COMBINED USE OF SAR AND OPTICAL SATELLITE IMAGES FOR LANDSCAPE DIVERSITY ASSESSMENT

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ABSTRACT

Land cover change analysis is essential for effective land use management and biodiversity conservation. The advantages of Sentinel-1 and Landsat-8 image fusion for land cover classification and landscape diversity maps development were studied. The methodology of landscape metrics interpretation for sustainable land use planning is developed and tested on agricultural landscapes in Ukraine.

1. INTRODUCTION

Land cover change reflects the landscapes transformation under natural or anthropogenic pressure. Landscape metrics are algorithms that evaluate spatial characteristics of landscapes based on land cover maps developed by remote sensing data classification [1].

Landscape diversity is a relative indicator, which is also sensitive to input data resolution [2], so the question is how to interprete the landscape metrics for sustainable land management. How metrics values correspond to the optimum, or vice versa unsatisfactory landscape and land use structure? For recognition of landscape classes (such as arable land, water, grass, forest, etc.) the image spatial resolution should be close to 5-10 m. Thus, the aim of the study was to assess the effectives and feasibility of Sentinel-1 and Landsat-8 image fusion method for recognition of landscape classes and landscape diversity monitoring.

2. METHOD

Two basic data fusion algorithms were applied, the method of principal component (PCA) and the Brovey transformation. Image classification accuracy was used as a quality criteria of data fusion, by comparing the areas of classified land cover classes. RapidEye images and field surveys were used as control data. QGIS semi-automated classification module was used and supervised classification was applied based on the signatures, obtained in field surveys.

Test site was located in Central Ukraine (Kaniv and Myronivka districts) – a forest steppe normal precipitation climate zone (Fig. 1).

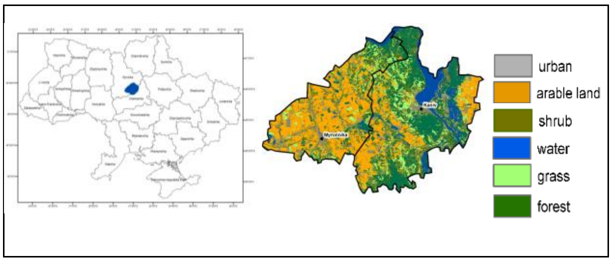


Figure 1. Test site location and land cover map

Arable land occupies up to 85% of the land use in the region, causing land degradation processes.

3. RESULTS

Data fusion of optical Landsat-8 and radar Sentinel-1 images provided an image with 8.25 m spatial resolution (Fig. 2).

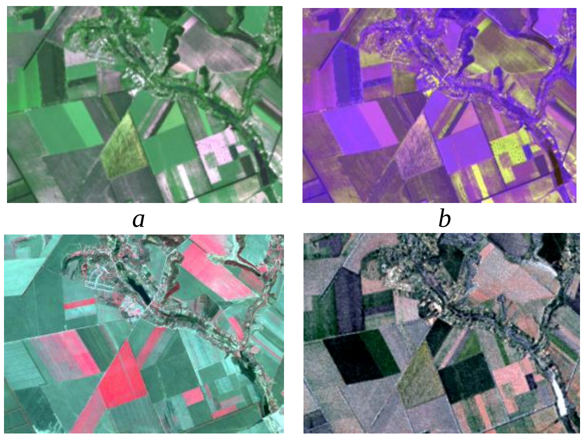


Figure 2. Satellite images: a) Landsat-8 image of 30 meter resolution; b) Landsat-8 image merged by 8th panchromatic band of 15 meter resolution; c) RapidEye image of 5 meter resolution; d) Landsat 8 image merged by Sentinel-1 data using Brovey transformation (8.25 m resolution.

Classification accuracy of merged Landsat-Sentinel data by Brovey transformation is higher than Landsat data and close to 5-meter Rapid-Eye image, which confirms

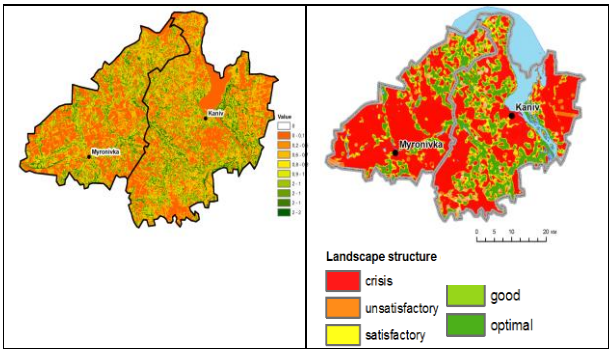
Proc. 'Living Planet Symposium 2016', Prague, Czech Republic, 9–13 May 2016 (ESA SP-740, August 2016)

the feasibility of proposed method (Tab. 1). The effectiveness of the optical and radar data fusion from other satellite systems has also been demonstrated in many studies [3]

