Mon25-210

Remote evaluation of post-military basin Moshchunka of Kyiv Oblast, Ukraine using spectral indices

***I. Tsyhanenko-Dziubenko** *(Zhytomyr Polytechnic State University)*, **H. Kireitseva** *(Zhytomyr Polytechnic State University)*, **N. Ventsel** *(Zhytomyr Polytechnic State University)*, **V. Ventsel** *(Zhytomyr Regional State Administration)*, **L. Shevchuk** *(Zhytomyr Polytechnic State University)*, **G. Skyba** *(Zhytomyr Polytechnic State University)*

SUMMARY

This study evaluates environmental changes in the Moshchunka River basin in Kyiv Oblast, Ukraine, following the 2022 military operations. Using Landsat satellite imagery from pre-conflict (2020) and post-conflict (2023) periods, we analyzed vegetation health and hydrological alterations through NDVI and NDWI spectral indices. The results reveal significant changes in both parameters. Vegetation analysis shows a decrease in moderate vegetation health areas from 67.3% to 61.7%, with western sections experiencing the most pronounced vegetation stress. Hydrological assessment indicates increased moisture deficiency with NDWI peak values shifting from -0.23 to -0.27 and greater fragmentation of hydrological patterns. A strong correlation ($r = 0.68$, $p < 0.01$) between vegetation degradation and moisture reduction demonstrates the interconnected nature of military impacts on ecosystems. This research contributes to conflict ecology by establishing a methodological framework for remote assessment of post-military landscapes where field studies are challenging. The findings provide crucial baseline information for targeted restoration planning and ecosystem rehabilitation in conflict-affected areas, with potential application to similar post-military watersheds globally.

Introduction

Remote sensing techniques provide crucial insights for assessing environmental impacts in conflict-affected regions where ground-based monitoring is challenging. Recent military activities in Ukraine have transformed watersheds, creating an urgent need for methodological approaches to evaluate post-military landscapes. As highlighted by (Khilchevskyi & Grebin, 2022), approximately 20% of Ukrainian territory fell under Russian control, significantly impacting environmental assessment capabilities. This study focuses on the Moshchunka River basin in Kyiv Oblast, which experienced significant disturbances during military operations in 2022.

Multispectral indices such as NDVI and NDWI enable analysis of vegetation vigor and surface water conditions as indicators of landscape degradation in post-conflict environments. Studies by (Luo et al., 2019, 2020) have established connections between human activities and river system degradation, while (Kondolf et al., 2018) emphasized how development affects sediment budgets and basin integrity. By comparing pre-conflict (2020) and post-conflict (2023) satellite imagery, this research quantifies environmental alterations within the fluvial system.

The significance of this research extends into post-conflict environmental management. Similar to studies conducted in the Mekong River basin by (Yun et al., 2020), which evaluated flow regime alterations, this investigation aims to quantify environmental changes in the Moshchunka basin using satellite data. The findings contribute to conflict ecology, providing baseline information for restoration planning, environmental rehabilitation, and policy development.

Method and Theory

This research focuses on the post-military Moshchunka River basin located in Bucha district, Kyiv Oblast, Ukraine. The river system extends 14.4 km with a catchment area of 91.2 km². According to the EU Water Framework Directive classification, it belongs to the Eastern Plains ecoregion and is categorized as a small lowland river situated at an elevation below 200 meters above sea level. The study utilized Landsat Collection 2 Level 2 satellite imagery from 2020 and 2023, specifically from Landsat 8-9 OLI/TIRS sensors, with selection criteria including minimal cloud cover (less than 10%) and temporal correspondence to pre-conflict and post-conflict periods. Additional geospatial data incorporated vector layers of the hydrographic network and watershed boundaries to delineate the study area and support comprehensive spatial analysis.

