TẠP CHÍ KHOA HỌC & CÔNG NGHỆ ĐẠI HỌC DUY TÂN
DTU Journal of Science and Technology 01(56) (2023) 9-15
TRƯỜNG ĐẠI HỌC DUY TÂN
DUYTAN UNIVERSITY

Remote sensing-based mapping of urban green space in Da Nang

Xây dựng bản đồ không gian xanh đô thị tại Đà Nẵng từ dữ liệu ảnh viễn thám

Hoang Nhat Duc[a,b*], Nguyen Quoc Lam[b]
Hoàng Nhật Đức[a,b*], Nguyễn Quốc Lâm[b]

[a]*Institute of Research and Development, Duy Tan University, Da Nang, 550000, Vietnam*
[a]*Viện Nghiên cứu và Phát triển Công nghệ Cao, Đại học Duy Tân, Đà Nẵng, Việt Nam*
[b]*Faculty of Civil Engineering, Duy Tan University, Da Nang, 550000, Vietnam*
[b]*Khoa Xây dựng, Trường Đại học Duy Tân, Đà Nẵng, Việt Nam*

(Ngày nhận bài: 18/11/2022, ngày phản biện xong: 18/12/2022, ngày chấp nhận đăng: 02/02/2023)

Abstract

Urbanization creates various challenging issues, such as air pollution, noise pollution, traffic accidents, and heat island effects. These issues have flagged up the need for solutions to enhance public health in urban environments. It is evident that urban green spaces bring about significant physical and psychological benefits. Therefore, information on their spatial distribution is crucial for urban management and planning. This paper relies on remote sensing images, collected from Sentinel-2 satellite, to preliminarily map the green space in Da Nang city. The remote sensing data was collected in November 2022. The normalized difference vegetation index (NDVI) is used to recognize the green space pixels. Based on this preliminary study, the area of green space in Da Nang city is approximately 140 km^2, which occupies roughly 56% of the total urban area.

Keywords: Urban green space; Remote sensing; Sentinel-2; NDVI.

Tóm tắt

Đô thị hóa tạo ra nhiều thách thức như vấn đề về ô nhiễm không khí, ô nhiễm tiếng ồn, tại nạn giao thong, và hiệu ứng nhiệt đô thị. Các vấn đề đó đòi hỏi những giải pháp để nâng cao sức khỏe cộng đồng trong môi trường đô thị. Các không gian xanh trong đô thị đem lại nhiều lợi ích rõ ràng về sức khỏe cơ thể và tinh thần. Do đó, thông tin về sự phân bố của chúng là rất quan trọng cho công tác quản lý và hoạch định đô thị. Bài báo của chúng tôi sử dụng dữ liệu ảnh viễn thám, được thu nhận từ vệ tinh Sentinel-2, để xây dựng bản đồ sơ bộ về không gian xanh tại Đà Nẵng. Dữ liệu ảnh đã được chúng tôi thu thập trong tháng 11 năm 2022. Chỉ số thực vật (NDVI) được sử dụng để nhận diện các điểm ảnh thuộc về các vùng không gian xanh. Thông qua phân tích sơ bộ, diện tích của các vùng xanh tại Đà Nẵng là khoảng 140 km^2, chiếm khoảng 56% diện tích của khu vực được khảo sát.

Từ khóa: Không gian xanh; Viễn thám; Sentinel-2; NDVI.

[*]*Corresponding Author:* Hoang Nhat Duc, Institute of Research and Development, Duy Tan University, Da Nang, 550000, Vietnam; Faculty of Civil Engineering, Duy Tan University, Da Nang, 550000, Vietnam.
Email: hoangnhatduc@duytan.edu.vn

1. Introduction

The fast pace of land use transformations and urban development creates ever-increasing pressures on the surrounding environment and ecosystems. Globally, a dramatic demographic shift towards urbanization is occurring. Between 2000 and 2050, the proportion of people residing in urban areas is expected to increase from 46.6 to 69.6% [1]. The process of urbanization brings about various challenging issues, including air pollution, noise pollution, traffic accidents, and heat island effects [2]. Hence, urban developers must find a trade-off between various objectives, such as economic development, ecosystem preservation, and urban sustainability [3].

