought tolerant planting designs were carried out in three different study areas selected. Both functionally and aesthetically group drought-resistant plants have been proposed. In the study areas, drought tolerant planting designs were developed and variables and expert opinion surveys were evaluated. As a result, it has been concluded that aesthetic usage areas can be created at the same time with drought tolerant planting designs.

KEYWORDS:
Drought tolerant plant, landscape planning, open green areas, Rize

INTRODUCTION

Human beings are in constant development and change throughout their lifetime. Therefore, it has to be able to meet its increasing needs. In order to keep up with the developing technology, it continues to change the environment in which it lives. Green tissue is the most important component of reducing the effects of heat island in urban areas and for the people living in the city to live in a better environment [1]. As a result of the decrease in green areas, the effect of global warming has increased and drought has begun to manifest itself. Drought stress is among the most important issues in environmental problems [2, 3]. Drought is one of the most destructive global environmental problems facing the world today [4].

Environmental pollution problems are considered to be the beginning of the destruction of nature as a result of misuse of natural resources. In recent years, it has been understood that today's problems will be effective in future generations. Thus, it has emerged that solutions should be sought for these problems and the necessity of implementing these solutions [5]. For this reason, arrangements that require less maintenance, especially less water, are made in current landscape applications [6]. Saving water is an important step towards preserving the pristine beauty of the biodiversity of any country and natural environment [7].

Landscape applications aimed at the efficient use of energy have increased. Systems that generate their own energy using renewable energy sources, consist of recycled materials, protect the green environment as much as possible, and use recycling methods to treat and reuse rainwater and gray water are important [8,9]. There are many methods that help reduce water consumption in energy efficient landscape design. New urbanization, green architecture and sustainability have been adopted as new concepts in landscape architecture [10,11]. Regulatory approaches that take the protection of water resources and the environment as a principle have been adopted by using water at the least level [12].

Natural landscape design; the use of natural species in urban open green areas is a drought tolerant design approach. Natural plants, on the other hand, adapt to the environment. In this respect, it is less maintenance and economical in terms of water

saving [13,14]. The main purpose of the designs is to be handled with a self-sufficient and sustainable system [15]. The use of natural plant species is both ecologically and ecologically compatible with local environmental conditions. Ecologically it protects biological diversity; it saves water economically [16]. For this reason, natural plant species should be preferred for water saving and drought tolerance in landscaping areas to be planted.

In order to tolerate drought, it is necessary to reduce the use of grass in landscape areas and be more careful considering drought and water scarcity. In addition, drought-resistant grass mixtures should be preferred in areas exposed to drought [17]. One of the most effective methods is to reduce the use of grass, which is also a principle of arid landscape application. Xeriscape, as an ecological planning, comes to the fore. [18]. The method is applied according to 7 basic principles (appropriate planning and design, soil preparation, appropriate plant species selection, designing easy and practical grass areas, effective irrigation, use of mulch and proper care) [19].

In this context, the study was conducted to draw attention to the drought caused by climate change, especially in recent years. Although the province of Rize is seen as rainy in all seasons, it has experienced extremely dry and dry days due to climate change in recent years. For this reason, water conservation is important in watering plants in landscapes where water consumption is intense. For this purpose, Recep Tayyip Erdoğan University campus in Rize province in the eastern Black Sea has been used as a study area. Drought tolerant planting designs have been developed in designated study areas on the campus. The variables were evaluated with expert opinion questionnaires.



