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GIS ASSESSMENT OF LAND COVER FLOWS IN NORTH MACEDONIA USING CORINE LAND COVER DATABASE IN THE PERIOD 2000-2018

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ABSTRACT

The land use (LU) and land cover (LC) categories in the North Macedonia are characterized with great heterogeneity. Dominantly present are forests and semi-natural areas with 60%, and agricultural areas with 35%. Based on the Corine Land Cover (CLC) database, analyzed are the changes in three periods, 2000-2006, 2006–2012, and 2012-2018. Quantified are basic input information which are analyzed on the total territory of the country and separately for the eight planning regions of the country: Skopje (I), Eastern (II), Southeast (III), Northeast (IV), Pelagonia (V), Vardar (VI), Southwest (VII) and Polog (VIII). A number of 2522 types of change (CLC classification level 3) were identified across North Macedonia for the three-time period or if we consider them as aggregate data in 18 years we can see LC change processes of around 900 km2 which is 3.53% of the total area of the country. Applying them to the conversion table, seven major change processes (LC flows) were identified such as urbanization, intensification, and extensification of agriculture, afforestation, deforestation, water bodies' construction and management, and other changes of which three main directions of change have been of interest. As a dominant change, deforestation is a result of two destructive factors: illegal woodcuts and forest fires. Following is afforestation, which as a process of expansion of the forest area is due primarily to the activities of the Public enterprise for forestry. Urbanization was marked by the process of decentralization (2005) and initiated by the Law on Local Self-Government (2002), legal acts by which many of the competencies of the central government have been transferred to the local level, a level that affects cities and urban regions. Observing the spatial distribution of CLC change processes most conversions from LULC to another took place in the Pelagonia, Southwest, and Vardar planning region, and the least affected are Northeast, Eastern, and Polog planning regions. As such, the main purpose of the present study was to document major LULC trends in North Macedonia during the three periods..

Keywords: GIS, Land cover Flows, LC changes, CLC; North Macedonia

INTRODUCTION

Land cover represents a concrete set of natural and anthropogenic features, resulting largely from its use [1] and of being an indivisible part of the landscape [2]. Land use (LU) and land cover (LC) changes can be considered relevant information sources on landscape processes [3]. Land cover and land use are important datasets in the research

methodologies of geo and environmental research [4] and the decision-making process. Also, the land cover data provides useful information for many GIS and Remote Sensing based applications for determinations and assessment of the natural hazard risk, suitability analysis, flood plain risk, etc. [5]. Thus, it is useful to determine measures and monitor actual and further land cover changes, but also the availability of appropriate and comparable data for different periods. Timely detection and precise information about land-use and land-cover changes are extremely important for understanding the relationships and interactions between human and natural phenomena if the management of decision-making is to be improved [6]. Based on GIS processing of the CORINE Land Cover data layer some studies at the national, as well as regional level have been achieved [7], [8], [9], [10], [11], [12]

STUDY AREA

The Republic of North Macedonia is situated in South-Eastern Europe on the southern part of the Balkan Peninsula. The total area of the country is 25713 km and according to the last Census of the population in 2021, it has 1836713 inhabitants. Administratively it is divided into the eight planning regions: Skopje, Eastern, Southeast, Northeast, Pelagonia, Vardar, Southwest, and Polog Region.

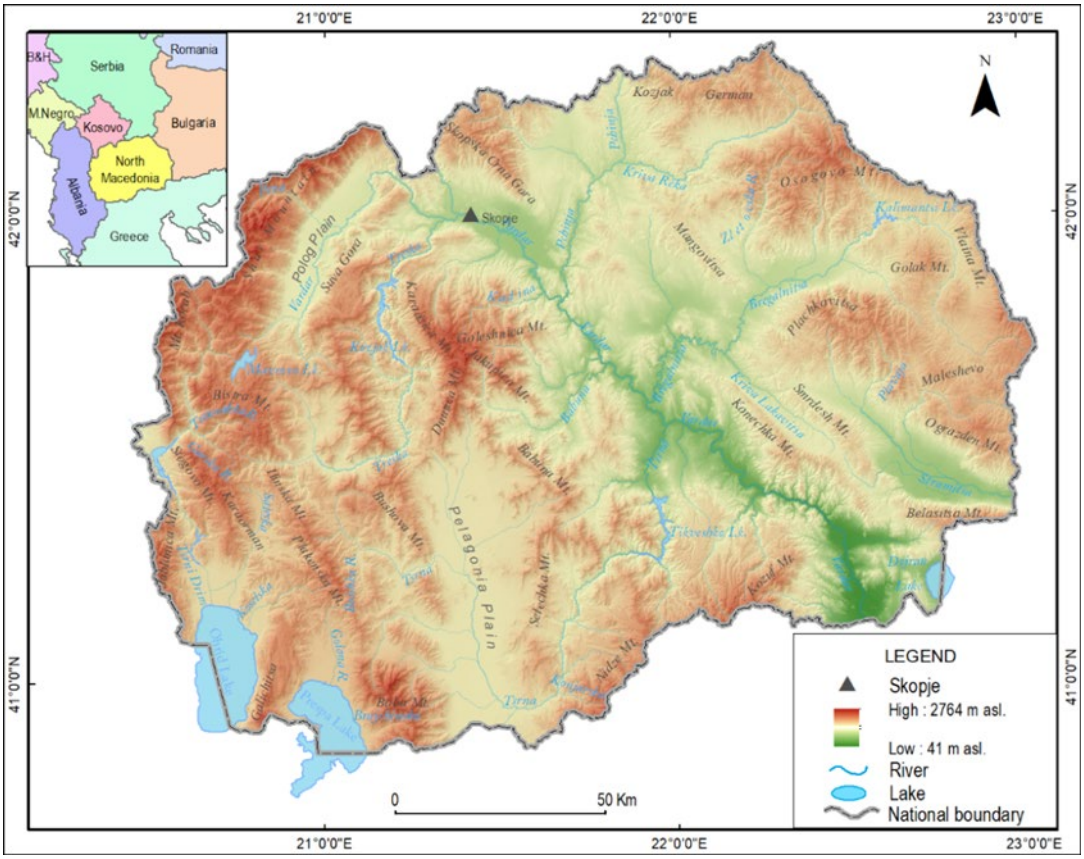


Figure 1. Map of North Macedonia

The capital city is Skopje with 526502 inhabitants or almost 1/3 or 27.6 % of the country's population. The country has a very complex geology with geological formations from almost all geological periods. Climatic characteristics are diverse. In the southern part, widely open to the Aegean Sea prevails a modified Mediterranean climate, in other parts

of the country prevails continental climate. On the high mountains prevails mountain climate. The relief characteristics are also diverse, the lowest altitude is approximately 40 m.a.s.l. and the highest altitude is on the Korab mountain peak 2764 m.a.s.l.

