DOI https://doi.org/10.30525/978-9934-26-542-6-8

DETERMINATION OF DROUGHT/HUMIDITY TRENDS USING REMOTE SENSING DATA AND GEOINFORMATION TECHNOLOGIES ON THE EXAMPLE OF LAKE SVITYAZ

ВИЗНАЧЕННЯ ТЕНДЕНЦІЙ ПОСУХИ/ВОЛОГОСТІ ІЗ ЗАСТОСУВАННЯМ ДАНИХ ДИСТАНЦІЙНОГО ЗОНДУВАННЯ ЗЕМЛІ ТА ГЕОІНФОРМАЦІЙНИХ ТЕХНОЛОГІЙ НА ПРИКЛАДІ ОЗЕРА СВІТЯЗЬ

Melnychenko T. A.
Candidate of Geological Sciences, Senior Researcher, State Scientific Institution "Center for problems of marine geology, geoecology and sedimentary ore formation of the National academy of sciences of Ukraine" Kyiv, Ukraine

Мельниченко Т. А.
кандидат геологічних наук, старший науковий співробітник, ДНУ "Центр проблем морської геології, геоекології та осадового рудоутворення Національної академії наук України" м. Київ, Україна

The rapid climate change in Europe and the world over the past decade has been recorded by global Earth observation services: European Space Agency (ESA), World Meteorological Organization (WMO), NASA, NOAA. In particular, drought trends are growing every year, which creates the need for rapid research and study of this problem using optimal methods. An important step in solving this problem is the prompt recording of changes in water bodies, which clearly reflects the drought/wetness trends of the study area.

The object of the present research is Lake Svityaz, the biggest lake among the group of Shatsk lakes belonging to the Western Bug River basin, which covers the territory of Ukraine, Poland and partially Belarus. The Shatsk Lakes cover about 30 lakes located in the northwestern part of Ukraine within the Polissya Lowland (Figure 1). This is the biggest group of water bodies in the Western Bug basin. Lake Svityaz – can serve as a kind of reporter of changes in the water content of the Shatsk lakes and reflect the situation in the whole basin. The optimal method for determining changes in the water surface of open water bodies is to use remote sensing data. This method provides a number of advantages: quick fixation of changes, regular monitoring, archive of observation data, accuracy of the data obtained.

Fig. 1. Map of Lake Svityaz, created using Google Earth Pro [1]

The satellite image data are used to monitoring changes in natural, anthropogenic and, in particular, water bodies. To determine changes in water surface areas, RGB composite bands or various indices with formulas are used: NDWI (Normalized Water Difference Index) [1-3], MNDWI (Modified Normalized Difference Water Index), AWEI (Automated Water Selection Index), SWI (SAR Water Index), WRI (Water Ratio Index), NDMI (Normalized Difference Moisture Index) [4]. Researchers have modernized the formulas over time by changing the calculations, adding or replacing various indicators. The most popular water index remains the NDWI [2,5], its formula is quite simple and the resulting resolution of 10 m (for Sentinel-2) allows it to be used for mapping single water bodies:

$$NDWI = B_{GREEN} - B_{NIR} / B_{GREEN} + B_{NIR}, \quad (1)$$

where B_{GREEN} – green spectral band, B_{NIR} – near infrared spectral band.

MNDWI is a modified NDWI, where NIR has been replaced by SWIR-2, and is excellent at identifying water bodies:

$$MNDWI = B_{GREEN} - B_{SWIR\,2} / B_{GREEN} + B_{SWIR\,2}, \quad (2)$$

where B_{GREEN} – green spectral band, B_{SWIR2} – shortwave infrared spectral band.

Indices are used to determine changes in the water surface of the studied lake: NDWI and MNDWI for the monitoring period in the driest and driest

months of the year from 2019 to 2023 according to the service Copernicus Climate Change Service/ECMWF https://climate.copernicus.eu/ hydrological-variables (Table 1).

Table 1

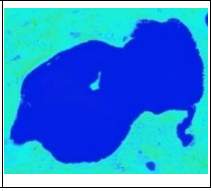
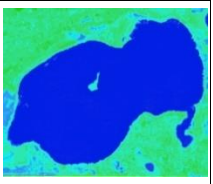
The wet and driest months of the year for the period from 2019 to 2023

Monitoring date	**Dry season**			**Wet season**		
2019	February	March	Juny	April	November	December
2020	March	April	September	-	November	December
2021	-	July	October	-	August	September
2022	February	April	October	March	April	September
2023	February	September	October	-	August	-

As a result of processing Sentinel-2 images, product: T34UFC (downloaded from the open service: https://browser.dataspace.copernicus.eu/) in the SNAP software (https://step.esa.int/main/download/snap-download/), with the use of NDWI and MNDWI, the identification of Lake Svityaz in wet (Figure 2) and dry (Figure 3) periods was performed.

