Classification of Land and Crops Based on Satellite Images Landsat 8: Case Study SD Timisoara

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ABSTRACT

Agriculture benefits increasingly from the several services of related areas, including satellite technology and informatics, which have a substantial contribution lately. The present study aimed to analyze and classify the habitat, and crops of the SD Timisoara based on spectral information from satellite images. Analysis of the habitat and agricultural crops was done with ArcGIS 10 software based on satellite images Landsat8. Of the tested algorithms, Maximum Likelihood was used and as method, the supervised classification was used in order to analyze the spectral information contained by satellite images. The high and stable level of the correlation between spectral bands and satellite index NDVI recorded in May, has determined that satellite images from the certain month should be used for the classification the territory, evaluation of crop structure and areas occupied by them. There was an interdependent relationship between NDVI index and Band 543 having high statistical accuracy ($p < 0.001$, $R^2 = 0.820$). Analysis done by supervised method based on Maximum likelihood algorithm has facilitated land and crop classification in four classes in the year 2013 and six classes in the year 2014 and the determination of crop areas with high level of accuracy.

Keywords: *algorithms, classification, crops, GIS, precision agriculture, satellite images*

INTRODUCTION

Methods based on satellite techniques are increasingly used in order to analyze and characterize the terrain and vegetation cover (Gitelson, 2004; Thenkabail *et al.*, 2007; Motohka *et al.*, 2010; Borsan *et al.*, 2013; Dimen *et al.*, 2013; Wu 2014). Characterization of vegetation cover can be done based on specific properties of absorbance, reflectance and emittance but also based on indices calculated from spectral information contained by satellite images (Thenkabail *et al.*, 2002; Huang *et al.*, 2013; Mondal *et al.*, 2014; Herbei *et al.*, 2015a). Classification of satellite images, based on the analysis and distribution on pixel groups with similar spectral characteristics for brightness value, offering high accuracy of image analysis and implicit areas represented (Akgün *et al.*, 2004).

Many researches had the purpose of analysis and classification and monitoring of agricultural crops based on satellite images (Vyas *et al.*, 2005; Johnson and Mueller 2010; Guindin-Garcia *et al.*, 2012; Liu *et al.*, 2014). The growing interest in monitoring land and crops on the basis of satellite images has made more research to target these methods, models and algorithms to increase the accuracy of analysis (Hansen *et al.*, 2008; Dalmau and Rivera, 2009, 2010, 2011; Oliva *et al.*, 2014). There were also analyzed the sources of error in remote sensing analysis of crops distributions, in order to increase accuracy of analysis and certainty of the results, (Ozdogan and Woodcock 2006).

In the context of the interest for using GIS technology in the study and management of

agricultural crops, the present study used satellite technology to classify and analyze specific crops in a vegetable farm system.

MATERIALS AND METHODS

The present study had as purpose achieving a classification of the territory and agricultural crops based on the analysis of satellite images Landsat 8. Based on GIS technology, the study was conducted in 2013-2014 and it covered the land of USAMVB Didactic Station Timisoara, located in Timis County, Romania, Figure 1. The system Landsat 8 has provided the satellite images based on which the study was conducted. Satellite images were taken between 2013 and 2014, during several months in crop vegetation.

From the Earth Explorer database (26) there were downloaded satellite images and spectral information. These were analyzed in the digital environment (ArcGIS 10) and were subject to complex mathematical operations, in order to extract geographic information and to calculate indices NDVI, NDMI, NDBR, relations (1), (2), and (3).

$$\text{NDVI} = \frac{(NIR - IR)}{(NIR + IR)} \quad (1)$$

$$\text{NDMI} = \frac{(NIR - IR)}{(NIR + IR)} \quad (2)$$

$$\text{NDBR} = \frac{(NIR - MIR)}{(NIR + MIR)} \quad (3)$$

Landsat 8 satellite images related to the study area, taken from Earth Explorer international database, have presented a set of standard parameters necessary and useful in the analysis process: type and image format (Level 1T - terrain corrected, GeoTIFF) resolution (15 meters/30 meters/100 meters, panchromatic/multispectral/thermal) map projection (UTM-PolarStereographic for Antarctica), geodetic datum (WGS 84, North-up map; Cubic convolution), accuracy (LI: 12 meters circular error, 90-percent confidence; TIRS: 41 meters circular error, 90-percent confidence) etc. Landsat spectral bands used in this study and their properties, with respect to wavelength and resolution, are presented in Table 1.

In order to analyze the terrain and vegetation cover, the classification process has implied grouping of the pixels from the composition of digital imaging in classes of land cover, in relation with spectral properties. Analysis of the territory and the structure of agriculture land and was done based on Landsat8 satellite images and software ArcGIS 10. Algorithm Maximum Likelihood were used and the method of supervised classification. Classified images were subjected to a post-processing process in order to obtain results with high accuracy.