FIGURE 1
The Location of the Study Area-Recep Tayyip Erdogan University, Zihni Derin Campus

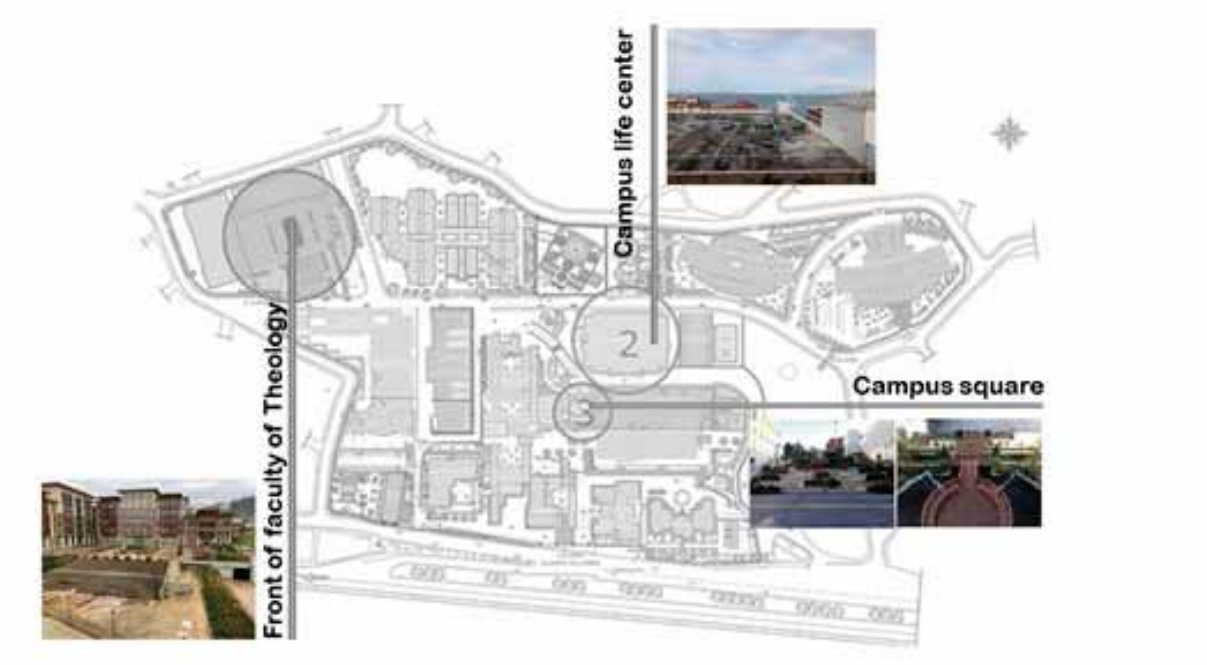

FIGURE 2
Faculty of Theology (first area), Campus Life Center (second area) and Campus Square (third area)

MATERIALS AND METHODS

The research area is the campus area of Recep Tayyip Erdoğan University in Rize province in the Eastern Black Sea Region. Rize has the characteristics of the Eastern Black Sea Region. It has a particularly geographical and cultural structure [20]. The first step towards higher education in Rize was achieved with the opening of the two-year Technician School established in 1950. Later, Rize Education Institute was opened in 1975 and Rize Vocational School was opened in 1976 within the scope of common higher education institution under the Ministry of Education. As of today, Recep Tayyip Erdogan University has 13 Faculties, 3 Institutes, 5 Colleges and 6 Vocational Schools (Figure 1) [21].

The study area is in Zihni Derin Campus Central Campus in Fener District. In front of the Faculty of Theology (first area), Campus Life Center (second area) and Campus square (third area) were selected (Figure 2). Drought plants have been proposed by carrying out drought tolerant planting designs in the study area. A survey of 105 experts (landscape architects) was conducted with the variables determined in the modeled study areas. Then the survey results were analyzed in the SPSS program. Plant groups have been suggested both functionally, drought tolerant and aesthetically in the study area. The proposed planting design was selected from drought tolerant plant groups for the Rize region.

Climate data of the study area. Rize region has Black Sea climate. The characteristic of the Black Sea climate is that it is cool in summers, mild in winters and rainy in all seasons. The biggest factor in this is that the mountains extend parallel to the shore. According to meteorological data for many years, the annual average temperature in Rize is 14.3°C, and the annual average precipitation is 2254.4 mm. According to the temperature data of long years, the winter temperature is not below 5°C. Considering the sunshine duration, temperature and precipitation conditions, the number of foggy and cloudy days (cloudy and overcast days) reaches an annual average of 307.6 days [22].

