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CONFERENCE PROCEEDINGS CONTENTS

SECTION GEODESY AND MINE SURVEYING

SECTION CARTOGRAPHY AND GIS

LAND COVER CHANGES IN THE OGOSTA VALLEY FOR THE PERIOD 1993-2019

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ABSTRACT

The current research aims to present land cover changes for the period 1993-2019 in the arsenic-contaminated Ogosta River valley in the context of the contaminant dispersal in the soils of the river floodplain caused by the agricultural practices and land use. The investigation is conducted for two test sites situated in the upper and lower stretch of the valley near the villages of Gorna Kovatchitsa and Mihaylovo, respectively. The changes are established for the fourth level of the CORINE Land Cover nomenclature, which is developed for the PHARE countries [1]. Nineteen classes are defined in the study areas. As expected, the classes which indicate arable lands are most common in the valley's bottom due to its flat topography and fertile soils, followed by the orchards and built-up areas of the settlements. The land cover changes have a similar pattern in the two test sites. Vegetable gardens, orchards and vineyards have significantly reduced their area or disappeared completely. The assumed reason is the lack of labour force as a result of the depopulation of this region of Bulgaria. They are abandoned or replaced by crops which allow mechanized cultivation. Some of the arable lands are also left not cultivated and are gradually grassed or covered with bush vegetation. Because of the higher share of orchards and abandoned arable lands in the upper stretch of the Ogosta Valley, the land cover changes there are deeper compared to its lower part. The transformation of the land cover cause reduction of the irrigated lands like vegetable gardens and orchards, thus decreasing the transfer of arsenic and heavy metals from the contaminated Ogosta River to the soil in the floodplain via irrigation.

Keywords: Remote sensing, Geographic Information Systems (GIS), CORINE Land Cover (CLC), Satellite images, Orthophoto

INTRODUCTION

A very topical in recent decades is the issue for studying and mapping the land cover. The European Commission launched the first land cover mapping for the European Union in 1985 with the program Coordination of Information on the Environment (CORINE). The initial data from CORINE goes back to 1990 and have updates in 2000, 2006, 2012, and 2018.

In recent years for studying and mapping land cover changes, remote sensing technology and the geographic information systems (GIS) are used [2], [3], [4], [5], [6], [7], [8].

Man has the greatest influence on the change of the land cover, followed by natural disasters. The anthropogenic impact on the land cover is one of the highest in the valleys compared to other landscapes on the Earth.

In this study, the changes in land cover for the period 1993-2019 are investigated in the Ogosta River valley in order to reveal how the economic changes in Bulgaria affected the agriculture in the valley after the end of the communist period, since land use and irrigation practices affect the spread of the arsenic and heavy metal pollution in the soil of the river floodplain.

STUDY AREA

The Ogosta River drains a part of Northwestern Bulgaria (Figure 1) where the river runs for 141.1 km from its springs in the Stara Planina Range to the confluence into the Danube. Two test sites are selected in the upper and lower stretch of the Ogosta Valley where are situated near the villages of Gorna Kovatchitsa and Mihaylovo, respectively. The study areas are 1918.66 ha in total size and have an average inclination of slopes about 2˚.