MATERIALS AND METHODS

The assessment of the Land-use flows has been conducted in the following order: literature research, data collecting, and adoption of a suitable methodological approach. During the phase of literature research, we have found several similar studies and papers such as the treatment of Landscape changes in the region of Skalica [13], the region of Trnava in Slovakia [14], the municipality of Bansko in Bulgaria [15], region of Plovdiv in Bulgaria [16], the comparative study between the regions of Trnava and Plovdiv in Slovakia and Bulgaria [7] the assessment of land cover changes in Romania [11], the overview of Changes in Land Use and Land Cover in Eastern Europe [9], etc.
Based on the literature review and the available datasets the methodological approach developed by the Institute of Geography at the Slovak Academy of Sciences has been adopted and applied [17], [18], [7].

Table 1. Example of Conversion table (CLC classes into Land cover flow processes)

		2006 classes (2012, 2018)														
2000 classes (2006, 2012)		**11**	**12**	**13**	**14**	**21**	**22**	**23**	**24**	**31**	**32**	**33**	**41**	**42**	**51**	**52**
	11	**0**	7	7	7	7	7	7	7	7	7	7	7	7	7	7
	12	7	**0**	7	7	7	7	7	7	7	7	7	7	7	7	7
	13	7	7	**0**	7	7	7	7	7	7	7	7	7	7	6	7
	14	7	7	7	**0**	7	7	7	7	7	7	7	7	7	6	7
	21	1	1	1	1	**0**	2	3	3	4	4	7	7	7	6	7
	22	1	1	1	1	3	**0**	3	3	4	4	7	7	7	6	7
	23	1	1	1	1	2	2	**0**	2	4	4	7	7	7	6	7
	24	1	1	1	1	2	2	3	**0**	4	4	7	7	7	6	7
	31	1	1	1	1	5	5	5	5	**0**	5	5	5	7	6	7
	32	1	1	1	1	2	2	2	2	4	**0**	5	7	7	6	7
	33	1	1	1	1	2	2	2	2	4	4	**0**	7	7	6	7
	41	1	1	1	1	2	2	2	2	4	4	7	**0**	7	6	7
	42	1	1	1	1	2	2	2	2	4	4	7	7	**0**	6	7
	51	1	1	1	1	7	7	7	7	4	4	7	7	7	**0**	7
	52	1	1	1	1	7	7	7	7	4	4	7	7	7	7	**0**

0-Unchanged class; 1- Urbanization; 2- Intensification of agriculture; 3- Extensification of agriculture; 4- Afforestation; 5- Deforestation; 6-Water bodies construction and management and 7- Other changes

The dataset used in the research has been produced by the EEA. For most of the European countries, Corine Land Cover datasets were produced for the five referenced years (1990, 2000, 2006, 2012, and 2018). In the case of the Republic of North Macedonia, the first reference year (1990) has not been produced. Besides the CLC dataset for the country, we have used the dataset with detected changes between the different periods. The dataset with CLC changes is for the period of 2000-2006, 2006-2012, and 2012-2018. The territory of the Republic of North Macedonia is administratively divided into eight planning regions: Skopje (I), Eastern (II), Southeast (III), Northeast (IV), Pelagonia (V), Vardar (VI), Southwest (VII) and Polog (VIII).

The standard CLC nomenclature includes 44 land cover classes. These are grouped in a three-level hierarchy. The five main (level 1) categories are: 1) artificial surfaces, 2) agricultural areas, 3) forests and semi-natural areas, 4) wetlands, and 5) water bodies [19]. At level 2 fifteen types of land cover were distinguished, and at level 3, 44 land cover classes were distinguished. In North Macedonia, a number of 33 out of the 44 classes in the CLC nomenclature were identified.
The analysis of LULC categories has been facilitated in MS Excel, ArcGIS, and QGIS.
The transformation process from Corine land cover changes into Land cover flow processes was performed by the transformation of the second level of CLC classes through conversion table (Table 1). This conversion table, i.e., the "matrix of changes" groups LC changes of the same type. There are 15 x 14 = 210 possible combinations of one-to-one changes between the 15 CLC classes at the second level [20]
According to this referenced methodology, the 210 possible combinations of LUCC classes are grouped into seven major LCFs that represent seven major LULC change processes (LC flows):

- Urbanization: conversion from agricultural (CLC classes 21, 22, and 23), forest lands (CLC classes 31, 32, and 33), wetlands (classes 41 and 42), and water bodies (51 and 52) into urbanized land (CLC class 11) and industrialized land (class 12);
- Intensification of agriculture: transition of LC classes associated with lower intensity use like natural areas (CLC classes 32, 33, except forest class 31 and wetland class 4) into higher intensity agricultural use (classes 21 and 22);
- Extensification of agriculture: transition of LC types from a higher intensity agricultural use (classes 21 and 22) to a lower intensity agricultural use (classes 23 and 24);
- Afforestation: forest regeneration, i.e., the establishment of forests by planting and/or natural regeneration in other natural areas or agricultural lands (change of classes 21, 22, 23, 24, 33, 41, and 42 into classes 31 and 32);
- Deforestation: involving forestland (class 31) changes into another LC or damaged forest (classes 21, 22, 23, 24, 32, 33 and 41);
- Water bodies construction and management: the change of mainly agricultural (classes 21, 22, 23, and 24) and forest land (classes 31 and 32) into water bodies and the consequences of the management of water resources and the water surface area of reservoirs;
- Other changes: changes resulting from various anthropogenic activities, such as the recultivation of former mining areas, dump sites, unclassified changes, etc.

RESULTS

A number of 950 types of change (CLC classification level 3) were identified across North Macedonia during the 2000-2006 period covering an area of 349.18 km2, which represents 1.36% of the total study area. Almost 1/3 less from the first period, a number of 647 types of change (level 3) were identified over the 2006-2012 period covering an area of 250.43 km2 which represents 0.97% of the total study area. During the 2012-2018 period identified are 925 types of change (level 3) which is again similar to the first period, but now covering an area of 271.86 km2, which represents 1.06% of the total study area similar to the second period.
Through this empirical analysis, we can confirm a uniform trend of LU change processes with a slight decline in value that varies from 1.36% to 0.97% of the total area of the case study (Table 2.), or if we consider them as aggregate data for the three comparative

periods (2000-2018) in 18 years we can see LU change processes of a total of 871.47 km2 which is 3.39% of the total area of North Macedonia.
Subsequently, these changes were generalized to CLC classification level 2 and used to establish and analyze the 13 classes of change and according to their change processes to undermine the 7 LU flows (Table 2). Apart from their change classes, they are also sorted according to the three periods through which the equal degree of change is confirmed for each of the classes that go into a significant decline in value (Fig.2.).

