LAND COVER AND LAND USE CHANGE IN KARST REGION
DEVETASHKO PLATEAU

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Abstract
The data of Corine, land cover (CLC) are digital data about land cover which is distributed into 44 classes, whereas for the territory off Bulgaria, the classes are 36. The minimal mappable unit is 25 hectares (for 2D objects and 100 m for linear objects). Data sets for the years 1990, 2000, 2006, 2012, and 2018 are available, as well as for the changes which have occurred between each couple of years (1990-2000, 2000-2006, 2006-2012, and 2012-2018). The great data sets provide to track over a nearly 30-year period of land cover changes in model karst regions which are strongly vulnerable to anthropogenic and natural influences.

This paper considers the changes in the land cover types on the Devetashko plateau – a typical karst plateau in North Bulgaria. Land cover and land use changes affect directly the processes of modern karst-genesis, the soil-vegetation cover, the quantity and quality of underground karst waters.

Introduction
Karst is a widely spread natural phenomenon with which the lives of millions people are directly or indirectly related [Ford & Williams, 2007]. Karst territories are made of karst geosystems which are characterized by the fact that they consist of clearly expressed underground (caves) and above-ground part which are closely related genetically and dynamically [Andrejczuk & Stefanov, 2016, 2017]. Karst geosystems feature high vulnerability and enhanced risk of influences, especially against the background of the increasingly expanding global changes. In Bulgaria, karst territories comprise ¼ of its area [Popov, 1970] and form specific living and economic activity environment for the people who must take into account its peculiarities on a daily basis. And this puts forward on the agenda the urgent need of good knowledge of and compliance with karst specifics. This is the only way to
achieve sustainable development of karst territories and to resolve successfully the topical social and economic problems during their handling and management.

The active processes occurring on a global and European scale since the end of the 20th century affect the social and economic development of Bulgaria, as well. After 1989, a number of structural (with respect to ownership and production), technological and organizational reforms are ongoing, which affect all spheres of economic activity: industry, agriculture, services. After the passing of the Restoration of Land Ownership Act (1991) and with the start of the reform in 1992, minor owners and unemployed became predominant in the field of agriculture (as a result of the destroyal of the production structures existing before). The new users of the former publicly owned land became the owners of agricultural land, the tenants, the hired workforce, the self-employed people, i.e. differentiation of economic interests occurred. Subsequently, the access to European subsidies from the pre-accession funds and mostly, from the structural European funds in the field of agriculture, resulted in new changes in the use of agricultural land and the grown agricultural crops. These changes affect especially strongly the vulnerable karst territories. Changes in the development of agriculture and cattle breeding occurred also after the adoption of Natura 2000 and the application of the relevant environmental protection law.

Changes are also observed in the use of building material quarries which are typical for karst territories. Some of the quarries are abandoned, but others are let on concession. New quarries are also developed.

The sequence of changes in land use affects strongly the fragile balance in karst geosystems. The role of anthropogenic pressure is of various nature. For instance, incorrect agricultural practices in karst territories result in accelerated erosion and pollution of underground karst waters. This requires prevention and undertaking of urgent measures for sustainable development of karst territories. These are also indispensable on account of the depopulation of karst regions which makes them socially unstable. At the same time, during the recent years, external users (tenants) are widely applying deep ploughing with heavy machines of the arable lands, including the lands that were neglected during the transition. The economic objectives of these land users are not always related with the ecological standards imposed by the karst specifics of the regions [Zapletalova, et al., 2016]. The consequences of the increasingly active manifestations of global climatic changes and the increasing number of extreme climatic events, especially torrential rains and quick snow melting, are not accounted for, either. On the karst terrains with shallow soils and a number of whirlpools and pot-holes, they cause accelerated erosion, especially of the arable lands. This results in import and deposition of great quantities of solid (clayish) deposits in the underground cave systems (Fig. 3).

During the recent years, karst territories with their attractive forms are becoming an object of increasing interest for tourists and are turning into sports and leisure sites. [Костова Б. и др., 2013; Костова Б., Р. Берберова, 2016; Костова Б.,
Р. Берберова, 2017; Костова Б. и др., 2018]. They attract both organized, as well as unorganized tourists. Regretfully, tourist infrastructure in karst terrains is insignificant or badly designed and built, including the ecopaths to popular karst objects. These pose a number of risks for visiting tourists, with one lethal accident already recorded (Krushunska ecopath). The major reason is that the available ecopaths lack clear status and their handling and maintenance is not regulated by law. No control on the visits is exercised, including along the ecopaths in protected karst territories. This has often negative effect on karst objects, incl. pollution, knocking-off, scratching. But karst territories will continue to be attractive tourist destinations with positive regional and local economic effect. The latter, however, is still weak because of the insufficient experience of local communities in tourist industry, on the one hand, and on the other hand – their insufficient knowledge of karst specifics.

All this requires, especially at managerial level, better understanding of the relations between the major activities in karst terrains, such as agriculture, mining, forestry, tourism and more. The long–term and short term effect which these activities might have and have on karst environment and karst heritage should be also accounted for. It is also important to observe the changes in agriculture and to assess and forecast the consequences thereof in view of rational management and minimizing the negative effects on biodiversity, health, and life of the population. In this relation, land cover changes are an important information source [Z. Fan et al., 2015]. Within the earth surface monitoring service of the EU Copernicus Programme and under the guidance of the European Environment Agency under the Corine, land cover (CLC) Project, the vector layers with the land cover types and their change with time are maintained and updated on a regular basis [В. Димитров и др. 2019]. The major thesis of this publication is to determine the extent to which this information may be useful to analyse the changes in land use in a typical karst region. It aims to track the land cover changes on the Devetashko plateau in Northern Bulgaria which is a model region for multi-annual studies by the Experimental Laboratory of Karst Studies of the National Institute of Geophysics, Geodesy and Geography of the Bulgarian Academy of Sciences (NIGGG – BAS).

