Analele Universităţii din Craiova, seria Agricultură – Montanologie – Cadastru (Annals of the University of Craiova - Agriculture, Montanology, Cadastre Series) Vol. XLIII 2013

PROCESSING AND INTERPRETATION OF SATELLITE IMAGES LANDSAT 8

MIHAI VALENTIN HERBEI, LUCIAN DRAGOMIR , COSMIN POPESCU, RAZVAN PIRSAN

Banat University of Agriculture Sciences and Veterinary Medicine Timisoara
Faculty of Agronomy

INTRODUCTION

The **Landsat program** is the longest running enterprise for acquisition of satellite imagery of Earth. On July 23, 1972 the Earth Resources Technology Satellite was launched. This was eventually renamed to Landsat. The most recent, Landsat 8, was launched on February 11, 2013. The instruments on the Landsat satellites have acquired millions of images.

The images, archived in the United States and at Landsat receiving stations around the world, are a unique resource for global change research and applications in agriculture, cartography, geology, forestry, regional planning, surveillance and education.

Satellite chronology:

- Landsat 1 (originally named Earth Resources Technology Satellite 1): launched July 23, 1972, terminated operations January 6, 1978
- Landsat 2: launched January 22, 1975, terminated January 22, 1981
- Landsat 3: launched March 5, 1978, terminated March 31, 1983
- Landsat 4: launched July 16, 1982, terminated 1993
- Landsat 5: launched March 1, 1984, still functioning, but severe problems since November 2011. On December 26, 2012, USGS announced that Landsat 5 will be decommissioned.
- Landsat 6: launched October 5, 1993, failed to reach orbit
- Landsat 7: launched April 15, 1999, still functioning, but with faulty scan line corrector (May 2003)
- Landsat 8: Landsat Data Continuity Mission was launched February 11, 2013. May 30, 2013 Landsat Data Continuity Mission was turned over to USGS and renamed Landsat 8.

MATERIALS AND METHODS

Description of Landsat 8

Landsat 8 is an American Earth observation satellite launched on February 11, 2013. It is the eighth satellite in the Landsat program; the seventh to reach orbit successfully. Originally called the **Landsat Data Continuity Mission** (LDCM), it is a collaboration between NASA and the United States Geological Survey (USGS). NASA Goddard Space Flight Centerprovided development, mission systems engineering, and acquisition of the launch vehicle while the USGS provided for development of the ground systems and will conduct on-going mission operations.

One important property of the Landsat satellites has been their ability to record data from a number of different spectral channels distributed across the range where the earth atmosphere is transparent. This does not only cover the visual spectrum allowing color images to be recorded but also covers several parts of the infrared spectrum with particular interest to identify and differentiate earth surface properties. There are three new spectral channels in Landsat 8 in addition to the ones existing already in previous Landsats.