Looking at the current climate data (2018-2019), the average temperature in Rize is 23.2^0C in August, the lowest temperature is 2.2°C in January, and the longest sunshine duration is 6.6 hours in June. Average precipitation values are seen to be calculated as 294.4 mm and the total amount of rainfall in the year 2303.7 mm in October. The number of annual rainy days is 172.2 days in total throughout the province. While the average number of rainy days is 14.8 mm at most in October, the lowest value is 13.5 mm in November. Humidity values are at most 82.0% in August and 83.0% in October [23]. According to the data of Rize between 1964 and 2014, the lowest annual precipitation at the Rize meteorology station was 1694 mm in 1984; The highest amount of precipitation occurred in 1988 with 2698 mm [24]. The annual average pressure was measured as 1014 mb. The dominant wind direction is Southwest in Rize, as the winds blowing from the south to the coast are open to the air currents coming from the Black Sea. Considering the insolation, temperature and precipitation, the number of foggy and cloudy days is high, so evaporation is also low. In Rize, where there is no water scarcity, the soil is always moist and the vegetation is lush. When these features are evaluated, it is seen that humid and temperate climatic conditions are experienced in Rize [22].

RESULTS AND DISCUSSION

Findings regarding the modeling of the study area. Within the scope of the study, modeling was carried out in front of the Faculty of Theology, the environment of the Campus Life Center and the campus square in Rize province with natural plant groups. A data base was created for the visualized spaces and expert surveys (Figure 2).