**Materials and Methods**

Using geographic information systems (GIS), the spatial distribution and quantitative characteristics of the land cover and land use (LCLU) classes of the Devetashko plateau are analysed.

During the conduct of this study, a GIS data base was composed (KARST.gdb), with a set of vector and raster layers containing: administrative
boundaries (of districts, municipalities, lands/settlements’ land-use areas (SLUAs)\(^1\), populated places and state boundary), water objects (lakes, dams, and river network), contour of the model regions, protected territories under Natura 2000 (according to the Directive on birds, Directive on habitats), Corine, land cover (CLC) under the Copernicus Programme, containing vector layers for 1990, 2000, 2006, 2012, 2018, and the change of land cover (Corine, Land Cover Change, LCC) over the subperiods: 1990–2000, 2000–2006, 2006–2012, 2012–2018, digital elevation model (altitude belts) – ASTER Global Digital Elevation Model (GDEM) with spatial resolution of 30 m.

Table 2. Nomenclature „Corine, land cover“, Level 1÷3, Fig. 2÷5.

| Level 1       | Level 2                          | Level 3                                                                 |
|---------------|----------------------------------|------------------------------------------------------------------------|
| 1 Artifical   | 11 Urban fabric                 | 112 Discontinuous urban fabric                                        |
| surfaces      | 12 Industrial, commercial and    | 121 Industrial or commercial units                                    |
|               | transport units                  |                                                                         |
|               | 13 Mine, dump and construction   | 131 Mineral extraction sites                                           |
|               | sites                            |                                                                         |
| 2 Agricultural| 21 Arable land                   | 211 Non-irrigated arable land                                         |
| areas         | 22 Permanent crops              | 221 Vineyards                                                          |
|               | 23 Pastures                      | 222 Fruit trees and berry plantations                                 |
|               | 24 Heterogeneous agricultural    | 231 Pastures                                                          |
|               | areas                            | 242 Complex cultivation patterns                                      |
|               |                                  | 243 Land principally occupied by agriculture, with significant areas of |
|               |                                  | natural vegetation                                                   |
| 3 Forest and  | 31 Forests                      | 311 Broad-leaved forest                                               |
| semi natural  |                                  | 312 Coniferous forest                                                 |
| areas         |                                  | 313 Mixed forest                                                      |
|               | 32 Scrub and/or herbaceous       | 321 Natural grasslands                                                |
|               | vegetation associations          | 324 Transitional woodland-shrub                                       |
|               | 33 Open spaces with little or no | 332 Bare rocks                                                        |
|               | vegetation                      |                                                                         |
| 5 Water       | 51 Inland waters                 | 512 Water bodies                                                      |
| bodies        |                                  |                                                                         |

Source: I.I., Elaboration: Georgi Jelev

\(^1\)The totality of the land properties belonging to a given settlement (i.e. the land properties both in the settlement and in the settlement’s adjacent territory).
The methods of spatial analysis and statistics in the medium of a geographic information system (GIS) were used. The data were processed within the boundaries of the Devetashko plateau and were matched at SLUAs level. The data were organized in a Pivot table and the spatial relationships between the land cover/land use types and their change over the period 1990–2018 were studied. The period after 1990 was studied when the change of ownership and the restitution of agricultural land caused exceptionally serious changes in the organization of agriculture, too.

The spatial distribution and the quantitative characteristics of the presented land cover and land use classes were analysed at two levels: for the entire region of the Devetashko plateau and for groups of lands/SLUAs, falling within parts of municipalities which are included within the plateau’s boundaries. The analyses were made at level 1 and level 3 of Corine, land cover. Comparative analysis was also used. The transition from one land cover class to another over subperiods was also tracked.

**Devetashko Karst Plateau**

The Devetashko plateau (343,08 km²) is located between the valleys of the rivers Rositsa and Osam in the southern periphery of the Danube (Moesian) plane in Bulgaria. Its northern foot features altitude of 100–150 m a.s.l. and are outlined by a clearly expressed fault area in the relief, and its southern foot features altitude of 350–400 m a.s.l. and is not expressed clearly. The plateau-shaped ridge part varies between 350 and 450 m a.s.l. and is inclined to the north. The highest point of the plateau is the Chukata peak (558 m).

The Devetashko plateau is composed mainly of organogenic limes of Lower Cretaceous age (Apt-Urgon). They make up subhorizontal layers with slight inclination to the north. The prevailing development of limes is the reason for which, on the plateau, classical karst of autochthonous type has developed [after Л. Якуч, 1979], without permanently running river waters. In the relief, morphologic karst complexes of classical forms – surface and underground, dominate, with prevailing whirlpools and hollows, their total number being several thousand. They are elements of well differentiated karst geosystems whose exits are mostly on the northern slopes and the foot of the Plateau, which are marked by high-capacity karst springs and large entrances of spring caves. One of the most typical karst geosystems is the Kurshunska one (43 km², located in the eastern part of the plateau), which since 1990 has been the model karst region of the Experimental Laboratory of Karst Studies of the NIGGG–BAS (Fig. 3).

Many of the plateau’s pot-holes have been reshaped into precipices and precipice caves. Another part of the pot-holes have been tamponed (incl. by humans), with karst lakes and bogs formed around – one of the most typical in Bulgaria [Петров, П., 1933; Попов и др., 1965].
On the Devetashko plateau, 68 karst caves with total length of about 18 km have been studied. The longest one is the water Boninska cave (Popova cave) by the Krushuna village – 4530 m, which is connected with the spring cave Vodopada (1995 m) – one of the longest studied water cave systems in Bulgaria (above 6.5 km). Some of the caves on the plateau are former objects of economic activity (the Chavdarska cave/Mandrata and the Devetashka cave – a former object of the army) or have been used for water supply. As tourism in the Devetashko plateau became more popular, 7 caves are already objects of non-regulated tourist activity. The most frequently visited one is the Devetashka cave where the greatest cave hall in Bulgaria has formed.
The climate of the Devetashko plateau is moderately continental, with average annual temperature about 10.5°C. In winter, the plateau-shaped part features temperature which is by about 2°C higher than the temperature of the north foot. During the recent years, abrupt heatings have been observed even in February, which cause quick snow melting in the ridge parts (Fig. 3). The average annual amount of precipitation is between 650 and 700 mm, with spring-to-summer maximum (May–June). About 33% of the precipitation form underground water outflow which is a typically karst one. The biggest karst springs are concentrated in the northern periphery of the plateau (near-fault drainage system). Their waters are fresh, hydrocarbon-calcium. A typical feature of the underground karst waters is their strong vulnerability to pollution. Its sources are the non-regulated landfills in the widely spread whirlpools with active pot-holes, as well as the continuous anthropogenic loading (mainly agricultural) on the plateau’s territory. The settlements located on the plateau lack sewerage systems and waste water is not treated. Therefore, the abounding underground karst waters on the plateau are strongly polluted and the greatest part of them is not potable.