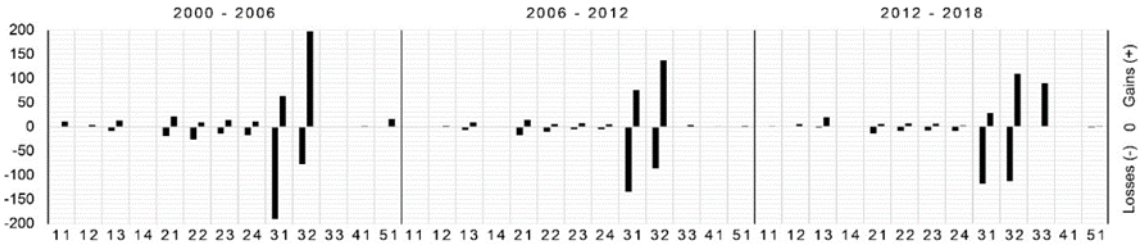


Figure 2. Gains and losses by land use and land cover classes (level 2) over the periods 2000-2006, 2006-2012, and 2012-2018 (values in km2)

Artificial surfaces (CLC classes 11, 12, 13, 14) are noting constant gains in the three-time period. In the first period of 2000-2006, they are having the highest gain of 26.961 km2. The second period of 2006-2012 is noting a gain of 12.669 km2 which is a double lower value compared to the first one, but the third period of 2012-2018 is again noting a similar value of gain as the first period of 25.939 km2. Loses of this LULC class are dominantly lower than the gains and summed for the three-period are noting 17.554km2.
Agricultural areas (CLC classes of 21, 22, 23, and 24) during the first-period note almost double losses than gains evidencing 78.084 km2 losses and 53.067 km2 gains. In continuation visible are almost equal values of losses and gains during the second period of 2006-2012, noting 37.68 km2 losses and 31.919 km2 gains. The third period of 2012-2018 again is noting double losses than gains of 40.131 km2 losses and 19.716 km2 gains.
The forests and semi-natural areas (CLC classes of 31, 32, and 33) during the first period note slightly bigger losses than gains noting 268.48 km2 losses and 260.25 km2 gains. In continuation visible are almost equal values of losses and gains during the second and third periods, noting 219.63 km2 losses and 217.48 km2 gains for the 2006-2012 time period and 231.53 km2 losses and 228.38 km2 gains for the 2012-2018 time period.
Wetlands (CLC class of 41) during the tree period time 2000-2018 are noting almost equal values for losses and gains evidencing 1.5 km2 for losses and 1.8 km2 for gains.
Water bodies (CLC class of 51) are noting drastically higher gains than losses which are dominantly evident in the first period of 2000-2006 where losses are 0.7 km2 but gains have a value of 15.5 km2. The other two periods are characterized by a more smooth difference between the losses and gains having 0.6 km2 for losses and 1.9 km2 for gains in the second period of 2006-2012 and 1.3 km2 for losses and 1.5 km2 for gains in the third period of 2012-2018.

Table 2. LC flow types in North Macedonia for the periods 2000-2006, 2006-2012, and 2012-2018

	2000 - 2006 period			2006 - 2012 period			2012 - 2018 period		
LC Flows	Total changes (km^2)	% of study area	% of total changes	Total changes (km^2)	% of study area	% of total changes	Total changes (km^2)	% of study area	% of total changes
Urbanization	26,9	0,10	7,7	11,81	0,05	4,72	24,75	0,10	9,1
Intensification of agriculture	15,4	0,06	4,4	9,96	0,04	3,98	10,32	0,04	3,8
Extensification of agriculture	27,7	0,11	7,9	9,87	0,04	3,94	7,96	0,03	2,9
Afforestation	69,5	0,27	19,9	77,21	0,30	30,83	66,59	0,26	24,5
Deforestation	184,6	0,72	52,9	133,01	0,52	53,11	155,47	0,60	57,2
Water bodies construction	15,5	0,06	4,4	1,89	0,01	0,75	1,53	0,01	0,6
Other changes	9,6	0,04	2,7	6,69	0,03	2,67	5,25	0,02	1,9
Total changes (km^2)	349,18	1,36	100,00	250,43	0,97	100,00	271,86	1,06	100,00
Total study area (km^2)	25713			25713			25713		

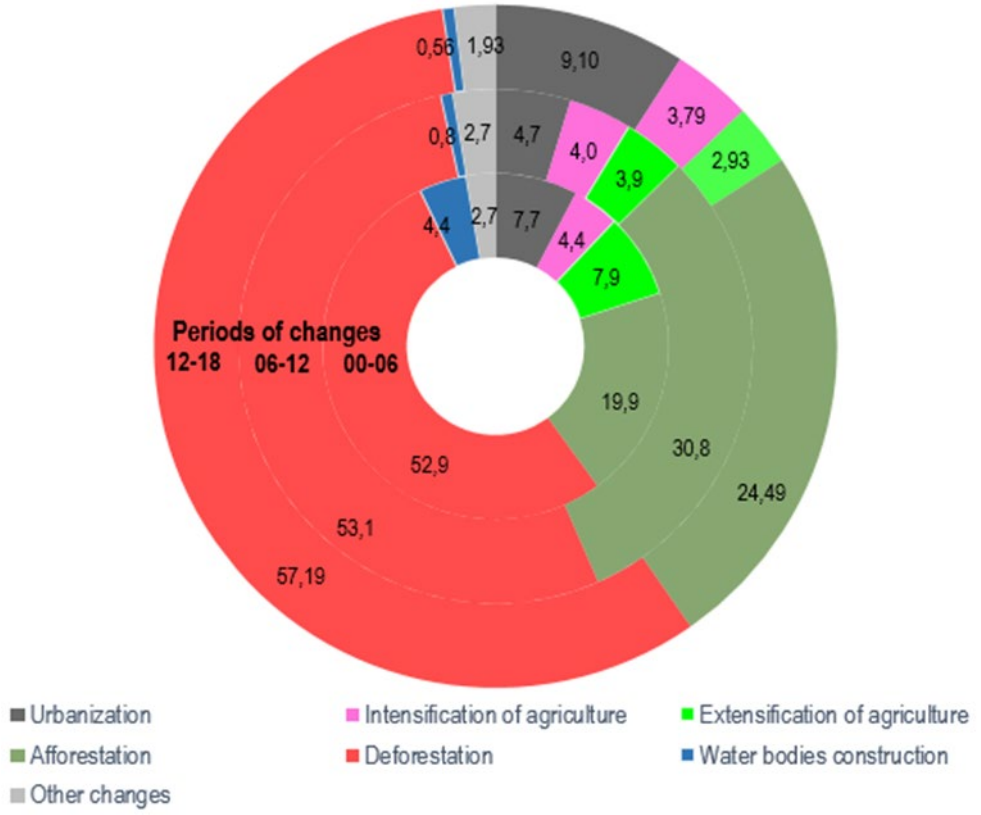


Figure 3. Land cover flows change through three periods (chart values in %)

Observing the spatial distribution of CLC change processes (Fig. 4), the most frequent LU flows in North Macedonia over the 2000-2018 periods were deforestation with 53% and afforestation with 24% of the total LUCC area. Following are the processes of

urbanization characteristic of the outskirts of the large cities in North Macedonia transforming the agricultural land use categories covering 7% of the total LUCC area. The rest is covered by the change processes of extensification of agriculture with 5% and intensification of agriculture with 4% of the total LUCC area, and a 7% of the area in total for the processes of water bodies' construction and management, unchanged classes and other changes.

