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LAND COVER TYPES AND CHANGES IN LAND USE IN REPUBLIC OF SRPSKA (BOSNIA AND HERZEGOVINA) OVER THE PERIOD 2000–2018

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Abstract: Republic of Srpska (RS) covers an area of 24,666 km^2 or about 48.5% of Bosnia and Herzegovina's territory. Spatial and environmental changes accelerated due to dynamic historical period upon the RS formation and the following development period. The extent of these changes can be determined by comparing satellite images obtained from different acquisition periods. By processing images, with the support of geographic information systems, it is possible to create a database that aims to analyze spatial processes in a specific area in order to determine quantitative and qualitative parameters. In this way, the trends of spatial development (e.g. excessive logging, land cover damage, water pollution, etc.) and potentially vulnerable components of the environment can be monitored. The data for Bosnia and Herzegovina were collected from CORINE Land Cover (CLC) database for 39 European countries. The CLC is a project launched by the European Environment Agency (EEA) more than thirty years ago with the aim of collecting, coordinating and ensuring the consistency of information on natural resources and the environment. The goal of the paper is to identify land cover types and determine environment changes in the territory of Republic of Srpska over the period 2000–2018 as a consequence of the land use conversion.

Keywords: land cover; CLC database; spatial trends; Republic of Srpska

Introduction

Bosnia and Herzegovina (B&H) is situated in southeastern Europe (Figure 1) and is composed of two autonomous political entities roughly equal in size: The Federation of Bosnia and Herzegovina (FB&H) and Republic of Srpska (RS), including a third unit as well, Brčko District (BDB&H) governed by the local government. The population of Bosnia and Herzegovina is around 3.5 million. Republic of Srpska's population is 1.2 million (Agency for Statistics of Bosnia and Herzegovina, 2016). It is located at the contact zone of three major natural and geographic regions: the Pannonian Plain, the Adriatic Sea, and the Dinarides Mountains. The relief of Bosnia and Herzegovina is mainly hilly and mountainous with only 8% of the land beneath 150 m above sea level.

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The entity is characterized by an uneven distribution of water resources, so one of the main problems is water shortage especially in those parts of the territory where water is most needed. Other issues are insufficient sustainability planning of the exploration of natural resources, insufficient exploration of mineral resources, inadequate use of natural resources (water, ore, and forests) from the point of view of the country and local self-government units as well as the unsustainability in use of agricultural land (reduction in quantity and quality) and forests (cutting down faster than growing back) (Institute for Urban Planning of Republic of Srpska, 2013).

Generally speaking, Republic of Srpska has a relatively preserved environment since the rural area dominates with more than half of the territory covered by forests. Communal infrastructure is impoverished in some areas which indirectly endangers the environment components: water, air, and land. There is a shortage of regional sanitary dump sites. The processes of urbanization and construction of transport infrastructure result in increasing the pressure on the environment. In some locations, residential and commercial buildings and roads are being built on the highest quality agricultural land. In such cases, land use changes should be better controlled by spatial planning (Institute for Urban Planning of Republic of Srpska, 2013).