Table 1. Classification accuracy of merged images

	Input data type	Land cover classes area (km^2)				
		Forest	Grass	Shrub	Arable land	Water
1	Control landcover map	530	144	69	945	126
2	RapidEye 5m image	570	153	80	900	124
	Error (%)	*7.55*	*6.25*	*15.94*	*4.76*	*1.59*
3	**Landsat-Sentinel Brovey merged image**	485	140	90	985	131
	Error (%)	***8.49***	***2.78***	***30.43***	***4.23***	***3.97***
4	Landsat-Sentinel PCA merged image	644	154	243	670	185
	Error (%)	*21.51*	*6,94*	*> 50*	*29.10*	*46.83*
5	Landsat 30m image	676	117	279	451	121
	Error (%)	*27,55*	*18.75*	*> 50*	*> 50*	*3.97*
6	Landsat 15m image	785	115	284	448	119
	Error (%)	*48.11*	*20.14*	*> 50*	*> 50*	*5.56*

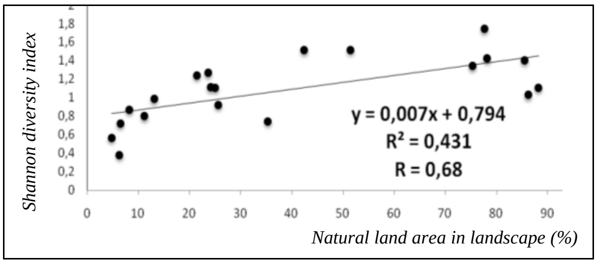
Based on the land cover maps the landscape diversity indexes were calculated (fig. 3a) using Fragstats software (Shannon diversity, Simpson evenness, and edge density indexes).



a b

Figure 3. Landscape diversity maps: a) Shannon diversity index, b) Landscape diversity structure

Landscape structure is considered optimal if the arable land area does not exceed 20% of the total area, and natural lands occupy 80% or more. And it is in the critical condition if this ratio is 70% : 30% accordingly. To interprete the landscape diversity metrics the regression analysis of arable and natural lands ratio could be used to determine the threshold values of landscape diversity indexes (fig. 4).



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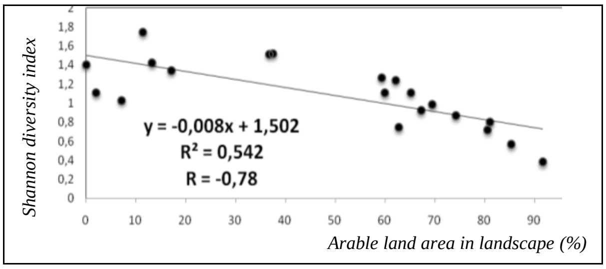

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Figure 4. The relationship between Shannon diversity index and: a) natural land area; b) arable land area in the landscape

It was discovered that landscape structure of sagnificant part of Kaniv district (220 km^2) and the northern part of the Myronivska district are in optimal condition, unlike the southeastern part of Myronivsky district which requires the land use reorganization (fig. 3b). In general landscape structure analysis confirms that the river network and forested gullies and shelterbelts contribute to higher landscape diversity.

4. CONCLUSIONS

Data fusion of freely available Landsat-8 and Sentinel-1 images by Brovey transformation improves the spatial resolution of input data for automated land cover classification (30 m to 8.25 m with classification accuracy up to 93% in the study above for main land cover classes: forest, grass, arable land, water). Further achievements could be obtained with Sentinel-1 and Sentinel-2 data fusion.

Landscape diversity metrics could be an effective tool for land use and land cover change analysis. Proposed landscape diversity index interpretation, based on the ratio of arable land and natural ecosystems in the landscape, could be used for landscape diversity monitoring.

5. REFERENCES

1. McGarigal, K.,Cushman, S. A. and Stafford S. G. (2000). Multivariate Statistics for Wildlife and Ecology Research. Springer-Verlag, New York

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