![Fig. 3. Active mechanical denudation in the Krushuna karst geosystem in the Devetashko plateau resulting from intensive snow melting (February, 2012) (archive of the Experimental Laboratory of Karst Studies of the NIGGG–BAS, Drawn by P. Stefanov)](image)

The soil cover of the plateau is made of typical-for-Bulgarian-karst soil types [Нинов, 2002], with prevailing luvisols (LV), rendzik, (LPk), and dystric (CLd) soils, developed in the foot of the Plateau and in the uvalas, hollows, and whirlpools.
Albeit the karst terrain, the slightly sloped ridge parts are covered with thick soil layer (mostly luvisols) where traditional agriculture is developing. The eroded arable lands and the slopes of the negative karst forms with karren fields are used as pastures. Cattle breeding in the Devetashko plateau has deep historical roots and with it, the artificial tamponing of whirlpools’ pot-holes in which karst bogs and lakes where cattle drinks water have formed, is related. Calcic (GLk) soils have also formed there. During the dating of the depositions in Irmanov gyol, located westward of Gorno Slivovo village, it was established that the age of the bog is about 3 centuries [Svetlik et al., 2005]. The results from the palinologic studies show that grass vegetation with rich diversity of ruderal and anthropophyte types was dominating. They evidence of active anthropopressure – the paleoecological circumstances have been favourable for development of agriculture and cattle breeding in the region.

The prevailing natural vegetation on the Devetashko plateau is broad-leaved, mostly oak and Carpinus orientalis. There are some limited areas which have been artificially planted with coniferous forests. Part of the plateau’s territory has been included in the ecological network Natura 2000. Two natural landmarks and six protected countrysides with area of 55,64 ha have been announced.

The arable land which occupies a great percent of the plateau’s ridge part is attacked by accelerated erosion during torrential rains and especially, during active snow melting, when arable lands are most vulnerable to erosion. And it is particularly active in the ploughed periphery of the whirlpools and hollows into which the generated snow water flows out. The ploughing applied by the tenants does not comply with the specifics of the karst relief and is carried out up to the edge of the whirlpools and hollows falling within the boundaries of the rented land. As a result, part of the soil is carried away through the underground karst systems and the springs that drain them. A typical example is the Krushunska karst geosystem (Fig. 3). During the observed active snow melting in February 2012, within 24 hours only, about 100 tons of deposits (mostly at the expense of eroded ploughed soils) were carried away through the Vodopada karst spring, whereas 10 tons of them were deposited along the Krushunska travertine cascade proclaimed as natural landmark under the name „Maarata”.

The area of the Devetashko plateau includes, in whole or in part, 20 lands pertaining to five municipalities and three administrative regions (Fig. 4). On the territory of the Devetashko plateau and along its periphery, 15 settlements are located2 (Fig. 4). The administrative partitioning of the Devetashko plateau poses significant risks for its management from the viewpoint of sustainable development. The reason for this lies in the lack of integrated regional and sector policies, incl. in

2The settlements located on the other five lands included in the Devetashko plateau are at a great distance from the plateau and their population has not been included in the population of the plateau. The tendencies with them are the same.
the field of agriculture, tourism, and other activities exercised on the plateau’s territory.

The population of the Devetashko plateau amounts to 5,858 (2018). Over the period 1990–2018, the region has lost 45.50% of its population. (Fig. 5). Ageing and depopulation are typical demographic processes of the plateau which account for the old residential buildings, some of which have been abandoned and are crumbling down.

The economically active population is less than one third of the overall active population. In some of the villages (Tepava, Devetaki, Brestovo, Gostinya and more), the economically inactive population exceeds 90%.

**Fig. 4. Territorial and administrative location of the Devetashko plateau.**
*Drawn by Georgi Jelev*

**Fig. 5. Movement of the population by settlements on the territory of the Devetashko plateau over the period 1990–2018.**
*Source: NSI – Bulgaria, Elaboration: D. Stefanova*
On the territory of the Devetashko plateau, there are no industrial enterprises. Agriculture is the main developing economic activity which is exercised by tenant farmers and, to a lesser degree, by local users of agricultural land. EU subsidies for direct payments stimulate the farmers to increase the area of the used agricultural land (UAL). Active activity is ongoing, aimed at changing the manner of the agricultural land’s lasting use – more areas with cereals and less with orchards compared to the period up to 1989. The widest grown cereals are wheat and barley; in the gardens, they plant maize, sunflower, as well as plums, cherries, and peaches. Vines are traditionally typical for Suhindol and, to a lesser degree, for Krushuna. Because of the established system of middlemen of forest fruits, the growing of strawberries, raspberries, and blackberries is increasing steadily. A tendency for restoration of the old orchards is also observed, due to the possibility to obtain additional agroecological payments [Zapletalova, et al., 2016].

Cattle breeding is related mostly with the growing of cows, sheep, and goats, using the pastures in the karst terrains. It pertains to the small, mostly family sector which provides no conditions to breed a large number of animals.

