QUANTIFYING AND VISUALIZING LAND COVER CHANGES: AN ANALYSIS FROM THE HASI REGION (KOSOVO)

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Abstract
Hasi region lies in the southwestern part of Kosovo and is dominated by karstic, ultramafic landscapes in Hasi Mts., and fluvial depositional landforms near White Drini and Erenik Rivers. Karstic landscapes are distinguished by the absence of surface waters and the karstic springs found at the foothills of Pashtrik and Hasi Mts. Broad-leaved forests and transitional woodland-shrubs cover most of middle and high-altitude areas. In the last two decades, the region has experienced landscape transformation resulting in Land Use/Land Cover (LULC) changes, where settlements are extended towards agricultural areas, mainly in lower part of the region. The GIS technique and statistical methods were useful in quantifying, mapping, and visualizing spatiotemporal changes of Land Cover data from Copernicus Land Monitoring Service (CLMS) for 2000-2018, while Sankey diagram is used to visualize the magnitude and the flow of Land Cover Changes in the Hasi region over the last two decades. All the data were analyzed in the ArcMap 10.8 environment. The analysis shows that most of the Land Cover categories have experienced a transformation. From the total area of 30,939 ha, agricultural land decreased by 998 ha, artificial surfaces increased by 293 %, and broad-leaved forest and sparsely vegetated areas experienced an increase. In contrast, transitional woodland-shrubs experienced the most change gaining and losing areas.

Key words
Land Cover Changes, karstic landscape, mapping, landscape change visualization, Hasi region, Kosovo.

INTRODUCTION

Natural processes will have a great influence on Land Cover changes, but human activities are and will be decisive in landscape transformation. Land Use/Land Cover (LULC) consists of different land covers, from single-family residential to large areas of natural environments like forest cover (Treitz and Rogan, 2004), and analysis of them is one of the main contemporary topics of geographical research (Feranec et al., 2016). LULC is related to anthropogenic disturbance, where the distribution of the human population is evident in nearly every part of the Earth, where it shows its presence through natural landscape changes. Land Cover changes show a long interaction between humans and the natural environment (Michaeli et al., 2015), and are the product of different factors and conditions (Solár et al., 2016). Land Cover identifies natural landscapes, which are the product of natural processes like geological, hydrological, ecological, etc., and includes the human-transformed landscape with artificial surfaces. Land Cover change analysis is important for environmental planning and natural resource management (Al-Taei et al., 2023). Estimations show that 17 % of the terrestrial ecosystem has experienced a change at least once between 1960 and 2019 (Winkler et al., 2021). Among other changes, the increase of artificial surfaces on agricultural lands is of high magnitude, introducing human impact. Land cover changes are related to water balance (Bridgewater, 2018). Land Cover changes are occurring around the world. In Europe, 70 Mha of LULC have occurred changes during the period 1992-2015 (Huang et al., 2020), with widespread of urbanization in all regions, especially in central and eastern Europe (Hoffmann et al., 2023), as it is shown by different studies (Cegielska et al., 2018).

Detecting changes in Land Cover in terms of their magnitude and flow, allows plans and projects to interpret correctly spatial planning, regional food security, and environment risk analysis (Doğruer et al., 2023), and for protected areas is important to identify the changes in landscape's structure (Michaeli et al., 2017) and future projections. At the European level, LULC is presented in a unique dataset every 6 years where changes in the landscape can be observed (Feranec et al., 2016), where the territory of Kosovo belongs to it. In recent years, Kosovo, in general, has been losing agricultural land, shifting towards artificial surfaces, where the area per capita is decreasing. Agricultural land conservation is highly important for Kosovo because of its natural conditions with the dominance of hilly-mountainous terrain. Land Cover changes in the Hasi region show the relationship of humans to the environment, but also the succession as a natural process of landscape transformation, as other studies have confirmed, finding human-environment and environment-environment inter-connection (Meyfroidt et al., 2013). According to the studies (Zhang et al., 2023), land cover changes in the karst landscape covered 1.3 million km^2.

OBJECTIVES

The objectives of the study are to quantify and visualize the Land Cover changes in a fragile region in Kosova, located between White Drini's right alluvial plain and Pashtrik-Hasi karstic terrain, where both landscapes have experienced transformation after extracting sand and gravel and the abandonment of the settlements. Karst terrains have groundwater resources of high importance and biodiversity values, which, with time passing, are becoming vulnerable to human impacts. Land Cover changes have been more emphasized in decreasing agricultural areas while increasing forest and semi-natural areas, and especially artificial surfaces, both in terms of transition from one category to another. In contrast, broad-leaved forests increased, and transitional woodland-shrubs were the category with the most changes experienced in both directions.

THEORETICAL FRAMEWORK

Land Use and Land Cover changes have become the key studies of different scientists with application in the environment, geology, hydrology, and ecology (Weng, 2001), but also in understanding the driving forces of landscape change (Lambin, 1997), which were followed in development of new techniques in tracing Land Use and Land Cover changes. Rapid urbanization has consequences of changes in the local climate, the water cycle, biodiversity loss, and, in general terms, degrades the living environment.

