USING NBUI TO EXTRACT BUILT-UP AREA IN IAŞI MUNICIPALITY AREA, ROMANIA

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***Abstract**: Urban built-up areas are vast stretches of constructed areas equipped with basic public facilities. Urban built-up area information is necessary in numerous applications of land use planning and management. The detection and calculation of the built-up area with the highest possible accuracy is of big importance in agricultural urban and suburban studies. Urban built-up area extraction from Landsat data, which has moderate spatial resolution, is challenging because of important intraurban heterogeneity and spectral confusion between other landcover types. In this paper is used a method to extract urban built-up surface from Landsat Thematic Mapper and Enhanced Thematic Mapper Plus data and determines urban area changes between 1994 to 2016 of Iaşi Municipal Area of Romania. The Enhanced Built-Up Bareness Index (EBBI), Soil Adjusted Vegetation Index (SAVI), Modified Normalized Difference Water Index (MNDWI) were selected, to define three major urban landuse (LU) classes: built-up and barren or bare land, vegetation and open waterbody. In this paper built-up area was extracted as difference between indices EBBI, SAVI, MNDWI to eliminate water noises and vegetation, the obtained index image was spectrally sectioned to separate built-up area from the nonurban built-up lands. The obtained index is used to extract built-up area for 1994 and 2016 periods. Built-up area showed an overall growth about 203% in a span of 22 years. The accuracy of this index is 88.72%.*

***Keywords:** Remote Sensing; Built-up Area; Landsat*

1. Introduction

The identification (distribution, size, location etc.) of the built-up area is of high importance in suburban, urban and agricultural studies. The study of urban spatial extension always needs quick and accurate information on urban built-up zones in the form of spatial and size context for urban landuse (LU) planners and decision makers. Urban zones are dominated by built-up lands with impervious covering (Xu et al., 2000). According to Xu, the expansion of urbanized zones results in minimaize of surrounding valuable natural lands. Changing of the nature lands into built-up area can have major effects on the hydrologic system, ecosystem, biodiversity, etc. in the zone (Xu, 2007).

Remote sensing data are useful and efficient for monitoring, according to several researchers, the spatial distribution and increased of urban built-up zones because of their ability to deliver timely and synoptic views of landcover (Guindon et al. 2004, H. Xu 2008, Griffiths et al. 2010, Bhatta 2009). Mapping urban built-up zones using moderate resolution remote sensing imagery like from Landsat TM and ETM+ images is complex because urban zones comprise of natural and man made features such as: bareland, vegetation, waterbody etc. These urban zones often display heterogeneous spectral particularities and important spectral confusion between landcover classes and as a result decrease mapping accuracy. To fix this spectral confusion, many techniques have been define for urban landcover mapping using remote sensing data. Some indices to map the built-up and other landcover classes in urban zones, like: Urban Index (UI) (Kawamura et al., 1996), Bare soil index (BI) (Rikimaru, Miyatake, 1997), Normalised Difference Bareness Index (NDBaI) (Zhao et. al., 2005), Index-based Built-Up Index (IBI) (Xu, 2008) and Normalised Difference Built-Up Index (NDBI) (He, 2010) have been employed in numerous studies. Anyway, each has its own disadvantages and advantages.

In this study, is used New Built-Up Index (NBUI) (Sinha et al., 2016) to extract urban built-up area from Landsat imagery based on new image determined from 3 thematic indices, Enhanced Built-Up Bareness Index (EBBI) (A. As-syakur, 2012; Bouhennache et al., 2015), Soil Adjusted Vegetation Index (SAVI) (R. Huete, 1988; Ren et al.,, 2014), Modified Normalized Difference Water Index (MNDWI) (H. Xu, 2005, Zhang et al., 2015). The process is used to extraction of urban built-up area of Iasi Municipality from Landsat TM/ETM+ images for 1994 and 2016, and identification of changes in built-up zones between 1994-2016 periods.

2. Data and methods

2.1. Study Area

Iași, the seat of Iași County, is the largest city in eastern Romania. Located in the historical region of Moldavia, municipality Iași has traditionally been one of the leading centres of Romanian academic, social, cultural and artistic life. The city is crossed by the Bahlui River, affluent of Jijia, which flows into the Prut River. The Moldavian capital is one of the "legendary city of the seven hills", like Rome. The name of the seven hills are Cetățuia, Galata, Copou, Bucium, Repedea, Breazu and Șorogari.