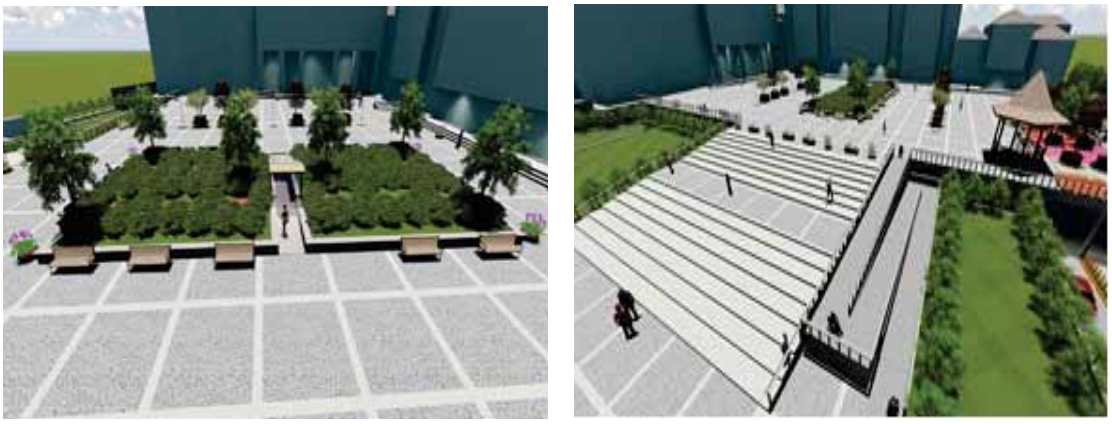

FIGURE 3
Modeling of the Theology Faculty

TABLE 1
Suggestion plants belonging to the faculty of theology

No	Latin name	Family	Turkish name	Water Req
1	Artemisia tridentata Nutt.	ASTERACEAE		Very little
2	*Aster alpinus* L.	COMPOSITAE	Aster	little
3	*Berberis thunbergii* DC. 'Atropurpurea'	BERBERIDACEAE	Kırmızı Yap. Hanım Tuzluğu	little
4	*Betula pendula* Roth	BETULACEAE	Siğili Huş	little
5	*Canna generalis* Bailey	CANNACEAE	Bordo Tespih Çiçeği	Medi.-high
6	*Centaurea dealbata* Willd.Susanna et.	COMPOSITAE	Pembe Güneş Dikeni	little
7	*Chamaerops excelsa* Thunb.	ARECACEAE	Tüylü Akdeniz Yelpaze Palmiye	little
8	*Cotoneaster lacteus* WW. Sm.	ROSACEAE	Büyük Yap. Dağ Muşmulası	little
9	*Crocus sativus* L.	IRIDACEAE	Safran	little
10	*Daphne odora* Thunb.	THYMELAEACEAE	Kafkas Gül	little
11	*Erica manipuliflora* Salisb.	ERICACEAE	Güz fundası	Very little
12	*Forsythia intermedia* Zabel	OLEACEAE	Altın Çanak	little
13	*Hedera helix* L.	HEDERACEAE	Duvar Sarmaşığı	little
14	*Hedera colchica* K. Koch	HEDERACEAE	Sarmaşık	little
15	*Hippophae rhamnoides* L.	ELAEAGNACEAE	Yalancı İğde	Very little
16	*Iberis sempervirens* L.	BRASSICACEAE	İberide Çiçeği	little-medi.
17	*Kniphofia uvaria* L.	LILIACEAE	Fener Çiçeği	little
18	*Juniperus horizontalis* Moench	CUPRESSACEAE	Yayılıcı Ardıç	Very little
19	*Lantana camara* L.	VERBENACEAE	Mine Çiçeği	little
20	*Lonicera nitida* Wils.	CAPRIFOLIACEAE	Çalı Hanımeli	little
21	*Mesembryanthemum nodiflorum* L.	AIZOACEAE	Buz Çiçeği	little
22	*Musa acuminata* Colla.	MUSACEAE	Muz	little
23	*Muscari racemosum* Mill.	ASPARAGACEAE	Dağ Sümbülü	Very little
24	*Phoenix canariensis* Hort.	ARECACEAE	Yalancı Hurma	little
25	*Pinus ponderosa* Douglas ex C.Lawson	PINACEAE	Ponderosa Çamı	Very little
26	*Pseudotsuga menziesii* Franco	PINACEAE	Duglas	Very little
27	*Ribes alpinum* L.	GROSSULARIACEAE	Frenk Üzümü	little
28	*Rhus typhina* L.	ANACARDIACEAE	Boyacı Sumağı	Very little
29	*Sambucus nigra* L.	CAPRİFOLIACEAE	Mürver	little
30	*Salvia argentea* L.	LABIATAE	Ateş Çiçeği	little-medi.
31	*Sedum album* L.	CRASSULACEAE	Beyaz Çiçek Dam Koruğu	little
32	*Spiraea* x *vanhouttei* (Briot) Zabel	ROSACEAE	Beyaz Çiçek Keçi Sakalı	little-medi.
33	*Tamarix tetrandra* Pallas	TAMARICACEAE	İlkbahar Ilgını	little
34	*Tilia rubra* DC.	TILIACEAE	Kafkas Ihlamuru	little
35	*Tilia tomentosa* Moench	TILIACEAE	Gümüşi Ihlamur	little
36	*Verbena rigida* Spreng.	VERBENACEAE	Mine Çiçeği	little
37	*Zinnia elegans* L.	COMPOSITAE	Kirli Hanım Çiçeği	little



FIGURE 4
Modeling of the Campus Living Center

Modeling of the theology faculty. A planting design was carried out in the faculty of theology and in front of it, mostly in evergreen and linear lines. Alleles were created in order to strengthen the effect of the ladder created for transportation in large dimensions. Particular attention has been paid to the use of natural plant species in herbal design. Care has been taken to ensure that the plants to be used other than natural plant species should be able to withstand the conditions of the region where it will be applied and require as little watering as possible (Figure 3). In this context, the plant species used in the first study are given in Table 1.

