Mimarlık Bilimleri ve Uygulamaları Dergisi
Araştırma makalesi
MBUD 2022, 7 (2), 615-623
e-ISSN: 2548-0170

Journal of Architectural Sciences and Applications
Research article
JASA 2022, 7 (2), 615-623
e-ISSN: 2548-0170

Assessment of Urban Green Space Distribution within the Scope of European Green Deal Using NDVI Indice; Case of Nicosia/Cyprus

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Abstract

In this study, the urban green space distribution was determined, and the city's compliance with the European Green Deal was evaluated. Firstly, Landsat 8 satellite images were radiometrically corrected with the Quantum GIS software. Then, NDVI was produced using the Red-Green-Blue and Near-Infrared bands of the processed data obtained. Finally, the NDVI image with a value between -1 and +1 was reclassified to define urban open green spaces. The classification data showed that open green areas have a nonhomogeneous distribution throughout the city, and the amount of green space per capita is approximately 200 m². According to the classification results of Northern Nicosia, a surface area of 475 km², the amount of green space is calculated as 16m², constituting 2.97%. Thus, it has been concluded that open green regions are denser in certain parts of the city than others and do not have a homogeneous distribution that can serve the whole town.

Keywords: *Open-green spaces, NDVI, remote sensing, landsat 8, European green deal*

Avrupa Yeşil Mutabakatı Kapsamında Lefkoşa'nın Kentsel Yeşil Alan Dağılımının NDVI ile Değerlendirilmesi

Öz

Bu çalışmada, şehrin kentsel yeşil alan dağılımı belirlenmiş ve mevcut yeşil alan varlığı Avrupa Yeşil Mutabakatı kapsamında değerlendirilmiştir. Çalışmada, Landsat 8 OLI görüntüleri kullanılmış olup, görüntülere öncelikle Quantum GIS yazılımı ile radyometrik düzeltme işlemi yapılmıştır. Ardından elde edilen işlenmiş verilerin Kırmızı-Yeşil-Mavi ve Yakın Kızılötesi bantları kullanılarak Normalleştirilmiş Fark Bitki Örtüsü İndeksi üretilmiştir. Son olarak, -1 ile +1 arasında değer olan NDVI görüntüsü, kentsel açık yeşil alanları belirlemek üzere yeniden sınıflandırılmıştır. Sınıflandırma verileri, açık yeşil alanların şehir genelinde homojen olmayan bir dağılıma sahip olduğunu ve kişi başına düşen yeşil alan miktarının yaklaşık 200 m² olduğunu göstermiştir. 475 km² yüzölçümüne sahip Kuzey Lefkoşa'nın sınıflandırma sonuçlarına göre yeşil alan miktarı %2,97 olmak üzere 16m² olarak hesaplanmıştır. Böylece açık yeşil bölgelerin kentin belirli bölgelerinde diğerlerine göre daha yoğun olduğu ve tüm kente hizmet edebilecek homojen bir dağılıma sahip olmadığı sonucuna varılmıştır.

Anahtar Kelimeler: *Açık-yeşil alan, NDVI, uzaktan algılama, landsat 8, Avrupa yeşil mutabakatı*

Citation: Eyileten, B., Esendağlı, Ç. & Selim, S. (2022). Assessment of urban green space distribution within the scope of European green deal using NDVI indice; case of Nicosia/Cyprus. *Architectural Sciences and Applications*, 7 (2), 615-623.
DOI: https://doi.org/10.30785/mbud.1152364