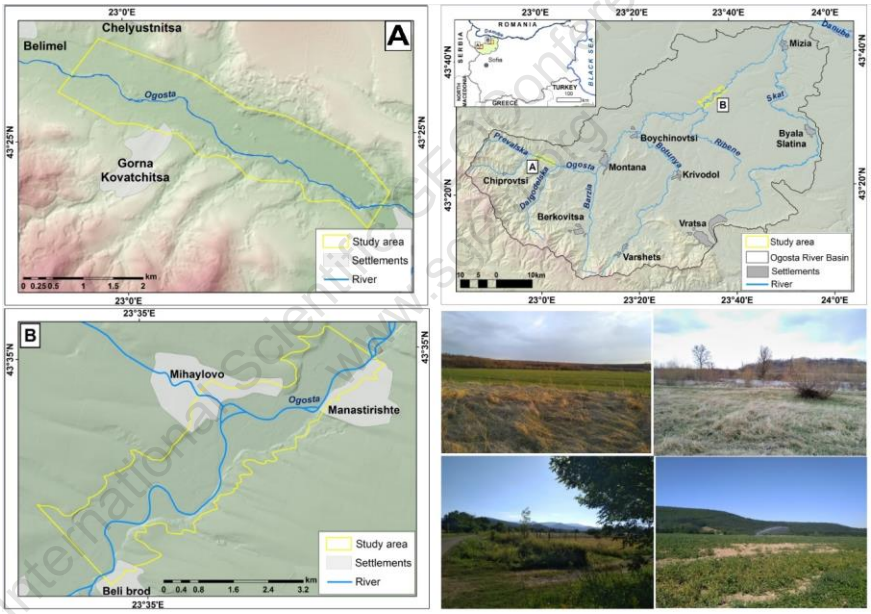

Fig. 1. Location map of the study areas: A-test site of G. Kovatchitsa; B-test site of Mihaylovo

The Neozoic and Mesozoic underlying rocks of the Ogosta River floodplain in the study areas are covered by alluvial deposits with a two-layer structure: a lower layer built of gravels and boulders with sand, and an upper layer of sandy-clayey deposits [9]. The climate is temperate continental with a relatively cold winter and hot summer. The study areas are characterized by westerly and northwesterly winds. The annual amount of precipitation varies between 518-592 mm with a maximum in May and June, and a minimum in February [10]. The soil types in the valley are determined according to FAO (Food and Agriculture Organization of the United Nations) classification [11]. The valley's bottom in the test sites is covered with alluvial soils, primarily Eutric Fluvisols, Dystric Fluvisols, and Eutric Gleysols.

According to the administrative division of Bulgaria, the study area of G. Kovatcitsa is shared between the municipalities of Chiprovtsi and Georgi Damyanovo (Montana District), and the test site of Mihaylovo is located in the municipality of Hairedin in the Vratsa District.

DATA AND METHODS

For studying the land cover changes, we used aerial photographs from 1993 and 1998, as well as orthophoto mosaics from 2006, 2011, and 2019. Vector data for Bulgaria from the third level of the European program CORINE Land Cover (CLC1990, CLC2000, CLC2006, CLC2012, and CLC2018) is also applied for the mapping of the land cover.

The aerial photographs have been purchased from the archives of the Military Geographic Service (Bulgarian Army) in the town of Troyan. The photos are monochromic (Figure 2).

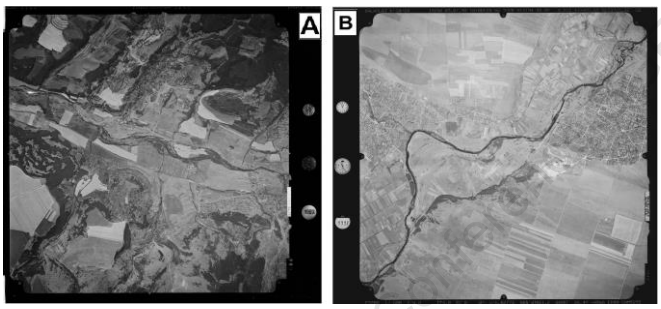

Fig. 2. Aerial photographs from 1993 and 1998: A-test site of G. Kovatchitsa; B-test site of Mihaylovo

The images from 1993 were taken with a Wild RC-10 metric camera and the photographs from 1998 with metric camera Wild RC-30. The flight altitude was 3050-4000 m (1993) and 3200 m (1998), and the focal length was approx 153 mm. These photos are georeferenced using ArcGIS 10.6.1.

The orthophoto mosaics from 2006 and 2011 have been provided by the Ministry of Agriculture, Food, and Forestry. The images from 2019 were taken with WingtraOne VTOL mapping drone with camera Sony 42 Mpix (DSC-RX1RM2) and with high-precision GNSS GPS for measurement of ground control points (GCP) (Figure 3). The flight altitude was 400 m and the focal length approx 35 mm. Photo processing is done with a photogrammetry software for drone mapping Pix4Dmapper.

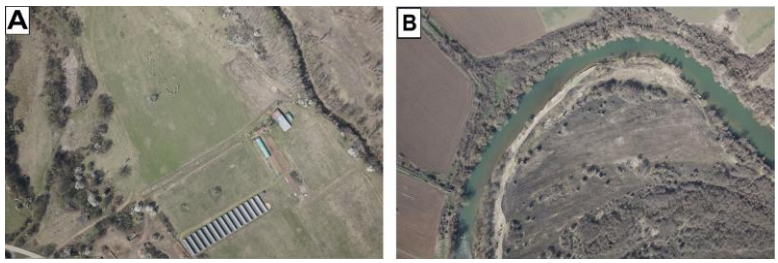

Fig. 3. Orthophotos from 2019: A-test site of G. Kovatchitsa; B-test site of Mihaylovo

In the present study, images with high quality are used, which allows us to achieve significantly higher accuracy compared to the satellite images. Therefore, in studying changes of land cover in the test sites we use CORINE nomenclature for the fourth level which is developed for the PHARE countries and corresponds to M 1:50 000 [1].