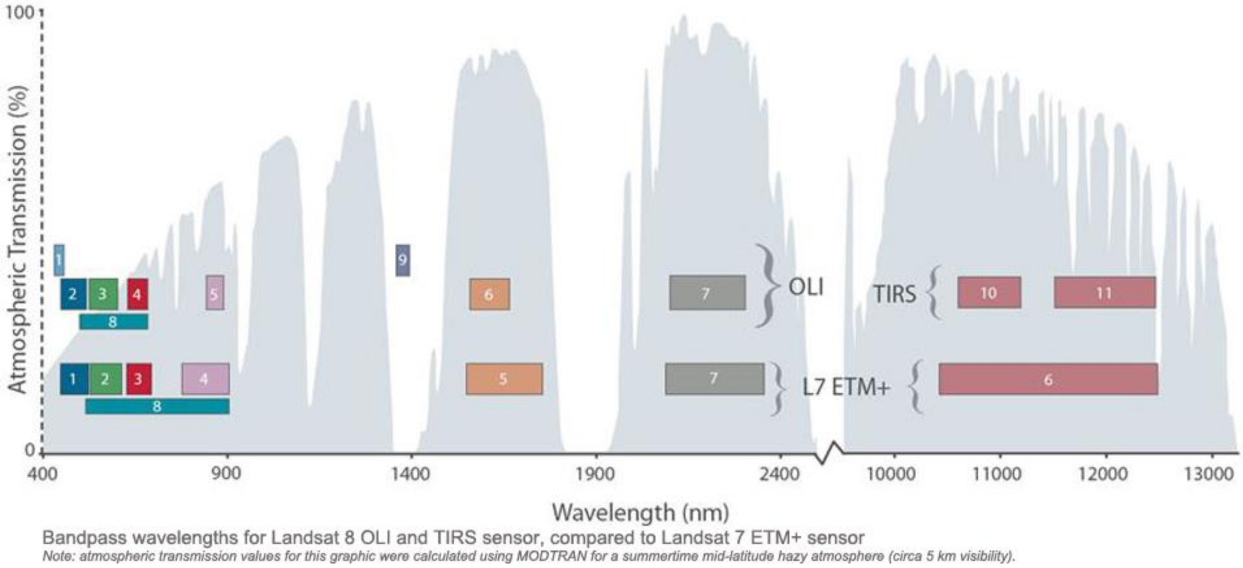

Fig. 1 Landsat 7 and 8 bands (sursa usgs.gov)

The satellite was built by Orbital Sciences Corporation, who served as prime contractor for the mission. The spacecraft's instruments were constructed by Ball Aerospace and NASA'sGoddard Space Flight Center, and its launch was contracted to United Launch Alliance. During the first 108 days in orbit, LDCM underwent checkout and verification by NASA and on 30 May 2013 operations were transferred from NASA to the USGS when LDCM was officially renamed to Landsat 8.

Fig. 2 Landsat 8 satellite (sursa Wikipedia)

The satellite was launched aboard an Atlas V 401 carrier rocket with an Extended Payload Fairing. The launch took place at 18:02 UTC (10:02 PST) on 11 February 2013, from Space Launch Complex 3E at Vandenberg Air Force Base. Seventy eight minutes and thirty seconds later, the spacecraft separated from the upper stage of its carrier rocket, successfully completing the launch.

Landsat 8 joins Landsat 7 on-orbit, providing increased coverage of the Earth's surface.

Providing moderate-resolution imagery, from 15 meters to 100 meters, of Earth's land surface and polar regions, Landsat 8 will operate in the visible, near-infrared, short wave infrared, and thermal infrared spectrums. Landsat 8 will capture approximately 400 scenes a day, an increase from the 250 scenes a day on Landsat 7. The Operational Land Imager - OLI and Thermal Infrared Sensor - TIRS sensors will see improved signal to noise (SNR) radiometric performance, enabling 12-bit quantization of data allowing for more bits for better land-cover characterization.

Table 1 Landsat 8 Spectral Bands

Landsat 8 bands

Band	Wavelength	Useful for mapping
Band 1 – coastal aerosol	0.43-0.45	coastal and aerosol studies
Band 2 – blue	0.45-0.51	Bathymetric mapping, distinguishing soil from vegetation and deciduous from coniferous vegetation
Band 3 - green	0.53-0.59	Emphasizes peak vegetation, which is useful for assessing plant vigor
Band 4 - red	0.64-0.67	Discriminates vegetation slopes
Band 5 - Near Infrared (NIR)	085.-0.88	Emphasizes biomass content and shorelines
Band 6 - Short-wave Infrared (SWIR) 1	1.57-1.65	Discriminates moisture content of soil and vegetation; penetrates thin clouds
Band 7 - Short-wave Infrared (SWIR) 2	2.11-2.29	Improved moisture content of soil and vegetation and thin cloud penetration
Band 8 - Panchromatic	.50-.68	15 meter resolution, sharper image definition
Band 9 – Cirrus	1.36 -1.38	Improved detection of cirrus cloud contamination
Band 10 – TIRS 1	10.60 – 11.19	100 meter resolution, thermal mapping and estimated soil moisture
Band 11 – TIRS 2	11.5-12.51	100 meter resolution, Improved thermal mapping and estimated soil moisture