Received: *01/08/2022 –* ***Accepted:*** *03/10/2022*

1. Introduction

Population growth has deepened relationships between people and nature, which has had a negative impact on living conditions due to factors including environmental issues and the depletion of natural resources. All these drawbacks have grown to be significant elements that endanger the planet's future by raising the likelihood that environmental issues on a global scale may have negative consequences (Tuğluer & Çakır, 2019). The rapid and frightening increase in global environmental problems has led the world to take urgent and decisive steps (Arora, Fatima, Mishra, Verma, Mishra & Mishra, 2018). In this context, to prevent global climate change and environmental pollution, The European Green Deal (EGD) was announced by the European Commission in December 2019. This memorandum includes a series of environmental measures, particularly the main aim of achieving carbon neutrality by 2050 (Tutak, Brodny & Bindzár, 2021). Clean air, clean water, healthy soil and biodiversity, smart transportation, sustainable energy, zero waste, and a non-toxic environment can be listed as other important goals in this endeavour also (Sikora, 2021). The consensus's climate and environmental action plans include reducing air-water-soil pollution, as well as protecting biodiversity, and increasing the sustainability of the environment in general (Montanarella & Panagos, 2021). As a matter of fact, this scope has made urban green areas even more important for ecosystem services in terms of their contributions (Selim, 2021). With these facts considered, it can be said that green areas play a crucial role and undertake many ecological functions in reaching the 2050 goals of the European Green Deal, such as balancing the microclimate, carbon sequestration, reducing air pollution, supporting biodiversity, and adjusting the soil-water balance (Semeraro, Scarano, Buccolieri, Santino, & Aarrevaara, 2021).

Green spaces enhance both the physical health and mental well-being of urban residents (WHO, 2017) by offering innovative approaches to enhance the general quality of the urban environment and promote sustainable lifestyles (Selim & Karakuş, 2016). Through urban green spaces; biodiversity is maintained and protected (Schebella, Weber, Schultz, & Weinstein, 2019), wildlife mobility is ensured, ecological links are strengthened (Selim & Demir, 2019), environmental hazards such as air pollution and noise decrease (Feltynowski, Kronenberg, Bergier, Kabisch, ŁAszkiewicz, & Strohbach, 2018), the effects of extreme weather events (heatwaves, heavy rainfall, or floods) are alleviated (Lin & Zhu, 2018), heat island effects are reduced (Arghavani, Malakooti, & Ali Akbari Bidokhti, 2020), and various socio-cultural possibilities arise (Farahani & Maller, 2018). Urban green areas not only enhance the aesthetic appeal of the city but also offer economic, psychological, recreational, and ecological benefits to city dwellers (Tuğluer & Çakır, 2021). Urban green spaces are very crucial urban components to address the recreational needs of city dwellers. The natural and cultural values of a city are considered the wealth of that city. The amount of green space in cities is regarded as a sign of civilization and quality of life (Çakır, 2021). The amount and distribution of urban green areas in the city should also be at a sufficient level in terms of their contribution to it and its inhabitants. Urban green areas are essential parts of both the public open spaces and the communal services that are provided by the city and serve as a health-promoting environment for all demographic and socio-cultural groups of society. Therefore, it is necessary to ensure that public green spaces are readily accessible to all citizens and are distributed equally and fairly all of the city.

Remote Sensing (RS) and Geographical information systems (GIS) technologies are used in many planning studies, especially in land use (Selim & Demir, 2018; Hong, Yokoya, Ge, Chanussot, & Zhu, 2019; Chowdhury, Hasan, & Abdullah-Al-Mamun, 2020; Zheng, Jia, Guo, Chen, Sun, Xiong, & Xu, 2021). These technologies are preferred because they provide fast and accurate results at a low cost (Ardahanlioglu, Selim, Karakus, & Cinar, 2020). For example, the Normalized Difference Vegetation Index (NDVI) can be obtained through remote sensing, with the objective of measuring several different parameters of the vegetation of a given location and acquiring data from it. It is used for the exploration of the vegetation density in an area and the assessment of the changes in plant health (Ke, Im, Lee, Gong, & Ryu, 2015).

In this study, green areas of urban were determined with using RS and GIS technologies, and the distribution and adequacy of these green areas in the city were evaluated within the scope of the European Green Deal (EGD). The NDVI was produced specifically for the study area from current satellite images, the data obtained from these were reclassified with reference to spectral reflectance's, and green areas were determined automatically at the city scale. The distribution of green spaces in the city and the number of users were analysed, and the results obtained from these were used to determine the amount of green area per capita to be compared with international literature. As a result, recommendations specific to the study area have been developed in line with the 2050 targets of the European Green Deal. It is anticipated that this study will be instructive both local and central governments in urban planning and combating the effects of environmental problems/climate change.

