Determination of the urbanization and changes in open-green spaces in Nevsehir city through remote sensing

Meliha Aklibasinda · Asli Ozdarici Ok

Abstract The physical texture of cities is comprised of built-up spaces, open-green spaces, and transportation arteries. Urbanization is a dynamic that compose of each of the factors above in a fair proportion to human beings and nature. On the other hand, due to the rapid increase in urban population, urbanization has become a concept that poses serious problems for cities in the last decades and this leads a pressure on open-green spaces in urban areas. Open-green spaces have a great importance in improving urban life conditions and balancing the destroyed relations between humans and environment. For this reason, the sustainability of urban open-green spaces cannot be ignored in the planning studies. In this study, the change in the urban texture in Nevsehir (Turkey) was evaluated in a 10-year period (2004–2014) through the integration of remote sensing (RS) and geographical information systems (GIS). Through the use of satellite images with high ground sample distance—QuickBird (60 cm) (2004) and Worlview-2 (50 cm) (2014)—the direction of urban expansion and changes which occurred in urban open-green spaces and urban development areas were examined in detail at the whole city and district scales. Analyses consist of satellite image classification, plant index production, and GIS-based analyses methods. According to the results, it was determined that from 2004 to 2014, the 23.28% decrease in urban open-green spaces was detected in Nevsehir city. It was observed that the city expands towards the north-east, south-west, and west. It was indicated that there is a serious increase in built-up areas especially at the north-east part of the city (107.11%). Thus, a significant decrease has happened in the amount of urban open-green spaces in this area.

Keywords Urban · Open-green space · Built-up area · Remote sensing · Geographical information systems

M. Aklibasinda (✉)
Faculty of Engineering and Architecture, Department of Landscape Architecture, Nevsehir Haci Bektas Veli University, 50300 Nevsehir, Turkey
e-mail: meliha38@hotmail.com

e-mail: melihaaklibasinda@nevsehir.edu.tr

A. Ozdarici Ok
College of Land Registry, Department of Real Estate and Property Management, Ankara Haci Bayram Veli University, Ankara, Turkey

Introduction

The population in cities increases due to the effects and interaction of many factors such as social and economic opportunities offered by cities and national policies. Following the industrial revolution, the urbanization process started in developed countries has spread to all countries around the world especially after the Second World War. The rate of urbanization was 7% in the whole world at the beginning of the twentieth century and it continued to rise constantly and reached 29.1% in 1950 and exceeded 50% by the 2007s (Karadağ 2009). In Turkey, this rapid urbanization increased after the 1950s was shaped by migration from rural areas to urban areas still continues today (Işık 2005).

Generally, cities are comprised of masses and spaces. Masses are created by buildings and spaces are created by urban open-green spaces and transportation arteries. Conceptually, urban open spaces are the pieces of urban that are left in their natural condition or allocated to agronomic or non-residential recreational purposes except for the constructed areas. On the other hand, green space is defined as shared spaces such as walkways with trees in cities or towns arranged by city administrators allocated for people's recreation to prevent cities from having a densely constructed look (Keleş 1998). Green spaces are surfaces of existing open areas covered or combined by plant elements (woody or herbaceous plants). In regard to these definitions, every green space is characterized as open space; however, every open space may not necessarily be a green space (Gül and Küçük 2001).

In cities, in addition to their ecological functions such as reducing air pollution, producing oxygen, protecting biological diversity, flood control, and arranging city climate, urban open-green spaces have an important role in creating a livable environment for human beings (Rafiee et al. 2009; Wu 2014; Kabisch and Haase 2014; Xu et al. 2018). With the effect of urbanization, and the rapid development of economy and society, urban land use has been expanding and spreading outwards. The changes in landscape pattern can cause strong changes in the components and structure of the ecosystem, ecological processes, and biological diversity (Fan et al. 2018).

In the process of rapid urbanization, planning projects and applications that are not ecologically based create pressure on open-green spaces in the city and at the urban fringe. For this reason, in many studies on urban open-green spaces, their effects on air quality (Bagheri et al. 2017; Zhu et al. 2017; Matos et al. 2019), on human health (Richardson and Mitchell 2010; Lee et al. 2015; Nutsford et al. 2015; Van den Bosch et al. 2016; Huang et al. 2017), and on thermal comfort (Klemm et al. 2015; Yang et al. 2017; Goncalves et al. 2019; Masoudi and Tan 2019), and their contribution to social life (Germann-Chiari and Seeland 2004; Home et al. 2012; Lindholst et al. 2015; Jennings and Bamkole 2019) and recreation opportunities (Arnberger 2012; Zhang et al. 2013; Ersoy et al. 2015) have been examined from different perspectives.

The benefits provided by urban open-green spaces, their function on sustainability and life quality, have led researchers to investigate green spaces in cities, the amount and distribution of these areas (Doygun and Ilter 2007; Hofmann et al. 2011; Kabisch and Haase 2014; Badiu et al. 2016; Santos et al. 2016; Sun et al. 2019) and their accessibility (Packe and Aldunce 2010; Fan et al. 2017; Atasoy 2018; Kolcsar and Szilassi 2018). According to literature review performed, Rafiee et al. (2009) has specifically investigated the change occurring in open-green spaces with the effect of urbanization. Additionally, in various studies focusing on the determination of the changes occurring in land cover, urban open-green spaces have also been examined in general terms. In the recent years, the spread of GIS and RS techniques due to the advances in computer technologies has started to provide fast, reliable, semi-automatic, or automatic alternatives for the evaluation of urban open-green spaces, compared with traditional methods.