To ensure the sustainable development of urban area, it is required to promote public health in urban populations via green spaces [4]. Through their purported effects on various physical activities, physical and psychological benefits that are linked to green spaces were demonstrated [5]. Observable health benefits of physical activity related to the use of public green space have been documented, such as the reduction in diabetes [6]. The improvements in mental functioning, mental health, and longevity can be attributed to green space [7-9].

Hence, information on the spatial distribution of green space is crucial for urban management and planning [10]. This paper uses remote sensing images, collected from Sentinel-2 satellite collected in November 2022, to preliminarily map the green space in Da Nang city. The normalized difference vegetation index (NDVI) is employed to categorize the pixels in the study area into two classes: green space and non-green space. The remote sensing data are processed by the Arcmap 10.8 package [11].

2. Research method

This study relies on remotely sensed data that was obtained from the Sentinel-2 satellite in November 2022. The employed spectral bands are band 2 (blue), band 3 (green), band 4 (red), and band 8 (near infrared). The basic information about the spectral bands is provided in Table 1. The spatial resolution of these bands is 10m. Based on the individual spectral bands, various band composites can be constructed to facilitate the photo-interpretation and observation of the study area [12]. The overview of the Da Nang study area is provided in Fig. 2.1.

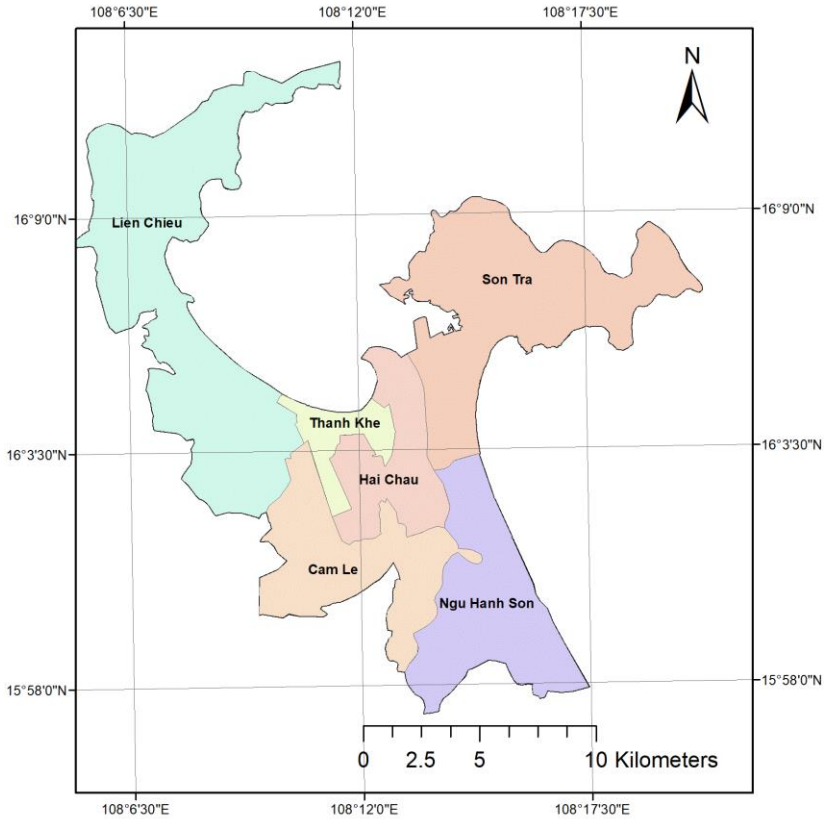

Fig. 2.1 The study area

Table 1. The used spectral bands of Sentinel-2

Band number	Band name	Spatial resolution (m)
2	Blue	10
3	Green	10
4	Red	10
8	Visible and Near Infrared (NIR)	10