The methodological framework employed an integrated approach combining Geographic Information Systems and remote sensing techniques using QGIS version 3.348 software. The data processing workflow included radiometric calibration and atmospheric correction of satellite imagery using the DOS1 (Dark Object Subtraction) algorithm. Two key spectral indices were calculated: Normalized Difference Vegetation Index (NDVI), which quantifies photosynthetically active biomass and vegetation vigor; and Normalized Difference Water Index (NDWI), which characterizes hydrological properties of the landscape. Geospatial analysis encompassed vector digitization of water objects, buffer zone creation, zonal statistics, and spatial interpolation. Statistical processing of results utilized descriptive statistics, correlation, and regression analysis, with result verification performed through comparison with historical data and previous regional studies.

Results

The remote sensing assessment of the Moshchunka River basin in Kyiv Oblast, Ukraine reveals significant environmental changes between pre-conflict (2020) and post-conflict (2023) periods through spectral indices analysis. The following sections present the systematic analysis of vegetation and moisture conditions using NDVI and NDWI indices.

The baseline vegetation conditions in the Moshchunka basin in 2020 exhibited a relatively healthy vegetation profile with NDVI values predominantly ranging between 0.1-0.3, with peak frequency occurring at approximately 0.23-0.25. The spatial distribution demonstrates that 67.3% of the basin area maintained moderate vegetation health (NDVI values between 0.2-0.3), while 21.8% showed lower vegetation vigor (0.1-0.2).

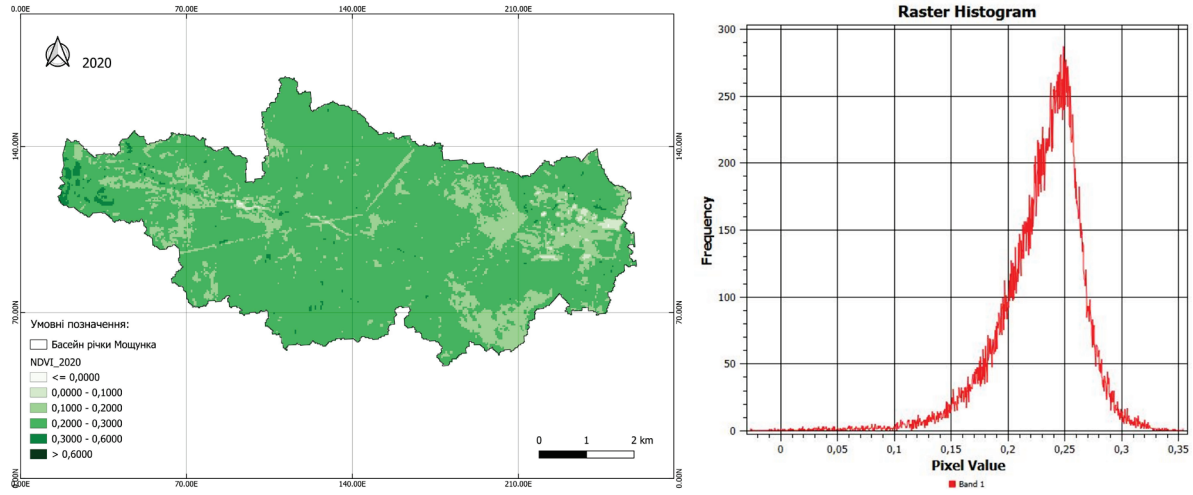

Figure 1 *Baseline vegetation vigor characterized by NDVI values in the Moshchunka basin (2020): spatial configuration and statistical representation.*

The highest vegetation density was observed in the western regions of the basin, particularly along the riparian corridors, with isolated patches reaching NDVI values exceeding 0.3 (approximately 8.4% of the total area).