In the present study, it has been aimed at investigating the change that has occurred in urban open-green spaces in Nevsehir city through the 10-year period (2004–2014) via high spatial resolution satellite images. To the best of our knowledge, studies using high spatial resolution satellite images are limited, which increases the value of our study. Results indicated that densely built-up areas, the direction of urbanization, and its effect on urban open-green spaces have been evaluated. It is envisaged that the results obtained in the study are going to provide a basis for planning projects to be done within the urbanization process of Nevsehir city which is an important tourism center of the world.

Material and methods

Study area

Nevsehir is located in the Cappadocia Region which carries World Heritage status with its natural, historical, and cultural characteristics. The city is in the Central Anatolia region of Turkey between 38° 12′ and 39° 20′ north latitudes and 34° 11′ and 35° 06′ east longitudes (Fig. 1). The city center located at the southern slope of the Kızılırmak Valley has an altitude of 1150 (Anonymous 2019).

The volcanic relief has been effective on spatial development and land use of the city. The mountains located in the area where the city was founded have affected the developmental direction of the city. For this reason, the city has developed in the northeast-
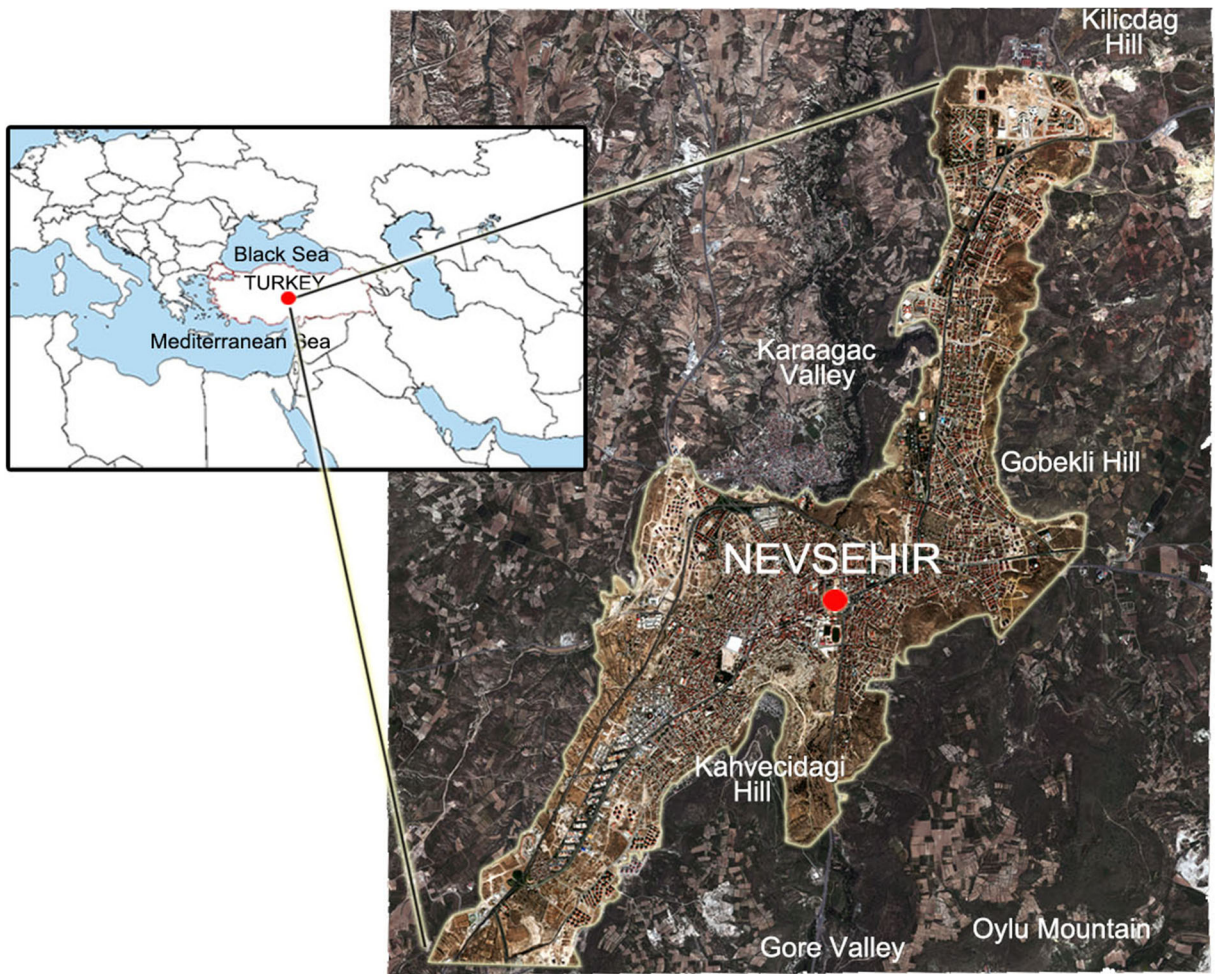
Fig. 1 The location of the study area and natural formations that affect the physical development of the city

southwest direction. The city is surrounded by heights such as Aşıklı Mountain (1695 m), Oylu Mountain (1642 m), Göbekli Hill (1327 m), and Kılıçdağ Hill in the south-north direction in the east section. In the south, there is Kahvecidağı Hill (1370–1400 m) penetrating into the foundation area of the city like a triangle shape.

Nevsehir Castle is located at the north edge of this hill. There are two important valleys limiting the development of the city. The first of these is the Karaağaç Creek Valley, situated in the middle part of the city, which separates Nevsehir city and Nar town. Karaağaç Creek is a continuous river valley which produces steep cliff formations at times and flows directly into Kızılırmak. The other important valley is Göre Valley which is almost a continuation of Karaagaç Creek Valley located to the south of the foundation area of the city (Arslan et al. 2017).