The Hasi region is a mixture of karstic, fluvial, and ultramafic landscapes, indicating socio-economic processes in the region with footprints on the type of living environment. One of the changes in karstic landscape are grassland ecosystems (Bátori et al., 2023), which are interrelated to lithological settings and climate conditions and show a positive relationship in Land Cover change, related to gaining areas in abandoned settlements in study area. Fluvial landforms are attractive for living and are the homes of millions living near them. Nevertheless, as a specific landscape rich in soils and water, it has attracted rapid urbanization, where land cover changes were inevitable (Kayitesi et al., 2022). As studies suggest, Land Cover changes could have an impact on the river's morphology (Kang & Kanniah, 2022), runoff and sediment yield (Munot, Goyal, 2019), surface runoff (Vojtek, Vojtekova, 2019), and flooding will be related as a consequence of hydrologic response (Naha et al., 2021).

Analysis and interpretation, including the consequences of Land Cover changes, are made possible by developing new datasets that various scientists can download and analyze. Land Cover change analysis is made with different focuses. Some authors have analyzed the natural landscape changes in terms of climate change and relation to natural landscapes, with emphasis on biodiversity

loss (Boussema et al., 2023), habitat quality, (Jin et al., 2022), impact in agricultural policy and regional planning (Feranec et al., 2007), and based on future projections, the natural landscape will have the largest effect (Sala et al., 2000).

DATA AND METHODS

To quantify and visualize the Land Cover Changes, data with 100 m spatial resolution of the Hasi region for the years 2000, 2006, and 2018 were downloaded from Copernicus Land Monitoring Service (CLMS) ("CORINE Land Cover"). Data for the year 2012 were not taken into consideration for their reliability, showing similar data in 2018, which, based on our observations, we can conclude that there were changes in the region. Vector (shapefiles) and other raster data were assembled in the ArcMap 10.8 environment. The GIS technique and statistical methods were useful for estimating changes and presenting their spatial-temporal distribution on the study site. Firstly, it enables the categorization of different Land Cover types. Secondly, by using this technique, it enables comparing data and finding temporal changes. Vector and raster data were clipped for the study site and intersected for selected years, and later, the changes were mapped and presented with interesting results. A 10 m DEM was used to estimate slope gradient and altitude classes, while population statistics were downloaded from official censuses for the study area. these data were compared, and changes over the years were presented in thematic maps. ArcMap 10.8 environment has made it possible to quantify and visualize the changes in a thematic map. In contrast, the Land Cover change's magnitude and flow are presented in a diagram where the source and their target destination can be seen (Wang & Feng, 2008).

STUDY AREA

Kosovo is a small country in Balkan Peninsula with diverse physical features. Surrounded by high-altitude mountains in the border zone, inside of them are tectonic plains with high-capability soils. Mountain regions in Kosovo are distinguished by their physical features. Hasi region is located in the southwestern part of Kosovo (Fig 1). According to the regional division of Kosovo, the Hasi region is distinguished by its characteristics, mainly the presence of a karstic landscape and ultramafic rocks topography, where the absence of surface waters is evident. The northern part of the region lies at the foothill of Pashtrik Mt. (1,988 m.a.s.l) and White Drin River (Albanian: Drini i Bardhë) right alluvial plain (Çavolli, 1997).

