LAND-149 - Combined use of SAR and optical satellite images for landscape diversity assessment

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Land cover plays global planetary role, affecting the climate and energy processes, nutrients cycle and species migration. Land cover change reflects the level of landscapes transformation under natural or anthropogenic pressure. Information about land cover is necessary for the sustainable management, planning and implementation of environmental policies.

Landscape metrics are algorithms that evaluate spatial characteristics of landscapes based on land cover maps developed by remote sensing data classification. One of the key factors for satellite data classification is proper spatial and spectral resolution of input data. For recognition of landscape classes (such as arable land, water, grass, forest, etc.) the spatial resolution should not be less than 5-10 m. For identification of landscape classes of Central and Eastern Europe, the multispectral imagery is required, obtained during vegetation season in following spectral range: 0,52-0,58, 0,64-0,68 and 0,80-0,90 mkm.

To achieve the necessary spatial resolution (less than 10 m) the multispectral optical and radar data fusion was implemented, using open data of Landsat-8 and Sentinel-1, which made it possible to obtain an image with 8.25 m spatial resolution. Preliminary data processing included Landsat-8 band composite (bands 2-5) and geometric correction of Sentinel-1 data.

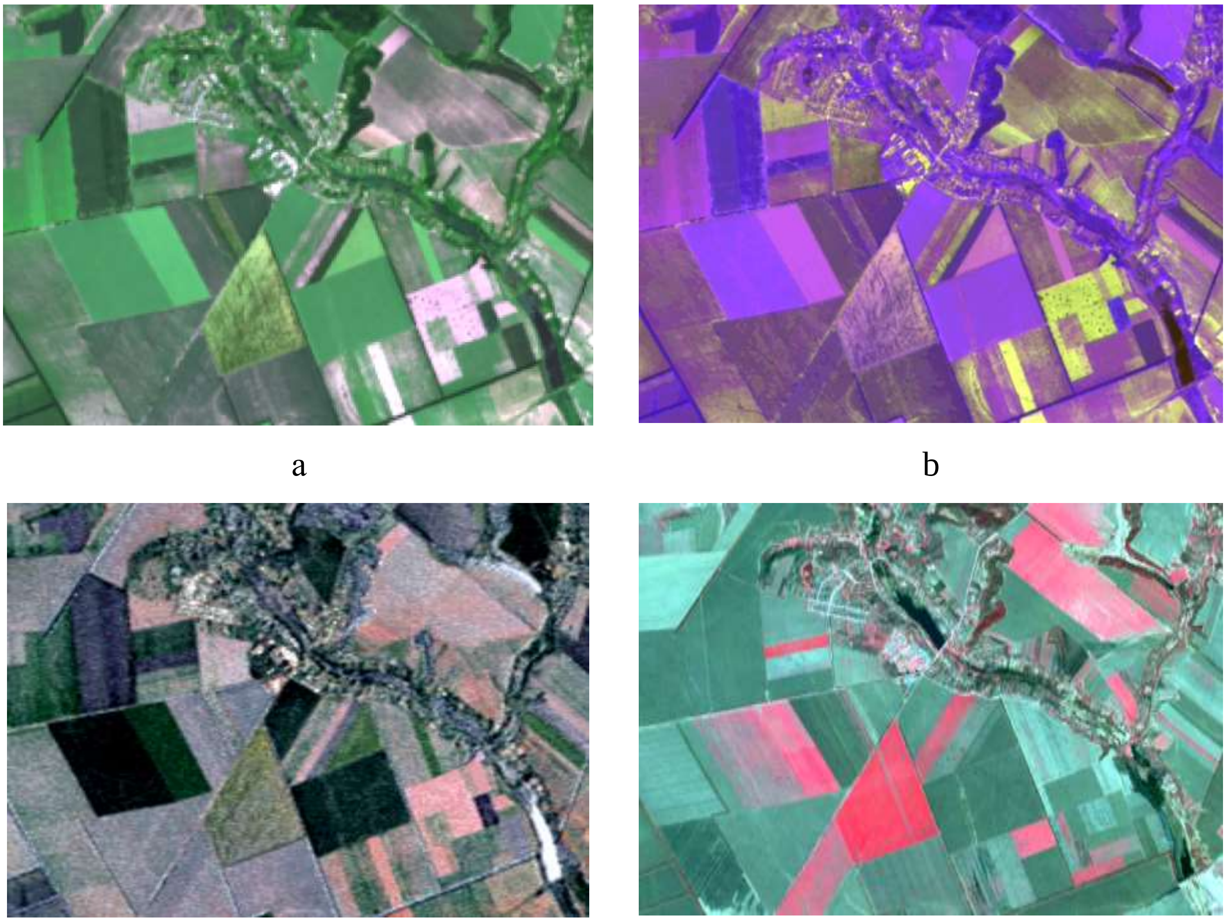
In order to study a more effective method of data fusion of Landsat-8 and Sentinel-1 images two basic algorithms, the method of principal component and the Brovey transformation, was applied using ErdasImagine 10 software.