2. Material and Method

The steps of the methodology of this study consist of the basic stages of taking inventory, NDVI analysis, and evaluation according to European Green Deal regulations, respectively. The lack of a comprehensive study on the amount and adequacy of urban green spaces in Nicosia/Cyprus constitutes the motivation of this study.

2.1. Study Area

The study area selected as North Nicosia, the most populated city of Northern Cyprus, has the distinction of being the most important cultural, industrial, commercial, and transportation centre. According to the 2021 data of the Supreme Election Board (YSK), the population of Northern Cyprus is 245,869, while the city of Nicosia, located at 35°10'59.32"N and 33°21'44.78"E coordinates (Figure 1), has a population of 79,189 (Kıbrıs Newspaper, 2021). However, due to the fact that it is an important tourist island during the tourism season, it is estimated that this figure reaches around 150,000.

Figure 1. Study area location

Having a hot semi-arid climate according to Köppen climate classification, Nicosia receives the most precipitation in January, while the hottest months of the town are July and August, and the coldest months are January and February. It is known that the city of Nicosia is also very rich in terms of biological diversity (Kaşot, 2013).

According to the data of the Forestry Arrangement Plan made in 2008, the actual forest area of the country is 65,426 hectares, and this value constitutes 19.69% of the country's land. Therefore, it can be said that the country, of which 25,712 hectares (39.30%) is fertile and 39.714 hectares (60.70%) is degraded forest, is covered with approximately 7% productive forests (Devlet Planlama Örgütü, 2010). Considering the presence of trees forming green areas, the most common tree species in Cyprus are oak (*Quercus* sp.), cypress (*Cupressus* sp.), (*Eucalyptus* sp.), and pine (*Pinus* sp.). Apart from these, Cyprus acacia (*Acacia cyanophylla*), pomegranate (*Punica granatum*), olive (*Olea* sp.), and citrus (*Citrus* sp.) trees can also be seen. In addition, there are many dwarf plants as well as deciduous trees in the forests (Kuzey Kıbrıs'ta Doğal Yaşam – Flora, 2009).

2.2. Method

Freely accessible images of the Landsat 8 Satellite, officially named Landsat Data Continuity Mission (LDCM) and launched with the Atlas-V rocket in 2013, were chosen to be used in the research. Due to the satellite's carrying Operational Terrain Imager (OLI) and Thermal Infrared Sensor (TIRS) appliances, OLI (Table 1) bands were preferred to generate NDVI (USGS, 2018).

Table 1. Landsat 8 spectral bands used

Spectral Range	Wavelength	Spatial Resolution (meters)
Blue (Band 2)	0.45 - 0.51 µm	30
Green (Band 3)	0.53 - 0.59 µm	30
Red (Band 4)	0.64 - 0.67 µm	30
Near Infrared (Band 5)	0.85 - 0.88 µm	30

After obtaining satellite images, pre-processing and NDVI stages were started. The method flowchart is shown below that Figure 2.