Landsat 8 Sensors

Landsat 8's Operational Land Imager (OLI) improves on past Landsat sensors and was built, under contract to NASA, by Ball Aerospace. OLI uses a technological approach demonstrated by the Advanced Land Imager sensor flown on NASA's experimental EO-1 satellite. The OLI instrument uses apushbroom sensor instead of whiskbroom sensors that were utilized on earlier Landsat satellites. The pushbroom sensor aligns the imaging detector arrays along Landsat 8's focal plane allowing it to view across the entire swath, 115 miles (185 kilometers) cross-track field of view, as opposed to sweeping across the field of view. With over 7,000 detectors per spectral band, the pushbroom design results in increased sensitivity, fewer moving parts, and improved land surface information.

OLI collects data from nine spectral bands. Seven of the nine bands are consistent with the Thematic Mapper (TM) and Enhanced Thematic Mapper Plus (ETM+) sensors found on earlier Landsat satellites, providing for compatibility with the historical Landsat data, while also improving measurement capabilities. Two new spectral bands, a deep blue coastal / aerosol band and a shortwave-infrared cirrus band, will be collected, allowing scientists to measure water quality and improve detection of high, thin clouds.

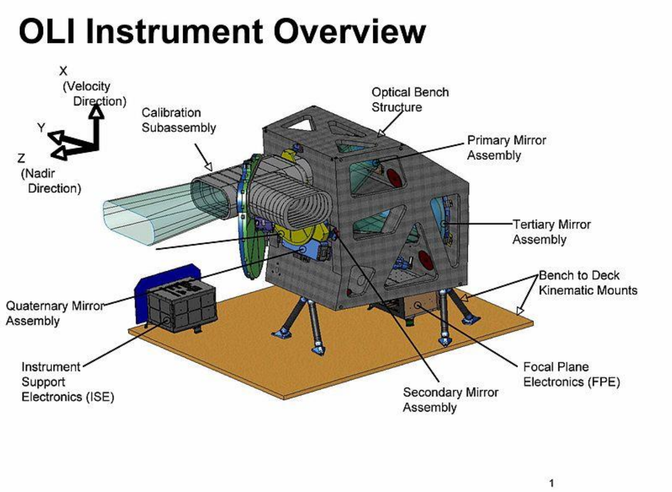

Fig. 3 Landsat 8 OLI Sensor (sursa usgs.gov)

Table 2

OLI Spectral Bands (**usgs.gov**)

Spectral Band	Wavelength	Resolution
Band 1 - Coastal / Aerosol	0.433 - 0.453 µm	30 m
Band 2 - Blue	0.450 - 0.515 µm	30 m
Band 3 - Green	0.525 - 0.600 µm	30 m
Band 4 - Red	0.630 - 0.680 µm	30 m
Band 5 - Near Infrared	0.845 - 0.885 µm	30 m
Band 6 - Short Wavelength Infrared	1.560 - 1.660 µm	30 m
Band 7 - Short Wavelength Infrared	2.100 - 2.300 µm	30 m
Band 8 - Panchromatic	0.500 - 0.680 µm	15 m
Band 9 - Cirrus	1.360 - 1.390 µm	30 m

Thermal InfraRed Sensor

The Thermal InfraRed Sensor (TIRS), built by the NASA Goddard Space Flight Center, conducts thermal imaging and supports emerging applications such as evapotranspiration rate measurements for water management. The TIRS focal plane uses GaAs Quantum Well Infrared Photodetector arrays (known as QWIPs) for detecting the infrared radiation—a first for the Landsat program. The TIRS data will be registered to OLI data to create radiometrically, geometrically, and terrain-corrected 12-bit Landsat 8 data products.[9] Like OLI, TIRS employs a pushbroom sensor design in addition to a 185 kilometer cross-track field of view. Data for two long wavelength infrared bands will be collected with TIRS; however, TIRS only provides Landsat data continuity with one band—Band 10. With TIRS being a late addition to the Landsat 8 satellite, the design life requirement was relaxed in order to expedite development of the sensor. As such, TIRS only has a three-year design life.

