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ISSUES OF REMOTE SENSING OF THE ECOLOGICAL STATE OF AGRICULTURAL LANDSCAPES AS A RESULT OF IRRIGATION

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Abstract: The article is written about remote sensing of irrigated areas and identification of irrigated areas. The capabilities of the Landsat-7, Landsat-8 and Sentinel-2 programs are covered. The maps compiled by the programs show all aquatic and non-aquatic territories.
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Key words: Landsat -7, Landsat -8, Sentinel-2, Copernicus.

Various methods are used to analyze water sources and irrigated areas. In this case, it is very important to analyze the recharge of water sources and their distribution in the basin using modern remote sensing systems, since it clearly shows aspects that are invisible to humans.

Initially, when working with data sources to assess water resources, it is necessary to identify systems that analyze satellite images and them at different depths.

Modern space images are not just pictures, but a product of scanning in a different spectrum. When we take open-source satellite images of the desired areas, we need to select two large source systems. One of them is the Landsat program, which started on July 23, 1972, and the Landsat-8 phase of this program is widely used today. This system takes thousands of satellite images in different years and forms a database. In our studies, we used the Landsat-7 and Landsat-8 systems of this program (see Tables 1-2).

Table 1. Landsat 7 ETM+ satellite image channels

Spectral channels	Wavelengths are calculated in microns	1 pixel coverage
OLI (Operational Land Imager) range		
Channel -1 Blue	0.441-0.514	30 m
Channel -2- Green	0.519-0.601	30 m
Channel -3- Red	0.631-0.692	30 m
Channel -4- Close to infrared (NIR)	0.772-0.898	30 m
Channel -5- Close to infrared (SWIR-1)	1.547-1.749	30 m
Channel -7- Close to infrared (SWIR-2)	2.064-2.345	30 m
Channel -8- Panchromatic (PAN)	0.515-0.896	15 m
TIRS (Thermal Infrared Sensor) range		
Channel -6- Far from infrared	10.31-12.36	60 m

Table 2. Landsat 8 OLI/TIRS satellite image channels

Spectral channels	Wavelengths are calculated in microns	1 pixel coverage
OLI (Operational Land Imager) range		
Channel -1-	0,433-0,453	30 m
Channel -2- Blue	0,450-0,515	30 m
Channel -3- Green	0,525-0,600	30 m
Channel -4- Red	0,630-0,680	30 m
Channel -5- Infraqizilga yaqin (NIR)	0,845-0,885	30 m
Channel -6- Close to infrared (SWIR-1)	1,560-1,1,660	30 m
Channel -7- Close to infrared (SWIR-2)	2,100-2,300	30 m
Channel -8- Panchromatic (PAN)	0,500-0,680	15 m
Channel -9- Spindrift clouds (SWIR)	1,360-1,390	30 m
TIRS (Thermal Infrared Sensor) range		
Channel -10- Far from infrared (TIR1)	10,30-11,30	100 m
Channel -10- Far from infrared (TIR2)	11,50-12,50	100 m

"The Normalized Difference Water Index" (NDWI), proposed by S.K. McFeeters in 1996, was used to determine the index of water sources using the channels of the above satellite images.