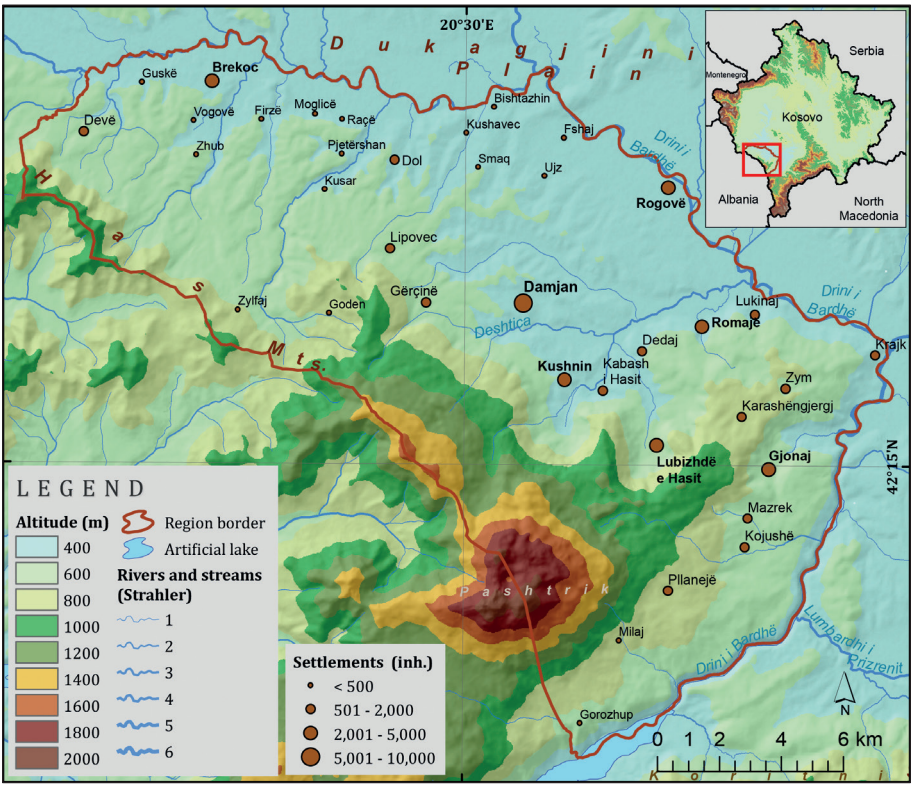

Fig. 1 Location map of the study area
Source: Authors

The Hasi region is located in the Mirdita geological zones (Elezaj, Kodra, 2008; Pruthi, 2013), which stretches in Albania and Kosovo and is marked by the presence of ultramafic rocks, which are located on the western side and are distinguished with the presence of serpentine, gabbro and diabase rocks, while, southern part of regions with the presence of different type of limestones (Fig 2). Both types of rocks have impacted surface and groundwater hydrology, with absence of surface runoff, but with karstic springs at the foothill of the mountain terrain where most of the settlements are located. At the lowest part of the region, which lies in the lowest terrain and near rivers of Drini i Bardhë and Ereniku, loose sediments of fluvial and lacustrine origin are found, which have played an important role in determining their main economic activity. The region's altitude lies between 261 m and the highest peak, Pashtrik – 1,988 m. The average altitude of the whole region is 577 m. The uppermost relief is a typical karst landscape with surface karstic landforms, while the lowest part is a flat one lying on the alluvial plain of Drini i Bardhë and Erenik River (Fig 2).

One of the main terrain features with Land Cover associated is the slope, which has played an important impact in the distribution of agricultural land and settlements. Slopes are classified according to FAO classification (FAO, 2006), while slope category until 2° are only 12.4 % of the region, while slope category between 2-5° are 15.8 % and are considered flat or gently sloping terrain. Between 5-10° are 24 % of slopes, while >10° where terrains are considered sloping, strongly sloping, moderately steep, and steep are dominant covering 71.7 % of the region (Fig 2), which indicates high altitude mountains and rugged terrains of limestones and ultramafic rocks (Table 1).

Tab. 1 Slope categories in the Hasi region according to FAO classification

Slope (degree)	Description	Area (km^2)	%
< 2	Flat to very gently sloping	38.39	12.41
2 - 5	Gently sloping	48.97	15.83
5 - 10	Sloping	74.09	23.95
10 - 15	Strongly sloping	55.19	17.84
15 - 30	Moderately steep	83.65	27.04
> 30	Steep	9.10	2.94
	Sum:	309.39	100.00

Source: Calculated by authors

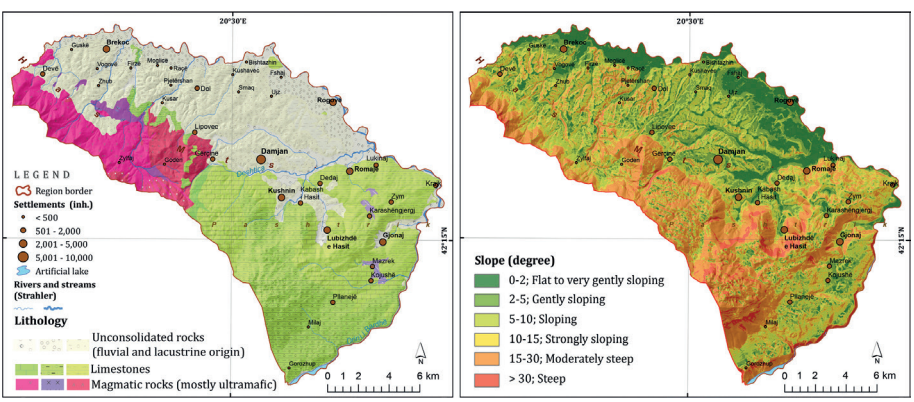

Fig. 2 Lithology (left) and slope map (right) of the study area
Source: Authors

In the lowest altitude, climate conditions are continental under the influence of Mediterranean air masses toward Kosovo, moved along Drini and White Drini Valley into Dukagjini Plain. Altitude plays an important role in the climatic condition of the whole region, while the altitude of Pashtrik Mt. (1,988 m), has indicated

a mountainous climate. The mean annual air temperature in the plain area is between 11-12°C, while the uppermost altitude goes down to 6°C. On the other hand, the mean annual rainfall is between 800 mm in the plain areas and 1,500 mm at the highest altitude of Pashtriku (Pllana, 2013; Pllana, 2015). The Hasi region is considered one of the driest regions with surface waters, where the presence of limestones and ultramafic rocks has indicated such conditions.

There are 37 settlements in the Hasi region in Kosovo, distributed at different altitudes and distances to the main rivers. Because of a karstic landscape, most of the settlements were found in nearby karstic springs. In 1948, the total population number was 13,935 inhabitants, and in the last census, there were 41,642, or an increase of 3 times (Statistical Agency of Kosovo, 2013). The settlement's altitude varies from 316 m (the lowest) to 686 m (the highest). With the increasing population number, most changes happened to artificial surfaces, which showed the highest increase for the analyzed period. In the last years, recreation and tourism have started developing with the possibility of visiting karstic landscapes (caves, natural bridges, springs, potholes), high peaks (Pashtriku, 1,988 m), etc., and the possibilities of future "green corridor" for cross-border tourism between Kosovo and Albania (Ramadani et al., 2020).