One of the quality criteria of data fusion is the accuracy of image classification.

Thus, to assess the effectiveness the classification results was compared of four input data types:

- Landsat 8 image (bands 2-5 composite) of 30 meter resolution (fig. 1a);
- Landsat 8 image merged by 8th panchromatic band of 15 meter resolution (fig. 1b);
- Landsat 8 image merged by Sentinel-1 data using principal component analysis (8.25 m resolution);
- Landsat 8 image merged by Sentinel-1 data using Brovey transformation (8.25 m resolution) (fig. 1c).

As control data land cover map was used, created by visual interpretation of images RapidEye with spatial resolution of 5 meters and verified in field surveys (fig. 1d).



c d

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

Classification accuracy was evaluated by comparing areas of resultion land cover classes. QGIS semi-automated classification module was used and supervised classification was applied based on the signatures, obtained in field surveys.

It was found, that classification reliability of merged Landsat-Sentinel data is higher than Landsat data, and classification accuracy is close to 5-meter RapidEye image, and for some classes even higher, particularly for agricultural land and grass vegetation (table 1).

Table 1. Classification accuracy

	Data Type	Classes Area (km^2)					
		Forest	Grass	Bushes	Agriculture	Water	Roads
1	Landcover 5m	530	144	69	945	126	6
2	RapidEye 5m	570	153	80	900	124	37
	Error (%)	*7,55*	*6.25*	*15.94*	*4.76*	*1.59*	*> 50*
3	Landsat-Sentinel Vrovey	485	140	90	985	131	8
	Error (%)	*8.49*	*2.78*	*30.43*	*4.23*	*3.97*	*33,33*
4	Landsat-Sentinel PCA	644	154	243	670	185	23
	Error (%)	*21.51*	*6,94*	*> 50*	*29.10*	*46.83*	*> 50*
5	Landsat 30m	676	117	279	451	121	23
	Error (%)	*27,55*	*18.75*	*> 50*	*> 50*	*3.97*	*> 50*
6	Landsat 15m	785	115	284	448	119	19
	Error (%)	48.11	20.14	> 50	> 50	5.56	> 50

Thus, excluding the area of urban areas (roads and buildings) and the association of forest-shrub vegetation in one class, classification accuracy of merged Landsat-Sentinel images by Brovey transformation is over 93%, confirming the feasibility of using the proposed method of classification for automated mapping of land cover.

Based on land cover maps the landscape diversity indexes were calculated using Fragstats software, including such landscape metrics as Shannon diversity, Simpson evenness, edge density, contact index, etc (fig 2).

But the value of landscape metrics are relative structure indicators, so the question is how to interpret them in the ecological sense, and how index values correspond to the optimum, or vice versa unsatisfactory structure of landscapes.