The local climate is temperat-continental with minimal rainfall and with lImportant temperature differences between the seasons. Summer lasts between the end of the May to the half of September. Autumn, a season of transition, is short. In the second part of November there is usually frost. Winter, the temperatures dropping to –20 ºC (https://en.wikivoyage.org).

Study Area is geographically situated on latitude 47°12'N to 47°06'N and longitude 27°32'E to 27°40'E.

Fig. 1. Study Area (wikipedia, rotravel)

2.2.Landsat data

The Landsat Thematic Mapper, a sensor carried on Landsats 4 or, and 5, have seven spectral bands of radiant energy from the earth of surface. The wavelength range for the Thematic Mapper sensor is from the visible (Vis) through the mid-infrared (MIR) and into the thermal-infrared (TIR) portion of the electromagnetic spectrum (https://lta.cr.usgs.gov/LTM).

The satellites operated from a sunsynchronous, near-polar orbit, imaging the same 185 km swath every sixteen days. The images are about of 170 by 185 km with a resolution of 30 meters for the 6 reflective bands and 120 meters for the TIR (thermal band). Band 7 and bands 1 through 5 are reflective radiation. The sixth band represent thermal radiation (https://lta.cr.usgs.gov/LTM).

Table 1.Spectral Bands/Wavelengths-Landsat Thematic Mapper (TM)

Band	Resolution	Wavelength μm	Description
1	30m	0.45-0.52	Blue
2	30m	0.53-0.61	Green
3	30m	0.63-0.69	Red
4	30m	0.78-0.90	Near Infrared
5	30m	1.55-1.75	Short-wave Infrared
6	60m	10.4-12.5	Thermal Infrared
7	30m	2.09-2.35	Short-wave Infrared

The Enhanced Thematic Mapper Plus instrument is a fixed “whisk-broom”, eight-band, multi-spectral scanning radiometer capable of providing medium resolution imaging information of the Earth of surface. It detects spectrally-filtered radiation in LNIR, SWIR, VWIR and panchromatic band (B8) from the sun-lit Earth in a 183 km wide swath when orbiting at an altitude of 705 km (landsat.gsfc.nasa.gov/the-enhanced-thematic-mapper-plus/).

The primary new features on Landsat 7 ETM are a panchromatic band with 15 metter spatial resolution, an on-board full aperture solar calibrator, 5 percents absolute radiometric calibration and the TIR channel with a 4 fold improvement in spatial resolution over TM (landsat.gsfc.nasa.gov/the-enhanced-thematic-mapper-plus/).

Table 2.Spectral Bands/Wavelengths-Enhanced Thematic Mapper Plus (ETM+)

Band	Resolution	Wavelength μm	Description
1	30m	0.45-0.52	Blue
2	30m	0.53-0.61	Green
3	30m	0.63-0.69	Red
4	30m	0.78-0.90	Near Infrared
5	30m	1.55-1.75	Short-wave Infrared
6	60m	10.4-12.5	Thermal Infrared
7	30m	2.09-2.35	Short-wave Infrared
8	15m	0.52-0.90	Panchromatic

Landsat Thematic Mapper (TM) data of August 1994 and Enhanced Thematic Mapper plus (ETM+) data of August 2016 (path 182, row 27) – were acquired for built-up zone extraction and change detection for this research. All image processing tasks were implemented in ArcMap 10.1. The goal of image preprocessing is to make all of the remote sensing data similar so that imagies can be considered to be taken in same environmental conditions with the same sensors (Hall et al., 1991). To fill the gaps with Landsat 7 images, a specialized toolbox of ArcMap 10.1 was used.

