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SPATIAL AND TEMPORAL DYNAMICS OF THE MORPHOMETRIC PARAMETERS AND LAND COVER USING REMOTE SENSING METHODS AND GIS

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Key words: *land cover dynamics, digital elevation model, morphomertry, remote sensing, visual interpretation*

Abstract: *Analysis of the spatial and temporal dynamics of the morphometric parameters and land cover is conducted using archive and modern aerial photos. Two digital elevation models are created and the change of the slopes and aspects is studied. To assess land cover dynamics a computer-aided visual interpretation for 1940, 1966 and 2006 is conducted. A change matrix is composed as a result of which it was found that 73% of the study area land cover has been changed.*

ПРОСТРАНСТВЕНА И ВРЕМЕВА ДИНАМИКА НА МОРФОМЕТРИЧНИТЕ ПАРАМЕТРИ И ЗЕМНОТО ПОКРИТИЕ С ИЗПОЛЗВАНЕ НА ДИСТАНЦИОННИ МЕТОДИ И ГИС

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Ключови думи: *динамика на земното покритие, цифров модел на релефа, морфометрия, дистанционни изследвания, визуална интерпретация*

Резюме: *Извършен е анализ на пространствената и времева динамика на морфометричните параметри и земното покритие на базата на архивни и съвременни аерофотоснимки. Съставени са 2 цифрови модела на релефа, като е проследено изменението на наклоните и експозициите на склоновете. За динамиката на земното покритие е извършено компютърно подпомогната визуална интерпретация за три времеви периода – 1940, 1966 и 2006 г. Съставена е матрица на изменението в резултат на което се установи, че 73% от изучаваната територия е претърпяла изменение на земното покритие.*

Introduction

The integration of RS and GIS technology is invaluable for study various resource management problems including land use and landscape changes (Gautam et al., 2002). Most studies follow the process of the change of the spatial and temporal characteristics land-use, playing major role in the assessment from the consequences from the urbanization on the environment. (Deng et al., 2009; Xiao et al., 2006; Li and Yeh, 2004; Weng, 2001; Ji et al., 2001). Human activity is a major force in affecting spatial and temporal changes in land use, but the landscape structure often constrains the use of land (Verburg and Chen, 2000). The satellite images with medium and high spatial resolution allow large-scale studies on small areas to be conducted, providing with detailed land use information (Baskent et al., 2007). The change of morphometric parameters and land use has a significant effect on the natural processes of a given territory. Few studies assess the land-use/land-cover change and its relationship to the slope degree and soil type (Zhao et al., 2006). According to them the slope degree and soil type appears as stable discriminating parameters, which might constrain land use and their use in the analysis enhance the prediction of landscape dynamics. The availability of remote sensing data with high spatial and temporal resolution as well as the development of GIS technologies

and the possibilities for spatial analyses which they provide give us the opportunity to obtain land cover information, fast and unbiased, for various years.

Location of the study area

The site Delino Gumno is located in the Kutina drainage basin, northwest from Kutina village. In administrative aspect the Delino Gumno drainage basin belongs to Novi Iskur region, Metropolitan Municipality and its area is 7.9 ha (Fig. 1). The study of this drainage basin is of interest to us, because natural formations of the rock pyramids type are located on its territory, which are seriously affected as a result of human impact. These natural formations have smaller sizes than the Kutina pyramids and they are not announced for a natural landmark. The rock pyramids in Delino Gumno are described for a first time in the work of Popov (1957), according to which they have reached 4.5 m.