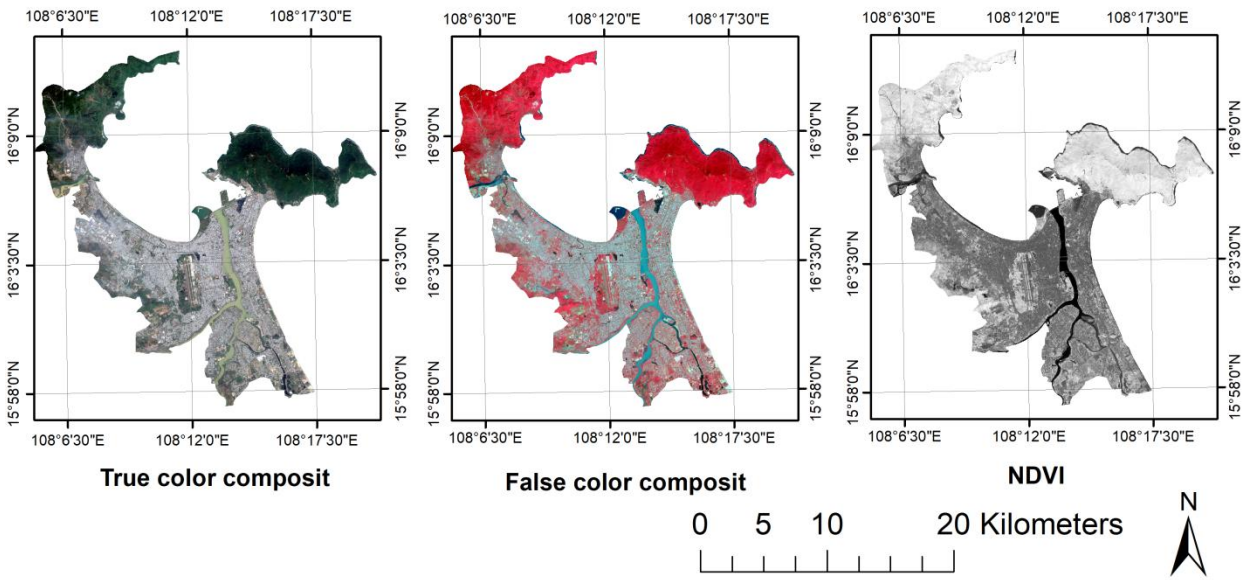

Fig. 2.2 The used remote sensing images: (a) True color composite, (b) False color composite, and (c) NDVI

The true color band composite includes bands 2, 3 and 4 (refer to Fig. 2.2). The colors of the bands, used in this composite, all fall into the visible range of the electromagnetic spectrum. In addition, the color infrared composite (or false color composite) (refer to Fig. 2.1) assigns the NIR, red, and green bands to the Red, Green, and Blue channels of an image, respectively. Generally, this band composite facilitates the recognition of areas covered with vegetation that are shades of red [13]. In addition, the NDVI is a widely used index for quantifying the greenness of an area [14, 15]. Notably, healthy vegetation tends to reflect strong NIR and green light. The NDVI values of the study are shown in Fig. 2.1. The NDVI values range from -1 to +1. Dense green leaves are often characterized by an NDVI value close to 1. Negative values of the NDVI indicate bodies of water. Low positive values point out that there is no green area. This index can be computed as follows:

$$NDVI = \frac{B8 - B4}{B8 + B4} \quad (1)$$

where $B8$ and $B4$ represent the band 8 and band 4, respectively.