On the forest territory, apart from logging, a number of auxiliary uses are available – pasture of large and small cattle, collecting of hay from the bare areas, collection of leaf fodder. Herbs, forest fruits, mushrooms and nuts are also collected.

The Devetashko plateau provides possibilities for development of various forms of sport and tourism: ecotourism, educational tourism, and cultural tourism. Karst objects – caves and waterfalls, are very attractive. Because of the low economical level of the settlements located on the Devetashko plateau and along its periphery, tourism in karst terrains is a good prospect for improving the life quality of the local communities. From this point of view, it is also possible to establish leisure and recreation territories.

The active social and economical changes in the Devetashko Plateau have been also reflected as land cover and land use changes which, because of the specific karst territory, require analysis in the three aspects – economical, social, and ecological.

**Results and Discussions**

**Overall review of Corine, land cover and land use on the territory of the Devetashko plateau**

On the territory of the Devetashko plateau, four land cover and land use classes have been observed after the CORINE nomenclature, level 1: artificial surfaces (1\(^3\)), agricultural areas (2), forest and semi natural areas (3), and water bodies (5) over the whole observation period, 1990–2018 (Fig. 6). Of them, *Artificial surfaces* (1) feature the greatest area. These account for a little bit less than 60% of

\(^{3}\text{Code after the Corine, land cover nomenclature (Table 2)}\)
the plateau’s area. Over the whole period their share has been declining within the range 59.29% – 58.76%, i.e. a tendency for minor decrease by 0.53% is available. On the contrary, with Forest and semi natural areas (3), which come second by area, a tendency for minor increase from 37.11% to 38.33% is observed. Ranking third by their share presentation are Artificial surfaces (1). With this class, the tendency is for slight decrease, which starts from 2006, their share being preserved during the reporting years afterwards. Artificial surfaces (1) are mostly formed by class Discontinuous urban fabric (112) and, to an insignificant degree – by Industrial or commercial units (121) and Mineral extraction sites (131), (Fig. 6, Fig. 7). The identified change the identified change is mostly due to the depopulation of the Devetashko plateau and the scrambling down of the abandoned anthropogenic infrastructure. The share of Water bodies (5) is less than one percent.

![Fig. 6. Distribution and dynamics of Corine, land cover level 1 on the territory of the Devetashko plateau](image)

Source: [I.1.], Elaboration: D. Stefanova, G. Jelev

The analysis of Corine, land cover level 1 demonstrates insignificant dynamics of the major four classes identified on the plateau. This means that it is mandatory to track the changes at lower levels so as to not ignore changes with effects of significance for the karst territory.

On the territory of the Devetashko plateau, four classes of Corine, land cover and land use level 3 are observed (Fig. 7, Fig. 8). They are included in the above-mentioned classes at level 3 and are tracked for the years 1990, 2000, 2006, 2012, and 2018. The review at this level reveals in greater details the change, which is important to observe when accounting for potential negative impacts.
Fig. 7. Distribution and dynamics of Corine, land cover level 3 on the territory of the Devetashko plateau
Source: [I.1.], Elaboration: D. Stefanova, G. Jelev

During the five observed years, Non-irrigated arable land (211) features greatest shares (above 33%) of the plateau’s territory. Irrespective of preserving its greatest shares with respect to the other classes, a tendency for declining by less than 3% during the last year (2018 – 33.90%) compared to the first year (1990 – 36.78%) (Fig. 7) is observed. Second come Broad-leaved forests (311) which drop from 23.13% (1990) to 21.94% (2018) (Fig. 7). As of 2018, these two classes of Corine, land cover level 3 occupy a bit more than half of the territory of the plateau which makes them exceptionally important from the viewpoint of impact on the karst. Ranking third is the share of Transitional woodland-shrub (324) whereas, during the years, a lasting tendency for the shares’ increase from 12.23% to 13.81% (Fig. 7) is observed. Featuring shares close to class (324) is class Land principally occupied by agriculture which ranks third, with significant areas of Natural vegetation (243). It increases from 10.23% (1990) to 12.37% (2006, 2012), after which it decreases to 11.39% (2018) (Fig. 7).

The shares of class Pastures (231) are also significant, which change over the years within the range 7–9% (Fig. 7). Their change is closely related with the development of cattle breeding on the territory of the plateau which, after 1989, was strongly affected by the social and economic changes in the country and, more specifically, with those in agriculture. The shares of class Complex cultivation patterns (242) (Fig. 7) also increase, which is related again with the changes in agriculture and the reinstitution of land in actual boundaries to its owners. The other
presented classes (Fig. 7) feature insignificant shares, but irrespective of this, the change therein may also produce some negative impacts on karst.

From the viewpoint of the performed analysis, the changes related with the transition of one class into another in Corine, land cover (Fig. 9), are interesting, as well.

Fig. 8. Territorial distribution of Corine, land cover (CLC) level 3 (classes, Table 1) of the Devetashko plateau Source: Drawn by G. Jelev
The greatest number of changes of one class into another are effected in **subperiod 1990–2000**, predominantly for 7 classes of agricultural areas (2) (Fig. 9, Table 1), logically following the economic changes in the country. A significant share of the changes over this time interval (30,90%) is related with the transition of Non-irrigated arable land (211) into Land principally occupied by agriculture, with significant areas of natural vegetation (243). Other nearly one fourth of the changes are effected by Pastures (231) turning into Non-irrigated arable land (211). Changes from Pastures (231) to Land principally occupied by agriculture, with significant areas of natural vegetation (243) and Transitional woodland-shrub (324) are also observed. On the overall, most strongly affected are Pastures, of which a total of 44,85% have been transformed into other classes over this period. Vineyards (221) and Fruit trees and berry plantations (222) also lose areas, passing to Non-irrigated arable land (211). In conclusion, this subperiod is characterized by exceptionally great dynamics within Agricultural areas (2) (Fig. 9, Table 1).

**During the next subperiod, 2000–2006**, the changes are only in Forest and semi natural areas (3) and they are related with transition of Broad-leaved forest (311) into Transitional woodland-shrub (324) which accounts for 85,90% of the change. The other 24,91% of the changes over the period are in the reverse direction – from (324) to (311) (Fig. 9, Table1).

