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Monitoring of Deforestation in the Democratic Republic of the Congo in the Kisangani Region Using Earth Observation Data (2017-2026)

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SUMMARY

This study presents a comprehensive monitoring and quantitative assessment of deforestation and vegetation cover degradation in the Democratic Republic of the Congo, Kisangani (Tshopo Province), over the period 2017-2026. The research is based on Earth observation data and spatial analysis tools. Through the calculation of the Normalized Difference Vegetation Index (NDVI) and spatial area measurements, zones of new deforestation and significant vegetation loss were identified. It was established that the maximum area of new deforestation was recorded in 2017 (over 1,100 ha), followed by another peak in 2026 (over 1,000 ha). Spatial measurements confirmed structural landscape changes, notably the formation of a large-scale grid-patterned deforestation area that expanded to approximately 2,053.28 ha after 2023. An analysis of the mean NDVI dynamics revealed a sharp decline in vegetation health toward the 2025-2026 period. The obtained results demonstrate the effectiveness of using multispectral satellite data and spatial analysis tools for the rapid assessment of anthropogenic environmental impact.

Keywords: Deforestation monitoring; NDVI index; Vegetation degradation; Remote sensing; Spatial analysis; Democratic Republic of the Congo; Google Earth Engine; Google Earth Pro; Sentinel-2.

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Introduction

The immediate causes of deforestation in Central Africa are the production and exploitation of commodities that involve land-use change. National economies in the subregion are not highly diversified and depend heavily on the export of agricultural products and mining commodities, with the production of palm oil, cocoa, coffee, rubber, cotton, and timber being the main drivers of severe deforestation ("Central Africa: Fighting Deforestation," 2023). In the Democratic Republic of the Congo, around the city of Kisangani, spatial changes in land cover occurred between 2017 and 2026, which we aimed to document. Satellite monitoring allows for the detection of vegetation cover changes, tracking the spread of deforested zones, and assessing the overall state of the ecosystem using indices such as NDVI. A similar approach, integrating multispectral and radar data to analyze damaged lands, was applied to assess the impact of extreme factors on land cover (Malik et al., 2025) and to compare NDVI values and calculate the area of damaged forests using Google Earth Engine (Malik et al., 2026).

The widespread use of satellite data is supported by a series of recent studies in the Congo Basin region. In particular, in (Koy et al., 2025), based on long-term satellite observation data, it was established that the key factor driving tropical forest degradation around Kisangani is the gradual conversion of forest tracts into agricultural land and large-scale charcoal harvesting. Research in (Shapiro et al., 2023) further proves that small-scale traditional slash-and-burn agriculture remains the primary driver of ecosystem degradation in Africa. This aligns with the analysis of landscape ecological integrity in (Balandi et al., 2025), who used spatial analysis to record a significant increase in edge effects and large-scale fragmentation of forest tracts directly in the Kisangani region. In the context of armed conflict, military camps within forest areas become hotspots of intensified anthropogenic pressure, where the primary drivers of ecosystem degradation are the expansion of commercial crops (74.2%) and food crops (72.5%), as well as tree logging to meet the energy needs of the population and camps (61.6%) (Musavandalo et al., 2025).

Method

To assess the extent of deforestation in the area of Kisangani (Tshopo Province, Democratic Republic of the Congo) over the period 2017-2026, the study area was defined, encompassing the Kisangani urban agglomeration and adjacent forest tracts connected to the nearest river systems.

To detect and quantify forest cover changes, multispectral Sentinel-2 satellite data and the cloud platform Google Earth Engine (GEE) were used. The platform contains a vast array of satellite data and processing tools that enable monitoring of changes in land cover, forest ecosystems, and other environmental components (Google, n.d.; Ivano-Frankivsk National Technical University of Oil and Gas, n.d.).

Multispectral Sentinel-2 data were utilized to evaluate the condition of vegetation cover and identify areas of its degradation. For this purpose, the NDVI (Normalized Difference Vegetation Index) was calculated:

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

where NIR is the reflectance in the near-infrared spectrum and Red is the reflectance in the red spectrum. Annual analysis of mean NDVI values allowed for the assessment of the overall vegetation condition and the identification of periods of its most intensive decline.

To establish the spatiotemporal dynamics of deforestation, satellite data were compared across consecutive periods: 2017-2018, 2019-2020, 2021-2022, 2023-2024, and 2025-2026. Based on spatial comparison and decreases in NDVI values, areas with new vegetation cover changes were identified. The detected territories were classified as "new deforestation," after which their boundaries were determined through vectorization and the formation of geospatial polygons. For a more detailed visual interpretation of the largest deforested area, identified from the 2025-2026 analysis in Google Earth

Engine, the Google Earth Pro platform was additionally used (Google, 2023). Its application allowed for refining the spatial configuration and the nature of the observed structural landscape changes.

Results

Monitoring of the mean NDVI revealed high variability: following an initial drop in 2016, the index fluctuated between 0.690 and 0.710 until 2024, after which a sharp decline occurred in 2025 and 2026 (down to approximately 0.677). Such a significant reduction in NDVI values indicates a large-scale loss of vegetation (Figure 1).