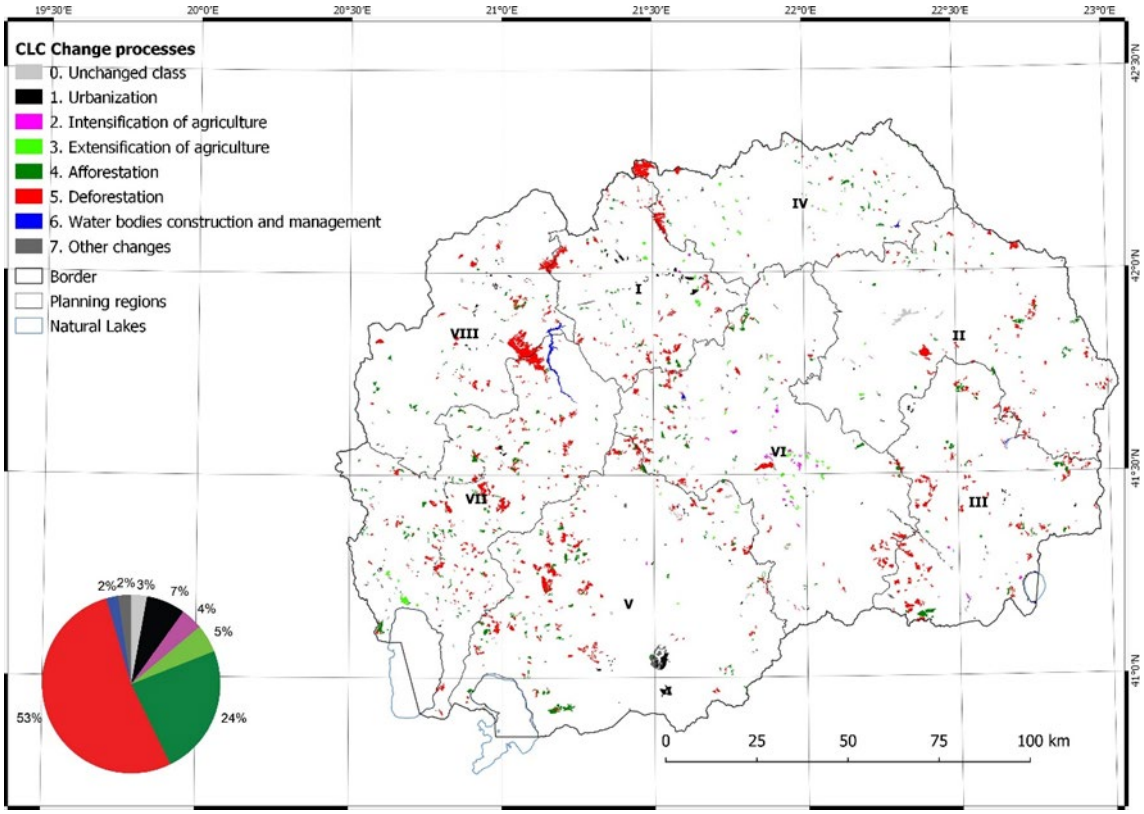


Figure 4. Spatial distribution of land use and land cover change processes in North Macedonia over the 2000-2018 period (Data source: CLC 2000-2006, 2006-2012, 2012-2018).

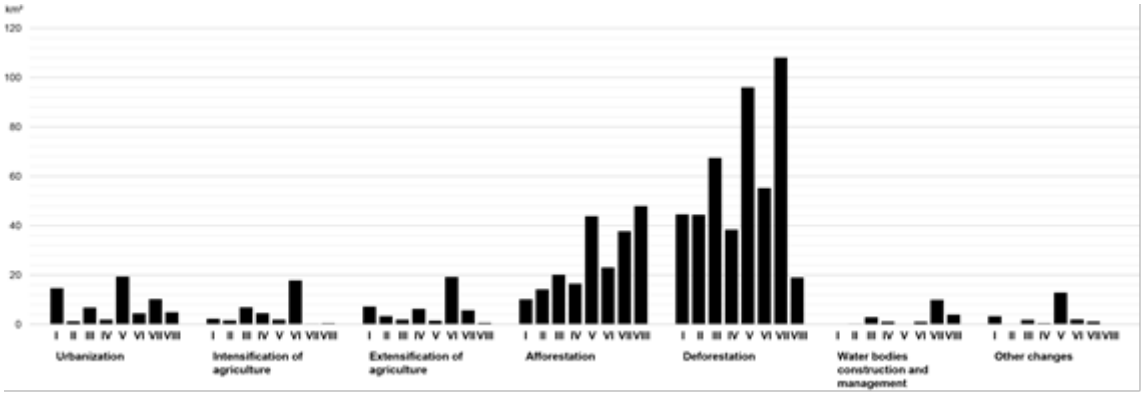


Figure 5. Land use flows in the period 2000-2018 by region (values in km2)

Table 3. LU flows in North Macedonia over the 2000-2018 period by planning region

	Urbanization		Intensification of agriculture		Extensification of agriculture		Afforestation		Deforestation		Water bodies constriction		Other changes		Total	
	km^2	%	km^2	%	km^2	%	km^2	%	km^2	%	km^2	%	km^2	%	km^2	%
I	14,6	17,8	2,3	2,8	7,2	8,8	10,1	12,3	44,6	54,3	0	0	3,3	4,0	82,0	100,0
II	1,2	1,8	1,6	2,5	3,3	5,1	14,2	21,9	44,4	68,5	0,2	0,3	0,0	0,0	64,8	100,0
III	6,8	6,3	6,9	6,4	1,9	1,7	20,1	18,6	67,4	62,6	2,9	2,7	1,8	1,7	107,8	100,0
IV	1,9	2,7	4,6	6,6	6,3	9,1	16,5	23,9	38,4	55,6	0,9	1,4	0,4	0,6	69,1	100,0
V	19,4	11,0	1,9	1,1	1,5	0,8	43,8	25,0	96,0	54,7	0	0	12,9	7,3	175,4	100,0
VI	4,5	3,7	17,8	14,4	19,7	16,0	23,0	18,7	55,2	44,8	0,9	0,7	2,0	1,6	123,2	100,0
VII	10,2	5,9	0,2	0,1	5,7	3,3	37,7	21,8	108,1	62,5	10	5,7	1,1	0,6	172,9	100,0
VIII	4,9	0,6	0,4	0,1	0,6	0,1	47,9	6,0	19,0	2,4	4	0,4	0,0	0,0	795,2	

I. Skopje, II. Eastern, III. Southeast, IV. Northeast, V. Pelagonia, VI. Vardar, VII. Southwest, and VIII. Polog planning region

Most conversions from one land use and land cover category to another took place in the Pelagonia, Southwest, and Vardar planning region, and the least affected are the Northeast, Eastern, and Polog planning regions. (Fig. 5 & Table 3.).

