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Remote Sensing Application for Agricultural Land Value Classification Integrated in the Land Consolidation Survey

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Abstract* – Purpose of the present research is aimed at remote sensing application, integrated with the conventional methods, in agricultural land value classification within the land consolidation survey procedure. The paper provides overview of agricultural land value classification, as determined by the conventional methods, with comparative overview of remote sensing application in identification of agricultural crops using multispectral temporal images of crops, where yields of agricultural crops are being one of the variables in agricultural land value classification. The need for geospatial data increases, over the vast areas in the certain timeframes, especially in the field of agriculture, which is an important industry of any country. The present paper contributes to methodology development for the remote sensing application in the land consolidation survey procedure, where technical procedure provides for land territory arrangement and organization and environment protection.

***Index Terms*–Land Consolidation Survey, Remote Sensing, Satellite Images, Classification of Crops, Agricultural Land Value**

I. INTRODUCTION

Remote sensing is a research method providing for identification and analysis of spatial – temporal elements of the environment; land use and land cover change, in order to obtain timely information on environment and influence of human activities. Geospatial datasets with spatial and temporal resolution detect, discover and analyze topographic changes of surfaces, along with the changes of landscape vertical component. Spatial information on earth surface is gaining on importance for monitoring local, regional and global resources and environment. Numerous researches had presented methodology of remote sensing and monitoring changes on earth surface, which may be used to deduct some very beneficial and important conclusions [2]. Apart from plentitude of successful research of remote sensing application for monitoring and detection of environment changes, there are vast challenges in multispectral temporal images use for obtaining certain information about the environment and events. Technological development of new platforms and sensors for data acquisition had contributed to the major advance in the remote sensing application and development of several advanced methods for satellite imagery processing [3] and new approaches in analysis and use of image data with temporal dimension [1]. This paper does not cover specific methods or algorithms for satellite imagery processing; instead, the focus is on potential use of satellite imagery for the purposes of agricultural land value classification and analysis of estimated changes on earth's surface. The research had been conducted in the governmental institution, Republic Geodetic Authority, which successfully implements activities on the NSDI (National Spatial Data Infrastructure) establishing in Serbia according to the European initiatives and trends, in line with the INSPIRE (Infrastructure for SPatial InfoRmation in Europe initiative) Directive principles, with the support of the IGIS (Integrated Geo-Information Solution) Project implemented by French consortium "IGN France International" and "EADS Astrium", with the objective to develop the Remote Sensing center on the national level. Test area for the research was the territory of the Cadastral Municipality of Feketic, the Municipality of Mali Idjos in Vojvodina, where land consolidation survey is being performed over 6 thousand hectares of the agricultural land (Fig. 1).

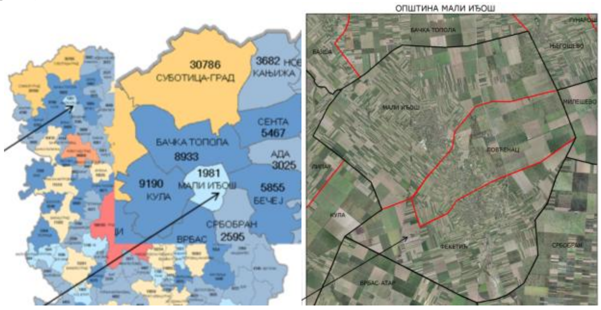

Fig. 1: Test area – the Municipality of Mali Idjos, Cadastral Municipality Feketic

II. AGRICULTURAL LAND VALUE CLASSIFICATION

Methodological procedures for agricultural land value classification within the land consolidation survey procedure using conventional methods integrated in the GIS environment, over the same test area, had been described in the previous paper [7]. Previous research was aimed at verifying the set hypothesis that the agricultural land value classification in the land consolidation procedure gets exceptional improvements by utilization of geographic information systems [4] and spatial graphical databases, giving the overview of vast areas for which the land value classification needs to be performed, by utilizing new information technologies in geospatial data acquisition. Conventional methodology for establishing agricultural land value classification involves geo-morphological

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parameterization in determination of land fertility grade and economic criteria parameterization that contains average yields of agricultural crops per hectare of arable agricultural land. Coefficients of agricultural land value classification are given in Table 1, where the values are weights in the model for determination of land polygon value in the land consolidation survey [7].