RESULTS AND DISCUSSION

Land Cover Change Analysis

Human activities are the main driving force in changing the landscape of specific regions. Based on the characteristics of a region, their scale, magnitude, and target destination of land cover appeared. Land Cover change is one of the main changes that occur during anthropogenic impact. However, in recent years, rapid urbanization has indicated extensive changes with increasing artificial surfaces and a decrease of agricultural land. Socio-economic activities as the main driving force in the landscape have intensified environmental changes altering the landscape and impacting the water cycle and local climate.

Physiographical features of the Hasi region have impacted the distribution of different types of Land Cover, where forest and semi-natural areas are dominant. Based on the Land Cover data for the year 2000, forest and semi-natural areas dominate the region with 64.5 % of the total area (Table 2). Their distribution is correlated with high altitude in the karstic landscape of Pashtrik mountain and other hilly-mountainous areas of the region. Broad-leaved forests are widely distributed forest types, accounting for 43.8 % of the region's total area. They cover enormous areas and represent the highest vegetation zone. Transitional woodland-shrub represents bushy and herbaceous vegetation, covering 14.8 % of the region's total area. Other categories of forests and semi-natural areas were: natural grasslands (2.9 %), sparsely vegetated areas (1.7 %), and others (mixed forests, burnt areas, etc.).

Tab. 2 Land cover classes in the years 2000-2006-2018

Code	Description	2000		2006		2018	
		Area (ha)	%	Area (ha)	%	Area (ha)	%
112	Discontinuous urban fabric	176.8	0.6	515.4	1.7	695.7	2.2
121	Industrial or commercial units	-	-	-	-	1.1	-
211	Non-irrigated arable land	3,117.7	10.1	3,161.9	10.2	2,120.1	6.9
231	Pastures	672.6	2.2	598	1.9	417.8	1.4
242	Complex cultivation patterns	4,559.8	14.7	4,408.0	14.2	4,122.90	13.3
243	Land principally occupied by agriculture, with significant areas of natural vegetation	2,346.7	7.6	2,071.8	6.7	2,559.6	8.3
311	Broad-leaved forest	13,551.0	43.8	13,668.8	44.2	13,870.8	44.8
313	Mixed forest	77	0.2	77	0.2	77	0.2
321	Natural grasslands	890.4	2.9	724.4	2.3	327.7	1.1
323	Sclerophyllous vegetation	0.5	-	0.1	-	0.3	-
324	Transitional woodland-shrub	4,594.4	14.8	4,792.80	15.5	4,723.2	15.3
331	Beaches, dunes, sands	101.7	0.3	-	-	-	-
333	Sparsely vegetated areas	538.8	1.7	528.8	1.7	1,839.8	5.9
334	Burnt areas	214.7	0.7	0	0	86.2	0.3
411	Inland marshes	-	-	295.2	1	-	-
511	Water courses	25.9	0.1	25.9	0.1	25.9	0.1
512	Water bodies	71.7	0.2	71.7	0.2	71.7	0.2
		30,939.7	100	30,939.7	100	30,939.7	100

Source: Copernicus Land Monitoring Service

The second most distributed category of Land Cover is agricultural lands. In 2000, they covered 34.6 % of the region's total area, while complex cultivation patterns (14.7 %) and non-irrigated arable land (10.1 %) were the most extensive type of agricultural land sub-categories. Land principally occupied by agriculture, with significant areas of natural vegetation, covered 7.6 %, and pastures were found in 2.2 % of the region's area. Agricultural lands were found in loose sediments of fluvial and lacustrine origin, in which high-quality soils were created, and played an important portion of the agricultural activity of the population. Artificial surfaces

covered 0.6 % of the total area, while 0.3 % were water courses and water bodies of White Drini and an artificial lake built on it – Vërmica (Fierza) Lake.

Between the years 2000 and 2018, based on natural processes and socio-economic activities, most LULC happened in artificial surfaces (+294 %), forests, and semi-natural areas (+4.8 %), while agricultural areas and wetlands/water bodies had a decrease (-13.8 %, respectively -0.1 %) (Table 3; Figure 3). Firstly, the rapid urbanization of settlements with changes in family structure and migration significantly impacted these changes, while leaving agriculture for another economic activity has detached the population from the land. The presence of inland marshes (wetlands) in the year 2006 is associated with the extraction of sand and gravel from the White Drini floodplain, which degraded the waterway, whereas the process was later considered illegal by the Ministry of Environment.