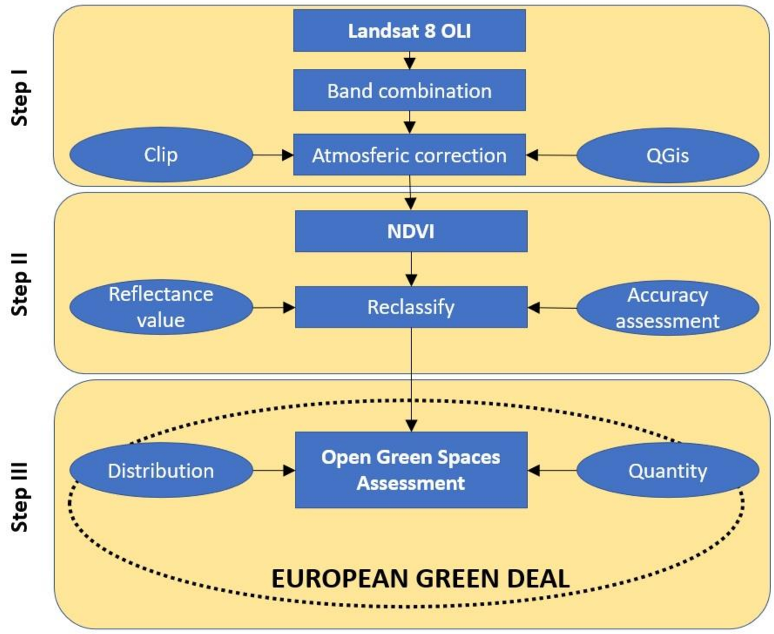

Figure 2. Method flowchart

2.3. Radiometric/Atmospheric Correction

Landsat 8 data is known to have low accuracy about radiometric when used to generate information such as land use classification, vegetation indices, and biomass (Muchsin, Supriatna, Harmoko, Prasasti, Rahayu, Fibriawati, & Pradhono, 2022). Therefore, amend of remote sensing images is required to enhance the quality of pixel values and correct possible radiometric errors (Kamal, Muhammad, & Mahardhika, 2020; Czapla-Myers, McCorkel, Anderson, Thome, Biggar, Helder, Aaron, Leigh, & Mishra, 2015). For this reason, within this study's scope, the QGIS program was used for the atmospheric correction process, and the operations performed throughout the program are given in Figure 3, respectively.

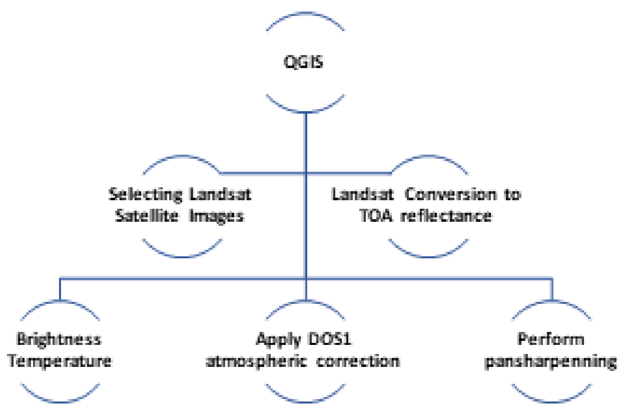

Figure 3. Atmospheric correction with open access QGIS

By converting the digital numbers (DN) of the Landsat 8 OLI data pixels to the Above Atmosphere (TOA) Reflection value, the radiometric correction was made, and the TOA formula given below was used.

$$\rho\lambda' = M\rho * Qcal * A\rho$$

$\rho\lambda'$ = TOA planetary reflectance (solar angle will be corrected later)

$M\rho$ = Band-specific multiplicative rescaling factor from the MTL file (REFLECTANCE_ADD_BAND_x, where x is the band number)

Qcal = Quantized and calibrated standard product pixel values (DN)

$A\rho$ = Band-specific additive rescaling factor from the MTL file (REFLECTANCE_ADD_BAND_x, where x is the band number).

Thus, the atmospheric correction of the Landsat satellite images was completed by applying the steps, and then the data was transferred to the ArcGIS program for NDVI calculation.

2.4. NDVI

The Normalized Difference Vegetation Index (NDVI) describes the vegetation rate by measuring the difference in the near-infrared portion of the electromagnetic spectrum that is strongly reflected by green vegetation and the red portion of the spectrum absorbed by vegetation. (Malik, Shukla, & Mishra, 2019). NDVI was calculated with the following equation (1) using Landsat 8's NIR and Red Bands in ArcGIS software.

$$NDVI = \frac{\text{NIR} - \text{Red}}{\text{NIR} + \text{Red}}$$

NDVI values range from +1.0 to -1.0. Areas of sand, rock, bare or snow show quite low NDVI values, usually 0.1 or less. Sparse vegetation such as grassland and shrubs or aging green cover has moderate NDVI values corresponding to the 0.2 to 0.5 range. High NDVI values in the range of 0.6 to 0.9 occur in tropical forests and areas with dense vegetation (USGS, 2018). However, these values may vary slightly depending on the physical and ecological characteristics of the study area.