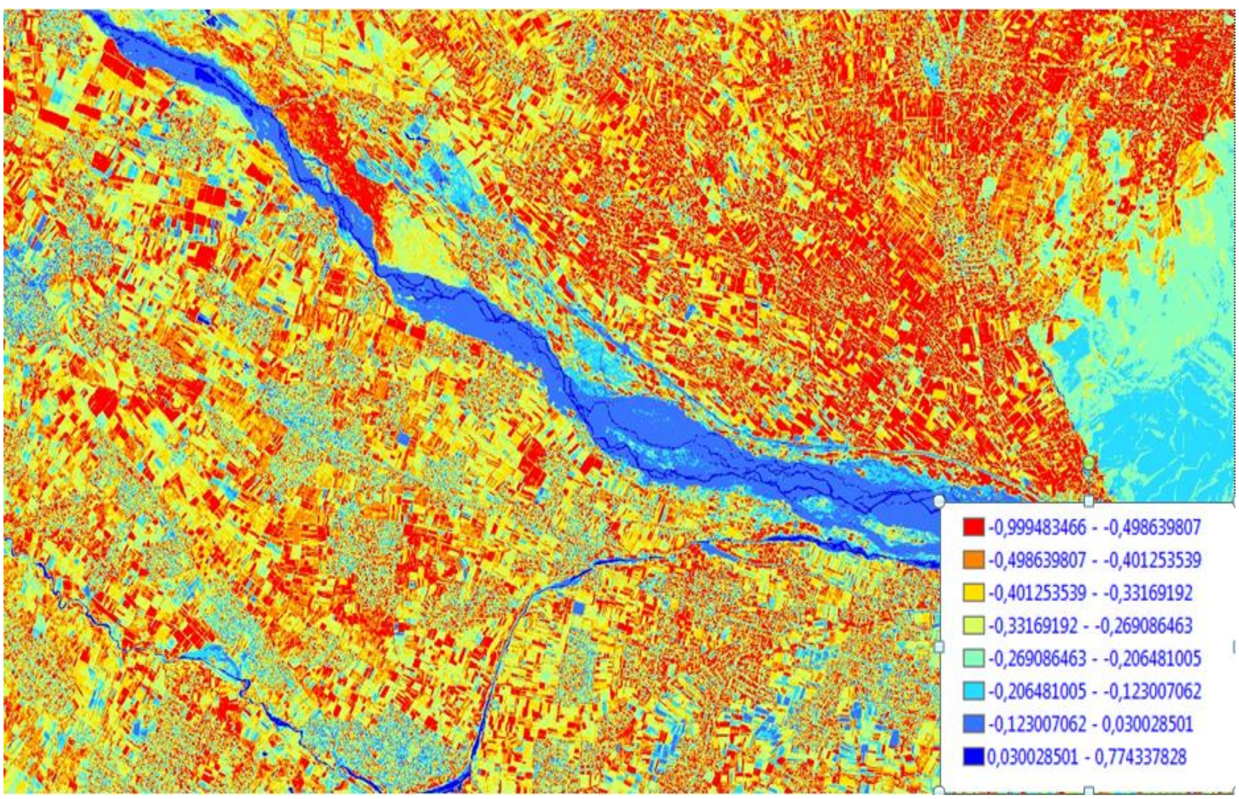

Figure 1. NDWI analysis in ArcGIS software
(analysis performed by the author)

Here, numbers starting with 0.2 µm indicate aqueous media. The return of spectra from surface layers allows the identification of irrigated areas, as this is unique in wet weather. In the numbers in Figure 3.1, the colors starting at 0.2 µm indicate an increase or decrease in water content.

In general, in the process of processing space images, the spectrum of images received by satellites is very important. For NDWI, the predominantly green and UV-green spectrum is very important. In this case, we will take the following expression as the basis for performing the corresponding action.

For the Landsat-7 space system

$$NDWI = \frac{Band2 - Band4}{Band2 + Band4}$$

For the Landsat-8 space system

$$NDWI = \frac{Band3 - Band5}{Band3 + Band5}$$

One common Earth observation system is Copernicus, a remote sensing program. The program's goal is to provide global, continuous, autonomous, high-quality Earth observation capabilities over a wide spectral range. Accurate, timely and easily accessible, Copernicus data can be used for a variety of purposes, including better understanding the impacts of global climate change and citizen safety. The data is available to citizens, service providers, government, international and commercial organizations with the primary goal of improving the quality of life of people in Europe and beyond, and the database is provided to users free of charge. The Copernicus program consists of dedicated space satellites (satellites belonging to the Sentinel family of satellites), satellite missions (previously launched commercial and mass satellites), and collects and processes a large volume of global data from a variety of sensors located at ground stations, in air and sea surveillance systems.

Sentinel-2 is a high-resolution polar-orbiting multispectral imaging mission that will provide images of planet Earth and certain regions and is designed to monitor planet Earth and certain regions for various purposes, such as imaging vegetation, soil and water cover, inland waterways and coastal areas. Sentinel-2 can also provide information to emergency services. Sentinel-2A was launched on June 23, 2015, Sentinel-2V on March 7, 2017.

Sentinel-2 observes land with a multispectral instrument that includes coastal, red, green, blue, near-infrared and short-wave infrared bands. Every five days, Sentinel-2A and Sentinel-2V monitor changes on planet Earth in 12 spectral bands. The pixel size of each stripe is from 10 to 60 ms.

Table 3. Information about some remote sensing parameters

Busv	Resolution	Wavelength	Description
B1	60 m	443 nm	Ultra Blue (Coastal and Aerosol)
B2	10 m	490 nm	Blue
B3	10 m	560 nm	Green
B4	10 m	665 nm	Red
B5	20 m	705 nm	Visible and near infrared (VNIR)
B6	20 m	740 nm	Visible and near infrared (VNIR)
B7	20 m	783 nm	Visible and near infrared (VNIR)
B8	10 m	842 nm	Visible and near infrared (VNIR)
B8a	20 m	865 nm	Visible and near infrared (VNIR)
B9	60 m	940 nm	Shortwave infrared (SWIR)
B10	60 m	1375 nm	Shortwave infrared (SWIR)
B11	20 m	1610 nm	Shortwave infrared (SWIR)
B12	20 m	2190 nm	Shortwave infrared (SWIR)

In our studies, lines 3 and 8 correspond to the use of Sentinel-2 satellite images when performing the corresponding database operations. In these lines, the 3rd green spectrum is the 8th ultraviolet, or NiR. When calculating NDWI, it can be said that it is usually based on the amount of moisture returning from the surface of the plants. In our calculations we used formula $NDWI = \frac{Band3-Band8}{Band3+Band8}$ for Sentinel-2.

In 2006, Xu H (Xu H), who conducted research on these processes, proposed a new, that is, a modified system, rather than NDWI indices. This is the modified normalized difference water index - MNDWI (The Modified Normalized Difference Water Index), the MNDWI formula is as follows $MNDWI = \frac{\text{Green}-\text{SWiR2}}{\text{Green}+\text{SWIR2}}$

To analyze the irrigated areas of the Middle Zarafshan basin, five-year and 10-year data were analyzed based on Landsat images. Using the above expressions, the results could be seen.