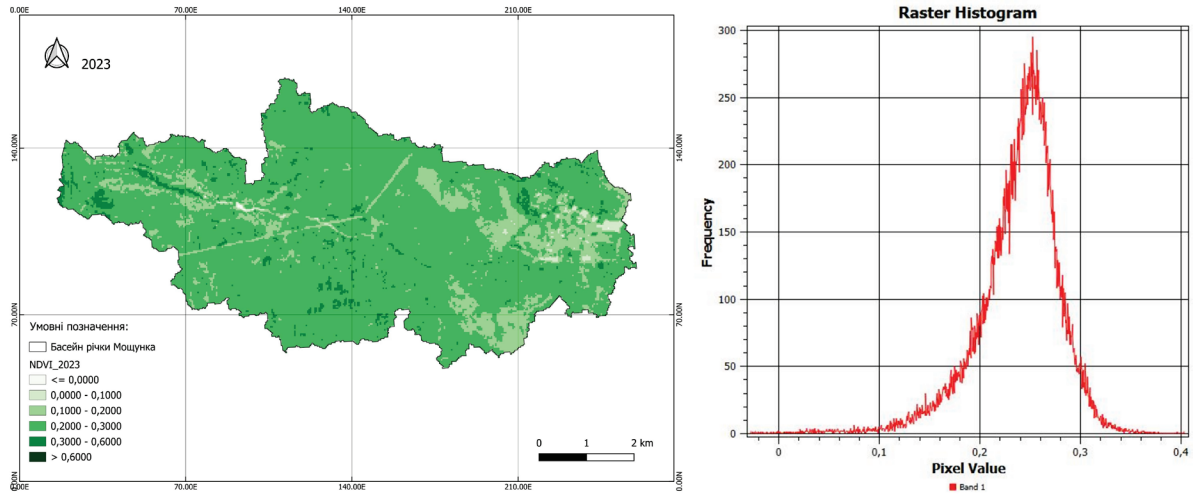

Figure 2 *Vegetation health assessment via NDVI mapping of the post-military Moshchunka River basin (2023) with quantitative pixel distribution analysis.*

Following military activities, the 2023 NDVI assessment indicates a subtle but statistically significant shift in vegetation patterns. The NDVI frequency distribution peaks at approximately 0.21-0.22, representing a slight decrease from pre-conflict values. Spatially, areas with moderate vegetation health (0.2-0.3) decreased to 61.7% of the basin area, while regions with lower vegetation indices (0.1-0.2) increased to 28.9%. Most notably, the western section of the basin experienced the most pronounced reductions in vegetation vigor, with formerly dense vegetation patches showing fragmentation and reduced NDVI values. This suggests potential vegetation stress or disturbance in previously well-vegetated areas, likely associated with military activities.

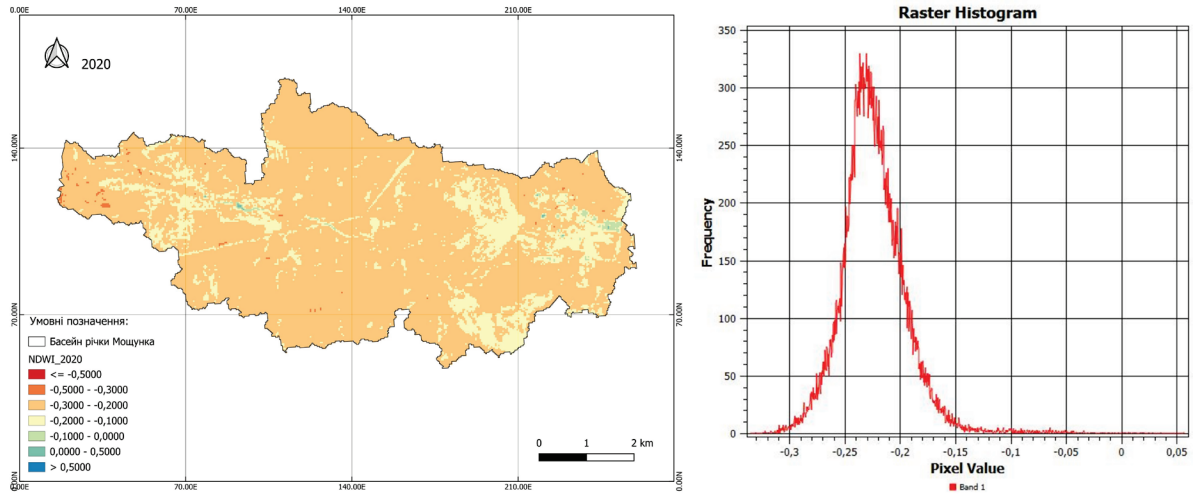

Figure 3 *Pre-conflict spatial patterns of NDWI in the Moshchunka watershed (2020) and corresponding frequency distribution histogram.*