Tab. 3 Changes over the years in main categories of Land Cover classes

Land Cover Category (ha)	Year			Changes 2000-2018 (%)
	2000	2006	2018	
Artificial surfaces	176.8	515.4	696.8	294.1
Agricultural areas	10,696.7	10,239.8	9,220.4	-13.8
Forest and semi-natural areas	19,968.5	19,791.8	20,924.9	4.8
Wetlands	-	295.2	-	-
Water bodies	97.6	97.6	97.5	-0.1

Source: calculated by authors

Changes in artificial surfaces

All types of artificial surfaces in 2018 experienced an increase compared to the year 2000. Artificial surfaces in the Hasi region appear as discontinuous urban fabric and industrial or commercial units. Discontinuous urban fabric is associated with built-up areas or impervious surfaces. In 2000, there were 176.8 ha or 0.6 % of the total area, but in 2018, they experienced an increase of 293 %, being the class with the most changes during the analyzed timespan. From 2000 to 2018, the discontinuous urban fabric was changed at an annual rate of 28.8 ha. Industrial and commercial units are primarily associated with small enterprises or services, mostly found on two sides of roads. The changes in artificial surface are done with the rapid extension of settlements, changing the style with big houses and yards. The discontinuous urban fabric was shifted towards land principally occupied by agriculture, with significant areas of natural vegetation in 2006 with 270.8 ha and another 56.5 ha, toward complex cultivation pattern (80 ha in 2006 and another 113 ha until 2018), non-irrigated arable land with 4.4 ha in 2006 and another 113 ha until 2018, increasing the total areas of artificial surfaces in 2018 to 696.8 ha.

Changes made towards agricultural land puts in danger regional food security, and the situation becomes worse when comparing the agricultural fund of Kosovo, which has less area per capita than the European level.

Changes in agricultural areas

In the past, agriculture was the main economic activity of Kosovo's population; even the Hasi region wasn't well known for it. The presence of a karstic landscape made nearly impossible the development of agriculture. In the White Drini and Erenik Rivers floodplain, the settlements there could get engaged in agriculture. The analysis for the selected years (2000 and 2018) shows that agricultural land

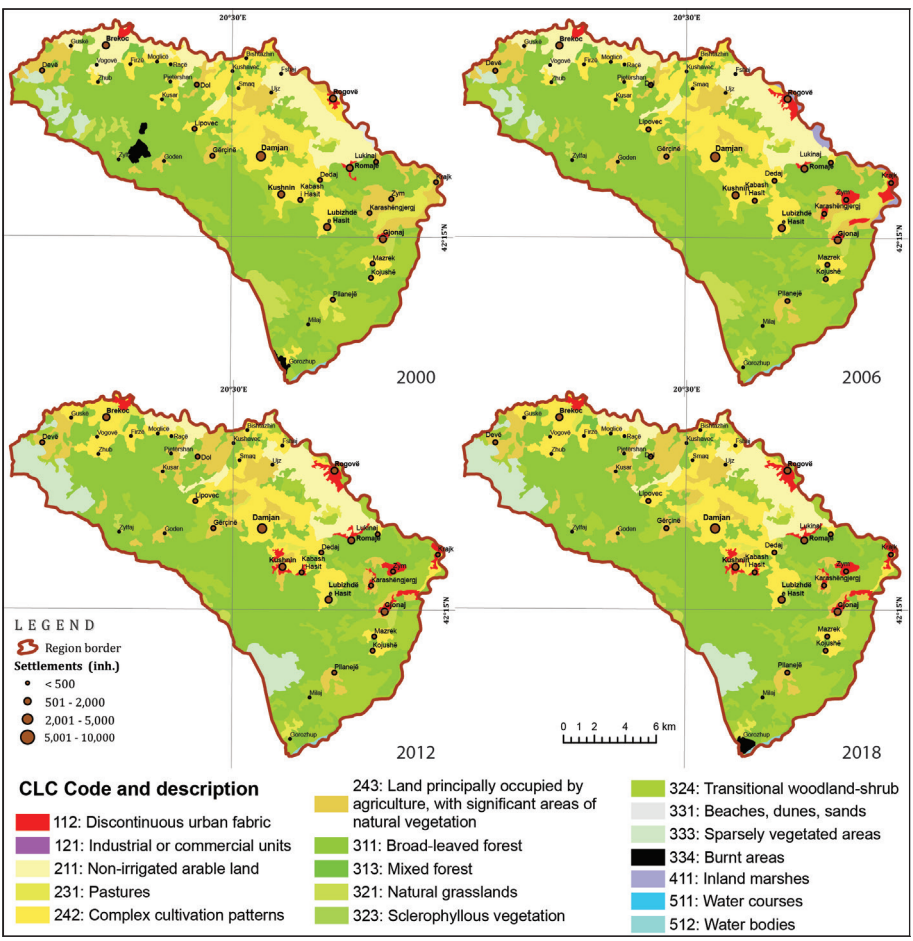

Fig. 3 Mapping changes over the year 2000-2018 in Hasi region
Source: compiled by authors

experienced a decrease of 13.8 %, or in absolute values from 10,696 ha (2000) to 9,220 ha (2018), or an annual change of 82 ha. The flow of changes from agricultural land for 18 years shows different patterns. Changes between 2000 and 2006 were very different. Complex cultivation patterns were shifted towards discontinuous urban fabric (80 ha), non-irrigated arable land (64 ha), and pastures (70 ha). In contrast, land principally occupied by agriculture, with significant areas of natural vegetation, was mostly shifted toward discontinuous urban fabric (270 ha), complex cultivation patterns (63 ha), and non-irrigated arable land (16 ha). However, there was a natural succession, converting them to broad-leaved forests (7 ha) (Fig 3 & 4; Tab 4).