**During the third subperiod, 2006–2012**, the changes are again in Forest and semi natural areas (3) between classes (311) and (324), but the difference lies
in the fact that now the greater share of the change (80.36%) is oppositely directed, from Transitional woodland-shrub (324) to Broad-leaved forest (311) (Fig. 9, Table 1).

**During the last subperiod, 2012–2018,** the greatest share of the changes (64.26%) comprises three classes of Agricultural areas of Corine, land cover (Fig. 9, Table 1). Most significant are the changes in Pastures (231), the greatest share being occupied by the transition into Non-irrigated arable land (211). The changes in Forest and semi natural areas (3) are also significant. They comprise Broad-leaved forest (311) and Natural grasslands (321). A greater share for the subperiod is characteristic of the transition of Broad-leaved forest (311) into Transitional woodland-shrub (324) – 27.97%.

In relation with the karst plateau, the changes related with the transition of Non-irrigated arable land (211) into Mineral extraction sites (131) deserve particular attention.

**Review of CORINE, land cover and land use by types of SLUAs within the boundaries of municipalities falling within the territory of the Devetashko Plateau**

The Devetashko karst plateau is managed by different municipal administrations (Fig. 4). Because of the specifics of karst geosystems, the handling and use of the land requires integrated management approach. In this sense, the observation of the changes in the land cover/land use types by groups of the SLUAs within the boundaries of the municipalities falling within the territory of the Devetashko plateau provides information which may be used in the development of ecological assessments and policies for local development and planning.

**Lands from the Municipality of Letnitsa (Lovech District)**

The lands of the villages from the Municipality of Letnitsa (Lovech District) which fall within the plateau’s boundaries are located mostly in the planar ridge part (Fig. 4). The SLUAs of Gorsko Slivovo and Karpachevo villages are included in whole, and the land of Krushuna village is included in part. Their total area amounts to 84.53 km² or 24.64% of the plateau’s territory. The population of the three settlements amounts to 934 people (2018). The drop in the population compared to 1990 (2158 people) is 56.72% (Fig. 5). The major economic activities are farming (agriculture and cattle breeding) and tourism.

This part of the plateau houses one of the most typical karst geosystems – the Krushunsko geosystem (area of 43 km²) (Fig. 3). Of the surface karst forms, whirlpools prevail, their number only in this karst geosystem being 379.

Based on the performed analysis, in this group of SLUAs at CORINE level 1, Agricultural areas (about and over 60%), Forest and semi natural areas (about 1/3 of the total area), and with insignificant shares – Artificial surfaces and Water
bodies (Fig. 10a) are identified. The share distribution is preserved until 2000, and since 2006, changes occur in the first three classes at this level. Artificial surfaces have dropped by about 2%. Agricultural areas display a tendency of gradual weak increase during the next years, and Forest and semi natural areas display the opposite tendency – insignificant drop during the next two observed years followed by insignificant increase during the last year, 2018.

![Graph](image)

**Fig. 10. Land cover changes (classes, Table 1) in a group of SLUAs from the Municipality of Letnitsa falling within the territory of the Devetashko plateau (%):**

a) (Level 1); b) (Level 3)

*Source: [I.1.], Elaboration: D. Stefanova, G. Jelev*

At CORINE level 3 on the lands of the Municipality of Letnitsa, changes in the number of the presented classes are observed over the years. For 1990 and 2000 they are 11, in 2006 and 2012 they increase to 12, and in 2018 they are 11 again (Fig. 10b). With respect to the plateau as a whole, on these lands, the classes Coniferous forest (312), Mixed forest (313), and Bare rocks (332) are lacking – all of them pertaining to the Forest and semi natural areas. In the beginning of the period, Fruit trees and berry plantations (222) and Complex cultivation patterns (242) from Agricultural areas are also lacking, which is closely related with the changes in agriculture and their specific impact on these territories. The other absent classes in the end of the period, and more specifically, Industrial or commercial units (121) and Mineral extraction sites (131) refer to Artificial surfaces.

The typical thing about the lands of the Municipality of Letnitsa are the exclusively great shares of Non-irrigated arable land (211), followed by Broad-
leaved forest (311) (Fig. 10b). Transitional woodland-shrub (324), Land principally occupied by agriculture, with significant areas of natural vegetation (243) and Pastures (231) feature approximately equal shares within the limits of up to 12%. Another characteristic is the dynamics of the changes in the shares within Agricultural areas where decrease and increase alternate.

**Lands from the Municipality of Lovech (Lovech District)**

The SLUs from the Municipality of Lovech (Lovech District), which fall within the boundaries of the plateau, include in whole the SLUs of Devetaki and Tepava villages and partially, the lands of another seven villages (Fig. 4). Their total area amounts to 126,93 km², or 37% of the plateau’s area. The population numbers 891 people (2018). The drop of the population compared to 1990 (2072 people) is 57% (Fig. 5). This is the most depopulated part of the plateau. In economic aspect, mainly agriculture and forestry are presented. In the northern part, the Devetashka cave is located which is a landmark and has been turned into tourist attraction.

On the SLUs from this Municipality, in contrast to the Municipality of Letnitsa, relatively close shares of Agricultural areas and Forest and semi natural areas (Fig. 11a) are observed. The changes in both classes at level 1 are insignificant, with alternating drops and increases. Class Water bodies (512) is absent, and class Artificial surfaces retains exclusively low values during the whole observed period.

At CORINE level 3, changes in the number of the presented classes over the years are also observed. For 1990 and 2000 they are 10, and after 2006 they increase to 11 (Fig. 11b). The classes permanently lacking on the plateau as a whole are Mineral extraction sites (131), Coniferous forest (312), Mixed forest (313) and Bare rocks (332), all of them pertaining to Forest and semi natural areas. For the beginning of the period 1990–2000, absence of areas with Fruit trees and berry plantations (222) is identified.