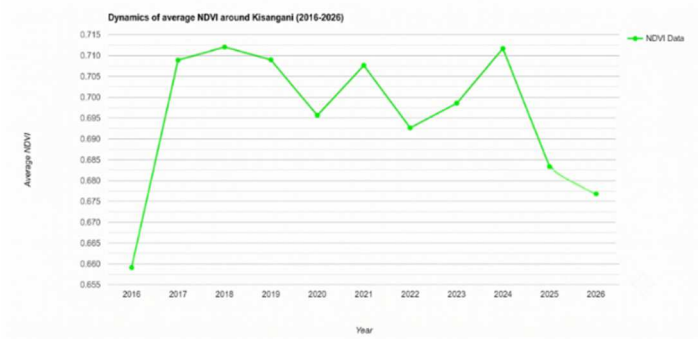

Figure 1. *Dynamics of the mean NDVI in the Kisangani region (2017-2026)*

Spatial analysis of new deforestation reveals a shift in land degradation hotspots. In 2017-2018, intensive localized deforestation was distributed across the entire territory (Figure 2).

Figure 2. *Intensive localized deforestation near the city of Kisangani (2017-2018)*

During 2023-2026, a clearly structured, large-scale deforestation grid appears to the southwest of the main river (Figure 3,4).

Figure 3. *Deforestation grid 2023-2024*

Figure 4. *Deforestation grid 2025-2026*

This is consistent with spatial measurement data from the Google Earth Pro online platform: while no deforestation grid was recorded to the southwest of the city of Kisangani in 2022, it covered 15.54 ha in 2023, and reached 2,053.28 ha in 2025 (Figure 5,6).

Figure 5. *Onset of deforestation to the southwest of the city of Kisangani in 2023, with an area of 15.54 hectares*

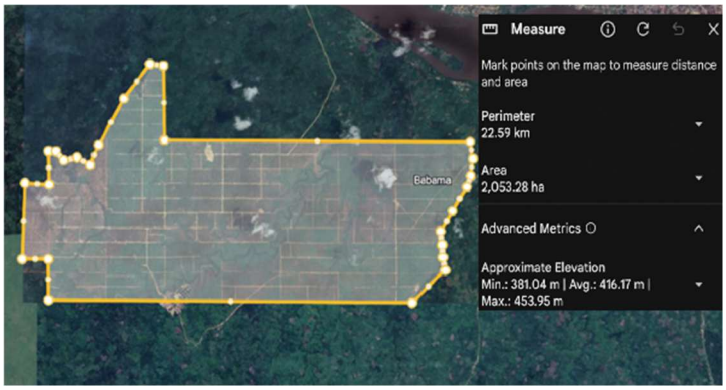

Figure 6. *Expansion of the deforestation area to the southwest of the city of Kisangani in 2025, with an area of 2053.28 hectares*

Comparing the quantitative assessment of new affected areas across years reveals two primary anomalous events. The largest areas of newly deforested land were recorded in 2017 (approximately 1,160 ha) and 2026 (approximately 1,030 ha), whereas in the intervening years (2018-2024), this metric remained well below 100 ha annually (Figure 7).

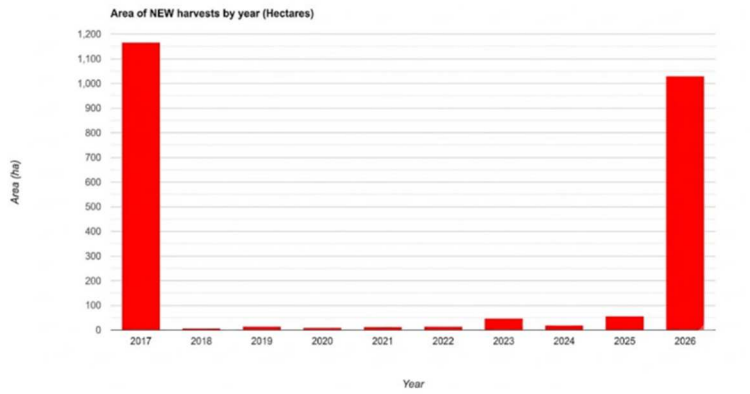

Figure 7. *Area of new deforestation from 2017 to 2026 (in hectares)*

Conclusions

Analysis of human impact on forest resources in the Democratic Republic of the Congo, near the city of Kisangani (Tshopo Province) from 2017 to 2026, using remote sensing data revealed large-scale

vegetation cover degradation and artificial structural changes introduced into the landscape. According to spatial measurements, deforestation occurs not at a constant rate, but in intensive, clearly defined phases. The maximum area of new damage was recorded in 2017 (>1100 ha) and in 2026 (>1000 ha), whereas during the intervening period, the consolidation of cleared lands into massive structured blocks was observed, such as the 2053.28 ha plot recorded in 2025. The mean NDVI effectively captured this activity, demonstrating a sharp decline corresponding to the deforestation surge in 2025-2026. The obtained results confirm the effectiveness of the integrated use of multispectral optical data and can be applied for further monitoring of this area in the Republic of the Congo by researchers or local government authorities of the city of Kisangani.

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