Table 1: Scale of ratio between appraisal grades

Appraisal grade	1st AG	2nd AG	3rd AG	4th AG	5th AG	6th AG
	1.0000	0.9500	0.8600	0.7400	0.5500	0.2000
1st AG	1.0000	1.0526	1.1628	1.3513	1.8182	5.0000
2nd AG	0.9500	1.0000	1.1046	1.2838	1.7273	4.7500
3rd AG	0.8600	0.9053	1.0000	1.1622	1.5636	4.3000
4th AG	0.7400	0.7789	0.8605	1.0000	1.3454	3.7000
5th AG	0.5500	0.5789	0.6395	0.7432	1.0000	2.7500
6th AG	0.2000	0.2105	0.2326	0.2703	0.3636	1.0000

$$V_i = \sum_{j=1}^{n} w_i \times P_{ij}$$

where:

$\boldsymbol{v_i}$ – value of agricultural land of appraisal grade i

w_i– weight of the appraisal grades

P_{ij}–area of polygons of appraisal grade

Overview map of agricultural land value classification, produced using conventional methods in the classification procedure shows the value of land under consolidation, being the subject of land consolidation and environment protection project (Fig. 2).

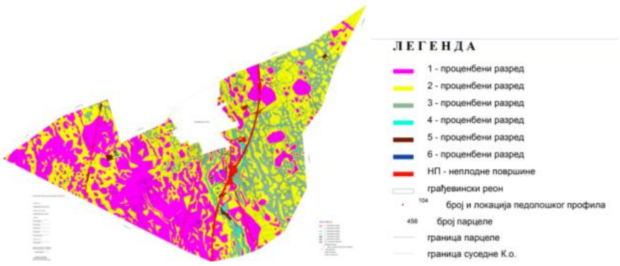

Fig. 2: Overview map of agricultural land value classification (appraisal grades)

Actual state of land cover over the test area pertaining to the agricultural crops and value of yields achieved per one hectare had been tested by field investigation, and correlated with data from the Real Estate Cadastre, public register of real estate. Established discrepancies between data on cadastral cultures in the register of real estate and the state in the field had been identified using spatial analysis, which integrates data from graphical databases (digital cadastral map and orthophoto) and alphanumerical data from the Real Estate Cadastre database (REC). Development and application of the remote sensing within the Republic Geodetic Authority's (*R*GA) competences had streamlined this research towards the potential to develop methodology for the remote sensing application to collect certain data over the vast areas, which can in turn provide for decision making in land territory organization and infrastructural projects designing for agricultural production (drainage systems, channel and road network, silos positioning, etc) [9]. The most important and the most demanding phase in the land consolidation technical procedure is determination and classification of all agricultural parcels' values for each owner and new positioning and grouping agricultural parcels within the scope of land territory consolidation survey. In the Republic of Serbia, land consolidation survey is being performed pursuant to the laws regulating the field of state survey and the field of agriculture [10, 11].

II. REMOTE SENSING DATA

Remote sensing is presently being used in numerous scientific research projects covering various fields and disciplines, where the results obtain interpret a vast volume of information on distant features and areas. A set of methodological procedures for acquisition and processing of digital records, obtained from sensors of various wavelengths of visible, thermal and invisible part of the spectrum is one of the definitions of the remote sensing [2], i.e. the remote sensing is the process that observes differences at a single feature or phenomena in various times [8].