About 50% of the areas are distributed between Non-irrigated arable land (211) and Broad-leaved forest (311), with their values tending to become equal as of the end of the period (Fig. 11b). Agricultural areas are supplemented by Land principally occupied by agriculture, with significant areas of natural vegetation (243) and Pastures (231), with shares of varying dynamics ranking between 6% and 8%. Forest and semi natural areas supplements its shares mainly by Transitional woodland-shrub (324), which feature almost constant values (Fig. 11b). The changes in the classes pertaining to Agricultural areas are more obvious.
Lands from the Municipality of Sevlievo (Gabrovo District)

The SLUAs from the Municipality of Sevlievo (Gabrovo District) which fall within the limits of the plateau include in whole the SLUA of Agatovo village and partially that of Kramolin village (Fig. 4). Their total area amounts to 49,12 km² or 14,32% of the plateau’s area. The population in both settlements numbers 604 people (2018). The drop with respect to 1990 (1398 people) is 56,80% (Fig. 5).

On the SLUAs from the Municipality of Sevlievo, similarly to the Municipality of Letnitsa, at level 1, the shares of Agricultural areas are significantly greater (more than 2 times) then those of Forest and semi natural areas (Fig. 12a). At this CORINE, land cover level, insignificant changes are recorded over the years. The situation at level 3, however, is different. More essential changes take place there in both classes from level 1.

The number of the presented classes also manifests changes and difference with respect to the plateau as a whole. In 1990 and 2000, they are 12, and from 2006 to 2018, the classes are 13 (Fig. 12b). Mineral extraction sites (131) from Artificial surfaces and Coniferous forest (312) and Natural grasslands (321) from Forest and semi natural areas are permanently lacking over the entire period. In the beginning of the period (1990 and 2000), lack of areas of Industrial or commercial units (121) is also identified.

Non-irrigated arable land (211) demonstrates exclusively high shares, retaining relatively close values over the entire period (Fig. 12b). The other classes from level 3 of Agricultural areas which feature significantly lower shares display
varying dynamics. *Broad-leaved forest* (311) is the second ranking land cover, with lasting tendency for dropping down. With *Transitional woodland-shrub* (324), increase is observed after 2000, but on the overall it is exceptionally weak.

Fig. 12. Land cover changes (classes, Table 1) in a group of SLUAs from the Municipality of Sevlievo (Lovech District) falling within the territory of the Devetashko plateau (%): a) (Level 1); b) (Level 3)
Source: [I.1.], Elaboration: D. Stefanova, G. Jelev

**Lands from the Municipality of Pavlikeni (Veliko Tarnovo District)**

The SLUAs from the Municipality of Pavlikeni (Veliko Tarnovo District), which fall within the boundaries of the plateau, include in whole the SLUAs of Dimcha village, and in part – of Varbovka village and the town of Byala Cherkva (Fig. 4). Their total area amounts to 22,83 km² or 6,65% of the plateau’s area. The population of both settlements falling entirely within the plateau’s periphery numbers 1687 people (2018). The drop with respect to 1990 (2034 people) is 17,06% (Fig. 5).

Similarly, with the SLUAs from the Municipality of Pavlikeni, as well as with those from the Municipality of Sevlievo, *Agricultural areas* are over twice greater than *Forest and semi natural areas* (Fig. 13a.). Over the entire observed period, they feature about 66%, whereas the changes during the years are insignificant. During the first four years, *Forest and semi natural areas* retain constant shares of 26,70% and only in 2018, they increase insignificantly to 27,49%.
Fig. 13. Land cover changes (classes, Table 1) in a group of SLUAs from the Municipality of Pavlikeni (Lovech District) falling within the territory of the Devetashko plateau (%): a. (Level 1); b. (Level 3)

Source: [1.1.], Elaboration: D. Stefanova, G. Jelev

Over the entire observed period, six of the classes at level 3, characteristic of the whole plateau, are not present on the SLUAs of the Municipality of Pavlikeni. These are mainly classes from Forest and semi natural areas, namely Coniferous forest (312), Mixed forest (313), Natural grasslands (321) and Bare rocks (332). No areas from the classes Industrial or commercial units (121) and Water bodies (512) are available, either.

Characteristic of this Municipality are the high shares of Non-irrigated arable land (211), which in 2000 reach 49.59%, irrespective of the subsequent drop in 2018 to 42.50%. The other classes from level 3 of Agricultural areas experience continuous changes in their shares. With Forest and semi natural areas and Broad-leaved forest (311), the drop is a lasting one, and vice versa, with Transitional woodland-shrub it displays a tendency for increase.

Lands of the Municipality of Suhindol (Veliko Tarnovo District)

The SLUAs from the Municipality of Suhindol (Veliko Tarnovo District), which fall within the boundaries of the plateau, include in whole the SLUA of Koevci village and in part – of the town of Suhindol and Gorsko Kosovo village (Fig. 4). Their total area amounts to 59.67 km², or 17.39% of the plateau’s area. The population in both settlement numbers 1742 people for 2018. The drop with respect to 1990 (2034 people) is 43.55%.
In the SLUAs from the Municipality of Suhindol, the shares of Agricultural areas are approximately close to those of Forest and semi natural areas. This is the second municipality after Lovech, where such ratio between these two classes at level 1 is observed. The third class at level 1, which is presented by very small shares during the whole period, is Artificial surfaces (Fig. 14a). As a tendency, with Agricultural areas, there is decrease of shares in 2006 and maintenance of constant shares during the years afterwards. With Forest and semi natural areas, it is vice versa – increase of shares in 2006 and maintenance of constant shares during the years afterwards.

![Fig. 14. Land cover changes (classes, Table 1) in a group of SLUAs from the Municipality of Suhindol (Lovech District) falling within the territory of the Devetashko plateau (%): a) (Level 1); b) (Level 3)](image)

*Source: [I.1.], Elaboration: D. Stefanova, G. Jelev*

The characteristic thing for the number of classes at level 3 from this subregion is the absence of one class from each of the classes Artificial surfaces (incl. Mineral extraction sites (131), Agricultural areas (incl. Fruit trees and berry plantations (222)), and Water bodies (incl. Water bodies (512)) (Fig. 14b).