RESULTS

The results of the mapping of the land cover (level 4) are presented in figures 4 and 6, and the names of the classes of land cover together with their areas are presented in tables 1 and 2.

In 1993, the agricultural areas took the biggest share of the territory of the two test sites. These are the classes 2111 - Arable land prevailingly without dispersed (line and point) vegetation, 2431 - Agricultural areas with a significant share of natural vegetation and with the prevalence of arable land, and 2433 - Agricultural areas with a significant share of natural vegetation and with the prevalence of scattered vegetation. These are followed by the orchards (class 2221) in the test site of Gorna Kovatchitsa and by built-up areas with family houses (class 1122) in the second test site of Mihaylovo (Figures 4A and 6A, Tables 1 and 2).

The analysis of the map of land cover in 2019 for the first test site shows drastic change as 77% of the area has transformed into other classes since 1993 (Figures 4B and 5, Table 1). This applies to the vegetable gardens (2113), vineyards (2211), orchards (2221) and various grasslands (2311 and 2312), which are absent on the map of 2019. The natural vegetation in the agriculture areas seemed to have expanded and took prevalence over the arable lands in many places. Thus, class 2431 transformed into the new categories of 2432, 2433 and 2435. Additionally, two more classes also appeared - natural young stands (3242) and wetland areas occupied by reeds (4111). In 2019, the agricultural areas (2111, 2432, 2433 and 2435) took the biggest share of the territory as in 1993 but were followed by broad-leaved forests (3113) instead of orchards (Table 1).

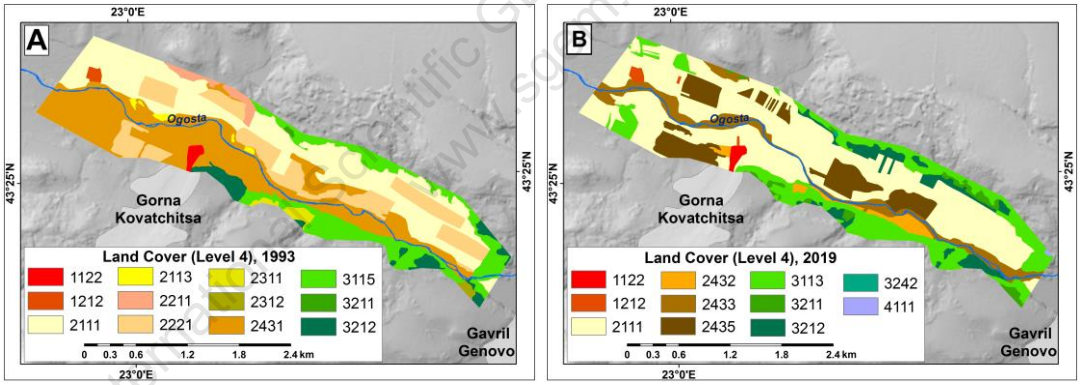

Fig. 4. Maps of the land cover (level 4) in 1993 (A) and 2019 (B) for the test site near the village of Gorna Kovatchitsa. The names of the classes are given in Table 1.

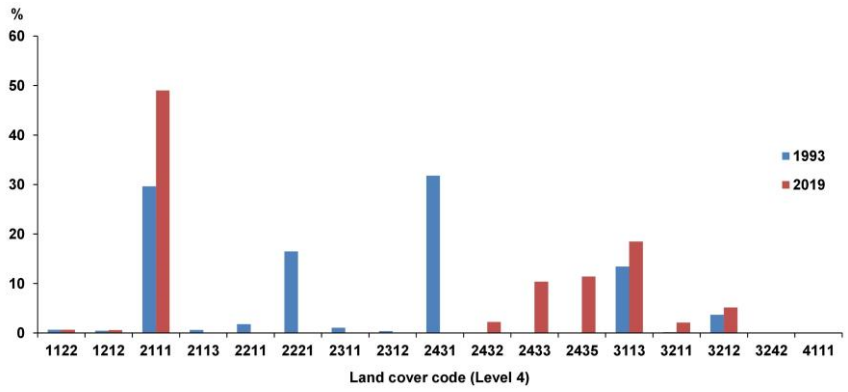

Fig. 5. Land cover changes for the period 1993-2019

Table 1. Land cover classes (level 4) in 1993 and 2019 for the test site near the village of Gorna Kovatchitsa