3. Result

In the first step, the true color and false color composites are used to inspect the study area and identify green space and non-green space areas. Using the first composite, healthy vegetation is displayed as green color. Urban areas are characterized by shades of white and gray colors. In addition, water bodies are shown as dark blue shapes [13]. Meanwhile, using the second composite, shades of red indicate areas covered by vegetation. Deep red hues show areas with broad leaf and/or healthier vegetation. Grasslands or sparsely vegetated areas are characterized by light red hues. Impervious surfaces appear in cyan and soils are identified by shapes of brown [13]. Via inspection of these color composites and additional verifications with Google Earth, 100 green space locations and 100 non-green space locations are identified. The NDVI values of those locations are extracted from the map of the study area. Various thresholds are used to determine the most suitable NDVI value that yields the highest classification accuracy rate (CAR). It is experimentally found that the threshold value of 0.185 results in the best outcome with CAR = 97% (refer to Fig. 3.1).

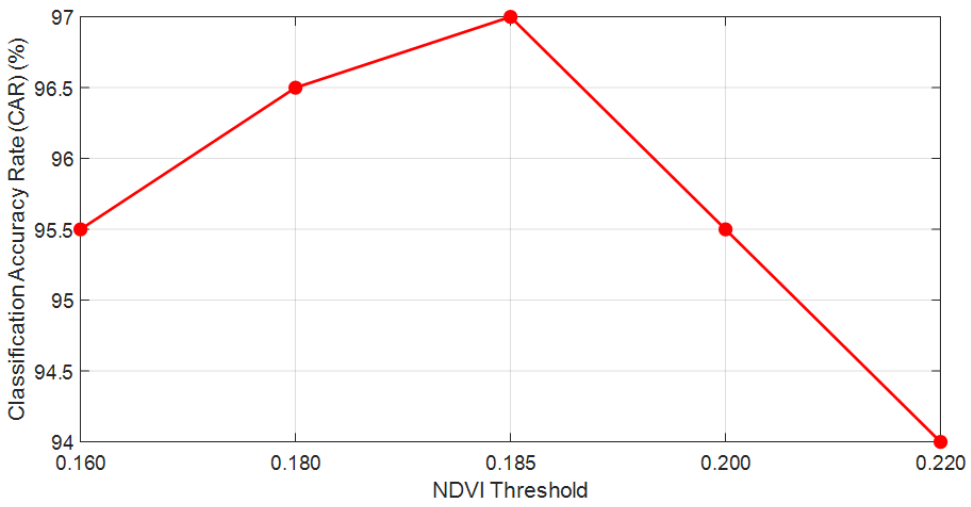

Fig. 3.1 Classification accuracy rate (CAR) with respect to different thresholds of NDVI

Accordingly, a green space map is constructed using the aforementioned threshold of the NDVI value. This map is shown in Fig. 3.2. As can be seen from the map, the central areas, which are the northern section of Hai Chau district and the eastern section of Thanh Khe district, have a relatively low density of green space. Meanwhile, the northern part of Son Tra district (or Son Tra Peninsula) has a robust green space due to the fact that this area is a natural preservation area under the protection of the national forest regulation. The northern part of Lien Chieu district is an undeveloped area with a high proportion of green space. At the fringe of the city center, there is a combination of different land covers. These areas, located in the south of the city, are characterized by a low density of residential areas and farmlands. In the areas along Cam Le and Do Toa rivers, there are notable patches of wetlands and green spaces. Based on the Arcmap package's calculations, the area of the green space area is about 140 km^2, which corresponds to about 56% of the total area. Based on these findings, it is recommended that the local authority preserves the existing green spaces of the study area and enhance the green spaces in the central areas of Hai Chau and Thanh Khe districts. Based on [16], it is recommended to develop green spaces near water bodies where possible and design green spaces that are decently large for meaningful social interaction in the local areas.