Data

In the study, satellite images of QickBird-2 (60 cm) and WorldView-2 (50 cm) taken in 2004 and 2014, respectively, were used to determine the change in the area. The images were obtained as panchromatic (black and white) and multispectral (color) formats to benefit from both spatial and spectral characteristics. The QuickBird-2 panchromatic image has a 60-cm spatial resolution with a spectral band width of 0.45–0.90 μm. The spatial resolution of WorldView-2 panchromatic image is 50 cm. The spectral band range for this image is 0.45–0.80 μm. Multispectral images contain 4 spectral bands named as blue, green, red, and near infra-red. Ranges of spectral band of QuickBird-2 image are 0.45–0.52 μm, 0.52–0.60 μm, 0.63–0.69 μm, and 0.76–0.89 μm while the spectral ranges of WorldView-2 image are

0.40–0.45 μm, 0.45–0.51 μm, 0.51–0.58 μm, and 0.58–0.62 μm, respectively.

Method

The method of the study has three main stages: (i) data collection, (ii) analysis of satellite images, and (iii) GIS-based analysis at district scale (Fig. 2). At the second stage including the analysis of satellite images, a series of operations as listed below such as image sharpening, atmospheric adjustment correction, orthorectification, NDVI, image classification, accuracy analysis, and change determination has been applied to the images.

(i)   Data collection
(ii) Analysis of satellite images

- Image sharpening
- Atmospheric correction
- Orthorectification
- Normalized difference vegetation index (NDVI)
- Image classification
- Accuracy assessment
- Change detection analysis

(iii) Conversion of raster data into vector format and district scale analysis by transferring into ArcGIS environment

At the data collection stage, the first part of the study, borders of the study area were determined based on the development plan. With a detailed review process, maps and data related to the study area were obtained from relevant institutions and organizations. At the second part, the image sharpening of panchromatic and multi-spectral images was carried out. The purpose of this part was to obtain new images with multiple bands with high-ground sampling distance by combining the spatial information of panchromatic band and spectral information of multispectral bands. Next, the image was corrected atmospherically in order to resolve the spectral differences in the analyses which could stem from images having been captured at different dates. This process is important for producing reliable maps from image analyses with multiple dates.

The next step which follows is the orthorectification process of satellite images which have been sharpened and adjusted. The purpose of this process is to geometrically correct raw images which contain basic geometrical distortions through sensitive mathematical models. Whereby, satellite images have been transformed into data from which sensitive coordinate information can be obtained in order to carry out image analyses. Ground control points were gathered homogenously from explicit intersection points in the field by using a sensitive global positioning device. To create the numeric field model required for the orthorectification process, numeric elevation maps with a scale of 1/25,000 obtained
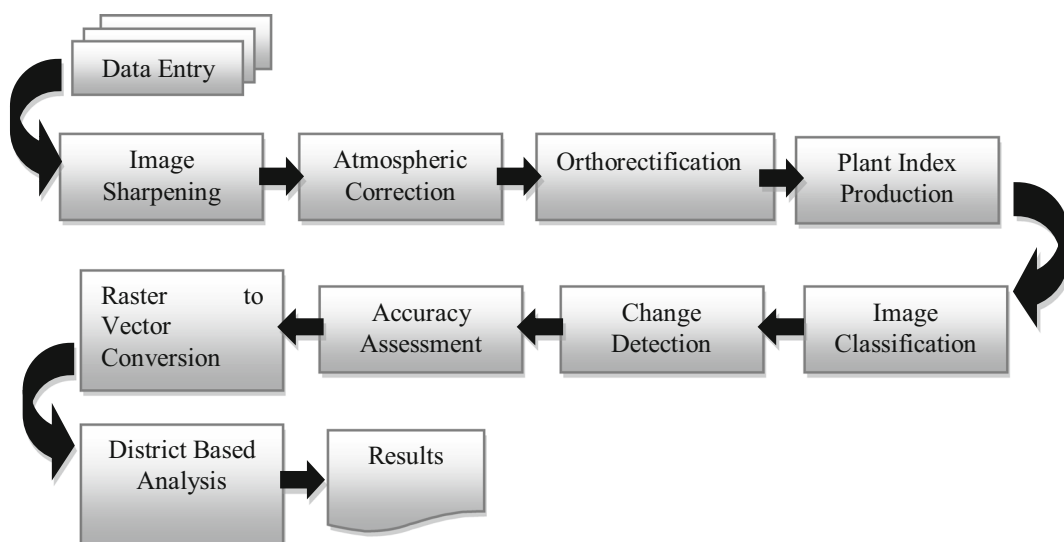

Fig. 2 Methodology

from General Command of Mapping of Turkey were used. The value of root mean square error calculated by using ground control points for the orthorectification process was estimated to be less than one pixel. As a result of this process, the spatial resolution of the QuickBird-2 satellite image was re-sampled to 50 cm to bring the pixel sizes of Worldview-2 image.