Land cover (level 4)	Code	1993		2019	
		ha	%	ha	%
Discontinuous built-up areas with family houses with gardens	1122	3.70	0.64	3.66	0.64
Areas of special installations	1212	2.56	0.45	3.23	0.56
Arable land prevailingly without dispersed (line and point) vegetation	2111	170.23	29.63	281.61	48.99
Vegetable garden	2113	3.44	0.60	-	-
Vineyards	2211	10.10	1.76	-	-
Orchards	2221	94.63	16.47	-	-
Grassland (pastures and meadows) prevailingly without trees and shrubs	2311	5.96	1.04	-	-
Grassland (pastures and meadows) with trees and shrubs	2312	2.15	0.37	-	-
Agricultural areas with a significant share of natural vegetation, and with the prevalence of arable land	2431	182.68	31.79	-	-
Agricultural areas with a significant share of natural vegetation, and with the prevalence of grasslands	2432	-	-	12.68	2.21
Agricultural areas with a significant share of natural vegetation, and with the prevalence of scattered vegetation	2433	-	-	59.60	10.37
Agricultural areas with a significant share of permanent crops, and with the presence of scattered vegetation	2435	-	-	65.45	11.39
Broad-leaved forests with discontinuous canopy, not on the mire	3113	77.10	13.42	106.25	18.49
Natural grassland prevailingly without trees and shrubs	3211	0.86	0.15	12.06	2.10
Natural grassland with trees and shrubs	3212	21.13	3.68	29.59	5.15
Natural young stands	3242	-	-	0.28	0.05
Fresh-water marshes with reeds	4111	-	-	0.38	0.07

The land cover changes from 1993 to 2019 take 24 % of the area of the test site of Mihaylovo: the classes 1123, 2211, 2221, 2431 and 3242, which are available in 1993 are absent in 2019. Similarly, to the test area in the upper stretch of the valley, they are mostly vineyards, orchards and agricultural areas with a prevalence of the arable land over natural vegetation. New classes 1212 and 3113 appeared in 2019 (Figures 6B and 7, Table 2). The first one is related with the construction site of a small hydroelectric power plant, while the

second class indicates the transformation of natural young stands into a broad-leave forest on the steep right slope of the valley. The structure of the land cover did not change significantly from 1993 to 2019, dominated again by the agricultural areas (class 2111 and class 2433) and followed by built-up areas with family houses (class 1122) (Table 2).

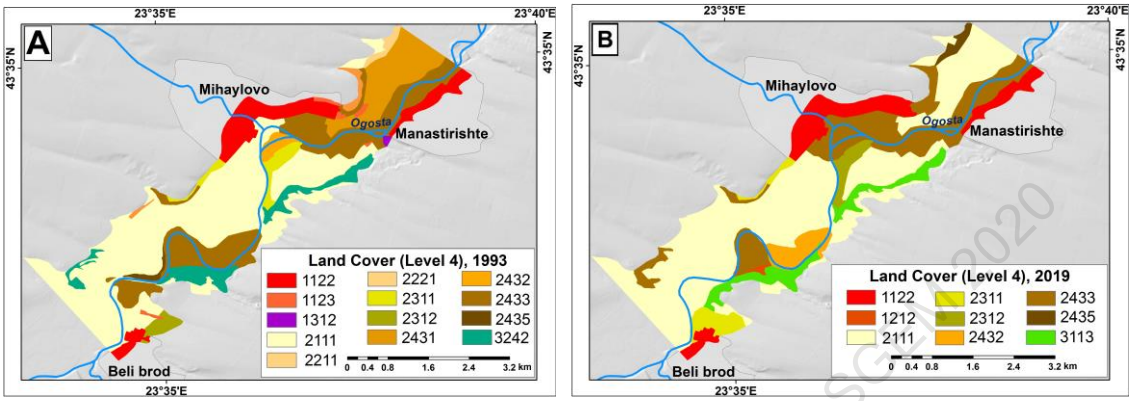

Fig. 6. Maps of the land cover (level 4) in 1993 (A) and 2019 (B) for the test site situated near the village of Mihaylovo. The names of the land codes coverage are given in Table 2.