As a result, using NDWI and MNDWI, we calculated the water surface area of Lake Svityaz in the driest and wettest months of the year (Table 2). The lowest values of the water surface area occurred in 2021, both in the dry and wet seasons, and the highest values are recorded in 2022, which may indicate a dry 2021 and a wet 2022.

This research method recommended for determining drought/moisture trends within the entire river basin, subject to monthly monitoring over the past 10–20 years.

True color	SWIR	NDWI	MNDWI
			
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	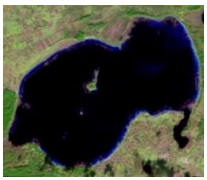	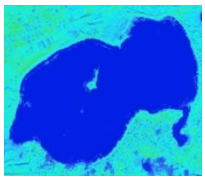	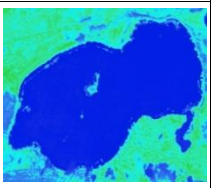
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	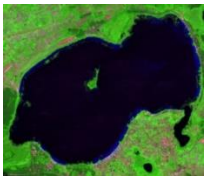	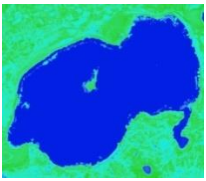	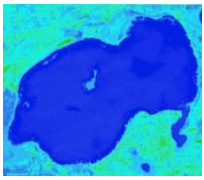
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		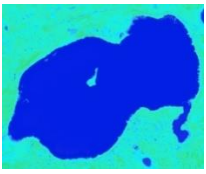	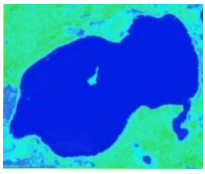
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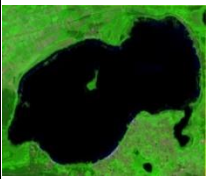
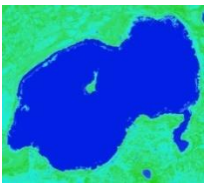
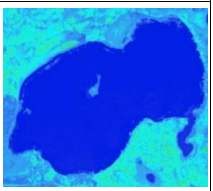
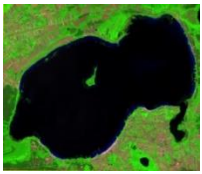
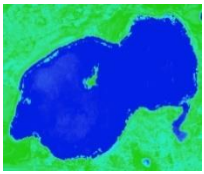
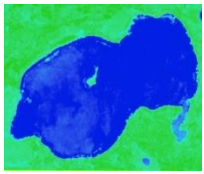
			
Product: Sentinel-2 (T34UFC) Date of monitoring: 2023.08.19			

Fig. 2. Visualization of changes in the water surface of Lake Svyatiaz (wet season)

RGB (True color)	SWIR	NDWI	MNDWI
			
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		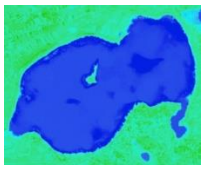	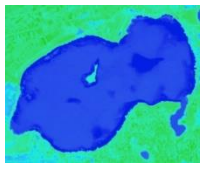
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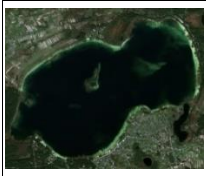		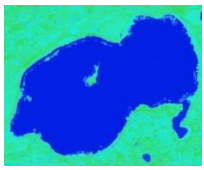	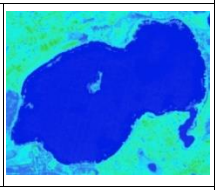
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		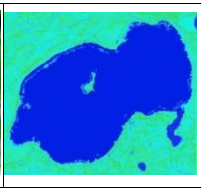	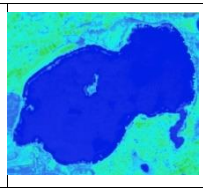
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		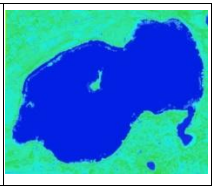	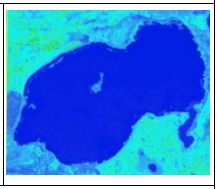
Product: Sentinel-2 (T34UFC) Date of monitoring: 2023.09.28			

Fig. 3. Visualization of changes in the water surface of Lake Svyatiaz (dry season)

Table 2

Water surface area of Lake Svityaz according to Sentinel-2

Seasons	Date of monitoring:	NDWI (area, km^2)	MNDWI (area, km^2)
Dry season	2019.06.26	24,155	24.079
	2020.04.11	24,248	24,492
	2021.10.08	24,057	23,903
	2022.10.08	24,658	24.445
	2023.09.28	24,634	24,538
Wet season	2019.04.02	24,827	25,025
	2020.11.05	24,432	24.592
	2021.08.07	24.412	24.449
	2022.03.25	25,115	24,903
	2023.08.19	24,675	24.398

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