Urbanization expansion is most visible in Skopje, Pelagonia, and Southwest planning region notes covering 44.23 km2 or 70% of the total changed area.

Intensification of agriculture is most characteristic of the Vardar planning region where we can identify 17.75 km2 or 50% of the total changed area. Extensification of agriculture is visible in Skopje, Northeast, and Southwest planning region transforming an area of 19.15km2 or 42% of the total changed area.

Afforestation changing processes were most successful in Polog, Pelagonia, and Southwest planning region regaining the forestland of 129.45 km2 or 61% of the total changed area.

Deforestation processes applied their destructive repercussion the most in the Southwest, Pelagonia, and Southeast planning regions with 271.54 km2 or 57% of the total changed area.

Water bodies' construction and management influenced the most in the Southwest and Polog planning region with 13.82 km2 or 73% of the total changed area.

LAND COVER FLOWS BY REGIONS

The following part is an overview of the analysis of land use processes by planning regions. For that purpose, an analysis was made of the data obtained from GIS by individual regions for the three periods by region.

In the Skopje region, the dominant process for the three periods is deforestation, which has a decreasing trend. The second more important process is afforestation tends to increase, although in the last period it has decreased compared to the middle period. An important process in this region is urbanization which is constantly growing, especially in the last period of change.

In the Eastern region, as in others, the most important process is deforestation, followed by afforestation. There is a slight increase in the last period of changes in the urbanization process.

Table 4. LU flows in North Macedonia over the 2000-2018 period by planning region

Skopje region	2000-2006	2006-2012	2012-2018
Urbanization	7,7%	4,7%	9,1%
Intensification of agriculture	4,4%	4,0%	3,8%
Extensification of agriculture	7,9%	3,9%	2,9%
Afforestation	19,9%	30,8%	24,5%
Deforestation	52,9%	53,1%	57,2%
Water bodies constr. & manag.	4,4%	0,8%	0,6%
Other changes	2,7%	2,7%	1,9%

Eastern region	2000-2006	2006-2012	2012-2018
Urbanization	0,3%	0,0%	4,7%
Intensification of agriculture	0,6%	10,1%	1,8%
Extensification of agriculture	3,0%	0,0%	10,5%
Afforestation	20,6%	25,1%	22,2%
Deforestation	74,7%	64,8%	60,8%
Water bodies constr. & manag.	0,7%	0,0%	0,0%
Other changes	0,0%	0,0%	0,0%

Southeast region	2000-2006	2006-2012	2012-2018
Urbanization	3,5%	4,2%	12,5%
Intensification of agriculture	5,3%	0,0%	13,9%
Extensification of agriculture	0,5%	2,1%	3,2%
Afforestation	11,3%	27,1%	22,4%
Deforestation	74,9%	63,5%	42,5%
Water bodies constr. & manag.	3,0%	2,8%	2,1%
Other changes	1,4%	0,2%	3,4%

Northeast region	2000-2006	2006-2012	2012-2018
Urbanization	2,5%	3,5%	2,1%
Intensification of agriculture	1,5%	18,2%	1,9%
Extensification of agriculture	11,8%	5,1%	9,1%
Afforestation	26,1%	16,2%	28,9%
Deforestation	57,5%	56,2%	51,8%
Water bodies constr. & manag.	0,0%	0,6%	4,7%
Other changes	0,6%	0,0%	1,5%

Pelagonia region	2000-2006	2006-2012	2012-2018
Urbanization	11,0%	8,7%	17,6%
Intensification of agriculture	0,5%	0,0%	5,6%
Extensification of agriculture	1,9%	0,0%	0,0%
Afforestation	25,3%	31,1%	7,2%
Deforestation	50,9%	54,8%	66,3%
Water bodies constr. & manag.	0,0%	0,0%	0,0%
Other changes	10,4%	5,5%	3,3%

Vardar region	2000-2006	2006-2012	2012-2018
Urbanization	1,7%	1,4%	8,5%
Intensification of agriculture	20,0%	12,7%	8,4%
Extensification of agriculture	19,0%	21,7%	5,6%
Afforestation	25,7%	10,5%	16,5%
Deforestation	33,7%	49,7%	56,6%
Water bodies constr. & manag.	0,0%	3,0%	0,0%
Other changes	0,0%	1,1%	4,4%

Southwest region	2000-2006	2006-2012	2012-2018
Urbanization	7,6%	0,3%	9,8%
Intensification of agriculture	0,2%	0,0%	0,2%
Extensification of agriculture	9,8%	0,4%	0,1%
Afforestation	14,0%	46,1%	5,4%
Deforestation	49,4%	53,2%	83,3%
Water bodies constr. & manag.	18,2%	0,0%	0,0%
Other changes	0,7%	0,0%	1,2%

Polog region	2000-2006	2006-2012	2012-2018
Urbanization	15,7%	5,6%	0,2%
Intensification of agriculture	1,0%	0,6%	0,2%
Extensification of agriculture	0,0%	3,9%	0,0%
Afforestation	18,0%	49,0%	99,6%
Deforestation	50,0%	41,0%	0,0%
Water bodies constr. & manag.	15,3%	0,0%	0,0%
Other changes	0,0%	0,0%	0,0%

In the Southeast region, as in the previous ones, deforestation is the dominant process, followed by afforestation. In the last period of changes, there is an intensification of the process of urbanization and the intensification of agriculture.

The Northeast region has a high growth rate of the deforestation process. There is also an increase in the afforestation process. It is worth mentioning the intensification of agriculture in the second period.

In the Pelagonija region, the dominant process is deforestation, which is constantly growing. Afforestation is growing in the first two periods, after which it significantly decreases in the third. On the other hand, urbanization tends to grow in the three periods.

For the Vardar region, in addition to the deforestation which is in constant growth, the processes of intensification and extension of agriculture are characteristic, which have significant growth in the first two periods.

The steady growth of deforestation is also noticeable in the Southwest region. Specifically, afforestation is in significant growth only in the second period.

The Polog region is the only one in which the growth of afforestation has an advantage over deforestation. There is growth in urbanization, but with a strong tendency to decrease in the second and third periods.