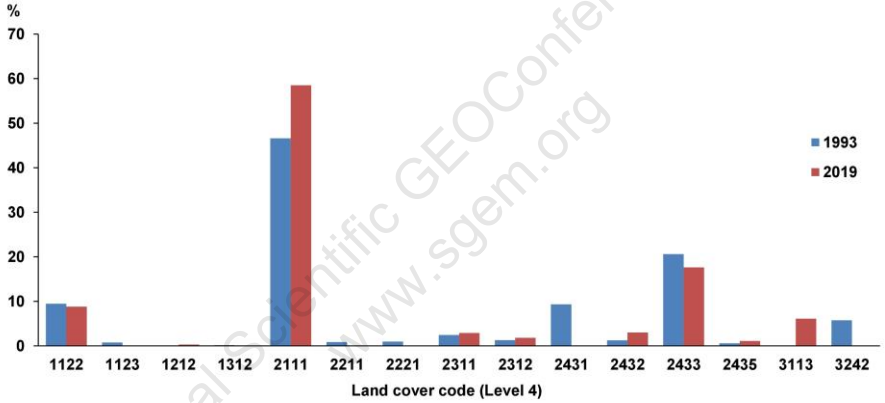

Fig. 7. Land cover changes for the period 1993-2019

Table 2. Land cover classes (level 4) in 1993 and 2019 for the test site near the village of Mihaylovo

Land cover (level 4)	Code	1993		2019	
		ha	%	ha	%
Discontinuous built-up areas with family houses with gardens	1122	127.32	9.47	134.2	8.8
Discontinuous built-up areas with greenery	1123	10.31	0.77	-	-
Areas of special installations	1212	-	-	5.1	0.3
Quarries	1312	2.15	0.16	-	-
Arable land prevailingly without dispersed (line and point) vegetation	2111	625.90	46.58	897.5	58.5
Vineyards	2211	11.59	0.86	-	-
Orchards	2221	12.85	0.96	-	-
Grassland (pastures and meadows)	2311	32.93	2.45	44.0	2.9

prevailingly without trees and shrubs					
Grassland (pastures and meadows) with trees and shrubs	2312	17.02	1.27	27.9	1.8
Agricultural areas with a significant share of natural vegetation, and with the prevalence of arable land	2431	125.34	9.33	-	-
Agricultural areas with a significant share of natural vegetation, and with the prevalence of grasslands	2432	16.96	1.26	46.2	3.0
Agricultural areas with a significant share of natural vegetation, and with the prevalence of scattered vegetation	2433	276.73	20.59	269.3	17.6
Agricultural areas with a significant share of permanent crops, and with the presence of scattered vegetation	2435	7.63	0.57	16.1	1.1
Broad-leaved forests with discontinuous canopy, not on the mire	3113	-	-	93.0	6.1
Natural young stands	3242	77.12	5.74	-	-

CONCLUSION

The paper presents land cover changes for the period 1993-2019 examined for two test sites situated in the upper and lower stretch of the Ogosta Valley near the villages of Gorna Kovatchitsa and Mihaylovo, respectively. The study uses the fourth level of the CORINE Land Cover nomenclature for more detailed results. As expected, the classes which indicate arable lands are most common in the valley's bottom due to its flat topography and fertile soils, followed by the orchards and built-up areas of the settlements. The land cover changes have a similar pattern in the two test sites. Vegetable gardens, orchards and vineyards have significantly reduced their area or disappeared completely. The assumed reason is the lack of labor force as a result of the depopulation of this region of Bulgaria. They are abandoned or replaced by crops which allow mechanized cultivation. Some of the arable lands are also left not cultivated and is gradually grassed or covered with bush vegetation. Because of the higher share of orchards and abandoned arable lands in the upper stretch of the Ogosta Valley, the land cover changes there are deeper compared to its lower part. The transformation of the land cover cause reduction of the irrigated lands like vegetable gardens and orchards, thus decreasing the transfer of arsenic and heavy metals from the contaminated Ogosta River to the soil in the floodplain via irrigation.

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