Modeling of the Campus Living Center. The campus living center is like a roof garden. This place of the campus was chosen because green roofs reduce the effect of urban heat island, especially in dry climate periods. For this reason, planting designs on green roofs are very important in terms of affecting the urban climate. In this context, while second area creates a more sense of space, colorful bush groups that create a trust effect are preferred. It is aimed to create biodiversity by creating a natural environment for users (Figure 4). In this context, the plant species used in the first study are given in Table 2.

Campus Square Modeling. The campus square is an active courtyard used extensively by the users. The area consisting of wide steps provides opportunities for students' recreational activities. A green area was created with flower boxes on the stairs. Colored and mostly evergreen shrub species were used in these cases in the modeling (Figure 5). In this context, the plant species used in the first study are given in Table 3.

TABLE 2
Suggestion plants belonging to the Campus Living Center

No	Latin name	Family	Turkish name	Water Req.
1	*Agave americana* L.	ASPARAGACEAE	Amerikan Agavı	Very little
2	*Berberis julianae* C.K.Schneid.	BERBERIDACEAE	Hedemyeşil Kadın Tuzluk.	little
3	*Calendula officinale* L.	COMPOSITAE	Altuncuk-Kandil Çiçeği	little-medi.
4	*Centaurea cineraria* L.(Lacaita) Pign.	COMPOSITAE	Sarı Çiçek Güneş Diken	little
5	*Cotoneaster horizontalis* C.K.Schneid	ROSACEAE	Yayılıcı Dağ Muşmulası	little-medi.
6	*Crocus nudiflorus* Sm.	IRIDACEAE	Safran	little
7	*Cycas revoluta* Thunb.	CYCADACEAE	Yalancı Sagu Palmiyesi	Very little
8	*Erica spiculifolia* Salisb.	ERICACEAE	Dağ fundası	Very little
9	*Gazania linearis* Thunb.	COMPOSITAE	Gazanya	medium
10	*Hedera canariensis* L. 'Gloire de Marengo'	HEDERACEAE	Duvar Sarmaşığı	little-medi.
11	*Iris germanica* L.	IRIDACEAE	Mor Süsen-İris	little-medi.
12	*Juniperus sabina* L.	CUPRESSACEAE	Sabin Ardıcı	little
13	*Lonicera caprifolium* L.	CAPRIFOLIACEAE	Sarılıcı Hanımeli	little
14	*Mesembryanthemum cordifolium* L.f.	AIZOACEAE	Buz Çiçeği	little
15	*Muscari parviflorum* Desf.	ASPARAGACEAE	Dağ Sümbülü	Very little
16	*Osteospermum ecklonis* Norl.	COMPOSITAE	Bodrum Papatyası	little
17	*Pinus mugo* Tura 'Mops'	PINACEAE	Dağ Çamı	little
18	*Portulaca oleracea* L.	PORTULACACEAE	İpek Çiçeği	little
19	*Pyracantha coccinea* M.Roem.	ROSACEAE	Ateş Dikeni	medium
20	*Ribes aureum* Pursh	GROSSULARIACEAE	Frenk Üzümü	little
21	*Salvia nemorosa* L.	LABIATAE	Çayır Ateş Çiçeği	little-medi.
22	*Santolina chamaecyphrissus* L.	ASTERACEAE	Lavantin	little-medi.
23	*Sedum spectabile* Bor.	CRASSULACEAE	Pembe Çiçek Dam Koruğu	little
24	*Sempervivum hybrids* L.	CRASSULACEAE	Kaya Koruğu	little
25	*Spiraea* x *bumalda* Burv.	ROSACEAE	Pembe Çiçekli Keçi Sakalı	little-medi.
26	*Syringa vulgaris* L.	OLEACEAE	Leylak	little-medi.
27	*Verbena carolina* L.	VERBENACEAE	Mine Çiçeği	little
28	*Yucca filamentosa* L.	AGAVACEAE	Avize Çalısı/Yukka	Very little
29	*Zinnia maritima* Kunth	COMPOSITAE	Kirli Hanım Çiçeği	little