A. Satellite Images

Our research had used satellite images from the appropriate satellite systems, with the following performances:

1) SPOT4 satellite – Panchromatic images with 10 m resolution and multispectral images with 20 m resolution;
2) SPOT5 satellite – Panchromatic images with 2.5 m resolution and multispectral images with 10 m resolution;
3) SPOT6 satellite – Panchromatic images with 1.5 m resolution and multispectral images with 6 m resolution.

Satellite images had been processed in the Geometric Workshop for the purposes of the Remote Sensing Workshop, using Pixel Factory production system based on scalable, user oriented and centralized system for mass production management and processing high volumes of data from the various sensor systems, with the high degree of production processes automation.

B. Agricultural Land Cover Map

Based on the data collected through the remote sensing, Agricultural Land Cover maps had been produced for 2011 and 2012 for the territory of Vojvodina, with the intensive agricultural production present, and the scope including test area where our research had been performed. In the production process of these maps, multi-temporal approach was the key, for the reason of utilizing satellite images from different temporal epochs, following phenology development of agricultural crops (April – September) and covering the same geographical territory. For production of (thematic) agricultural map, Overland, eCognition (eCognition Architect, eCognition Developer) and ArcGis packages had been used. Figure 3 shows the production

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procedures from integral data (satellite images) to the final product – Agricultural Land Cover map.

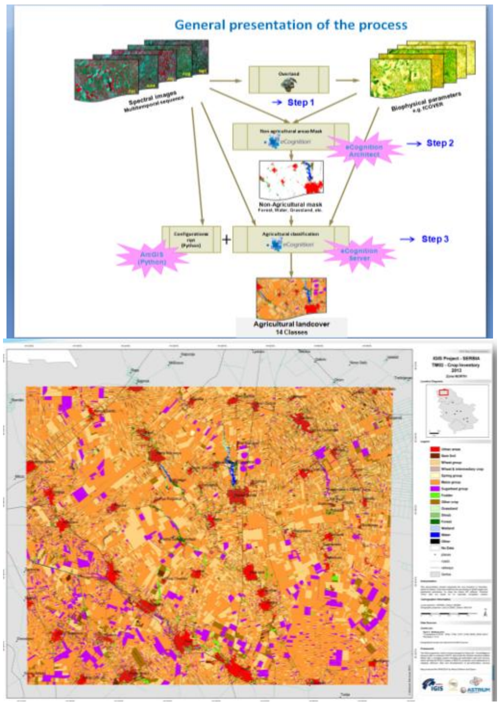

Fig. 3: Methodological procedure of Agricultural Land Cover map production

C. Classification of Agricultural Crops

Classification of agricultural crops had been defined pursuant to the biophysical parameters generated using the Overland software. The software uses SAIL/PROSPECT physical model as the key component in the process of biophysical parameters creation. The most commonly used biophysical parameter is LAI (Leaf Area Index) – parameter giving the numeric value that indicates leaf coverage per area unit, i.e. defining vegetation density and detecting certain agricultural crops[6].

III. EXPERIMENTAL RESULTS AND ANALYSES

Within the framework of experimental research, comparative analysis had been performed between the agricultural land classification in the Real Estate Cadastre database and agricultural crops classification on the Agricultural Land Cover map, based on the data collected by the means of the remote sensing. Agricultural land in the Real Estate Cadastre databases is classified into cadastral cultures (crops) and cadastral classes. Lands with the cadastral culture arable fields and cadastral class ranging from first to third are the highest quality soils for agricultural crops production, which had been covered by the comparative analysis, with the remote sensing data. Application of comparative analysis of agricultural crops spatial distribution had at its disposal satellite images from the same annual period, with two temporal dimensions (2011 and 2012), over the same geographic territory. Figures 4a and 4b show agricultural map for the Cadastral Municipality of Feketic in 2011, for which satellite images from mid-summer (July) had been used, and graphical overview of shares belonging to the most common agricultural crops; and Figures 5a and 5b show agricultural map produced using the images from the same period in 2012, with graphical overview of the most common agricultural crops.