Table 3. Landsat data

Nr. Crt.	Path	Row	Date	Landsat satelitte
1	182	27	1994-08-09	Thematic Mapper (TM)
2	182	27	2016-08-05	Enhanced Thematic Mapper plus (ETM+)

2.3. Data processing

The concept of NBUI was based on the understanding that the urban zone is a complex ecosystem composed of 4 main heterogeneous elements: green vegetation/bare soil, impervious surface area (ISA), exposed soil and waterbody (Sinha et al., 2016). Consequently, NBUI applies almost the whole wavelengths of Landsat data to exemplify these significant urban landuse classes and calculated as:

$$\text{NBUI}=\frac{B_5 - B_4}{10x\sqrt{B_5 + B_4}} - \left(\frac{(B_4 - B_3)x(1+l)}{B_4 + B_3 + 1} + \frac{B_2 - B_5}{B_2 + B_5}\right)$$

where, l is: (l = 0) for low density vegetation and (l = 1) for high density vegetation (Sinha et al., 2016).

The first part of equation represent EBBI and uses NIR-0.83 µm, SWIR-1.65 µm and TIR-11.45 µm of Landsat data to highlight, according to Zha, the contrast reflection range and absorption in bare or built-up land zones (Zha, 2003; Chen., 2003). The second part of index, to highlight vegetation, uses Soil Adjusted Vegetation Index, by taking ratio of near-infrared to a red band to take advantage of high density vegetation reflectance in near-infrared and high pigment absorption of red light (R. Jensen, 2007). The SAVI, according to Ray, was found effective even in zone with vegetation cover as low as 15%, while the "classic" NDVI is effective in zone where vegetation cover is above 30% (W. Ray, 1994). The final part of expression of NBUI was used to map water, a important component in urban landuse, using a SWIR and green band. (Xu, 2005).

2.4. Accuracy Assessment

The orthophotoplasms for the city of Iasi from 2015 were used to evaluate the accuracy of the extruded surfaces using NBUI. The total area of the built-up area extracted from the orthophotomaps was compared to the surface area built-up on the satellite imagery using NBUI. They also overlapped the images with the built-up surfaces obtained by applying NBUI to the built-up areas obtained from orthopoplanes. The accuracy of this index is 88.72%

3. RESLUTS AND DISCUSSION

The proposed method - New Built-Up Index (NBUI) was used to map built-up area for the years 1994 and 2016, which were then compared to define the built-up area extension between 1994–2016 periods. Figure 2 shows the expansion map of the built area that highlights the change between the two years The images show a dynamics of change over this 22-year period for land cover. Nevertheless, the results show a important groth in only two landuse classes: built-up area and sparse vegetation. In 22 years built-up area highlighted an overall groth of almost 203%.

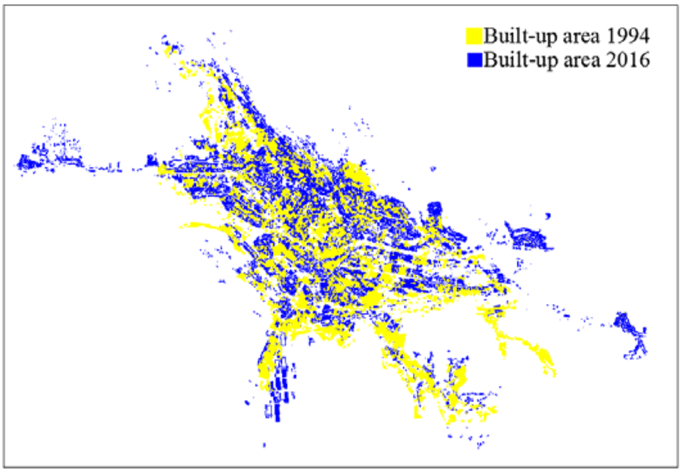

Fig. 2. Built-up area expasion

4. Conclusions

Indices obtained from Remote sensing data for urban areas are usually used to discern different urban landuse features like: barren land, built-up, waterbody and vegetation. Nevertheless, exact extraction of these landuse characteristics is very difficult because of high mixing between classes, particularly in urban zones. In this paper NBUI was used to highlights built-up area. First of all highlighting built-up and barren land area was done by the instrumentality of information from near-infrared (NIR), shortwave-infrared (SWIR) and thermal infrared (TIR) data, and then to exclude the water noises and vegetation to map built-up area. NBUI was applied to map built-up area from Landat TM/ETM data from 1994 to 2016, in Iasi municipal area, Romania. The accuracy of this index is 88.72%. In a period of 22 years (1994-2016), the built-up area in Iasi municipality has increased almost by 203%, that showed important change of landuse occurring in the area.

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