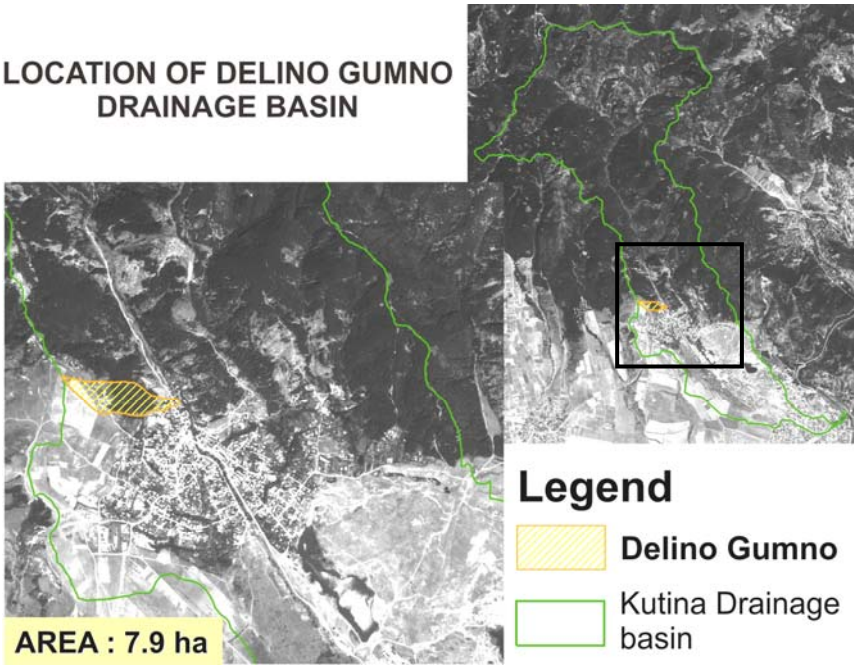

Fig. 1. Location of the study area

Fig. 2. Rock pyramids

The purpose of the presented paper was to study the change of the morphometric parameters and the spatial land cover dynamics of Delino Gumno drainage basin over 68-year period of time (1940-2008).

Structural scheme of the study

The structural scheme of the study includes 6 stages:
1. Preliminary examination of the study area;

2. Assessment of the input information and choosing appropriate years to study the land cover's dynamics and the change of morphometric parameters;
3. Generation of digital elevation models and derivative morphometric parameters – slope and aspect for 1963 and 1989;
4. Conductance of computer-aided visual interpretation of the aerial photos and panchromatic satellite images – 1940, 1966 and 2006;
5. Conductance of several field checks of the interpretation results;
6. Assessment of the land cover dynamics and creation of land cover change maps;
The spatial analyses for the study area are conducted using data from the geodatabase of the created *Kutina* GIS (Naydenova V., E. Roumenina, 2009).

Results and discussion

Two digital elevation models for the study area are composed using large-scale topographic maps (1:5000) for 1963 and 1989. The altitude of the study area varies from 605 to 693 m. The greatest percentage has the territories with altitude higher than 680 m, which are situated in the upper part of the drainage basin. Significant changes are not observed in the histogram distribution of the relief for both years. The composed digital elevation models are used for generating of derived morphometric parameters such as slope and aspect, and comparative analysis of their change is accomplished. The plain and slightly hill territories with slope 0-7^{o} predominate in the upper part of the basin, which percentage share is almost 50%. The territories with slope over 45^{o} are located mainly in the middle part of the studied basin and their percentage is the smallest. This is due to the fact that the middle and lower part of Delino Gumno drainage basin is strongly segmented by the active erosional processes. In 1989 a slight increase of the territories with slope 3-7^{o} and 7-12^{o} is observed, respectively from 17.8% and 12.8% (for 1963) to 20.7% and 13.5% (for 1989) This increase has happened on account of the territories with slope 0-3^{o} (from 28.3% to 25.6%) and 45-60^{o} (from 1.8% to 1.6%). Territories with slope over 60^{o} appeared in 1989, but their area is insignificant (0.04%).
Regarding the aspect considerable changes are not observed. With highest percentage are the areas with SE, E and S aspect. According to the percentage ratio, an increase of the territories with SE aspect is shown (from 31.9 to 35%) on account of the decrease of these with NE and E aspect, respectively from 10.5% to 8.8% and from 19.3% to 19%. With smallest area are territories with NE and SW aspect, and such with W aspect are not observed. Almost 12% of the study area is flat and its percentage has not been changed during this period.