Massive change happened between 2006 and 2018, where complex cultivation pattern changed to discontinuous urban fabric (113 ha), non-irrigated arable land (68 ha), pastures (67), land principally occupied by agriculture, with significant areas of natural vegetation (758), and the others to natural vegetation: broad-leaved forest (60 ha), natural grasslands (113 ha) and transitional woodland-shrubs (75 ha). During the last years, the region has experienced migrations, and the land hasn't been a priority for production.

Land principally occupied by agriculture, with significant areas of natural vegetation, was transformed to discontinuous urban fabric (56 ha), complex cultivation pattern (28 ha), and to other natural vegetation: broad-leaved forest (127 ha), natural grasslands (7 ha), transitional woodland-shrub (265 ha) and sparsely vegetated areas (93) (Fig 3 & 4; Tab 4).

Changes in forests and semi-natural areas

The region is well known for the existence of extensive amounts of forest and semi-natural areas, which are a consequence of natural conditions. In 2000, the area covered by this category was 64.5 % of the region's total area. Most appeared types of forests and semi-natural areas are broad-leaved forests (13,551 ha), transitional woodland-shrub (4,594 ha), natural grasslands (890 ha), sparsely vegetated areas (538 ha), and mixed forest (77 ha). Other categories of semi-natural areas were beaches, dunes, and sands (101 ha), which were a result of sand and gravel extraction from the floodplain of Drini i Bardhë (White Drin River), which resulted from construction works done after the war in Kosovo (1999), and the need for construction materials was immense.

Broad-leaved forests, the most extensive type of forests, and semi-natural areas have experienced changes. During the years 2000-2006, broad-leaved forests were changed to discontinuous urban fabric (0.2 ha), non-irrigated arable land (34 ha), natural grasslands (5 ha), and transitional woodland-shrub (6 ha). As a widespread category, they have gained areas from discontinuous urban fabric (13 ha), natural

Tab. 4 Cross-tabular data of Land Cover changes in the analyzed period

CLC Code		2018																
		112	121	211	231	242	243	311	313	321	323	324	331	333	334	511	512	Total
2000	112	157.9		0.1	0.6	2.5	0.0	15.7				0.0						176.8
	121																	
	211	75.6	1.1	1,929.9	178.1	755.2	54.0	20.2	0.0	0.0		104.1						3,117.7
	231	2.0		5.8	85.3	6.7	160.1	1.0				411.9						672.6
	242	199.0		110.0	138.0	3,101.5	758.5	59.4	0.0	113.5		80.7			0.0			4,559.8
	243	250.4		4.5	0.0	121.1	1,299.1	153.8		7.2		417.4		93.7	0.0		0.0	2,346.7
	311	4.1		55.7	0.0	117.0	168.4	12,742.7		24.2	0.0	192.0		221.4	27.6		0.0	13,551.0
	313			0.0	0.0	0.0			77.0									77.0
	321	0.0		0.0		0.0	46.4	109.9		182.8	0.0	25.2		526.3				890.4
	323							0.2		0.0	0.3	0.0		0.0				0.5
	324	5.7		14.4	0.0	19.6	70.3	728.1		0.0		3,229.9		486.2	40.9	0.0	0.0	4,594.4
	331	1.2		0.0								100.5						101.7
	333						3.4	12.9		0.1		10.0		512.5				538.8
	334				15.8			29.1				152.3			17.7			214.7
	511							0.0				0.0				25.9	0.0	25.9
	512							0.0				0.0			0.0		71.7	71.7
	Total	695.7	1.1	2,120.1	417.8	4,122.9	2,559.6	13,870.8	77.0	327.7	0.3	4,723.2	0.0	1,839.8	86.2	25.9	71.7	30,939.7

Explanation: 112 - Discontinuous urban fabric; 121 - Industrial and commercial unit; 211 - Non-irrigated arable land; 231 - Pastures; 242 - Complex cultivation patterns; 243 - Land principally occupied by agriculture; with significant areas of natural vegetation; 311 - Broad-leaved forest; 313 - Mixed forest; 321 - Natural grasslands; 323 - Sclerophyllous vegetation; 324 - Transitional woodland-shrub; 331 - Beaches; dunes; sands; 333 - Sparsely vegetated areas; 334 - Burnt areas; 511 - Water courses; 512 - Water bodies

Source: calculated by authors

grasslands (51 ha), sparsely vegetated areas (28 ha), land principally occupied by agriculture (7 ha), and other small areas. Settlements located on the southern slopes of the Pashtrik Mt. were nearly abandoned, and broad-leaved forests were spread there. Between the years 2006 and 2018, broad-leaved forests experienced loss to discontinuous urban fabric (4 ha), non-irrigated arable land (22 ha), complex cultivation patterns (117 ha), land principally occupied by agriculture, with significant areas of natural vegetation (168 ha), natural grasslands (25 ha), transitional woodland-shrubs (187 ha), sparsely vegetated areas (249 ha), and by burning were lost 27 ha (Fig 3 & 4; Tab 4).