2.5. Results

Within the scope of the study area, first, NDVI ranges determined in the literature were used, and after the controls of these values were made on the current map, they were reclassified. According to the data, it was seen that the NDVI image took a value between -0.6 and 0.9. With reference to certain sampling points on the map, the NDVI value ranges were determined as 0.8 - 1.0 for Dense vegetation cover, 0.4 - 0.8 for Sparse vegetation cover, and -1.0 to 0.4 for non-vegetation cover (Figure 4). These operations were obtained by reclassifying the NDVI generated from the Landsat 8 satellite image corrected by radiometric correction using the Spatial Analyst Tool in ArcGIS software.

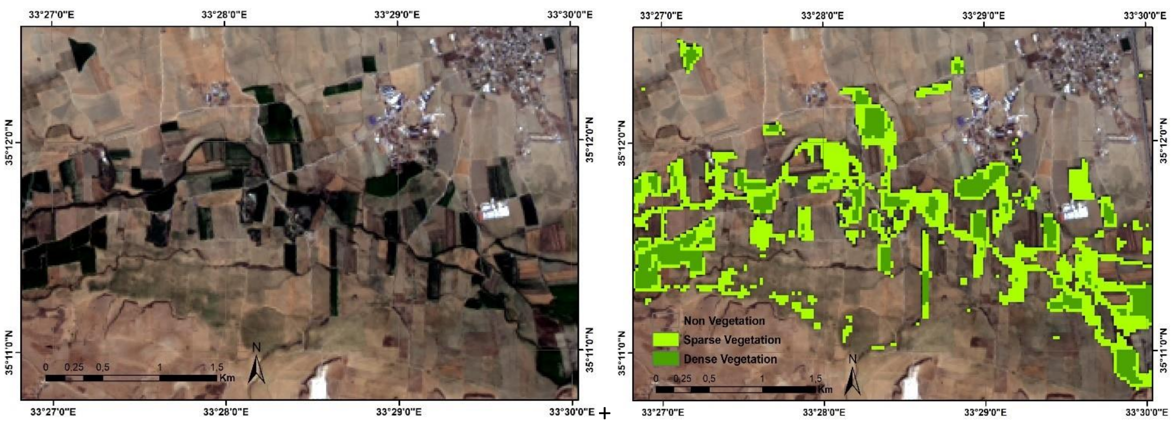

Figure 4. Example of reclassified NDVI image (Before NDVI above, after NDVI below)

Since the satellite image used in the study has a resolution of 15m x 15m, the reclassification data showed that the non-Vegetation class covers an area of 458.7 km², Sparse Vegetation class covers 14.8

km², and Dense Vegetation class covers 1.16 km²; corresponding to "2038704", "66188" and "5172" pixels respectively (Figure 5).