The next stage of the study includes creation of the normalized difference vegetation index (NDVI) which was performed to the purpose of focusing on the healthy planted areas. The method has a well-known formula where the difference between near infra-red and red bands of images is divided by the sum of identical bands (Eq. 1). With the help of the method, planted areas belonging to the images were determined.

$$NDVI = (near\ infrared - red)/(near\ infrared + red) \tag{1}$$

This process is followed by classification of the images, where sample pixels were collected from homogeneous areas in the images and information was obtained by introducing the sample areas into the classification algorithm. In the image classification, while all hard surfaces such as roads, buildings, and terraces were included in the built-up areas, planted areas or those which are bare and in a natural green condition were evaluated as urban open-green spaces. For the pixel-based classification process of the images, the maximum likelihood classification algorithm (MLC) was used. The classification process was performed by two different ways with 4 image bands and the inclusion of NVDI to the bands. MLC method calculates the probability values for each pixel that creates the image according to the sample areas introduced before the classification and assigns the highest probability value to the pixel as a label (Eq. 2). The method is based on the assumption that the sample data to be used in the classification process has normal distribution (Lillesand et al. 2004).

$$p_i = -\frac{1}{2}\log_e|v_i| - \left[\frac{1}{2}(X-M_i)^T V_i^{-1}(X-M_i)\right] \tag{2}$$

In the equation, M_i denotes the average vector of its classification, V_i is the covariance vector, X defines the reflection value of the pixels in the image, and p_i is the probability value for each classification. In order to determine the accuracies of the thematic maps dated 2004 and 2014, accuracy assessment was applied to the results. As a result, error matrices including overall accuracies and Kappa values as well as user's and producer's accuracies of the maps were calculated.

Next, a change detection analysis was carried out to compute difference between urban open-green spaces classified. In other words, the change was determined by logically subtracting built-up area and urban open-green space classifications in the thematic maps dated 2004–2014 from each other. In this way, information on the 10-year variation of the city was accessed.

At the third and last part of the study, through transferring the data into ArcGIS environment, the classified images (thematic maps) were transferred into a vector format. Then, the vector data containing district borders was created by using the Nevsehir City Master Plan. By combining all vector data, distribution maps of urban open-green spaces and built-up areas at district scale and tables (amount of urban open-green spaces and built-up areas, variation percentage, their total amount at city scale, and variation percentages according to districts in 2004 and 2014) showing numerical data were obtained.

Results and discussions

The study was carried out in an area of 2,251.02 hectares based on the Nevsehir municipality and development border. Satellite images belonging to 2004 and 2014 were classified as built-up areas and open-green spaces. There are shaded areas depending on the image acquisition angle and these areas cause variation in both images acquired on two different years. Although there is a loss of data because of these undefined areas, the results obtained provide important information about the change of the city (Table 1) (Fig. 3).

According to the analyses, it was determined that through the 10-year period, there has been an important increase of 311.39 ha in built-up areas and a decrease of 322.05 in urban open-green spaces. The decrease in urban open-green spaces is not parallel with the increase in built-up areas. This is because there are undefined areas in the shades of buildings within the green spaces which were transformed into the built-up areas. When the satellite images are examined, it was determined that these areas mainly consisted of gardens of buildings; therefore, the change which occurred in the urban open-green spaces can be defined with the change that occurred in built-up areas quantitatively. When the change

Table 1 Amount of open-green spaces and built-up areas in Nevsehir in 2004–2014 (hectares (ha))

	Satellite image taken on 2004	Satellite image taken on 2014
Amount of open-green spaces (ha)	1383.62	1061.57
Amount of built-up areas (ha)	773.83	1085.22
Amount of shaded areas (ha)	93.57	104.23
Total	2251.02	2251.02

was examined for the whole city, it can be observed that the agricultural lands owned by public and empty lands, where no agricultural activity is being done and which are outside the city, have entered a process of a fast development, and accordingly, open-green spaces have decreased considerably. According to current records, it was revealed that the population of Nevsehir city center was 67,864 in 2000, it was 81,688 in 2007, and 95,476 in 2014, and that showed an increasing trend (TÜİK 2019). The buildings built to meet the housing need with population growth have developed horizontally in most of the city due to the low number of floors. This increase has also brought about developments such as vehicle-pedestrian transportation systems and car parks.

According to the results, although there is a serious increase in built-up areas, there are regions in the city where open-green spaces have increased. When the areas where changes have occurred were examined by overlaying the high-resolution satellite images with change vector data, it was determined that between 2004 and 2014, it was given importance to landscaping of main transportation arteries, sidewalks, and median strips, and green junctions were created. In addition, the surroundings of housing areas are also sites where green texture has increased due to arrangements performed and previously planted tree growths. Nevsehir Castle is the most prominent regions in the city where positive changes occur. The results obtained from the analyses at district level are given in Table 2.

Considering the percentages of change occurring at district level, it can be seen that the areas where most changes have occurred are 2000 Evler (107.11%), Cevher Dudayev (79.21%), and 15 Temmuz (58.75%) districts. The 2000 Evler district, the place where the highest amount of increase in developments has occurred, is an indication that the first developmental
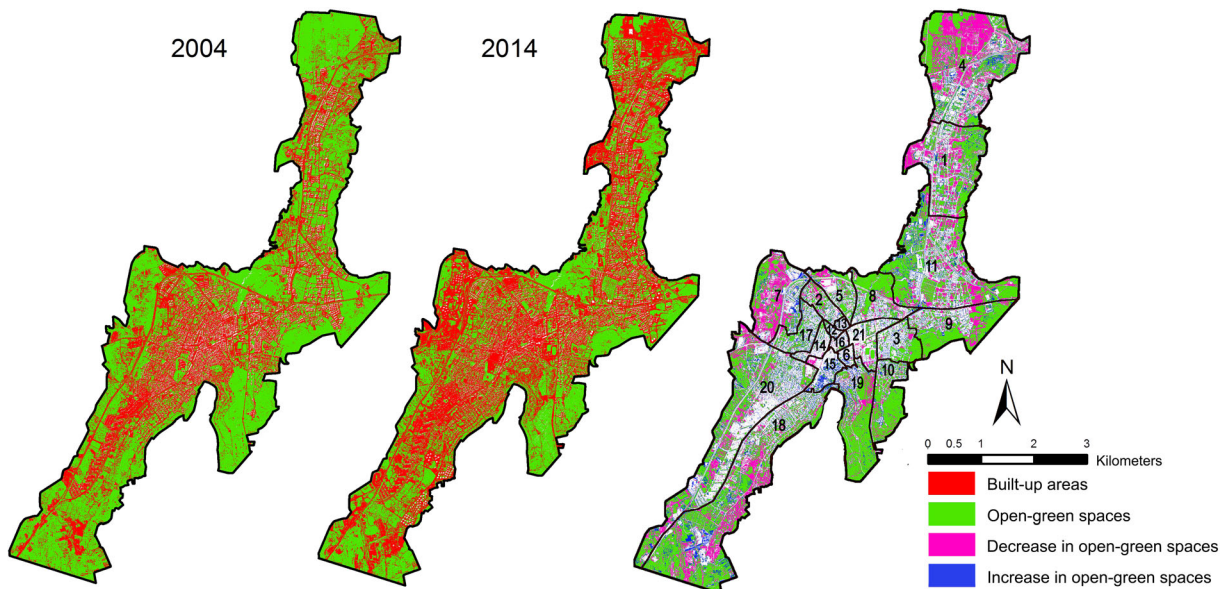