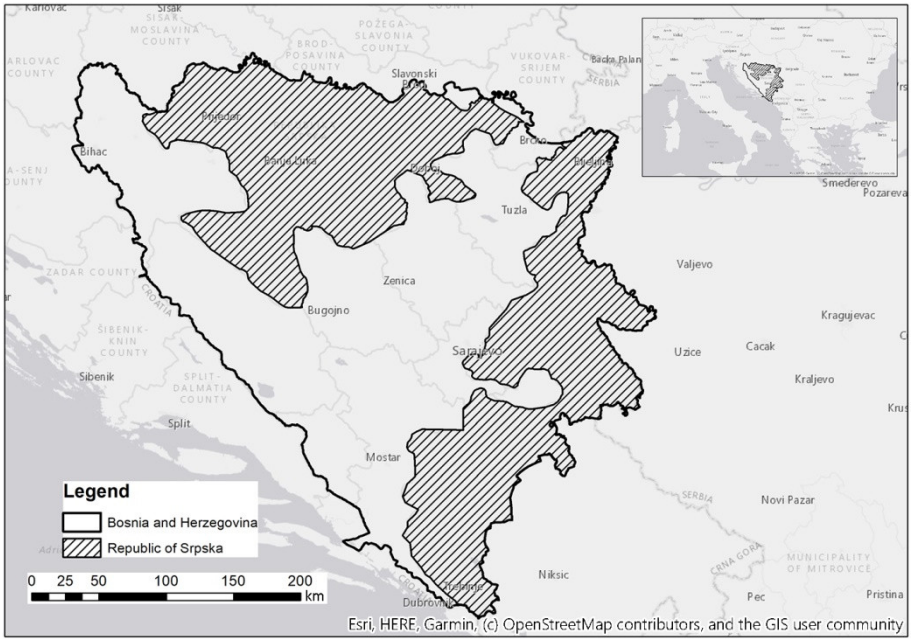

Figure 1. Geographical position of Republic of Srpska.

The thematic mapping of the biophysical cover can be viewed from two aspects: (1) surface cover or soil cover deals with the nature of certain features (forests, crops, water bodies, naked rocks, etc.); (2) The use of land deals with the socio-economic function and the purpose of the basic areas (agriculture, habitats, environmental protection) (Drašković & Drešković, 2017). There are two most important objectives of the study: to show land cover types in Republic of Srpska according to

CORINE[1] Land Cover (CLC) database, and to determine the intensity of changes in land use during the period 2000–2018 according to changes (CHA) database.

Depopulation is the dominant socio-economic process during the observed period. The population of Republic of Srpska was estimated to 1.428 million in 2000. The 2013 official census stated around 1.2 million. The estimation for 2018 is 1.147 million (Republika Srpska Institute of Statistics, 2018). The population density is just 46.5 persons per km^2, one of the lowest in Europe. The B&H population decreased from 4.37 million in 1991 (Institute for Statistics Federation Bosnia and Herzegovina, 1998) to 3.53 million in 2013 (Agency for statistics of Bosnia and Herzegovina, 2016).

Methodology

The images acquired by earth observation satellites are used as the main source of data to derive the land cover information. The choice of scale (1:100,000), minimum mapping unit (MMU) of 25 ha and minimum width of linear elements (100 m) for CLC mapping represent a trade-off between production costs and the level of detail of land cover information (European Environment Agency [EEA], 2007).

As one of the most important projects for collecting environmental data, types of land cover and changes in the Europe, the CLC inventory, was initiated in 1985 (reference year 1990). The project is coordinated by the EEA. The number of countries participating in the project increased from 29 to 39. The first CLC database refers to 1990; the data were updated afterwards in 2000, 2006, 2012, and 2018 (databases update every six years). The national centers created national CLC bases in coordination with the EEA (Büttner & Cosztra, 2017).

The first CLC project for Bosnia and Herzegovina started in 1998 and was successfully completed in 2000. The result was the creation of the B&H CLC 2000 database, which included the identification of the types of surface cover at the level of the main classes, and also the second and third level subclass with a detailed description of the structural characteristics. Subsequently, the CLC 2006, CLC 2012, and CLC 2018 databases were created with the aim to monitor the dynamic changes in the land cover.

CLC nomenclature comprises three levels: the first level (5 items) indicates the major categories of land cover on the planet, the second level (15 items) is for uses on scales of 1:500,000 and 1:1,000,000, and the third level (44 items) is for uses on a scale of 1:100,000 (EEA, 1995). The single-date Landsat TM used in CLC 2000 was replaced by two satellite images (usually taken by IRS and SPOT-4) acquired in two different seasons (Büttner & Cosztra, 2017).

Geometric accuracy for CLC 2018 is less than 10 m, source Sentinel-2 (and Landsat-8 for gap filling) and time consistency 2017–2018. The 2012 version of CLC was the first one embedding the CLC time series in the Copernicus program, thus ensuring sustainable funding for the future. Copernicus is the European Union's Earth observation program coordinated and managed by the European Commission in partnership with the European Space Agency, the EU Member States and EU Agencies. The 2018 version also funded by Copernicus was produced in less than 1 year (Copernicus Land Monitoring Services, 2019).

