GeoTerrace-2026-067

Preliminary Mapping of Potential Wetland Areas and Seasonal Land Surface Temperature Patterns within the Bug–Styr Plain: A Case Study of Sheptytska Hromada

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SUMMARY

Wetlands are important components of natural landscapes, but their preliminary mapping remains challenging in spatially heterogeneous and highly transformed environments. This study combines preliminary mapping of potential wetlands with an assessment of their seasonal land surface temperature (LST) patterns within the Bug–Styr Plain, using a part of Sheptytska Hromada as a case study. Potential wetland complexes were delineated using Sentinel-2 imagery and supporting geospatial data and subsequently used as spatial units for thermal analysis. Seasonal LST was derived from Landsat 8 and Landsat 9 imagery for spring, summer, and autumn 2025. For each season, a median LST composite and the number of valid observations per pixel were calculated. Median LST within the potential wetland complexes was compared with that of areas outside the mapped complexes, referred to as the remaining study area. The potential wetland complexes covered approximately 300 ha, corresponding to 3.95% of the study area. Median LST for the entire study area was 21.69 °C in spring, 27.94 °C in summer, and 17.28 °C in autumn. Potential wetland complexes exhibited lower median LST than the remaining study area in all seasons, with the strongest thermal contrast observed in spring (- 3.31 °C), followed by summer (- 2.21 °C) and autumn (- 1.11 °C). The results indicate that seasonal LST can provide complementary information for characterising preliminary potential wetland areas, while not being sufficient to independently confirm wetland presence or validate their boundaries.

Keywords: Wetlands; Land surface temperature; Seasonal analysis; Landsat; Sentinel-2; Remote sensing; Google Earth Engine; Bug–Styr Plain.

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Introduction

Wetlands perform essential hydrological and ecological functions, including water retention, regulation of surface runoff, groundwater recharge and provision of habitats for specialised plant and animal communities (Ramsar Convention Secretariat, 2013). However, drainage, river regulation and agricultural development have substantially transformed many wetland landscapes and altered their natural hydrological regimes. In such territories, remaining wetlands frequently occur as fragmented and heterogeneous complexes, making their identification and spatial monitoring difficult.

Satellite remote sensing provides repeatable observations for preliminary wetland mapping across large and heterogeneous areas. Sentinel-2 is suitable for distinguishing water, vegetation and surface-moisture conditions, while Landsat archives provide complementary information on seasonal and long-term wetland dynamics (Kaplan & Avdan, 2017; Demarquet et al., 2023). Sentinel-2 composites can also support land-cover analysis in heterogeneous landscapes (Marusazh & Petryk, 2025), while LST provides complementary information on wetland thermal characteristics and their relationship with moisture and vegetation conditions (Muro et al., 2018). Google Earth Engine facilitates the integration and processing of such datasets within reproducible monitoring workflows (Abdelmajeed et al., 2023; Gorelick et al., 2017). However, wetland heterogeneity and shallow or vegetation-covered water may limit the reliability of delineation (Lefebvre et al., 2019). Preliminary mapping can therefore identify potential wetland areas, but it does not describe the seasonal thermal patterns associated with them.

This study aims to combine preliminary mapping of potential wetland areas with analysis of seasonal LST patterns within the Bug–Styr Plain, using its part located within Sheptytska Hromada as a case study. Particular attention is given to seasonal LST differences between the mapped potential wetland complexes and the remaining study area.

Method

The Bug–Styr Plain is a low-lying physiographic region in the interfluve of the Western Bug and the Ikva, a tributary of the Styr, characterised by gently undulating relief and widespread areas with favourable conditions for waterlogging and peat formation (Mukha, 2004; Andreichuk et al., 2021). Extensive drainage and agricultural development have transformed many wetland areas, leaving fragmented wetland complexes within a mosaic of agricultural land, forests, water bodies and drainage channels. The study focused on the part of the Bug–Styr Plain located within Sheptytska Hromada, Lviv Oblast (Fig. 1).