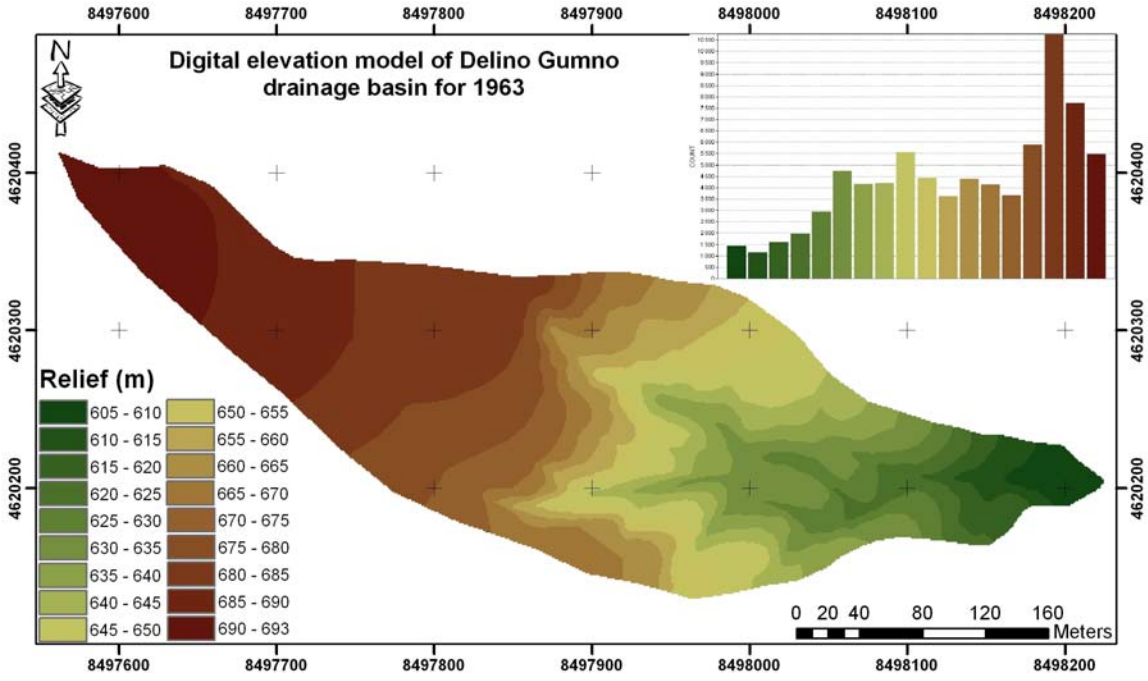

Fig. 3. Digital elevation model for 1963

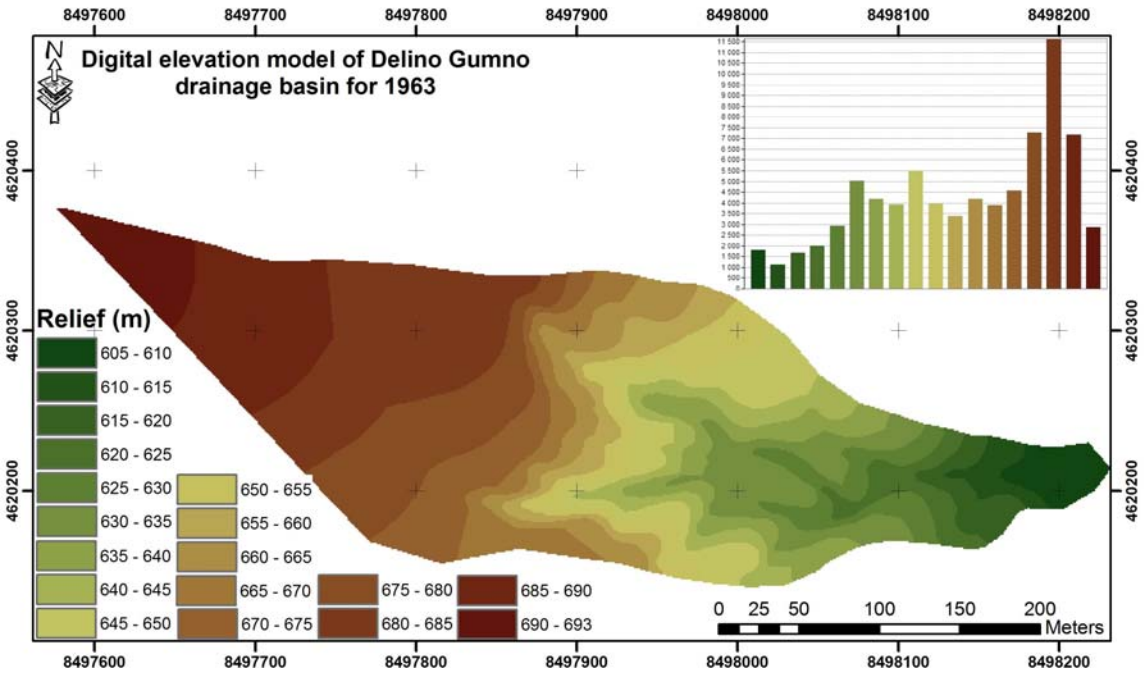

Fig. 4. Digital elevation model for 1989

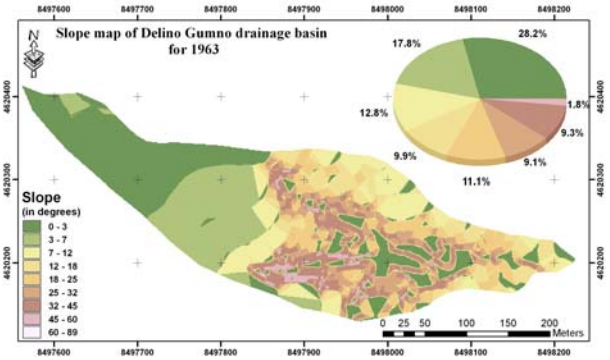

Fig. 5 Map and diagram of the actual slopes for 1963

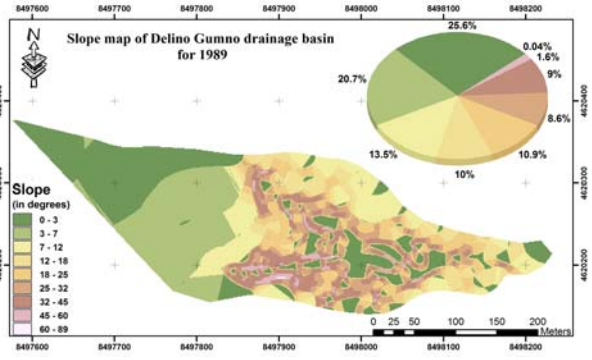

Fig. 6 Map and diagram of the actual slopes for 1989

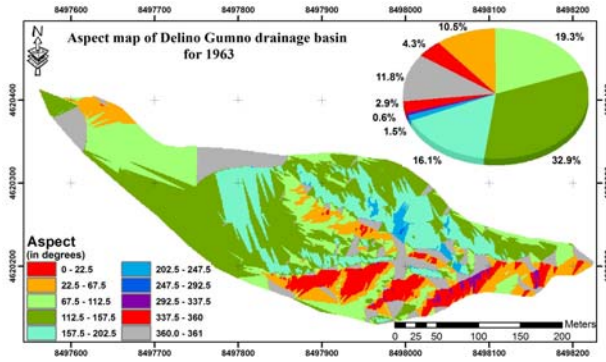

Fig. 7. Map and diagram of the aspect values for 1963

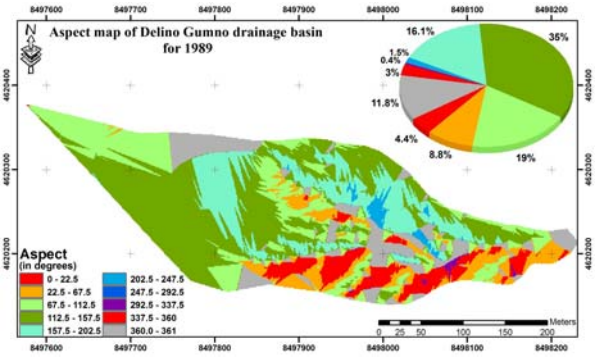

Fig. 8. Map and diagram of the aspect values for 1989

As a result from the conducted analyses it was established that in 1940 the Delino Gumno drainage basin was coved mainly by barren land with scarce vegetation (56.1%) and arable land (31.3%), whereas the percentage of forest areas was insignificant (0.3%) and urban areas were not observed (Fig. 9). An increase of the area covered by arable land with 10% was observed in 1966 and a significant part of the territory is forested by deciduous species (33.8%), which was occurred on the account of the decrease of the barren lands with scarce vegetation (Fig. 10). Nowadays, the study area is characterized with high percentage of the forest – 39% deciduous and 12.7% coniferous

forests (Fig. 11). The area of the barren land with scarce vegetation has decreased to 3.4%, and several new land cover classes have appeared – urban areas, roads and perennial crops.