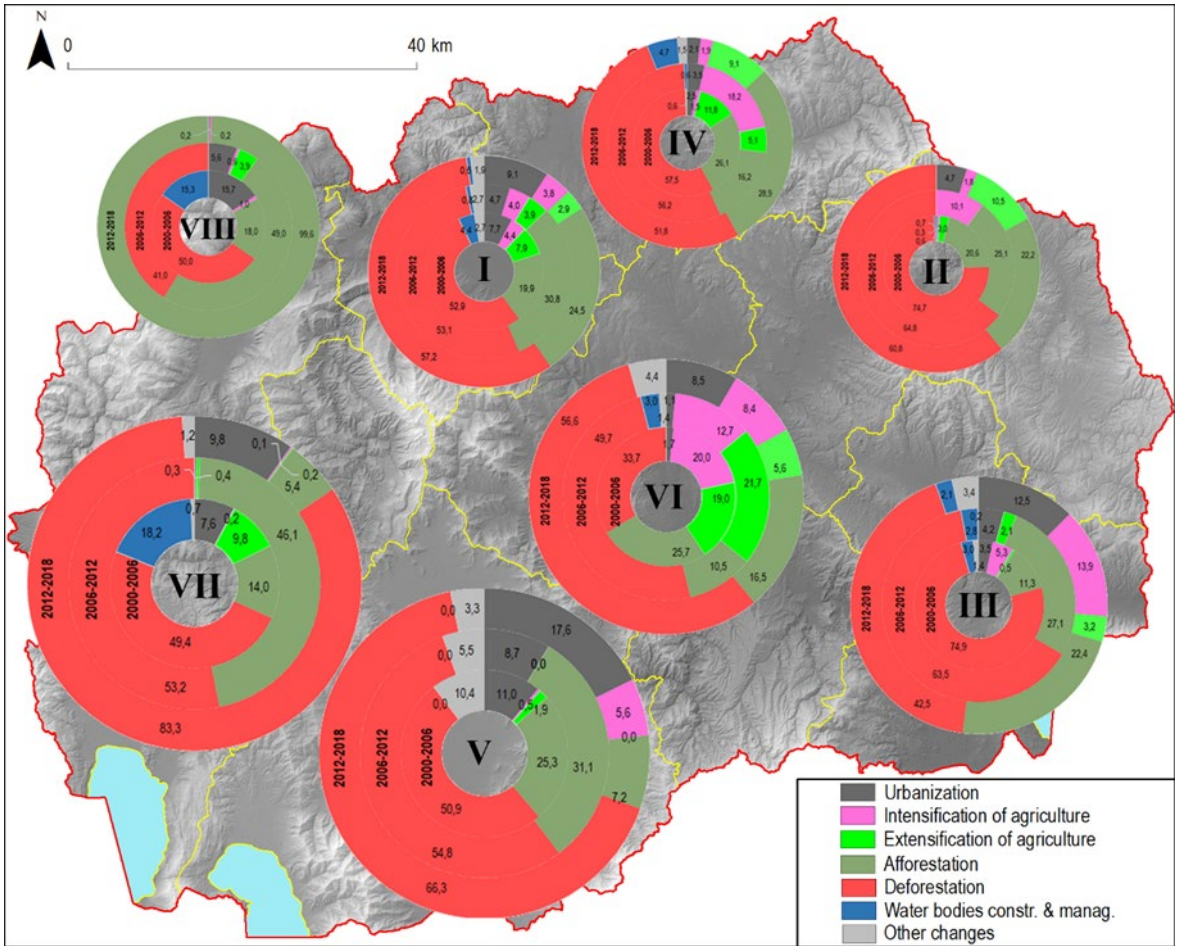


Figure 6. Land cover flows in North Macedonia by planning regions (chart values in %)

DISCUSSION

The process of deforestation is in general the result of two destructive factors: illegal woodcuts and forest fires. State and private forests in the Republic of North Macedonia are integrally managed by the Public enterprise for forest management PE "Makedonski Sumi". According to the State Statistical Office, 88.88% of the total area under forests is state-owned and 11.2% belongs to private forests.

Illegal woodcut is one of the biggest problems for forestry. According to the data of PE "Makedonski Sumi" [21] on the territory of North Macedonia in 2002, illegally was cut about 177.000 m3 of wood on an area of 0.06 km2. This situation was similar in 2003 and 2004 affecting the forests in Skopje, Southeast, Pelagonia, Southwest, and Polog planning regions. In 2004, according to the amendments to the Law on Forests Public enterprise formed a Forest guarding Service working in two cities covering the western and eastern regions. This service in 2004 had submitted Reports for illegal logging against 2.793 persons. Fort the first period (2000-2006) according to the statistic from the Sector for forest protection, supervision, and internal control two forest fires are detected. The one in 2000 counted 476 fires with 0.46 km2 size of burned area and the one in 2007 counted 652 fires with 0.35 km2 burned area.

In this way, the deforestation process is a leading one in the first period (2000-2006) covering a territory of 184.565 km2 which represents 51.76% of the total LUCC area or 0.73% of the case study (Table 3.). Most conversion phenomena involved forest land

(class 31, level 2) and its transition to Scrub and/or herbaceous vegetation associations (class 32, level 2).

In 2009, new Law on Forests came into force, according to which the forest police is the unique institution authorized to protect the forests from illegal logging, forest fires, diseases and pests, and other disasters. It is authorized to intervene, legitimate, and take into custody persons who have been caught doing illegal or criminal activities according to the Law, both in the state and private-owned forest areas. For the second period (2006-2012) two forest fires are also detected. The one in 2011 counted 302 fires with 0.17 km2 size of burned area and the one in 2012 counted 476 fires with 0.16 km2 burned area.

Subsequently, in the second period of 2006-2012, the deforestation processes have lower usurpation on the territory compared with the first period with 133.011 km2 with 0.52% of the study area but are still leading one compared to the others with 50.24% of the total LUCC area (Table 3.).

To increase the efficiency of forest protection, in 2014 the Law on Forests was amended, according to which the authority for forest guarding and protection was given back to the subject managing the forests. According to the new amendments, there are two levels of security of the forests: control patrol carried out by the forest police and regional executed by the forest guarding department of PE "Makedonski Sumi". With this, the Public enterprise received more authorizations to control the regions they are in charge of. Another change in the system was the inclusion of the Ministry of Interior, as an institution that is over the top of all the institutions involved in forest guarding. For the third period (2012-2018) one forest fire is detected. The one in 2017 counted 364 fires with a 0.13 km2 size burned area.

For the third period of 2012-2018, the deforestation processes have again increased the usurpation of the territory with 155.47 km2 and 0.61% of the study area and are the leading process with 56.35% of the total LUCC area (Table 3.).

Afforestation is the second significant process that took place in North Macedonia during the studied period, representing over 24% of the total LUCC area (Fig. 3 & Fig. 4). According to the CORINE Land Cover database (2018), the forests and semi-natural areas of North Macedonia amounts to 15273.07 km2 or 60.06% of the total territory of the country.

