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Use of NDVI and NDBI Indices for Assessing Built-Up Areas of Kyiv (Case Study of the Darnytskyi District)

***T. Kostyrko, I. Stakhiv, T. Shovkoplias, T. Pastushenko** (*Taras Shevchenko National University of Kyiv*), **I. Tsyguliov** *(National University of Bioresources and Nature Management of Ukraine)*

SUMMARY

This study examines changes in vegetation cover and built-up areas in the Darnytskyi District of Kyiv using remote sensing data and geoinformation technologies. The aim of the research is to assess the dynamics of vegetation cover and built-up areas during the period of 2016–2025 and to verify the compliance of actual land use with urban planning documentation. Sentinel-2 satellite imagery was used for the analysis, on the basis of which the NDVI and NDBI indices were calculated. The results revealed a decrease in vegetation cover by approximately 12%, which is associated with rapid development and urbanization of the area. The obtained results confirm the effectiveness of Sentinel-2 satellite data, NDVI and NDBI indices, as well as GIS technologies for monitoring land-cover changes, assessing urbanization processes, and controlling compliance between actual land use and urban planning documentation.

Keywords: NDVI; NDBI; Land assessment; Remote Sensing; Geographic information systems.

Corresponding Author: kostirkot@gmail.com

Introduction

In today’s world, as cities are growing at an extraordinary rate, an key challenge is to create comfortable living conditions for the population; therefore, obtaining timely, reliable, and up-to-date information on urban development, the state of the territory, built-up areas, and changes in land use is of paramount importance. Traditional assessment methods based on field surveys and statistical data have a number of limitations: they are labor-intensive, require significant financial resources, and do not provide sufficient operational efficiency. Consequently, the role of remote sensing is continuously increasing, as it enables regular monitoring of large areas with high accuracy (Naser et al., 2025).

One of the key environmental indicators is vegetation cover, which reflects both the natural characteristics of an area and the extent of its anthropogenic transformation (Byalyi et al., 2026). In urban areas, the level of greening determines environmental quality and living comfort. The amount of green space in urban regions is negatively affected by the pace of urbanization. Due to the rapid development of urban areas worldwide, the amount of green space is decreasing (Kaufmann et al., 2007), which increases pressure on urban infrastructure and leads to continuous changes in land development patterns. Remote sensing, multispectral satellite imagery, and multitemporal Earth observation data provide reliable scientific tools for calculating built-up areas and analyzing their use.

Objective. To assess the dynamics and spatial distribution of built-up areas in the Darnytskyi district of Kyiv based on the combined use of satellite indices NDVI and NDBI for the analysis of urbanization changes.

Method and Theory

The research methodology involves the use of Earth observation satellite data, their geoinformation processing, the calculation of spectral indices, and the subsequent analysis of spatial patterns within the study area. Multispectral Sentinel-2 satellite imagery, acquired as part of the Copernicus program, was used as the primary data source.

Satellite data processing was carried out using ArcGIS and QGIS software. Within the framework of the study, NDVI and NDBI indices were calculated for two time periods: 2016 and 2025.

The Normalized Difference Vegetation Index (NDVI) (1) was used to assess the condition and density of vegetation cover and to distinguish green areas from other land-cover types:

$$NDVI = \frac{NIR - Red}{NIR + Red} \tag{1}$$

where:
NIR – the amount of near-infrared radiation reflected by the surface;
Red – the amount of visible red radiation reflected by the surface (Normalized Difference Vegetation Index, 2026).

At the same time, the Normalized Difference Built-up Index (NDBI) (2) is characterized by increased sensitivity to built-up surfaces and is used for detecting and mapping urbanized areas:

$$NDBI = \frac{SWIR - NIR}{SWIR + NIR} \tag{2}$$

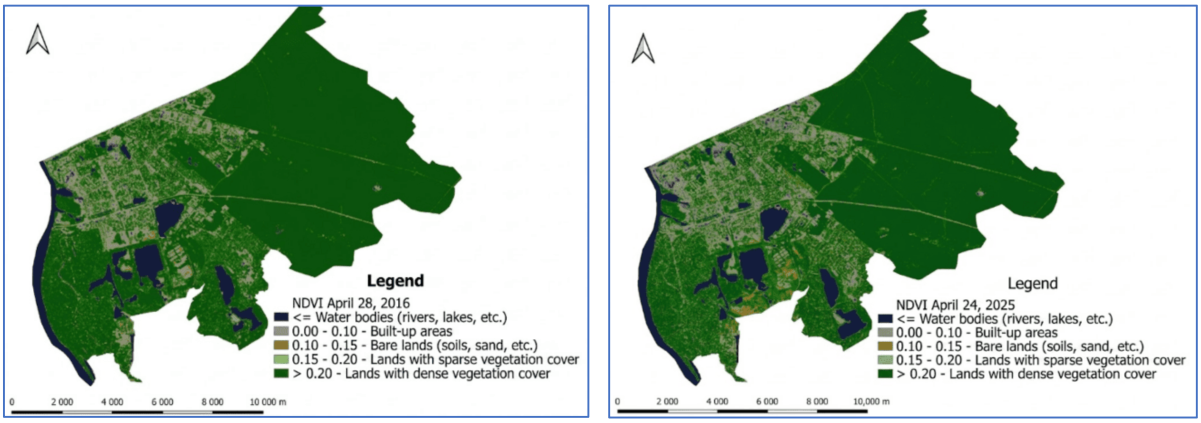
where:
NIR – the amount of near-infrared radiation reflected by the surface;
SWIR – the amount of shortwave infrared radiation reflected by the surface (Normalized Difference Built-up Index: Urban Change Guide, 2026).
The NDBI index is an effective tool for identifying built-up areas; however, its application has certain limitations. NDBI values may be similar not only for artificial surfaces but also for bare soil, sandy