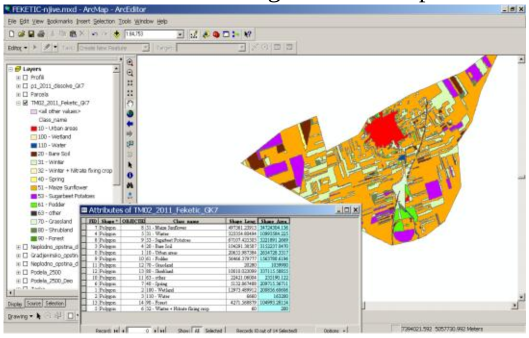

Fig. 4a: Map of agricultural crops

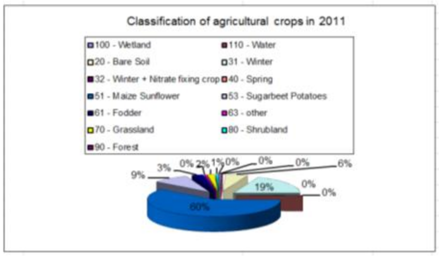

Fig. 4b: Classification of crops per areas, remote sensing, 2011

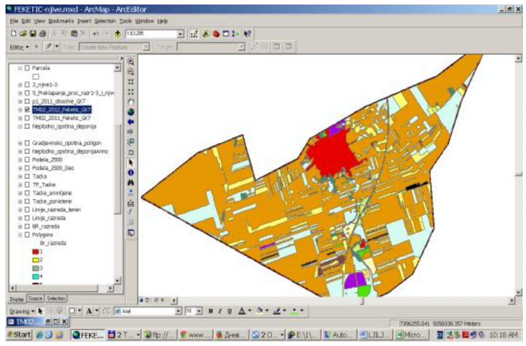

Fig. 5a: Map of agricultural crops

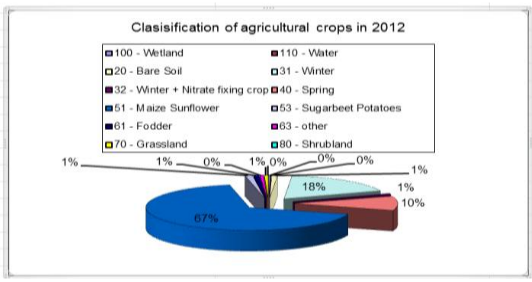

Fig. 5b: Classification of crops per areas, remote sensing, 2012

Comparative analysis of cadastral cultures and agricultural crops classification had been performed per areas, by overlapping layers of data from the remote sensing and data from the Real Estate Cadastre. Area under the cadastral cultures is 5519 hectares, and area under agricultural crops from the remote sensing is 5271 hectares in 2011 and 5511 hectares in 2012. Identification of area

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differences between the cadastral cultures and agricultural crops from remote sensing from 2011 is shown in Figures 6a and 6b.