The observation of the shares at level 3 shows that Non-irrigated arable land (211) comes first with the greatest share. Second comes Broad-leaved forest (311), followed by Transitional woodland-shrub (324). The drop with Non-irrigated arable land is accompanied by increase of Vineyards (221), Pastures (231) and Land principally occupied by agriculture, with significant areas of natural vegetation (243). Another regularity which is observed within Forest and semi natural areas is drop of Broad-leaved forest (311) and increase of Natural grasslands (321) and
Transitional woodland-shrub (324) and retaining of the values of Coniferous forest (312) and Mixed forest (313) (Fig. 14b).

Change of the land cover classes

The changes in subperiod 1990–2000 comprise 14 SLUAs from five municipalities on the territory of the Devetashko plateau with total area of 7,62 km² (Table 2, fig. 15). For this period, eight groups of transformation of areas from one class into another at CORINE, land cover level 3 may be differentiated, the most of them being the transformations in Agricultural areas.

The transformation from Non-irrigated arable land (211) into Land principally occupied by agriculture, with significant areas of natural vegetation (243) with area of 2,41 km² comprises the SLUAs of strongly depopulated villages and the SLUAs of Aleksandrovo village, which is outside the plateau’s territory. All of them pertain to the Municipality of Lovech.

Table 2. Corine, land cover change in Model karst area “Devetashko plateau” by classes and lands for the subperiods 1990-2000, 2000-2006, 2006-2012, 2012-2018. Source: [I.1.], Elaboration: D. Stefanova, G. Jelev

| SLUAs  | 1990-2000 | 2000-2006 | 2006-2012 | 2012-2018 |
|--------|-----------|-----------|-----------|-----------|
|        | Total area - 7,62 km² | Total area - 3,84 km² | Total area - 0,88 km² | Total area - 4,82 km² |
| Aleksandrovo | 211-243 | 0,00 | Agatovo | 311-324 | 0,69 | Kramolin | 311-324 | 0,17 | Gorsko Slivovo | 131-231 | 0,26 |
| Gostinya | 211-243 | 0,00 | Brestovo | 311-324 | 0,02 | Kramolin | 324-311 | 0,46 | Suhindol | 211-131 | 0,09 |
| Devetaki | 211-243 | 0,71 | Gostinya | 311-324 | 0,11 | Suhindol | 324-311 | 0,16 | Varbovka | 221-211 | 0,11 |
| Tepava | 211-243 | 1,69 | Devetaki | 311-324 | 0,79 | Koevci | 324-311 | 0,08 | Agatovo | 231-211 | 0,21 |
| Varbovka | 222-211 | 0,04 | Dimcha | 311-324 | 0,30 | | | | | |
| Dimcha | 222-211 | 0,63 | Kramolin | 311-324 | 0,42 | | | | | |
| Suhindol | 222-211 | 0,03 | Karpachevo | 311-324 | 0,00 | | | | | |
| Dimcha | 222-211 | 0,06 | Suhindol | 311-324 | 0,76 | | | | | |
| Gorsko Slivovo | 231-211 | 1,89 | Tepava | 311-324 | 0,08 | | | | | |
| Karpachevo | 231-211 | 0,01 | Чавдарци | 311-324 | 0,01 | | | | | |
| Agatovo | 231-243 | 0,62 | Agatovo | 324-311 | 0,09 | | | | | |
| Chavdaritsi | 231-243 | 0,47 | Devetaki | 324-311 | 0,26 | | | | | |
| Brestovo | 231-324 | 0,39 | Krschan | 324-311 | 0,07 | | | | | |
| Tepava | 231-324 | 0,42 | Karpachevo | 324-311 | 0,06 | | | | | |
| Devetaki | 243-311 | 0,30 | Smocan | 324-311 | 0,03 | | | | | |
| Smocan | 243-311 | 0,06 | Chavdaritsi | 324-311 | 0,01 | | | | | |
| Krschan | 313-324 | 0,07 | | | | | | | | |
| Karpachevo | 313-324 | 0,22 | | | | | | | | |
| Chavdaritsi | 313-324 | 0,01 | | | | | | | | |

Another type of transformation during this period is from Fruit trees and berry plantations (222) into Non-irrigated arable land (211) with area of 0,77 km², which comprises the SLUAs from the Municipality of Pavlikeni (Varbovka and Dimcha villages) and from the Municipality of Suhindol (town of Suhindol). When
the Agrarian–Industrial Complexes (AICs) were liquidated, the orchards were abandoned.

The liquidation of cattle breeding during the period 1990–2000 resulted in transformation of pastures with area of 4,10 km². This process affects the SLUAs of Gorsko Slivovo and Karpachevo villages, with transformation into Non-irrigated arable land (211), of Agatovo and Chavdartsi villages, with transformation into Land principally occupied by agriculture, with significant areas of natural vegetation (243), and of Brestovo and Tepava villages with transformation into Transitional woodland-shrub (324).

Insignificant transformation of area of 0,29 km² comprises Broad-leaved forest (311), which has been transformed into Transitional woodland-shrub (324) on the SLUAs of Chavdartsi, Krushuna, and Karpachevo villages.

The changes in subperiod 2000–2006 comprise 12 SLUAs from five municipalities on the territory of the Devetashko plateau with total area of 3,84 km² (Table 2, Fig. 15). The transformations have been differentiated into two groups: transformation of Broad-leaved forest (311) into Transitional woodland-shrub (324), which comprises the SLUAs of 10 settlements (Agatovo, Brestovo, Gostinya, Devetaki, Dimcha, Kramolin, Karpachevo, Suhindol, Tepava, and Chavdartsi villages); reverse transformation from Transitional woodland-shrub (324) into Broad-leaved forest (311) (on the SLUAs of Agatovo, Devetaki, Krushuna, Karpachevo, Smodcan, and Chavdartsi villages).