surfaces, quarries, and other areas with sparse vegetation cover. Therefore, the use of NDBI alone may lead to the misclassification of certain land-cover types as built-up areas.

The study area is the Darnytskyi District of Kyiv, which is characterized by intensive development rates and active urbanization processes. During the period 2016–2025, the district became one of the leaders in the expansion of residential and public development areas. At the same time, the construction of new facilities was accompanied by a reduction in green spaces (General Plan of Kyiv, 2015).

Results

Based on the calculated NDVI values, distribution maps were created for 2016 and 2025 (Fig. 1).



28.04.2016 *21.04.2025*

Figure 1. *NDVI distribution maps for the Darnytskyi District of Kyiv based on Sentinel-2 imagery for the period 2016–2025*

The analysis of the obtained NDVI values showed that the highest index values are characteristic of areas with dense vegetation cover, particularly forested areas and green spaces. Low NDVI values mainly correspond to built-up areas, bare soil, and transportation infrastructure. A comparison of the results for 2016 and 2025 revealed changes in the spatial distribution of vegetation cover, manifested by an increase in areas with low index values and a local reduction in territories covered by dense vegetation.

Based on the calculated NDBI values, distribution maps were also created for 2016 and 2025 (Fig. 2).

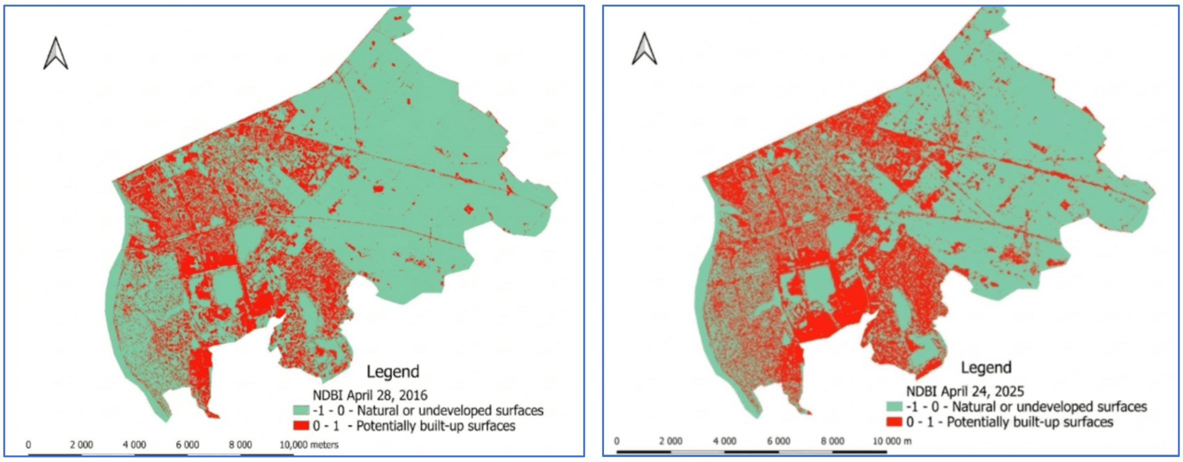


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Figure 2. *NDBI distribution maps for the Darnytskyi District of Kyiv based on Sentinel-2 imagery for 2016 and 2025*

The calculated NDBI values made it possible to identify built-up areas and assess their changes during the study period. A comparison of the maps for 2016 and 2025 showed an increase in areas with positive index values, which are typical of urbanized territories.

To improve the reliability of the results, it is advisable to use NDBI in combination with other spectral indices, particularly NDVI, which allows a more accurate distinction between built-up and non-built-up areas (Fig. 3).