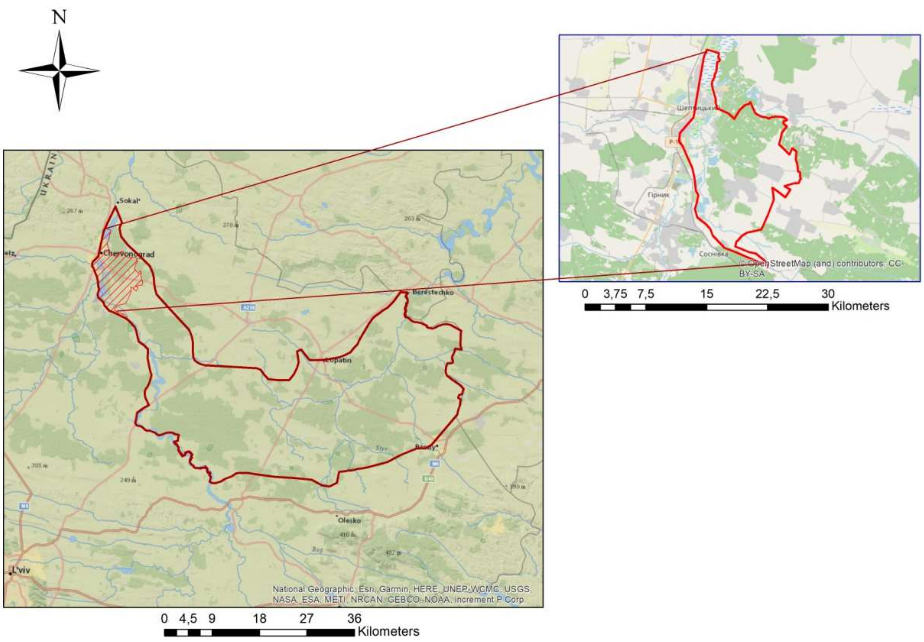

Figure 1. *Location of the case-study area within the Bug–Styr Plain and Sheptytska Hromada*

Potential wetland areas were first mapped in Google Earth Engine using a cloud-masked median composite of Sentinel-2 surface reflectance imagery acquired in April–May 2025. NDWI, MNDWI, NDMI, NDVI and the Water in Wetlands indicator (WIW) were combined with wetland-related soil units, OpenStreetMap hydrological features and low-slope terrain derived from the Copernicus DEM. A conservative rule-based classification produced a 10 m raster with three classes: open water, higher-confidence potential wetland and probable potential wetland. Within the case-study area, the three classes were converted to polygons in ArcGIS Pro and aggregated into potential wetland complexes by filling internal gaps and dissolving touching areas. As field verification has not yet been conducted, these complexes represent preliminary areas of interest rather than confirmed wetland boundaries.

Seasonal land surface temperature (LST) was derived from Landsat 8 and Landsat 9 Collection 2 Tier 1 Level-2 imagery in Google Earth Engine for spring (1 March–31 May), summer (1 June–31 August) and autumn (1 September–30 November) 2025. Scenes with cloud cover ≥50% were excluded. At pixel level, QA_PIXEL and QA_RADSAT bands were used to remove invalid, cloudy, shadowed, snow-covered and saturated pixels. LST was calculated from the ST_B10 band using the Collection 2 scale factor and offset:

$$\boldsymbol{LST = ST\_B10 \times 0.00341802 + 149.0 - 273.15.} \quad (1)$$

For each season, a median LST composite and a corresponding valid-observation count (ValidObs) raster were generated. Pixels with fewer than two valid observations were excluded. For visualisation, each seasonal composite was displayed using its own temperature range to reveal within-season spatial variability; comparisons among seasons were based on numerical LST statistics. The composites were exported at 30 m spatial resolution in WGS 84 / UTM zone 35N.

For thermal comparison, potential wetland complexes were treated as one spatial group, while areas outside them formed the remaining study area; this term does not imply the absence of wetlands outside the mapped complexes. Seasonal LST statistics were calculated at a 100 m analysis scale, and thermal contrast was expressed as the difference between the median LST of the two groups. The comparison was descriptive and was not intended to validate wetland classification or boundaries.

Results

Within the case-study area, the three preliminary wetland classes were aggregated into potential wetland complexes covering approximately 300 ha (3.95% of the total study area), including open-water components. Their boundaries represent preliminary areas of interest rather than verified wetland extent.

The seasonal LST composites showed sufficient temporal support for spatial comparison across the study area. Spring had the highest number of valid observations, with 8–13 observations per pixel, followed by summer with 4–9 observations. Autumn had the lowest temporal support, with most pixels represented by 2–4 observations. After applying the minimum observation threshold, the resulting composites covered the entire study area in spring, summer, and 99.99% in autumn. The lower temporal support of the autumn composite was therefore considered when interpreting its fine-scale spatial patterns.

The seasonal LST distribution showed a clear temperature pattern across the three analysed periods (Fig. 2). Median LST increased from 21.69 °C in spring to 27.94 °C in summer and decreased to 17.28 °C in autumn. The spatial distribution was heterogeneous, with relatively cooler surfaces occurring mainly in the north-central and eastern parts of the study area, while warmer conditions were more pronounced in the southern and north-western parts. Several larger potential wetland complexes, particularly in the western and south-western parts of the study area, coincided with local areas of relatively low LST. However, low-temperature areas also occurred outside the mapped complexes, indicating that the observed thermal pattern was not specific to potential wetlands.