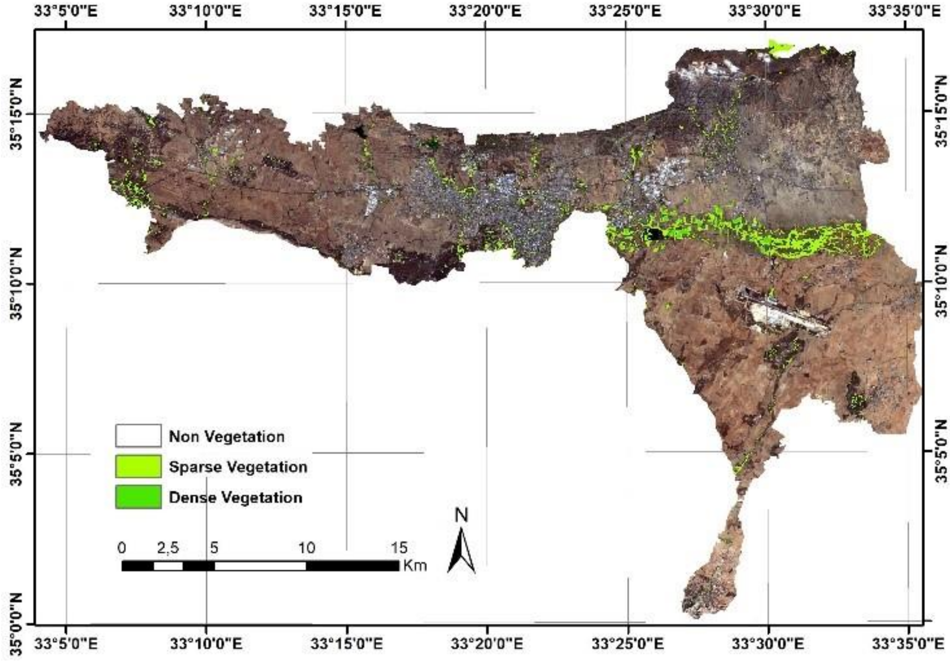

Figure 5. North Nicosia classified NDVI image results

The total area of North Nicosia, produced from Landsat 8 satellite images and is the subject of the study, is 474,754 km². 15.96 km² of this area has been determined as green areas, consisting of sparse and dense vegetation. The total green areas in the study area are spread over Nicosia central region, Değirmenlik region and Ercan region and constitute %2.97. However, it is seen that the green areas in the city centre are not in an interconnected system. Although the amount of green space in the northern and southern parts of the region is quite low, the existence of a linear green area in the east-west direction of the city draws attention. In addition to these, partially dense green areas were determined due to the presence of forests at the northern and western ends of the study area.

4. Discussion and Conclusion

In this study, the open green areas of the Northern Nicosia region of Cyprus, which has an island ecology, were tried to be determined by NDVI generated from Landsat 8 satellite images. According to 2007 data, although the amount of green space in the Nicosia district is %3.77 of the total area (KKTC Tarım Bakanlığı, 2007), the rate of green space obtained within the scope of this study is %2.97. By considering the population growth and development of the city and the region in the last 15 years, it can be said that there is a partial pressure on green areas, and an assessment can be made that this decrease in green areas is due to this pressure.

The amount of green space, which is accepted as an indicator of the level of urban development (Artmann, Inostroza, & Fan, 2019), was determined as 200 m² per person in the study area. However, this rate was found to be quite low since it covers about %3 of the entire area. In addition, it has been determined that most of the green areas in the region are independent and disconnected from each other. This situation leads to the conclusion that the study area could not benefit from the benefits of interconnected green space systems, which are an output of the European Green Deal. As stated in the European Green Deal titles, protecting, and developing the ecosystem and biodiversity, and ensuring sustainable and intelligent mobility can only be possible with the provision of green infrastructure, an interconnected green space system (Liu & Russo, 2021). The green areas of North Nicosia, which are independent of each other and have a non-homogeneous distribution throughout the city, pass over benefit from the profits of the green infrastructure system because unplanned connections.

Aiming to zero greenhouse gas emissions by 2050, support ecosystem services, increase biodiversity, and enable sustainable and intelligent mobility (Sikora, 2021), the European Green Deal should not be the target of only European cities or countries that have signed the Agreement. Instead, all countries and cities in the world must take steps together to support ecosystem services that know no political borders and achieve the ecological success targeted within the framework of the Agreement.

As a result, by using RS and GIS, open green spaces in the relevant area were analysed quickly and practically, their quantities and general distribution in the region were defined. The scope of this study revealed that the determination of the current situation is the first step toward the healthy development of ecological processes. To achieve the goals of the European Green Deal, central and local governments need to create green infrastructure strategies and make ecological planning starting from the local scale in the following stages. The results of this study determined the green areas necessary for the creation of green infrastructure systems at the regional scale and created an infrastructure for the planners in line with the European Green Deal goals.

Acknowledgement and Information Note

An oral presentation of this study was made in TUFUAB 2022: XI. Turkish National Photogrammetry and Remote Sensing Association Technical Symposium. And the abstract of this article was published in the abstract booklet of the same conference. The article complies with national and international research and publication ethics. Ethics committee permission was not required for the study.

Author Contribution and Conflict of Interest Declaration Information

The first author contributed 25%, the second author 35% and the third author 40%. All authors have read and approved the final version of the article. There is no conflict of interest.

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