The expansion of the forest area is due primarily to the activities of the Public enterprise "PE Makedonski Sumi" through their programs for simple and expanded forests reproduction of the state-owned forest. Simple forest reproduction means breading and protection of the existing forests, besides the preservation. The activities of the Public enterprise in this area are in accordance with the Special forest management plans. Expanded forest reproduction is a long-term program of the Public enterprise for forestry that represents afforestation of new forests by planting bare fields and erosive areas, melioration of non-productive degraded forests and bushes, nurturing and preventive protection of the culture of the forest, etc.

Within the long-term program for afforestation in North Macedonia PE "Makedonski Sumi" in the period of 2008-2016 had implemented the project of the government, the Action "Tree day – plant your future". Within this action for the period of 2008-2016 total area of 0.13 km2 has been afforested. In 2018 the enterprise made a field and financial analysis for this action after which it was determined that the percentage of success of this action is 21% i.e. 7.394.518 out of 35.211.985 seedlings have survived. Before the beginning of this action, the state enterprise has been executing regular afforestation of the expanded forest reproduction program. In the period 2002-2007, the

total area of 0.13 km2 has been afforested with a total of 34.514,800 seedlings showing even more successful statistics than the ones of the campaign "Tree day-plant your future".

In this way change process of afforestation is having some dominant values in the three-time period, covering a very similar surface in the first and third periods with 69.54 km2 for the first period (2000-2006) representing 19.5% of the total LUCC area or 0.27% of the case study and 66.59 km2 fort the third period (2012-2018) representing 24.14% of the total LUCC area or 0.26% of the case study. We can notice a slight enlargement of this change process in the second period (2006-2012) with 77.2 km2 representing 29.16% of the total LUCC area or 0.3% of the case study. The most common type of transition was from Scrub and/or herbaceous vegetation (class 32, level 2) associations to forests (class 31, level 2).

Examining the reasons for the phenomenon of urbanization visible as the third significant LU change process in North Macedonia, we started with an analysis of the democratization process transmitted through European perspectives and incorporated into national legislation. A process that is undoubtedly one of the key initiators of this spatial reprogramming, and in North Macedonia it is marked by the process of decentralization (2005) and initiated by the Law on Local Self-Government (2002), legal acts by which many of the competencies of the central government have been transferred to the local level, a level that affects cities and urban regions. Decentralization of government, fiscal decentralization, territorial organization, and capacity building of municipalities were key segments of the decentralization process, competencies that enabled municipalities to implement several processes at the local level, including urban (urban and rural) planning and local economic development.

Urban planning has become one of the pillars of local autonomy, and at the same time, it is among the most complex competencies that have been transferred to the municipalities with the introduction of decentralization. Stimulated, but not completely confident in their intention, the municipalities reached for the regulations that directly visualized this strategic commitment and mostly focused on the urbanization process. The urbanization of their urban areas and rural settlements have taken a back seat to the perceived opportunity for economic development in areas that do not belong to urban units. Applying the guidelines set by the Law on Spatial and Urban Planning (2005 and 2014), a series of urban plans for out-of-town settlements were prepared and adopted for groups of buildings and complexes, larger buildings, or infrastructure buildings of local importance, which are treated neither by the general urban plan nor by the urban plan for the village. The permanent conversion of agricultural into construction land is still legally regulated if it enters the planning scope of the new urban plan.

All this has contributed to the emergence of intensive urban sprawl in the outlying rural areas and new local economic zones and economic complexes on the territory of municipalities, outside their urban centers. And except in a form initiated and implemented at the local level, such phenomena are further strengthened by the emergence of the Directorate for Technological Industrial Development Zones (TIDZ), which began operations in January 2002. Their spatial repercussion caused the usurpation of territories near large urban centers in all parts of the country, areas that possessed specific soil characteristics and up to that time with constant agricultural activity. Their positioning is based on two aspects, the first is state ownership, and the second is the proximity and extension of the regional transit axes. In the form of urbanized units, with

highly developed infrastructure within their borders, they significantly complement the emergence of partial positioning and the formation of independent spatial-program units. Over the first period (2000-2006) artificial surfaces would enlarge by 28,866 km2 which represents 7.5% of the total change-affected area or 0.11% of the study case, especially to the detriment of all agricultural land-use categories. This change process is halfway lowering its intensity in the second period (2006-2012) covering an area of 11.8 km2 which represents 4,4% of the total LULC area or just 0.05% of the case study. In the third period (2012-2018) this change process is again enlarging its visibility covering an area of 24.75 km2 representing 8.9% of the total change-affected area or 0.1% of the case study. This expansion in the third period is due to the construction of new highways and regional roads in the Skopje, Southeast, and Southwest planning region, as well as mining activities in the largest coal mine in the Pelagonija planning region.

Water bodies' construction and management during the three-time periods encompassed a total of 18.926 km2 which is 2.11% of the total changed area, or 0.07% of the study case. Although it's a high percentage compared to the others it's important to state that the largest amount of transformation of the land use for this category is made in the first period (2000-2006) with a total of 15.511 km2 which is 4.35% of the total LUCC area or 0.06% of the study case. This is due to the construction activities connected with the dam and hydropower plant "St. Petka" are located on the river Treska, located in Polog and Southwest planning regions. The plant is located between the larger HPP Kozjak and the smaller HPP Matka, which completed the hydro system "Kozjak-Matka" and fully used the hydro potential of the river Treska. The hydropower plant was put into operation on August 1, 2012, with a capacity of 36.4 megawatts. The first construction works for the plant started in February 2004. According to initial plans, the plant was to be completed in 2009. The contract for the construction of the hydropower plant was signed in 2005, and the construction of the hydropower plant began in 2006 and lasted for six years. The hydropower plant was put into operation in 2012 on a trial basis.

CONCLUSION

The main purpose of the present study was to document major Land Use Cover trends in North Macedonia during the periods 2000-2006, 2006-2012, and 2012-2018.

For the first period in 2000-2006 was identified LULC area of approximately 349.18 km2 or 1.36% of the total country area, 271.86 km2 for the second period of 2006-2012 or 1.06% of the total country area, and 250.86km2 or 0.97% of the total country area, comprising a total area of 25,444.2 km2. The most frequent LU flows in North Macedonia over the 2000-2018 periods were deforestation with 53% of the total changed area, afforestation with 24% of the total changed area, and the processes of urbanization with 7% of the total changed area. The rest is covered by the change processes of extensification of agriculture with 5% and intensification of agriculture with 4% of the total changed area, and a 7% of the area in total for the processes of water bodies' construction and management, and other changes. We can confirm a uniform trend of LU change processes with a slight decline in value that varies from 1.36% to 0.97% of the total area of the case study, or if we consider them as aggregate data for the three comparative periods in 18 years we can see LU change processes of a total of 871.47 km2 which is 3.39% of the total area of North Macedonia.