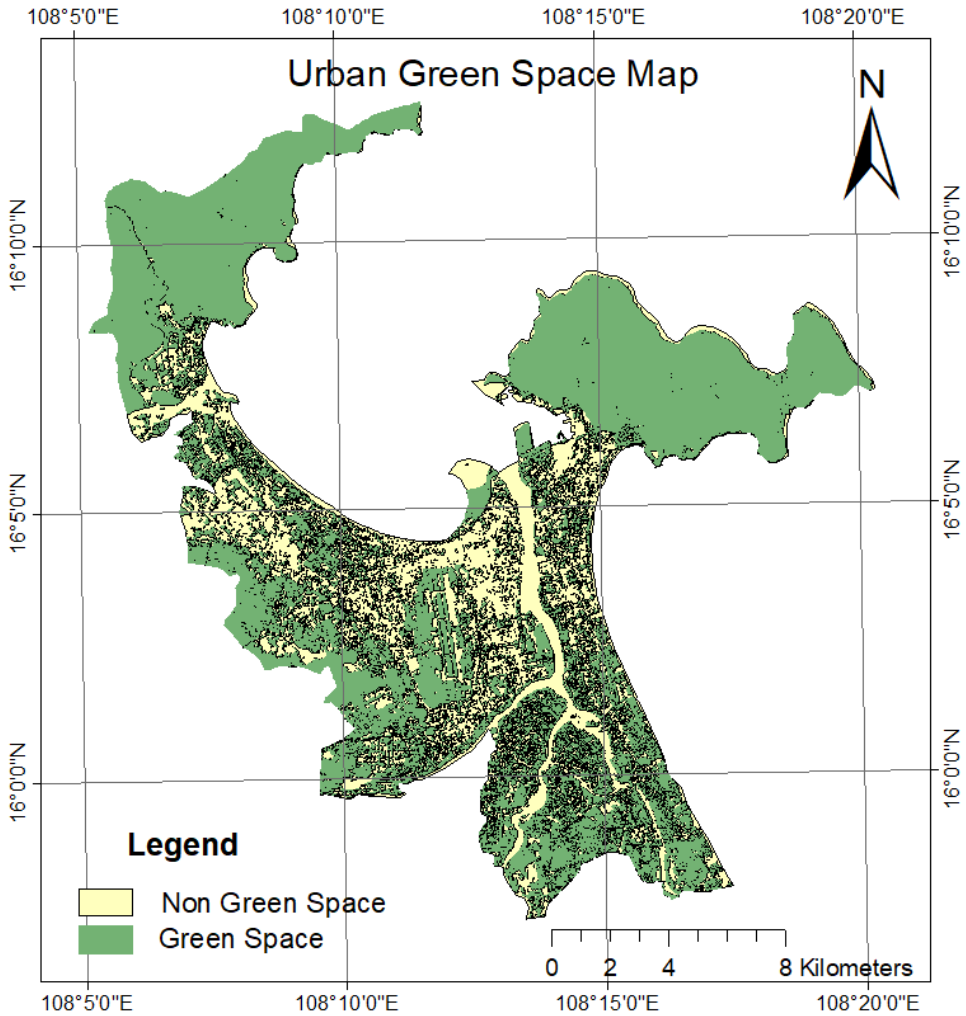

Fig. 3.2 The constructed green space map of Da Nang

4. Conclusion

This paper has presented a method for quick assessment of the spatial distribution of urban green spaces. Remote sensing images, collected from the Sentinel-2 satellite, are used to map the green space in Da Nang city. A NDVI map of the study area is used to recognize green space pixels. Based on the data collected in November 2022, it is preliminarily estimated that the area of green space in Da Nang city is approximately 140km^2, which occupies roughly 56% of the total urban area. However, it is apparent that the green spaces are not evenly distributed. The green spaces in the central areas of Hai Chau and Thanh Khe districts are sparse. Meanwhile, the majority of the green space is located in Son Tra peninsula, the underdeveloped areas in Lien Chieu district, as well as wet lands along Cam Le and Do Toa rivers.

Although the proposed method helps quickly attain spatial information on urban green space, it only provides a preliminary assessment on the subject of interest. It is because the method only relied on NDVI as the predictor variable for delineating green space from non-green space. In addition, the classification model is only assessed at 200 sampled points within the study area. The reliability and accuracy of the current method should be enhanced by employing more sophisticated data classifiers and sampling more points in future works. Moreover, the current study only considers the green space covered by vegetation, water bodies were excluded from the analysis. However, according to [16], surface water should also be taken into account. Thus, the actual green space of the study area can be larger if the area of water bodies is considered. In a future study, urban green spaces, including land covered by vegetation and surface water, can be mapped to provide a more comprehensive view of the land cover in Da Nang city.