Fig. 3 Distribution of the built-up areas and urban open-green spaces and change occurred between 2004 and 2014 (districts: (1) 15 Temmuz, (2) 20 Temmuz, (3) 350 Evler, (4) 2000 Evler, (5) Bahçelievler, (6) Camicedit, (7) Cevher Dudayev, (8) Emek, (9) Esentepe, (10) Fatih Sultan Mehmet, (11) Güzelyurt, (12) Hacırüştü, (13) Herikli, (14) İbrahim Paşa, (15) Kapucubaşı, (16) Karasoku, (17) Kıratlıoğlu, (18) Mehmet Akif Ersoy, (19) Raşitbey, (20) Sümer, (21) Yeni)

Table 2 The amount and percentage of change occurred in open-green spaces and built-up areas at the district level of the study area

Map code	District name	State of built-up areas (ha)				State of open-green spaces (ha)			
		2004	2014	Amount of change	Percentage of change	2004	2014	Amount of change	Percentage of change
1	15 Temmuz	54.95	87.23	32.28	58.75%	115.60	80.79	− 34.81	− 30.11%
2	20 Temmuz	13.83	17.47	3.64	26.31%	14.57	11.00	− 3.57	− 24.50%
3	350 Evler	21.90	23.23	1.33	6.08%	24.35	23.92	− 0.43	− 1.77%
4	2000 Evler	80.59	166.92	86.33	107.11%	210.69	116.73	− 93.96	− 44.60%
5	Bahçelievler	21.69	26.19	4.50	20.74%	23.20	19.05	− 4.15	− 17.89%
6	Camicedit	6.36	6.60	0.24	3.83%	1.15	1.57	0.42	37.03%
7	Cevher Dudayev	42.83	76.75	33.92	79.21%	81.03	44.86	− 36.17	− 44.64%
8	Emek	21.98	28.11	6.13	27.90%	44.86	39.42	− 5.44	− 12.12%
9	Esentepe	28.25	39.41	11.16	39.48%	81.92	69.27	− 12.65	− 15.44%
10	Fatih Sultan Mehmet	17.71	23.16	5.45	30.79%	60.11	54.63	− 5.48	− 9.11%
11	Güzelyurt	88.77	117.33	28.56	32.17%	175.83	143.22	− 32.61	− 18.55%
12	Hacırüştü	3.60	3.72	0.12	3.27%	1.16	1.43	0.27	22.86%
13	Herikli	3.56	3.87	0.31	8.87%	0.72	0.85	0.13	17.35%
14	İbrahim Paşa	13.04	13.89	0.85	6.49%	3.80	3.92	0.12	2.94%
15	Kapucubaşı	19.68	20.29	0.61	3.11%	6.11	9.26	3.15	51.60%
16	Karasoku	5.87	6.58	0.71	12.08%	1.60	1.56	− 0.04	− 2.28%
17	Kıratlıoğlu	25.71	24.92	− 0.79	− 3.07%	17.43	19.36	1.93	11.08%
18	Mehmet Akif Ersoy	111.35	158.50	47.15	42.34%	241.74	189.04	− 52.70	− 21.80%
19	Raşitbey	24.06	35.88	11.82	49.09%	95.61	83.57	− 12.04	− 12.59%
20	Sümer	141.40	175.19	33.79	23.90%	168.70	136.82	− 31.88	− 18.90%
21	Yeni	26.71	29.99	3.28	12.31%	13.42	11.29	− 2.13	− 15.91%
	Total	773.83	1085.22	311.39	40.24%	1383.62	1061.57	− 322.05	− 23.28%

direction of the city is the south-east part of the area. The most effective factor of that development is the Nevsehir Haci Bektas Veli University which was established in 2007 at the north-east border of the city. The central campus of the city has an area of 414 ha and 17.2 ha of this area is taken up by built-up areas (Anonymous 2018). The amount of built-up areas of this location continues to increase with hard surfaces around buildings, social areas, car parks, and roads. The university where currently 16,288 students are taking higher education has caused new buildings to densify in the area in order to provide housing for the students. For this purpose, dormitories, studio houses, and connected social areas have been built in the area. Another factor causing an increase in built-up areas in this region is the mass housing area which was built after 2004. Mass housing areas trigger development in their surrounding and

determine the development direction of the city depending on the needs of the population. For this reason, future population projections and factors that increase the structure should be well defined in order to ensure the sustainability of open-green areas while establishing residential areas.