Ecological landscapes assessment can be carried out by the ratio of arable land to total natural land area (in particular forests, grasslands, wetlands and other areas with natural vegetation). Structure of landscapes is considered optimal if the area of arable land not exceeding 20% of total area, and the rate of natural lands is 80% or more; and critical if > 70% and <30% accordingly. Thus the threshold values of landscape diversity indexes that match the classification by arable and natural lands ratio were determined from regression analysis, which made it possible to interpret the values of landscape metrics.

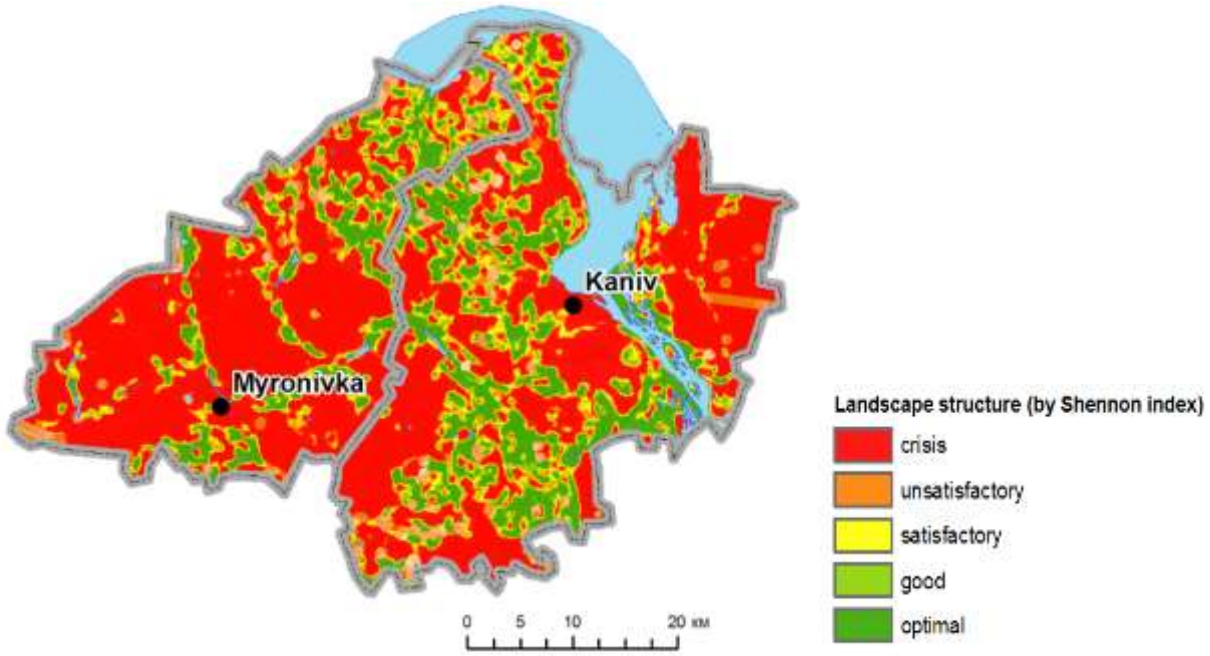


Fig. 2. Zoning of Kaniv and Myronivka districts using landscape diversity index by Shannon

Overall analysis of the structure of landscapes confirms that river network and forest belts contribute to higher landscape diversity.

Conclusions:

1. The technique of combined use of optical Landsat-8 and radar Sentinel-1 satellite data for automated land cover classification is proposed. Synthesis of freely available images of Landsat-8 and Sentinel-1 by Brovey transformation improved the spatial resolution of multispectral data from 30 m to 8.25 m.

2. The method of interpretation of landscape metrics for assessing landscape diversity and zoning the territory according to diversity level is demonstrated with subdivition to the following classes: best, good, satisfactory, unsatisfactory, and critical landscape structure, which can be used for cultural landscape structure and land use optimization.