A minimum cartographic unit for the CLC-Change map (CHA) is set to 5 ha. Mapping of CLC-Change is carried out by applying the "change mapping first" approach. Multi-temporal images (each location was captured by at least two satellite images) were useful in separating some land cover classes (e.g.,

[1]CORINE—COoRdination of INformation on the Environment

arable land and pastures). The interpretation was supported by ancillary data such as national orthophotomaps, BDOT10K (available in the WMS format), Google Earth, and city maps (Hościło & Tomaszewska, 2015).

The analysis of CLC data and land cover changes data was done by extracting the territory of Republic of Srpska using QGIS 3.6 (2019) clip tool and exported to excel worksheet where the data was sorted and summarized using SUBTOTAL tool by land cover types and changes for all the three levels and all the three periods. Considering the different time periods of data acquisition, it is possible to monitor and visualize changes that occur in the space. By overlapping data layers from different periods we can get information in which zones the changes are the largest and determine the spatial coverage. Spatial interpolation defines differences at the level of the same subclass, which can determine trends of spatial development.

The analysis of the types of land cover, according to CLC nomenclature, showed that in Republic of Srpska there are 5 first-class levels, 13 second-class levels, and 29 (out of 44) third-class levels, with the following designations and definitions (EEA, 1995):

1. Artificial surfaces
- 1.1.1. Continuous urban fabric;
- 1.1.2. Discontinuous urban fabric;
- 1.2.1. Industrial or commercial units;
- 1.2.2. Road and rail networks and associated land;
- 1.2.4. Airports - Airport installations: runways, buildings and associated land;
- 1.3.1. Mineral extraction sites;
- 1.3.2. Dump sites;
- 1.3.3. Construction sites;
- 1.4.2. Sport and leisure facilities;

2. Agricultural areas
- 2.1.1. Non-irrigated arable land;
- 2.2.1. Vineyards;
- 2.2.2. Fruit trees and berry plantations;
- 2.3.1. Pastures;
- 2.4.2. Complex cultivation patterns;
- 2.4.3. Land principally occupied by agriculture, with significant areas of natural vegetation;

3. Forests and semi-natural areas
- 3.1.1. Broad-leaved forest;
- 3.1.2. Coniferous forest;
- 3.1.3. Mixed forest;
- 3.2.1. Natural grasslands;
- 3.2.2. Moors and heathland;
- 3.2.3. Sclerophyllous vegetation;
- 3.2.4. Transitional woodland-shrub;
- 3.3.1. Beaches, dunes, and sand plains;
- 3.3.2. Bare rocks;
- 3.3.3. Sparsely vegetated areas;
- 3.3.4. Burnt areas.

4. Wetlands
- 4.1.1. Inland marshes.

5. Water bodies
- 5.1. 1. Water courses;
- 5.1.2. Water bodies.

Results and discussion

As regards the area of Republic of Srpska, according to CLC 2018 database, on the first level of classification, forest and semi-natural areas represent the biggest land coverage of 61.25% (code 3), followed by agricultural areas with 36.70% (code 2), while the category of artificial surfaces covers 1.3% (code 1). On the second level, the most common categories are: forest vegetation (code 3.1.) with 47.25% and arable land (code 2.4.) covering 26.91%. Concerning the third level of classification (Figure 2), the broad-leaved forest vegetation dominates (code 3.1.1.) covering 34.61%, complex cultivation patterns (code 2.4.2.) with 17.47%, agricultural areas with significant natural vegetation (code 2.4.3.) with 9.45%, mixed forest (code 3.1.3.) 7.58%, pastures (code 2.3.1.) 5.47%, coniferous forest vegetation (code 3.1.2.) 5.06%, sclerophyllous vegetation (code 3.2.3.) 4.92%, transitional

woodland-shrub (code 3.2.4.) 4.19%, non-irrigated arable land (code 2.1.1.) 4.14% and natural grasslands (code 3.2.1.) 3.24%. Among other types of surface cover having representation below 1% was discontinuous urban area (code 1.1.2.) covering 0.97%.

