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ANALYSIS OF THE APPLICATION OF THE NORMALIZED DIFFERENCE WATER INDEX (NDWI) IN THE ODESA BAY AREA OF THE BLACK SEA

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Today, studies of the condition of coastal strips of water bodies are relevant all over the world, in particular in Ukraine. After all, the issue of protection and preservation of the maritime coastal zone is one of the most important directions in the legislative and scientific fields of the seaside states of the World. Coastal ecosystems are known to be among the most productive on Earth. They provide essential ecosystem services such as coastal protection from storms, fish feeding grounds and others. [1].

Marine science research is greatly facilitated by the availability of satellite remote sensing information. This is due to the fact that satellite measurements make it possible to cover large areas with high spatial resolution, despite the state borders of individual states, their economic zones, etc. Deciphering water and land objects using vegetation indices is very popular among international and Ukrainian scientists in the field of Earth Sciences.

Recently, multispectral satellite images of the Earth's surface have been used to study the variability of the state of the sea coastline. The combination of data from different spectra of the Earth's surface survey gives us detailed information about the type and location of the corresponding object on the Earth's surface.

The aim of our work was to investigate the state of the coastal strip in the Odesa Bay based on satellite information. For this, we needed to clearly distinguish the boundary between land and sea in the data of satellite images. We applied Normalized Difference Water Index (NDWI) and Modified Normalized Difference Water Index (MNDWI) satellite image processing methods to solve this problem.

The NDWI is used to identify open water features and highlight them on a satellite image against the background of soil and vegetation. The NDWI is calculated using a combination of GREEN-NIR (visible green and near-infrared) to detect subtle changes in water content of the water bodies [2]. The NDWI is calculated by the formula:

$$NDWI = \frac{Green - NIR}{Green + NIR} \quad (1)$$

The MNDWI is calculated using a combination of GREEN-SWIR (visible green and shortwave infrared channels). This combination allows for improved display of open water

objects. It also reduces the values of built-up areas, which are often correlated with open water areas in other indices [3, 4]. The MNDWI is calculated by the formula:

$$MNDWI = \frac{Green - SWIR}{Green + SWIR} \quad (2)$$

We will give an example of the application of NDWI and MNDWI in the Odesa Bay of the Black Sea in August 2005 to visualize the results obtained on the basis of satellite information. Information from the Landsat 5 satellite with the Landsat Thematic Mapper (TM) sensor served as the initial data. The distribution of the spectral channels of the Landsat 5 [5] satellite is given in the table. 1.

We first applied formula (1) to separate the boundary between land and water. Channels 2 and 4 served as the initial data (Table 1). Calculations were made on the basis of a professional geographic information system with open-source code (QGIS)[6]. Also, the Semi-Automatic Classification Plugin (SCP) was additionally installed to the QGIS software. The Semi-Automatic Classification Plugin is a free open-source plugin for QGIS that allows for the semi-automatic classification (also known as supervised classification) of remote sensing images. It provides several tools for the download of free images, the preprocessing, the postprocessing, and the raster calculation [7].

Table 1

Landsat 5 (TM) Bands

Band number	Band name	Wavelength, μm	Resolution, m
1	Visible Blue	0.45 – 0.52	30
2	Visible Green	0.52 – 0.60	30
3	Visible Red	0.63 – 0.69	30
4	NIR	0.76 – 0.90	30
5	SWIR 1	1.55 – 1.75	30
6	Thermal	10.40 – 12.50	120
7	SWIR 2	2.08 – 2.35	30

The results of the calculations of the separation of water and land in the Odesa Bay of the Black Sea based on the QGIS software according to formula (1) are shown in Fig. 1.