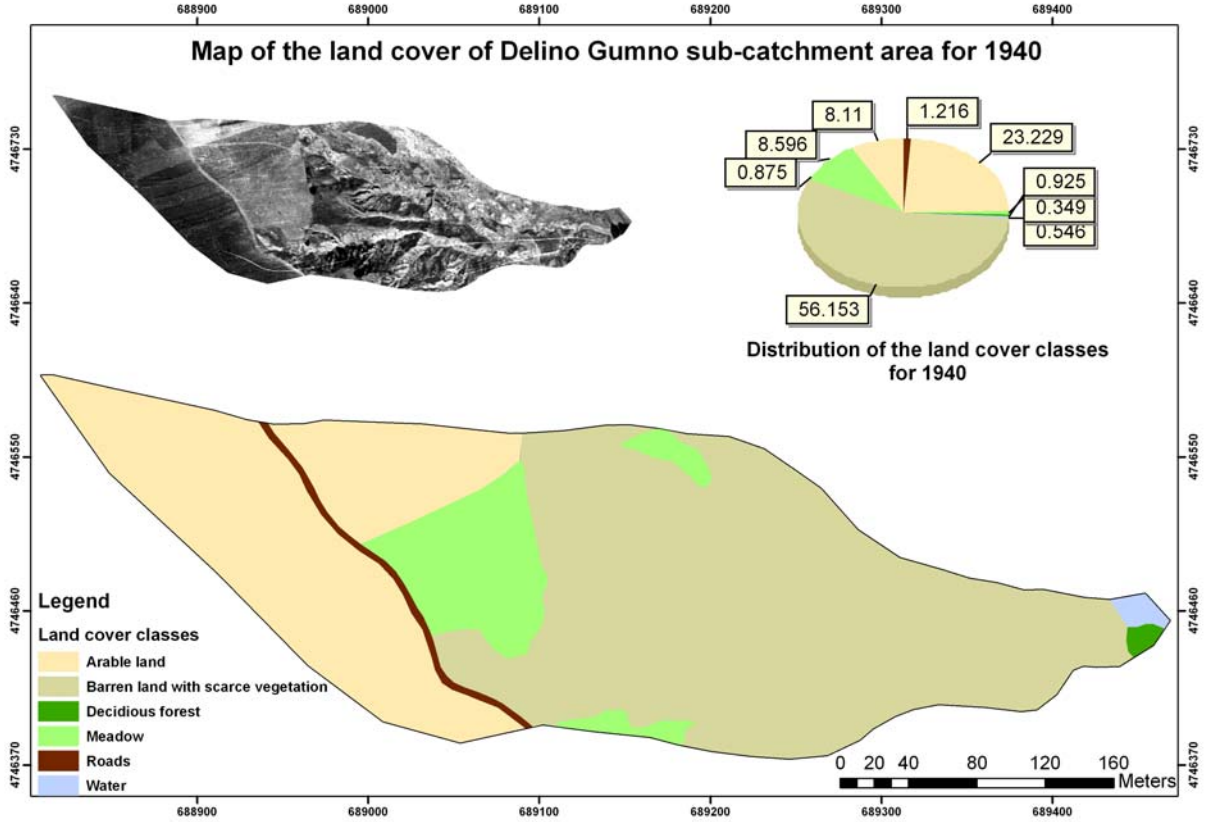

Fig. 9 Map and diagram of the land cover classes for 1940

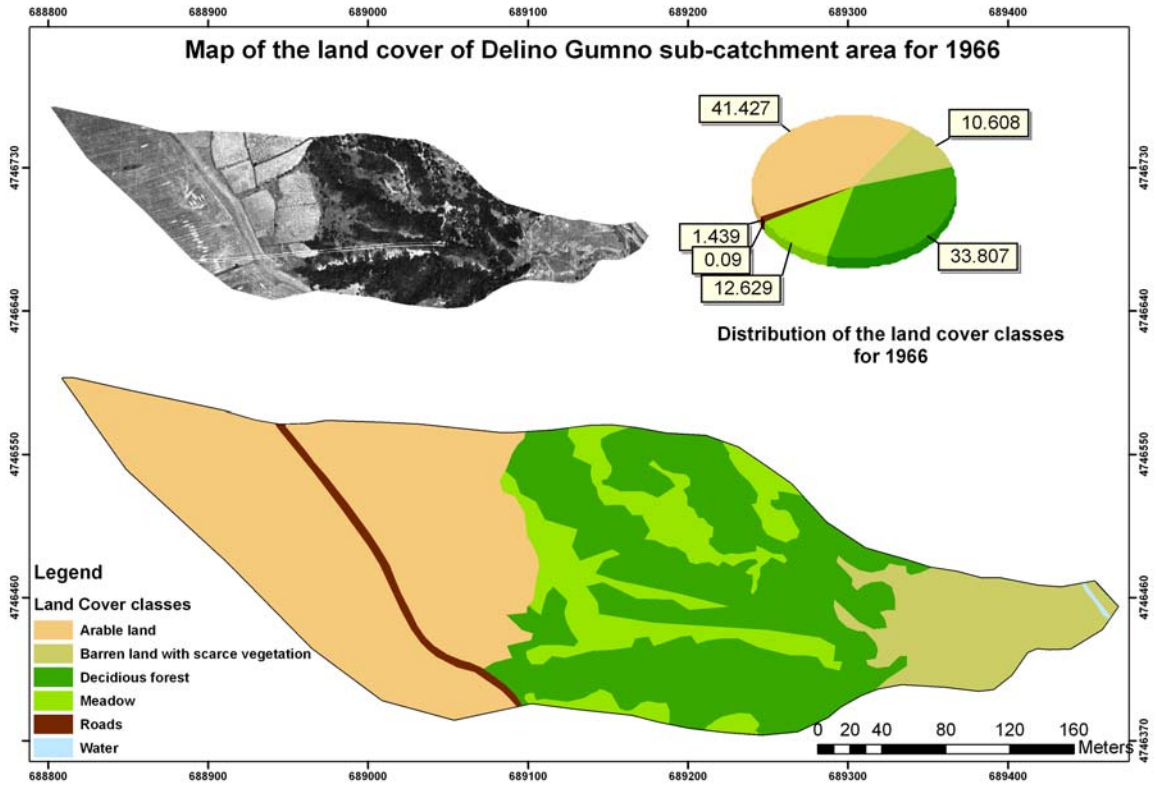

Fig. 10 Map and diagram of the land cover classes for 1966

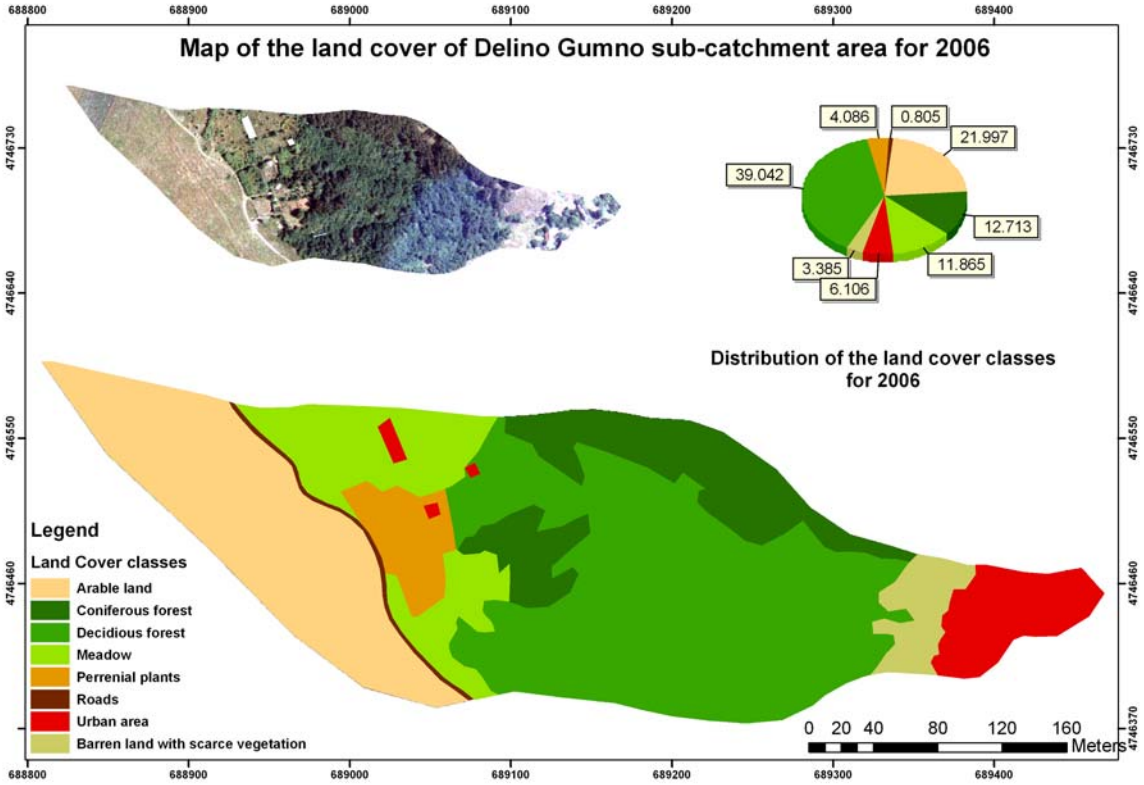

Fig. 11 Map and diagram of the land cover classes for 2006

Conclusions

Difference map and a change matrix for the period 1940 -2006 are created for assessment of the land cover change (Fig. 12, Table 2). The greatest changes are observed in the arable lands and the

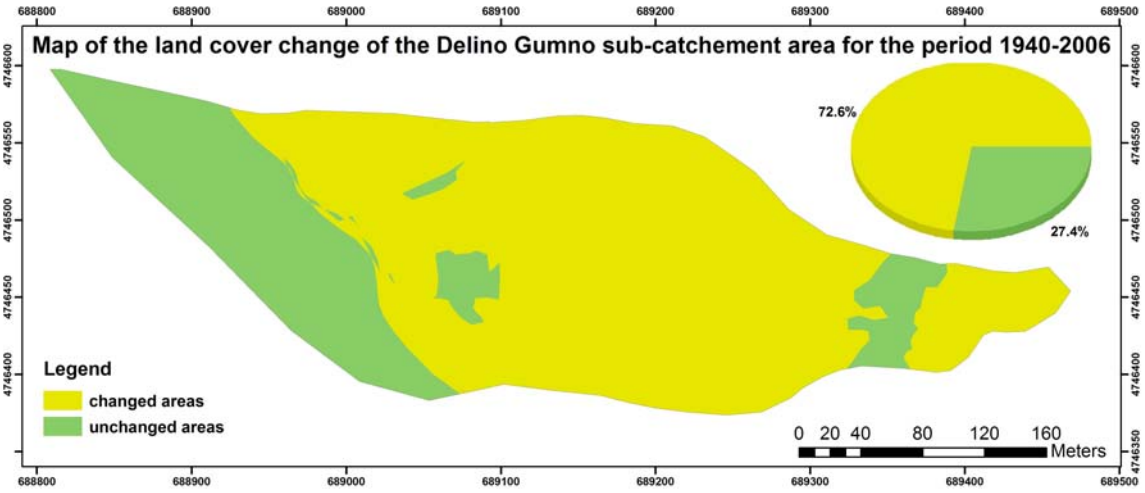

Fig. 12 Map and diagram of the change of the land cover classes for the period 1940-2006

Table 2. Change matrix of the area of land cover classes (in %) for 2006 compared to 1940

Land cover classes		2006								Total
		Arable land	Barren land with scarce vegetation	Coniferous forest	Decidious forest	Meadow	Perrenial plants	Roads	Urban area	
1940	Arable land	21.81			0.08	8.11	0.52	0.60	0.30	31.43
	Barren land with scarce vegetation		3.36	10.93	35.99	0.95	0.10		4.72	56.06
	Decidious forest								0.35	0.35
	Meadow	0.05		1.82	2.84	2.09	3.41	0.06	0.15	10.42
	Roads	0.20			0.07	0.74	0.06	0.15		1.22
	Water								0.52	0.52
Total		22.06	3.36	12.75	38.98	11.89	4.10	0.81	6.04	100.00

barren lands with scarce vegetation. Most of the arable lands remain unchanged in 2006, and the rest of them have transferred in meadows. The most significant changes have occurred in the class Barren land with scarce vegetation, where only 3.4% of them have remained unchanged and the rest has turned into deciduous forest, coniferous forest and urban area.

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