Subperiod 2006–2012 comprises 3 SLUAs from two municipalities – Kramolin village from the Municipality of Sevlievo and Koevci village and town of Suhindol from the Municipality of Suhindol, with total area of 0,88 km² (Table 2, Fig. 15). The transformations are from Transitional woodland-shrub (324) into Broad-leaved forest (311) and vice versa for Kramolin village – from Broad-leaved forest (311) into Transitional woodland-shrub (324).

The last subperiod 2012–2018 comprises 12 SLUAs from five municipalities with total area of 4,82 km² (Table 2, Fig. 15). The transformations have been differentiated into 5 groups, whereas in 2 of them the changes are more essential and comprise more SLUAs. On 9 SLUAs, Pastures (231) are transformed into Non-irrigated arable land (211), and on other 8 SLUAs – from Broad-leaved forest (311) into Transitional woodland-shrub (324).

The results from the performed analyses and the assessment of the land cover and land use of the Devetashko plateau after the CORINE nomenclature, have been summarized, as follows:

- the land cover on the territory of the Devetashko plateau is presented with greatest share by Agricultural areas, followed by Forest and semi natural areas, the difference between the two being about 20%. The values of Artificial surfaces are exceptionally low and those of Water bodies are minor. At this level, the observation of the share distribution by classes displays insignificant changes, which are in the
direction of increase for *Forest and semi natural areas*, and vice versa – decrease for *Agricultural areas* (Fig. 6);

![Diagram](image)

**Fig. 15. Corine, land cover change in Model karst area “Devetashko plateau”;
 a) 1990-2000, b) 2000-2006, c) 2006-2012, d) 2012-2018)**

*Source: [1.1.], Elaboration: Georgi Jelev*

- at CORINE, land cover level 3 on the territory of the Devetashko plateau, 16 land cover and land use classes are observed. *Non-irrigated arable land* (211) and *Broad-leaved forest* (311) feature the greatest relative shares, whereas the tendency with them is for weak decrease. Another characteristic is that the changes are mainly concentrated in classes within *Agricultural areas* and *Forest and semi natural areas*;

- over the entire period, the changes of one class into another comprise 5% of the plateau’s territory;

- with time, the changes in land cover follow the social and economic changes in society – from the restitution of land and the liquidation of agricultural farms to provision of subsidies in agriculture which triggered again changes in the
share of the individual classes of *Agricultural areas*. Their specific manifestation is expressed in the fact that, during the early years of the „transition“, transformation of *Pastures* (231), *Non-irrigated arable land* (211), *Fruit trees and berry plantations* (222) is mostly observed, resulting from collapse in cattle breeding and abandonment of arable land. A change in the areas of *Broad-leaved forest* (311) is also observed resulting from intensified logging. The recent years witness the reverse tendency – with the development of large-scale agriculture, pastures and natural grass areas are transformed into agricultural land;

- at the level of a group of SLUAs, located within the boundaries of territorial and administrative units (municipalities) on the territory of the Devetashko plateau, two types of combinations of land cover are observed. On three municipal lands (Letnitsa, Sevlievo, and Pavlikeni), the shares of *Agricultural areas* outdistance significantly (almost two-fold with respect to *Forest and semi natural areas*). With the other two municipalities (Lovech and Suhindol), the shares of these two classes from level 1 are approximately equal. These means that, when implementing current and future economic activities, the municipal administrations and the persons handling the lands must keep a track of the current changes and forecast the upcoming changes and possible transformations by land cover classes. But, minding the specifics of these territories, they should also comply with karst’s high vulnerability to anthropogenic impacts and climatic changes.

**Conclusion**

The land cover and land use types and their change as a result of anthropogenic pressure or natural intervention have a strong impact on karst geosystems. Relief character and special distribution of karst regions influence economic activity and it, on its part, influences karst geosystems.

The social and economic factor also affects land use and thence, land cover change. The pressure on karst systems is further aggravated by various conflicts of interests arising during the exercising of different economic activities, such as farming (agriculture and cattle breeding), forestry, mining, settlement development, industry, protected territories. The new circumstances of transition and continuous changes require adequate management complying with the karst specifics of the territory, among others. The absence of such management would result in serious ecological problems. In this sense, observation of land use in the highly vulnerable karst territories and the possibilities for its planning require special attention. The studies based on land cover and land use, especially in sensitive territories, such as the karst ones, may provide additional valuable information which might improve land management and assist the designing of strategic development policies. Because human activity, incl. traditional agricultural activity which prevails on the Devetashko plateau results in transformation of karst types [Гвоздецкий, 1972] and structural and functional changes in karst geosystems [Andrejczuk & Stefanov,
These changes, on their part, reflect, sometimes unexpectedly, on the anthropogenic activity and social environment in karst territories.

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ПРОМЕНИ В ЗЕМНОТО ПОКРИТИЕ И ЗЕМЕПОЛЗВАНЕТО НА КАРСТОВ РАЙОН ДЕВЕТАШКОТО ПЛАТО

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Резюме

Данните на CORINE Land Cover (CLC) представляват цифрови данни за земното покритие, разпределено в 44 класа, като за територията на България класовете са 36. Минималната картируема единица е 25 хектара (за площни обекти) и 100 м за линейни обекти. Налични са набори от данни за годините 1990, 2000, 2006, 2012 и 2018 г., както и за промените настъпили между всяка двойка години (1990–2000, 2000–2006, 2006–2012 и 2012–2018).

Големият набор от данни дава възможност да се проследи за период от близо 30 години как се е променяло земното покритие в моделни карстови райони, които са силно уязвими на антропогенни и природни въздействия.

Настоящата статия разглежда промените в типовете земно покритие в Devetashko plateau – типично карстово плато в Северна България. Промените в земното покритие и в земеползването пряко влияят върху процесите на съвременния карстогенезис, почво-растителната покривка, количеството и качеството на подземните карстови води.