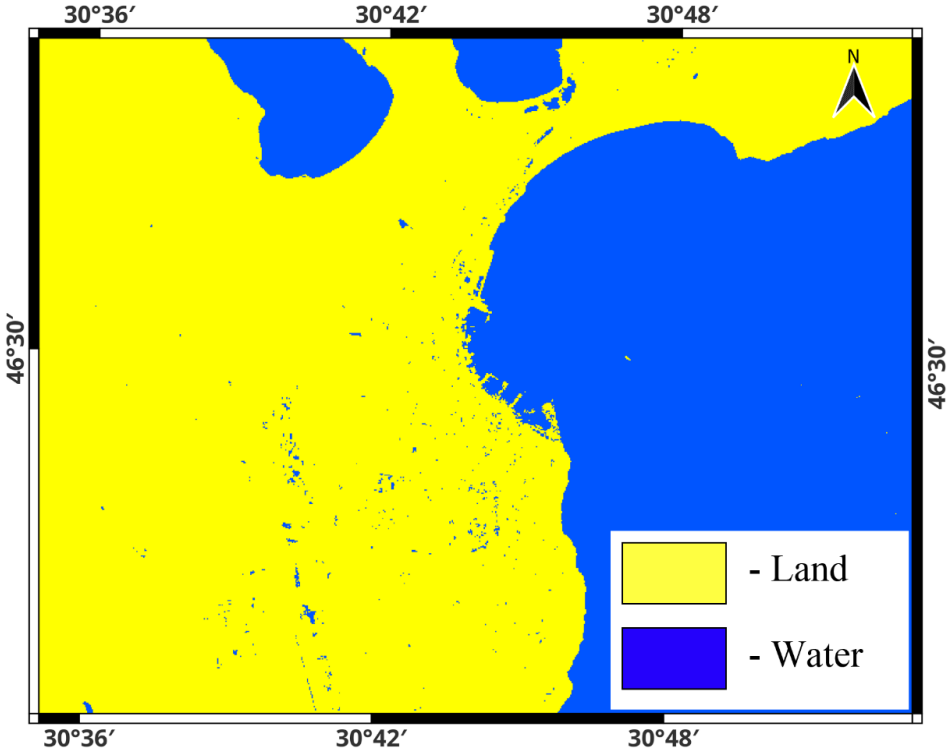

Fig. 1. **NDWI raster surface map**

As can be seen from fig. 1, we managed to clearly distinguish the territory of the land and the water area of the sea. But a lot of "noise" can be observed along the coastline, in particular in the Odesa seaport area and on a large area of land. This "noise" can be explained by the fact that built-up areas correlate with areas of open water.

We checked the quality of the calculations for calculating the separation of water and land according to formula (2) under the identical conditions of the calculations in Figure 1. The results of calculations in the Odesa Bay area of the Black Sea based on the QGIS software according to formula (2) are shown in Fig. 2.

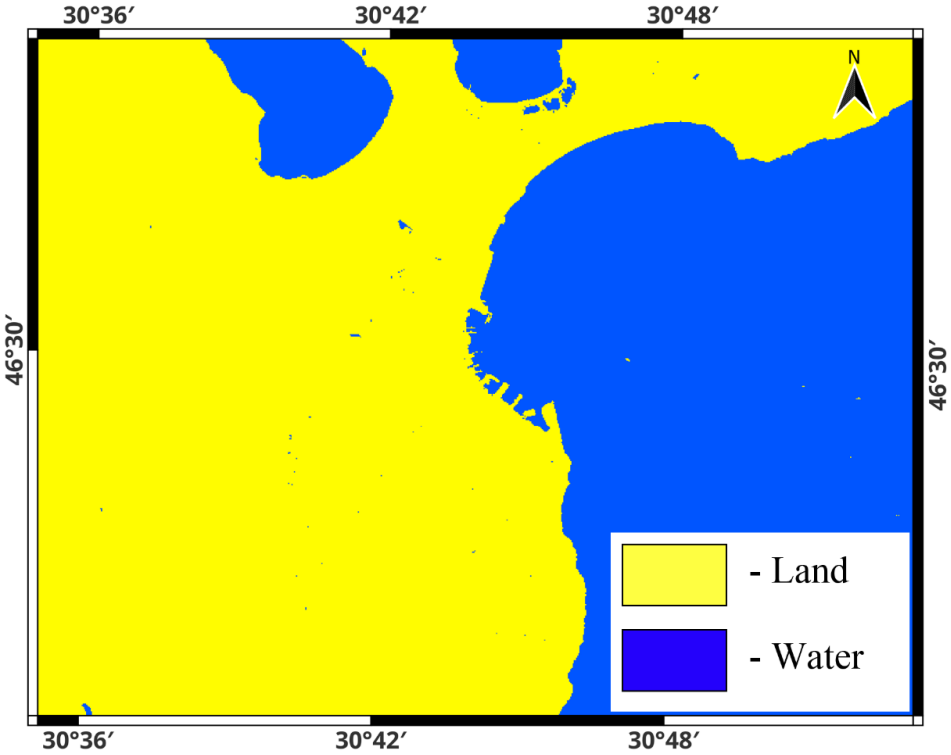

Fig. 2. **MNDWI raster surface map**

In fig. 2, it can be seen that a significant area of "noise" has disappeared. In fig. 2 visually more clearly displayed elements of the coastline and water bodies.

Thus, we believe that it is better to use the MNDWI method for detailed studies of the state of coastlines and water bodies, tracking their spatial-temporal variability.

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