The second developmental direction is detected to Mehmet Akif Ersoy district with 47.15 ha located to the south-west direction of the city. In this district, the main source of increase in built-up areas was observed to the mass housing area built after 2004. The Cevher Dudayev district, which has gone through a fast process of change in the 10-year period located to the west of the city, is the third developmental direction of the city. In contrast to the low-storey buildings in the north-east part, high-storey buildings can be seen in the south-west and west directions.

Karasoku, Camicedit, Kapucubaşı, İbrahim Paşa, Kıratlıoğlu, Hacırüştü, and Herikli districts located in the city center form the old settlement pattern, and therefore, no significant increase was observed in the amount of built-up areas. Although the number of floors of the buildings in this region is low, the density of the buildings is very high, so there is little space for new constructions. It has been detected an increase in green texture due to the demolishing of old buildings and landscape design applications in this region. The district where urban open-green spaces have increased the most is Kapucubaşı (3.15 ha). Nevsehir Castle having historical importance is located within the borders of this neighborhood and surrounded by slums. All of the buildings around the castle have been demolished during the urban transformation project. Because of the discovered underground city, the area was put under protection and constructions were not allowed. According to the analysis, it was observed that the 0.61-ha increase in the classification of built-up areas in this district is due to the bare areas created by the excavation. Currently, there is no new construction in the region; however, while the gardens of the houses were included in the open-green spaces in the classification of satellite image of 2004, they were included in the excavation area in 2014. This is reflected in the results as an increase in structure. A similar situation is observed in the Raşitbey district in the north-east and south direction of the castle. In this area, although there has been a decrease in built-up areas in the 10-year period, the reason of the numerical increase in the classification of built-up areas is the bare areas caused after demolishing and leveling these areas.

When the districts are out of the old settlement texture of the city, it was seen that open-green spaces have considerably increased in all districts. Among these in Cevher Dudayev (44.64%) and 2000 Evler (44.60%) districts, about half of the open-green spaces have diminished. In 15 Temmuz district located in the northeast developmental direction of the city, there is a considerable decrease, too (30.11%).

Change detection of urban-green spaces has been examined in several studies, so far. Rafiee et al. (2009) performed a study to assess changes in urban-green spaces of Mashad city using medium resolution Landsat TM and IRS LISS-III images for a 19-year period (from 1897 to 2006). Vatseva et al. (2016) stated that RS and GIS provide strong tools for the mapping and analysis of urban open-green spaces at various spatial and temporal scales. In the decision process of urban planning when transforming world observation data into useful information, high-resolution satellite images (≤ 1 m) and geographical data from multiple sources are needed a great deal. A post-classification comparison strategy has been applied to the images with the usage of landscape metrics and vegetation indices similar to our study to the image analyses. Results have revealed a significant decrease for the open-green spaces for that area. Trends in green spaces have been studied for city of Port Elizabeth (South Africa) by Odindi and Mhangara (2012) with three sets (1990, 1995, 2000) of medium-resolution Landsat-5 TM satellite images. Results indicated that RS is an effective tool to estimate changes of green spaces. A recent study has been conducted to analyze spatial pattern of urban green spaces in Xiamen Island of China between 1973 and 2010 with five sets of GF-1 images (2-m panchromatic and 8-m multispectral resolution). Similar to our study, vegetation index and GIS have been included into the analyses to perform a better estimation. It has been stated that a 2-m resolution is not enough to obtain reliable results to the urban green spaces.

The research results have shown that RS has yielded effective outputs in the analysis about changes occurring in urban areas through various methods, especially with the usage of high-resolution images. RS is the art and science of collecting and analyzing information about the objects in the world without a physical contact of the objects (Lillesand et al. 2004). GIS on the other hand is systems comprised of computer hardware, software, and users used in order to store, process, manage, analyze, and visualize position-based data of the world in computer environment (Tecim 2008). Both methods are increasingly becoming widespread in recent decades.

Conclusion

This study examines the effects of change of the 10-year period occurred in Nevsehir city texture on the urban open-green spaces between 2004 and 2014. Analyses performed based on high spatial resolution images (50 cm) have revealed important results in regard to urban planning. The changed areas, their amounts, and change percentages have been obtained at the whole city and district scale which is the smallest administrative unit. In this way, characteristics of the changed areas and the sources of change have been examined. The results

obtained through spatial analyses with the integration of the RS and GIS revealed that there was a considerable increase of built-up areas at the whole-city scale and decrease of 23.28% (322.05 ha) in urban open-green spaces. Although, in the 10-year period, an increase has been observed in the total amount of urban open-green spaces, it has also been determined that some regions have been transformed into green areas from buildings. Numerical data obtained and the variation maps have facilitated the determination of districts where the fastest and the biggest change occurred and the main developmental directions of the city. For healthy urbanization, it is required to determine the developmental dynamics of the city, to put forth the current situation, and to develop sustainable planning strategies for the future in this direction. The RS and GIS technologies provide convenience in both holistically evaluation of the area and carrying out various analyses at the sub areas. The satellite images with a 50-cm spatial resolution have facilitated obtaining more detailed results and increased the readability of the area in facilitating interpretations of the sources with respect to change. The results of the study are expected to be a guide for decision makers and practitioners in giving directions to healthy urbanization in Nevsehir city. Thus, it is considered that the method can be used effectively in urban planning studies.

References

Anonymous. (2018). Nevşehir Hacı Bektaş Veli Üniversitesi İdare Faaliyet Raporu. https://dosyalar.nevsehir.edu.tr/684421cd81c46f8a82430b33639bb631/2018-yili-idare-faaliyet-raporu.pdf. Accessed 11 February 2019.

Anonymous. (2019). T.C. Nevşehir Valiliği. http://www.nevsehir.gov.tr/kurumlar/nevsehir.gov.tr/ilimizrehber/2018yeni/cografi.pdf. Accessed 07 February 2019.