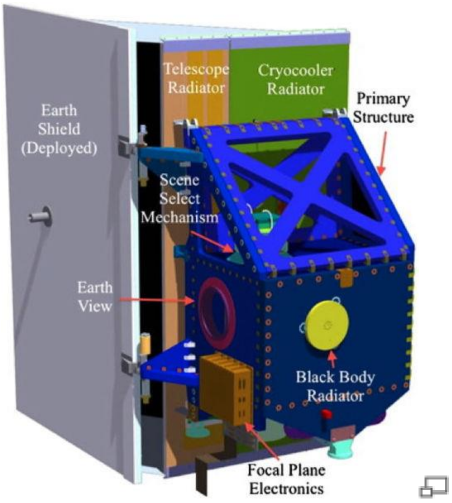

Fig. 4 Landsat 8 TIRS Sensor (sursa usgs.gov)

Table 2

TIRS Spectral Bands (**usgs.gov**)

Spectral Band	Wavelength	Resolution
Band 10 - Long Wavelength Infrared	10.30 - 11.30 µm	100 m
Band 11 - Long Wavelength Infrared	11.50 - 12.50 µm	100 m

Downloading the Landsat 8 images

Satellite image was downloaded from Earth Explorer database (http://earthexplorer.usgs.gov), and subjected to complex mathematical operations in the digital environment.

Image covering the study area has the following indication: LC81860282013221LGN00 which has the following meaning:

LC8 (Landsat 8 satellite and sensor)
186 (orbit), 028 (row) from WRS-2
2013 registration year
237 number of days in 2013
LGN00 land station capturing the signal and creating the image

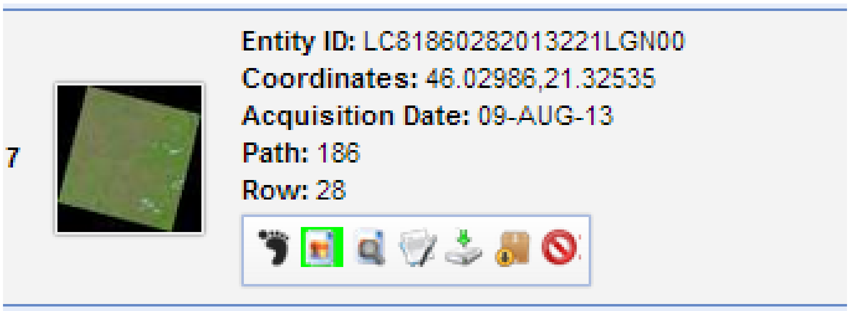

Fig. 5 Satellite image downloading

RESULTS AND DISCUSSIONS

Landsat 8 has been online for a couple of months now, and the images look incredible. While all of the bands from previous Landsat missions are still incorporated, there are a couple of new ones, such as the coastal blue band water penetration/aerosol detection and the cirrus cloud band for cloud masking and other applications. Here's a rundown of some common band combinations applied to Landsat 8, displayed as a red, green, blue (RGB):

Below are the most important combinations of spectral bands, which were processed from Landsat 8 satellite image of Timişoara metropolitan area, processing performed using ArcGIS software v10, ***Raster Processing module - Composite Bands***.