FIGURE 5
Modeling of the Campus Square

TABLE 3
Suggestion plants belonging to the Campus Square

No	Latin name	Family	Turkish name	Water Req.
1	*Agave americana* L. 'Marginata'	ASPARAGACEAE	Alacalı Amerikan Agavı	Very little
2	*Berberis vulgaris* L.	BERBERIDACEAE	Kadın Tuzluğu	little
3	*Cotoneaster dammeri* Schn.	ROSACEAE	Sürünücü Dağ Muşmulası	Little-medi.
4	*Crocus speciosus* M.Bieb.	IRIDACEAE	Safran	little
5	*Erica arborea* L.	ERICACEAE	Ağaç Fundası	Very little
6	*Gaillardia aristata* Pursh	COMPOSITAE	Gayardiya	little
7	*Hedera helix* L. 'Aureo-Variegata'	HEDERACEAE	Dış Sarı Alacalı Yap Kaya Sarmaşığı	Little-medi.
8	*Juniperus communis* L. 'Hibernica'	CUPRESSACEAE	Sütün Yaygın Ardıç	Very little
9	*Juniperus sabina* L. 'Tamariscifolia'	CUPRESSACEAE	Yayılıcı Sabin Ardıcı	Very little
10	*Juniperus squamata* Buch.-Ham ex D. Don 'Blue Carpet'	CUPRESSACEAE	Pulsu Ardıç	Very little
11	*Muscari botryoides* (L.) Mill.	ASPARAGACEAE	Dağ Sümbülü	Very little
12	*Pinus pinea* L.	PINACEAE	Fıstık Çamı	little
13	*Portulaca grandiflora* Hook.	PORTULACACEAE	İpek Çiçeği	little
14	*Sambucus nigra* L. 'Aurea'	OLEACEAE	Sarı Alacalı Mürver	litle
15	*Salvia farinacea* L.	LABIATAE	Adaçayı	Little-medi.
16	*Sedum acre* L.	CRASSULACEAE	Sarı Çiçekli Dam Koruğu	little
17	*Syringa x chinensis* Schmidt ex Willd	OLEACEAE	Çin Leylağı	Little-medi.
18	*Weigela floribunda* K. Koch.	CAPRIFOLIACEAE	Vangelya	Little-medi.
19	*Washingtonia robusta* H.Wendl.	ARECACEAE	Meksika Yelpaze Palmiyesi	little
20	*Verbena officinalis* L.	VERBENACEAE	Mine Çiçeği	little
21	*Zinnia peruviana* (L.) L.	COMPOSITAE	Kirli Hanım Çiçeği	little

TABLE 4
Suggestion plants for the faculty of theology

	naturalness	diversity	harmony	interesting	openness	mystery	impressive	emphasis	like	perspective	trust	relaxing	tidy	complex	perceptible	exciting	original	landscape	view	recreational value
1	4.69	2.75	4.80	2.46	4.86	1.97	3.31	3.73	2.95	4.89	3.74	4.80	4.80	4.22	2.83	2.85	2.78	2.50	2.10	5.05
2	3.76	5.03	4.95	5.04	2.83	5.01	5.32	2.59	5.08	4.69	2.70	4.37	5.33	2.81	4.74	5.15	2.90	4.55	4.69	5.50
3	2.81	4.47	5.22	4.05	5.24	3.08	4.35	3.06	5.04	4.20	2.83	2.77	2.56	3.68	4.70	4.26	5.27	5.15	5.12	5.44

1*. faculty of theology, 2*. campus living center, 3*. Campus square

Findings of the survey results. Within the scope of the study, a questionnaire was conducted with 105 expert landscape architects using face-to-face interviews. Variables determined in 3 different study areas in the questionnaire were evaluated in 7-Likert attitude scale. According to the results of the survey, the mean of variables in three different study areas were determined. For the Faculty of Theology, it was evaluated as recreation with 5.057, with perspective angle 4.895, with relaxing 4.800, with natural appearance 4.695 and mysterious with the lowest value is 1.971. It was concluded that the campus living center has a recreational effect with a value of

5.504, regular with 5.336, exciting with 5.152 and an emphasis effect with 2.590. (Table 4).