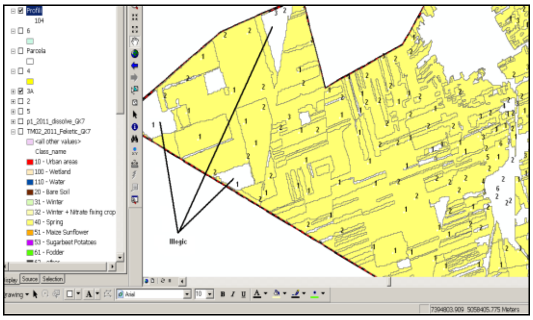

Fig. 6a: Cadastral areas

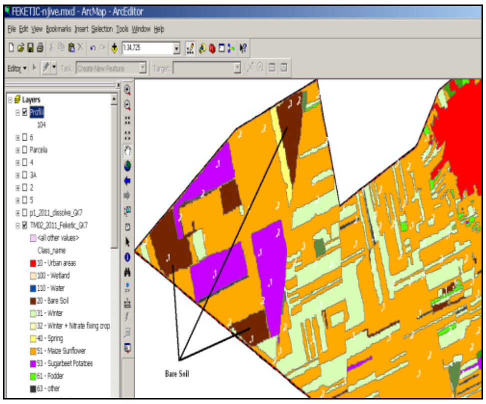

Fig. 6b: Remote sensing areas

Further research had been directed towards verifying the quality of identified soil and land use. Visual and spatial analysis had been performed by comparing orthophoto and overview map with land classification value, where the orthophoto had served to identify the areas marked on the agricultural map as “bare soil” (Figures 7a, 7b). Subject area belongs to high quality soil (Figure 7b, appraisal grade 1, 2 and 3) and their way of use was the agricultural crop: wheat. Due to early harvesting of this crop in 2011, in the land classification procedure using remote sensing, the subject land was detected as bare, i.e. no agricultural crop. Remote sensing data integrated with data from the other databases in geographical information system can provide reliable information on land cover [1].

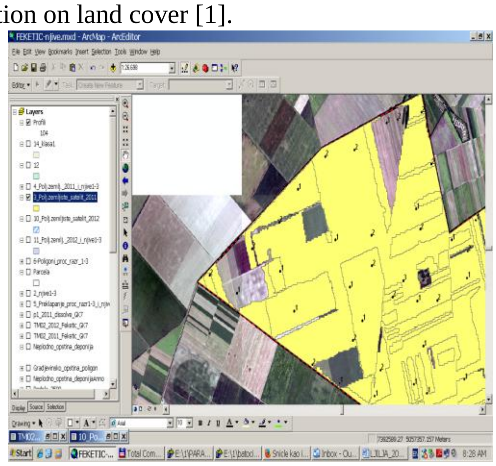

Fig. 7a: Orthophoto-remote sensing

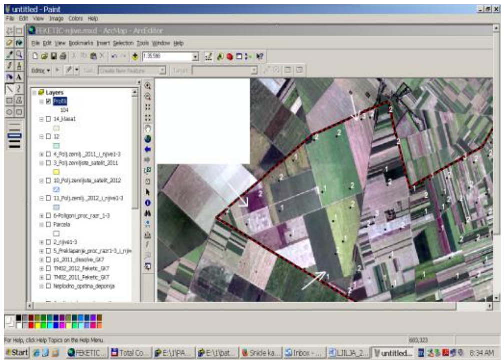

Fig. 6b: Land fertility grade classification

Agricultural land value classification had been performed using the conventional methods, as shown in Figure 8, with the great number of small area polygons with different values (each color represents one classification coefficient) indicates the necessity of the model for multi-criteria optimization of agricultural land value, for which the land consolidation survey is being planned [5].

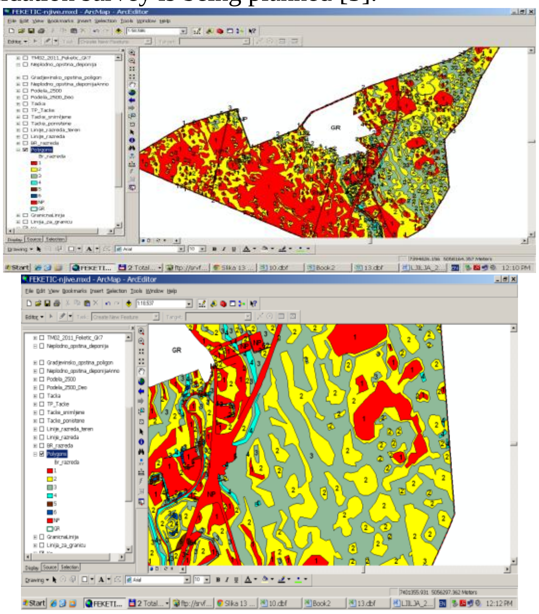

Fig. 8: Agricultural land classification (conventional method)

Described research methodology had been implemented using *GIS* tools, software suite *Arc GIS 9.3.1* and its extensions, *Access 2000* and *Excel 2010*, which had been used to perform the analyses presented above.