Other landscapes transformed into broad-leaved forests between 2006 and 2018, which marked a gain in the category. The gain was made from transitional woodland-shrub (740 ha), land principally occupied by agriculture, with significant areas of natural vegetation (128 ha), complex cultivation patterns (60 ha), transitional woodland-shrub (59 ha), inland marshes (33 ha) natural grasslands (17 ha), sparsely vegetated areas (12 ha) and others in small scale less than 10 ha (Tab. 4).

Natural grassland was another category of forests and semi-natural areas that experienced changes during the analyzed period. Between 2000 and 2006, losses were made towards land principally occupied by agriculture, with significant areas of natural vegetation (50 ha), broad-leaved forest (51 ha), and transitional woodland shrubs (68 ha). However, they gained a small area from broad-leaved forests (5 ha). During the second period of our analysis (2006-2018), changes occurred in both directions regarding gaining and losing. Loses were towards broad-leaved forests (17 ha) and more into sparsely vegetated areas (526 ha). The gain was mostly from complex cultivation patterns (113 ha), broad-leaved forests (25 ha), and land principally occupied by agriculture, with significant areas of natural vegetation (7 ha), a process which shows changes by natural succession.

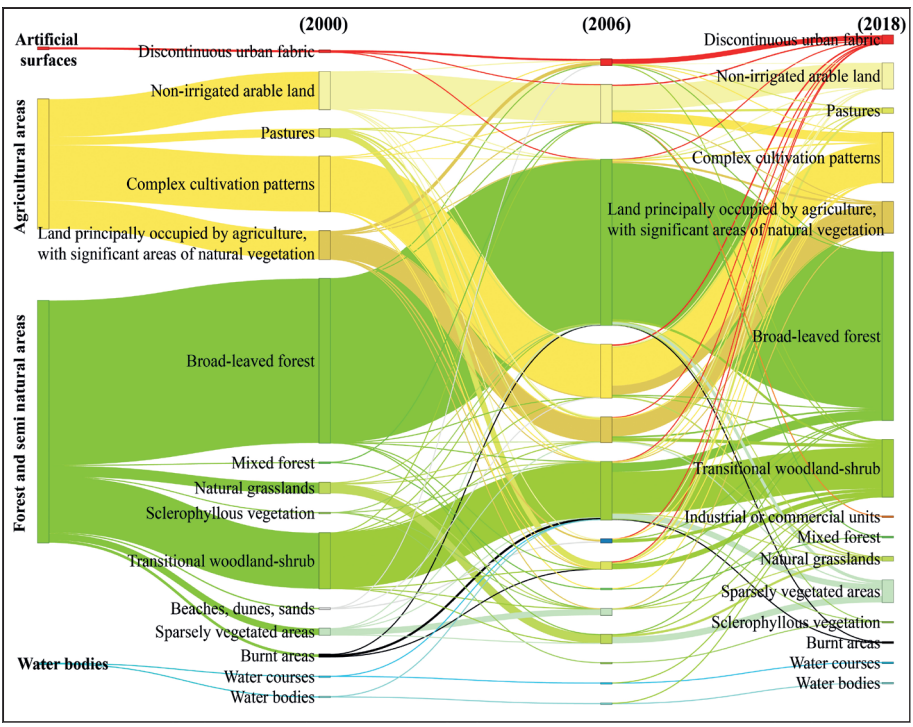

Fig. 4 Land Cover classes magnitude and their flow throughout the years in the Hasi region
Source: compiled by authors

Transitional woodland-shrubs were another category of Land Cover that experienced a transformation by losing or gaining area. Between 2000-2006, losses were found towards broad-leaved forests (33 ha) and sparse vegetation (26 ha), while gains were made from natural grasslands (68 ha) and from burnt areas (170 ha) as part of secondary succession. Between 2006 and 2018, transitional woodland-shrubs were transformed toward discontinuous urban fabric (5 ha), non-irrigated arable land (14 ha), complex cultivation pattern (19 ha), broad-leaved forest (739 ha), sparsely vegetated areas (467 ha) and burnt areas (58 ha). Gaining were made from discontinuous urban fabric (38 ha), non-irrigated arable land (62 ha), pastures (411 ha), complex cultivation pattern (75 ha), land principally occupied by agriculture, with significant areas of natural vegetation (265 ha), broad-leaved forest (187 ha), inland marshes (256 ha) (Fig 4; Tab 4). A main driving force for this landscape transformation is the settlements' future. In the settlements, which experienced an increase in the population where the socio-economic perspective is still alive, changes were made towards discontinuous urban fabric, while in near settlements areas which are experiencing a depopulation, changes were made towards natural landscapes (Fig 3 & 4; Tab 4).

Tab. 5 Changes over the years in main categories of Land Cover classes (%)

Land Cover Category (%)	Year			Changes 2000-2018 (%)
	2000	2006	2018	
Artificial surfaces	0.6 %	1.7 %	2.3 %	+294.1 %
Agricultural areas	34.6 %	33.1 %	29.8 %	-13.8 %
Forest and semi-natural areas	64.5 %	64.0 %	67.6 %	4.8 %
Wetlands	0.0 %	1.0 %	0.0 %	-
Water bodies	0.3 %	0.3 %	0.3 %	-0.1 %

Source: calculated by authors

Throughout the years, in the floodplains of White Drini and Erenik rivers, were created inland marshes as a specific category of Corine Land Cover, initiated by human activities in terms of sand and gravel extraction, which resulted in river bed and bank erosion, with high environmental impact. The extraction was made firstly after the war in Kosovo (1999) as construction material, and later the consequences were evident, mostly in flood with material damages. Due to big changes in floodplains, sand and gravel extraction was prohibited (Law No. 04/L-147 on Waters of Kosovo, 2013), in which the ecological stability of rivers could be preserved.