Correlation analysis was conducted to reveal the relationship between all variables. Pearson's correlation coefficients obtained at 99% significance level were calculated. The highest correlation of r=0.306 and (p<0.01) was obtained between naturalness and perceptible for the faculty of theology. Similarly, between naturalness and perceivable r=0.266 (p <0.01), between diversity and taste (p<0.01), between perceptible-like at r=0.259 (p<0.01), between original-perspective r=0.261 (p<0.01) positive correlation was found at a rate. As a result of the correlation analysis performed in the campus living center, the highest correlation (r=0.432) and (p<0.01) was obtained between likes and influencers. R=0.384 (p <0.01) between likes and interesting, r=0.305 (p<0.01) between landform and perceptible, r=0.295 between excitement-naturalness (p<0.01), and regular harmony (r=0.272) (p<0.01) positive correlation was found. As a result of the correlation analysis performed in the campus square, the highest correlation was obtained with r=0.426 and (p<0.01). Between original-variety r=0.345 and (p<0.01), perspective-like between r=0.423 and (p<0.01), perceptible-original between r=0.392 and (p<0.01), between excitement-interesting r=0.301 and (p<0.01) positive correlation was found.

CONCLUSION

In the future, it will experience the most intense water shortage especially in big cities. For this reason, plans for new landscaping where water use is at the lowest level are discussed. Regardless of the scale, precautions to minimize water consumption should be taken in order to protect existing green areas. For this purpose, less water consuming species specific to the region should be used in planting designs. The designs created should be aesthetically pleasing as well as being functional. Measures to be taken for green areas that will occur with water scarcity should be taken especially in our big cities. As a result, it will save a significant amount of water and prevent the loss of existing green areas.

This study was conducted to draw attention to the drought caused by climate change in recent years. Careful use of water has come to the fore for irrigating plants in landscapes where water consumption is intense. For this purpose, Recep Tayyip Erdoğan University in Rize province has been evaluated as a campus study area. Drought tolerant finishing designs were developed in the study areas determined on the campus and variables were evaluated with expert opinion surveys.

Species such as *Betula pendula* Roth, *Hedera helix* L., *Juniperus horizontalis* Moench, *Rhus typhina* L., *Salvia argentea* L., *Sedum album* L., *Tamarix tetrandra* Pallas were proposed for theology faculty. *Agave americana* L., *Cotoneaster horizontalis* C. K. Schneid, *Iris germanica* L., *Juniperus sabina* L., *Santolina chamaecyphrissus* L., *Syringa vulgaris* L., *Yucca filamentosa* L. were proposed for the campus living center. Colorful and mostly evergreen shrubs are used in the campus square. *Cotoneaster dammeri* Schn., *Pinus pinea* L. *Sambucus nigra* L.'Aurea', *Sedum acre* L., *Verbena officinalis* L., *Zinnia peruviana* (L.) L. were suggested and modeled for this area. As a result of the surveys conducted according to expert opinions, it was found that the modeling around the Faculty of Theology created a recreational and perspective effect; the campus living center was also found suitable for recreation, as well as tidy and exciting. The campus square is also perceived in harmony with the shape of the land, creating a harmonious, original and openness effect for recreation.

As a result, planting studies for water saving can be evaluated for aesthetic and recreational purposes. More work should be done in order to save water in these days when studies in this scope are deemed necessary.

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average amount of water used by 120 houses, it was determined how much rainwater collected on the roofs met this amount. In addition, the costs of the rainwater collection system and annual water savings were calculated.

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