Arnberger, A. (2012). Urban densification and recreational quality of public urban green spaces - a viennese case study. *Sustainability, 4*(4), 703–720. https://doi.org/10.3390/su4040703.

Arslan, H., Şıkoğlu, E, & Karadoğan, S. (2017). *Nevşehir yakın çevresinin jeolojik-jeomorfolojik özellikleri ve kentleşmeye etkileri.* International Symposium on Geomorphology, Proceedings Book, 264-273, 12-14 October, Elazığ/Türkiye.

Atasoy, M. (2018). Monitoring the urban green spaces and landscape fragmentation using remote sensing: a case study in Osmaniye, Turkey. *Environmental Monitoring and Assessment, 190*(12), 713.

Badiu, D. L., Ioja, C. I., Patroescu, M., Breuste, J., Artmann, M., Nita, M. R., Gradinaru, S. R., Hossu, C. A., & Onose, D. A. (2016). Is urban green space per capita a valuable target to achieve cities' sustainability goals? Romania as a case study. *Ecological Indicators, 70*, 53–66. https://doi.org/10.1016/j.ecolind.2016.05.044.

Bagheri, Z., Nadoushan, M. A., & Abari, M. F. (2017). Evaluation the effect of green space on air pollution dispersion using satellite images and landscape metrics: a case study of Isfahan City. *Fresenius Environmental Bulletin, 26*(12A), 520–530.

Doygun, H., & Ilter, A. A. (2007). Investigating adequacy of existing and proposed active green spaces in Kahramanmaras city. *Ekoloji, 17*(65), 21–27.

Ersoy, E., Jorgensen, A., & Warren, P. H. (2015). Measuring the spatial structure of urban land uses: the case of Sheffield, UK. *Journal of Environmental Protection and Ecology, 16*(1), 393–401.

Fan, P. L., Xu, L. H., Yue, W. Z., & Chen, J. Q. (2017). Accessibility of public urban green space in an urban periphery: the case of Shanghai. *Landscape and Urban Planning, 165*, 177–192. https://doi.org/10.1016/j.landurbplan.2016.11.007.

Fan, X., Liu, J., Chen, J., Zhao, L., Hong, W., Hong, T., & Lin, H. (2018). Effects of landscape changes on ecosystem services: a case study in Nanping, Northern Fujian Province, China. *Fresenius Environmental Bulletin, 27*(5A), 3561–3570.

Germann-Chiari, C., & Seeland, K. (2004). Are urban green spaces optimally distributed to act as places for social integration? Results of a geographical information system (GIS) approach for urban forestry research. *Forest Policy and Economics, 6*(1), 3–13. https://doi.org/10.1016/S1389-9341(02)00067-9.

Goncalves, A., Ribeiro, A. C., Maia, F., Nunes, L., & Feliciano, M. (2019). Influence of green spaces on outdoors thermal comfort-structured experiment in a mediterranean climate. *Climate, 7*(2), 20. https://doi.org/10.3390/cli7020020.

Gül, A., & Küçük, V. (2001). Kentsel açık-yeşil alanlar ve Isparta kenti örneğinde irdelenmesi. *Süleyman Demirel Üniversitesi Orman Fakültesi Dergisi, 2*(A), 27–48.

Hofmann, P., Strobl, J., & Nazarkulova, A. (2011). Mapping green spaces in Bishkek—how reliable can spatial analysis be? *Remote Sensing, 3*, 1088–1103. https://doi.org/10.3390/rs3061088.

Home, R., Hunziker, M., & Bauer, N. (2012). Psychosocial outcomes as motivations for visiting nearby urban green spaces. *Leisure Sciences, 34*(4), 350–365. https://doi.org/10.1080/01490400.2012.687644.

Huang, C. H., Yang, J., Lu, H., Huang, H. B., & Yu, L. (2017). Green spaces as an indicator of urban health: evaluating its changes in 28 mega-cities. *Remote Sensing, 9*(12), 1266. https://doi.org/10.3390/rs9121266.

Işık, S. (2005). Türkiye'de Kentleşme ve Kentleşme Modelleri (urbanisation and urbanisation models in Turkey). *Ege Coğrafya Dergisi (Aegean Geographical Journal), 14*, 57–71.

Jennings, V., & Bamkole, O. (2019). The relationship between social cohesion and urban green space: an avenue for health

promotion. *International Journal of Environmental Research and Public Health, 16*(3), 452. https://doi.org/10.3390/ijerph16030452.

Kabisch, N., & Haase, D. (2014). Green justice or just green? Provision of urban green spaces in Berlin, Germany. *Landscape and Urban Planning, 122*, 129–139. https://doi.org/10.1016/j.ecolind.2016.02.029.

Karadağ, A. (2009). Kentsel ekoloji: kentsel çevre analizlerinde coğrafi yaklaşım. *Ege Coğrafya Dergisi, 18*(1–2), 31–47.

Keleş, R. (1998). *Kentbilim Terimleri Sözlüğü*. Ankara: İmge Yayıncılık.

Klemm, W., Heusinkveld, B. G., Lenzholzer, S., Jacobs, M. H., & Van Hove, B. (2015). Psychological and physical impact of urban green spaces on outdoor thermal comfort during summertime in The Netherlands. *Building and Environment, 83*, 120–128. https://doi.org/10.1016/j.buildenv.2014.05.013.

Kolcsar, R. A., & Szilassi, P. (2018). Assessing accessibility of urban green spaces based on isochrone maps and street resolution population data through the example of Zalaegerszeg, Hungary. *Carpathian Journal of Earth and Environmental Sciences, 13*(1), 31–36. https://doi.org/10.26471/cjees/2018/013/003.