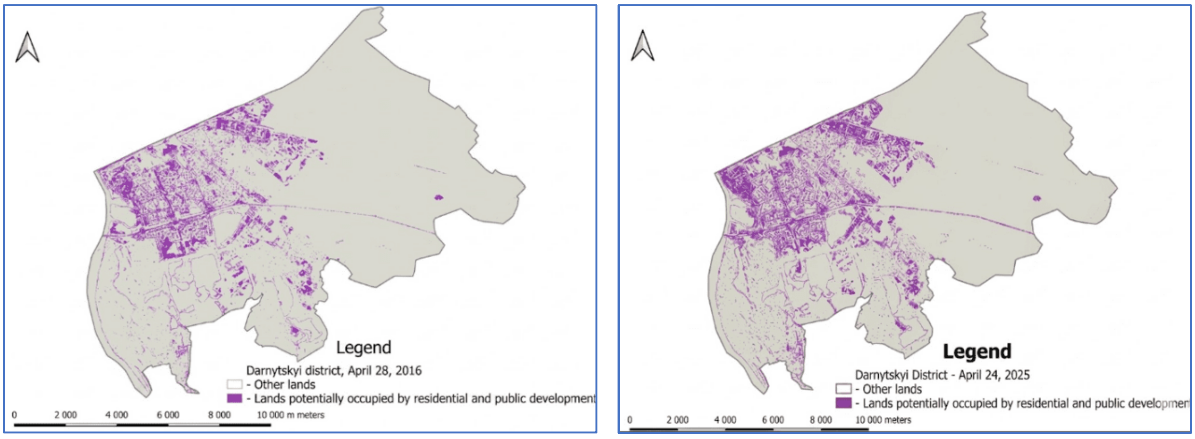

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Figure 3. *Cartographic representation of built-up areas obtained through the processing and vectorization of index analysis results*

Based on the combined analysis of NDVI and NDBI indices, areas potentially occupied by residential and public development were identified. The resulting raster images were converted into vector format. Prior to vectorization, raster data were reclassified using the Reclassify tool in the ArcGIS environment, which enabled the identification of classes corresponding to vegetation and built-up land cover.

Using the obtained NDVI and NDBI distributions for the Darnytskyi District of Kyiv, a comparative analysis of vegetation cover and built-up area changes was performed for the period from 2016 (Table 1) to 2025 (Table 2).

Table 1. *Dynamics of vegetation cover and built-up areas in the Darnytskyi District of Kyiv in 2016*

Land-cover type	Area, km²
Built-up land	35.9340
Vegetated land	87.3649
Other land	4.3261

Table 2. *Dynamics of vegetation cover and built-up areas in the Darnytskyi District of Kyiv in 2025*

Land-cover type	Area, km²
Built-up land	40.2541
Vegetated land	76.5939
Other land	10.7770

According to the obtained results, the area and density of residential and public development increased by approximately 10%, indicating the expansion of the urban environment. At the same time, the area covered by vegetation decreased by approximately 12%. These differences may also be associated with seasonal factors, differences in image acquisition dates, illumination conditions, and variations in vegetation conditions during specific years.

Conclusions

The study analyzed the spatiotemporal changes in land cover within the Darnytskyi District of Kyiv during the period 2016–2025 using remote sensing data and geoinformation technologies. The application of NDVI and NDBI indices derived from Sentinel-2 satellite imagery enabled a quantitative assessment of changes in vegetation cover and built-up areas.

A decrease in vegetation cover of approximately 12% was identified during the study period. The most pronounced changes were observed in the central and northern parts of the district. At the same time, an increase in built-up areas was detected, reflected by higher NDBI values. The highest concentration of these changes was observed along major transportation routes and within newly developed residential areas.

The results indicate a persistent trend toward the reduction of vegetation cover and the expansion of urbanized areas within the Darnytskyi District. The obtained data can be used for monitoring land-cover changes, assessing the environmental condition of urban areas, and supporting decision-making in the field of urban planning.

References

Boori, M. S., Netzband, M., Choudhary, K., & Voženílek, V. (2015). Monitoring and modeling of urban sprawl through remote sensing and GIS in Kuala Lumpur, Malaysia. *Ecological Processes, 4*(1), Article 15. https://doi.org/10.1186/s13717-015-0040-2

Byalyi, M., Andrievska, A., Stakhiv, I., & Pastushenko, T. (2026). Monitoring the environmental consequences of war using geographic information systems and remote sensing. *Bulletin of the Taras Shevchenko National University of Kyiv. Geology, 1*(112), 133–146. https://doi.org/10.17721/1728-2713.112.15

EOS. (2026, March 22). *Normalized difference vegetation index (NDVI).* https://eos.com/blog/normalized-difference-vegetation-index-or-ndvi/

EOS. (n.d.). *Normalized difference vegetation index (NDVI).* https://eos.com/uk/blog/ndvi-pytannia-i-vidpovidi/

Kaufmann, R. K., Seto, K. C., Schneider, A., Liu, Z., Zhou, L., & Wang, W. (2007). Climate response to rapid urban growth: Evidence of a human-induced precipitation deficit. *Journal of Climate, 20*(10), 2299–2306. https://doi.org/10.1175/JCLI4109.1

Kyiv City State Administration (Executive Body of Kyiv City Council), Department of Urban Planning and Architecture, & Municipal Organization “Institute of General Plan of Kyiv.” (2015). *General plan of Kyiv.*

Naser, N. F., Ibraheem, I. F., & AlHadithi, M. (2025). Integrated index analysis for monitoring urban growth based on GIS and remote sensing data in Karbala province, Iraq. *Geodesy and Cartography, 51*(3), 131–140. https://doi.org/10.3846/gac.2025.19884