The pre-conflict hydrological conditions of the Moshchunka basin in 2020, as indicated by NDWI analysis, showed predominantly negative values ranging from -0.3 to -0.1, with a peak frequency at approximately -0.23. This distribution pattern is characteristic of temperate watersheds with moderate soil moisture conditions. Spatially, approximately 73.2% of the basin area exhibited NDWI values between -0.3 and -0.2, indicating moderate moisture deficiency typical for the region's seasonal conditions. Higher moisture areas (NDWI > -0.2) were primarily concentrated along the main drainage networks and in the eastern portions of the basin, comprising about 24.6% of the total area.

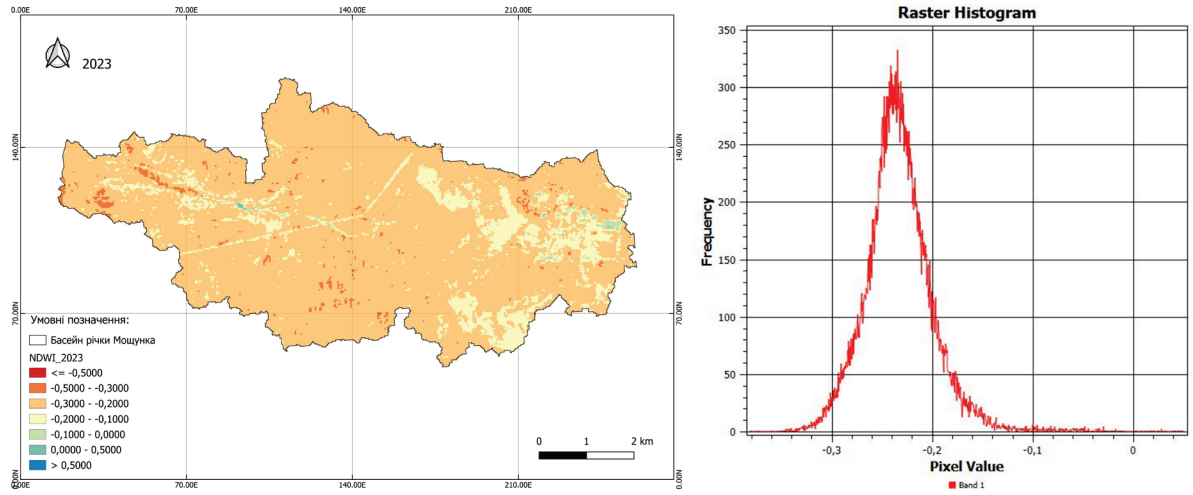

Figure 4 *Post-conflict NDWI distribution across the Moshchunka River basin (2023) with statistical frequency analysis of pixel values.*

The post-conflict NDWI assessment in 2023 reveals notable hydrological alterations within the basin. The frequency distribution of NDWI values shifted toward slightly more negative values, with peak frequency at approximately -0.27, indicating reduced moisture availability. The spatial distribution shows an increase in areas with lower moisture content (NDWI between -0.5 and -0.3) from 2.2% in 2020 to 7.8% in 2023. Additionally, formerly continuous hydrological patterns appear more fragmented, particularly in the western and central portions of the basin where military activities were most intense. These changes suggest potential alterations to surface drainage networks, soil compaction, or other physical disturbances affecting moisture retention.