References

[1] UNs (2007). *World Urbanization Prospects: The 2007 Revision Population Database [online]*. Population Division of the Department of Economic and Social Affairs. http://www.esa.un.org/unup/

[2] A.J. McMichael (2000). *The urban environment and health in a world of increasing globalisation: issues for developing countries*. Bull World Health Organ 78 (9):1117–1126

[3] G. Pulighe, F. Fava, F. Lupia (2016). *Insights and opportunities from mapping ecosystem services of urban green spaces and potentials in planning*. Ecosystem Services 22:1-10. doi:https://doi.org/10.1016/j.ecoser.2016.09.004

[4] A.C.K. Lee, R. Maheswaran (2010). *The health benefits of urban green spaces: a review of the evidence*. Journal of Public Health 33 (2):212-222. doi:10.1093/pubmed/fdq068

[5] M. N. (2003). *Health, well-being and open space: literature review*. Edinburgh: OPENspace

[6] G.C.M. Gast, F.J.M. Frenken, L.A.T.M. van Leest, G.C.W. Wendel-Vos, W.J.E. Bemelmans (2007). *Intra-national variation in trends in overweight and leisure time physical activities in The Netherlands since 1980: stratification according to sex, age and urbanisation degree*. International Journal of Obesity 31 (3):515-520. doi:10.1038/sj.ijo.0803429

[7] T. Sugiyama, E. Leslie, B. Giles-Corti, N. Owen (2008). *Associations of neighbourhood greenness with physical and mental health: do walking, social coherence and local social interaction explain the relationships?* Journal of Epidemiology and Community Health 62 (5):e9-e9. doi:10.1136/jech.2007.064287

[8] A. Sacker, N. Cable (2005). *Do adolescent leisure-time physical activities foster health and well-being in adulthood? Evidence from two British birth cohorts*. European Journal of Public Health 16 (3):331-335. doi:10.1093/eurpub/cki189

[9] T. Takano, K. Nakamura, M. Watanabe (2002). *Urban residential environments and senior citizens' longevity in megacity areas: the importance of walkable green spaces*. Journal of Epidemiology and Community Health 56 (12):913-918. doi:10.1136/jech.56.12.913

[10] N.-D. Hoang, X.-L. Tran (2021). *Remote Sensing–Based Urban Green Space Detection Using Marine Predators Algorithm Optimized Machine Learning Approach*. Mathematical Problems in Engineering 2021:5586913. doi:10.1155/2021/5586913

[11] Esri (2022). *Get started with ArcMap*. <https://desktop.arcgis.com/en/arcmap/latest/get-started/main/get-started-with-arcmap.htm>

[12] S. Staridas (2022). *How to Make Outstanding Maps with Sentinel-2 and ArcGIS Pro – Part 1: Band Combinations*. <https://www.staridasgeography.gr/how-to-make-outstanding-maps-with-sentinel-2-and-arcgis-pro-part-1-band-combinations/>

[13] Gisgeography (2022). *Sentinel 2 Bands and Combinations*. <https://gisgeography.com/sentinel-2-bands-combinations/>

[14] Gisgeography (2022). *What is NDVI (Normalized Difference Vegetation Index)?* <https://gisgeography.com/ndvi-normalized-difference-vegetation-index/>

[15] S. Shekhar, J. Aryal (2019). *Role of geospatial technology in understanding urban green space of Kalaburagi city for sustainable planning*. Urban Forestry & Urban Greening 46:126450. doi:https://doi.org/10.1016/j.ufug.2019.126450

[16] U.G. Sandstrom (2002). *Green Infrastructure Planning in Urban Sweden*. Planning Practice & Research 17 (4):373-385. doi:10.1080/02697450216356