RESULTS AND DISCUSSION

Starting from Landsat8 satellite maps, the spectral information was obtained which characterized vegetation cover in the studied area. The spectral information was represented by

Fig. 1. Territory location of USAMVB Didactic Station Timisoara Timiș County, Romania

spectral bands (R,G,B,NIR). In this study we used the combinations of spectral bands 4-3-2 (REED – GREEN – BLUE) and 5-4-3 (NIR – REED – GREEN) which facilitated obtaining useful information for the classification of land and agricultural crops based on the analysis of satellite images. The combination of spectral bands 4-3-2 (RGB) of the studied area is shown in Figure 2, each color being shown based on the primary spectral components red, green and blue. Subsequently were calculated indices NDVI, NDBR, NDMI for characterizing the vegetation cover. Based on that information and also the algorithms, the classification of satellite images was performed with high accuracy corresponding to agricultural crops (wheat, barley, spring barley, maize, sunflower and rape) of the study period.

By analyzing interdependencies of the spectral information contained by bands R, G, B,

NIR and satellite indices NDVI, NDBR and NDMI, a variable level of correlation was identified during the study period. The highest and most stable level of correlation was recorded in May for satellite index NDVI, and for this reason the satellite images from that certain month were used to classify the territory, to evaluate of crop structure and areas occupied by them.

The relationship of dependence between index NDVI and band 543 was described by a 2nd degree polynomial equation, equation (4), under conditions of high statistical accuracy ($p < 0.001$, $R^2 = 0.820$). Particular distribution of the NDVI index values calculated based on the spectral values contained by band 543 are shown in Figure 2. High correlations of the spectral bands R,G,B and 543 with indices NDVI, NDMI and NDBR have been identified also in other studies (Herbei *et al.*, 2015a,b; Herbei and Sala 2015). Wardlow

Tab. 1. Presentation of Spectral Bands– Landsat 8 used for the classification of land and agricultural crops

Band No.	Band	Wavelength (mm)	Resolution (pixel)
Band 2	Blue	0.45-0.51	30
Band 3	Green	0.53-0.59	30
Band 4	Red	0.64-0.67	30
Band 5	NIR	0.85-0.88	30

Fig. 2. The relation of interdependence between the combinations of spectral bands 543 and index NDVI

et al. (2007) also studied the possibility of crop classification based on vegetation index data in MODIS system.

$$y = -1E - 09x^2 + 8E - 05x - 0.7596 \quad (4)$$

where: y – NDVI; x – 543 combination spectral band

The images obtained through combinations of spectral bands 543 (NIR – RED – GREEN), were subjected to supervised classification process based on the Maximum Likelihood algorithm, having as result Fig. 3, and Fig. 4.

Maximum likelihood classification, equation (5), assumes that the statistics for each class in each band are normally distributed and calculates the probability that a given pixel belongs to a specific class. Unless you select a probability threshold, all

pixels are classified. Each pixel is assigned to the class that has the highest probability (that is, the maximum likelihood). If the highest probability is smaller than a threshold you specify, the pixel remains unclassified (Richards, 1999).

$$g_i(x) = \ln p(\omega_i) - 1/2 \ln |\Sigma_i| - 1/2 (x - m_i)^T \Sigma_i^{-1} (x - m_i) \quad (5)$$

where: i = class; x = n -dimensional data (where n is the number of bands); $p(\omega_i)$ = probability that class ω_i occurs in the image and is assumed the same for all classes; $|\Sigma_i|$ = determinant of the covariance matrix of the data in class ω_i ; Σ_i^{-1} = its inverse matrix; m_i = mean vector.

Starting from the analysis of the information contained by spectral bands 543 and NIR, the

Fig. 3. Graphical representation of the combination of spectral bands 543 for the year 2013

Fig. 4. Graphical representation of the combination of spectral bands 543 for the year 2014

Tab. 2. Classification of SD Timisoara area, based on combinations of spectral bands 543 through supervised classification analysis

Year 2013			Year 2014		
CLASS	Crop	Percentage	CLASS	Crop	Percentage
1	wheat	33.38	1	wheat	14.42
2	barley	25.80	2	barley	7.51
3	maize	7.59	3	spring barley	4.02
4	sunflower	33.23	4	maize	11.31
			5	sunflower	5.08
			6	rape	57.66

classification of the crops was performed during the study period with high precision. For the year 2013, 4 classes were obtained and 6 classes for 2014, which corresponded to the reality from the field, results being shown in Tab. 2 and Fig. 5, and Fig. 6.

From the analysis of satellite images through supervised method and based on Maximum Likelihood algorithm, the surfaces of the crops were obtained with high precision from the Didactic Station of USAMVB Timisoara during 2013 - 2014. The structure of crops and cultivated areas are shown in Table 3.

CONCLUSION

Image analysis based on satellite images Landsat8, through supervised method has facilitated the classification of land and agricultural crops in the study area with high precision. The method can be promoted for monitoring crops and land use.

Due to high correlations with spectral data, the index NDVI presented high importance in crop classification and calculation of areas occupied.

For safety, it is necessary to perform the analysis and processing of digital images to achieve pixel corrections in accordance with the

Fig. 5. Supervised classification of agricultural crops in SD Timisoara for the year 2013

Fig. 6. Supervised classification of agricultural crops in SD Timisoara for the year 2014

Tab. 3. Distribution of the crops and areas within the study period

Crop	Surface of the crops in SD Timisoara (ha)	
	2013	2014
wheat	440	190
barley	340	99
spring barley	-	53
maize	100	149
sunflower	438	67
rape	-	760
Total	1318	1318

reality from the field, some deterioration being caused by weather conditions at the moment of sampling the images.

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