Lee, A. C. K., Jordan, H. C., & Horsley, J. (2015). Value of urban green spaces in promoting healthy living and wellbeing: prospects for planning. *Risk Management and Healthcare Policy, 8*, 131–137. https://doi.org/10.2147/RMHP.S61654.

Lillesand, M., Kiefer, R. W., & Chipman, J. W. (2004). *Remote sensing and image interpretation* (5th ed. p.763). Hoboken: Wiley.

Lindholst, A. C., Caspersen, O. H., & Van den Bosch, C. C. K. (2015). Methods for mapping recreational and social values in urban green spaces in the nordic countries and their comparative merits for urban planning. *Journal of Outdoor Recreation and Tourism-Research Planning and Management, 12*, 71–81. https://doi.org/10.1016/j.jort.2015.11.007.

Masoudi, M., & Tan, P. Y. (2019). Multi-year comparison of the effects of spatial pattern of urban green spaces on urban land surface temperature. *Landscape and Urban Planning, 184*, 44–58. https://doi.org/10.1016/j.landurbplan.2018.10.023.

Matos, P., Vieira, J., Rocha, B., Branquinho, C., & Pinho, P. (2019). Modeling the provision of air-quality regulation ecosystem service provided by urban green spaces using lichens as ecological indicators. *Science of the Total Environment, 665*, 521–530. https://doi.org/10.1016/j.scitotenv.2019.02.023.

Nutsford, D., Pearson, A. L., & Kingham, S. (2015). An ecological study investigating the association between access to urban green space and mental health. *Public Health, 127*(11), 1005–1011. https://doi.org/10.1016/j.puhe.2013.08.016.

Odindi, J. O., & Mhangara, P. (2012). Green spaces trends in the city of Port Elizabeth from 1990 to 2000 using remote sensing. *International Journal of Environmental Research, 6*(3), 653–662. https://doi.org/10.22059/IJER.2012.535.

Packe, S. R., & Aldunce, I. M. F. (2010). Distribution, extent and accessibility of green spaces in Santiago de Chile. *Eure-Revista Latinoamericana De Estudios Urbano Regionales, 36*(109), 89–110.

Rafiee, R., Mahiny, A. S., & Khorasani, N. (2009). Assessment of changes in urban green spaces of Mashad city using satellite

data. *International Journal of Applied Earth Observation and Geoinformation, 11*, 431–438. https://doi.org/10.1016/j.jag.2009.08.005.

Richardson, E. A., & Mitchell, R. (2010). Gender differences in relationships between urban green space and health in the United Kingdom. *Social Science & Medicine, 71*(3), 568–575. https://doi.org/10.1016/j.socscimed.2010.04.015.

Santos, T., Tenedorio, J. A., & Goncalves, J. A. (2016). Quantifying the city's green area potential gain using remote sensing data. *Sustainability, 8*(12), 1247. https://doi.org/10.3390/su8121247.

Sun, C., Lin, T., Zhao, Q., Li, X., Ye, H., Zhang, G., Liu, X., & Zhao, Y. (2019). Spatial pattern of urban green spaces in a long-term compact urbanization process—a case study in China. *Ecological Indicators, 96*, 111–119. https://doi.org/10.1016/j.ecolind.2017.09.043.

Tecim, V. (2008). *Coğrafi Bilgi Sistemleri*. 354 s., Renk Form Ofset Matbaacılık, Ankara. (In Turkish)

TÜİK. (2019). Türkiye İstatistik Kurumu. http://www.tuik.gov.tr/Start.do. Accessed 07 February 2019.

Van den Bosch, M. A., Mudu, P., Uscila, V., Barrdahl, M., Kulinkina, A., Staatsen, B., Swart, W., Kruize, H., Zurlyte, I., & Egorov, A. I. (2016). Development of an urban green space indicator and the public health rationale. *Scandinavian Journal of Public Health, 44*(2), 159–167. https://doi.org/10.1177/1403494815615444.

Vatseva, R., Kopecka, M., Otahel, J., Rosina, K., Kitev, A., Genchev, S. (2016). *Mapping urban green spaces based on remote sensing data: case studies in Bulgaria and Slovakia*. Proceedings, 6th International Conference on Cartography and GIS, pp 569- 578, 13-17 June 2016, Albena, Bulgaria.

Wu, J. (2014). Urban ecology and sustainability: the state-of-the-science and future directions. *Landscape and Urban Planning, 125*, 209–222. https://doi.org/10.1016/j.landurbplan.2014.01.018.

Xu, C., Haase, D., & Pauleit, S. (2018). The impact of different urban dynamics on green space availability: a multiple scenario modeling approach for the region of Munich, Germany. *Ecological Indicators, 93*, 1–12. https://doi.org/10.1016/j.ecolind.2018.04.058.

Yang, J., Sun, J., Ge, Q. S., & Li, X. M. (2017). Assessing the impacts of urbanization-associated green space on urban land surface temperature: a case study of Dalian, China. *Urban Forestry & Urban Greening, 22*, 1–10. https://doi.org/10.1016/j.ufug.2017.01.002.

Zhang, H., Chen, B., Sun, Z., & Bao, Z. Y. (2013). Landscape perception and recreation needs in urban green space in Fuyang, Hangzhou, China. *Urban Forestry & Urban Greening, 12*(1), 44–52. https://doi.org/10.1016/j.ufug.2012.11.001.

Zhu, C. Y., Ji, P., & Li, S. H. (2017). Effects of urban green belts on the air temperature, humidity and air quality. *Journal of Environmental Engineering and Landscape Management, 25*(1), 39–55. https://doi.org/10.3846/16486897.2016.1194276.