Regarding spatial development in the period 2000–2018, the growth of urban areas in the amount of 31.61% is notable (from 244.2 km^2 to 321.79 km^2 at code 1 level), while agricultural zones decreased by 10.53% (from 10,131.52 km^2 to 9,064.55 km^2 at code 2 level). Forest and semi-natural areas increased by 6.91% (from 14,151.2 km^2 to 15,128.73 km^2 at code 3 level), as well as wetlands and water bodies with 26.04% and 5.57% respectively (these areas are small: water bodies covering 167.10 km^2 and wetlands 16.67 km^2).

The Intensity of urbanization in Republic of Srpska is lower than in the entity of FB&H because of the fact that only 35% of the B&H population lives on 49% of the B&H territory (i.e., RS territory). Analysing the periods, higher intensity of changes occurred over the period from 2000 to 2006 and from 2012 to 2018 compared to the period from 2006 to 2012. According to the inter-period spatial changes, it was found that the intensity of urbanization gradually reduced and in the future it can be expected to continue this downward trend because the migration population is greatly reduced in comparison to the first decade of the twenty-first century (Drašković, Drešković, & Mirić, 2016).

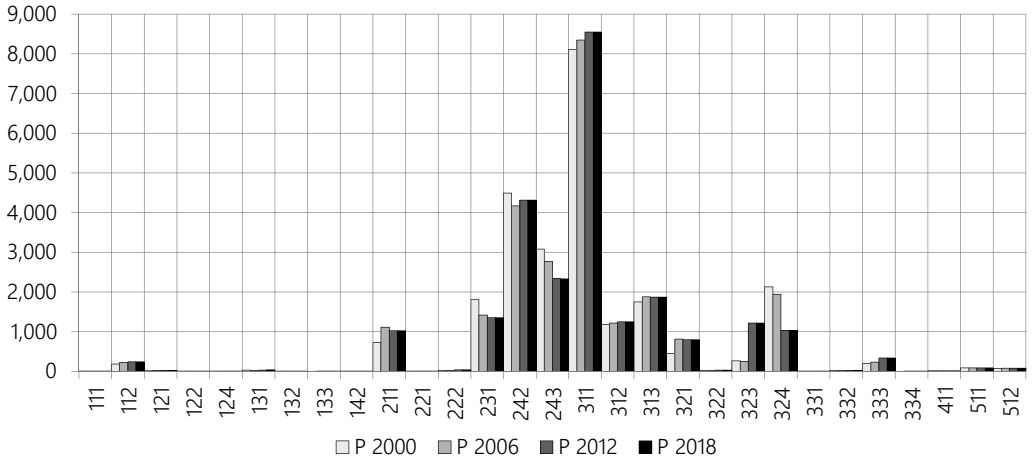

Figure 2. CLC third level subcategories cover (shown as km^2) the area of Republic of Srpska in 2000, 2006, 2012, and 2018 (according to CLC 2000, CLC 2006, CLC 2012, and CLC 2018 geodatabases).

Based on the analysis of the total turnover of land cover by periods, the period 2000–2006 witnessed more intense changes, amounting to 137.56 km^2, followed by the period 2012–2018 with 109.38 km^2, and the least changes were recorded during the period 2006–2012 with 84.25 km^2 (Table 1). The analysis of data on changes in RS (CHA 2000–2006, CHA 2006–2012, and CHA 2012–2018) at the first level of classification confirms that there is a trend of expansion of artificial surfaces at the expense of other areas. In the initial 2000–2006 period, this trend was the most intensive, covering 29.36 km^2, in the period 2006–2012 it reduced to 12.57 km^2, to increase to 17.02 km^2 in the period 2012–2018. The process of the conversion in the opposite direction, the transition of artificial surfaces to other types of surface cover, was significantly less represented and amounted to 6.63 km^2 for all the three periods. The artificial areas were mostly spread at the expense of agricultural

land. In the first period, 92.74% of the newly-formed artificial areas cover former agricultural land, in the second 61.57% and in the third 72.21%.