A new MNDWI is proposed for Landsat TMETM+

$$MNDWI = \frac{Pband2 - Pband5}{Pband2 + Pband5}$$

Having studied the expression in order to find out the distribution of moisture in the irrigated lands of the Middle Zarafshan basin in June and July, we will be able to see the division of irrigated agricultural areas using special spectra. This allows you to see how land changes are separated by the contours of water sources. It can be seen that in the process of cleaning the rasters, the lines of the pool's water sources can be clearly distinguished.

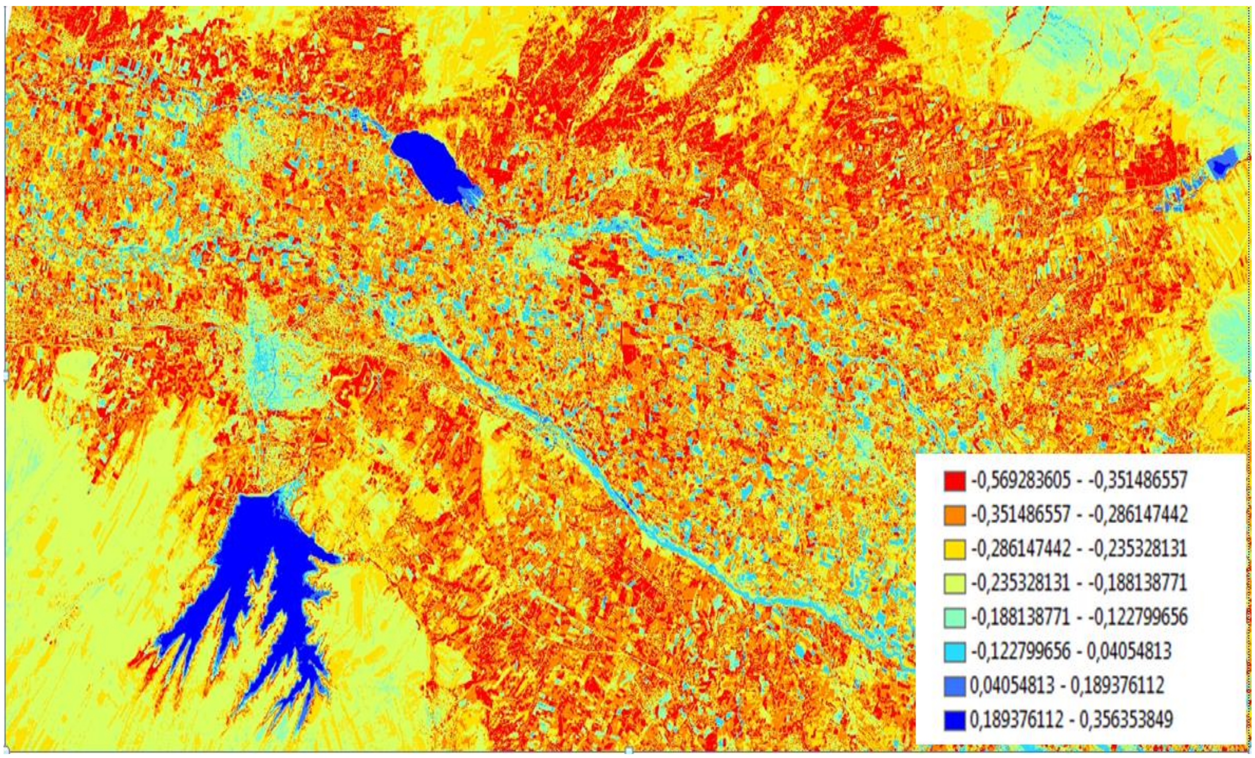

Figure 2. NDWI analysis in ArcGIS software
(analysis performed by the author)

Knowing that research has used different approaches to delineating agricultural landscapes and their boundaries, various indices were used to find out the results of modern technological solutions. We implemented **AWEI**, which has quite complex expressions. Here the double **AWEI** index is considered the best:

1) $AWEI_{NSH}=4(Pb_2-Pb_5)-(0,25.Pb_4+2,75\ Pb_7)$

2) $AWEI_{SH}= Pb_1+2,5* Pb_2-1,5(Pb_4+ Pb_3-0,25+ Pb_7$

When carrying out calculations for our research object, ArcGIS classifiers identified an area for the Middle Zarafshan basin with a boundary starting with blue. We can conclude that it was irrigation in these isolated zones that made it possible to see a change in landscapes.

Conclusion. It became clear that the use of Earth remote sensing data in studying the influence of irrigation on landscape complexes and the dynamic processes occurring as a result creates great opportunities. As a result, this made it possible to create thematic maps that have a number of scientific and practical implications.

When creating modern maps created by remote sensing of the impact of irrigation on landscape complexes, we relied more on the method of relief plasticity and the basin principle.

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