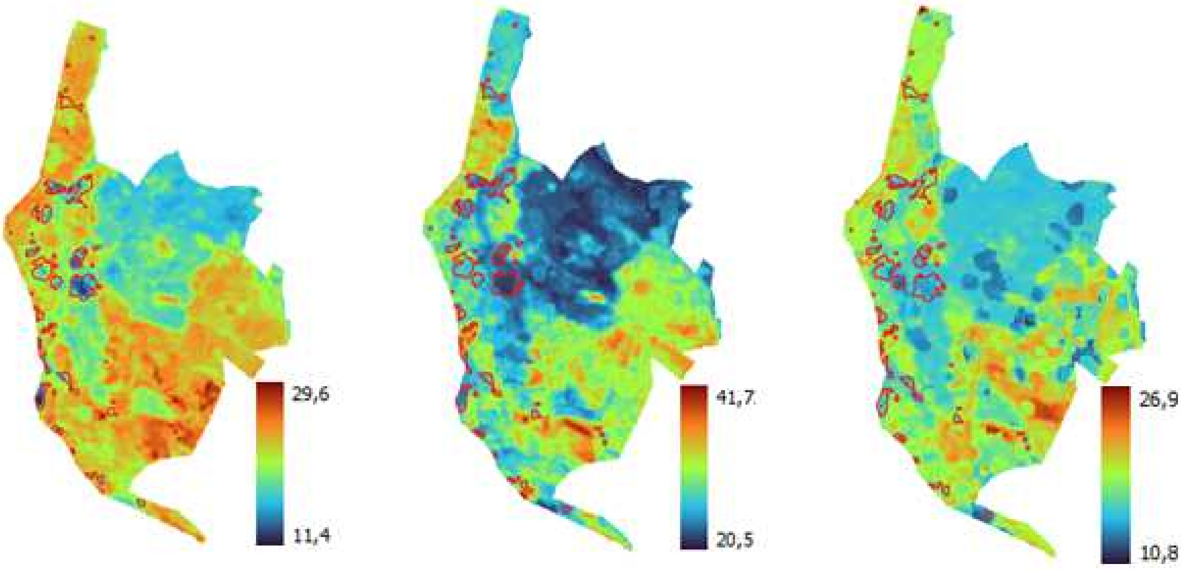

Figure 2. *Spatial distribution of median land surface temperature within the case-study area in (a) spring, (b) summer and (c) autumn 2025; potential wetland-complex boundaries are shown by the overlaid outlines*

The comparison between potential wetland complexes and the remaining study area showed a consistent thermal contrast in all seasons (Table 1). Median LST within the complexes was 18.47 °C in spring, 25.85 °C in summer and 16.23 °C in autumn, compared with 21.78 °C, 28.06 °C and 17.34 °C, respectively, in the remaining study area. The resulting ΔLST values were - 3.31 °C in spring, - 2.21 °C in summer and - 1.11 °C in autumn, corresponding to relative differences of - 15.2%, - 7.9% and - 6.4%.

Table 1. *Seasonal LST characteristics and thermal contrast between potential wetland complexes and the remaining study area in 2025*

Season	**Study area median LST, °C**	**Potential wetland complexes, °C**	**Remaining study area, °C**	**ΔLST, °C**	**Relative difference, %**
Spring 2025	21.69	18.47	21.78	-3.31	-15.2
Summer 2025	27.94	25.85	28.06	-2.21	-7.9
Autumn 2025	17.28	16.23	17.34	-1.11	-6.4

ΔLST represents the median LST of potential wetland complexes minus that of the remaining study area. Negative values indicate lower LST within the potential wetland complexes. Relative difference was calculated in relation to the median LST of the remaining study area.

The spatial expression of the thermal contrast varied among individual complexes. Larger western and southwestern complexes generally coincided with cooler surfaces, particularly in spring and summer, whereas some smaller complexes showed weak or indistinct thermal differences. In summer, cool conditions extended beyond the mapped complexes, while the autumn contrast was weaker and less spatially consistent. Thus, lower LST was associated with several potential wetland complexes but was not restricted to them.

Overall, the results indicate a persistent but seasonally variable thermal difference between the two spatial groups, with the strongest contrast in spring. The observed pattern may reflect differences in surface moisture, vegetation and daytime heating. However, because the comparison pools complexes of different sizes and includes open-water areas, it should be interpreted as a descriptive thermal association rather than independent confirmation of wetland status.

Conclusions

The study delineated approximately 300 ha of preliminary potential wetland complexes and assessed their seasonal thermal characteristics using Landsat-derived LST. The complexes were consistently cooler than the remaining study area, with the strongest median contrast in spring (- 3.31 °C) and the weakest in autumn (- 1.11 °C). However, the thermal pattern was spatially heterogeneous, and low LST also occurred outside the mapped complexes. Therefore, LST can provide complementary information for characterising potential wetland areas but cannot independently confirm wetland status or boundaries. Further work should include field verification, analysis of individual complexes and land-cover effects, and multi-year observations.

Acknowledgements

The study was conducted within the framework of the research project DB/KOMBIS “Comprehensive geodetic and geotechnical monitoring of wetland systems of the Bug–Styr Plain for sustainable management” (No. 0126U000565).

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