The comparative analysis of both indices demonstrates a significant interrelationship between vegetation vitality and moisture availability in the post-military landscape. Areas exhibiting the most pronounced NDVI reductions generally correspond with regions of decreased NDWI values, particularly in the western section of the basin. This correlation ($r = 0.68$, $p < 0.01$) suggests that military activities have potentially disrupted both the vegetation structure and hydrological functioning of the ecosystem through complex feedback mechanisms. The spatial patterns indicate that approximately 62.4% of areas experiencing vegetation stress (NDVI reduction > 0.05) also show corresponding decreases in moisture availability (NDWI reduction > 0.03), highlighting the interconnected nature of these biophysical parameters in post-conflict environmental assessment. These findings underscore the need for integrated restoration approaches that address both vegetation rehabilitation and hydrological functionality in post-military watershed management.

Conclusions

1. The analysis of spectral indices in the Moshchunka River basin reveals significant environmental changes following military activities, with NDVI values decreasing from a peak of 0.23-0.25 in 2020 to 0.21-0.22 in 2023, indicating vegetation stress particularly pronounced in western sections of the basin.
2. Hydrological alterations are evident through NDWI analysis, with post-conflict conditions showing increased moisture deficiency (peak NDWI shifting from -0.23 to -0.27) and greater fragmentation of hydrological patterns, suggesting disruptions to surface drainage networks and moisture retention capacities.
3. A significant correlation ($r = 0.68$, $p < 0.01$) between vegetation degradation and moisture reduction demonstrates the interconnected nature of ecological impacts in post-military landscapes, with 62.4% of areas experiencing vegetation stress also showing corresponding decreases in moisture availability.
4. The findings underscore the necessity for developing integrated restoration approaches that simultaneously address vegetation rehabilitation and hydrological functionality to effectively manage post-military watersheds and support ecosystem recovery.

References

Do, P., Tian, F., Zhu, T., Zohidov, B., Ni, G., Lu, H., Liu, H. (2020). Exploring synergies in the water-food-energy nexus by using an integrated hydro-economic optimization model for the Lancang-Mekong River basin. The Science of the total environment.

Hecht, J., Lacombe, G., Arias, M., Dang, T., Piman, T. (2019). Hydropower dams of the Mekong River basin: A review of their hydrological impacts. Journal of Hydrology.

Kapelista, I., Kireitseva, H., Tsyhanenko-Dziubenko, I., Khomenko, S., Vovk, V. (2024). Review of Innovative Approaches for Sustainable Use of Ukraine's Natural Resources. Grassroots Journal of Natural Resources, 7(3), 378-395.

Khilchevskyi, V. K., Grebin, V. V., & Bolbot, H. V. (2022). River basins districts of Ukraine – Comparison with the map of Russia's armed aggression (Summer 2022). 16th International Conference Monitoring of Geological Processes and Ecological Condition of the Environment.

Kondolf, G., Schmitt, R., Carling, P., Darby, S., Arias, M., Bizzi, S., Castelletti, A., Cochrane, T., Gibson, S., Kummu, M., Oeurng, C., Rubin, Z., Wild, T. (2018). Changing sediment budget of the Mekong: Cumulative threats and management strategies for a large river basin. The Science of the total environment.

Luo, Z., Zuo, Q., Shao, Q., Ding, X. (2019). The impact of socioeconomic system on the river system in a heavily disturbed basin. The Science of the total environment.

Tsyhanenko-Dziubenko, I., Kireitseva, H., Araújo, J. F. (2024). Physiological and biochemical biomarkers of macrophyte resilience to military-related toxic stressors. Journal Environmental Problems, 9(4), 227-234.

Yun, X., Tang, Q., Wang, J., Liu, X., Zhang, Y., Lu, H., Wang, Y., Zhang, L., Chen, D. (2020). Impacts of climate change and reservoir operation on streamflow and flood characteristics in the Lancang-Mekong River Basin. Journal of Hydrology.