Table 1
Overview of changes in the first level of classification in RS (shown as km^2)

Changes[a]	CHA 2000–2006	CHA 2006–2012	CHA 2012–2018	Sum
1xx–xxx	2.45	3.17	1.01	6.63
xxx–1xx	29.36	12.57	17.02	58.95
1xx–1xx	0.17	0.58	0.12	0.86
2xx–xxx	44.55	19.38	19.36	83.29
xxx–2xx	8.30	20.64	2.52	31.46
2xx–2xx	7.12	9.90	0.79	17.81
3xx–xxx	88.25	54.88	88.06	231.18
xxx–3xx	94.11	50.15	88.07	232.33
3xx–3xx	83.74	47.83	80.52	212.10
Total changes	137.56	84.25	109.38	331.19

[a]x can be any number from 1 to 4 and also 5 for the first column.

The changes in agricultural land were even more dynamic. Namely, the conversion of this type into other types of surface cover in the period 2000–2006 was 44.55 km^2. In the next two periods it was reduced to 19.38 km^2 (2006–2012) and 19.36 km^2 (2012–2018). On the other hand, the conversion of other types to agricultural land had a much lower intensity. In the first period it amounted to 8.30 km^2 (of which 7.12 km^2 refers to the internal conversion, i.e. the transition of one type of agricultural land to another), in the second 20.64 km^2 (internal conversion 9.90 km^2), and in the third only 2.52 km^2 (internal conversion 0.79 km^2).

When it comes to forests and semi-natural areas, they are, as in other European countries, a major trigger for changes. Internal conversion of one type to another in the period 2000–2006 amounted to 83.74 km^2 or 60.87% of all (total) changes in that period. In the second period this volume was almost doubly reduced and amounted to 47.83 km^2 or 56.77% of the total changes. The period 2012–2018 brought an increase to 80.52 km^2 or 73.61% of the total changes. Thus, most of the changes took place within forests and semi-natural areas that have a growing trend, as well as artificial areas, while the area under agricultural land is decreasing.

Based on the analyses for B&H conducted by EEA, the slowdown during the period 2006–2012 was caused mostly by the rapid decrease of the intensity of forest creation and management—in particular of recent felling and transition—which, in the long term, is by far the most significant driver of land cover change in the country—even after the slowdown. The other flows with rapid decrease of intensity were urban residential sprawl and internal agricultural conversions. After this shift in distribution of intensity among particular flows, sprawl of economic sites and infrastructures, and the conversion from forested land to agriculture, both with higher intensity than in 2000–2006, became the other most significant flows behind forest development. It has to be mentioned here, that the sprawl in the period 2006–2012 was driven mostly by the extension of mining areas and by construction, while residential sprawl—the main driver of artificial development in the previous period—almost disappeared from the landscape (EEA, 2017). Other reasons for reducing the intensity of change include the largely completed refugee return process in Bosnia and Herzegovina, as well as the global economic crisis that affected the stagnation of the economy and the decline in artificial land growth.

Geographically, the artificial development is distributed over the whole country of Bosnia and Herzegovina. The rate of artificial land take still remains one of the highest among European countries. Also, forest and shrub fires or the conversion from wetland to agriculture have been observed in the whole country (EEA, 2017). During the period 2000–2006, most changes (about 40%) in Republic of Srpska were related to the conversion of broad-leaved forest to transitional woodland-shrub and vice versa (3.1.1.–3.2.4. and 3.2.4.–3.1.1.). Furthermore, there are significant changes associated with the conversion of complex cultivation patterns (2.4.2.) and non-irrigated arable land (2.1.1.) to discontinuous urban fabric (1.1.2.). In the second period, 2006–2012, the largest volume of changes (about 35.6%) was related to the conversion of transitional woodland-shrub to broad-leaved forest. Other individual changes are significantly smaller. The biggest changes during the period 2012–2018 are related to the fires (Table 2, code 3.3.4.) in the south of the entities, in the region of East Herzegovina. The region is known for its Mediterranean climate with high temperatures and low rainfall during the summer season. Fires are represented by the conversion of transitional woodland-shrub, sclerophyllous vegetation, and broad-leaved forest to burnt areas (3.2.4.–3.3.4., 3.2.3.–3.3.4., 3.1.1.–3.3.4., and also 2.3.1.–3.3.4.), accounting for 44% of all the changes during this period.