IV. CONCLUSION

Researching the possibilities to use the remote sensing data integrated in the land consolidation survey was the explicit objective of this research. Visual and spatial analysis of data collected using various methods and for various purposes that had been jointly integrated in the GIS environment had indicated the possibility to use the data collected by remote sensing, for the purpose of land cover examination. Methodology for further development of remote sensing use is a potential option for planning and implementation of future land consolidation surveys. Structure of the available data (raster, vector) with

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utilization of GIS tools provides for preparation of various databases (thematic maps, topographic maps, land cover maps, agricultural crops maps, etc), along with the database attributes, which may contribute to the successful performance of land consolidation survey, firstly through the agricultural land value classification, having that it is the foundation for the new land arrangement over the land consolidation territory. Our future research will be focused towards studying further development of remote sensing data application and collecting potential attributes and changes occurring over the land territory, on the vast areas, which will improve methodology for the agricultural land value classification.

REFERENCES

[1] M. Ioannis, M.Meliadis, " Multi-temporal Landsat image classification and change analysis of land cover/use in the Prefecture of Thessaloiniki, Greece", Proceedings of the International Academy of Ecology and Environmental Sciences, 1(1), pp.15-25, 2011.

[2] Lu D, Mausel P, Brondizio E, et al. Change detection techniques", International Journal of Remote Sensing, 25(12): 2365–2401, 2004.

[3] J. Richard, Radke, A.Srinivas, A.K.Omar, and R.Badrinath, "Image Change Detection Algorithms: A Systematic Survey", IEEE Transactions on Image Processing, 14(3), pp.294-307, 2005

[4] P. Burrough, R. McDonnell, " Principles of Geographical Information Systems", Oxford University Press, 1998.

[5] P. Lugonja, S.Brdar, V.Minić, V.Crnojević, D.Ćulibrk, ″ Klasifikacija poljoprivrednih kultura na multispektralnim slikama upotrebom genetskog programiranja, Infoteh, Proceeding, Vol. 11, pp. 697/701, 2012.

[6] P. Coppin, and M. Bauer, "Digital change detection in forest ecosystems with remote sensing imagery, Remote Sensing of the Environment", The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences. 13, pp.207-304, 1996.

[7] S. Brankovic, Lj. Parezanovic, D. Simovic, " Land consolidation appraisal of agricultural land in GIS environment", Geodetski vestnik, accepted for publication, 2014.

[8] Singh A. 1989. Digital change detection techniques using remotely-sensing data. International Journal of Remote Sensing, 10(6), pp 989-1003, 1989.

[9] S. Brankovic, "Modern aspects of land consolidation in the organization and spatial planning", International scientific conference and XX meeting of Serbian surveyors, Kladovo, Serbia, Proceeding, spp. 387-392, 2011.

[10] Agricultural Land Act("RS Official" No. 62/2006, 41/2009).

[11] Law on State Survey and Cadastre ("RS Official" No. 72/09 and 18/2010) and Agricultural Development Strategy in the Republic of Serbia (2010).

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Mr Stojanka Brankovic Graduated from the Faculty of Civil Engineering in Belgrade, Serbia, in 1986. Finished post-graduate scientific level of Master at the same Faculty in the field of photogrammetry in land consolidation in 2002. Doctoral dissertation in the field of real estate mass appraisal system development on the national level, under preparation for presentation at the Faculty of Civil Engineering in Belgrade. Works in the governmental institution, Republic Geodetic Authority, tasked with geodetic works designing, performance and supervision. Previously performed the tasks of Head of Department and Assistant Director of the RGA. Fields of research: new technologies, GIS systems, real estate mass appraisal. Published her 28 years of practical and research experience through more than 23 professional and scientific papers and presentations on national and international symposia and congresses.

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