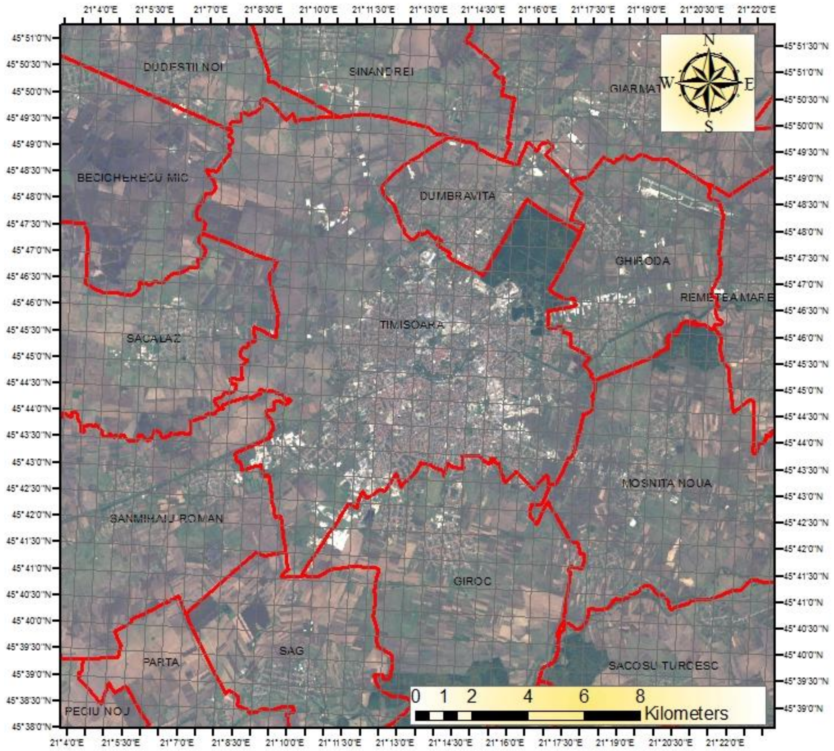

Fig. 6 Natural Color - 4 3 2

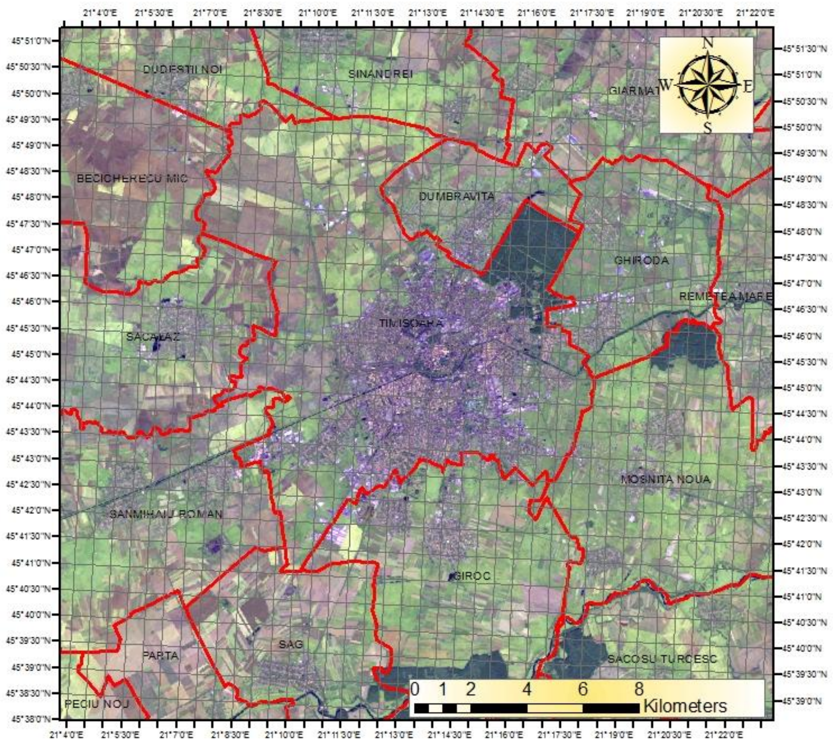

Fig. 7 False Color (urban) - 7 6 4

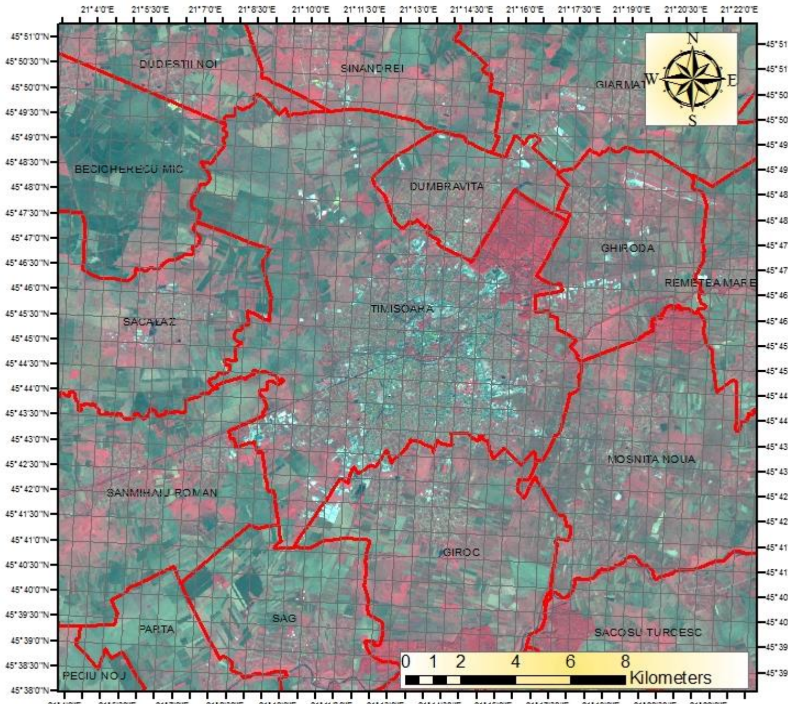

Fig. 8 Color Infrared (vegetation) -5 4 3

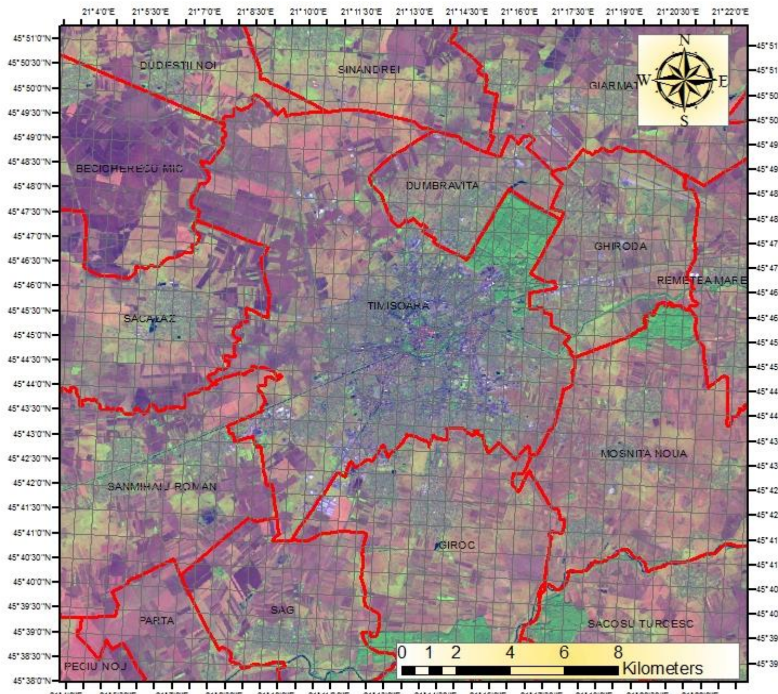

Fig. 9 Agriculture - 6 5 2

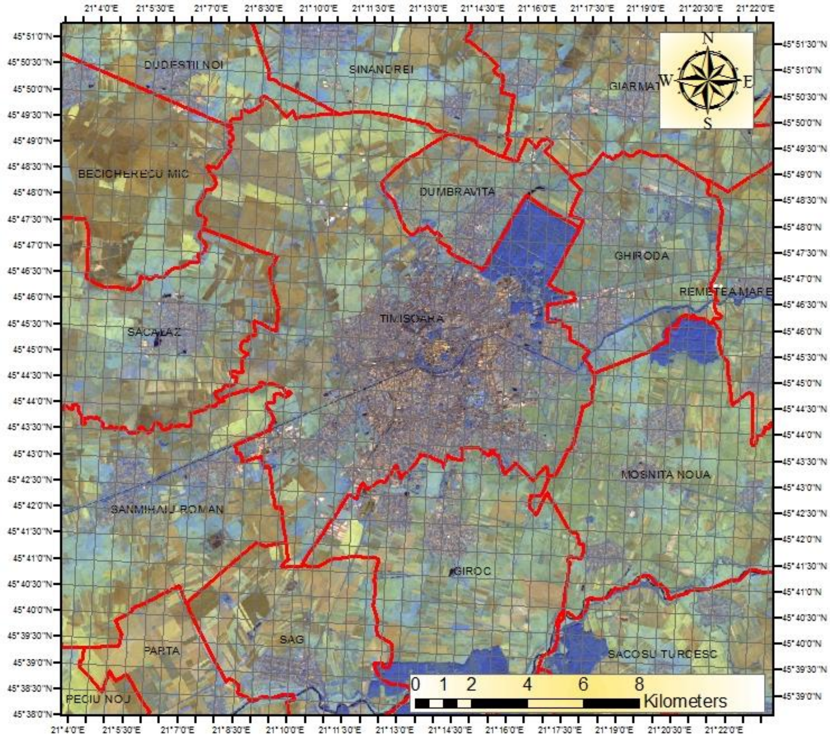

Fig. 10 Atmospheric Penetration - 7 6 5

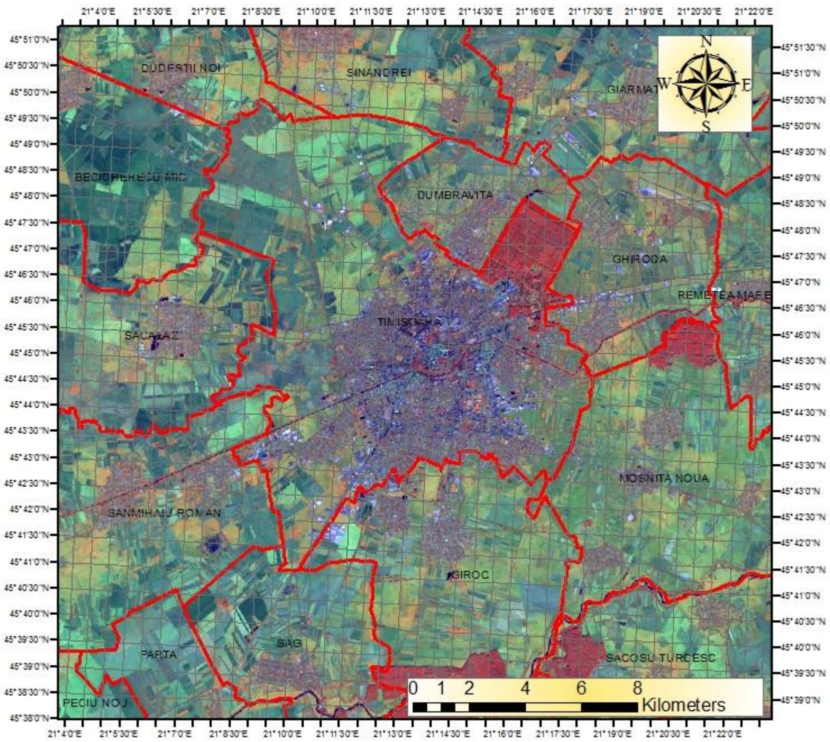

Fig. 11 Land/Water - 5 6 4

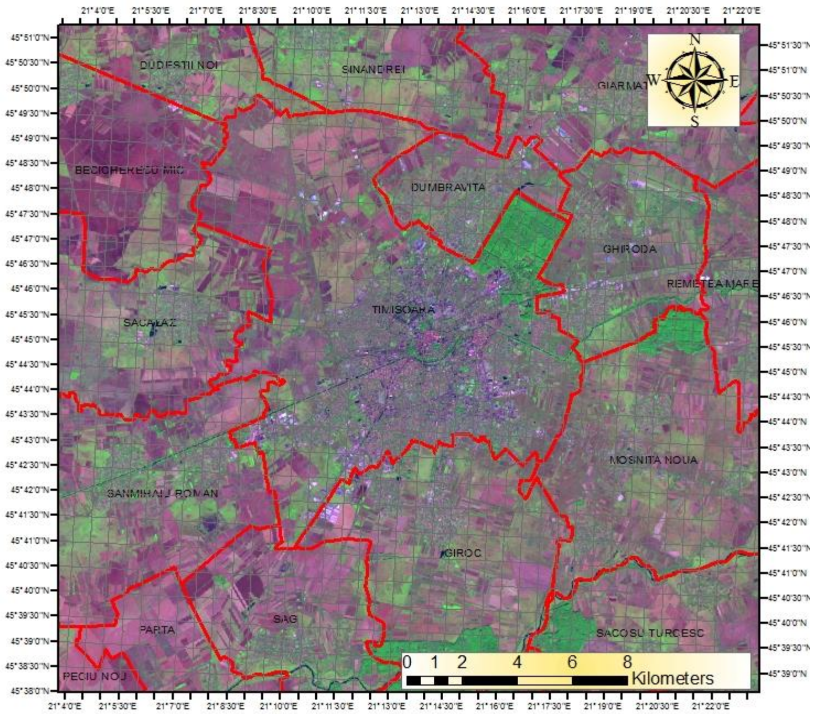