Table 2
The most significant inter-period relative spatial changes in land cover distribution

CHA 2000–2006		CHA 2006–2012		CHA 2012–2018	
Codes	km^2	Codes	km^2	Codes	km^2
3.1.1.–3.2.4.	34.29	3.2.4.–3.1.1.	30.25	3.2.4.–3.3.4.	25.31
3.2.4.–3.1.1.	21.32	2.4.3.–2.2.2.	6.47	3.2.3.–3.3.4.	13.65
2.4.2.–1.1.2.	10.19	3.2.4.–3.1.3.	5.42	3.2.3.–3.2.4.	12.88
2.1.1.–1.1.2.	9.35	5.1.2.–2.1.1.	4.18	3.1.1.–3.2.4.	9.60
3.2.4.–3.1.3.	3.96	3.1.1.–3.2.4.	3.90	3.1.1.–3.3.4.	8.30
2.3.1.–2.4.2.	3.90	3.1.2.–3.2.4.	3.65	3.2.4.–3.1.1.	5.80
3.1.1.–3.3.4.	3.66	2.4.2.–1.3.1.	2.39	2.4.3.–3.2.4.	5.03
3.1.2.–3.2.4.	3.33	4.1.1.–2.1.1.	1.98	2.4.2.–1.2.2.	3.12
2.3.1.–3.2.4.	3.20	3.2.4.–3.1.2.	1.98	3.1.3.–3.2.4.	2.28
3.1.3.–3.2.4.	2.82	2.4.2.–2.2.2.	1.67	2.3.1.–1.3.1.	1.98

Conclusions

There are significant changes according to the CLC geodatabase in land use over the course of 2000–2018 in the area of Republic of Srpska. Spatial development of urban areas increased by 31.61% only in respect of 18 years, which is mainly a consequence of post-war reconstruction and population migration during the process of ethnic homogenisation in Bosnia and Herzegovina. In total of the territory, the urbanisation increased from 0.98% to 1.3%.

The factors that are mostly affecting the trends in the period 2000–2018 are the reduction in the intensity of out-migration of the population (the refugee return process was more intense in 2000–2006) and global economic crisis starting from 2008 which slowed down the economic development. A depopulation process is widespread in Republic of Srpska where natural depopulation appears since 2002.

As regards the first-level classes, forest and semi-natural areas cover the highest percentage of the territory with 61.25%, followed by agricultural land with 36.70%, which makes 97.95% of the total territory of Republic of Srpska. Over the period 2000–2018, the area covered by the forest and

semi-natural areas increased by 6.91%, while the agricultural area decreased by 10.53%. In total, over the period 2000–2018, forest and semi-natural areas increased from 57.30% to 61.25% and agricultural areas decreased from 41.03% to 36.7%. Semi-natural areas are spreading to former agricultural zones. The largest reductions were recorded in areas with a natural vegetation, transitional woodland-shrub, complex cultivation and pastures and moors and heathland, while the highest increase was recorded in the bushy sclerophyllous vegetation, natural low-productive grassland, broad-leaved forest and non-irrigated arable land.

The most significant changes are related to forest and semi-natural areas (internal conversion from 56.77% to 73.61% of total changes over the three periods) and agricultural land. Artificial surfaces are spreading mostly to agricultural land (from 61.57% to 92.74%). During the third period, 2012–2018, almost half of the changes were caused by fires in the region of East Herzegovina, in the southern part of Republic of Srpska.

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