Apart from their change, classes are also sorted through their equal degree of change which is confirmed for each of the classes through the analysis of gains and losses for level 2 classes. Artificial surfaces note constant gains in the three-time period. From 2000

to 2006 they are having the highest gain. Loses of this class are dominantly lower than the gains and summed for the three-time period. Agricultural areas during the first period note almost double losses than gains evidencing. In continuation, visible are almost equal values of losses and gains during the second period. The forests and semi-natural areas during the first period note slightly bigger losses than gains. In continuation visible are almost equal values of losses and gains.

Using the CORINE land cover database through this GIS-based assessment of land use and land cover change for the period 2000-2018 we highlighted a various range of modifications in North Macedonia. This analysis can be taken as a reliable source for monitoring and qualifying spatial and temporal LULC changes, but we should count on possible limitations or uncertainties, having in mind that the minimum mapping area of the CLC database is 25ha. The main purpose of this study was to document major Land Use Cover trends in North Macedonia during the periods 2000-2006, 2006-2012, and 2012-2018. Further analyses could be developed based on the obtained results and cartographical and tabular materials. The most important conclusion of this study is the continuity in this process using the same or more advanced materials as resources for developing the results. In that way, we could stay informed about the crucial tendencies and the causalities of the changes.

REFERENCES

[1] Haines -Young, R. & Weber, J. Land account for Europe 1990–2000. Towards integrated land and ecosystem accounting, European Environment Agency, Copenhagen, pp. 107, 2006.

[2] Feranec, J., Jaffrain, G., Soukup, T. & Hazeu, G. Determining changes and flows in European landscapes 1990–2000 using CORINE land cover data. In: Applied Geography, vol. 30, pp. 19–35, 2010.

[3] Weber, J.L. Implementation of land and ecosystem accounts at the European environment agency. In: Ecological Economics, vol. 61(4), pp. 695–707, 2007.

[4] Turner II, B.L. & Meyer, W.B. Land use and land cover in global environmental change: Considerations for study. In: International Social Science Journal, vol. 43, 4(130), pp. 669-679, 1991

[5] Gorin, S., Radevski, I., Milevski, I., Markoski, B., & Dimitrovska, O. GIS based analysis of the land cover changes in Skopje region during the period 2000–2012. In: T. Bandrova & M. Konecny (Eds.): Bulgarian Cartographic Association, pp. 661–666, 2014

[6] Lu, D., Mausel, P., Brondizio, E. & Moran, E. Change detection techniques. In: International Journal of Remote Sensing, vol. 25, 12, pp. 2365–2407, 2004.

[7] Feranec, J., Stoimenov, A., Otahel, J., Vasteva, R., Ropecka, M., Betak, J. & Husar, K. Changes of rural landscape in Slovakia and Bulgaria in 1990–2000 identified by application of CORINE land cover data (case studies – Trnava and Plovdiv region). In: Braun, M. (ed): EARSeL eProceedings of the Second Workshop of the EARSeL SIG on Remote Sensing of Land Use and Land Cover Application and Development. EARSeL and Universität, Bonn, pp. 441–454, 2006.

[8] Feranec, J., Hazeu, G., Christensen, S. & Jaffrain, G. CORINE land cover change detection in Europe (case studies of the Netherlands and Slovakia). In: Land Use Policy, vol. 24, pp. 234–247, 2007.

[9] Feranec, J., Soukup, T., Taff, G.N., Stych, P., Bicik, I. Overview of Changes in Land Use and Land Cover in Eastern Europe. In: Gutman, G., Radeloff, V. (eds) Land-Cover and Land-Use Changes in Eastern Europe after the Collapse of the Soviet Union in 1991. Springer, Cham. pp. 13–33. 2017.

[10] Kuemmerle, T., Radeloff, V.C., Perzanowski, K. & Hostert, P. Crossborder Comparison of Land Cover and Landscape Pattern in Eastern Europe Using a Hybrid Classification Technique, Remote Sensing of Environment, vol. 103, pp. 449–464, 2006.

[11] Popovici, E. A., Bălteanu, D., Kucsicsa, G. Assessment of changes in Land-Use and Land-Cover pattern in Romania using Corine Land Cover database. In: Carpathian Journal of Earth and Environmental Sciences, vol. 8(4), pp. 195 – 208, 2013

[12] Popovici, E. A., Kucsicsa, G., Bălteanu, D., Grigorescu, I., Mitrică, B., Dumitrașcu, M., & Damian, N. Past and future Land Use/Cover flows related to agricultural lands in Romania. An assessment using Clue-S model and Corine Land Cover database. In: Carpathian Journal of Earth and Environmental Sciences, vol. 13(2), pp. 613–628, 2018.

[13] Feranec J, Otahel J, Cebecauer T. Examples of the CORINE land cover database application in Slovakia. In: Workshop CORINE Land Cover 2000 in Germany and Europe and its use for environmental applications, pp. 155-161, 2004.

[14] Oťaheľ J, Feranec J, Betak J, Husar K, Kopecka M. Landscape changes: analysis and classification. Klasyfikacja krajobrazu. Teoria i praktyka. Problemy Ekologii Krajobrazu, vol. XX, pp. 45-56, 2008.

[15] Vatseva R, Stoyanova Y. Landscape change analysis in Bansko municipality (Bulgaria) using satellite image data. GI Forum 2011, Symposium and exhibit Applied Geoinformatics with Learning with GI, 2011.

[16] Vatseva R, Stoimenov A, Borisova N. Assessment of the land cover changes in the Plovdiv region for the period 1990 – 2000 based on Corine land cover data. Second Scientific Conference with International Participation SPACE, ECOLOGY, NANOTECHNOLOGY, SAFETY, 2006

[17] Feranec J, Šúri M, Cebecauer T, Oťaheľ J. Methodological aspects of landscape changes detection and analysis in Slovakia applying the CORINE land cover databases. Geografický časopis, vol. 53, pp. 279-288, 2002.

[18] Feranec, J, Oťaheľ J, Husár K. Landscape changes mapping by application of aerial photographs. In: Ottoson, L., (ed). Proceedings of the 18th International Cartographic Conference, Gäwle (Swedish Cartographic Society), pp. 306-313, 1997.

[19] Bossard, M., Feranec, J. & Otahel, J. Technical report No 38. The revised and supplemented CORINE land cover nomenclature, European Environment Agency, 2000.

[20] Feranec, J., Jaffrain, G., Soukup, T. & Hazeu, G. Determining changes and flows in European landscapes 1990–2000 using CORINE land cover data. In: Applied Geography, vol. 30, pp. 19–35, 2010.

[21] Nikicevikj, S. (ed.), 2018. Monograph of PE Makedonski sumi 1998-2018. PE Makedonski Sumi (Translated from the original: Никчевиќ, С. (уредник), 2018. Монографија на ЈП Македонски Шуми 1998 – 2018. ЈП Македонски Шуми.).

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