Fig. 12 Shortwave Infrared - 7 5 4

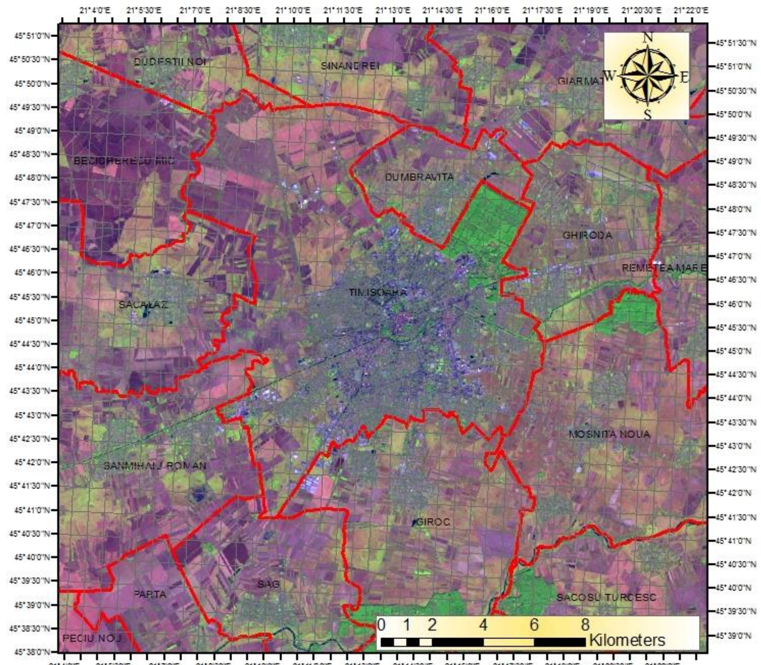

Fig. 13 Vegetation Analysis - 6 5 4

CONCLUSION

In order to optimize aspects of soil production capacity, an inventory management of this resource is required using remote sensing techniques.

Research of land area from airspace and outer space using remote sensing techniques delivers valuable information for many industries, among which: agriculture, forestry, geology, soil, hydrology, cartography, exploration and evaluation natural resources, environmental monitoring (soil, water and air) and others.

Landsat images can be used successfully in a number of scientific applications and practical problems: global urbanization, wetland delineation, detecting changes regarding the use of land, forest areas management, management of natural parks etc.

BIBLIOGRAPHY

1. DAVIS, D., - „GIS for Everyone", ESRI, 1999;
2. IONESCU, I. – "Engineering Photogrammetry", Ed. Matrixrom, Bucuresti, 2004;
3. POPESCU, C. – "Remote sensing and geographical informatics systems in agriculture" Eurobit press, Timisoara, 2007.
4. HERBEI O. & HERBEI M. – "Geographic Information Systems. Theoretical and applications", Universitas Press, Petrosani, 2010;
5. HERBEI M. – "Geographic Information Systems - Aapplications", Universitas Press, Petrosani, 2013;
6. VOROVENCII, I. – "Researches guarding the possibilities of using satellite images in forest" Development projects. Doctor's degree paper. "Transilvania" University, Brasov, 294 p, 2005;
7. http://www.usgs.gov/
8. www.wikipedia.org