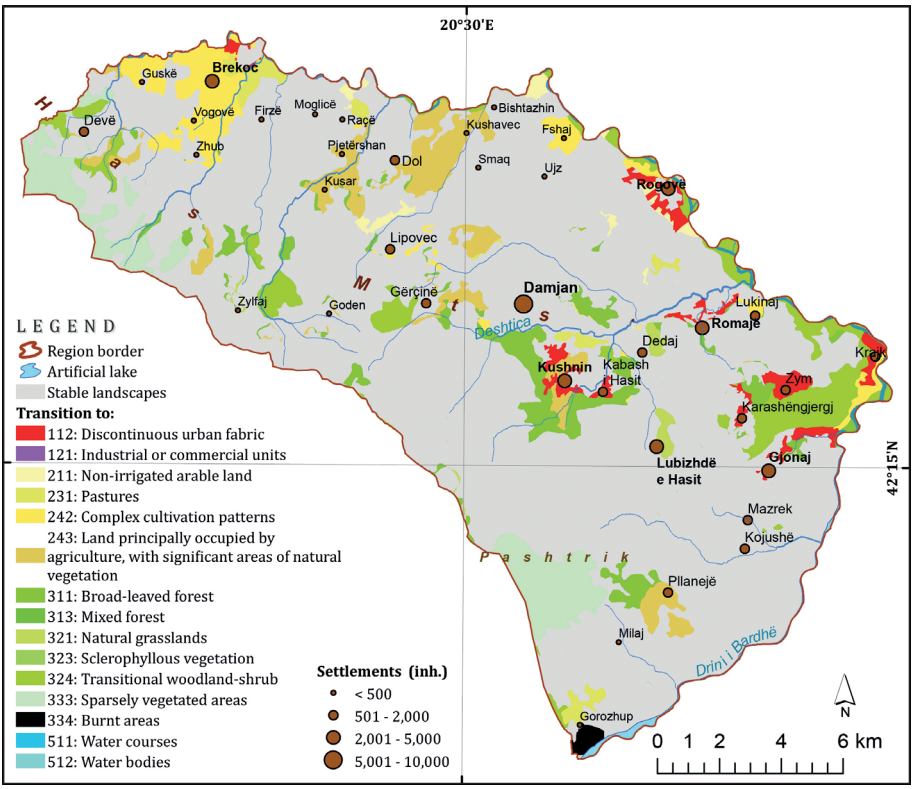

Fig. 5 Transition map of Land Cover changes from the year 2000 to 2018
Source: compiled by authors

CONCLUSIONS

Landscape transformations are changes that appear in all regions around the world. Their magnitude and flow show human activities towards landscapes, but also the development of natural process conditioned by natural factors. The Hasi region is distinguished by its landscape formed in ultramafic rocks, limestone, and loose sediments distinguished by their land cover. In last two decades, human activities as the main driving forces in landscape transformation have changed the land cover, mostly by decreasing agricultural land and shifting towards discontinuous urban fabric resulting from rapid urbanization.

With the GIS approach and statistical methods, it was possible to detect changes in terms of landscape transformation towards natural landscapes and artificial ones. At the same time, the Sankey diagram was used to show the magnitude and flow changes. Mapping the changes indicates the main driving forces in the natural landscape and artificial areas changes over the years, while visualization helped compare the flow of the changes. According to the analysis, artificial surfaces

in Hasi region were increased, mostly shifting towards broad-leaved forests (250 ha), land principally occupied by agriculture (199 ha), pastures (75 ha), etc., while losing 18.9 ha towards broad-leaved forests (15.7 ha), complex cultivation pattern (2.5 ha), etc. Gaining the new areas was made by rapid urbanization in settlements with better perspective while losing was done towards abandoned ones. Changes are occurring mostly in horizontal way built-up areas extension, where zoning maps are not applied. Agricultural land covered 34.6 % of the total area in 2000, which was mostly located in the northern part of the region, in the floodplain of White Drini and Erenik river. The region is well known for its karstic landscape, which indicated main economic activities of the population. In the last two decades, changes also happened to agricultural land, mostly decreasing their areas, and now they cover 29.8 %. Small areas were transformed into agricultural land, primarily from transitional woodland-shrubs. However, the reduction of their areas was towards discontinuous urban fabric. Forests and semi-natural areas have changed too, which is sometimes seen as a process of natural succession. Sparsely vegetated areas and broad-leaved forests were the most gaining area type. At the same time, transitional woodland-shrubs were the category that experienced a transition towards gaining and losing to other categories.

The study reveals that population is the main driving force in changing the landscapes in low areas where most of the settlements are located, where changes were made towards agricultural land, while, in settlements without perspective, changes were going towards natural landscapes.

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